CHAPTER 4. FULL MENU OF COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR LAGUNA DE BAY LAKESHORE AREA

4.1 Concept of Comprehensive Flood Management Plan

4.1.1 Basic Policy

The Laguna de Bay Comprehensive Flood Management Plan is formulated based on the following policy.

(1) Clarify the hydrological characteristics of the Flood in Laguna de Bay. The lake water level is gradually increased in the regular rainfall during the rainy season. In the case when the area is directly hit by Typhoon or tropical cyclone, the water level rapidly rises by the rainfall to the lake surface and the inflow from many rivers and drainage channel including the Mangahan Floodway and the inundation damage is occurred.

(2) Clarify the characteristics of the flood damage. It is the flood water level of the lake (at the past maximum flood recorded EL. 14.03 m, the water depth of about 2 m in the case of the lowest residential elevation of EL. 12.0m) and the long flood period of several months. Since 1949, the incident that the water level exceeding the lowest ground elevation of EL. 12.0 m occurred 47 times and the flood damage occurred once in 1.5 years.

(3) For the geographical range of flood damage, almost the entire area of the Laguna de Bay lakeshore is used, and the damage area covers almost entire shore area. Therefore, for the flood control measure of Laguna de Bay, the comprehensive flood management plan throughout the lakeshore area is examined.

(4) The plan period is set to 30 years and it is implemented separately for a short term, medium term and long term.

(5) The countermeasure menu is roughly classified into structural measure and non-structural measures.

(6) However, the entire shore area of the Laguna de Bay covers about 220 km, it is difficult to implement the structural measures in the entire area within the implementation period of 30 years. The priority areas are selected to firstly implement the countermeasure projects within the implementation period of 30 years.

(7) The optimal combination of structural and non-structural measures to be implemented in the priority area is investigated.

(8) In addition, the implementation schedule is investigated.

(9) Based on the above results, the Parañaque Floodway is comprehensively evaluated and positioned in the Comprehensive Flood Control Management Plan.

4.1.2 Proposal of Evaluation Criteria Considering Disaster Risk Mitigation, Disaster Rick Management and Climate Change Adaptation

In order to evaluate the flood management measures for the entire Laguna de Bay lakeshore area, the evaluation criteria were selected and shown in Table 4.1.1. Proposed criteria were regarding the disaster risk mitigation and management, technical difficulties (design and construction), difficulties on operation and management, financial feasibility (the project cost), economics, climate change adaptation influence on natural environment and influence on social environment.

Table 4.1.1 Proposal of Evaluation Criteria

No.	Evaluation Criteria	Indexes	Score
1	Mitigation and Management of Disaster Risk	Lake water drawdown, Reduction of Inundated area, Reduction of inundation period, Reduction of flood damage, Reduction of affected people	10
2	Technical Difficulty	Difficulty of Design, Difficulty of construction, Implementation period, Influence on existing and planned flood management facility	10
3	Adaptation to climate change and flood exceeding design scale	Adaptation to climate change, Adaptation to flood exceeding design scale	10
4	Natural Environment	Water quality, Lakeshore landscape preservation	10
5	Social Environment	Difficulty of necessary steps before construction, Nos of Relocated people, Area of land acquisition, Implementation Period, Influence of Construction, Influence on local area	20
6	O/M Difficulty	Difficulty of operation and Management, O/M Cost	10
7	Financial Feasibility	GOP fund or DPWH annual budget	10
8	Economics	EIRR、B/C、NPV	20
Total			100

Source: JICA Survey Team
* When evaluating, countermeasures will be evaluated comprehensively based on the above criteria

Adaptation to climate change and to flood exceeding design scale is additional part of disaster risk mitigation and management of which fulfils the target flood safety level of the comprehensive flood management plan. Those adaptation cannot be achieved with only the structural measures, and can be conducted with non-structural measures such as land use regulation, implementation of warning system as the disaster risk mitigation.

4.1.3 Full Menu of Comprehensive Flood Management Plan

In order to propose the full menu of comprehensive flood management plan, firstly sort the conditions for the selection, secondary propose and preliminary evaluate the measures and list up the feasible ones.

(1) Conditions for the Proposal of the Full Menu of Comprehensive Flood Management Plan

The entire Laguna de Bay lakeshore area at the length of approximately 220 km is used for some reason and flood prone area is wide spread all over the lakeshore area. However, there are some tendencies on the land use such as traditional agricultural area, residential area commercial and industrial area in the Metro Manila and its suburbs. On the other hand, hydrological features show the surge of the Laguna de Bay lake water level caused by Typhoons and monsoons.

Considering such hydrological and land use features, the full menu of comprehensive flood management plan was proposed. There are two types of the measures in the plan as shown below.

1) Water Level Rise Control at Laguna de Bay
2) Flood Damage Mitigation

Preliminary evaluation was conducted in the view point of flood management and mitigation effect, construction site availability and social impact feasibility.

(2) Study on Laguna de Bay Water Level Rise Control Menu

Controlling the water level rise in Laguna de Bay means reducing the direct flood damage and indirect flood damage such as the reduction of the inundation period.

There are three methods to controlling the water level rise as follows.

1) Reducing the inflow into Laguna de Bay
2) Increasing the outflow from Laguna de Bay
3) Increase the flood storing capacity of Laguna de Bay

Regarding these three methods, following menu was proposed.

Table 4.1.2 Menu for Water Level Rise Control (Structural Measure)

Purpose	Proposed Menu	Outline	Preliminary Evaluation
1) Reducing the inflow into Laguna de Bay	Construction of structural measures such as dams and retarding basins at each river around the lake	Dams and retarding basins at each river around the lake are required at each river around the lake.	If the natural conditions of Laguna de Bay such as the large basin area of 3,280 km^2 including the lake surface area of approx. 900 km and a large number of rivers are considered, enormous amount of structural measures are required. In addition, adequate site for the construction of the dam cannot be identified. Hence, this method is not feasible. ×
2) Increasing the outflow from Laguna de Bay	Dredging of Napindan Channel and Mangahan Floodway	Lake water runs through Napindan channel and Mangahan Floodway then Pasig River to Manila Bay. Pasig River which has been already improved with Japan ODA, is out of the scope for this improvement.	Both river bank is occupied by the residential buildings and widening of the channel is not feasible. Hence, dredging of the channels are studied. ○
	Widening of Napindan Channel	Utilizing remaining flow capacity of Pasig River, discharge from Laguna de Bay through Napindan channel with its length of 6 km with widening the Napindan channel.	The both banks are already highly occupied, and this method depends on the remaining flow capacity in Pasig River. Besides, this has large social impact. △
	Construction of Parañaque Spillway	The spillway crosses the highly developed area and it discharge the water from Laguna de Bay directly into Manila Bay. The length is about 10 km and it is much shorter than the one of Napindan channel-Pasig River, which is about 25 km.	The flood control effect is expected. It is feasible if the social impact can be minimized with underground tunneling type is adapted. ○

Purpose	Proposed Menu	Outline	Preliminary Evaluation
	Construction of Pacific Ocean Spillway	The spillway crossing the mountain whose height is about 500 m with tunnel type structure discharge the water from Laguna de Bay to the Pacific Ocean.	This is inferior as compared with the Parañaque Spillway in economical point of view since the length of the spillway is about twice as long, and it has the limit of the diameter due to the small fluctuation of water level (approx. 4m.), and tide level at the Pacific Ocean is a little higher than the one in Manila Bay. △
3) Increase the flood storing capacity of Laguna de Bay	Dredging of the sedimentation at Laguna de Bay	In order to enlarge the storage capacity of the lake, the bottom of the lake is dredged. The bottom of the lake is located at 2m to 6m lower than the average tide level at Manila Bay (approx. EL 10.5 m)	During the dry season, sea water is expected to inflow into the lake. Dredging lower than EL 10.5 m has no flood control effect since the mean low water level of the lake is at approx. EL 10.5m. ×
	Excavation of the lakeshore area of Laguna de Bay	As dredging, the storage capacity is enlarged in order to lower the lake water level. The bottom elevation of the excavation is designed at EL 10.5 m.	To have the effect on lowering the lake water level, large amount of excavation should be conducted. This has flood control effect but not feasible. ×

Legend: ○:Good/Possible △:Not Good/Some problem ×:Difficult/Impossible
Source: JICA Survey Team

(3) Study on Flood Damage Mitigation Menu

As flood mitigation measures in aspect of flood area and flood damaged assets caused by the surge of the water level of Laguna de Bay, Laguna Lakeshore Diking System is the general measure to be proposed. With the system, inland drainage measure is required.

Depending on the topographical features, land raising, resettlement to the hilly area and non-structural measures are also the choices to be taken.

Table 4.1.3 Menu for Flood Damage Mitigation

Measure	Outline	Preliminary Evaluation
Construction of the lakeshore diking system	The structure consisting of lakeshore dike, drainage channel, pumping station, community road and bridge is herein called as a lakeshore diking system. The diking system is constructed to prevent flooding from Laguna de Bay. The flood damage up to the design scale is prevented. It is necessary to consider backwater levee at major rivers, and treatment of internal water in the dike such as pumping station.	There are issues such as excessive flooding, the fear of collapse of the dike due to earthquake, landscape issues that the lake cannot be seen well due to dikes, and inconvenience of fishermen’s access to the lake. ○
River improvement of major basin	Since the flow discharge of river in major basin is large, flood overflows cause large damage. In addition.	The flood mitigation measures (river improvement) for each river is necessary. ○
Land raising for living	For the relatively steeper slope topography like western side of the Laguna de Bay, there is an idea of raising lakeshore land itself for protecting the areas against flooding of the Lake. By the land raising, it will be possible to conserve scenery of the Lake and access of the fishermen to the Lake. In addition, utilization of eco-tourism potential of the Lake will be possible by developing the raised land with consideration of environment of the Land. Through conducting stretch-wise land raising, the inhabitants along the lakeshore will be once resettled to temporary resettlement site, and then can come back and enter in to resettlement houses in the original places.	Progress of the project is considered to require a lot of time due to the necessity of temporary relocation of residents and the difficulty of forming consensus among all residents. Although it is possible in areas where the target area is small, it is not realistic to cover the entire area of Laguna de Bay lakeshore area. ×

Measure	Outline	Preliminary Evaluation
Resettlement of inhabitants from the inundation areas to higher safe areas	Inhabitants in the inundation areas along the Laguna de Bay lakeshore area to in-city of nearby places without inundation as much as possible by considering maintenance of their communities and livelihood. Although not only resettling informal settlers, as it is more difficult to resettle formal inhabitants with land titles living in the inundation areas, proper compensation and provision of resettlement houses will be necessary.	Progress of the project is considered to require a lot of time due to the necessity of temporary relocation of residents and the difficulty of forming consensus among all residents. Although it is possible in areas where the target area is small, it is not realistic to cover the entire area of Laguna de Bay lakeshore area. ×
Proposing Lake Management and its implementation	LLDA has the responsibility of managing water body and lakeshore below El. 12.50, which is the average annual maximum lake water level. However, the lakeshore above El. 12.50 is under responsibility of LGUs. Hence, consistent management of the lakeshore has not been conducted, and density of houses on the low land along lakeshore has been higher.	In order to conduct consistent management of the lakeshore, real lakeshore elevation will be set based on El. 12.50m plus wave run-up height plus some allowance. By adding some easement width (3m etc.) along the real lakeshore line, Lake Management shall be conducted from the easement zone to inside of the Lake. The Lake Management shall be conducted by LLDA under cooperation by the LGUs etc. ○
Establishing disaster risk reduction and management committee for the Laguna de Bay	The Laguna Lake Basin belongs to NCR and Region IV-A, and many LGUs belong to these Regions. In addition, several governmental agencies etc. relate to the Basin.	In order to implement and improve consistent DRRM for the whole Laguna Lake Basin, NDRRMC shall have a coordinating function, and implement Prevention & Mitigation and Preparedness including flood forecasting and warning systems based on the Master Plan for DRRM. ○
Land use management	Land use management for the lakeshore areas of the Laguna de Bay shall be conducted. For the areas without structural measures for the flood risk areas along the Laguna de Bay lakeshore, direction shall be set for not living in those areas. For the areas for providing structural measures, land use management shall be conducted for not increasing houses in the densely building areas by considering excess floods.	In the flood countermeasure, land use management has large effect of damage reduction and damage potential reduction. ○
Installing warning systems	In order to conduct flood warning for the rivers to the Laguna de Bay with flash flood problems as well as for the floods of the Lake, flood warning systems will be installed.	The Warning System will be PAGASA's system composed of a X-band radar rain station, radio telemetric rain gauges and radio telemetric water level gauges. In addition, as for the extension of EFCOS, in order to utilize for operating the Parañaque Spillway, radio telemetric lake water level gauge, radio telemetric water level gauge in the Manila Bay, and warning posts shall be installed. ○
Preparation of flood hazard maps	Flood hazard maps under probable floods shall be made based on flood simulation for the Laguna de Bay and river basins.	It is very effective for residents' disaster risk recognition. ○

Source: JIA Survey Team

As a result of the preliminary evaluation, the following alternatives for the firstly selected measures were listed.

Table 4.1.4 Flood Management Measures (First Step)

Control and Prevention of Water Level Rise	Mitigation of Inundation Damage	Non-Structural Measure
・ Dredging of Napindan Channel and Mangahan Floodway ・ Widening of Napindan Channel ・ Construction of Parañaque Spillway ・ Construction of Pacific Ocean Spillway	・ Construction of lakeshore diking system (with backwater levee and drainage facilities) ・ River improvement on the selected rivers	・ Implementation of the lakeshore management ・ Establishment of the committee for the Laguna de Bay Basin ・ Land use regulation ・ Implementation of warning system ・ Inundation hazard map
Reduction of inundation depth and period at the entire Laguna de Bay lakeshore area is expected.	Long construction period and selection of the priority area are required.	Effective for the entire Laguna de Bay lakeshore area

Source: JICA Survey Team

4.1.4 Design Criteria

DPWH updated its "Design Guidelines, Criteria and Standards” in 2015 which were compiled in 1984 (hereafter referred to as “DPWH Standard Guideline 2015”) and the department order was issued on December 8, 2015 to enable the DPWH Standard Guideline 2015 to be applied to all public infrastructures DPWH would implement. The validity of the criteria was taken and the design standards necessary for flood control across Laguna lakeshore area were proposed.

Supplemental criteria are set with reference to the Manual for Government Ordinance for Structural Standard for River Administration Facilities, Japan's River Management Facility (Cabinet Order No. 199 of July 20, 1977) and design standards of other countries. For Philippine river flood management projects, the major standards currently applied are as listed in Table 4.1.5, and Japan's standards to be applied are summarized in Table 4.1.6.

Table 4.1.5 Design Standards for Flood Management Structures in the Philippines

No.	Title	Summary of Contents
1	Design Guidelines, Criteria and Standards, 2015 Edition, Vol. 1 – 6	Standards and Guidelines compiled in 2015. Revision of the ones of Volume I and Volume II in 1984
2	National Building Code of the Philippines (NBCP), 2005 Revised Edition	Conditions and notes for designing of buildings
3	National Structural Code of the Philippines, Volume I (NSCP, Vol I) for buildings, towers and other vertical structures, 2010	Mainly, design methods and loading conditions for buildings
4	National Structural Code of the Philippines, Volume II (NSCP, Vol. II) for Bridges, 2005	Mainly, design methods and loading conditions for bridges and accessories

Table 4.1.6 Design Standards for Flood Management Structures in Japan

No.	Title
1	Technical Standards for River and Sabo Works, Survey-2014/4, Plannig-2014/4, Design-1997/09, Operation & Maitenace-2011/5, Japanese Ministry of Land, Infrastructure, Transport and Tourism
2	Guidelines for Urban River Planning, Flood Prevention Management Planining-1993/6 and Facility Planning of Spatial River- 1995/4
3	Standard Manual for Tunneling, 2016/8, Japan Society of Civil Engineers
4	Manual for Government Ordinance for Structural Standard for River Administration Facilities, Revised Version, 1999/11, Japan River Association
5	Guideline for Flexible Sluiceway, 1998/11, Japan Institute of Country-ology and Engineering
6	Technical Standard and Design Guideline for Pumping Equipment of Pump and Drainage, 2001/2, Association for Pump System Engineering

Specific design criteria for structures such as dikes, Parañaque Spillway are described in each section.

4.2 Study on Drainage and Excavation Capacity of Napindan Channel and Mangahan Floodway

4.2.1 Existing Conditions of Napindan Channel and Mangahan Floodway

(1) Existing Condition of Napindan Channel

The existing river specifications of Napindan Channel are shown in Table 4.2.1 and the cross-sectional survey diagrams in 2002 are given in Figure 4.2.2.

- The length is approximately 6 km with no longitudinal slope. River water flows down due to the difference of water level between the Laguna de Bay and the Pasig River. When water level of Laguna de Bay is higher than Pasig River water level, the flow is from Laguna de Bay to Pasig River. When the water level of Pasig River level is higher than that of Laguna de Bay, water flows from Pasig River to Laguna de Bay.
- Parapet wall is installed from Sta. 2+923 to Laguna de Bay and constraints were confirmed in some places.

Table 4.2.1 River Specifications of Existing Napindan Channel

STA	Accumulate Distance m	Distance m	Left Dike height m	Right Dike height m	Existing River Bed m	Width m
Sta.6+802	6,802	221	14.1	14.1	5.6	129.2
Sta.6+581	6,581	106	14.1	14.1	5.2	128.1
Sta.6+475	6,475	219	14.1	14.1	2.8	98.4
Sta.6+256	6,256	164	14.1	13.7	5.1	137.6
Sta.6+092	6,092	104	14.1	14.1	4.9	136.1
Sta.5+988	5,988	289	14.1	14.1	3.9	146.5
Sta.5+699	5,699	187	14.1	14.1	4.7	126.0
Sta.5+512	5,512	176	14.1	14.1	5.2	110.5
Sta.5+336	5,336	172	14.1	14.1	4.5	107.4
Sta.5+164	5,164	189	14.1	14.1	4.9	114.7
Sta.4+975	4,975	210	14.1	14.1	4.5	112.7
Sta.4+765	4,765	187	14.1	14.1	4.3	94.6
Sta.4+578	4,578	187	14.1	14.1	3.1	85.6
Sta.4+391	4,391	121	14.1	14.1	1.7	72.9
Sta.4+270	4,270	213	14.1	14.1	3.2	118.4
Sta.4+057	4,057	203	14.1	14.1	3.5	109.6
Sta.3+854	3,854	207	14.6	14.1	3.2	137.5
Sta.3+647	3,647	181	14.1	14.1	6.0	117.7
Sta.3+466	3,466	173	14.1	14.1	6.0	109.4
Sta.3+293	3,293	208	14.1	14.1	5.8	104.3
Sta.3+085	3,085	162	14.1	14.1	5.2	114.3
Sta.2+923	2,923	192	14.1	14.1	2.8	136.3
Sta.2+731	2,731	124	13.2	13.5	5.6	163.1
Sta.2+607	2,607	169	12.7	12.7	6.0	119.6
Sta.2+438	2,438	171	14.3	12.7	6.0	128.0
Sta.2+267	2,267	190	13.4	13.5	6.0	120.5
Sta.2+077	2,077	182	13.1	13.2	6.0	119.6
Sta.1+895	1,895	220	13.5	13.1	6.0	104.7
Sta.1+675	1,675	165	13.6	13.6	6.0	96.4
Sta.1+510	1,510	203	13.0	13.8	5.7	91.0
Sta.1+307	1,307	164	13.7	13.5	4.9	101.6
Sta.1+143	1,143	185	14.3	14.0	5.1	118.2
Sta.0+958	958	221	14.0	13.2	5.8	103.9
Sta.0+737	737	238	13.9	13.7	3.7	91.3
Sta.0+499	499	326	14.1	14.8	3.7	77.2
Sta.0+173	173	113	13.8	15.4	6.0	110.6
Sta.0+060	60	0	13.8	15.4	6.0	110.6

Figure 4.2.1 Longitudinal Profile of Napindan Channel (Upper Diagram) Width (Bottom Diagram)

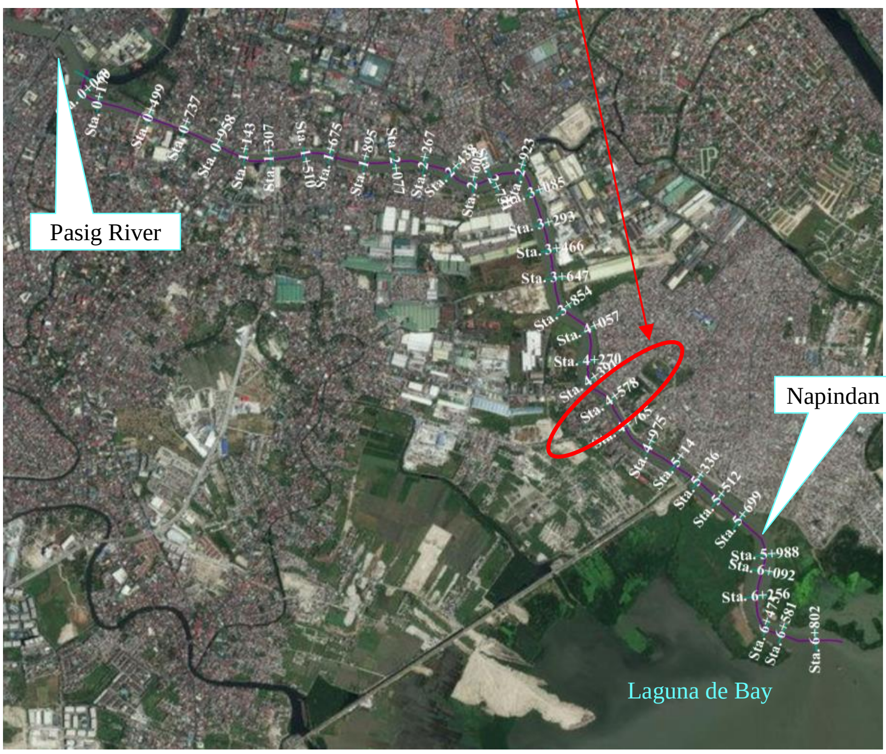


Figure 4.2.2 Location Map of Cross-sectional Survey in 2002

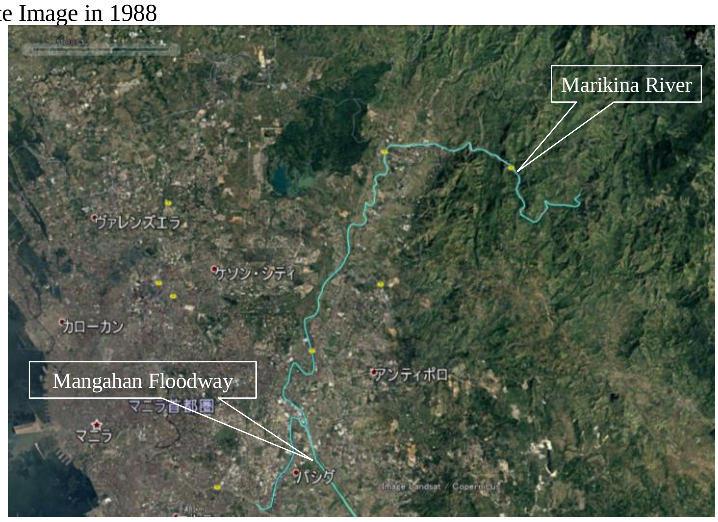
(2) Existing Condition of Mangahan Floodway

About 30 years has passed since the construction of Mangahan Floodway in 1988. Cross-sectional surveys have been carried out three times since its completion.

The riverbed sedimentary condition of Mangahan Floodway is shown in Figure 4.2.3. Regarding the secular change of riverbed, the riverbed tends to rise year by year due to the transport of sediment from the Marikina River.

By comparing the satellite images in 1988 and 2016 (lower figure), it is obvious that urbanization is progressing in the upper stream area of the Marikina River. It is inferred that these developments have affected the Mangahan Floodway and sediment has accumulated in the Pasig-Marikina River because the forests were devastated and sediment production in the watershed has increased. Illegal residents or ISFs (Informal Settler Families) are also present in the flood plain of Mangahan Floodway. These have reduced the cross section area of the floodway.

Satellite Image in 1988



Source: Google Earth

Satellite Image in 2016

Source: Google Earth

Figure 4.2.3 Comparison of Upper Area of Marikina River (1988, 2016)

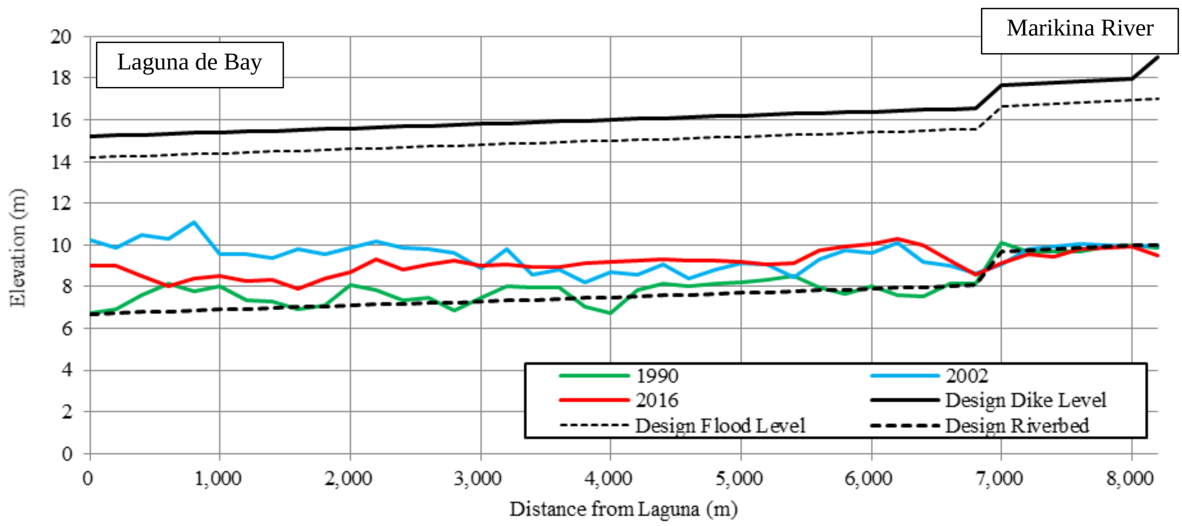
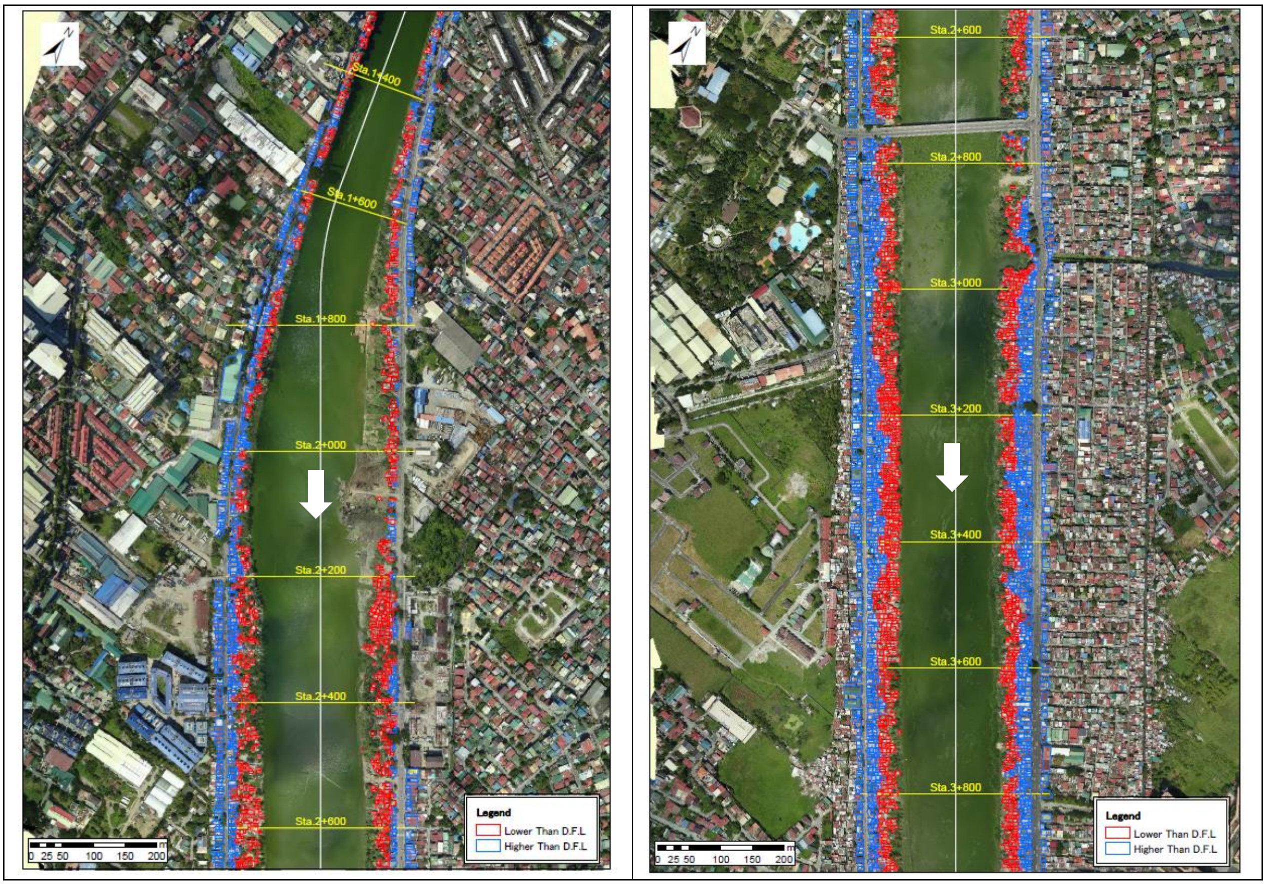


Figure 4.2.4 Change of Longitudinal Profile in Mangahan Floodway



Source: Consultant Team of Pasig Marikina River Improvement Project Phase III

Figure 4.2.5 Distribution Condition of ISFs (Informal Settler Families) along Mangahan Floodway

4.2.2 Evaluation of Drainage Capacity of Napindan Channel and Mangahan Floodway

(1) Study Case

As discussed above, considering the existing river channel condition of Napindan Channel and Mangahan Floodway, the effect of Laguna de Bay water level change due to the excavation of Napindan Channel, river channel widening, and dredging of the Mangahan Floodway was studied, as summarized in the table below. The probability scale used in these study cases is based on the 100-year probability of lake water level (14.3 m), which is expected to improve the Napindan Channel or the Mangahan Floodway.

Table 4.2.2 Study Cases on Napindan Channel and Mangahan Floodway

Case	Napindan Channel	Mangahan Floodway	Remarks
0	Existing condition (Cross section of 2002)	Existing condition (Cross section of 2002)	・Comparison case ・100-year return period lake water level=14.3m
1	Riverbed＝6.0m excavation Dike Height＝15.0m Width＝Existing width Slope Gradient＝1:0.5	Existing condition (Cross section of 2002)	・Existing height of parapet wall is 14.1m. Lake water level is 14.3m in 100-year return period. ・Heightening of parapet wall until 15.0m because existing parapet wall is lower than 100-year water level. ・Excavation of riverbed until 6m without river widening.
2	Riverbed＝6.0m (Excavation) Width=150m (Widening) Dike height＝15.0m Slope gradient＝1:0.5	Existing condition (Cross section of 2002)	・River widening until 150m in all sections.
3	Existing condition (Cross section of 2002)	Dredging to Design Cross Section (Execution section in 1988)	・Mangahan Floodway has sedimented since the constructed cross section in 1988 and river capacity impediments occurred due to ISFs living in river (flood plain). ・Water level exceeds DFL when peak flow is 2,400m^3/s in existing cross section.
4	Riverbed＝6.0m (Excavation) Dike height＝15.0m Width＝Existing width	Dredging to Design Cross Section (Execution section in 1988)	

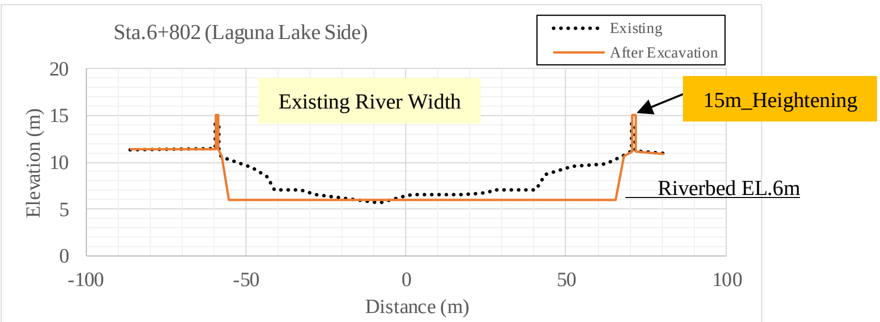


Figure 4.2.6 Napindan Channel Excavation (Case-1)

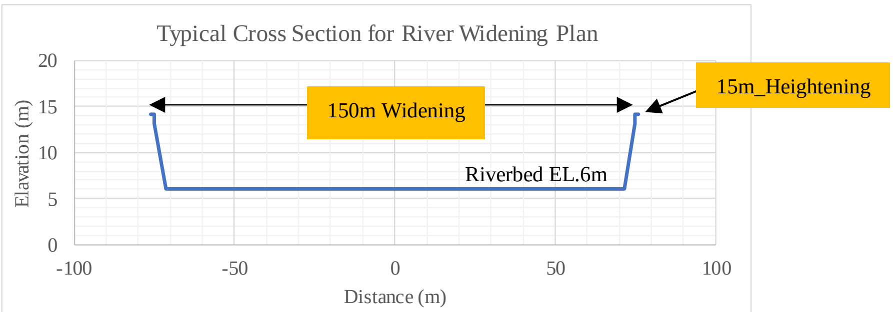


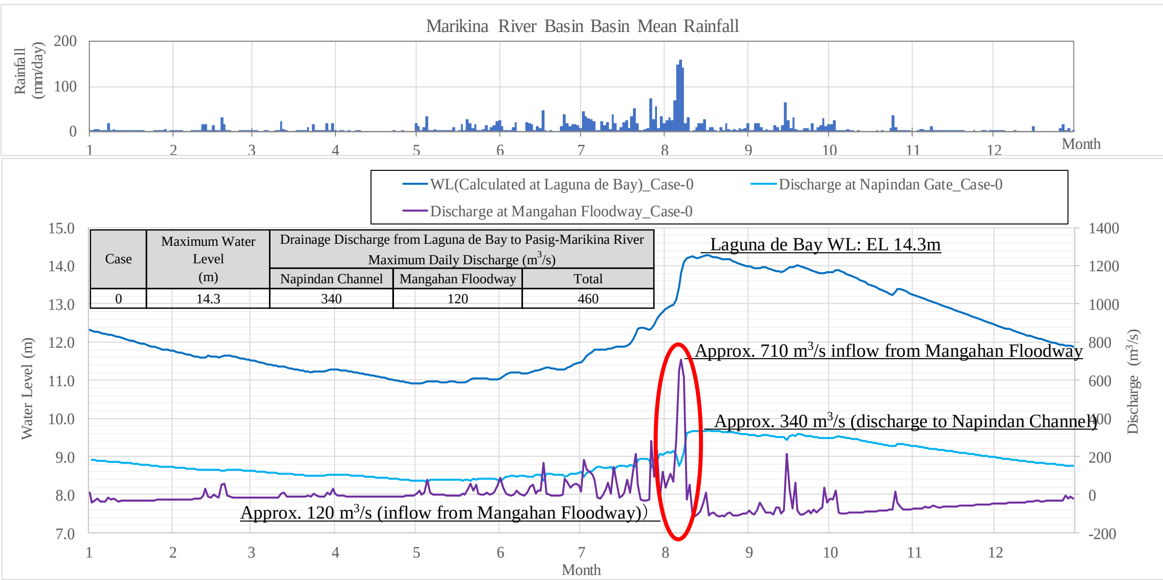
Figure 4.2.7 Napindan Channel Widening (Case-2)

(2) Evaluation of Napindan Channel and Mangahan Floodway under Existing Conditions (Case-0)

Analyses were conducted applying the cross sections surveyed in 2002 for Napindan Channel and Mangahan Floodway.

＜Outline of Case-0 Results (refer to Figure 4.2.8)＞

- The maximum daily discharge from Laguna de Bay to Pasig River through Napindan Channel is 340m^3/s.
- The maximum daily inflow from Pasig River to Laguna de Bay through Mangahan Floodway is 710 m^3/s and the inverse one is approx. 120 m^3/s.
- In August, increased rainfall at Marikina River Basin caused the flood in Marikina River and inflow to Laguna de Bay through Mangahan Floodway. After the flood and drawdown of the water level in Marikina River, the water flows inversely from Laguna de Bay to Marikina River through Mangahan Floodway. This means that the Napindan Channel and Mangahan Floodway contributed lowering the lake water level by discharging the water into Pasig-Marikina River.



* 1 The positive flow of Mangahan Floodway is the flow from Marikina River to the lake through Mangahan Floodway, the negative flow is flow from the lake to Marikina River through Mangahan Floodway.
* 2 The positive flow of Napindan channel is the flow to the lake Pasig River through Napindan Channel, the negative flow is the flow from Pasig River to the lake through Napindan Channel.

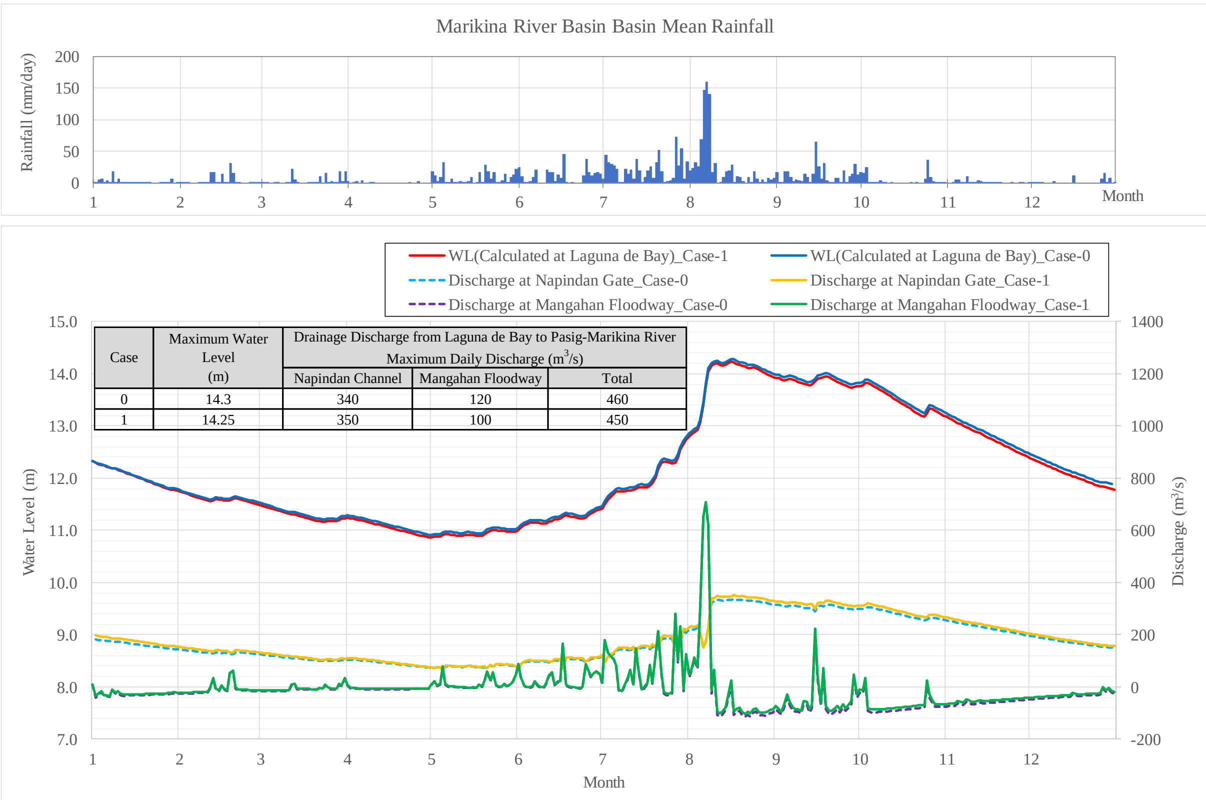
Figure 4.2.8 Result of Evaluation of Napindan Channel and Mangahan Floodway under Existing Conditions (Case-0)

(3) Excavation of Napindan Channel (Case-1)

Since the bed height of Napindan Weir is 6.0 m (see Figure 3.4.7), the influence of lake-water level when excavating the riverbed of the Napindan channel to 6.0 m was examined.

＜Outline of Case-1 Results (refer to Figure 4.2.9)＞

- The maximum lake water level decreased by 5 cm from 14.3m (Case-0) to 14.25 m.
- The maximum daily discharge through Napindan Channel to Pasig River increased to 350 m^3/s from 340 m^3/s (Case-0). The increment is approximately 10 m^3/s, or 3%.
- A little decrease of discharge to Mangahan Floodway was observed, from 120 m^3/s to 100 m^3/s.
- It has been confirmed that flows from Napindan Channel to Laguna de Bay due to precipitation increases in Marikina River Basin in August. After flooding, when the water level of Marikina River is decreasing, lake water flows back from Laguna de Bay to Mangahan Floodway (flow down to Marikina River). Lake water flows to Pasig-Marikina River through Napindan Channel and Mangahan Floodway after flooding in August, which contributes to the decline of lake-water level.
- The effect of the dredging of Napindan Channel on lowering the water level in Laguna de Bay is very small.



Case	Maximum Water Level (m)	Drainage Discharge from Laguna de Bay to Pasig-Marikina River Maximum Daily Discharge (m^3/s)		
		Napindan Channel	Mangahan Floodway	Total
0	14.3	340	120	460
1	14.25	350	100	450

* 1 The positive flow of Mangahan Floodway is the flow from Marikina River to the lake through Mangahan Floodway, the negative flow is flow from the lake to Marikina River through Mangahan Floodway.

* 2 The positive flow of Napindan channel is the flow to the lake Pasig River through Napindan Channel, the negative flow is the flow from Pasig River to the lake through Napindan Channel.

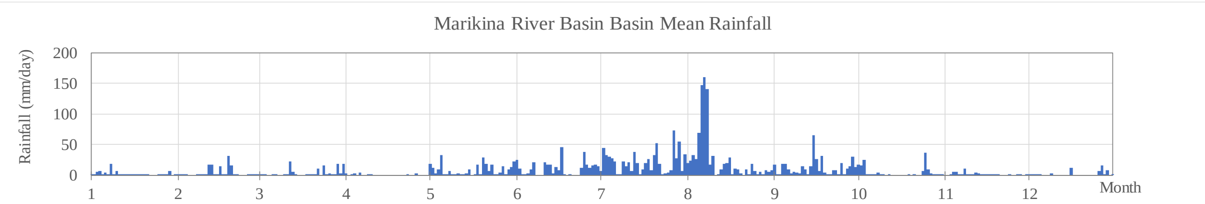
Figure 4.2.9 Result of Napindan Channel Excavation (Case-1)

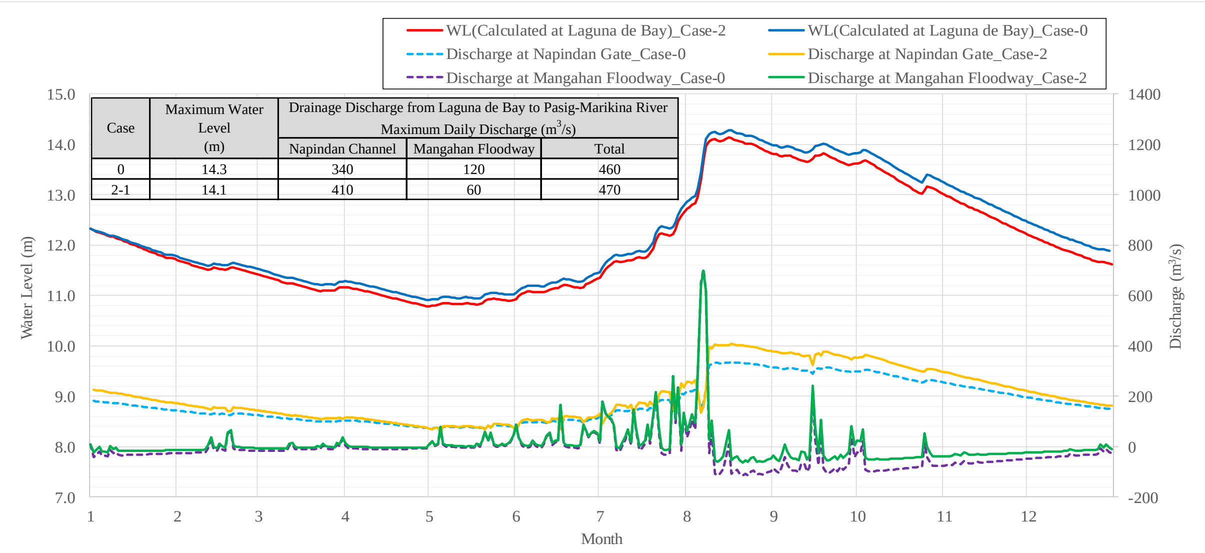
(4) Widening of Napindan Channel (Case-2)

The effects of lake-water level when the Napindan Channel is widened to 150 m and 250 m (Case-2) are as summarized below.

＜Outline of Case-2 Results (refer to Figure 4.2.10 and Figure 4.2.11)＞

- The maximum lake water level decreased by 20 cm from 14.3 m (Case-0) to 14.1 m for both Case 2-1 with 150 m width and Case 2-2 with 250 m width.
- The maximum daily discharge through Napindan Channel to Pasig River increased from approx. 340 m^3/s to approx. 410 m^3/s, On the other hand, the maximum daily discharge through Mangahan Floodway to Marikina River decreased from approx. 120 m^3/s to approx. 20 m^3/s.
- As described, the discharge through Mangahan Floodway is largely decreased due to the enlarged flow capacity of Napindan Channel. These phenomena cancel out the effects of the maximum daily discharge through Napindan Channel and Mangahan Floodway (approx. 470 m^3/s in total.) This is because increase of discharge raised the water level in Pasig River and resulted in limiting the increment of the discharge.
- Total of the maximum daily discharges through Mangahan Floodway and Napindan Channel in Case 2 is almost same with the one in Case 0. However, if the water level of Laguna de Bay is lowered before the flood, a peak of the water level during flood can be a little lowered.
- In addition, in the Napindan Channel widening case, since many houses are densely distributed along the Napindan Channel, a large scale of resettlement need to be taken.

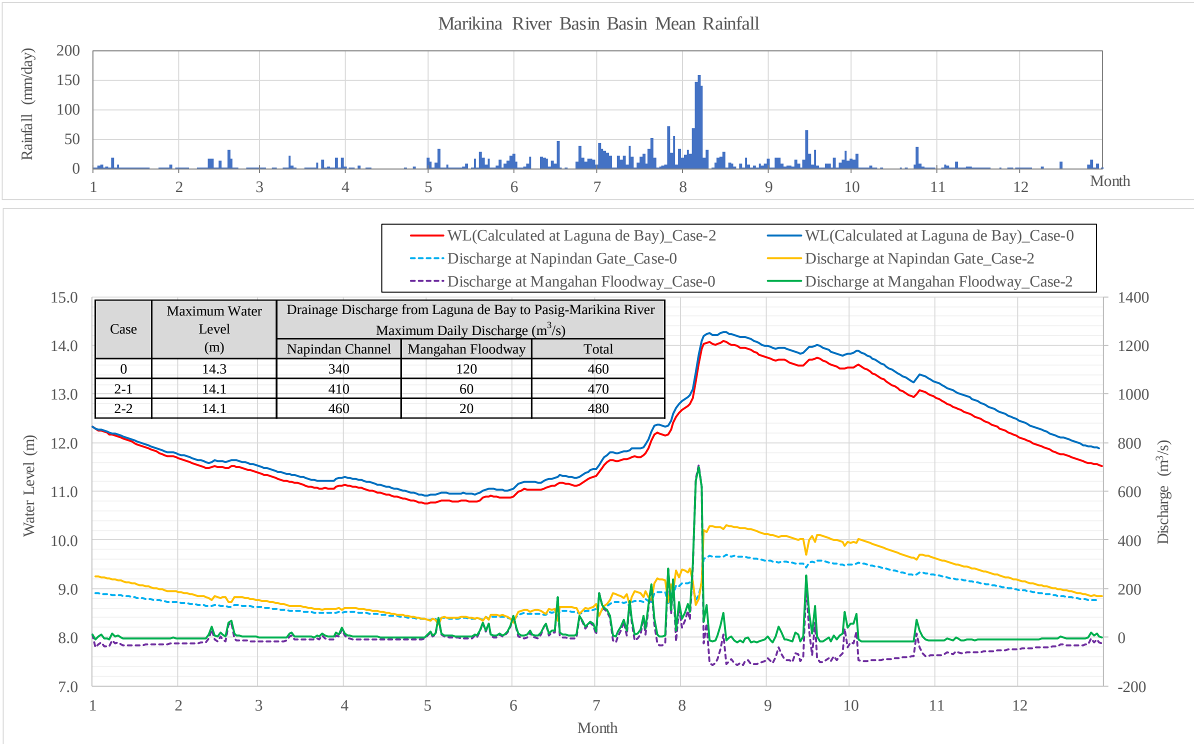




Case	Maximum Water Level (m)	Drainage Discharge from Laguna de Bay to Pasig-Marikina River Maximum Daily Discharge (m^3/s)		
		Napindan Channel	Mangahan Floodway	Total
0	14.3	340	120	460
2-1	14.1	410	60	470

* 1 The positive flow of Mangahan Floodway is the flow from Marikina River to the lake through Mangahan Floodway, the negative flow is flow from the lake to Marikina River through Mangahan Floodway.
* 2 The positive flow of Napindan channel is the flow to the lake Pasig River through Napindan Channel, the negative flow is the flow from Pasig River to the lake through Napindan Channel.

Figure 4.2.10 Result of Napindan Channel Widening at 150 m (Case-2-1)



Case	Maximum Water Level (m)	Drainage Discharge from Laguna de Bay to Pasig-Marikina River Maximum Daily Discharge (m^3/s)		
		Napindan Channel	Mangahan Floodway	Total
0	14.3	340	120	460
2-1	14.1	410	60	470
2-2	14.1	460	20	480

* 1 The positive flow of Mangahan Floodway is the flow from Marikina River to the lake through Mangahan Floodway, the negative flow is flow from the lake to Marikina River through Mangahan Floodway.

* 2 The positive flow of Napindan channel is the flow to the lake Pasig River through Napindan Channel, the negative flow is the flow from Pasig River to the lake through Napindan Channel.

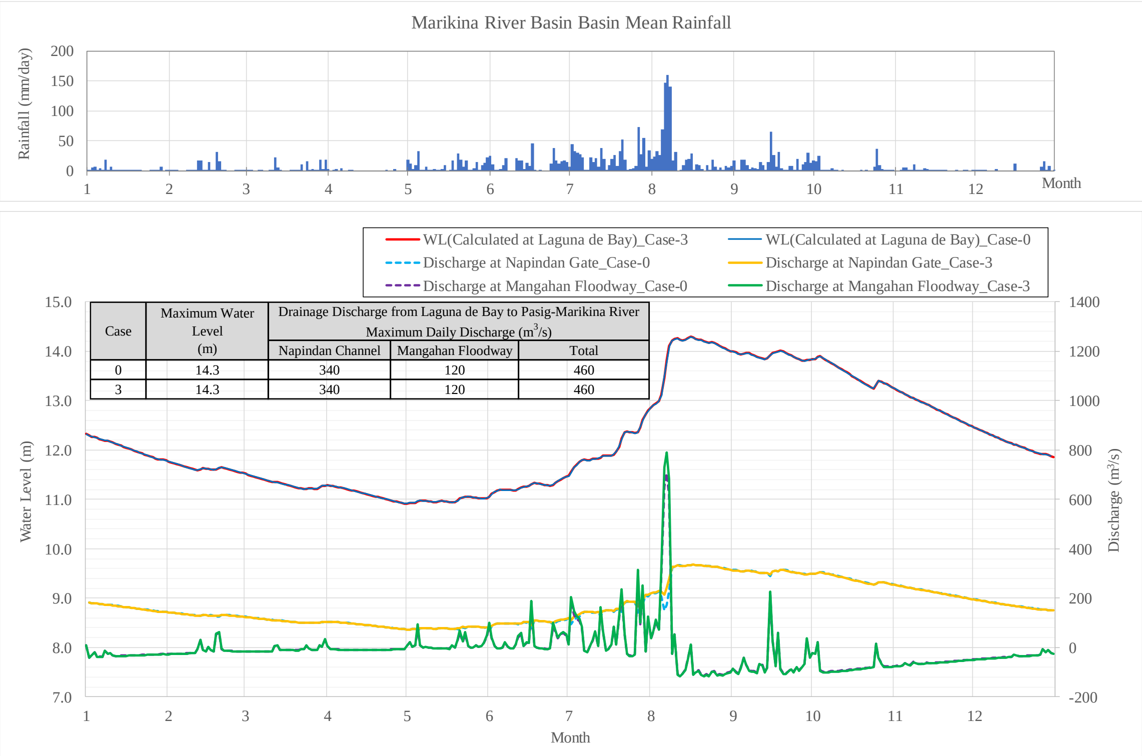
Figure 4.2.11 Result of Napindan Channel Widening at 250 m (Case-2-2)

(5) Mangahan Floodway Dredging (Case-3)

The effect of dredging at Mangahan Floodway to the lake-water level was studied. Flow capacity of Mangahan Floodway has been decreased due to the riverbed sedimentation and the increase of ISFs. In the analysis, the cross section in 1988, right after the construction of the channel was applied assuming that the dredging was conducted down to the section. On the one hand, no arrangement was taken for the cross sections for Napindan Channel.

＜Outline of Case-3 Result (refer to Figure 4.2.12)＞

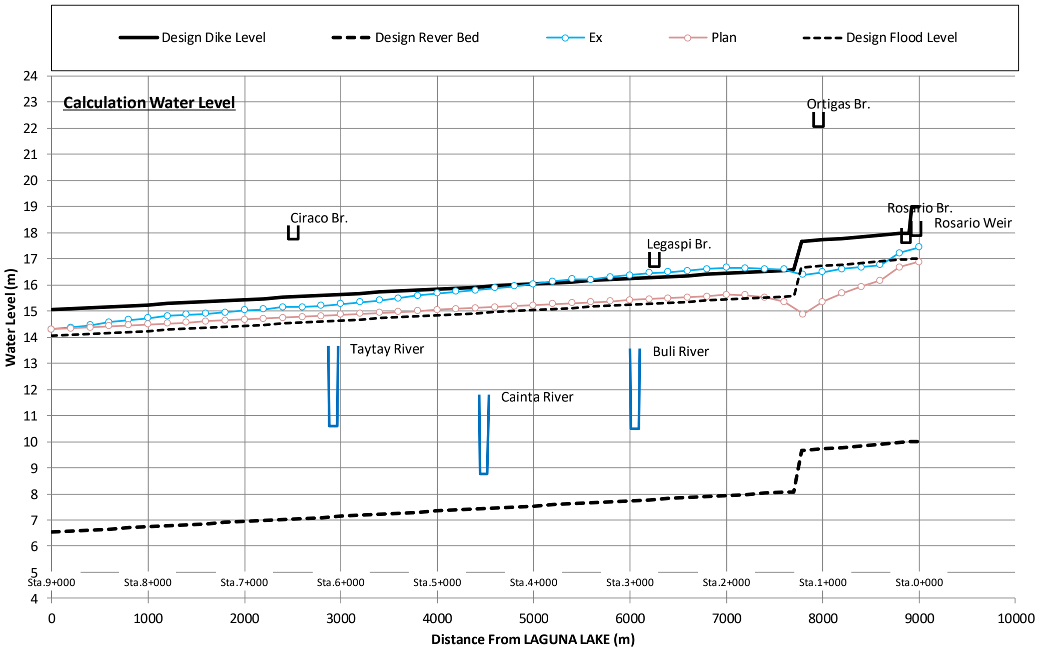
- No significant change on the maximum lake water level from EL 14.3m (Case-0)
- No significant change on the maximum daily discharge through Mangahan Floodway to Marikina River
- The maximum daily inflow from Marikina River through Mangahan Floodway increases from approx. 710 m^3/s to 790 m^3/s during the wet season, in August.
- No significant influence of dredging at Mangahan Floodway on discharge through Napindan Channel
- Regarding the dredging plan for Mangahan Floodway, when the design discharge of Mangahan Floodway (2,400 m^3/s) flows through Mangahan Floodway, the water level exceeds the Design Flood Level (D.F.L) in the existing cross-section. Therefore, the cross sections in 1988 shall be examined not to have the water level exceed D.F.L in the flood control plan of Pasig-Marikina River. Longitudinal profiles of the water levels with the existing cross sections and the cross sections in 1988 are shown in Figure 4.2.13.



Case	Maximum Water Level (m)	Drainage Discharge from Laguna de Bay to Pasig-Marikina River Maximum Daily Discharge (m^3/s)		
		Napindan Channel	Mangahan Floodway	Total
0	14.3	340	120	460
3	14.3	340	120	460

* 1 The positive flow of Mangahan Floodway is the flow from Marikina River to the lake through Mangahan Floodway, the negative flow is flow from the lake to Marikina River through Mangahan Floodway.
* 2 The positive flow of Napindan channel is the flow to the lake Pasig River through Napindan Channel, the negative flow is the flow from Pasig River to the lake through Napindan Channel.

Figure 4.2.12 Results of Mangahan Floodway Dredging (Case-3)



- The downstream end water level of Laguna Lake is 14.3 m equivalent to 100 years scale, and it is the result of examining the change of the water level in the Mangahan Floodway with unsteady flow calculation.

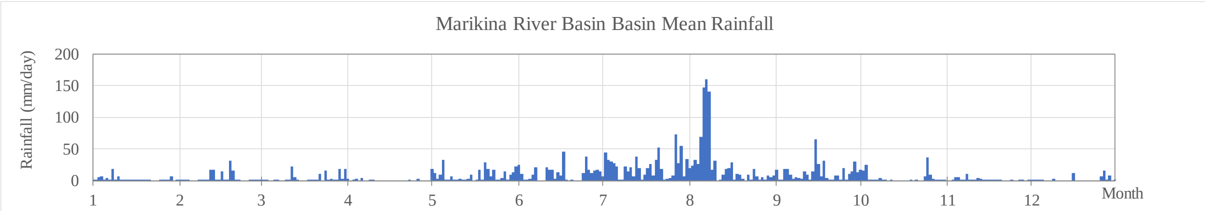
Figure 4.2.13 Longitudinal Water Level Profile of Mangahan Floodway with Existing Cross Sections and Cross Sections in 1988)

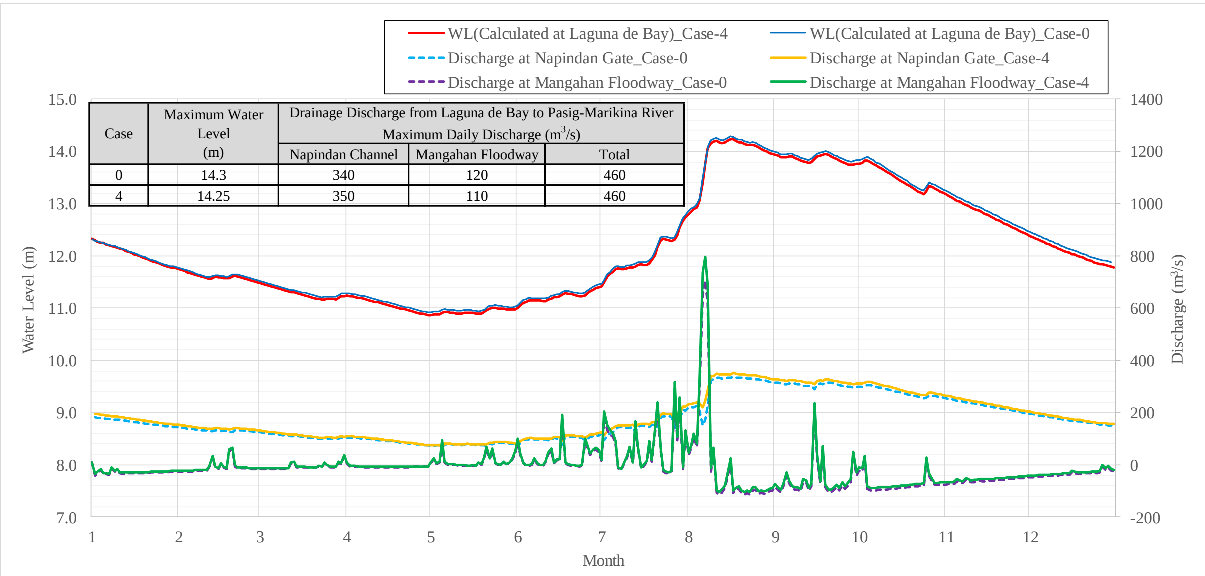
(6) Excavation of Napindan Channel and Dredging of Mangahan Floodway (Case-4)

The influence of lake water level when excavation of Napindan Channel and dredging of Mangahan Floodway are executed (dredging to execution cross section) is as summarized below.

＜Outline of Case-4 Results (refer to Figure 4.2.14)＞

- The lake level decreased by 5 cm from 14.3 m (Case-0) to 14.25 m.
- The maximum daily discharge through Napindan Channel increases from approx. 340 m^3/s (Case-0) to 350 m^3/s.
- The maximum daily inflow from Marikina River through Mangahan Floodway increases from approx. 710 m^3/s to 790 $m^3/$.
- Impact on the lake water level due to excavation of Napindan Channel and dredging of Mangahan Floodway is minor.





Case	Maximum Water Level (m)	Drainage Discharge from Laguna de Bay to Pasig-Marikina River Maximum Daily Discharge (m^3/s)		
		Napindan Channel	Mangahan Floodway	Total
0	14.3	340	120	460
4	14.25	350	110	460

* 1 The positive flow of Mangahan Floodway is the flow from Marikina River to the lake through Mangahan Floodway, the negative flow is flow from the lake to Marikina River through Mangahan Floodway.
* 2 The positive flow of Napindan channel is the flow to the lake Pasig River through Napindan Channel, the negative flow is the flow from Pasig River to the lake through Napindan Channel.

Figure 4.2.14 Result of Napindan Channel Excavation and Mangahan Floodway Dredging (Case-4)

(7) Influence of Napindan Channel and Mangahan Floodway Improvement on Lake Water Level (Summary of Results)

The results of Case-1 to Case-4 are summarized in Table 4.2.3. The case which is most effective in the lowering of the lake water level is Case-2, the widening of the Napindan Channel and reduction of the maximum water level of Laguna de Bay by approx. 20 cm.

However, it should be noted that the enlarged flow capacity of Napindan Channel and the decreased discharge through Mangahan Floodway were cancelled out (approx. 470 m^3/s in total.) This is because increase of discharge raised the water level in Pasig River and resulted in limiting the increment of the discharge. If the water level of Laguna de Bay is lowered before the flood, a peak of the water level during flood can be a little lowered. In addition, in the Napindan Channel widening case, since many houses are densely distributed along the Napindan Channel, a large scale of resettlement need to be taken and it does not make this idea feasible.

Table 4.2.3 Summary of Case Study Results

Case	Napindan Channel	Mangahan Floodway	Lake Water Level
0	With cross section in 2002	With cross section in 2002	Case 0: EL 14.3 m
1	Riverbed＝6.0m (excavation) Dike Height＝15.0m Width＝Existing width Slope Gradient＝1:0.5	With cross section in 2002	Case 0: EL 14.3 m Case 1: EL 14.25 m Effect: approx. -5 cm
2-1	Riverbed = 6.0m (excavation) Width = 150 m (widening) Dike height = 15.0 m Slope gradient = 1:0.5	With cross section in 2002	Case 0: EL 14.3 m Case 2-1: EL 14.1 m Effect: approx. -20 cm
2-2	Riverbed = 6.0 m (excavation) Width = 250 m (widening) Dike height = 15.0 m Slope gradient = 1:0.5	With cross section in 2002	Case 0: EL 14.3 m Case 2-1: EL 14.1 m Effect: approx. -20 cm
3	With cross section in 2002	Dredging to design cross section (cross section in 1988)	Case 0: EL 14.3 m Case 3: EL 14.3 m No effect
4	Riverbed＝6.0 m (excavation) Dike Height＝15.0 m Width＝Existing width	Dredging to design cross section (cross section in 1988)	Case 0: EL 14.3 m Case 4: EL 14.25 m Effect: approx. -5 cm

4.2.3 Proposed Operation Rules of Rosario Weir and of Napindan Weir (Draft)

(1) Existing Operation Rules of Rosario Weir and the Napindan Weir

The existing operation rule of Rosario Weir and Napindan Weir is as given below.

- When Rosario Weir is open during floods in Pasig-Marikina River basin, Napindan Weir is closed.
- The reference level to open and close the Rosario Weir is the water level at Sto. Niño.
- When water level at Sto. Niño is 13.8 m to 13.9 m, two gates of Rosario weir are opened.
- When water level at Sto. Niño reaches the middle water level (13.85 m) which is "Critical Level 1", four gates of Rosaria Weir are opened.
- When water level at Sto. Niño is 14.5 m to 15.1 m, six gates are opened and when water level reaches 15.3m which is the "Emergency Stage", all gates (8 gates) are opened.
- The gates are closed when water level at Sto. Niño subsides to 15.0 m after flood.

Table 4.2.4 Existing Operation Rules of Rosario Weir

Critical Level	Water Level at Sto. Niño	Gate No.	
1	13.8m	1	Gate 4
	13.9m	2	Gate 5
2	14.0 – 14.4m	4	Gate 3, 4, 5, 6
3	14.5 – 15.1m	6	Gate 2, 3, 4, 5, 6, 7
Emergency Stage	15.3 -	8	Gate 1, 2, 3, 4, 5, 6, 7, 8

Note: Reference of cross-sections of Rosario Weir and Napindan weir are shown in Fig 3.4.6 and Fig 3.4.7

(2) Recommendations on the Rosario Weir and Napindan Weir Operation Rules

According to the results of the study, prior flow before flood and flow in Mangahan Floodway and Napindan Channel after flood are effective to reduce lake-water level.

In the existing operation rules of Rosario Weir, when the water level at Sto. Niño subsides to 15.0 m, gates are closed. Therefore, the lake water level is still high when the water level in Marikina River has subsided, so that outflow from Laguna de Bay is not expected. It is thus necessary to revise the gate operation rules for after-flooding conditions.

Correlation of lake water level and discharge of Mangahan Floodway is shown in Figure 4.2.15 under a 100-year return period (water level is 14.3 m) of lake level. Negative discharge (-) of Mangahan Floodway indicates the reverse flow from Laguna de Bay to Mangahan Floodway, and Positive discharge (+) indicates the inflow from Mangahan Floodway to Laguna de Bay.

Regarding the result when lake level is 11m or more and water level of Marikina River is lower than lake level, flow from the lake to the Mangahan Floodway was confirmed. Therefore, the gate of Rosario Weir should be in open condition, if lake level is 11m or more, to decrease the lake level.

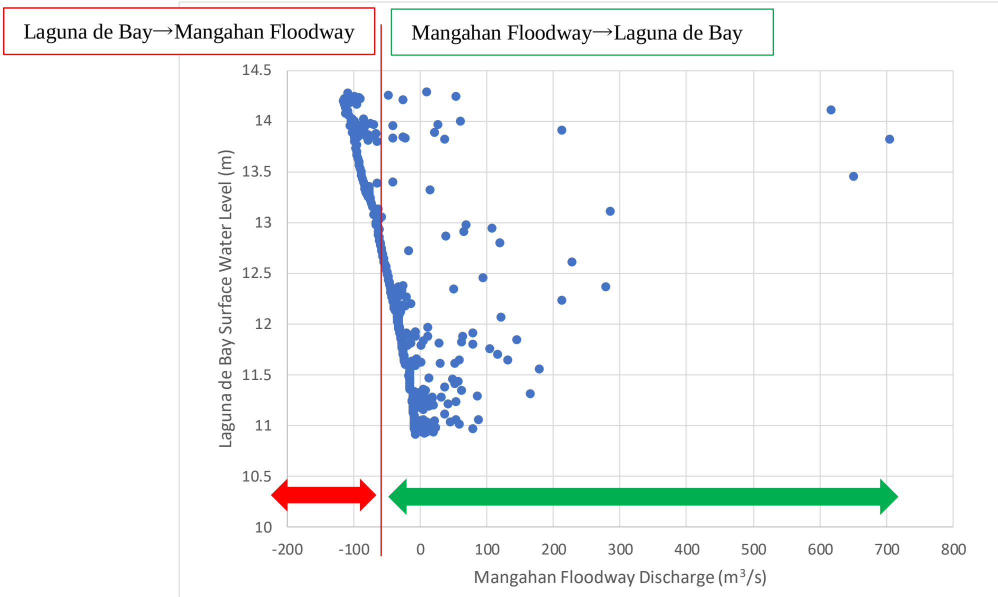


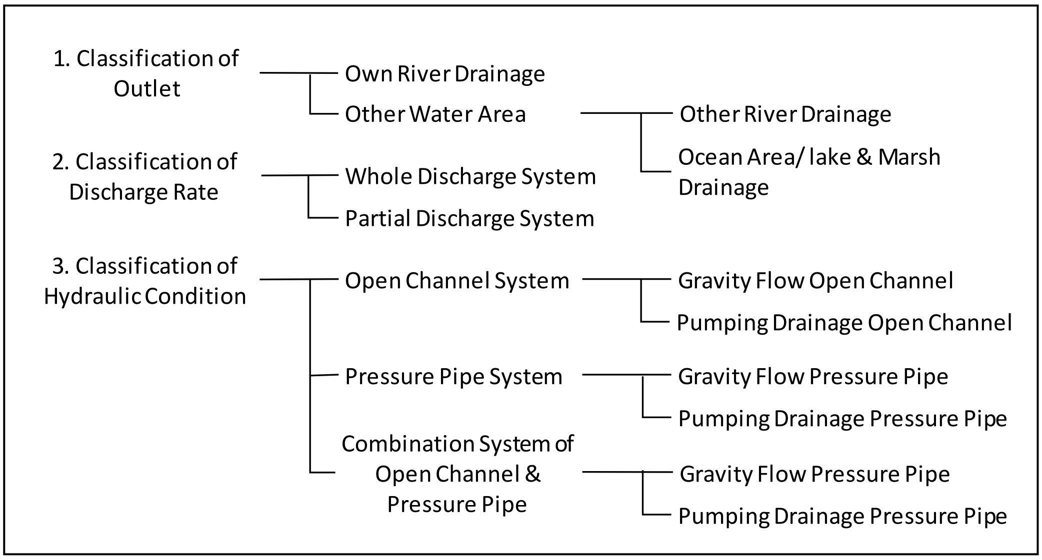
Figure 4.2.15 Relationship between Lake Level and Outflow of Mangahan Floodway (Case-0: 100-year return period, Napindan Channel and Mangahan Floodway under Existing Condition)

4.3 Study on Parañaque Spillway

4.3.1 Design Conditions

(1) Spillway System/Method

Figure 4.3.1 shows the classification of underground rivers as reference for designing the Parañaque Spillway.



Source: "Guidelines for Urban River Planning, Facility Planning of Spatial River"

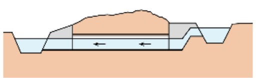
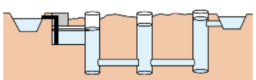
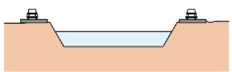
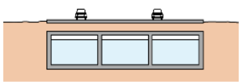
Figure 4.3.1 Classifications of Underground River

According to Figure 4.3.1, the Parañaque Spillway is classified as follows:

1. Classification of Outlet - Other Water Area - Ocean Area Drainage: Manila Bay
2. Classification of Discharge Rate - Partial Discharge System: Spillway of Laguna de Bay

The Classification of Hydraulic Condition of Parañaque Spillway is as shown in Table 4.3.1.

Table 4.3.1 Comparison of Hydraulic Condition of Parañaque Spillway

Case No.	Underground River Systems		Open Channel Systems	
	Case-1: Gravity Flow Open Channel System	Case-2: Pressure Pipe System	Case-3: Open Channel System	Case-4: Open Channel Tunnel System
Outline Figure				
Summary	Existing River/Spillway flows into the tunnel under the road/hill. It is the most common system for River Tunnels and the most desirable for Underground Rivers.	The discharge water flows through the pressure pile and is drained by syphon. Pumping is necessary for some hydraulic conditions.	This is the original plan of open channel. Construction Cost is cheap, but land acquisition and RAP have problems.	To utilize the upper portion of channel, the tunnel system is adopted. Generally, the space is used as road or park.

Case No.	Underground River Systems		Open Channel Systems	
	Case-1: Gravity Flow Open Channel System	Case-2: Pressure Pipe System	Case-3: Open Channel System	Case-4: Open Channel Tunnel System
Construction Experiences	Motsukisamu Discharge Channel, Katabira River Diversion Channel, Penke-Utashinai River New Channel, Koishikawa Underground River, etc., (Japan).	Metropolitan Area Outer Underground Discharge Channel, Neya Underground River, Gotanda Discharge Channel (Japan)	Arakawa Discharge Channel (Taisho Period), Ayasegawa Discharge Channel (Syowa Period), Sekiya Diversion Channel (Showa Period), etc. (Japan)	Many underground rivers, such as Shibuya River, in urban areas (Japan)
Construction	It is difficult to keep the minimum required earth covering of at least 1x diameter.	It is possible, but comprehensive technical management of tunneling is necessary.	No problem, because it is the most commonly used open channel system.	No problem, because it is an open channel excavation, but earth support is necessary.
	X	O	◎	O
Operation & Maintenance	Cost of Operation & maintenance is expensive due to the Tunneling system. However, some sediment materials may be flashed by tractive force.	Cost of Operation & Maintenance is very expensive due to no flash of sediment materials and limited cleaning condition; only vertical shaft.	Operation & Maintenance is easy as in ordinary rivers by using the maintenance road.	Cost of Operation & Maintenance is expensive due to Tunneling system. However, some sediment materials may be flashed by tractive force.
	O	△	◎	O
Social Environment	It requires compensation for sectional surface rights over the Spillway. In addition, land acquisition for Inlet & Outlet facilities is also necessary.	Compensation and land acquisition are required; not needed if the depth is over 50m*1. Therefore, only land acquisition for Inlet & Outlet facilities is necessary.	Land acquisition and resettlement for both Spillway & Inlet/Outlet are necessary, but these are extremely difficult.	Land acquisition and resettlement for both Spillway & Inlet/Outlet are necessary, but these are extremely difficult.
	△	O	X	X
Natural Environment	Relatively small and narrow influence because of limited construction areas; only Inlet & Outlet areas.	Relatively small and narrow influence because of limited construction areas, only Inlet & Outlet areas.	Comparatively large and considerable influence because of whole areas for Spillway Construction.	Comparatively large and considerable influence because of whole areas of Spillway Construction.
	O	O	△	△
Others	Gravity flow open channel is impossible due to the hydraulic condition, the small water level difference between Manila Bay and Laguna de Bay.	Garbage and sand sediment may worsen the discharge capacity. In the case of pumping, Operation & Maintenance, Cost is extremely expensive.	Feasibility is totally changed by the land acquisition price and the compensation of RAP.	Feasibility is totally changed by the land acquisition price and the compensation of RAP.
	X	△	△	△
Cost*2	Relatively Expensive	Most Expensive	Commonly Cheap (Depends on the scope of land acquisition and compensation of RAP)	Relatively Cheap, only in the case of shallow excavation
Evaluation	Gravity Flow Open Channel System is impossible because of not enough earth covering required for tunneling.	Possible case because of the relatively small area of land acquisition and small number of RAP.	Land acquisition and RAP are very difficult. In addition, the cost is not so cheap taking into account land & compensation cost.	The same as Case-3. In addition, construction cost and O&M are expensive so no reason for adoption.
	X: Impossible	O : Adopted	△ : Some Problems	X: Difficult

Legend: ◎ Excellent, ○ Good, △ Not Good/Some Problems, X Difficult/Impossible

Note *1: According to "IRR of RA 10752, Section 11", *2: Costs are evaluated by qualitative assessment because of the difficulty of quantitative assessment.

Source: JICA Survey Team

"Case-2, Pressure Pipe System," is selected because of the relatively small area of land acquisition and small number of RAP, and the high feasibility of the Spillway Project.

Incidentally, the study on either Gravity Flow Pressure Pipe (Syphon Type) or Pumping Drainage Pressure Pipe will totally depend on the Master Plan and Feasible Study for Laguna de Bay. Therefore, the basic priority of the Study is "Gravity Flow Pressure Pipe" and then, if necessary, the Pumping Drainage is considered.

(2) Design Discharge

In accordance with the "Guidelines for Urban River Planning, Facility Planning of Spatial River" (Japan Institute of Country-ology and Engineering), "the Design Discharge of Underground River shall be adequately decided based on the River Planning Discharge with consideration on the hydraulic condition inside tunneling and other aspects." As the example, the following explanations are given.

<u>Open Channel Type</u>: "The Design Discharge of Open Channel Type is generally increased to more than the River Planning Discharge because of planning change, flooding exceeding the design level and lowering of discharge capacity caused by garbage and soil sediment. As an example, 130% of River Planning Discharge has been generally adopted in the past."

<u>Pressure Pipe Type</u>: "The Design Discharge of Pressure Pipe Type is the same as the River Planning Discharge because it is mainly influenced by the hydraulic gradient rather than the Cross Section of Pipe. The Pressure Pipe type of countermeasure for the lowering of discharge capacity caused by garbage and soil sediment is to have an adequate and appropriate sectional surcharge.

Incidentally, according to the "Technical Standards for River and Sabo Works, Design" (Japanese Ministry of Land, Infrastructure, Transport and Tourism), the Design Discharge of River Tunnel is described as follows:

<u>Technical Standards for River and Sabo Works</u>: "The Design Discharge of River Tunnel is basically more than 130% of High Water Discharge of River Planning."

The above-mentioned regulation is as explained below.

"This increase ratio shall be individually decided to consider the type of river tunnel (Channel Type, Pressure Pipe Type, Gravity Flow Type and Pumping Drainage Type), Characteristics of River and Catchment Basin, and other matters, such as garbage and sediment soil which cause the lowering of discharge capacity. In general, more than 130% of High Water Discharge is adopted for the Open Channel…. *(Other sentences omitted)* …. In most cases, the Design Discharge of Pressure Pipe Tunnel is mainly the same as the High Water Discharge because Discharge Capacity is mainly influenced by the hydraulic gradient rather than the Cross Section of Pipe. To deal with the lowering of discharge capacity caused by garbage and soil sediment, an additional increase of the cross section is possibly adopted for the Pressure Pipe Tunnel. (Japanese Ministry of Land, Infrastructure, Transport and Tourism); "Technical Standards for River and Sabo Works, Planning, Chapter 10, Section 3.2.2"

In conclusion, both standards have the same contents. The Parañaque Spillway is a pressure type tunnel similar to a diversion channel rather than the underground tunnel river. Therefore, the design discharge of Parañaque Spillway is decided as follows:

Design Discharge = River Planning Discharge = 200m^3/s

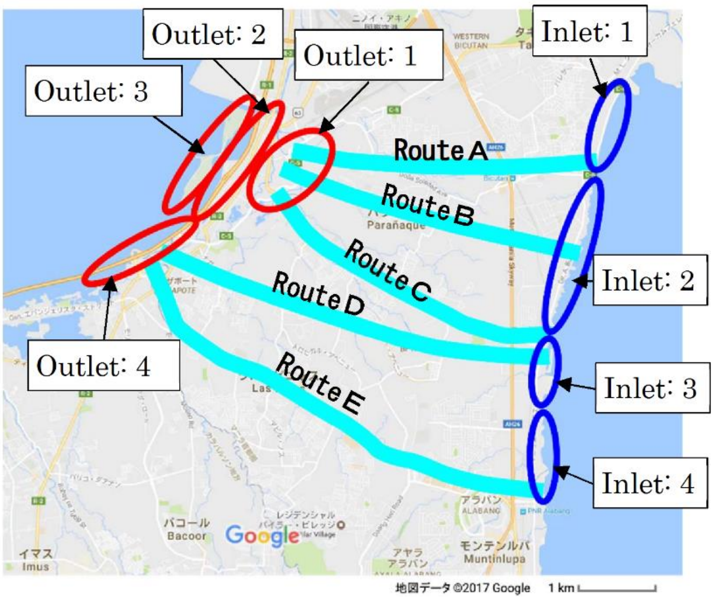
Incidentally, the increase ratio of cross section is reviewed in the Pre-Feasibility Study after the detail determination of facilities.

4.3.2 Layout Plan

(1) Layout Plan/Route Plan

The layout plan/route plan of Parañaque Spillway is decided by comprehensive consideration of the inlet location, outlet location, section surface rights and so on. Definitely, the layout plan is decided by feasibility study of the potential route plans formulated by the comparison of alternatives in the feasibility study, including cost and impact of social and natural environment.

The route plans utilized for the comparison of facility locations are shown in Figure 4.3.2.



Source: JICA Survey Team

Figure 4.3.2 Route Plans Utilized for Comparison of Facility Location

(2) Inlet Location

The study on Inlet Location considers the site condition of the lakeshore of Laguna de Bay and the longitudinal section study. The former is decided by the Inlet Location, and site conditions as open spaces and construction road for material handling are taken into account. On the other hand, the latter is studied after determination of the basic layout plan, because of the investigation of facility land and construction conditions. In this section, the former method is considered, to designate the basic layout plan.

The comparison of assumed inlet location is given in Table 4.3.2.

Table 4.3.2 Comparison of Inlet Locations

Case	Inlet-1	Inlet-2	Inlet-2	Inlet-2
Place	Lower Bicutan	Bagumbayan	Sucat	Buli (Alabang)
Site Condition	Lakeshore Dike has been constructed. The crown of Dike is utilized as promenade of the Park and the foot is equipped as a 2-lane road.	There are only the 2-lane road which is always jammed and the dense houses below it. The area between the road and the lake is narrow for utilization.	At lakeside, there is a curtain wall for the power plant which is not operated. In addition, there are also the high tower and the tanks to be confirmed.	There are only the 2-lane road which is partially narrow and the many houses below it. Some wide spaces between the road and the lake exist.
Land	There is no available area for Inlet Facility in landside. Therefore, landfill of Laguna de Bay is necessary for facility land.	There is about 15 ha area at Sucat. However, there are dense houses between the area and lake.	There is no available area for Inlet Facility in landside. Therefore, landfill of Laguna de Bay is necessary for facility land.	There are partially open spaces but not enough. Therefore, landfill of Laguna de Bay is necessary for facility land.
Satellite Image	 Photo:©2017Google	 Photo:©2017Google	 Photo:©2017Google	 Photo:©2017Google
Construction Road	Bicutan Entrance of Skyway, General Santos Avenue and Circumferential Road-6 are possible as the construction road.	For east-west, General Santos Avenue and Meralco Road are possible. For north-south, Dir. A. Bunye, but impossible because of traffic jam.	For east-west, Meralco Road is possible. For north-south, Manuel L. Quezon, but impossible because of traffic jam.	For east-west, Montillano Street is possible. For north-south, Manuel L. Quezon, but impossible because of traffic jam.
Photo of Construction Road	 	 	 	 
Evaluation	Inlet Land shall be landfill of Laguna de Bay. Construction Road is easy to be obtained.	Inlet Land may be either Sucat or the landfill of Laguna de Bay. Construction Road will mainly use existing one for east-west and landfill of lake for north-south.	Inlet Land shall be landfill of Laguna de Bay, except for Power Plant. Construction Road mainly uses existing one for east-west and landfill of lake for north-south.	Inlet Land shall be landfill of Laguna de Bay. Construction Road mainly uses existing one for east-west and landfill of lake for north-south.
	◎: Hopeful	**O: Possible**	**△: Partially Impossible**	**O: Possible**

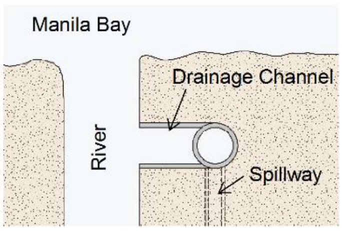
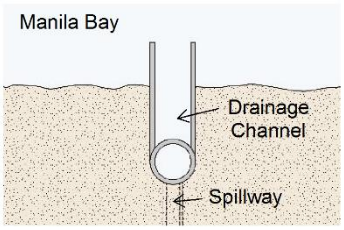
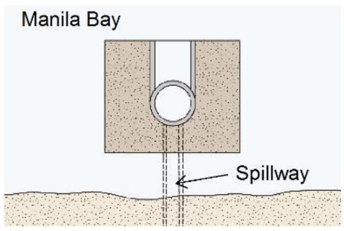
Legend: ◎ Excellent, O Good, △ Not Good/Some Problems, X Difficult/Impossible
Source: JICA Survey Team

According to Table 4.3.2, all cases of inlet location are possible if the landfill of Laguna de Bay is practicable. Therefore, the basic layout plan takes into account the outlet location and sectional surface rights and not the inlet location. Either the landfill of Laguna de Bay or the resettlement of residences are reviewed later at the Pre-Feasibility Study after determination of the Layout Plan.

(3) Outlet Location

Drainage Systems to Manila Bay are feasibly assumed as the three types shown in Table 4.3.3.

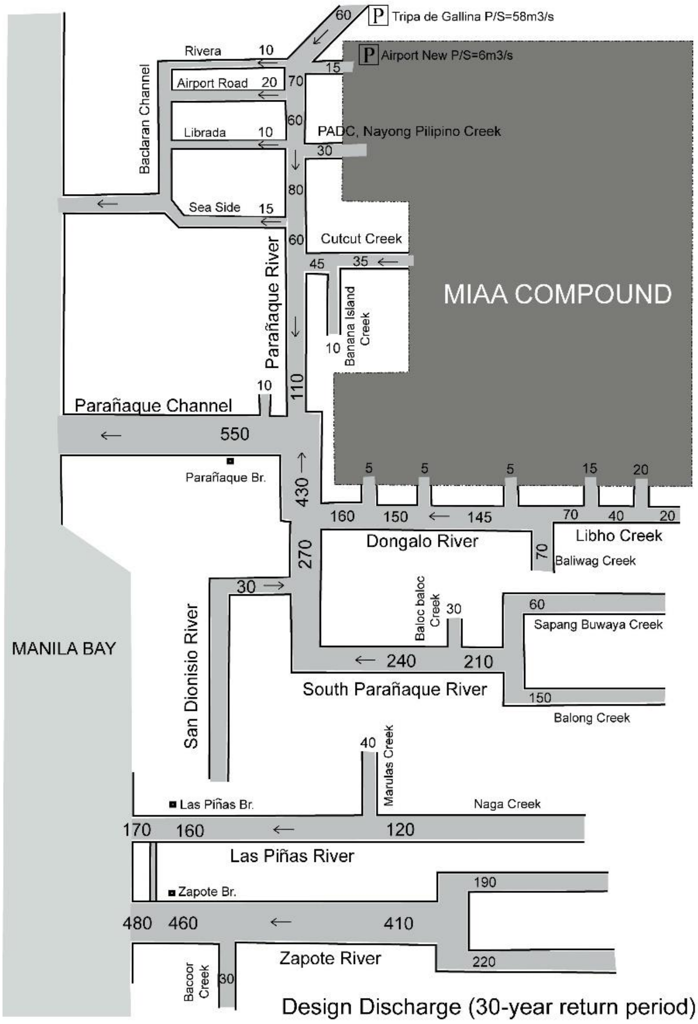
Table 4.3.3 Comparison of Drainage Systems to Manila Bay

Type	Existing River Connection	Jetty (Seawall)	Direct Drainage
Summary	Connects with the existing rivers flowing into Manila Bay (such as Parañaque River, Las Piñas River and Zapote River), and drained water flows indirectly to the sea.	New drainage channel is constructed. To avoid clogging by sea sand, Jetty (Seawall) is installed. This type of drainage to the sea is adopted for Tagoloan River in Mindanao.	Outlet facility is constructed in Manila Bay and the drained water flows directly to the sea. In the case of Parañaque Spillway, artificial island is necessary to sustain the operation and maintenance efficiently.
Outline Figure			
Advantage	Small influence of environmental loading than others because of using the existing river. New construction is not necessary if the drainage capacity of the river is enough.	No drainage volume limitation because of new channel construction.	No facility land requirement because of the landfill of Manila Bay.
Disadvantage	Drainage volume regulation if the connected river is flooding. River improvement is necessary if the river capacity is not enough.	The influence on sea area environment is larger than that of the existing river connection. Possibility of clogging by sea sand still remains.	It is difficult due to the opposition on the Manila Bay Landfill. Salinity dilution and worse influence against tide are anticipated. No example of river drainage. (Numakawa New Channel Project in Japan was planned, but finally not adopted.)
Suitability of Parañaque Spillway	According to the site investigation, it is possible for Parañaque and Zapote rivers with appropriate river improvement.	It is not impossible even if crossing the Highway (Manila-Cavite Expressway) is necessary.	No example as river drainage. In addition, it is actually difficult due to the opposition on the Manila Bay Landfill.
Evaluation	O: Possible	△: Not Impossible	X: Difficult

Legend: ◎ Excellent, O Good, △ Not Good/Some Problems, X Difficult/Impossible
Source: JICA Survey Team

According to Table 4.3.3, the Existing River Connection seems to be advantageous but the Jetty (Seawall) is not impossible as the Drainage System to Manila Bay. Therefore, the decision on the drainage system is subsequently considered as the combination of Outlet Location and Drainage System. Incidentally, Las

Piñas River is not considered as the connected river because of the small discharge capacity, according to "The Feasibility Study on Flood Control and Drainage Improvement Project for MIAA Compound and Parañaque–Las Piñas River System in the Republic of the Philippines", (CTI Engineering International Co., Ltd.). In addition, the distance from Zapote River to Las Piñas River is only 300m. To sum up, the Zapote River is more advantageous than the Las Piñas River. The design discharge diagram of the Parañaque and Las Piñas river systems (30-year return period) is as shown in Figure 4.3.3.



Source: (CTI Engineering International Co., Ltd.); "The Feasibility Study on Flood Control and Drainage Improvement Project for MIAA Compound and Parañaque-Las Piñas River System in the Republic of the Philippines"

Figure 4.3.3 Discharge Distribution Diagram of Parañaque and Las Piñas River Systems (30-Year Return Period)

According to Figure 4.3.3, the river discharge of Las Piñas River may be approx. 200m^3/s even if the design return period is changed to 50 years. Therefore, the possible days for drainage may be limited during flooding time at Las Piñas Basin.

The comparison of outlet locations is shown in Table 4.3.4.

Table 4.3.4 Comparison of Outlet Locations

Case	Outlet-1	Outlet-2	Outlet-3	Outlet-4
Outlet Type	Existing River Connection	Jetty (Seawall)	Jetty (Seawall)	Existing River Connection
Drainage	Downstream of Parañaque River System	Inner Bay of Freedom & Long Islands	Laguna Bay Side of Freedom & Long Islands	River Mouth of Zapote River
Summary	Drainage to Downstream of 3 tributaries of Parañaque River (South Parañaque River, San Dionisio River and Dongalo River)	Drainage directly to LPPCHEA by construction of new drainage channel at the triangle area in Jaleville.	New drainage facility is constructed at the landfill of Laguna Bay. where is out of 50m Seaward Buffer Area.	There is an open space at right bank near Zapote River mouth where a few houses exist. Required river improvement area is small due to river mouth
Satellite Image	 Photo:©2017Google	 Photo:©2017Google	 Photo:©2017Google	 Photo:©2017Google
Photo of Outlet Location	 South Parañaque River  San Denisio River	 From Island Side  From Manila Bay Side	 North of Manila Bay Side  Manila Bay Side of Long Island	 Left Bank of Zapote River  Right Bankof Zapote River
Land Condition	Some open spaces (Green Areas) exist along South Parañaque River and San Dionisio River.	There is approximately 2 ha of open space excluding the Cavitex Southbound Customer Service Booth.	It is not impossible to obtain landfill permission of Manila Bay.	There is about 7 ha of open space at right bank and also about 15 ha of green and swamp area at left bank, but many houses.
	O	O	△	O
Natural Environment	There are some open spaces and undeveloped areas. However, it is necessary to conduct a survey on precious species.	There is LPPCHEA which is enrolled with the Ramsar Convention. Therefore, worse influence against natural condition is concerned.	Out of LPPCHEA but nearby 50m Seaward Buffer. Therefore, worse influence against natural condition is concerned.	The area of right bank has been developed, so less influence to nature. However, the effect of drainage water shall be examined.
	O	△	△	O
Social Environment	RAP is not necessary but a hospital (Premier Medical Center) exists nearby. Therefore, countermeasures for noise and vibration are necessary.	It is practically impossible because of social effect, same as the opposition movement on Laguna Bay Landfill and protecting activity for LPPCHEA.	It is necessary to adjust with the existing landfill plan. It is practically impossible because of social effect, same as the opposition movement on Laguna Bay Landfill.	No problem about right bank side. However, it may be necessary to conduct the RAP of left bank side depending on the river planning and characteristics of Zapote River.
	△	X	X	◎

Case	Outlet-1	Outlet-2	Outlet-3	Outlet-4
Construction Road	No problem about the construction road by utilizing Parañaque - Sucat Road and Carlos P. Garcia Avenue.	It is possible to utilize the entrance of Manila–Cavite Expressway as construction road, but need toll fee.	It is possible to utilize the entrance of Manila–Cavite Expressway as construction road but need toll fee.	It is possible to utilize Carlos P. Garcia Avenue. In addition, the entrance to Manila-Cavite Expressway is nearby.
	O	O	O	O
Evaluation	It is possible to conduct river improvement of Parañaque River System.	It is practically impossible since it will worsen influence against LPPCHEA.	It is practically impossible due to landfill of Laguna Bay and adjust the 50m Seaward Buffer Area.	The width of Zapote River is wider than the others. In addition, less influence to natural & social environment because the area is already developed.
	O: Possible	**X: Impossible**	**X: Difficult**	◎: Hopeful

Legend: ◎ Excellent, O Good, △ Not Good/Some Problems, X Difficult/Impossible
Source: JICA Survey Team

According to Table 4.3.4, both Outlet-2 and Outlet-3 are virtually impossible because of the opposition movement on the Laguna Bay Landfill and the protection activity for LPPCHEA. Therefore, the Drainage System shall be the Existing River Connection to either the Parañaque River System or the Zapote River.

(4) Basic Layout Plan/Route Plan

Five basic layout plans are created depending on the comparison results of Outlet Location, the Parañaque River System or the Zapote River, to satisfy two aspects: the short distance to Laguna de Bay and the location under public road.

The comparison of Basic Route Plans of the Parañaque Spillway is shown in Table 4.3.5.

Table 4.3.5 Comparison of Basic Route Plans of Parañaque Spillway

Case	Route-A	Route-B	Route-C	Route-D	Route-E
Route Name	Bicutan – Parañaque Route	Bagumbayan – Parañaque Route	Sucat – Parañaque Route	Sucat – Zapote Route	Alabang – Zapote Route
Depth (Cover) of Spillway	more than 50m	more than 50m	Approximately 30m (Separation distance from Subway)	more than 50m	Approximately 30m (Separation distance from Subway)
Inlet Location	Inlet-1: Landfill at Lower Bicutan	Inlet-2: Landfill at Bagumbayan	Inlet-2: Landfill at Sucat	Inlet-2: Landfill at Sucat	Inlet-4: Landfill at Alabang
Outlet Location	Outlet-1: Dongalo River/South Parañaque River	Outlet-1: South Parañaque River/San Dionisio River		Outlet-4: Zapote River	
Main Route Locations	Lower Bicutan→ Sun Valley → Airport Village → Moonwalk	Bagumbayan→ Tanyag → Don Bosco → Moonwalk	Sucat → Parañaque- Sucat Road (Rout 63) → San Isidro → Parañaque	Sucat → Parañaque- Sucat Road (Rout 63) → San Isidro → Parañaque	Alabang → Alabang-Zapote Road→ Las Piñas → Zapote
Summary	• The inlet is located at the landfill of Laguna de Bay where both lakeshore dike and road have been constructed. • Almost straight lines route to the inlet of Dongalo River/South Parañaque River.	• The original Parañaque Spillway route (However, outlet location is little bit changed.) • Inlet facility and construction road shall be on the landfill of Laguna de Bay. • The shortest distance due to nearly straight line.	• Due to reduction of land acquisition, main route is situated under Route-63. • Longer distance than Route A&B due to the Inlet and Outlet Locations.	• Considering the environmental aspects, outlet is located at Zapote River apart from LPPCHEA as possible. • Almost straight line from Sucat Inlet to Zapote Outlet.	• To consider the environmental aspects, outlet is located at Zapote River apart from LPPCHEA as possible. • Mostly under the road from Alabang Inlet to Zapote Outlet. • The longest distance among the 5 routes.
Route Figure					
Advantage	• Relatively short distance • Easy negotiation with LLEDP and preparation of construction road due to already constructed lakeshore dike	• The shortest distance • Easy explanation of accountability to resident due to the original spillway route	• It is possible to make arbitrary depth instead of 50m because of location under the public road. • Public facility is desirable under public road.	• Less influence on LPPCHEA compared with Parañaque River Drainage. • River improvement area of Zapote River seems to be small.	• Less influence on LPPCHEA compared with Parañaque River Drainage. • It is possible to make arbitrary depth instead of 50m because of location under the public road. • Public facility is desirable under public road. • River improvement area of Zapote River seems to be small.
Disadvantage/ Problem	• Large influence on LPPCHEA • Assumingly difficult explanation for accountability to resident due to the different spillway route form the original.	• Large influence on LPPCHEA • Necessity of access and construction road on the landfill of Laguna de Bay because the existing north-south road is always jammed.	• Large influence on LPPCHEA • Sharp curve alignment is necessary if intermediate shaft is located on private land. (However, such construction is possible.)	• Higher cost than Parañaque River Routes	• The highest cost among 5 Routes • Sharp curve alignment is necessary if intermediate shaft is located in private land. (However, such construction is possible.)
Construction	Long Distance (Length>5km) and Large Cross Section (Diameter>10m) of Shield Construction, but technically possible O				
Operation & Maintenance	Daily inspection of Pressure Pipe System is impossible but Operation & Maintenance in dry season are possible under the dry condition. The cost of those is expensive because working area to remove garbage and sediment soil is only vertical shaft. △				
Correspondence to Inland Drainage	Possible to handle the flooding water of Parañaque River Basin if additional intermediate shaft is installed, but further study is necessary . O			Possible to handle the flooding water of Las Piñas Rive if additional intermediate shaft is installed O	Possible to handle thee flooding water of Zapote Rive if additional intermediate shaft is installed O

Case	Route-A	Route-B	Route-C	Route-D	Route-E
Social Environment	It is not necessary of the compensation of sectional surface rights due to over 50m of depth.*1 Therefore, required land acquisition areas are only for Inlet and Outlet facilities. Incidentally, countermeasures for noise and vibration are necessary because of the adjacent hospital (Premier Medical Centre). O		Mainly most of Spillway is located under the road and no compensation, but partial land acquisition of downstream and upstream are necessary. △	It is not necessary of the compensation of sectional surface rights due to over 50m of depth.*1 Therefore, required land acquisition areas are only for Inlet and Outlet facilities. O	Mainly most of Spillway is located under the road and no compensation, but partial land acquisition of downstream and upstream are necessary. △
Natural Environmental	• Spillway: Less influence because construction sites are only vertical shafts. • Inlet: Necessary to study the effects of the water quality of Laguna de bay because of the Landfill at 500m from lakeshore. • Outlet: Necessary to conduct the survey of precious species because of the undeveloped & green area. △			• Spillway: Less influence because construction sites are only vertical shafts. • Inlet: Necessary to study the effects of the water quality of Laguna de bay because of the Landfill at 500m from lakeshore. • Outlet: Less influence because the right bank side has been developed. O	
Influence to LPPCHEA	Relatively lager influence than Zapote River Drainage Case. In addition, further effect caused by the future Landfill of Manila Bay is expected because drainage channel will be narrowed. The final decision shall be taken into account with the result of the diffusion analysis of drainage water. △			Relatively lager influence than Parañaque River Drainage Case. The final decision shall be taken into account with the result of the diffusion analysis of drainage water. O	
Construction Road	Possible to partially utilize the existing Highway and Main Road as the construction road.	Necessity of the access construction road on the landfill of Laguna de Bay because the existing north-south road is always jammed.	Possible to partially utilize the existing Highway and Main Road as the construction road.	Possible to partially utilize the existing Highway and Main Road as the construction road.	Possible to partially utilize the existing Highway and Main Road as the construction road.
	O	△	O	O	O
Construction Area*2 (Measured by Google Earth)	Spillway L1 = 7.8 km River Improvement L2 = 2.8 km	Spillway L1 = 7.6 km River Improvement L2 = 2.8 km	Spillway L1 = 8.5 km River Improvement L2 = 2.8 km	Spillway L1 = 9.6 km River Improvement L2 = 1.3 km	Spillway L1 = 12.5 km River Improvement L2 = 1.3 km
Estimated Cost*3*4	Tunnel 35,329 River Improvement 2,662 Total 37,991 (Unit: Million PhP)	Tunnel 34,423 River Improvement 2,662 Total 37,085 (Unit: Million PhP)	Tunnel 38,500 River Improvement 2,662 Total 41,162 (Unit: Million PhP)	Tunnel 43,482 River Improvement 1,236 Total 44,718 (Unit: Million PhP)	Tunnel 56,617 River Improvement 1,236 Total 57,853 (Unit: Million PhP)
Evaluation	Construction cost is cheaper although the large influence to LPPCHEA. However, the river improvement area for Outlet may be enlarged beyond the original drained river.	Not so cheaper cost to consider the construction road on landfill of Laguna de Bay because of the expected expensive compensations for many of fishery rights. In addition, it may be expected to cause the opposition movement due to worsening social environment at Laguna de Bay.	Basically, public facility shall be desirable under the public road even if the distance is longer than Route A & B. However, compensations of sectional surface rights are necessary at both upstream and downstream of Spillway so lower possibility. In conclusion, it is practically impossible to be selected.	The area LPPCHEA is 175ha and the smallest one among the 7 locations of Ramsar Convention in the Philippines. Therefore, it is hopefully necessary to be selected because of the least influence to LPPCHEA. In addition, small area of river improvement of Zapote River is also advantageous	Construction cost is the most expensive. In addition, compensations of sectional surface rights are necessary at both upstream and downstream of Spillway so lower possibility. In conclusion, it is practically impossible to be selected.
	O	△	△	**O: Selected**	**X**

Legend: ◎ Excellent, O Good/Possible, △ Not Good/Some Problem、X Difficult/Impossible

Note *1: According to "IRR of RA 10752, Section 11"

*2: The length of Spillway from the lakeshore is 500m to consider the LLEDP and the river improvement areas are assumed until downstream from the Outlet and 1 km upstream.

*3: Exchange Rate is "PhP1.00= 2.183 JPY" (2017.9.30)

*4: Inside diameter of tunnel is assumed as 12m and not consider the section change due to the different tunnel lengths.

Source: JCA Study Team

According to Table 4.3.5, Route-D is selected as a most adequate plan from two main reasons: less influence on LPPCHEA and the small river improvement area of Zapote River. The reasons for the selection are as elaborated below.

In practice, all routes are possible. However, the selection shall be diverse based on certain considerations, i.e., it shall be based on the most important aspect to make a final decision. For example, if the selection is based on only cost efficiency, Route A or B is selected; if it were the alignment under public road, select Route C or E; if less influence on LPPCHEA and to the landfill of Manila Bay, Route D or E; and if the priority of inland drainage of Parañaque River Basin is considered, either one among Routes A to C is considered.

Incidentally, one of the most important factors considered in recent large public works projects is the effect on social and natural environment and hence environmental loading shall be minimized as much as possible. In fact, many public projects were not implemented due to the opposition movement of residents and the NGO's. Therefore, it is very important to explain the accountability of the project to all stakeholders.

To make the above explanation shorter, "Route-D" is selected as the most adequate plan that will be understood easily by the people based on the above-mentioned reasons and the following:

- Least influence on LPPCHEA (Consideration to natural environment);
- Small river improvement area and less affected residents of Zapote River compared with Dongalo River or South Parañaque River; and
- The most reasonably expensive cost is selected because of lower feasibility required for future plan change.

The detailed alignment shall be considered adequately later at the Pre-Feasibility Stage.

4.3.3 Cross Section Plan

(1) Basic Policy for Cross Section Plan

The feasible construction method for the Parañaque Spillway may be considered as either the Shield Method or the NATM (New Austrian Tunneling Method). The Shield Method is adopted in this section because of no geological investigation data and wide application range necessary. Therefore, the basic form of cross section is the "circular type" which has the advantage of stress and bearing capacity. Further, if the NATM is adopted based on the result of further geotechnical investigation, the basic form of cross section shall also be later reviewed in comparison with the other shapes at the Pre-Feasibility Stage.

(2) Flow Control System

Generally, the flow volume of a river diversion channel is restricted by the diversion discharge at overflow weir. (The case of flood exceeding the design level is separately handled as a special case.) In addition, with regard to the pumping drainage system, the pump controls the flow volume. However, it is necessary for the kind of drainage channel, like the Parañaque Spillway, which is connected to a lake, to install a flow control system, because the actual inflow volume is exceeded more easily than the design discharge. The comparison of flow control systems for the Parañaque Spillway is shown in Table 4.3.6.

Table 4.3.6 Comparison of Flow Control Systems for Parañaque Spillway

Case	No Control	Spillway Tunnel Control	Overflow Weir Control	Inflow Gate Control
Summary	Basically, there is no flow control. For operation and maintenance, emergency and saltwater intrusion, prevention gates are installed at Inlet and Outlet.	Maximum discharge capacity is controlled by hydraulic gradient which is defined by the condition of cross section and roughness of spillway.	Tumble gate is installed at the overflow weir to control flow discharge.	Roller gate is installed at Inlet and the operation of its opening limits the flow discharge.
Advantage	Operation is very simple because of only either "On" or "Off" control.	Operation is easy because the maximum discharge is limited.	A relatively small inlet facility is possible because only design discharge volume flows into it.	Since it is a roller gate, operation reliability is high and construction experiences are many and well.
Disadvantage	Some possibility of flooding at downstream drainage river if the discharge excesses the design.	Effectiveness of prior flow is lower because of maximum discharge limited by the largest condition. The roughness will be changed by aged deterioration	Operation and Maintenance is not so easy compared with the roller gate because of long gate length and mechanical complication of tilting gate.	None
Evaluation	Operations of prior flow and flooding of drainage river are lower; only either "On" or "Off" control. Therefore, it is not desirable.	It is very difficult to design an accurate discharge tunnel because of deterioration. In addition, effectiveness of prior flow is lower.	Reliability and Operation & Maintenance are lower because of tumble gate. In addition, gate facility becomes large.	Reliability, construction experiences, flow control and Operation & Maintenance are better than the others.
	X: Not Desirable	**X: Difficult**	**△: Reliability Problem**	**O: Selected**

Legend: ◎ Excellent, O Good, △ Not Good/Some Problems, X Difficult/Impossible
Source: JICA Survey Team

According to Table 4.3.6, "Inflow Gate Control" is selected and the cross section of tunnel is decided to be considered with the design discharge, flow water condition and additional increase section for garbage and soil sediment.

(3) Roughness Coefficient

Values of roughness coefficient according to the "Design Guidelines, Criteria and Standards", DPWH, is shown in Table 4.3.7. According to the table, roughness coefficient is from 0.014 to 0.018.

Table 4.3.7 Values of Roughness Coefficient by Design Standard of DPWH

Table 4-4 Values of Manning's Roughness Coefficient 'n' (Uniform Flow) – Man-made Channels & Ditches

Description	Minimum	Maximum
1. Earth, straight & uniform	0.020	0.025
2. Earth bottom, rubble sides / riprap	0.030	0.035
3. Grass covered	0.035	0.050
4. Dredged	0.028	0.033
5. Stone lined & rock cuts, smooth &uniform	0.030	0.035
6. Stone lined & rock cuts, rough & irregular	0.040	0.045
7. Lined - smooth concrete	0.014	0.018
8. Lined - grouted riprap	0.020	0.030
9. Winding sluggish canals	0.025	0.030
10. Canals with rough stony beds, weeds on earth banks	0.030	0.040

Table 4-5 Values of Manning's Roughness Coefficient 'n' (Uniform Flow) - Pipes

Description	Minimum	Maximum
1. Cast Iron, Uncoated	0.013	0.015
2. Cast Iron, Coated	0.012	0.013
3. Wrought Iron, Black	0.013	0.015
4. Wrought Iron, Galvanized	0.014	0.017
5. PVC, HDPE	0.009	0.013

Source: DPWH; Design Guidelines, Criteria and Standards”

The construction experiences in Japan show that 0.015 of roughness coefficient is adopted for the Metropolitan Area Outer Underground Discharge Channel, Gotanda Discharge Channel, Azumagawa Underground River, Kanda River/Loop Road No. 7 Underground Regulating Reservoir and Neya Underground River.

In past construction experiences, Manning’s Roughness Coefficient for tunnel is sometimes 0.023 in consideration of construction accuracy and deterioration due to aging. Recently, however, 0.015 of Roughness Coefficient has been adopted.

According to the “Technical Standards for River and Sabo Works, Design-1997/09”, (Japanese Ministry of Land, Infrastructure, Transport and Tourism), roughness coefficient shall be individually decided considering the following points:

- Frequency of use;
- Characteristics of garbage and sediment soil;
- Wear degree caused by inside velocity; and
- Operation and maintenance method of tunnel surface.

In the case of Parañaque Spillway, 0.015 of Roughness Coefficient is adopted for the following reasons:

- Recently, 0.015 has been commonly adopted because of construction accuracy and quality;
- Sedimentation basin catches most of gravel and sand which mainly cause wear; and
- In case of Shield Tunneling Method, concrete strength for concrete segment is very stiff, approximately 42~54N/mm^2, and its surface is durable.

In the case of 0.015 of roughness coefficient, the cross section of tunnel becomes smaller, the cost is reduced and influences of both underground water and neighboring construction works are also reduced. Incidentally, as the example of non-pressure type, tunnel construction experiences of roughness coefficient of less than 0.015 are as shown in Table 4.3.8.

Table 4.3.8 Tunnel Construction Experiences of Roughness Coefficient less than 0.015 in Japan

Name of Tunnel	Discharge (m^3)	Longitudinal Slope	Section Figure	Section Dimensions (m)	Roughness Coefficient	Velocity (m/s)	Diversion System
Hinuma Channel	25.0	1/350	Box	3.0×3.0	0.015	3.45	Fixed Weir
Senkawa Koganei Diversion Channel	20.0	1/223	Circle	R=1.4	0.013	3.25	Fixed Weir
Shinya River	14.1	－	Horseshoe	R=1.9	0.014	1.99～3.93	Natural Div.
Shinya River Diversion Channel	47.6	1/4000	Horseshoe	R=3.0	0.015	2.10	Natural Div.
Enzyouzi Tunnel	16.4	1/700	Horseshoe	R=1.5､H=3.1	0.015	2.31	Natural Div.
Katakai River Diversion Channel	60.0	1/155.6	Horseshoe	R=3.6	0.015	5.70	Fixed Weir
Uzi River	10.3	1/400	Horseshoe	R=1.1	0.015	2.56	Natural Div.
Kusaka River	21.5	1/516	Horseshoe	R=1.6	0.015	2.53	Natural Div.
Kanaya River	15.0	1/38	Horseshoe	R=1.1	0.015	8.00	Main River
Mae River	14.0	1/120	Box	2.2×2.0	0.015	4.53	Main River
Daikon River	13.0	1/526	Box	2～3.5×2.5	0.015	2.21～3.12	Main River
Chuyaei River	8.6	1/365	Box	2～3×2～2.5	0.015	1.90～3.71	Natural Div.
Tsuchihashi Discharge Channel	40.0	1/360	Circle	R=2.2	0.015	4.01	Fixed Weir
Motsukisamu Discharge Channel	40.0	1/420	Circle	R=2.3	0.015	3.92	Fixed Weir

Source: JICA Survey Team

(4) Increased Ratio of Cross Section

According to the “Technical Standards for River and Sabo Work, Design-1997/09”, (Japanese Ministry of Land, Infrastructure, Transport and Tourism), the design cross section of pressure pipe tunnel is described as, “Additional increase of cross section is necessary because of the obstruction to discharge capacity caused by garbage and soil sediment (Planning Chapter 10, Section 3.2.2)”.

According to the current standard, the “Technical Standards for River and Sabo Works, Planning, 2014/4”, (Japanese Ministry of Land, Infrastructure, Transport and Tourism), the cross section and longitudinal slope of a river tunnel is regulated as follows:

> 2.2.2 Cross Section and Longitudinal Slope
>
> Tunnel cross section shall have the required flow area for design discharge and enough air section is also necessary in general. In addition, Tunnel longitudinal slope shall be decided to consider the security for flood control management, hydraulic stability and requirement of operation and maintenance.

Source: (Japanese Ministry of Land, Infrastructure, Transport and Tourism); Technical Standards for River and Sabo Works, Planning, 2014/4”

According to the 2005 version, Cross Section is described as follows:

> 1. Cross Section
>
> For open channel tunnel, air pressure becomes lower if either obstruction of discharge capacity or fast-flow is caused by garbage, driftwood or sedimentation. Therefore, enough air area of cross section, such as more than approximately 15%, is necessary to be required in general.
>
> For pressure pipe type tunnel, the cross section shall be decided with consideration on the discharge capacity, entrained air volume, possibility of negative pressure, water-stop performance, surging phenomena, lining design and so on. Invert will be installed for operation and maintenance depending on the necessity. For pressure pipe type, the entrained air shall be accurately grasped by proper method, such as the hydraulic model test. If necessary, adequate additional increase cross section is necessary to consider the obstruction of discharge capacity caused by garbage, driftwood or soil sediment. In addition, it is necessary to construct the countermeasures, such as shape examination of inlet and intake and airduct of tunnel which minimize the entrained air volume.

Source: "Technical Standards for River and Sabo Works, Planning, 2005"

However, both standards do not define the proper increase ratio. In practice, it is difficult to accurately estimate the volume of garbage and soil sediment without practical data. Therefore, the Increase Ratio is based on the Technical Standards for River and Sabo Works, Planning, 1997; (Japanese Ministry of Land, Infrastructure, Transport and Tourism).

> 1. Cross Section
>
> For open channel tunnel, air pressure becomes lower if either obstruction of discharge capacity or fast flow is caused by garbage, driftwood or sediment. Therefore, enough air area of cross section, such as more than approximately 15%, is necessarily required in general.
>
> If the existing river channel is ignored for some reason or another, the tunnel cross section shall be decided to take into account the future safety. The design discharge to decide the cross section is to be in accordance with "Design Chapter 1, Section 10".
>
> On the other hand, for pressure pipe type tunnel, the cross section shall be decided in consideration of the discharge capacity, entrained air volume, possibility of negative pressure, water-stop performance, surging phenomena, lining design and so on. Invert will be installed for operation and maintenance depending on the necessity. The increase ratio of pressure pipe type is mainly adopted as approximately 10%. In addition, it is necessary to construct countermeasures, such as shape examination of inlet and intake and air-duct of tunnel to minimize the entrained air volume.

Source: (Japanese Ministry of Land, Infrastructure, Transport and Tourism); "Technical Standards for River and Sabo Works, Planning, 1997"

Design and facility conditions for the Parañaque Spillway is as itemized below:

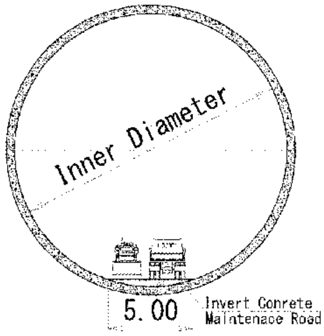
- Wood boom/floating weed trap and dust remover are installed to prevent the inflow of floating weeds and garbage. Therefore, most of the obstacles against the discharge capacity are assumingly relieved.
- It is expected that very few sand flows into the tunnel because enough sedimentation basin for sand trap is planned before the wide overflow weir.
- However, it is difficult to totally shut out the entrained air into the tunnel even if both the hydraulic model test and the countermeasures of inlet shape are conducted. In addition, it is still possible not to take enough countermeasures, such as the air duct, because of the difficulty of land acquisition.

Therefore, in accordance with the "Technical Standards for River and Sabo Works, Planning, 1997", (Japanese Ministry of Land, Infrastructure, Transport and Tourism), "10% of Increase Ratio" is adopted for the Parañaque Spillway.

(5) Inner Maintenance Road

A 5-m wide inner maintenance road/invert is planned inside of the tunnel. This width is decided to take into account the working area for cleaning the tunnel inside. Both dump truck and small bulldozer can go through and work simultaneously.

Furthermore, the discharge capacity of tunnel is calculated by the reduction area, to consider the increase ratio after the reduction of invert area. In practice, the conversion diameter calculated 10% reduction area is utilized to calculate design discharge.



Source: JICA Survey Team

Figure 4.3.4 Inner Maintenance Road

(6) Calculation of Discharge Capacity

The design condition and water levels to be used in discharge capacity is usually defined by the river planning, but in this case, these are reasonably assumed as follows

Laguna de Bay

Design High Water Level (Max. Experienced Flooding)	EL +14.03 m = 14.0 m
Operation Start Water Level (Temporarily assumed)	EL +12.0 m

Manila Bay

Mean Sea Level (MSL)	EL+10.47 m = 10.5 m
Mean Higher High Water (MHHW)	EL +11.0 m
Mean Lower Low Water (MLLW)	EL +10.0 m
Assumed Length of Spillway	L= 10 km

Head loss is generally calculated from all aspects, such as overflow weir of inlet, dust remover (screen), inlet vertical shaft, friction loss of spillway, curve figure loss of alignment, outflow loss of outlet, diffusion loss of drainage channel and so on, but the details of the facilities have not been decided yet. Therefore, main hydraulic losses, which are the friction loss of spillway, the inflow & outflow loss and the dust remover (screen) loss, are utilized for the calculation. The calculation results of discharge at Design High Water Level (EL +14.0 m) and Operation Start Water Level (EL +12.0 m) are shown in Table 4.3.9 and Table 4.3.10, respectively.

Table 4.3.9 Calculated Discharge Capacity at Design High Water Level (EL+14.0 m)

Water Level at Laguna Lake =	14.0	m	
Water Level at Manila Bay =	10.5	m	Red Letter: Input
Spillway Length =	10,000	m	Blue Letter; for Goal Seaking

1) 10% Reduction

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	10% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
15.00	176.715	5.00	19.471	1.438	157.749	14.172	157.749	0.015	0.50	1.00
14.00	153.938	5.00	20.925	1.549	137.150	13.215	137.150	0.015	0.50	1.00
13.00	132.732	5.00	22.620	1.680	117.947	12.255	117.947	0.015	0.50	1.00
12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015	0.50	1.00
11.00	95.033	5.00	27.036	2.026	83.706	10.324	83.706	0.015	0.50	1.00
10.00	78.540	5.00	30.000	2.265	68.648	9.349	68.648	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Screen Loss hs (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m/s)
2.626	2.872	0.176	0.352	0.100	3.500	0.000	OK	414.225
2.524	2.913	0.162	0.325	0.100	3.500	0.000	OK	346.164
2.417	2.953	0.149	0.298	0.100	3.500	0.000	OK	285.023
2.304	2.994	0.135	0.271	0.100	3.500	0.000	OK	230.703
2.185	3.035	0.122	0.243	0.100	3.500	0.000	OK	182.909
2.059	3.076	0.108	0.216	0.100	3.500	0.000	OK	141.365

Note *1: Velocity is Calculated by goal seeking between Velocity and Loss Difference under the condition of dh<0.001.

2) No Reduction

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	0% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
15.00	176.715	5.00	19.471	1.438	175.276	14.939	175.276	0.015	0.50	1.00
14.00	153.938	5.00	20.925	1.549	152.389	13.929	152.389	0.015	0.50	1.00
13.00	132.732	5.00	22.620	1.680	131.052	12.917	131.052	0.015	0.50	1.00
12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015	0.50	1.00
11.00	95.033	5.00	27.036	2.026	93.007	10.882	93.007	0.015	0.50	1.00
10.00	78.540	5.00	30.000	2.265	76.275	9.855	76.275	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Other Loss h' (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m/s)
2.704	2.840	0.186	0.373	0.100	3.500	0.000	OK	474.030
2.600	2.883	0.172	0.345	0.100	3.500	0.000	OK	396.273
2.491	2.925	0.158	0.316	0.100	3.500	0.000	OK	326.455
2.376	2.968	0.144	0.288	0.100	3.500	0.000	OK	264.351
2.254	3.011	0.130	0.259	0.100	3.500	0.000	OK	209.674
2.125	3.055	0.115	0.230	0.100	3.500	0.000	OK	162.115

Source: JICA Survey Team

Table 4.3.10 Calculated Discharge Capacity at Operation Start Water Level (EL+12.0 m)

Water Level at Laguna Lake =	12.0	m	
Water Level at Manila Bay =	10.5	m	Red Letter: Input
Spillway Length =	10,000	m	Blue Letter; for Goal Seaking

1) 10% Reduction

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	10% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
15.00	176.715	5.00	19.471	1.438	157.749	14.172	157.749	0.015	0.50	1.00
14.00	153.938	5.00	20.925	1.549	137.150	13.215	137.150	0.015	0.50	1.00
13.00	132.732	5.00	22.620	1.680	117.947	12.255	117.947	0.015	0.50	1.00
12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015	0.50	1.00
11.00	95.033	5.00	27.036	2.026	83.706	10.324	83.706	0.015	0.50	1.00
10.00	78.540	5.00	30.000	2.265	68.648	9.349	68.648	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Screen Loss hs (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m/s)
1.685	1.183	0.072	0.145	0.100	1.500	0.000	OK	265.786
1.619	1.199	0.067	0.134	0.100	1.500	0.000	OK	222.088
1.551	1.216	0.061	0.123	0.100	1.500	0.000	OK	182.885
1.478	1.232	0.056	0.111	0.100	1.500	0.000	OK	148.029
1.402	1.249	0.050	0.100	0.100	1.500	0.000	OK	117.359
1.321	1.266	0.044	0.089	0.100	1.500	0.000	OK	90.694

Note *1: Velocity is Calculated by goal seeking between Velocity and Loss Difference under the condition of dh<0.001.

2) No Reduction

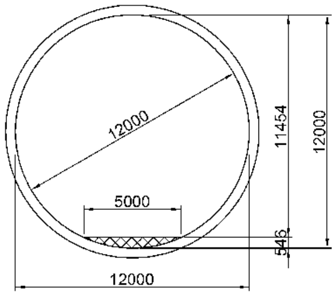
Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	0% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
15.00	176.715	5.00	19.471	1.438	175.276	14.939	175.276	0.015	0.50	1.00
14.00	153.938	5.00	20.925	1.549	152.389	13.929	152.389	0.015	0.50	1.00
13.00	132.732	5.00	22.620	1.680	131.052	12.917	131.052	0.015	0.50	1.00
12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015	0.50	1.00
11.00	95.033	5.00	27.036	2.026	93.007	10.882	93.007	0.015	0.50	1.00
10.00	78.540	5.00	30.000	2.265	76.275	9.855	76.275	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Other Loss h' (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m/s)
1.735	1.169	0.077	0.154	0.100	1.500	0.000	OK	304.162
1.669	1.187	0.071	0.142	0.100	1.500	0.000	OK	254.263
1.598	1.204	0.065	0.130	0.100	1.500	0.000	OK	209.470
1.525	1.222	0.059	0.119	0.100	1.500	0.000	OK	169.621
1.447	1.240	0.053	0.107	0.100	1.500	0.000	OK	134.535
1.364	1.257	0.047	0.095	0.100	1.500	0.000	OK	104.013

Source: JICA Survey Team

According to the above-mentioned calculation results, "Inner Diameter = 12.0 m" is adopted for the following reasons and the design cross section of Parañaque Spillway (See Figure 4.3.5).

- It is necessary to satisfy 200 m^3/s of Design Discharge at the Design High Water Level of Laguna de Bay (EL+14.0 m) with the additional cross section ratio (10%).
- It is desirable to keep large discharge volume as much as possible at the Operation Start Water Level (EL+12.0 m).
- On the other hand, smaller cross section is advisable to be taken into account with the construction cost.
- Some allowances of discharge capacity are necessary at the moment because other losses shall be considered in the future with the progress of planning and design.



Source: JICA Survey Team

Figure 4.3.5 Design Cross Section of Parañaque Spillway

Incidentally, the calculated discharge capacities of high tide and low tide at the Design High Water Level (EL+14.0m) in the case of 12m diameter are as follows:

Mean Higher High Water EL+11.0m Qmhhw = 213 m^3/s

Mean Lower Low Water EL+10.0m Qmllw = 244 m^3/s

Therefore, the 200m^3/s of design discharge shall be satisfied even in high tide. The issue in this case is how to deal with flow control. For example, if 200 m^3/s of discharge is fixed at the Mean Sea Level (EL +10.5 m), approximately 210 m^3/s will flow at the Low Tide Level (EL +10.0 m), because the difference between Laguna de Bay water level and Manila Bay water level increases by 50cm. The countermeasures in this case are presumed mainly in two cases, Case-1: Gate Control, and Case-2: larger drainage facility. This matter shall be studied later.

4.3.4 Longitudinal Plan

(1) Basic Policy for the Longitudinal Plan

Basically, the longitudinal slope is not a so important factor, because the Parañaque Spillway is the Pressure Pipe Type. Therefore, the longitudinal slope shall be decided in consideration of the final drainage location and the Operation and Maintenance. As the experiences in Japan, both the order slope (Metropolitan Area Outer Underground Discharge Channel, Kanda River/Loop Road No. 7 Underground Regulating Reservoir and so on) and the adverse slope (Gotanda Discharge Channel) exist and the order slope is commonly used.

(2) Basic Longitudinal Slope

The direction of the Basic Longitudinal Slope is decided by the drainage direction of residual water of tunnel for Operation and Maintenance. The residual water is anticipated to worsen the water quality of drainage location because of the possibility of long-term congestion. Therefore, the drainage location is cautiously decided to consider not only the cost, but also the influence to the natural and social environment.

To assist in deciding the Basic Longitudinal Slope of the Parañaque Spillway, examples of longitudinal slope of pressure pipe tunnels in Japan are given in Table 4.3.11.

Table 4.3.11 Longitudinal Slopes of Pressure Pipe Tunnels in Japan

River Tunnel Name	Direction of Slope	Design Discharge (m^3/s)	Inner Diameter (m)	Slope	Reason
Metropolitan Area Outer Underground Discharge Channel	Order	200	10.6	1/5000	—
Loop Road No. 7 Underground Reservoir (I & II)	Order	-	12.5	1/1500	—
Azumagawa Underground River "Plan" (Hyogo Pref.)	Order	171	12.0	1/1300	・ Flash of 1cm sand by 10% of design discharge ・ Froude number Fr<1.0 ・ Maximum Velocity less than 7m/s
Neya North Underground River	Order	250	11.5	1/1500	—
Neya South Underground River	Order	180	9.8	1/1500	—
Gotanda Discharge Channel	Adverse	150	8.7	1/1000	・ Drainage shall be drained to original river ・ Reduction of neighboring construction influence of underground facility ・ Difficulty of land acquisition
Azumagawa Underground River (Saitama Pref.)	Order	63	5.2	1/500	・ Flow condition of early flooding (Fr<0.8) ・ Minimum soil cover, 1.0xDiameter ・ Lower velocity to minimize abrasion

Source: JICA Survey Team

The direction of the Basic Longitudinal Slope of the Parañaque Spillway could either be Case-1: Order Slope (Inlet to Outlet), or Case-2: Adverse Slope (Outlet to Inlet). The comparison of longitudinal slope directions of Parañaque Spillway is shown in Table 4.3.12.

Table 4.3.12 Comparison of Longitudinal Slope Directions of Parañaque Spillway

Direction	Order Slope (Inlet to Outlet)	Adverse Slope (Outlet to Inlet)
Summary	The most common direction. Slope gradient is to outlet and the final residual water is also drained from Outlet.	Intake water is drained to original river. Incidentally, the influence of entrained air of adverse direction is smaller than the order slope.
Advantage	Easy explanation in case the utilization of underground storage pipe is to mitigate the drainage location. Less influence on fishery in Laguna de Bay	Theoretically, easy explanation on the case that water of Laguna de Bay is drained back to the lake. Less influence on LPPCHEA. Advantageous against the obstacle of discharge capacity caused by entrained air.
Disadvantage	There is anticipation on the water quality of drained river if the residual water becomes worse. Bad influence on LPPCHEA Obstacle problem caused by the entrained air depends on the volume.	Bad influence on fishery if the residual water is worse. Difficult to explain that the final residual water is drained to Laguna de Bay if the spillway is utilized as the underground storage pipe to mitigate the drainage location.
Evaluation	Less influence on the fishery in Laguna de Bay and easier explanation on its utilization as an underground storage pipe to mitigate the drainage location.	Possible, but lower possibility because of the bad influence to fishery in Laguna de Bay and its utilization as underground storage pipe.
	O: Selected	**△: Possible**

Source: JICA Survey Team

Therefore, both directions are possible. The “Order Slope (Inlet to Outlet)” is selected because of less influence on the fishery in Laguna de Bay and its utilization as temporary underground storage pipe (approximately 1.1 million m^3) to minimize the flooding of the drainage location. It is also possible to adopt the adverse direction, if it is not used as an underground storage pipe; however, the order slope is still desirable considering the bad influence caused by the worsened residual water to the fishery in Laguna de Bay. Therefore, the final decision on the Longitudinal Slope Direction shall be decided by negotiation with the stakeholders concerning not only the river planning and the natural environment, but also the influence on the social environment.

(3) Longitudinal Plan

The steeper longitudinal slope gradient is advisable because the higher velocity of tunnel at the early stage of flooding would flash the soil sediment. In addition, and ideally, to stabilize the hydraulic condition of tunnel, the Froude Number of around 1.0 shall be avoided. According to the “Guideline for Tunnel River (Draft), Public Works Research Institute”, Japan, the Froude Number of a tunnel river shall hopefully be less than approximately 0.8.

The longitudinal slope gradient shall be decided in consideration of the construction experiences and the following three reasons:

- According to the “Technical Standards for River and Sabo Work, Design, 1997/09”, (Japanese Ministry of Land, Infrastructure, Transport and Tourism), maximum velocity is less than 7 m/s, and according to the “Guidelines for Urban River Planning, Facility Planning of Spatial River, 1995/4”, (Japan Institute of Country-ology and Engineering), the desirable velocity in normal condition is around 2 m/s to 5 m/s.
- The Froude Number is less than approximately 0.8 to stabilize the hydraulic condition of tunnel.
- More than 10 mm diameter soils are hopefully flashed at the early flooding stage where volume is about 10 to 20% of Design Discharge.
-

Hydraulic conditions of spillway under different slopes at Design Discharge [(Discharge = 200 m^3/s), 10% of Design Discharge (Discharge = 20 m^3/s), and 20% of Design Discharge (Discharge = 40 m^3/s) are as shown in Table 4.3.13, Table 4.3.14 and Table 4.3.15, respectively.

Table 4.3.13 Hydraulic Conditions of Spillway under Different Slopes (Discharge = 200 m^3/s)

Diameter of Tunnel = 12.0 m Red Letter: Input
Design Discharge = 200.0 m3/s Blue Letter; for Goal Seaking

1) 10% Reduction

Slope	Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	10% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient
1/3,000	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/2,500	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/2,000	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/1,500	12.00	113.097	5.00	24.624	1.836	100.135	11.2914	100.135	0.015
1/1,000	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/500	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015

Water Depth H (m)	Flow Angle (Degree)	Flow Area Af (m2)	Wetted Perimeter L (m)	Hydraulic Radius R (m)	Velocity v (m/s)	Calculated Discharge Qc (m3/s)	Friction Velocity U* (m/s)	Froude Number Fr	Critacal Diameter dc (mm)
7.792	67.661	73.701	22.139	3.329	2.714	200.000	0.104	**0.310**	**13.451**
7.296	73.006	68.430	21.086	3.245	2.923	200.000	0.113	**0.346**	**15.736**
6.768	78.534	62.656	19.996	3.133	3.192	200.000	0.124	**0.392**	**18.991**
6.179	84.580	56.080	18.805	2.982	3.566	200.000	0.140	**0.458**	**24.100**
5.474	91.741	48.131	17.393	2.767	4.155	200.000	0.165	**0.567**	**33.544**
4.505	101.658	37.274	15.439	2.414	5.366	200.000	0.218	**0.807**	**58.532**

Note *1: Water Depth is Calculated by goal seeking between Water Depth and Calculated Discharge.

2) No Reduction

Slope	Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	0% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient
1/3,000	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/2,500	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/2,000	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/1,500	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/1,000	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/500	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015

Water Depth H (m)	Flow Angle (Degree)	Flow Area Af (m2)	Wetted Perimeter L (m)	Hydraulic Radius R (m)	Velocity v (m/s)	Calculated Discharge Qc (m3/s)	Friction Velocity U* (m/s)	Froude Number Fr	Critacal Diameter dc (mm)
7.435	75.562	73.106	21.695	3.370	2.736	200.000	0.105	**0.320**	**13.616**
7.002	79.833	68.069	20.808	3.271	2.938	200.000	0.113	**0.355**	**15.862**
6.527	84.450	62.471	19.849	3.147	3.202	200.000	0.124	**0.400**	**19.076**
5.985	89.677	56.030	18.763	2.986	3.570	200.000	0.140	**0.466**	**24.132**
5.324	96.047	48.182	17.440	2.763	4.151	200.000	0.165	**0.574**	**33.491**
4.401	105.099	37.390	15.559	2.403	5.349	200.000	0.217	**0.814**	**58.260**

Source: JICA Survey Team

Table 4.3.14 Hydraulic Conditions of 10% Design Discharge (Discharge = 20 m^3/s)

Diameter of Tunnel =	12.0	m		Red Letter: Input
Design Discharge =	20.0	m3/s		Blue Letter; for Goal Seaking

1) 10% Reduction

Slope	Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	10% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient
1/3,000	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/2,500	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/2,000	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/1,500	12.00	113.097	5.00	24.624	1.836	100.135	11.2914	100.135	0.015
1/1,000	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/500	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015

Water Depth H (m)	Flow Angle (Degree)	Flow Area Af (m2)	Wetted Perimeter L (m)	Hydraulic Radius R (m)	Velocity v (m/s)	Calculated Discharge Qc (m3/s)	Friction Velocity U* (m/s)	Froude Number Fr	Critacal Diameter dc (mm)
2.188	127.763	13.629	10.294	1.324	1.468	20.000	0.066	**0.317**	**5.349**
2.092	129.005	12.780	10.050	1.272	1.565	20.000	0.071	**0.345**	**6.166**
1.981	130.474	11.813	9.760	1.210	1.693	20.000	0.077	**0.384**	**7.336**
1.847	132.290	10.676	9.402	1.135	1.873	20.000	0.086	**0.440**	**9.176**
1.674	134.711	9.258	8.925	1.037	2.160	20.000	0.101	**0.533**	**12.574**
1.416	138.516	7.260	8.175	0.888	2.755	20.000	0.132	**0.739**	**21.531**

Note *1: Water Depth is Calculated by goal seeking between Water Depth and Calculated Discharge.

2) No Reduction

Slope	Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	0% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient
1/3,000	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/2,500	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/2,000	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/1,500	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/1,000	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/500	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015

Water Depth H (m)	Flow Angle (Degree)	Flow Area Af (m2)	Wetted Perimeter L (m)	Hydraulic Radius R (m)	Velocity v (m/s)	Calculated Discharge Qc (m3/s)	Friction Velocity U* (m/s)	Froude Number Fr	Critacal Diameter dc (mm)
2.153	129.661	13.714	10.457	1.311	1.458	20.000	0.065	**0.317**	**5.299**
2.059	130.846	12.861	10.211	1.260	1.555	20.000	0.070	**0.346**	**6.107**
1.950	132.248	11.890	9.920	1.199	1.682	20.000	0.077	**0.385**	**7.265**
1.818	133.984	10.747	9.559	1.124	1.861	20.000	0.086	**0.441**	**9.085**
1.649	136.302	9.321	9.078	1.027	2.146	20.000	0.100	**0.534**	**12.447**
1.396	139.950	7.312	8.320	0.879	2.735	20.001	0.131	**0.739**	**21.306**

Source: JICA Survey Team

Table 4.3.15 Hydraulic Conditions of 20% Design Discharge (Discharge = 40 m³/s)

Diameter of Tunnel = 12.0 m Red Letter: Input
Design Discharge = 40.0 m3/s Blue Letter; for Goal Seaking

1) 10% Reduction

Slope	Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	10% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient
1/3,000	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/2,500	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/2,000	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/1,500	12.00	113.097	5.00	24.624	1.836	100.135	11.2914	100.135	0.015
1/1,000	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015
1/500	12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015

Water Depth H (m)	Flow Angle (Degree)	Flow Area Af (m2)	Wetted Perimeter L (m)	Hydraulic Radius R (m)	Velocity v (m/s)	Calculated Discharge Qc (m3/s)	Friction Velocity U* (m/s)	Froude Number Fr	Critacal Diameter dc (mm)
3.096	116.851	22.286	12.445	1.791	1.795	40.000	0.077	0.326	7.236
2.955	118.458	20.883	12.128	1.722	1.915	40.000	0.082	0.356	8.349
2.793	120.346	19.289	11.756	1.641	2.074	40.000	0.090	0.396	9.944
2.599	122.662	17.416	11.300	1.541	2.297	40.000	0.100	0.455	12.455
2.349	125.722	15.087	10.697	1.410	2.651	40.000	0.118	0.552	17.097
1.981	130.474	11.813	9.760	1.210	3.386	40.000	0.154	0.768	29.343

Note *1: Water Depth is Calculated by goal seeking between Water Depth and Calculated Discharge.

2) No Reduction

Slope	Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	0% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient
1/3,000	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/2,500	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/2,000	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/1,500	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/1,000	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015
1/500	12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015

Water Depth H (m)	Flow Angle (Degree)	Flow Area Af (m2)	Wetted Perimeter L (m)	Hydraulic Radius R (m)	Velocity v (m/s)	Calculated Discharge Qc (m3/s)	Friction Velocity U* (m/s)	Froude Number Fr	Critacal Diameter dc (mm)
3.038	119.303	22.403	12.609	1.777	1.786	40.001	0.076	0.327	7.179
2.902	120.822	20.996	12.293	1.708	1.905	40.000	0.082	0.357	8.281
2.744	122.609	19.397	11.922	1.627	2.062	40.000	0.089	0.398	9.861
2.554	124.806	17.518	11.466	1.528	2.283	40.000	0.100	0.456	12.347
2.310	127.717	15.179	10.861	1.398	2.635	40.000	0.117	0.554	16.941
1.950	132.248	11.890	9.920	1.199	3.364	40.000	0.153	0.769	29.060

Source: JICA Survey Team

For the above calculations, critical tractive force is calculated by Iwagaki's Equation, as follows:

$$d \geqq 0.303 \text{ cm}; \qquad u_{*c}^2 = 80.9d$$
$$0.118 \leqq d \leqq 0.303 \text{ cm}; \qquad = 134.6d^{31/32}$$
$$0.0565 \leqq d \leqq 0.118 \text{ cm}; \qquad = 55.0d$$
$$0.0065 \leqq d \leqq 0.0565 \text{ cm}; \qquad = 8.41d^{11/32}$$
$$d \leqq 0.0065 \text{ cm}; \qquad = 226d$$

Where, u_{*c}: Critical Friction Velocity (cm/s)、d: Diameter (cm)

According to the above calculations, if 1/1500 of Longitudinal slope at 20 % of Design Discharge is adopted, u* = 10.0 cm and critical moving diameter dc=12.5 mm, which satisfy the target diameter, d=10mm. In addition, the calculated velocity at the Design Discharge, 200 m^3/s, is 3.6 m/s which also satisfies the target range of 2 m/s to 5 m/s. Therefore, based on the above calculations and the construction experiences in Table 4.3.11, “1/1500 of Longitudinal Slope” is decided. This Longitudinal Slope gradient shall be reviewed in detail after the determination of the Sedimentation Basin of Inlet later.

4.3.5 Effect of Climate Change

To consider the effect of climate change, the suggested approaches to incorporating sea level rise in the “Design Guidelines, Criteria and Standards, DPWH-BOD” are as shown in Table 4.3.16.

Table 4.3.16 Suggested Approach for Incorporating Sea Level Rise

Table 9-4 Suggested Approach for Incorporating Sea Level Rise

Approach	Recommendation
General Approach	Allow for a 0.3 m sea level rise in the design.
Alternative Approach	Determine the likely impacts of a 0.3 m sea level rise. Refer to potential for Planned Upgrade as discussed in Section 9.2.3.

Source: DPWH-BOD; “Design Guidelines, Criteria and Standards “

In accordance with the DPWH Standards, the calculated discharges with 30 cm sea level rise at the Design High Water Level (EL+14.0 m) and the Operation Start Water Level (EL+12.0 m) are as shown in Table 4.3.17 and Table 4.3.18, respectively.

Table 4.3.17 Calculated Discharge with 30cm Sea Rise at Design High Water Level (EL+14.0m)

Water Level at Laguna Lake =	14.0	m		
Water Level at Manila Bay =	10.8	m		Red Letter: Input
Spillway Length =	10,000	m		Blue Letter; for Goal Seaking

1) 10% Reduction

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	10% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
15.00	176.715	5.00	19.471	1.438	157.749	14.172	157.749	0.015	0.50	1.00
14.00	153.938	5.00	20.925	1.549	137.150	13.215	137.150	0.015	0.50	1.00
13.00	132.732	5.00	22.620	1.680	117.947	12.255	117.947	0.015	0.50	1.00
12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015	0.50	1.00
11.00	95.033	5.00	27.036	2.026	83.706	10.324	83.706	0.015	0.50	1.00
10.00	78.540	5.00	30.000	2.265	68.648	9.349	68.648	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Screen Loss hs (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m/s)
2.507	2.619	0.160	0.321	0.100	3.200	0.000	OK	395.528
2.410	2.655	0.148	0.296	0.100	3.200	0.000	OK	330.500
2.307	2.692	0.136	0.271	0.100	3.200	0.000	OK	272.160
2.200	2.729	0.123	0.247	0.100	3.200	0.000	OK	220.289
2.086	2.767	0.111	0.222	0.100	3.200	0.000	OK	174.647
1.966	2.804	0.099	0.197	0.100	3.200	0.000	OK	134.967

Note *1: Velocity is Calculated by goal seeking between Velocity and Loss Difference under the condition of dh<0.001.

2) No Reduction

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	0% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
15.00	176.715	5.00	19.471	1.438	175.276	14.939	175.276	0.015	0.50	1.00
14.00	153.938	5.00	20.925	1.549	152.389	13.929	152.389	0.015	0.50	1.00
13.00	132.732	5.00	22.620	1.680	131.052	12.917	131.052	0.015	0.50	1.00
12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015	0.50	1.00
11.00	95.033	5.00	27.036	2.026	93.007	10.882	93.007	0.015	0.50	1.00
10.00	78.540	5.00	30.000	2.265	76.275	9.855	76.275	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Other Loss h' (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m/s)
2.582	2.590	0.170	0.340	0.100	3.200	0.000	OK	452.637
2.483	2.628	0.157	0.314	0.100	3.200	0.000	OK	378.381
2.379	2.667	0.144	0.288	0.100	3.200	0.000	OK	311.722
2.269	2.706	0.131	0.262	0.100	3.200	0.000	OK	252.420
2.153	2.745	0.118	0.236	0.100	3.200	0.000	OK	200.207
2.029	2.785	0.105	0.210	0.100	3.200	0.000	OK	154.787

Source: JICA Survey Team

Table 4.3.18 Calculated Discharge with 30cm Sea Rise at Operation Start Water Level (EL+12.0m)

Water Level at Laguna Lake =	12.0	m	
Water Level at Manila Bay =	10.8	m	Red Letter: Input
Spillway Length =	10,000	m	Blue Letter; for Goal Seaking

1) 10% Reduction

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	10% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
15.00	176.715	5.00	19.471	1.438	157.749	14.172	157.749	0.015	0.50	1.00
14.00	153.938	5.00	20.925	1.549	137.150	13.215	137.150	0.015	0.50	1.00
13.00	132.732	5.00	22.620	1.680	117.947	12.255	117.947	0.015	0.50	1.00
12.00	113.097	5.00	24.624	1.836	100.135	11.291	100.135	0.015	0.50	1.00
11.00	95.033	5.00	27.036	2.026	83.706	10.324	83.706	0.015	0.50	1.00
10.00	78.540	5.00	30.000	2.265	68.648	9.349	68.648	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Screen Loss hs (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m/s)
1.494	0.929	0.057	0.114	0.100	1.200	0.000	OK	235.624
1.436	0.942	0.053	0.105	0.100	1.200	0.000	OK	196.885
1.375	0.955	0.048	0.096	0.100	1.200	0.000	OK	162.131
1.311	0.969	0.044	0.088	0.100	1.200	0.000	OK	131.231
1.243	0.982	0.039	0.079	0.100	1.200	0.000	OK	104.040
1.171	0.995	0.035	0.070	0.100	1.200	0.000	OK	80.402

Note *1: Velocity is Calculated by goal seeking between Velocity and Loss Difference under the condition of dh<0.001.

2) No Reduction

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	0% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
15.00	176.715	5.00	19.471	1.438	175.276	14.939	175.276	0.015	0.50	1.00
14.00	153.938	5.00	20.925	1.549	152.389	13.929	152.389	0.015	0.50	1.00
13.00	132.732	5.00	22.620	1.680	131.052	12.917	131.052	0.015	0.50	1.00
12.00	113.097	5.00	24.624	1.836	111.261	11.902	111.261	0.015	0.50	1.00
11.00	95.033	5.00	27.036	2.026	93.007	10.882	93.007	0.015	0.50	1.00
10.00	78.540	5.00	30.000	2.265	76.275	9.855	76.275	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Other Loss h' (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m/s)
1.538	0.919	0.060	0.121	0.100	1.200	0.000	OK	269.645
1.479	0.933	0.056	0.112	0.100	1.200	0.000	OK	225.409
1.417	0.946	0.051	0.102	0.100	1.200	0.000	OK	185.699
1.352	0.960	0.047	0.093	0.100	1.200	0.000	OK	150.372
1.282	0.974	0.042	0.084	0.100	1.200	0.000	OK	119.267
1.209	0.988	0.037	0.075	0.100	1.200	0.000	OK	92.210

Source: JICA Survey Team

Therefore, at the Design High Water Level (EL14.0m), the calculated discharge of 220m^3/s exceeds the Design Discharge of 200m^3/s. On the other hand, at the Operation Start Water Level (EL+12.0m), it reduces up to 11.3%. Reasonably, however, it seems that there is no problem if the Operation Start Water Level is lowered to 30cm. (A detailed study is necessary in the future process.)

In conclusion, the countermeasure for the effect of Climate Change is that the Operation Start Water Level shall be planned to get down to 30cm as much as possible. Therefore, it is necessary that the design facility plan shall not be significantly changed even under such future changes.

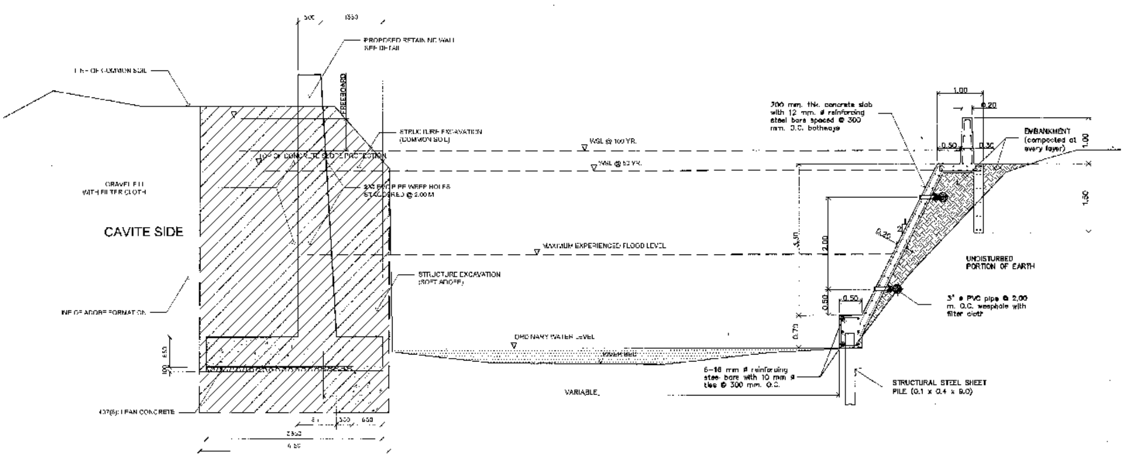
4.3.6 Outline Drawing

As the outline drawings, the Plan Drawing of Spillway and Vertical Shaft of Inlet and Outlet, Plan Drawing of Intake Facility (Inlet), Cross Section Drawing of Intake Facility (Inlet), Plan Drawing of Drainage Facility (Outlet) and Cross Section Drawing of Drainage Facility (Outlet) are shown from Figure 4.3.8 to Figure 4.3.12, respectively.

Incidentally, both vertical shafts of Inlet and Outlet consider the drainage pump for the residual water at this moment. After determination of the final plan of drainage shaft, it is necessary to minimize the dry area of vertical shaft for the reduction of water head loss. In addition, and in consideration of Operation and Maintenance and facility site visit of guests, the administration buildings and management equipment are also necessary later.

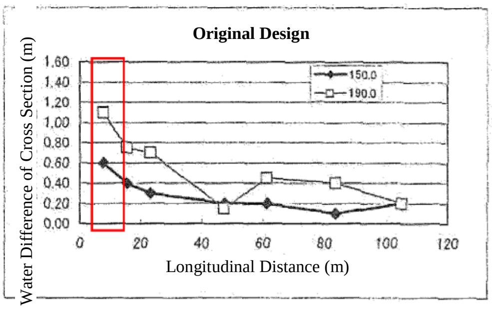
In addition, about the drainage facility, type of Width x Height = 5.0x5.0 x 4 Culverts is examined firstly depending on the experience of Width x Height = 5.4x4.2 x 6 Culverts in Metropolitan Area Outer Underground Discharge Channel. However, Width x Height = 5.0x5.0 x 4 culverts based on the experience of Gotanda Discharge Channel in Japan is finally suggested for the following reasons:

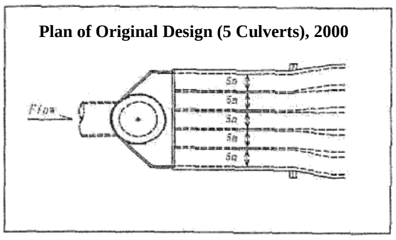
- According to Figure 4.3.6 obtained from the Cavite Sub-District Engineering Office, DPWH, design water depth of drained river, Zapote River, is 4m for ordinary water level. Therefore, even if future dredging is planned, shallow water depth is realistic.
- According to Figure 4.3.7, Hydraulic Model Test Result of Outlet Drainage of Gotanda Discharge Channel, the water condition of a 3-culvert type, wide box width, is hydraulically more stable than the 5-culvert type.



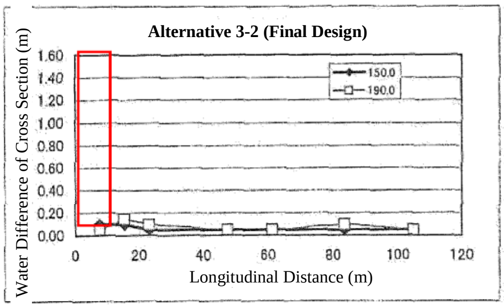
Source: "DPWH Cavite Sub-District Engineering Office"

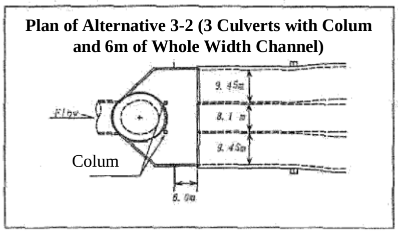
Figure 4.3.6 Standard Cross Section of River Improvement Project of Zapote River, Cavite, Philippines





Water Difference of Cross Section of Outlet Drainage (Original Design, 5-Culvert)





Water Difference of Cross Section of Outlet Drainage (Final Design, 3-Culvert)

Source: (CTI Engineering Co., Ltd.); "Final Report for Design of Fanning Outlet Drainage of Gotanda Discharge Channel"

Figure 4.3.7 Hydraulic Model Test Results of Outlet Drainage of Gotanda Discharge Channel, Japan

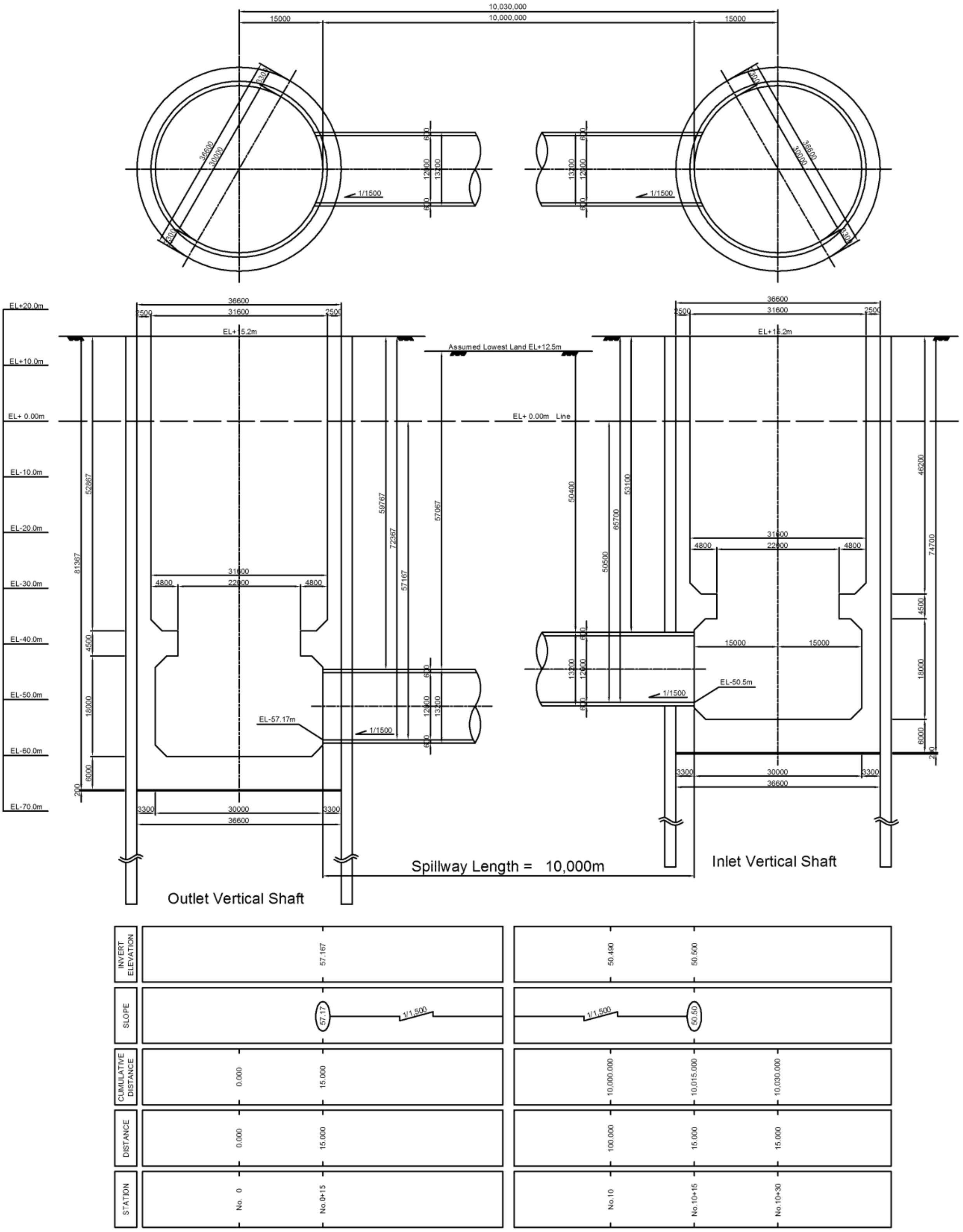


Figure 4.3.8 Plan Drawing of Spillway and Vertical Shaft of Inlet and Outlet

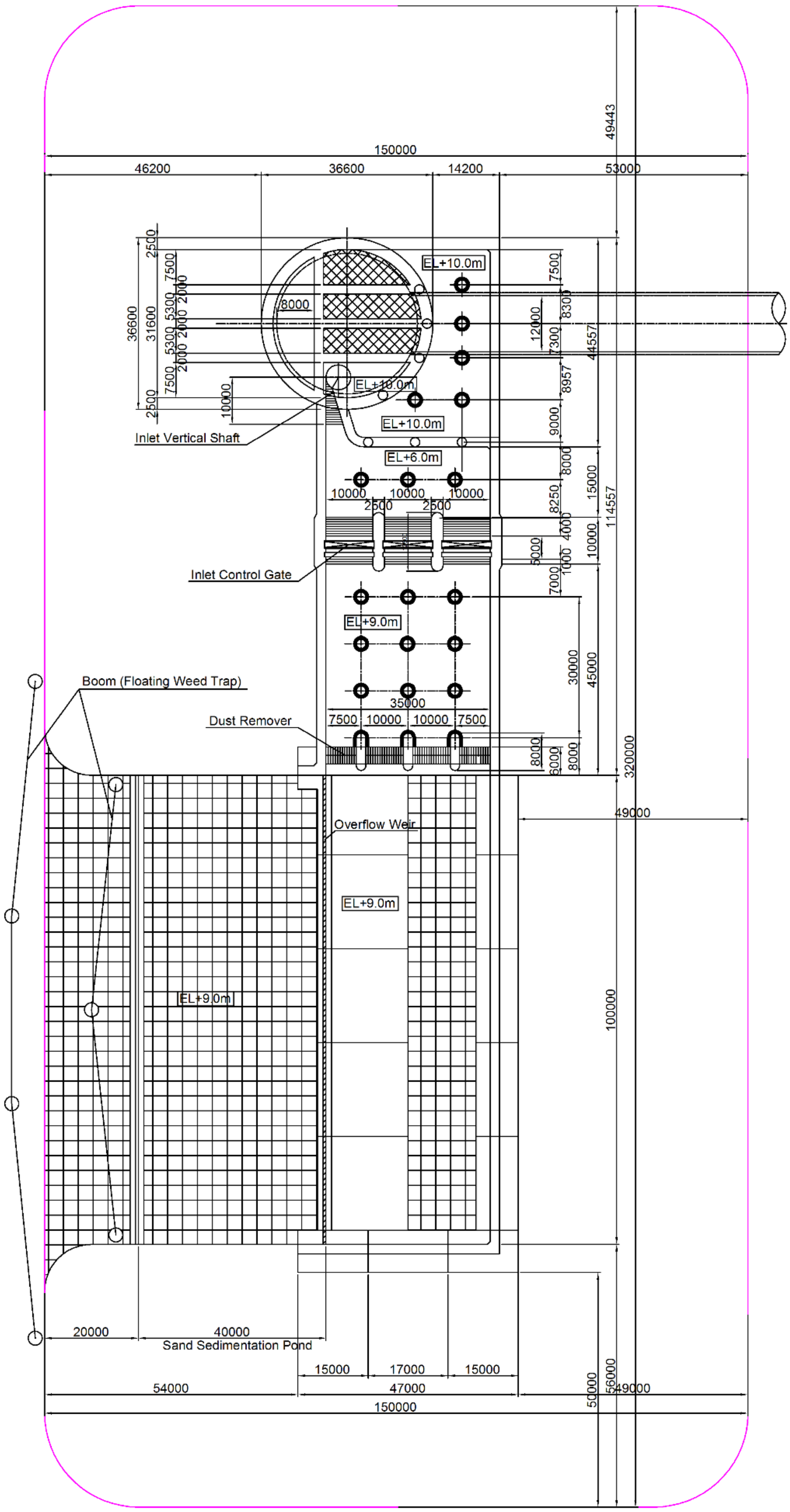


Figure 4.3.9 Plan Drawing of Intake Facility (Inlet)

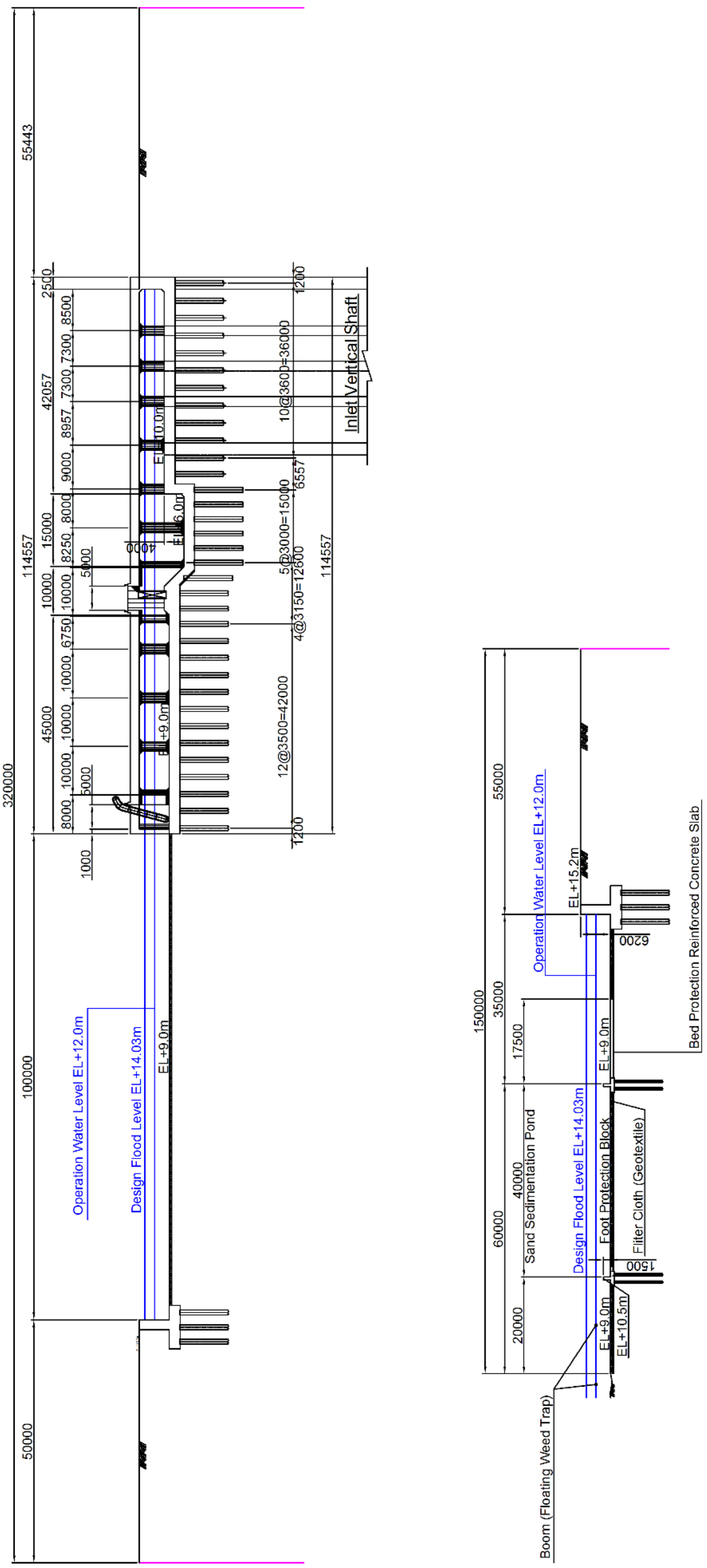


Figure 4.3.10 Cross Section Drawing of Intake Facility (Inlet)

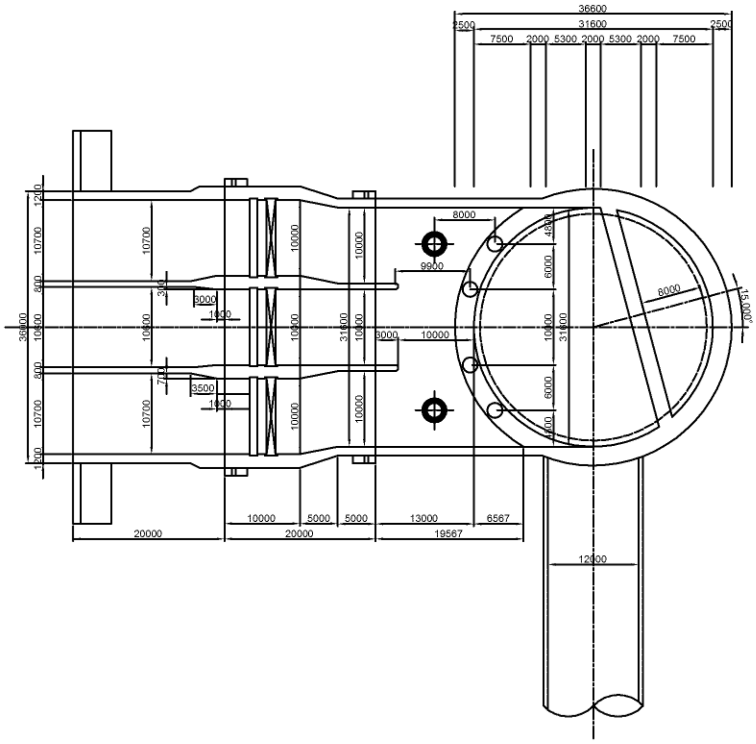


Figure 4.3.11 Plan Drawing of Drainage Facility (Outlet)

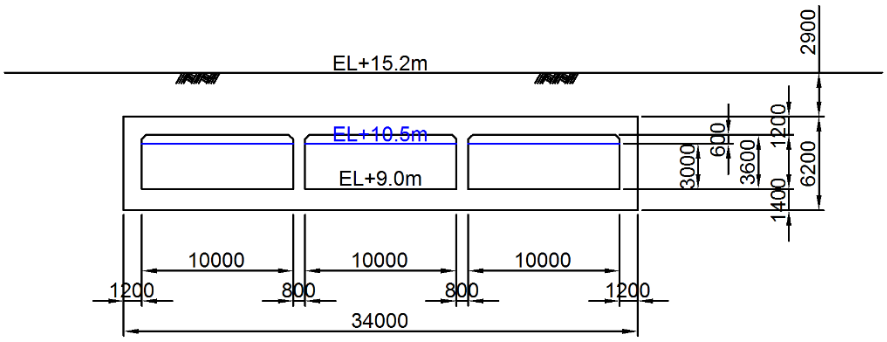


Figure 4.3.12 Cross Section Drawing of Drainage Facility (Outlet)

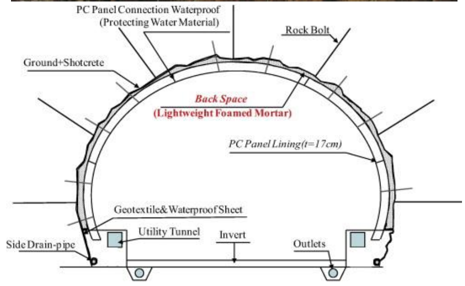
4.3.7 Construction Method

As shown in the Section 2.1.1, "Geology of the Philippines Second Edition" shows that the hilly area where the Paranaque Spillway is proposed between Manila Bay and Laguna de Bay is made from Guadalupe Formation of Pleistocene. Hence, it can be assumed that soft rock such as volcanic clastic rock, tuff rock, lapilli tuff, tuff-breccia and volcanic ash silt rock is widely spread.

In the Survey, two kinds of construction methods for a tunnel were proposed. The one was Shield Tunneling Method which was widely applicable for very weak alluvium, diluvium and Neogene soft rock. The other was NATM which was adequate for Neogene soft rock and hard rock.

The outlines of two methods were summarized in Table 4.3.19

Table 4.3.19 Summary of Shield Tunneling Method and NATM

Item	Shield Tunneling Method	NATM
Photo and Figure	  Source: http://www.ktr.mlit.go.jp/edogawa/gaikaku/index.html	  Source: Tunneling and Underground Space Technology, Volume 47, March 2015
Outline of method	Tunneling method using a shield machine to keep stability of the ground. Shield machine is driven coping with earth and water pressure at the cutting face by filling the chamber with slurry or excavated muddy soil. Tunnel walls are prevented from ground collapsing by a segmental lining which is erected in the shield machine.	Makes use of ground supporting function of the area surrounding the excavation. Shotcrete, rockbolts, steel rib supports, and other methods are used for stabilization. It requires the ground arch effect to be in effect and a self-standing face. When these two conditions are not satisfied, it may still be applied using auxiliary measures.
Applicable geological conditions (past applications and flexibility in condition changes)	Generally, it is applicable in alluvial, diluvial and very soft Neocene ground. It has flexibility to accommodate variations in ground conditions. Recently, there have been some cases of applications in hard rock.	Generally, it is applicable to ground of hard rock and Neocene soft rock. It can be used even in diluvial formations depending on ground conditions of the project. Methods of coping when the ground conditions are different to presumed include changing the support strength, changing excavation method, and adopting auxiliary measures.
Advantages and Disadvantage	<u>Advantage</u> A closed-face type shield usually requires to auxiliary measures except for at the departure and arriving portions. It is possible to achieve standard progress rate of around 350m per month and even progress rate of over 500m in case of application to the specification of high speed construction. Compared to NATM, construction speed is high. <u>Disadvantage</u> Compared to NATM, the construction cost will become high due to costly shield machine and segments.	<u>Advantage</u> Construction Cost will be less than half of shield tunneling method if auxiliary measures are not required. <u>Disadvantage</u> Auxiliary measures are needed in case of the appearance of the unforeseeable soft soil condition and/or large amount of water flow. As a result, construction cost will be significantly increased and in some cases the cost will become more expensive than Shield Tunneling Method. Compared to Shield Tunneling Method, construction speed of NATM, which is the rate of around 100m per month, is low.

Source: Editing by JICA Study Team in reference to Table 1.2 “Comparative Table of three major tunneling methods” (P.5) of Standard Specification for Tunneling 2006: Shield Tunnels.

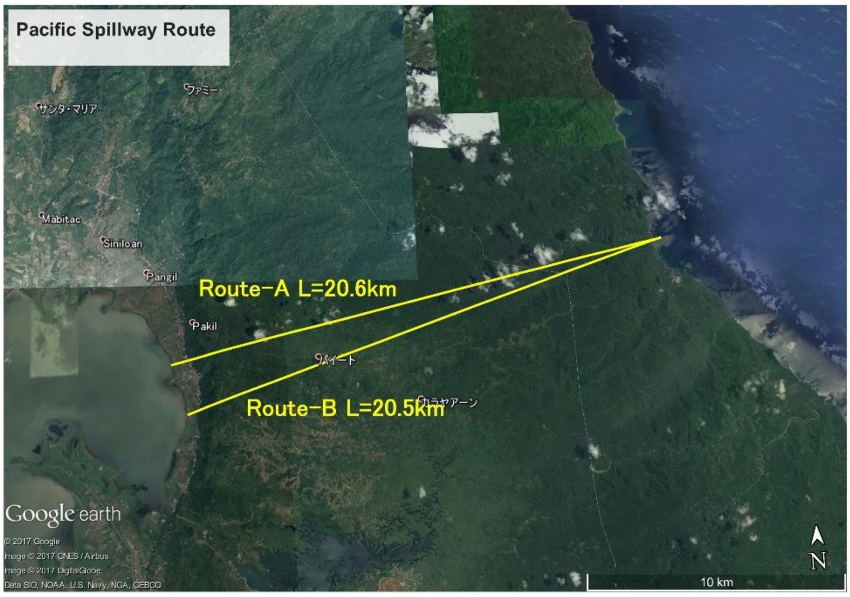
A cost for NATM is generally lower than the one for Shield Tunneling Method and possibly applicable to the Project. However, some data are presently missing such as geological characteristics, especially permeability of the foundation, it is overly optimistic about applying NATM in the Survey.

Hence, in the Survey, both the Shield Tunneling Method and NATM were studied.

4.4 Study on Pacific Ocean Spillway

The alternative plan instead of the Parañaque Spillway is the "Pacific Spillway" which goes from the east side of Laguna de Bay to the Pacific Ocean as described below.

The possible route plans and distances, which may be seemingly straight lines due to the reduction of project cost, are shown in Figure 4.4.1.



Source: JICA Survey Team based on Google Earth Data

Figure 4.4.1 Route Plans and Lengths of Pacific Spillway

According to Figure 4.4.1, the lengths of both Route-A and Route-B are not so significantly different. Therefore, the planning in this Study utilizes Route-A because of the slightly longer length.

(1) Planning Condition

<u>Hydraulic Condition</u>

Tide Observed Location:	Real, Quezon
Mean Sea Level (MSL)	EL +10.80 m
Mean High Water (MHW)	EL +11.46 m
Mean Low Water (MLW)	EL +10.17 m

Therefore, the planning hydraulic condition of Pacific Ocean is "MSL=EL+10.8m".

Planning and Design Condition

Planning Discharge:	Qp = 200m^3/s
Roughness Coefficient	n = 0.015
Required Air Area Ratio (for Gravity Flow Open Channel)	αr = 15% over

Length of Spillway measured by Google Earth

According to Figure 4.4.1, the lengths of Route-A and Route-B are L_A=20.6 km and L_B=20.5 km, respectively. In this case, the length of the Pacific Spillway is Ls=20.0 km because the connecting channels is constructed at the upstream and downstream ends. (Actually, the length of a Spillway is determined from several aspects, such as the ground formations of upstream and downstream portions and the dimensions of facilities. However, in this Study, there are a few available data at present so that the above length is reasonably assumed.)

(2) Pressure Pile Type

Design Discharge	Qd = 200m^3/s (100% of Planning Discharge)
Section Increase Ratio	10 %
Design Inner Diameter	D = 13.5 m
Discharge Capacity	Qc = 220m^3/s

Table 4.4.1 Calculated Discharge Capacity of Pressure Pipe Type of Pacific Spillway

Water Level at Laguna Lake = 14.0 m
Water Level at Manila Bay = 10.8 m
Spillway Length = 20,000 m
Red Letter: Input
Blue Letter; for Goal Seaking

1) 10% Reduction

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	10% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
15.00	176.715	5.00	19.471	1.438	157.749	14.172	157.749	0.015	0.50	1.00
14.50	165.130	5.00	20.171	1.492	147.275	13.694	147.275	0.015	0.50	1.00
14.00	153.938	5.00	20.925	1.549	137.150	13.215	137.150	0.015	0.50	1.00
13.50	143.139	5.00	21.738	1.612	127.374	12.735	127.374	0.015	0.50	1.00
13.00	132.732	5.00	22.620	1.680	117.947	12.255	117.947	0.015	0.50	1.00
12.50	122.718	5.00	23.578	1.754	108.868	11.773	108.868	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Screen Loss hs (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m/s)
1.846	2.839	0.087	0.174	0.100	3.200	0.000	OK	291.224
1.808	2.850	0.083	0.167	0.100	3.200	0.000	OK	266.225
1.769	2.861	0.080	0.159	0.100	3.200	0.000	OK	242.555
1.729	2.871	0.076	0.152	0.100	3.200	0.000	OK	220.187
1.688	2.882	0.073	0.145	0.100	3.200	0.000	OK	199.095
1.647	2.892	0.069	0.138	0.100	3.200	0.000	OK	179.254

Note *1: Velocity is Calculated by goal seeking between Velocity and Loss Difference under the condition of dh<0.001.

2) No Reduction

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	0% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
15.00	176.715	5.00	19.471	1.438	175.276	14.939	175.276	0.015	0.50	1.00
14.50	165.130	5.00	20.171	1.492	163.638	14.434	163.638	0.015	0.50	1.00
14.00	153.938	5.00	20.925	1.549	152.389	13.929	152.389	0.015	0.50	1.00
13.50	143.139	5.00	21.738	1.612	141.527	13.424	141.527	0.015	0.50	1.00
13.00	132.732	5.00	22.620	1.680	131.052	12.917	131.052	0.015	0.50	1.00
12.50	122.718	5.00	23.578	1.754	120.964	12.410	120.964	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Other Loss h' (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m/s)
1.906	2.822	0.093	0.185	0.100	3.200	0.000	OK	334.126
1.867	2.833	0.089	0.178	0.100	3.200	0.000	OK	305.484
1.827	2.845	0.085	0.170	0.100	3.200	0.000	OK	278.357
1.786	2.856	0.081	0.163	0.100	3.200	0.000	OK	252.719
1.744	2.867	0.078	0.155	0.100	3.200	0.000	OK	228.540
1.701	2.878	0.074	0.148	0.100	3.200	0.000	OK	205.790

Source: JICA Survey Team

(3) Open Channel Type

It is necessary that the design discharge for the Open Channel Type of Tunnel River shall be 130% of planning discharge because of “the difficulty of the increase improvement of discharge capacity, compared with the Pressure Pipe Type and the high possibility of clogging by the debris flow” (Technical Standards for River and Sabo Works, Design, 1997; (Japanese Ministry of Land, Infrastructure, Transport and Tourism). However, the above-mentioned requirement is basically in the case of Tunnel River and not the Spillway. It may be possible for Pacific Spillway that the design discharge is only 100% of the planning discharge. Consequently, both the above two cases are considered in this Study.

(i) Design Discharge Qd = 260 m^3/s (130% of Planning Discharge)

Slope Gradient	I = 1/(20,000/(14.0-10.8-0.1)) = 1/6,452 = 1/6,500
Design Inner Diameter	D = 14.0 m (In the case of D'= 13.5 m)
Air Area Ratio	α = 25.7 % >15 % OK (α'= 14.8 % NG)

Table 4.4.2 Hydraulic Condition of Open Channel Type of Pacific Spillway at Qd=260m^3/s

Pacific Spillway Tunnel

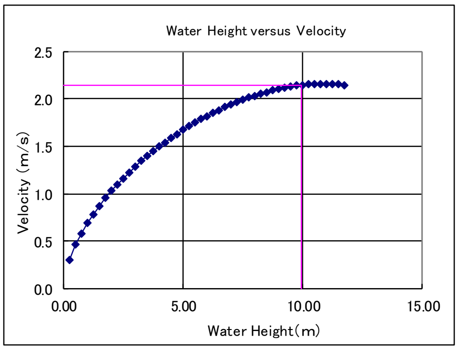
Open Channel Tunnel

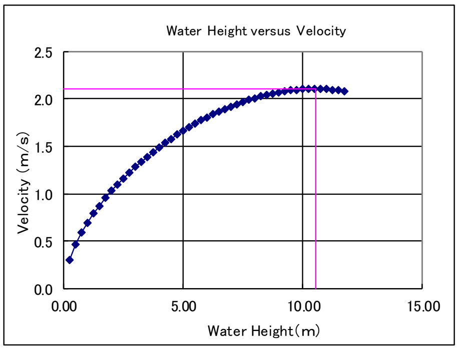
Roughness Coe.	n	0.015
Slope	1/I	6,500
Flow Area	A (m2) =A0-A1-A2	121.211
Wetted Perimeter	P (m)	29.012
Hydraulic Radius	R=A/P(m)	4.178
Velocity	v(m/s)	2.145
Froude Number	$F=v/(gh)^{1/2}$	0.217
Cal. Discharge	Q=Av(m^3/s)	260.000
Inner Diameter	D(m)	14.0
Invert Width	b(m)	5.000
Invert Height	h1(m)	0.46
Invert Area	A1(m^2)	1.541
Water Depth	h(m)	9.950
Water Width	B(m)	12.2
Air Ratio	A2(m^2)	31.186
Circular Area	A0(m^2)	153.938
Air ratio	α=A2/A(%)	25.7
Afford Height	h2(m)	3.590

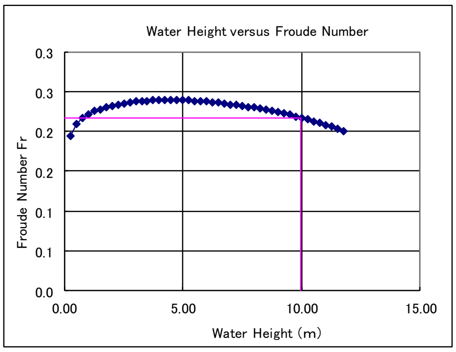
Pacific Spillway Tunnel

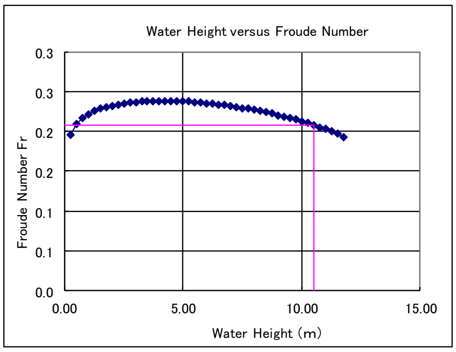
Open Channel Tunnel

Roughness Coe.	n	0.015
Slope	1/I	6,500
Flow Area	A (m2) =A0-A1-A2	123.317
Wetted Perimeter	P (m)	30.288
Hydraulic Radius	R=A/P(m)	4.071
Velocity	v(m/s)	2.108
Froude Number	$F=v/(gh)^{1/2}$	0.208
Cal. Discharge	Q=Av(m^3/s)	260.000
Inner Diameter	D(m)	13.5
Invert Width	b(m)	5.000
Invert Height	h1(m)	0.48
Invert Area	A1(m^2)	1.612
Water Depth	h(m)	10.524
Water Width	B(m)	10.5
Air Ratio	A2(m^2)	18.210
Circular Area	A0(m^2)	143.139
Air ratio	α=A2/A(%)	14.8
Afford Height	h2(m)	2.496









(ii) Design Discharge Qd = 200 m^3/s (100% of Planning Discharge}

Slope Gradient I = 1/(20,000/(14.0-10.8-0.1)) = 1/6,452 = 1/6,500

Design Inner Diameter D = 12.5 m (In the case of D'= 12.0 m)

Air Area Ratio α = 20.6 % >15 % OK (α'= 7. 3% NG)

Table 4.4.3 Hydraulic Condition of Open Channel Type of Pacific Spillway at Qd=200m^3/s

Pacific Spillway Tunnel

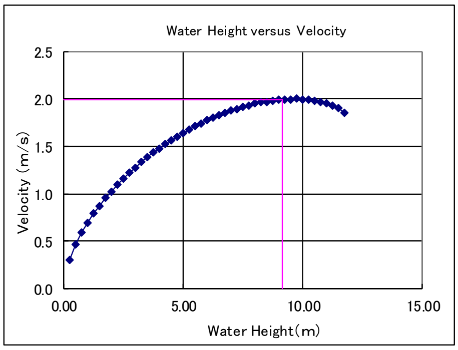
Open Channel Tunnel

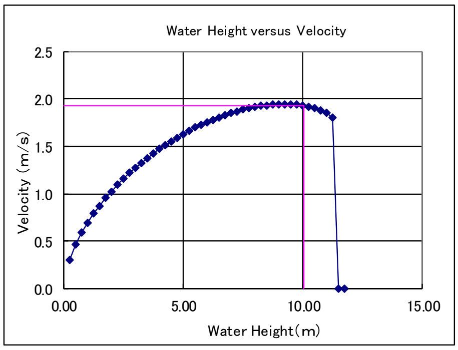
Roughness Coe.	n	0.015
Slope	1/I	6,500
Flow Area	A (m2) =A0-A1-A2	100.286
Wetted Perimeter	P (m)	26.775
Hydraulic Radius	R=A/P (m)	3.746
Velocity	v (m/s)	1.994
Froude Number	$F=v/(gh)^{1/2}$	0.210
Cal. Discharge	Q=Av (m^3/s)	200.000
Inner Diameter	D (m)	12.5
Invert Width	b (m)	5.000
Invert Height	h1 (m)	0.52
Invert Area	A1 (m^2)	1.745
Water Depth	h (m)	9.166
Water Width	B (m)	10.4
Air Ratio	A2 (m^2)	20.688
Circular Area	A0 (m^2)	122.718
Air ratio	α=A2/A (%)	20.6
Afford Height	h2 (m)	2.814

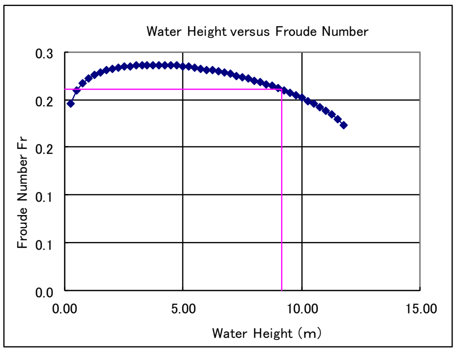
Pacific Spillway Tunnel

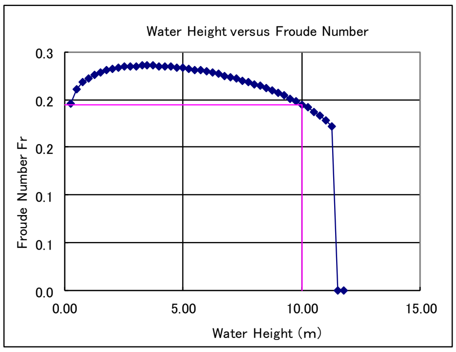
Open Channel Tunnel

Roughness Coe.	n	0.015
Slope	1/I	6,500
Flow Area	A (m2) =A0-A1-A2	103.626
Wetted Perimeter	P (m)	29.060
Hydraulic Radius	R=A/P (m)	3.566
Velocity	v (m/s)	1.930
Froude Number	$F=v/(gh)^{1/2}$	0.195
Cal. Discharge	Q=Av (m^3/s)	200.001
Inner Diameter	D (m)	12.0
Invert Width	b (m)	5.000
Invert Height	h1 (m)	0.55
Invert Area	A1 (m^2)	1.858
Water Depth	h (m)	10.019
Water Width	B (m)	7.8
Air Ratio	A2 (m^2)	7.614
Circular Area	A0 (m^2)	113.097
Air ratio	α=A2/A (%)	7.3
Afford Height	h2 (m)	1.431









(4) Alternative Subdivided Spillway Channels

The calculated water depths of the above Open Channel System of Pacific Spillway are more than 9m. Consequently, it is necessary to maintain a certain water depth at the Inlet and Outlet. Of course, it is technically possible but not desirable for Maintenance and Operation because frequent dredging operations are necessary to keep enough water depths at Inlet and Outlet. Therefore, alternative subdivided spillway channels, which are two and three-channel plans, are considered appropriately.

(i) Two-Subdivided Channel Plan of Open Channel System at Qd = 130 m^3/s (Qd' = 100 m^3/s)

Modified Invert Width	W = 4.0 m: Shrinkage width due to small inner diameter
Slope Gradient	I = 1/(20,000/(14.0-10.8-0.1)) = 1/6,452 = 1/6,500
Design Inner Diameter	D = 10.5 m (In the case of D'= 9.5 m)
Air Area Ratio	α = 17.2 % >15 % OK (α'=15.9 % OK)

Table 4.4.4 Hydraulic Condition of Two-Subdivided Channels at Qd=130m^3/s and 100m^3/s

Pacific Spillway Tunnel

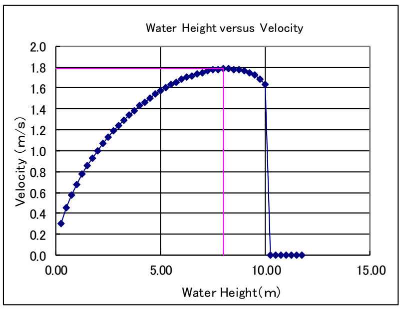
Open Channel Tunnel

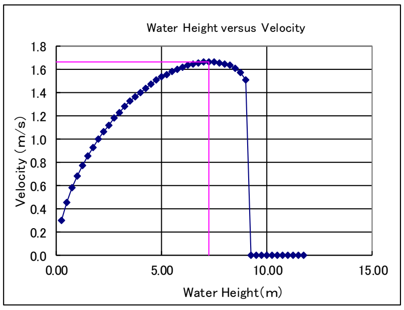
Roughness Coe.	n	0.015
Slope	1/I	6,500
Flow Area	A (m2) =A0-A1-A2	72.946
Wetted Perimeter	P (m)	23.055
Hydraulic Radius	R=A/P (m)	3.164
Velocity	v (m/s)	1.782
Froude Number	$F=v/(gh)^{1/2}$	0.202
Cal. Discharge	Q=Av (m^3/s)	130.000
Inner Diameter	D (m)	10.5
Invert Width	b (m)	4.000
Invert Height	h1 (m)	0.40
Invert Area	A1 (m^2)	1.080
Water Depth	h (m)	7.972
Water Width	B (m)	8.4
Air Ratio	A2 (m^2)	12.564
Circular Area	A0 (m^2)	86.590
Air ratio	α=A2/A (%)	17.2
Afford Height	h2 (m)	2.128

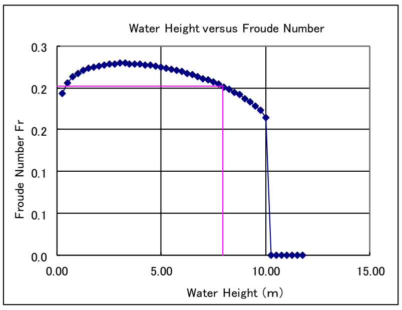
Pacific Spillway Tunnel

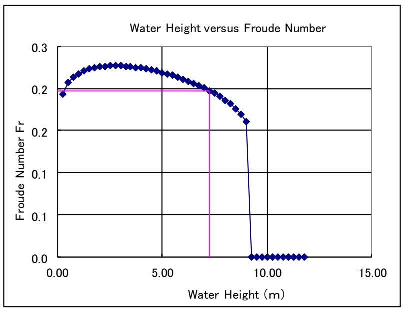
Open Channel Tunnel

Roughness Coe.	n	0.015
Slope	1/I	6,500
Flow Area	A (m2) =A0-A1-A2	60.143
Wetted Perimeter	P (m)	21.093
Hydraulic Radius	R=A/P (m)	2.851
Velocity	v (m/s)	1.663
Froude Number	$F=v/(gh)^{1/2}$	0.198
Cal. Discharge	Q=Av (m^3/s)	100.000
Inner Diameter	D (m)	9.5
Invert Width	b (m)	4.000
Invert Height	h1 (m)	0.44
Invert Area	A1 (m^2)	1.183
Water Depth	h (m)	7.231
Water Width	B (m)	7.5
Air Ratio	A2 (m^2)	9.556
Circular Area	A0 (m^2)	70.882
Air ratio	α=A2/A (%)	15.9
Afford Height	h2 (m)	1.829









(ii) 3-Subdivided Channel Plan of Open Channel System at Qd = 87 m^3/s (Qd' = 67 m^3/s)

Modified Invert Width	W = 4.0m
Slope Gradient	I = 1/(20,000/(14.0-10.8-0.1)) = 1/6,452 = 1/6,500
Design Inner Diameter	D = 9.5 m (In the case of D'= 8.5 m)
Air Area Ratio	α = 31.3 % > 15 % OK (α' = 26.2 % OK)

Table 4.4.5 Hydraulic Condition of Three-Subdivided Channels at Qd=87m^3/s and 67m^3/s

Pacific Spillway Tunnel

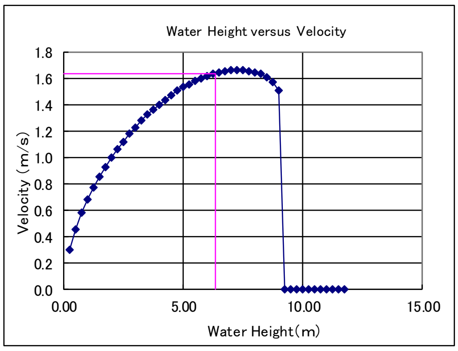
Open Channel Tunnel

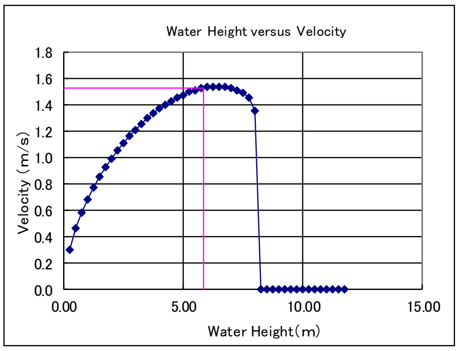
Roughness Coe.	n	0.015
Slope	1/I	6,500
Flow Area	A (m2) =A0-A1-A2	53.099
Wetted Perimeter	P (m)	19.038
Hydraulic Radius	R=A/P (m)	2.789
Velocity	v (m/s)	1.638
Froude Number	F=v/(gh) $^{1/2}$	0.208
Cal. Discharge	Q=Av (m^3/s)	87.000
Inner Diameter	D (m)	9.5
Invert Width	b (m)	4.000
Invert Height	h1 (m)	0.44
Invert Area	A1 (m^2)	1.183
Water Depth	h (m)	6.359
Water Width	B (m)	8.6
Air Ratio	A2 (m^2)	16.601
Circular Area	A0 (m^2)	70.882
Air ratio	α=A2/A (%)	31.3
Afford Height	h2 (m)	2.701

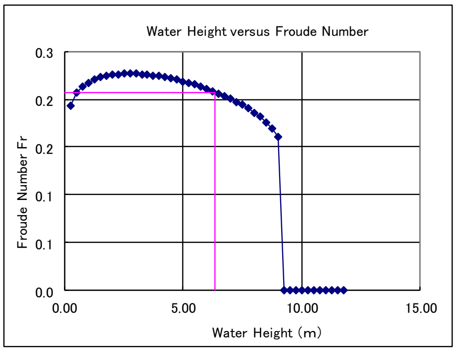
Pacific Spillway Tunnel

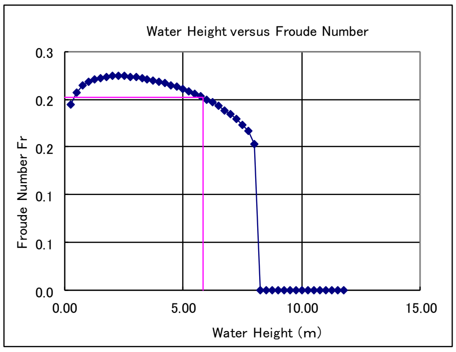
Open Channel Tunnel

Roughness Coe.	n	0.015
Slope	1/I	6,500
Flow Area	A (m2) =A0-A1-A2	43.908
Wetted Perimeter	P (m)	17.515
Hydraulic Radius	R=A/P (m)	2.507
Velocity	v (m/s)	1.526
Froude Number	F=v/(gh) $^{1/2}$	0.202
Cal. Discharge	Q=Av (m^3/s)	67.000
Inner Diameter	D (m)	8.5
Invert Width	b (m)	4.000
Invert Height	h1 (m)	0.50
Invert Area	A1 (m^2)	1.350
Water Depth	h (m)	5.822
Water Width	B (m)	7.4
Air Ratio	A2 (m^2)	11.488
Circular Area	A0 (m^2)	56.745
Air ratio	α=A2/A (%)	26.2
Afford Height	h2 (m)	2.178









Source: JICA Survey Team

(5) Alternative 6m Water Depth Plan of Box Culvert Plan of Open Channel System

In this section, 6m water depth plans of box culvert of Open Channel System are examined to consider that the adequate maximum water depth is "EL+14.0 m - EL+8.0 m = 6.0 m".

(i) One-Box Culvert Plan at Qd = 260m ^{3}/s (Qd' = 200 m^3/s)

Design Width x Height	22.0 m x 7.0 m (18.0 m x 7.0 m)
Slope Gradient	I = 1/(20,000/(14.0-10.8-0.1)) = 1/6,452 = 1/6,500
Air Area Ratio	α = 16.7 % >15 % OK (α'=16.7 % OK)

Table 4.4.6 Hydraulic Condition of One-Box Culvert Plans at Qd=260m^3/s and 260m^3/s

Design Discharge Qd=	260.00	m3/s		Design Discharge Qd=	200.00	m3/s	
<Input Data>				<Input Data>			
Bottom Width	B1=	22.000	(m)	Bottom Width	B1=	18.000	(m)
Water Depth	h=	6.00	(m)	Water Depth	h=	6.00	(m)
Slope (Left)	1:	0.00		Slope (Left)	1:	0.00	
Slope (Right)	1:	0.00		Slope (Right)	1:	0.00	
Gradient	I=	0.01538	(%)	Gradient	I=	0.01538	(%)
	= 1/	6,500			= 1/	6,500	
Roughness Coe.	n=	0.015		Roughness Coe.	n=	0.015	
<Output Data>				<Output Data>			
Water Width	B2=	22.000	(m)	Water Width	B2=	18.000	(m)
Flow Area	A=	132.000	(m2)	Flow Area	A=	108.000	(m2)
Wetted Perimeter	P=	34.000	(m)	Wetted Perimeter	P=	30.000	(m)
Hydraulic Radius	R=	A/P		Hydraulic Radius	R=	A/P	
	=	3.882	(m)		=	3.600	(m)
Velocity	V=	1/n*R^(2/3)*I^(1/2)		Velocity	V=	1/n*R^(2/3)*I^(1/2)	
	=	**2.042**	(m/s)		=	**1.942**	(m/s)
Cal. Discharge	Q=	**269.544**	(m3/s)	Cal. Discharge	Q=	**209.736**	(m3/s)
	≧	**260.000**	(m3/S) ---OK		≧	**200.000**	(m3/S) ---OK

(ii) 3-Box Culvert Plan at Qd = 87 m^3/s (Qd' = 67 m^3/s)

The 3-box culvert plan is studied as below because 1-box type is structurally difficult.

Design Width x Height	9.5 m x 7.0 m x 3 Culv. (9.5 m x 7.0 m x 3 Culv.)
Slope Gradient	I = 1/(20,000/(14.0-10.8-0.1)) = 1/6,452 = 1/6,500
Air Area Ratio	α = 16.7 % >15 % OK (α'=16.7 % OK)

Table 4.4.7 Hydraulic Condition of Three-Box Culvert Plans at Qd = 87 m^3/s and 67 m^3/s

Design Discharge Qd=	87.00	m3/s		Design Discharge Qd=	67.00	m3/s	
<Input Data>				<Input Data>			
Bottom Width	B1=	9.500	(m)	Bottom Width	B1=	8.000	(m)
Water Depth	h=	6.00	(m)	Water Depth	h=	6.00	(m)
Slope (Left)	1:	0.00		Slope (Left)	1:	0.00	
Slope (Right)	1:	0.00		Slope (Right)	1:	0.00	
Gradient	I=	0.01538	(%)	Gradient	I=	0.01538	(%)
	= 1/	6,500			= 1/	6,500	
Roughness Coe.	n=	0.015		Roughness Coe.	n=	0.015	
<Output Data>				<Output Data>			
Water Width	B2=	9.500	(m)	Water Width	B2=	8.000	(m)
Flow Area	A=	57.000	(m2)	Flow Area	A=	48.000	(m2)
Wetted Perimeter	P=	21.500	(m)	Wetted Perimeter	P=	20.000	(m)
Hydraulic Radius	R=	A/P		Hydraulic Radius	R=	A/P	
	=	2.651	(m)		=	2.400	(m)
Velocity	V=	1/n*R^(2/3)*I^(1/2)		Velocity	V=	1/n*R^(2/3)*I^(1/2)	
	=	**1.584**	(m/s)		=	**1.482**	(m/s)
Cal. Discharge	Q=	**90.288**	(m3/s)	Cal. Discharge	Q=	**71.136**	(m3/s)
	≧	**87.000**	(m3/S) ---OK		≧	**67.000**	(m3/S) ---OK

(6) Feasibility of Pacific Spillway

As to the feasibility of Pacific Spillway, its characteristics are compared with those of the Parañaque Spillway as follows:

- If the Pacific Spillway is the Pressure Pipe Type, its feasibility is lower than that of the Parañaque Spillway because of its more expensive cost since the length is double and the required cross section is 1.27 times (Inner Diameter 13.5 m).
- The most advantageous point of Pacific Spillway is that the "Open Channel Type" is possible theoretically. The Required Inner Diameter 14.0 m at Qd = 260 m^3/s for Open Channel Type (Inner Diameter 12.5 m at Qd = 200 m^3/s: no-consideration of increase planning discharge) is possible technically but not desirable. Since the required water depth is 9.95 m (9.17 m with no increase planning discharge), frequent dredging operations are necessary to keep enough depth and the Operation and Maintenance cost becomes expensive.
- If the adequate water depth is around 6m, the three-subdivided channel is required. This makes the feasibility lower because of the more expensive cost and longer length compared to the Parañaque Spillway.

In conclusion, the Pacific Spillway is theoretically possible, but its feasibility is lower than that of the Parañaque Spillway and it seems to be only an idea. Therefore, the Pacific Spillway will be considered only if the Parañaque Spillway is not possible for some reasons and the Economic Internal Rate of Return is much higher and enough.

4.5 Study on Lakeshore Dike

4.5.1 Concept of Lakeshore Dike

(1) Composition of Lakeshore Diking System

The structure consisting of lakeshore dike, drainage channel, pumping station, community road and bridge is called as a lakeshore diking system.

When constructing a dike along the lakeshore, it is necessary to treat the inland water. In general, the dike is crossed by a pipe which connects the inland to Laguna de Bay. However, when the water level of Laguna de Bay rises higher than the ground at the dike, the gate is closed to block the inflow from Laguna de Bay. At that time, the inland water is drained by drainage facilities. For drainage treatment, it is necessary to install a drainage channel, culverts and pumping station. Since the maintenance cost of a drainage facility is high, consideration should be given to the addition of a reservoir, if the drainage facility is necessary,

On the other hand, when a river flows in between dikes, it is necessary to install a dike for backwater influenced section. The river, as also explained in the following section, is necessary to be improved to have a sufficient flow capacity.

A maintenance road is set at the crest of the dike, while a road for the community is located on the inland side of the lakeshore dike. At the river, a bridge connecting the community road is installed.

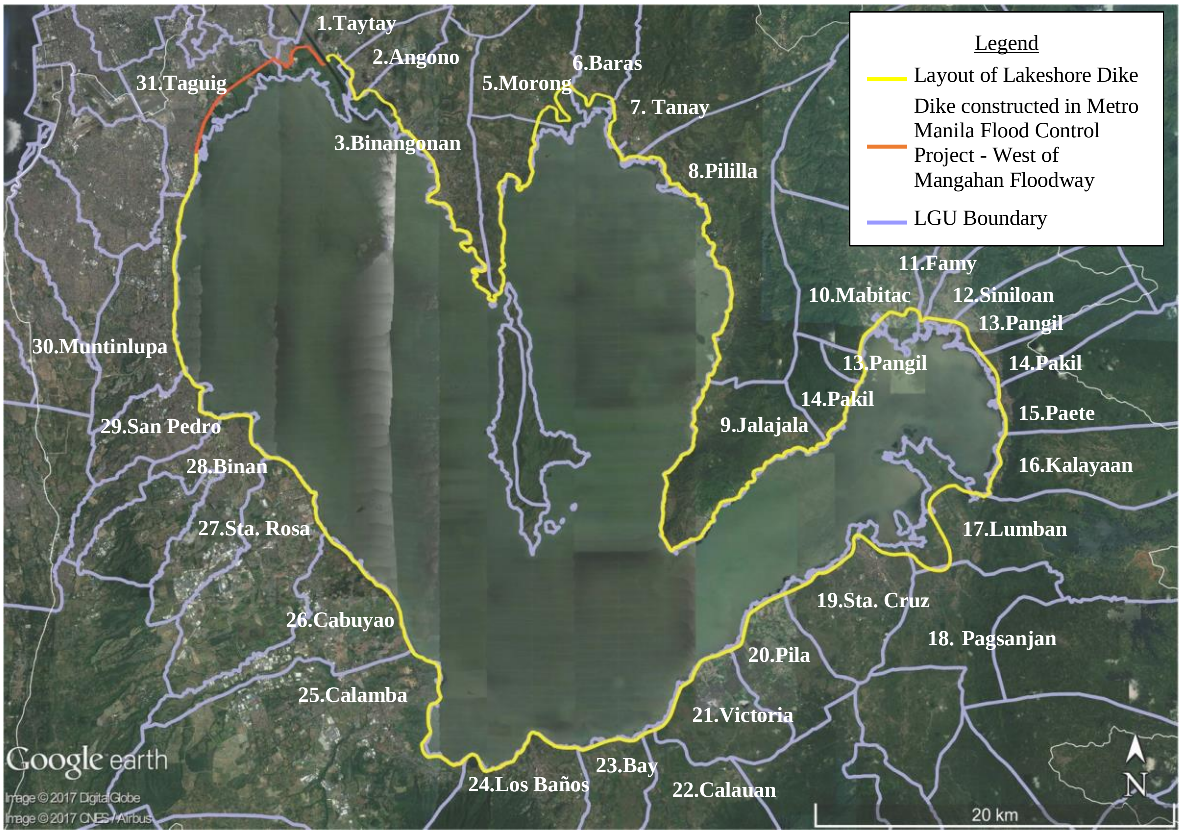
(2) Study on Priority Area

People live and have assets throughout the Laguna de Bay lakeshore area, about 220 km in length. However, some of the assets that may be damaged by flooding are different depending on the region. The lakeshore area varies with residential areas, areas where agricultural land is spreading, and areas where mountains are approaching. When planning the construction of only the lakeshore dike with the lakeshore stretch of about 200 km in all, the dike that can be constructed within the limited planning period are also limited. Therefore, the priority to dike construction is studied.

The method of selecting the priority area is examined separately for each of the 31 LGUs using the following indicators and taking into consideration the type of flooding and geographical classification:

- Topographical classification (Mountainous, Flats are wide to narrow)
- Land use (urban area and agricultural fishing village)
- Beneficiary population (flooded area between EL. 12.5 m and EL 13.5 m)
- Beneficiary population (flooded area between EL. 12.5 m and EL 14.3 m)
- Beneficiary area (flooded area between EL. 12.5 m and EL 14.3 m)

The layout plan of the lakeshore dike is proposed and the beneficiary population (calculated in two way based on the elevations) and beneficiary areas are calculated in 1 km each of the dike length. The locations of 31 LGUs and the proposed lakeshore dike are shown in Figure 4.5.1. The scoring of each LGU and index is shown in Table 4.5.1.



Source: Google Earth, Digital Globe, JICA Survey Team

Figure 4.5.1 Layout Plan of the Lakeshore Dike (Entire Area)

Table 4.5.1 Evaluation of Priority Area for the Lakeshore Diking System

No.	LGU	Length of Lakeshore Dike (km)	Topography	Land Use	Beneficiary EL 13.5 m or lower (persons/km)	Beneficiary EL 14.3 m or lower (persons/km)	Beneficial Area (km^2/km)	Total Score
I. Rizal								
1	Taytay	1.35	wide plain	urban area	18,909 (3)	37,634 (3)	1.62 (2)	8
2	Angono	3.31	wide plain	urban area	4,512 (3)	7,804 (2)	0.28 (1)	6
3	Binangonan	19.11	mountainous	urban area	952 (1)	1,949 (0)	0.08 (0)	1
4	Cardona	13.11	mountainous	agriculture, fishery area	173 (0)	396 (0)	0.08 (0)	0
5	Morong	5.67	plain	agriculture, fishery area	639 (1)	1,372 (0)	0.42 (1)	2
6	Baras	3.29	plain	agriculture, fishery area	762 (1)	1,785 (0)	0.33 (1)	2
7	Tanay	4.53	plain	agriculture, fishery area	1,893 (2)	3,295 (1)	0.36 (1)	4
8	Pililla	17.32	plain, mountainous	agriculture, fishery area	142 (0)	450 (0)	0.12 (0)	0
9	Jalajala	23.31	mountainous	agriculture, fishery area	149 (0)	306 (0)	0.03 (0)	0
	Sub Total	91.00			896 (1)	1,786 (0)	0.15 (0)	1
II. Laguna								
10	Mabitac	4.96	plain, mountainous	agriculture, fishery area	354 (0)	523 (0)	1.01 (1)	1
11	Famy	0.60	plain	agriculture, fishery area	967 (1)	2,702 (1)	2.05 (2)	4
12	Siniloan	1.59	plain	agriculture, fishery area	2,031 (2)	7,562 (2)	2.35 (2)	6
13	Pangil	4.26	plain	agriculture, fishery area	531 (1)	1,602 (0)	0.45 (1)	2
14	Pakil	6.30	narrow plain	agriculture, fishery area	136 (0)	302 (0)	0.11 (0)	0
15	Paete	2.73	narrow plain	agriculture, fishery area	767 (1)	1,050 (0)	0.27 (1)	2
16	Kalayaan	3.84	narrow plain	agriculture, fishery area	30 (0)	235 (0)	0.19 (0)	0
17	Lumban	8.90	plain	agriculture, fishery area	552 (1)	1,630 (0)	0.58 (1)	2
18	Pagsanjan	1.16	plain	urban area, agriculture, fishery area	593 (1)	1,505 (0)	0.91 (1)	2
19	Sta. Cruz	8.82	plain	urban area, provincial capital	2,614 (3)	4,174 (2)	0.78 (1)	6
20	Pila	4.75	plain	urban area, agriculture, fishery area	1,190 (2)	3,143 (1)	1.24 (1)	4
21	Victoria	6.47	plain	urban area, agriculture, fishery area	1,355 (2)	2,110 (1)	0.94 (1)	4
22	Calauan	0.84	plain	urban area, agriculture, fishery area	102 (0)	583 (0)	2.80 (2)	2
23	Bay	3.78	plain	urban area	1,931 (2)	3,426 (1)	0.90 (1)	4
24	Los Banos	8.24	plain	urban area	858 (1)	1,468 (0)	0.13 (0)	1
25	Calamba	9.92	plain	urban area	1,513 (2)	4,276 (2)	0.49 (1)	5
26	Cabuyao	8.39	plain	urban area	3,477 (3)	5,871 (2)	0.51 (1)	6
27	Sta. Rosa	5.78	plain	urban area	2,570 (3)	7,692 (2)	0.35 (1)	6
28	Binan	4.66	plain	urban area	10,286 (3)	16,267 (3)	0.53 (1)	7
29	San Pedro	4.08	plain	urban area	4,960 (2)	10,984 (3)	0.33 (1)	7
	Sub Total	100.07			1,955 (2)	3,924 (1)	0.61 (1)	4
III. Metro Manila								
30	Muntinlupa	9.87	narrow plain	urban area	2,388 (2)	6,015 (2)	0.24 (1)	5
31	Taguig	2.49	narrow plain	urban area	2,013 (2)	3,586 (1)	0.12 (0)	3
	Sub Total	12.36			2,312 (2)	5,526 (2)	0.21 (1)	5
Grand Total		203.43			1,503 (2)	3,065 (1)	0.38 (1)	4

*: The number in the parentheses are the scores.
3 points for 2,500 or more beneficiary population, 2 points for 1,000 or more and 1 point for 500 or more (beneficiary EL 13.5 m or lower),
3 points for 10,000 or more, 2 points for 4,000 or more and 1 point for 2,000 or more (beneficiary EL 14.3 m or lower),
3 points for 3.0 km^2/km or more beneficial area, 2 points for 2.0 km^2/km or more and 1 point for 1.0 km^2/km or more
Source: JICA Survey Team

Based on the above evaluation, priority areas are ranked as follows:

a) Taytay City (No. 1) and Angono (No. 2) located in the east side of Mangahan Floodway in Rizal Province next to Metro Manila has well-urbanized plain area and has a large damage amount. In addition, Taguig City (No. 31) and Muntinlupa City (No. 30) are also well-urbanized, has large amounts of houses which raises the damage amount high. Those are located at the south end of the lakeshore dike constructed in "the Metro Manila Flood Control Project - West of Mangahan" and the new lakeshore dikes are to be constructed from the dike. Hence, these 4 LGUs are considered to be "the first priority area".

b) San Pedro (No. 28), Biñan (No. 28), Santa Rosa (No. 27) located near Metro Manila ranked at the highest in the evaluation table. They are highly urbanized, the lakeshore area is also heavily populated, and the damage amount is large, so it makes them the "the second priority area".

c) Cabuyao (No. 25) and Calamba (No. 26) in the western part of the lakeshore, which are located near Metro Manila and located in Laguna Province where urbanization is progressing, shows the large damage amount with high scores. In addition, the demand for community roads constituting a part of the lakeshore diking system is also high and they are in "the third priority area".

d) As the capital of Laguna Province, the town of Sta. Cruz (No. 19), where residential, commercial and industrial areas have developed, and urban areas are spreading, are designated as "the fourth priority area".

e) LGUs (Pila, Victoria, Calauan, Bay and Los Baños, from No. 20 to No.24) between "d)" and "e)" are in "the fifth priority area"

f) Although Tanay (No. 7), Famy (No. 11) and Siniloan (No. 12) are basically the LGUs with agricultural and fishery lands, but those has a large inundation area. Hence, those are selected as the "6th priority area".

(3) Study on the combination of lakeshore diking system and non-structural measures

As a plan to prevent inundation damage on the lakeshore area, the concept of arrangement of the lakeshore diking system and warning system is as follows:

i. The 100-year probability water level (EL.14.30 m) of Laguna de Bay is targeted.

ii. It is impossible to place a lakeshore dike for the entire lakeshore area within the project period (assumed to be 30 years). For this reason, implementation schedule should be considered with priority ranking.

iii. There are some places with few assets where the economic effect of the lakeshore dike is small. Measures at such areas are handled with an alarm system.

iv. For example, when the plan period of 30 years is divided into 10 years at a single phase, consider the construction work volume of the lakeshore diking system from the high priority area and make the following implementation plan.

Table 4.5.2 Implementation Schedule of the Lakeshore Diking System

Item	Phase I (initial 10 years)	Phase II (middle 10 years)	Phase III (final 10 years)
Target Area	The 1st priority area (Taytay, Angono, Taguig and Muntinlupa)	The 2nd priority area (San Pedro, Binan, Santa Rosa) The 3rd priority area (Cabuyao, Calamba)	The 4th priority area (Sta. Cruz) The 5th priority area (Pila, Victoria, Calauan, Bay, Los Banos)
Lakeshore Dike Length (Total: 83km)	17 km*	33 km	33 km

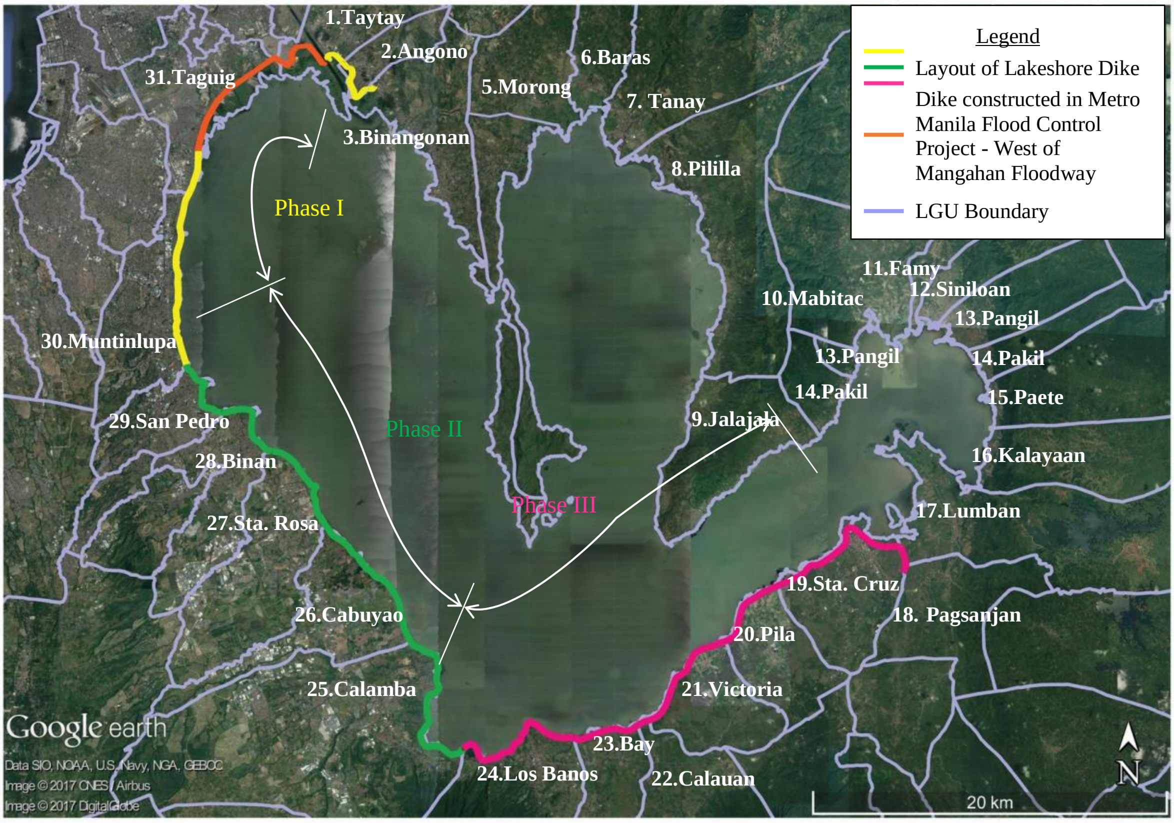
* The length of 17 km does not include the existing dike portion constructed for "Metro Manila Flood Control Project - West of Mangahan Floodway"
Source: JICA Survey Team

Table 4.5.3 Priority Area for Lakeshore Diking System

No.	LGU	Length of Lakeshore Dike (km)	Topography	Land Use	Beneficiary EL 13.5 m or lower (persons/km)	Beneficiary EL 14.3 m or lower (persons/km)	Beneficial Area (km^2/km)	Total Score
I. the First Priority Area								
2	Angono	3.31	wide plain	urban area	4,512 (3)	7,804 (2)	0.28 (1)	6
1	Taytay	1.35	wide plain		18,909 (3)	37,634 (3)	1.62 (2)	8
31	Taguig	2.49	narrow plain		2,013 (2)	3,586 (1)	0.12 (0)	3
30	Muntinlupa	9.87	narrow plain		2,388 (2)	6,015 (2)	0.24 (1)	5
	Sub Total	17.02			4,057 (3)	8,516 (2)	0.34 (1)	6
II. the Second and Third Priority Area								
29	San Pedro	4.08	plain	urban area	4,960 (3)	10,984 (3)	0.33 (1)	7
28	Binan	4.66	plain		10,286 (3)	16,267 (3)	0.53 (1)	7
27	Sta. Rosa	5.78	plain		2,570 (3)	7,692 (2)	0.35 (1)	6
26	Cabuyao	8.39	plain		3,477 (3)	5,871 (2)	0.51 (1)	6
25	Calamba	9.82	plain		1,513 (2)	4,276 (2)	0.49 (1)	5
	Sub Total	32.83			3,875 (3)	7,821 (2)	0.46 (1)	6
III. the Fourth and Fifth Priority Area								
24	Los Banos	8.24	plain	urban area	858 (1)	1,468 (0)	0.13 (0)	1
23	Bay	3.78	plain		1,931 (2)	3,426 (1)	0.90 (1)	4
22	Calauan	0.84	plain	urban area, agriculture, fishery area	102 (0)	583 (0)	2.80 (2)	2
21	Victoria	6.47	plain		1,355 (2)	2,110 (1)	0.94 (1)	4
20	Pila	4.75	plain		1,190 (2)	3,143 (1)	1.24 (1)	4
19	Sta. Cruz	8.82	plain	urban area, provincial capital	2,614 (3)	4,174 (2)	0.78 (1)	6
	Sub Total	32.90			1,578 (2)	2,764 (1)	0.78 (1)	4
Total for I. II. III		82.75			2,999 (3)	5,953 (2)	0.56 (1)	6
IV. the Sixth and Seventh Priority Area								
18	Pagsanjan	1.16	plain	urban area, agriculture, fishery area	593 (1)	1,505 (0)	0.91 (1)	2
17	Lumban	8.90	plain	agriculture, fishery area	552 (1)	1,630 (0)	0.58 (1)	2
16	Kalayaan	3.84	narrow plain		30 (0)	235 (0)	0.19 (0)	0
15	Paete	2.73	narrow plain		767 (1)	1,050 (0)	0.27 (1)	2
14	Pakil	6.30	narrow plain		136 (0)	302 (0)	0.11 (0)	0
13	Pangil	4.26	plain		531 (1)	1,602 (0)	0.45 (1)	2
12	Siniloan	1.59	plain		2,031 (2)	7,562 (2)	2.35 (2)	6
11	Famy	0.60	plain		967 (1)	2,702 (1)	2.05 (2)	4

No.	LGU	Length of Lakeshore Dike (km)	Topography	Land Use	Beneficiary EL 13.5 m or lower (persons/km)	Beneficiary EL 14.3 m or lower (persons/km)	Beneficial Area (km^2/km)	Total Score
10	Mabitac	4.96	plain, mountainous		354 (0)	523 (0)	1.01 (1)	1
9	Jalajala	23.31	mountainous		149 (0)	306 (0)	0.03 (0)	0
8	Pililla	17.32	plain, mountainous		142 (0)	450 (0)	0.12 (0)	0
7	Tanay	4.53	plain		1,893 (2)	3,295 (1)	0.36 (1)	4
6	Baras	3.29	plain		762 (1)	1,785 (0)	0.33 (1)	2
5	Morong	5.67	plain		639 (1)	1,372 (0)	0.42 (1)	2
4	Cardona	13.11	mountainous		173 (0)	396 (0)	0.08 (0)	0
3	Binangonan	19.11	mountainous	urban area	952 (1)	1,949 (0)	0.08 (0)	1
	Sub Total	120.68			477 (0)	1,085 (0)	0.25 (1)	1
Grand Total		203.43			1,503 (2)	3,065 (1)	0.38 (1)	4

*: The number in the parentheses are the scores. The criteria for scoring refers to Table 4.5.1.
Source: JICA Survey Team



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.5.2 Layout Plan of the Lakeshore Dike (Priority Area)

(4) Design Criteria

(a) Revetment Height

Revetment height is proposed to have the design flood level heightened with a freeboard referring to the Japanese and Philippine's national standards. The relation between the water level in Laguna de Bay and the surrounding dikes are as shown in Figure 4.5.3.

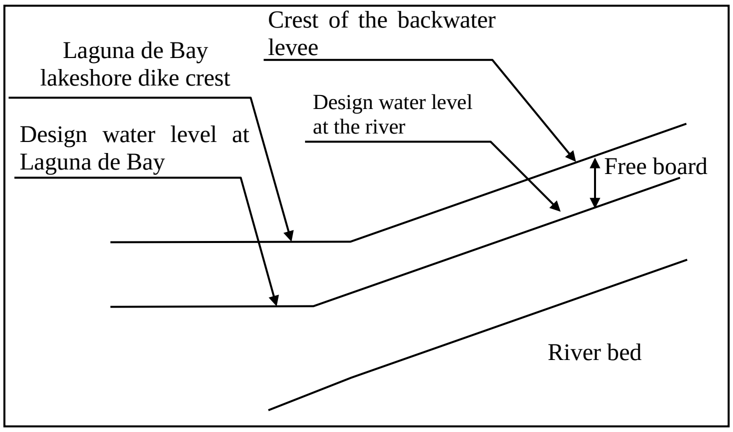


Figure 4.5.3 Water Level and Revetment Height Relation

(b) Freeboard

With reference to the Laguna de Bay Lakeshore dike installed in the "Metro Manila Flood Control Project - West of Mangahan Floodway", which has been used for 10 years as a flood countermeasure facility without any problem, the freeboard of the lakeshore dike is set at 1 m

The freeboard required for the river improvement is according to the flow rate as shown in Table 4.5.4. However, as shown in Figure 4.5.3, in the backwater influence section due to the design water level of Laguna de Bay, the height corresponding to the crest height of the lakeshore dike is required.

Table 4.5.4 Design Flood Discharge and Freeboard

Design Discharge (m^3/s)	Freeboard (m)
Less than 200	0.6
200 - 500	0.8
500 - 2 ,000	1.0
2,000 - 5,000	1.2

Source: DPWH Standard Guideline 2015, Manual for Government Ordinance for Structural Standard for River Administration Facilities

(c) Crest Width

The crest width of the lakeshore dike is set at 6.8 m, referring to the Laguna de Bay lakeshore dike constructed in the "Metro Manila Flood Control Project - West of Mangahan Floodway".

For river improvement works, the freeboard stipulated in the Japanese and Philippine National standards as shown in Table 4.5.5 is adopted.

Table 4.5.5 Crest Width

Design Flood Discharge (m^3/s)	Crest Width (m)	Adopted Width (m)
Less than 500	3	3
Equal or above 500 and less than 2,000	4	5
Equal or above 2,00 and less than 5,000	5	

Source: DPWH Standard Guideline 2015, Manual for Government Ordinance for Structural Standard for River Administration Facilities

(d) Slope

The slope of the lakeshore dike is the same as that of the Laguna de Bay lakeshore dike installed in the "Metro Manila Flood Control Project - West of Mangahan Floodway".

Since river improvement by widening the river channel is considered not easy in a developed area, the slope is set at 1:0.5 to minimize the area for land acquisition. On the other hand, channel widening for river improvement in an undeveloped area such as agricultural lands is considered to be easier, so that 1:3.0 slope is adopted to make slope stability higher and slope protection works inexpensive. In addition, when the slope is 1:0.5 and the revetment height exceeds 5 m, a berm 3 m in width is set in the middle of revetment.

4.5.2 Layout and Cross-Sectional Plan

(1) Layout plan of the Lakeshore Dike

In proposing the layout plan of the lakeshore dike, the basic concept is summarized as follows.

(i) Since land at EL 12.5 m and lower is basically considered to be the area of Laguna de Bay, except the special land (Prior land) where land ownership was given to the old resident who stayed there before the establishment of LLDA, it is considered that there is a little problem in land acquisition and that the compensation cost is relatively low.

(ii) Residential areas and commercial areas can be seen from the vicinity at EL. 12.0 m, and can be confirmed more from EL 12.5 m.

(iii) In the future, considering the case where a lakeshore dike is constructed around the entire Laguna de Bay, the area of the Laguna de Bay will decrease as the dike position moves towards the lake side, and it cause the rise of the Laguna de Bay lake water level during the flood. In addition, construction of the lakeshore dike at low elevation is less desirable as it may mislead the residents of the surrounding area to the boundary between the residential area and the lake.

(iv) Basically, EL 12.5 m has been set as the boundary of the lakeshore diking system. If developed areas such as residential and commercial areas are seen at that elevation, the lakeshore diking system should be placed at EL 12.0 m.

(v) The elevation of the crest of the lakeshore dike constructed in "Metro Manila Flood Control Project - West of Mangahan Floodway" is EL 15.0 m. If raising of the crest is within the freeboard required, a parapet is applied.

Table 4.5.6 Lakeshore Dike Length (with Laguna de Bay water level at EL. 14.3 m)

Place		Dike Length (m)	Foundation Elevation (EL.m)	Place		Dike Length (m)	Foundation Elevation (EL.m)
Province	LGU			Province	LGU		
Phase I							
Rizal	Angono	3,310	12.0	NCR	Taguig	2,490	12.0
Rizal	Taytay	1,350	12.0	NCR	Muntinlupa	9,870	12.0
NCR	Taguig Taytay	10,910	heightening of West Mangahan Lakeshore Dike				
Sub-total of Phase I						28,421	
Phase II							
Laguna	San Pedro	4,080	12.0	Laguna	Cabuyao	8,390	12.0
Laguna	Biñan	4,660	12.0	Laguna	Calamba	9,920	12.5
Laguna	Santa Rosa	5,780	12.0				
Sub-total of Phase II						32,830	
Phase III							
Laguna	Los Baños	8,240	12.0	Laguna	Victoria	6,470	12.0
Laguna	Bay	3,780	12.0	Laguna	Pila	4,750	12.5
Laguna	Calauan	840	12.0	Laguna	Santa Cruz	8,820	12.5
Sub-total of Phase III						32,900	
Sub-total of Priority Area						93,660	

Table 4.5.7 Lakeshore Dike Length (with Laguna de Bay water level at EL. 14.0 m)

Place		Dike Length (m)	Foundation Elevation (EL.m)	Place		Dike Length (m)	Foundation Elevation (EL.m)
Province	LGU			Province	LGU		
Phase I							
Rizal	Angono	3,310	12.0	NCR	Taguig	2,490	12.0
Rizal	Taytay	1,350	12.0	NCR	Muntinlupa	9,870	12.0
Sub-total of Phase I						17,020	
Phase II							
Laguna	San Pedro	4,080	12.0	Laguna	Cabuyao	8,390	12.0
Laguna	Biñan	4,660	12.0	Laguna	Calamba	9,920	12.5
Laguna	Santa Rosa	5,780	12.0				
Sub-total of Phase II						32,830	
Phase III							
Laguna	Los Baños	8,240	12.0	Laguna	Victoria	6,470	12.0
Laguna	Bay	3,780	12.0	Laguna	Pila	4,750	12.5
Laguna	Calauan	840	12.0	Laguna	Santa Cruz	8,820	12.5
Sub-total of Phase III						32,900	
Sub-total of Priority Area						82,750	

(2) Cross Section of the Lakeshore Dike

The lakeshore dike is basically based on the lakeshore dike constructed in "Metro Manila Flood Control Project - West of Mangahan Floodway" which has been well functioning as a flood control facility for ten years. However, structural changes are proposed in the following points.

(a) Asphalt pavement of community road

The community road of the lakeshore dike previously constructed was not designed to have a lot of traffic volume by general vehicles and did not consider the benefits generated by traffic. However, since the proposed lakeshore dike passes through areas that have already been developed, or connects those areas, a large amount of traffic volume by general vehicles is expected. Therefore, a durable pavement structure is desirable for community roads as a structure capable of withstanding heavy traffic volume. On the other hand, from the experience of the previously built lakeshore dike, pavement that can follow the deformation of the embankment shape is preferable, assuming inconsistent settlement of the embankment. Therefore, asphalt pavement is proposed.

(b) Omission of drainage embankment

The previously constructed lakeshore diking system had its embankment designed along the drainage channel because the foundation ground was low. Since the foundation ground for the new drainage embankment is assumed at between EL 12.0 m and EL 12.5 m, embankment along the drainage channel is omitted.

(c) Vegetation net

In recent years, DPWH has been recommending a vegetation net using recycled materials instead of sodding. This vegetation net is also described in detail in the DPWH Standard Specifications for Highways Bridges and Airports, 2013, which is common in the Philippines. Therefore, this type of vegetation net is proposed instead of the sodding works.

Figure 4.5.4 shows the standard cross section of the lakeshore dike, the community road, and the drainage channel of the lakeshore diking system reflecting the above update point.

(d) Standard Cross Section

The standard cross section of lakeshore dike is shown in Figure 4.5.4 and Figure 4.5.5.

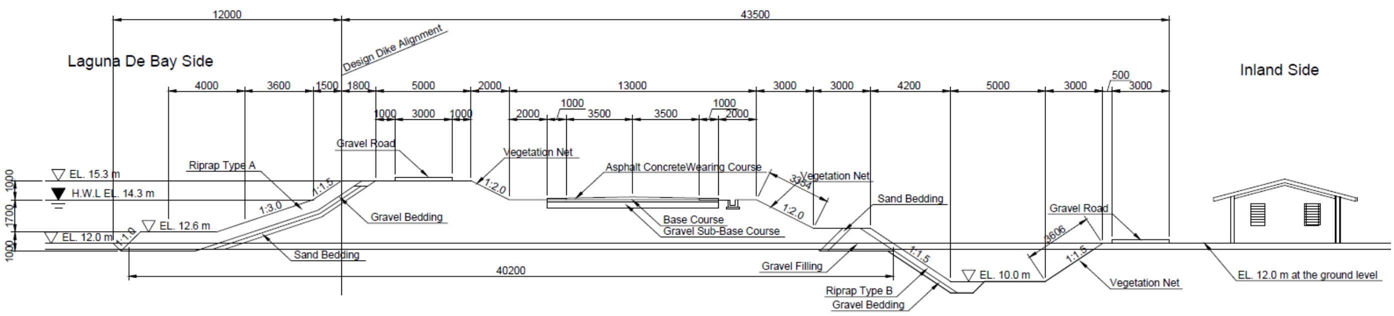


Figure 4.5.4 Standard Cross Section of Lakeshore Diking System (Design High Water Level 14.3 m)

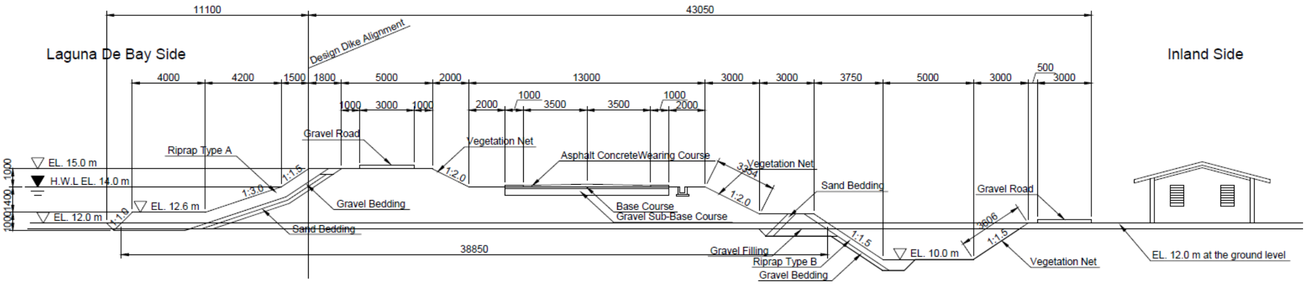


Figure 4.5.5 Standard Cross Section of Lakeshore Diking System (Design High Water Level 14.0 m)

(3) Pumping Station and Flood Gate

Pumping stations and floodgates are necessary to drain water from the inside of the bank surrounded by the lakeshore dike and the backwater levee described later. In the detailed design of the "Metro Manila Flood Control Project - West of Mangahan Floodway", pumping station has the target probability year of 5 years, and the depth of inundation is 0 m. For this proposed project, the contents of the detailed design are followed, and the drainage capacity required at the pumping stations is based on the water collection area ratio calculated.

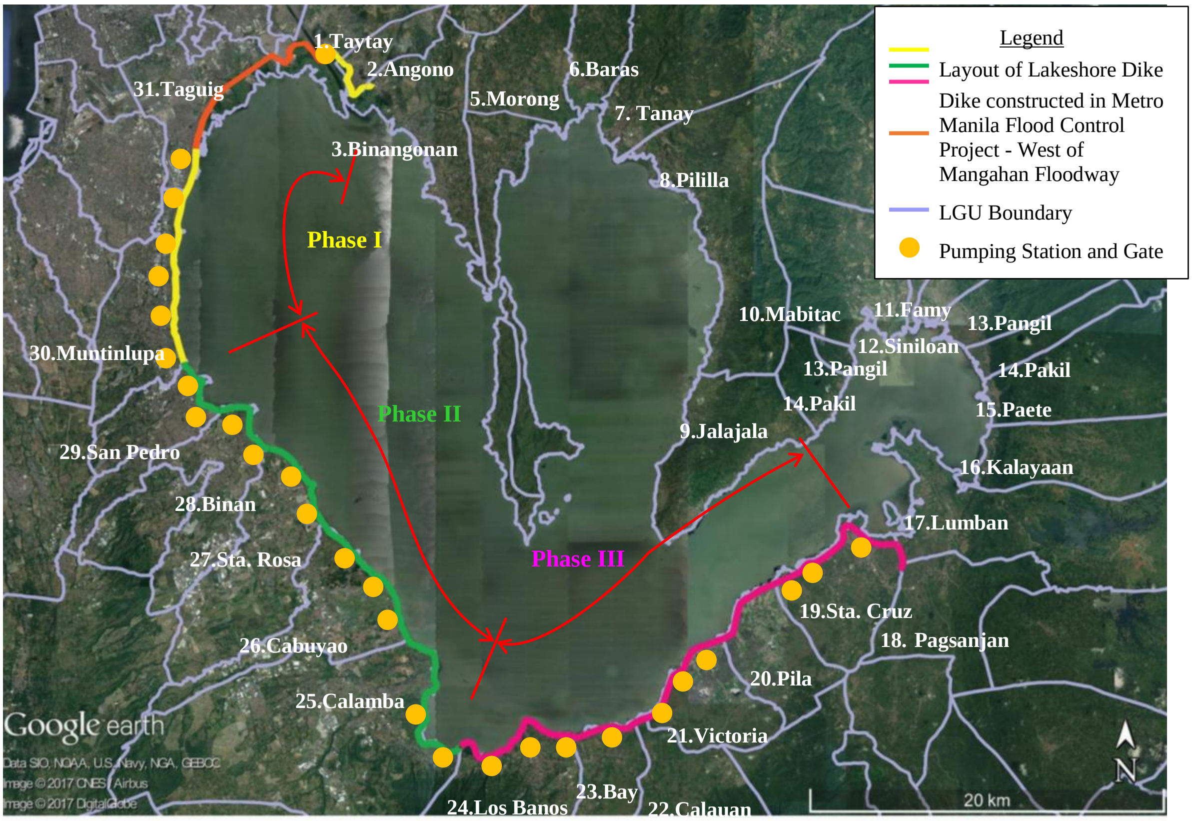
Table 4.5.8 and Table 4.5.9 describe the size of the pumping stations and the floodgates.

Table 4.5.8 Pumping Station and Flood Gate Size (1/2)

No	Basin			Catchment area (km^2)	Specific discharge 5-yr probability ($m^3/s/km^2$)	Peak discharge 5-yr probability (m^3/km^2)	Channel storage (m^3/s)	Required Pump Capacity w/o Regulation pond (m^3/s)
1	SB-23	Muntinlupa	SB23-RB1	1.7	8.4	14.3	7.1	7.1
2			SB23-RB2	2.3	8.4	19.3	9.7	9.7
3			SB23-RB3	2.7	8.4	22.7	11.3	11.3
4			SB23-RB4	1.0	8.4	8.4	4.2	4.2
5			SB23-RB5	0.5	8.4	4.1	2.1	2.1
6	SB-22	San Pedoro	SB22-RB1	0.9	5.6	5.0	2.5	2.5
7			SB22-RB2	3.4	5.6	19.0	9.5	9.5
8			SB22-RB3	2.4	5.6	13.2	6.6	6.6
9	SB-21	Binan	SB21-RB1	12.8	5.7	73.1	36.5	36.5
10			SB21-RB2	2.5	5.7	14.3	7.1	7.1
11	SB-20	Sta. Rosa	SB20-RB1	1.6	6.4	10.2	5.1	5.1
12			SB20-RB2	5.8	6.4	37.1	18.6	18.6
13			SB20-RB3	1.8	6.4	11.5	5.8	5.8
14			SB20-RB4	14.9	6.4	95.4	47.7	47.7
15	SB-19	San Cristobal	SB19-RB1	11.3	6.4	72.3	36.2	36.2
16	SB-18	San Juan	SB18-RB1	5.7	6.9	39.3	19.7	19.7
17	SB-17	Los Banos	SB17-RB1	3.3	10.7	35.1	17.5	17.5
18			SB17-RB2	2.0	10.7	21.6	10.8	10.8
19			SB17-RB3	5.8	10.7	62.2	31.1	31.1
20			SB17-RB4	0.6	10.7	6.2	3.1	3.1
21	SB-16	Calauan	SB16-RB1	0.7	7.0	4.9	2.5	2.5
22			SB16-RB2	0.6	7.0	4.1	2.0	2.0
23	SB-15	Pila	SB15-RB1	1.7	6.9	11.7	5.8	5.8
24			SB15-RB2	8.8	6.9	60.7	30.3	30.3
25			SB15-RB3	14.1	6.9	97.5	48.7	48.7
26	SB-14	Sta. Cruz	SB14-RB1	11.8	5.8	68.4	34.2	34.2
27			SB14-RB2	1.4	5.8	8.1	4.1	4.1
28	SB-02	Taytay	SB02-RB1	2.0	8.6	17.2	8.6	8.6
Total				124.0	206.8	856.9	428.4	428.4

Table 4.5.9 Pumping Station and Flood Gate Size (2/2)

No	Basin			Regulation Pond			Required Pump Capacity w/ Regulation pond (m^3/s)	Gate (W5m x H4m) (unit)
				Area (ha)	Depth (m)	Volume (m^3)		
1	SB-23	Muntinlupa	SB23-RB1	0.9	2.0	17,000	5.0	1
2			SB23-RB2	1.2	2.0	23,000	7.0	1
3			SB23-RB3	1.4	2.0	27,000	9.0	2
4			SB23-RB4	0.5	2.0	10,000	3.0	1
5			SB23-RB5	0.2	2.0	4,900	2.0	1
6	SB-22	San Pedoro	SB22-RB1	0.5	2.0	9,000	2.0	1
7			SB22-RB2	1.7	2.0	34,000	7.0	1
8			SB22-RB3	1.2	2.0	23,500	5.0	1
9	SB-21	Binan	SB21-RB1	6.4	2.0	128,200	27.0	4
10			SB21-RB2	1.3	2.0	25,000	5.0	1
11	SB-20	Sta. Rosa	SB20-RB1	0.8	2.0	16,000	4.0	1
12			SB20-RB2	2.9	2.0	58,000	14.0	2
13			SB20-RB3	0.9	2.0	18,000	4.0	1
14			SB20-RB4	7.5	2.0	149,000	36.0	5
15	SB-19	San Cristobal	SB19-RB1	5.7	2.0	113,000	27.0	4
16	SB-18	San Juan	SB18-RB1	2.9	2.0	57,000	15.0	2
17	SB-17	Los Banos	SB17-RB1	1.6	2.0	32,800	13.0	2
18			SB17-RB2	1.0	2.0	20,200	8.0	2
19			SB17-RB3	2.9	2.0	58,100	23.0	4
20			SB17-RB4	0.3	2.0	5,800	2.0	1
21	SB-16	Calauan	SB16-RB1	0.4	2.0	7,000	2.0	1
22			SB16-RB2	0.3	2.0	5,800	2.0	1
23	SB-15	Pila	SB15-RB1	0.8	2.0	16,900	4.0	1
24			SB15-RB2	4.4	2.0	87,900	23.0	4
25			SB15-RB3	7.1	2.0	141,300	37.0	5
26	SB-14	Sta. Cruz	SB14-RB1	5.9	2.0	118,000	26.0	4
27			SB14-RB2	0.7	2.0	14,000	3.0	1
28	SB-02	Taytay	SB02-RB1	1.0	2.0	20,000	6.0	1
Total				62.0		1,240,400	321.0	56



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.5.6 Location of Pumping Station and Gate along for the Lakeshore Diking System

(4) Bridges

Lastly, a bridge is described here as the component of the lakeshore diking system. Community roads designed in parallel with the lakeshore dikes are required to be connected over rivers to ensure traffic flow, hence a bridge is proposed. The width of the bridge is the same as the community road, single lane (3.5 m) on one side, 7 m in both directions, and 1 m sidewalk on both sides.

Major quantities for the construction of the bridges for lakeshore dike are as summarized in Table 4.5.10.

Table 4.5.10 Bridge Quantity for Lakeshore Dike

Item	Unit	Phase in Priority Area			
		Phase I	Phase II	Phase III	Total
Number of bridge	(nos)	8	12	10	30
Bridge area (3.5m x 2 for car and 1m x 2 for pedestrian)	(m^2)	938	3,355	3,277	7,570

4.5.3 Study on Backwater Levee

Based on the design lake water level in Laguna de Bay, cross section and length of backwater levee are proposed. As the preparation for a comprehensive flood management plan of the entire Laguna de Bay lakeshore area (the second draft), the following is the Laguna de Bay design water level condition in response to the case of “with” or “without” Parañaque Spillway.

Parañaque Spillway	Design High Water Level of Laguna de Bay	Description
without	EL.14.3m	Water level equivalent to 100-year probability
with	EL.14.0m	From the water level equivalent to 100-year probability, the design high water level was calculated from the analysis in consideration of Parañaque spillway

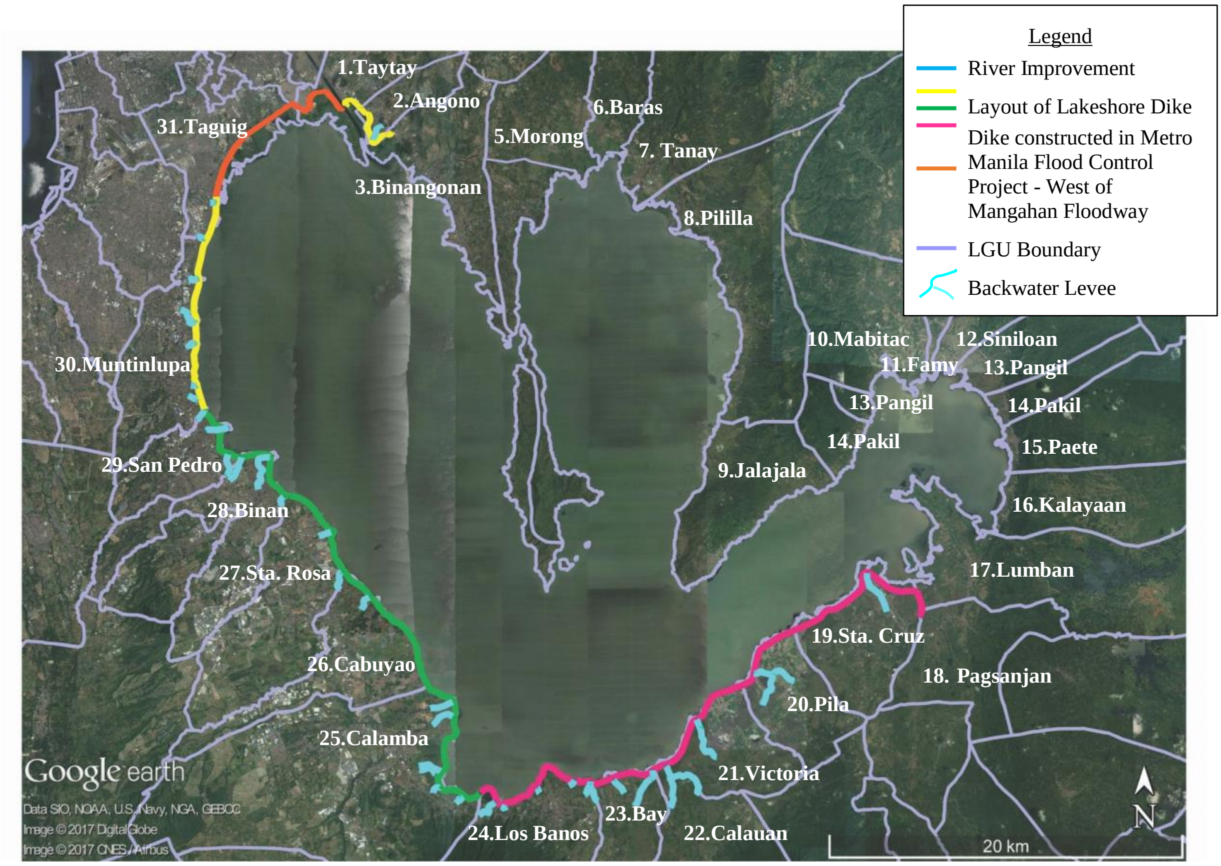
Channels with a catchment area of 10 km^2 or more are referred to as “rivers” and those with less than 10 km^2 are “drainages”. However, based on the scale of the design discharge, some called as “drainage” are also targeted for backwater lebee in terms of structural measures.

(1) Layout, Longitudinal and Cross-Sectional Plan

Based on the design high water level, backwater levees for major rivers are proposed.

At the upstream end of the improvement area where dredging is assumed to be not basically performed, the design water level is set at 1m above the existing ground level or lower, and the cross section is assumed so that the land acquisition width becomes as narrow as possible. In addition, the land acquisition area in each river is estimated by averaging the land acquisition width of the cross sections at the upstream end and at the downstream end, then multiplied by the length of backwater levee.

The layout of the backwater levee is shown in Figure 4.5.7, and the summary of levee is shown in Table 4.5.11 and Table 4.5.12. The standard cross sections are shown in Figure 4.5.8. Along with the backwater levee, it is necessary to renovate existing bridges, construct new bridges, and convert railroads into iron bridges. Their quantities are as shown in Table 4.5.13.



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

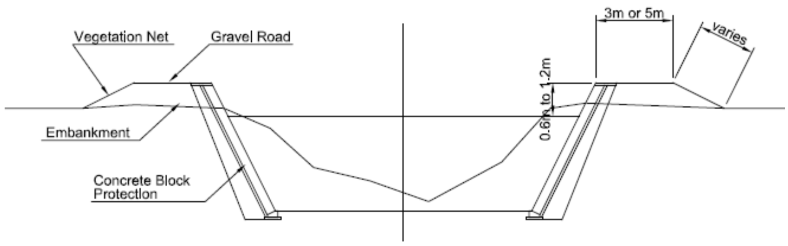
Figure 4.5.7 Layout of Backwater Levee
(with Design High Water Level of 14.3 m and 14.0 m in Laguna de Bay)

Table 4.5.11 Summary of Backwater Levee
(with Design High Water Level of 14.3 m in Laguna de Bay)

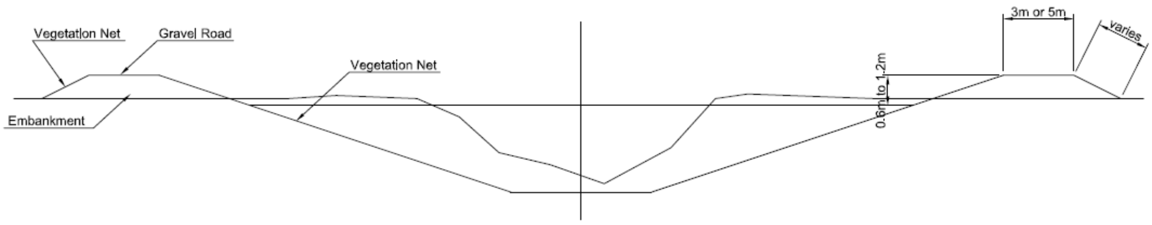
LGU	River Name	Return Period (yr)	Design Flood (m^3/s)	Dike Length (m)	LGU	River Name	Return Period (yr)	Design Flood (m^3/s)	Dike Length (m)
Phase I									
Angono	Angono	25	190	1,220	Muntinlupa	Poblacion	15	80	450
Taguig	SB-23-7	15	30	440		Magdaong	15	60	680
Muntinlupa	Alabang	25	170	1,680		SB-23-5	15	50	900
	Bayanan	15	60	740		SB-23-6	15	10	570
Sub-total of Phase I									6,680
Phase II									
San Pedro	San Isidro	25	290	1,390	Sta. Rosa	SB-20-3	25	170	1,060
	Tunasan	15	60	840	Calamba	San Juan	50	2,400	1,550
Binan	SB-20-4	25	160	820		San Cristobal	50	1,600	1,500
	Binan	50	700	2,940		SB-17-6	15	50	760
Sta. Rosa	Sta. Rosa	50	520	860		SB-17-7	15	130	800
	SB-20-2	25	200	1,290		SB-17-8	25	200	1,460
Sub-total of Phase II									15,270
Phase III									
Los Baños	Los Baños	25	430	2,150	Calauan	Calauan	50	800	2,020
	SB-17-3	15	50	500		SB-16-2	50	700	5,320
	SB-17-4	15	90	480	Victoria	Pila	25	380	2,460
	SB-17-5	25	210	1,600	Pila	SB-15-2	25	380	4,840
Bay	Colo	25	300	1,120	Sta. Cruz	Sta. Cruz	50	1,300	2,700
Sub-total of Phase III									23,190
Grand Total									45,140

Table 4.5.12 Summary of Backwater Levee (with Design High Water Level of 14.0 m in Laguna de Bay)

LGU	River Name	Return Period (yr)	Design Flood (m^3/s)	Dike Length (m)	LGU	River Name	Return Period (yr)	Design Flood (m^3/s)	Dike Length (m)
Phase I									
Angono	Angono	25	190	1,170	Muntinlupa	Poblacion	15	80	400
Taguig	SB-23-7	15	30	390		Magdaong	15	60	630
Muntinlupa	Alabang	25	170	1,630		SB-23-5	15	50	850
	Bayanan	15	60	690		SB-23-6	15	10	520
Sub-total of Phase I									6,280
Phase II									
San Pedro	San Isidro	25	290	1,340	Sta. Rosa	SB-20-3	25	170	1,010
	Tunasan	15	60	790	Calamba	San Juan	50	2,400	1,500
Binan	SB-20-4	25	160	770		San Cristobal	50	1,600	1,450
	Binan	50	700	2,890		SB-17-6	15	50	710
Sta. Rosa	Sta. Rosa	50	520	810		SB-17-7	15	130	750
	SB-20-2	25	200	1,240		SB-17-8	25	200	1,410
Sub-total of Phase II									14,670
Phase III									
Los Baños	Los Baños	25	430	2,100	Calauan	Calauan	50	800	1,970
	SB-17-3	15	50	450		SB-16-2	50	700	5,270
	SB-17-4	15	90	430	Victoria	Pila	25	380	2,410
	SB-17-5	25	210	1,550	Pila	SB-15-2	25	380	4,790
Bay	Colo	25	300	1,070	Sta. Cruz	Sta. Cruz	50	1,300	2,650
Sub-total of Phase III									22,690
Grand Total									43,640



(a) Cross Section at Development Area



(b) Cross Section at Agricultural Area

Figure 4.5.8 Standard Cross Section of Backwater Levee

Table 4.5.13 Other Quantity along with Backwater Levee

Item	Unit	Phase in Priority Area			
		Phase I	Phase II	Phase III	Total
Number of bridge	(nos)	10	10	14	34
Bridge area (3.5m x 2 for car and 1m x 2 for pedestrian)	(m^2)	1,226	2,807	5,168	9,201
Iron bridge for rail road	(nos)	2	0	0	2

4.6 Study on Flood Countermeasure in Laguna de Bay Basin

The external force targeted for flood control is "Overflow Inundation". Conditions for the Runoff-Inundation Analysis Model of the Laguna de Bay Basin are summarized in the table below.

Table 4.6.1 Conditions for Runoff-Inundation Analysis Model

Item	Setting Value	Contents
Precipitation	Basin Mean Rainfall (BMR)	Probability Basin Mean Rainfall (BMR) is given to each river basin.
Downstream Boundary	Lake water level ＝14.0m	If Parañaque Spillway is to be constructed, lake water level will decrease from 14.3m to 14.0m. Therefore, the downstream boundary is set at 14.0m.
Probability	50-year 25-year 15-year	Many small rivers exist in each river basin. Probability is studied because the design scale depends on the area of each river basin.

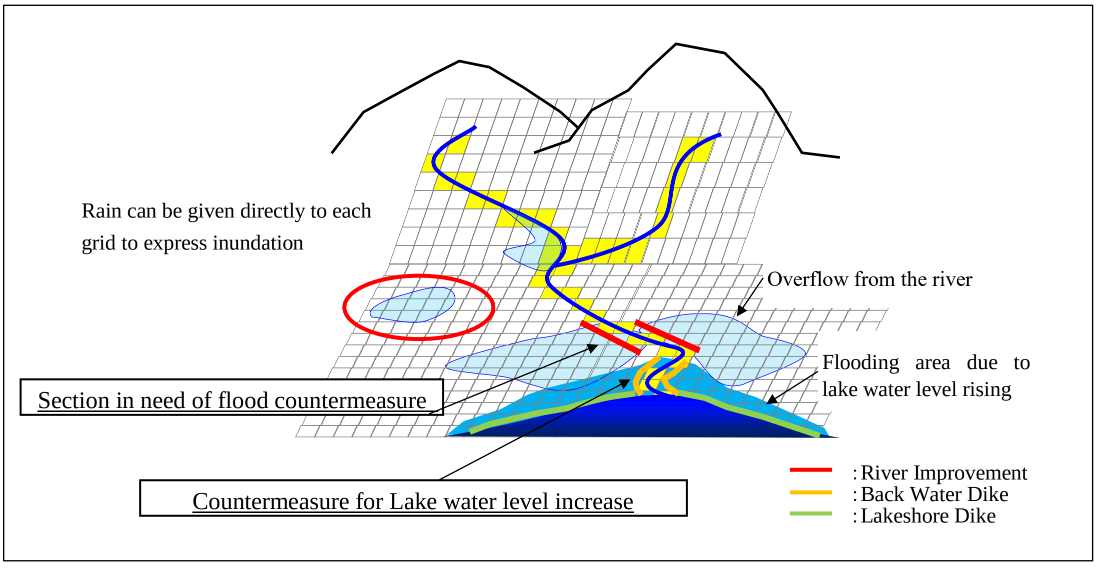


Figure 4.6.1 Concept of Flood Countermeasures for Laguna de Bay Basin

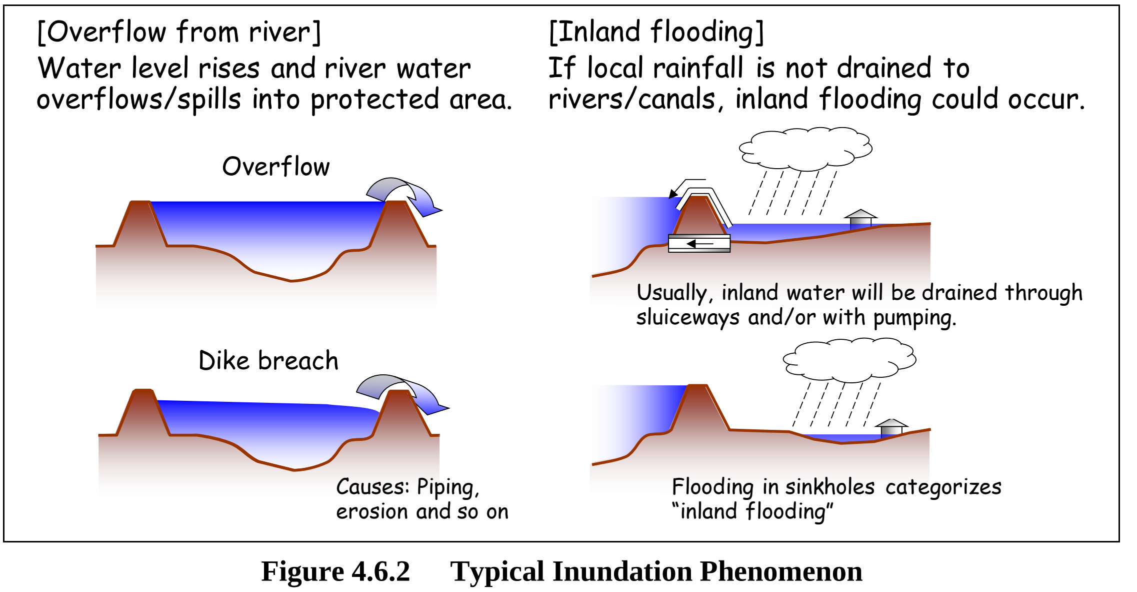


Figure 4.6.2 Typical Inundation Phenomenon

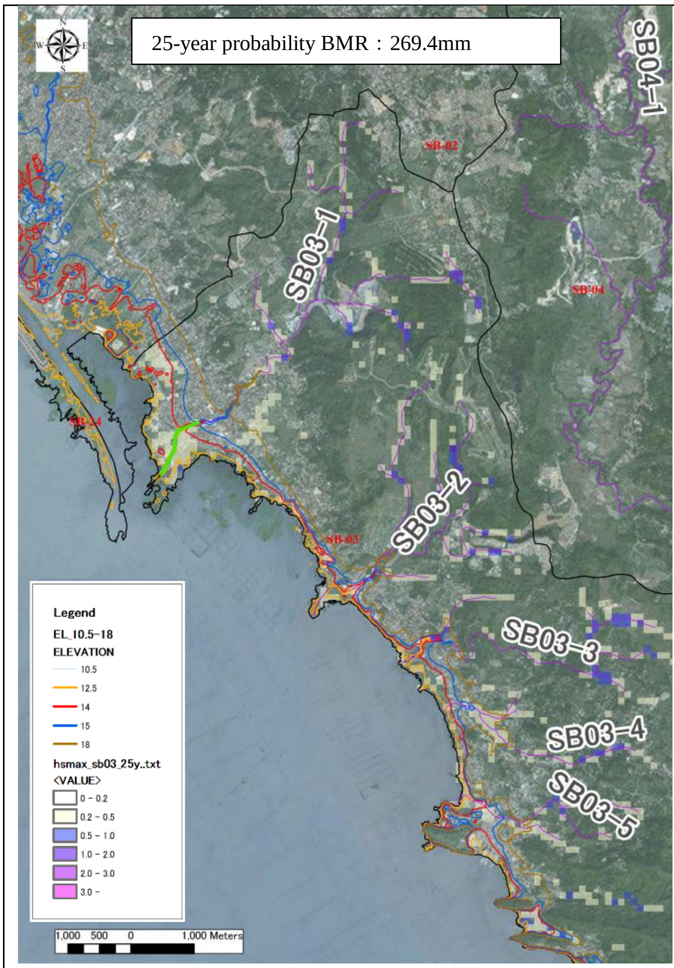
4.6.1 Result of Inundation Analysis for Laguna de Bay Basin

(1) Angono Basin (SB-03)

The total area of Angono Basin is 86.6 km^2, and some rivers exist. The results of inundation analysis of Angono River, which is a major river with the design scale of 25-year, are shown in Figure 4.6.3. Inundation areas as the result of inundation analysis of flood (river water) countermeasures are as follows.

Table 4.6.2 Outline of Angono Basin (SB-03)

River ID	River Name	Basin Area (km^2)	River Length (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	Assumed River Improvement (km)
SB-03-1	Angono	12.7	8.18	25	190	—
SB-03-2	unknown	9.9	5.66	15	130	—
SB-03-3	unknown	6.7	4.71	15	90	—
SB-03-4	unknown	4.0	3.92	15	60	—
SB-03-5	unknown	3.4	2.98	15	50	—
Sub-total		36.7				
Total Basin (Remaining Basin)		86.6 (49.9)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.3 Inundation Area of 25-Year Probability (SB-03, Angono)

＜Basin Mean Rainfall (BMR)＞

- 25-year: 269.4 mm
- 15-year: 234.9 mm

＜Flood Prone Area＞

- Flood prone area is assumed to be the coastal area of Laguna de Bay at altitude 15 m or less.

＜Assumed Flood Countermeasure＞

SB-03-1

- Lakeshore dike is proposed in this area and backwater levee is to be constructed at elevation 15.0m.
- Flood countermeasure for overflow flooding: None in particular

SB-03-2～SB-03-5

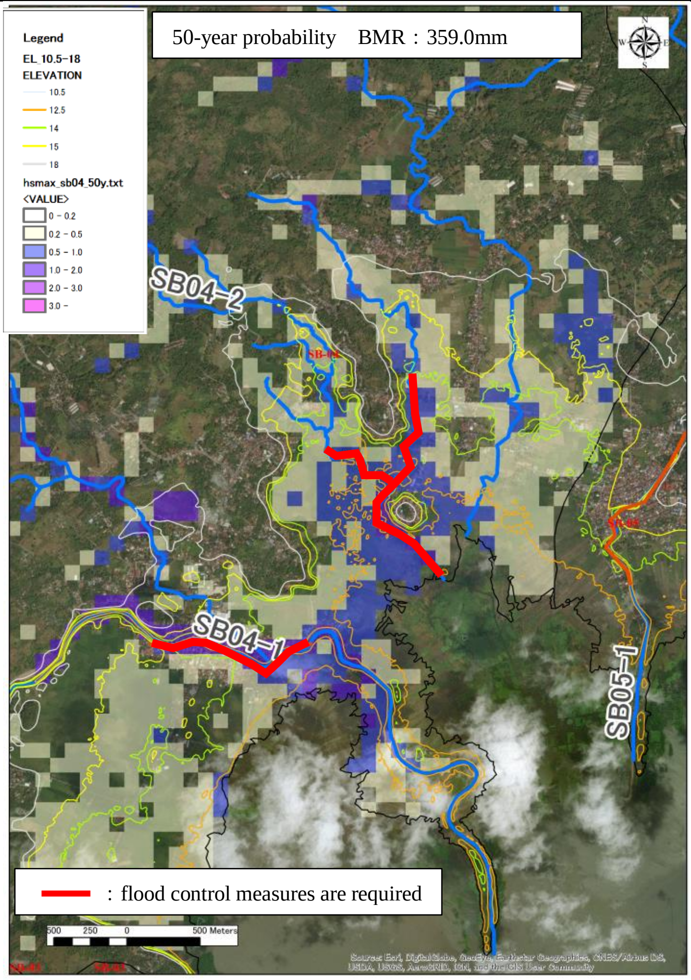
- None in particular

(2) Morong Basin (SB-04)

The total area of Morong Basin is 95.9km^2, and some rivers exist. The results of inundation analysis of Morong River, which is a major river with the design scale of 50-year, are shown in Figure 4.6.4. Inundation areas as the result of inundation analysis of flood (river water) countermeasures are as follows.

Table 4.6.3 Outline of Morong Basin (SB-04)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-04-1	Morong	67.0	29.16	50	1,100	1.0
SB-04-2	unknown	22.5	8.15	25	300	2.5
Sub-total		89.5				
Total for Basin (Remaining Basin)		95.9 (6.4)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.4 Inundation Area of 50-year (SB-04, Morong)

＜Basin Mean Rainfall :BMR＞

- 50-year:359.0mm
- 25-year:318.2mm

＜Flood Prone Area＞

- The assumed flood prone area is the coastal area of Laguna Lake at altitude 15m or less.
- Since the altitude is as low as 15m or less in a wide range, flooding is assumed due to rise of Laguna lake level and rainfall into the basin near the residential area.

＜Assumed Flood Countermeasure＞

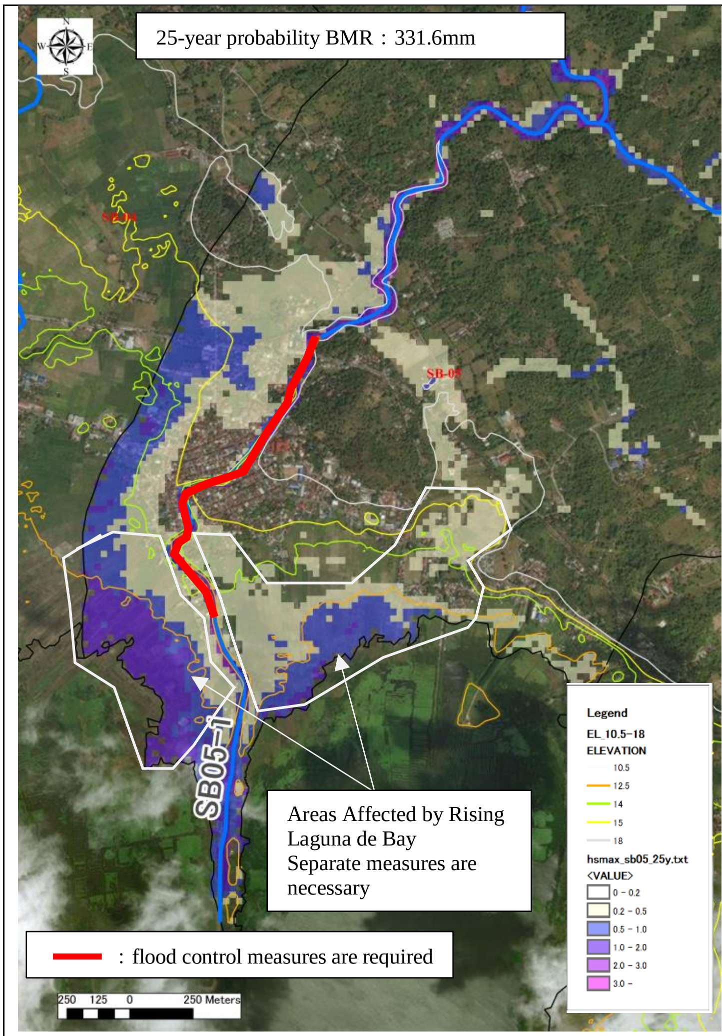
- <u>SB-04-1, aSB-04-2</u>
- Lowlands of 14.0 m or less spread widely; it is necessary to consider countermeasures against rising lake-water level as well as flood.
- River Improvement (River widening, Excavation)
- Dike
- Land raising of residential area
- Polder
- Countermeasure for the influence of lake water level rising.

(3) Baras Basin (SB-05)

The total area of Baras Basin is 21.7km^2 and some rivers exist. The results of inundation analysis for Baras River, which is a major river with the design scale of 25-year, are shown in Figure 4.6.5. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.4 Outline of Baras Basin (SB-05)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-05-1	Baras River	17.6	13.01	25	310	1.50
Sub-total		17.6				
Total for Basin (Remaining Basin)		21.7 (4.1)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.5 Inundation Area of 25-year (SB-05, Baras)

＜Basin Mean Rainfall (BMR)＞

- 25-year: 331.6 mm
- 15-year: 294.5 mm

＜Flood Prone Area＞

- The assumed Flood prone area is the coastal area of Laguna de Bay with altitudes of 15 m or less.
- Most residential areas are located at 14m or more, but inundation is assumed in a part along the river.
- This is supposed to be caused by the rise of lake level and rainfall falling into the basin.

＜Assumed Flood Countermeasure＞

<u>SB-05-1</u>

- River Improvement (River widening, Excavation)
- Dike

＜Measures for raising lake level＞

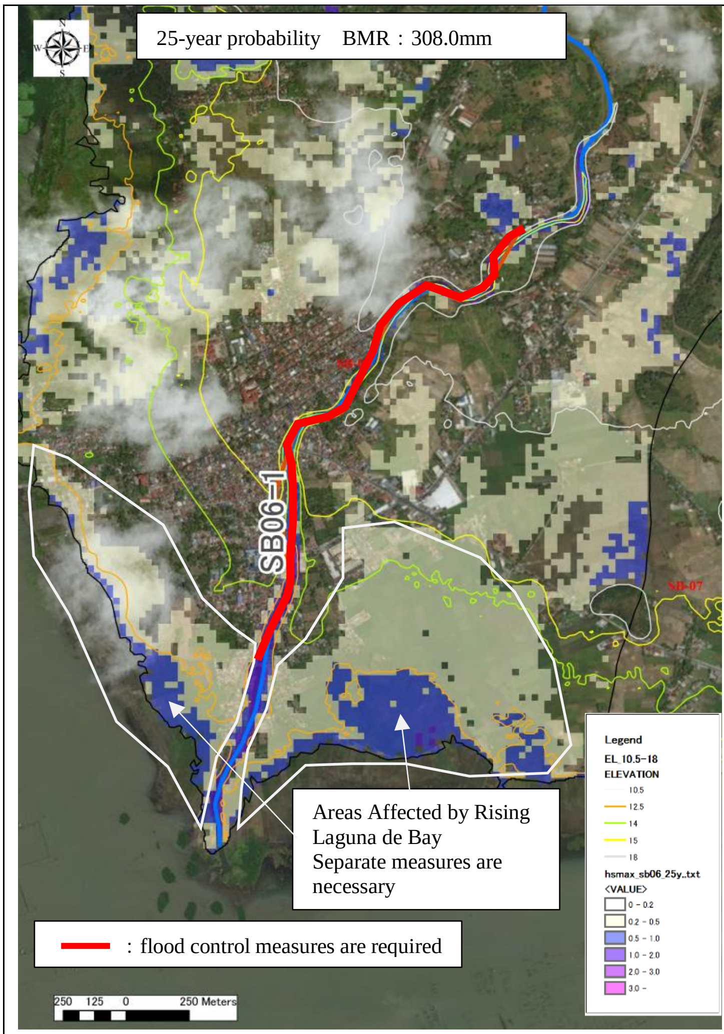
- Low lowlands of 14 m or less widely spread and it can be confirmed that residential areas are distributed.
- With the rise of Lake water level, it is considered that individual measures such as raising and relocating the residents are required in affected areas (14 m or less).

(4) Tanay Basin (SB-06)

The total area of Tanay Basin is 52.2km^2 and some rivers exist. The results of inundation analysis of Tanay River, which is a major river with the design scale 25-year, are shown in Figure 4.6.6. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.5 Outline of Tanay Basin (SB-06)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-06-1	Tanay River	39.3	20.7	25	580	2.3
Sub-total		39.3				
Total Basin Total Basin (Remaining Basin)		52.2 (12.9)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.6 Inundation Area of 25-year (SB-06, Tanay)

＜Basin Mean Rainfall (BMR)＞

- 25-year:308.0mm
- 15-year:272.8mm

＜Flood Prone Area＞

- The assumed Flood prone area is the coastal area of Laguna de Bay at altitude 15m or less.
- Due to the rise of lake level and the rainfall falling into the catchment area, flooding is assumed in lowlands of less than 15 m.
- Also, flood prone area is assumed along the river (Red line). This may be due to flooding from river.

＜Assumed Flood Countermeasure＞

SB-06-1

- River Improvement
  (River widening, Excavation)
- Dike

＜Measures for raising lake level＞

- Low lowlands of 14m or less widely spread, and residential areas are distributed.
- With the rise of lake water level, individual measures such as raising and relocation of residents are required in affected areas (14 m or less).

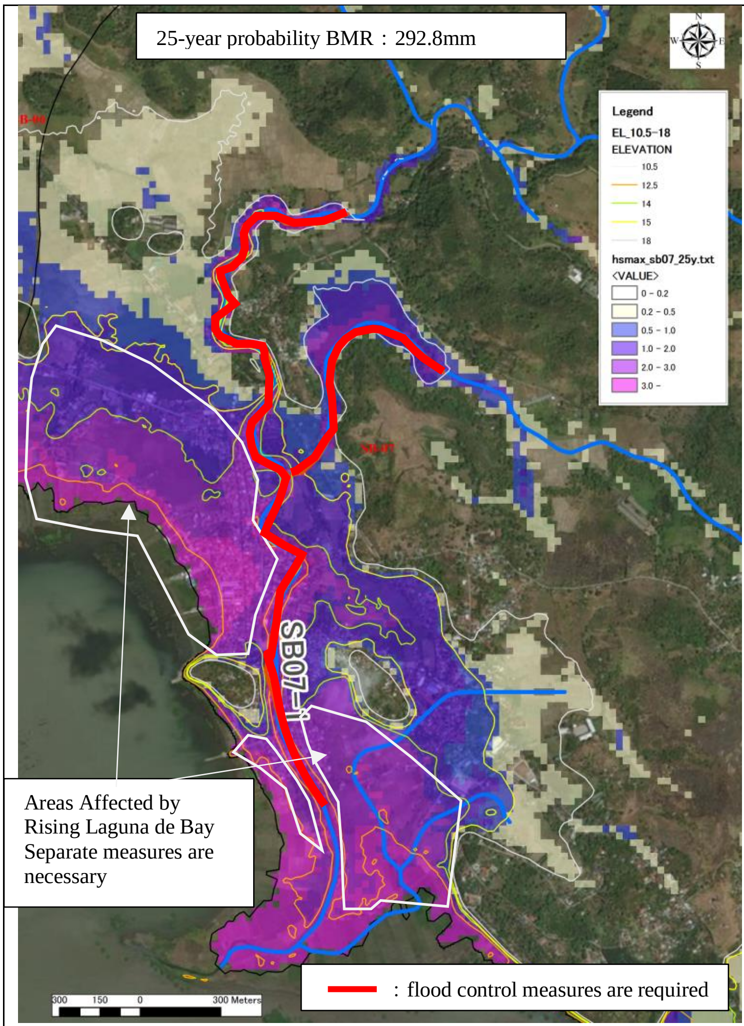
(5) Pillila Basin (SB-07)

The total area of Pilla Basin is 40.4km^2 and some rivers exist. The results of inundation analysis of Pilla River, which is a major river with the design scale of 25-year, are shown in Figure 4.6.7. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.6 Outline of Pilla Basin (SB-07)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-07-1	Pillila River	32.8	16.1	25	490	4.0
Sub-total		32.8				
Total Basin (Remaining Basin)		40.4 (7.6)				

Source: JICA Survey Team



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.7 Inundation Area of 25-year (SB-07, Pillila)

＜Basin Mean Rainfall (BMR)＞

- 25-year: 292.8mm
- 15-year: 261.2mm

＜Flood Prone Area＞

- The assumed Flood prone area is the coastal area of Laguna de Bay at altitude 15 m or less.
- Due to the rise of lake level and the rainfall falling into the catchment area, flooding is assumed in lowlands of less than 15 m.

＜Assumed Flood Countermeasure＞

<u>SB-07-1</u>

- River Improvement (River widening, Excavation)
- Dike
- Land raising of residential area

＜Measures for raising lake level＞

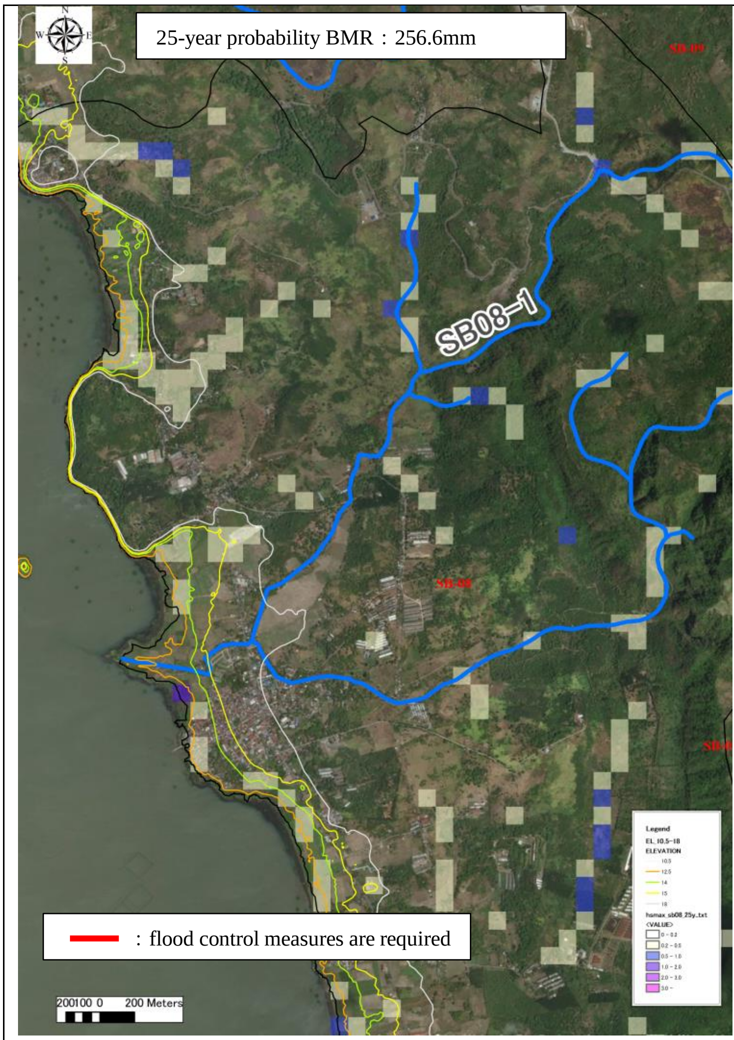
- Low lowlands of 14 m or less widely spread, and residential areas are distributed.
- With the rise of lake water level, individual measures such as raising and relocation of residents are required in affected areas (14m or less).

(6) Jala-jala Basin (SB-08)

The total area of Jala-jala Basin is 70.6km^2 and some rivers exist. The results of inundation analysis of Jala-jala River, which is a major river with the design scale of 25-year, are shown in Figure 4.6.8. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.7 Outline of Jala-jala Basin (SB-08)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-08-1	Jala-jala River	10.7	4.81	25	140	—
Sub-total		10.7				
Total Basin Total Basin (Remaining Basin)		70.6 (59.9)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.8 Inundation Area of 25-year (SB-08, Jala-jala)

＜Basin Mean Rainfall (BMR)＞

- 25-year: 256.6mm
- 15-year: 224.5mm

＜Flood Prone Area＞

- Inundation is assumed in a part of the coastal area of Laguna de Bay at altitudes of 14 m or less, but the area in which flooding is assumed is very limited.
- Inundation damage caused by overflow from river can be hardly ascertained.

＜Assumed Flood Countermeasure＞

<u>SB-08-1</u>

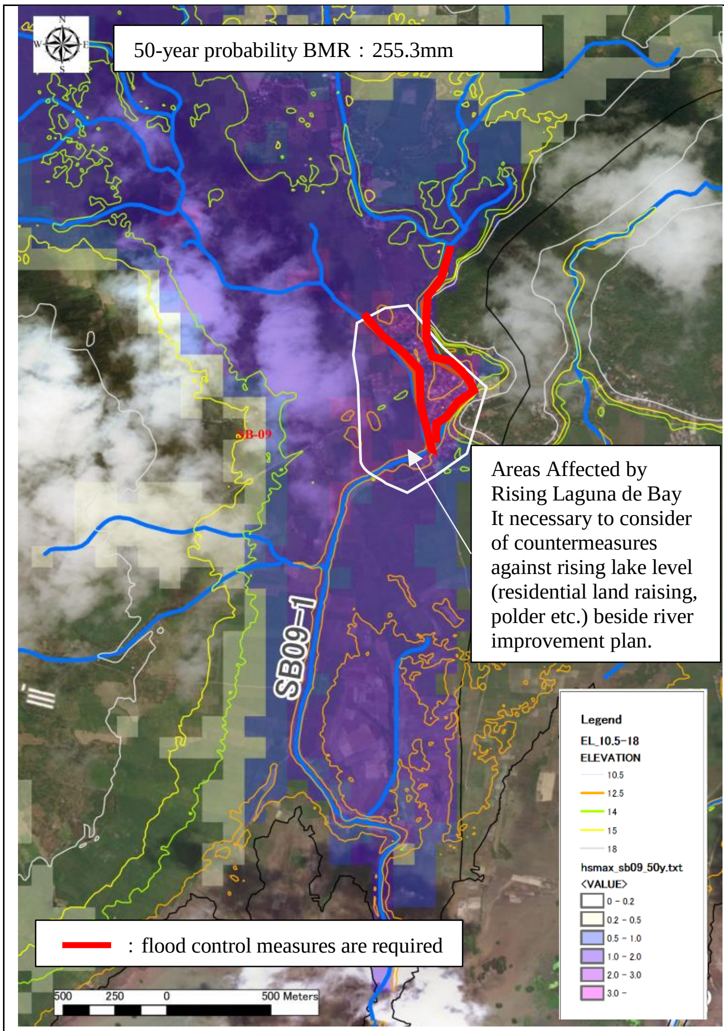
- None in particular

(7) Sta. Maria Basin (SB-09)

The total area of Sta. Maria Basin is 202.2 km^2 and some rivers exist. The results of inundation analysis of Sta. Maria River, which is a major river with the design scale of 25-year, are shown in Figure 4.6.9. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.8 Outline of Sta. Maria Basin (SB-09)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-09-1	Sta. Maria River	167.0	31.9	50	1,800	1.9
Sub-total		167.0				
Total Basin Total Basin (Remaining Basin)		202.2 (35.2)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.9 Inundation Area of 25-year (SB-09, Sta. Maria)

＜Basin Mean Rainfall :BMR＞

- 50-year BMR:255.3mm
- 25-year BMR:247.3mm

＜Flood Prone Area＞

- Lowland areas where elevation is 15m or less widely spread.
- The assumed flood prone area is the coastal area of Laguna de Bay at altitude 15 m or less.
- Residential areas are scattered at the middle of Sta. Maria River and flood prone areas spread at the left side lower land.

＜Assumed Flood Countermeasure＞

SB-09-1

- River Improvement
  (River widening, Excavation)
- Dike

＜Measures for raising lake level＞

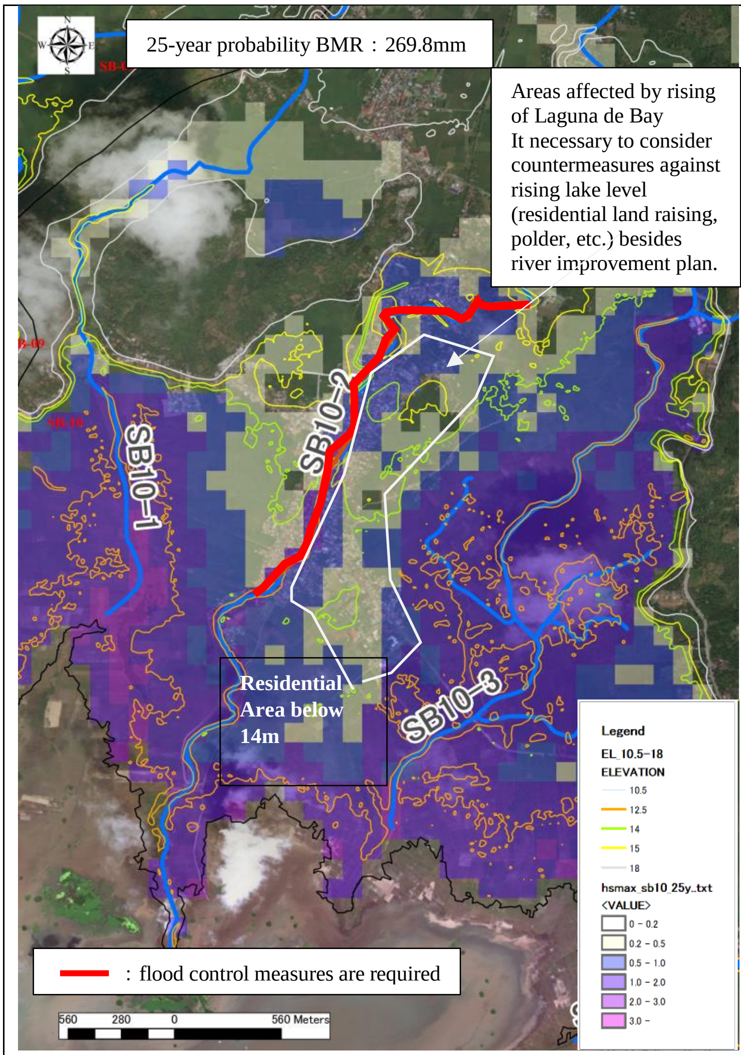
- Low-lying land of 14 m or less widely spread, and residential areas are distributed.
- With the rise of Lake water level, individual measures such as land raising and relocation of residents are required in affected areas (14 m or less).

(8) Siniloan Basin (SB-10)

The total area of Siniloan Basin is 71.7 km^2 and some rivers exist. The results of inundation analysis of Romeo River, which is a major river with the design scale of 25-year, are shown in Figure 4.6.10. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.9 Outline of Siniloan Basin (SB-10)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-10-1	Romeo River	39.3	10.9	25	470	—
SB-10-2	unknown	22.7	11.1	25	270	2.6
SB-10-3	unknown	6.9	0.8	15	90	—
Sub-total		39.3				
Total Basin Total Area (Remaining Basin)		71.7 (32.4)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.10 Inundation Area of 25-year (SB-10, Siniloan)

＜Basin Mean Rainfall (BMR)＞

- 25-year BMR：269.8mm
- 15-year BMR：244.9mm

＜Flood Prone Area＞

- The assumed flood prone area is the coastal area of Laguna de Bay at altitude 14m or less.
- Residential areas are scattered in the middle part of the river of SB-10-2, and the inundation area spreads along the river.
- It is assumed that flooding from the rivers are caused by the rise of lake level and the rainfall falling into the watershed.

＜Assumed Flood Countermeasure＞

<u>SB-10-1 and SB-10-3</u>

- Since there is no residential area in the inundation area, emergency measures are not necessary.

<u>SB-10-2</u>

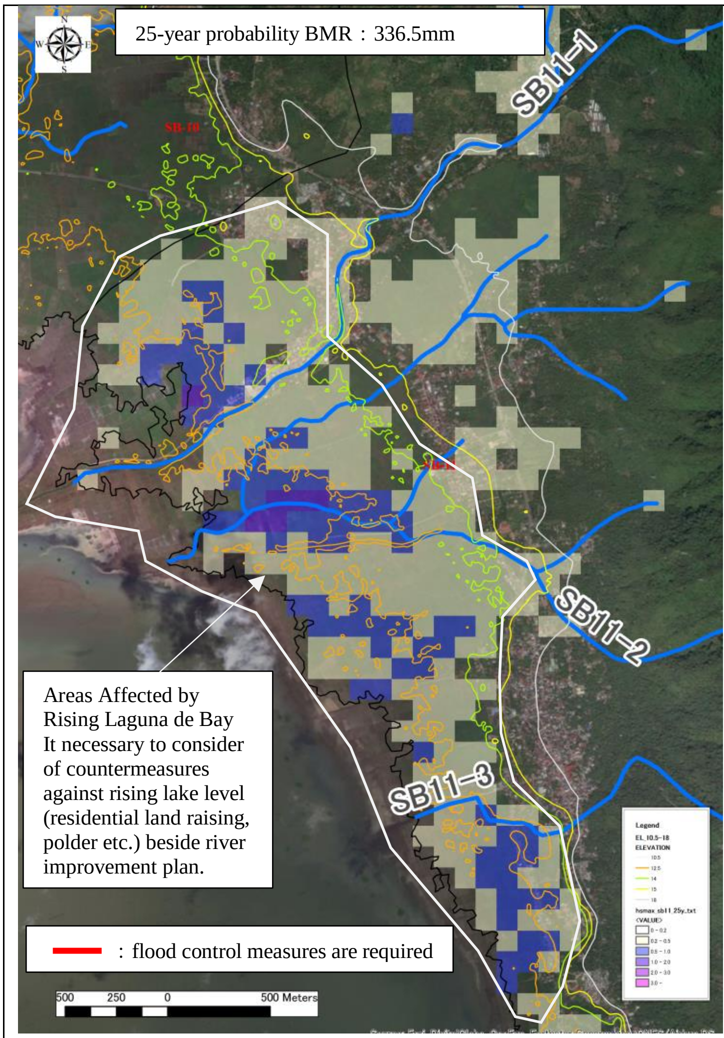
- River Improvement
(River widening, Excavation)
- Dike

(9) Pangil Basin (SB-11)

The total area of Pangil Basin is 50.1 km^2 and some rivers exist. The results of inundation analysis of Pangil River, which is major river with the design scale of 25-year, are shown in Figure 4.6.11. Inundation areas as the result of analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.10 Outline of Pangil Basin (SB-11)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-11-1	Pangil	21.2	13.7	25	370	—
SB-11-2	Unknown	5.2	3.2	15	80	—
SB-11-3	Tuyong Ilong	2.2	2.4	15	60	—
SB-11-4	unknown	3.7	2.8	15	60	—
SB-11-5	unknown	2.2	2.7	15	40	—
SB-11-6	unknown	3.2	2.2	15	50	—
Sub-total		39.3				
Total Basin (Remaining Basin)		71.7 (32.4)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.11 Inundation Area of 25-year (SB-11, Pangil)

＜Basin Mean Rainfall (BMR)＞

- 25-year BMR：336.5mm
- 15-year BMR：293.9mm

＜Flood Prone Area＞

- The assumed flood prone area is the coastal area of Laguna de Bay at altitudes of 14 m or less.
- Residential areas are scattered at altitudes of over 14 m, while in low flooded areas, most are agricultural lands or paddy fields.

＜Assumed Flood Countermeasure＞

<u>SB-11-1～SB-11-3</u>

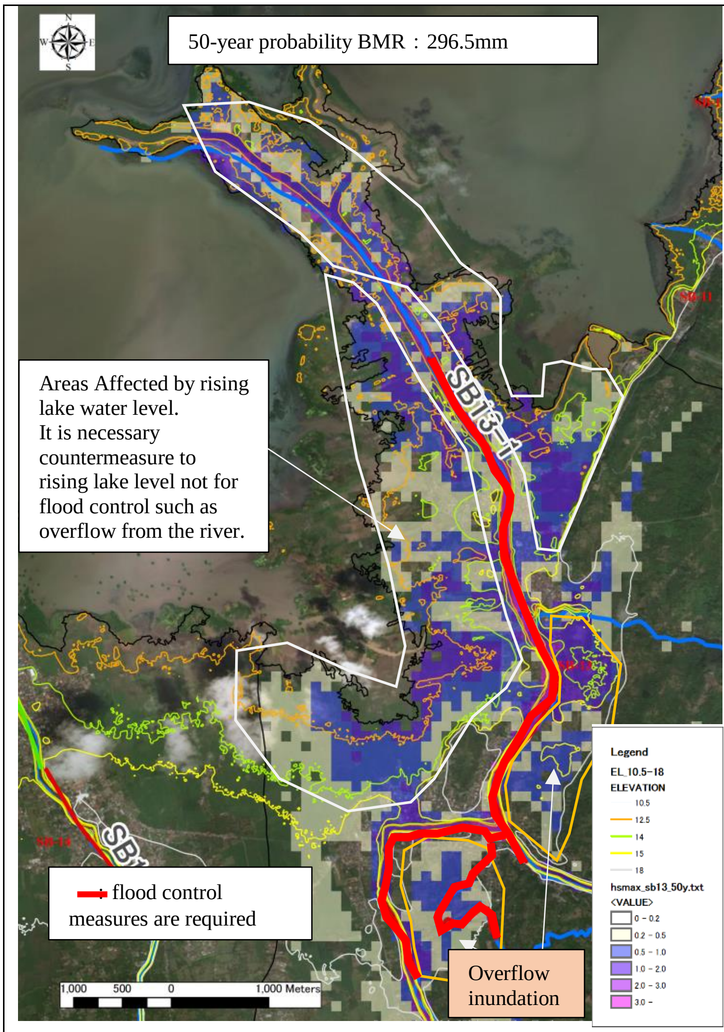
- For residential areas scattered at altitudes over 14m with flood depth of less than 50 cm, emergency measures are not necessary.

(10) Pagsanjan Basin (SB-13)

The total area of Pagsanjan Basin is 301.2km^2 and some rivers exist. The results of inundation analysis of Pagsanjan River, which is a major river with the design scale of 50-year, are shown in Figure 4.6.12. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows:

Table 4.6.11 Outline of Pagsanjan Basin (SB-13)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-13-1	Pagsanjan	258.7	53.2	50	2,600	10.5
Sub-total		258.7				
Total Basin (Remaining Basin)		301.2 (42.5)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.12 Inundation Area of 25-year (SB-13, Pagsanjan)

＜Basin Mean Rainfall (BMR)＞

- 50-year BMR： 296.5mm
- 25-year BMR： 256.2mm

＜Flood Prone Area＞

- Inundations occur in low-lying lands where elevation is 14m or less.
- Inundation areas along the river are assumed to be affected by rising lake level and river overflow.

＜Assumed Flood Countermeasure＞

SB-13-1

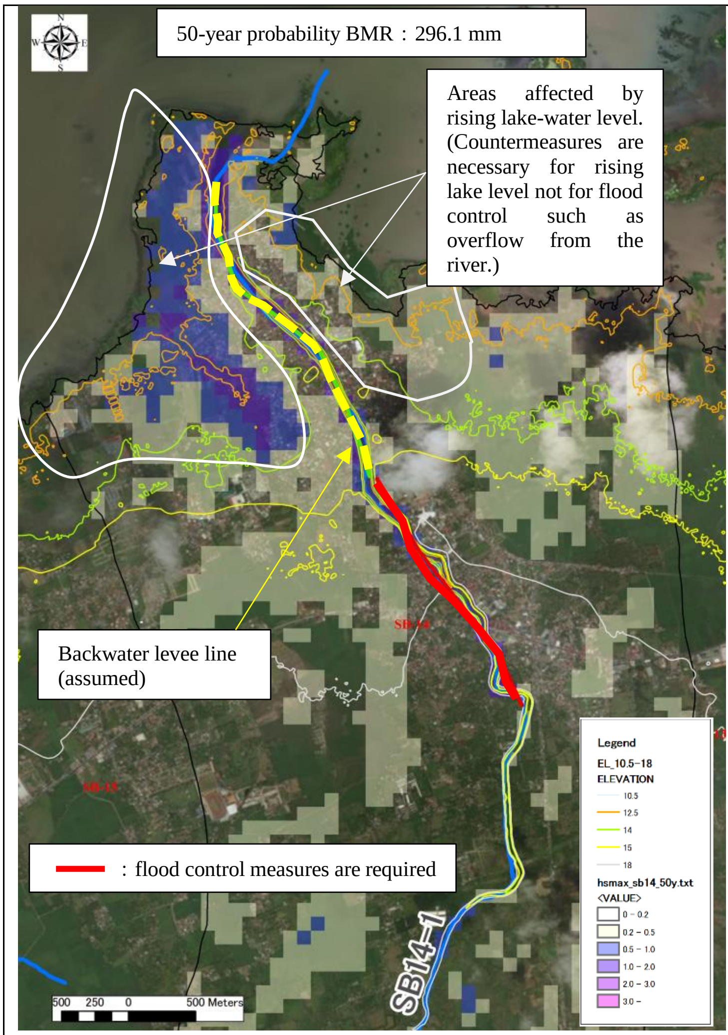
- River Improvement (River widening, Excavation)
- Dike
- With the rise of lake water level, individual measures such as land raising and relocation of residents are required in affected areas (14 m or less).

(11) Sta. Cruz Basin (SB-14)

Total area of Sta. Cruz Basin is 146.7 km^2 and some rivers exist. The results of inundation analysis of Sta. Cruz River, which is major river and design scale is 50-years, are shown in Figure 4.6.13. Inundation area as the result of inundation analysis and the assumed flood (river water) countermeasures are as follows:

Table 4.6.12 Outline of Sta. Cruz Basin (SB-14)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-14-1	Sta. Cruz	116.6	33.1	50	1,300	2.0
Sub-total		116.6				
Total Basin (Remaining Basin)		146.7 (30.1)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.13 Inundation Area of 50-year (SB-14, Sta.Cruz)

＜Basin Mean Rainfall :BMR＞

- 50-year BMR：296.1mm
- 25-year BMR：254.8mm

＜Flood Prone Area＞

- Lowlands where elevation is 14m or less are widely scattered and inundation of areas in low altitude are confirmed.
- Inundation is confirmed along the river at altitudes of 14 m to 18 m.
- Inundation damage in lakeshore area on the left bank (within the white frame) is not due to flooding from the river, but it is damage due to rising lake level.

＜Assumed Flood Countermeasure＞

SB-14-1

- River Improvement (River widening, Excavation)
- Dike

＜Measures for rising lake level＞

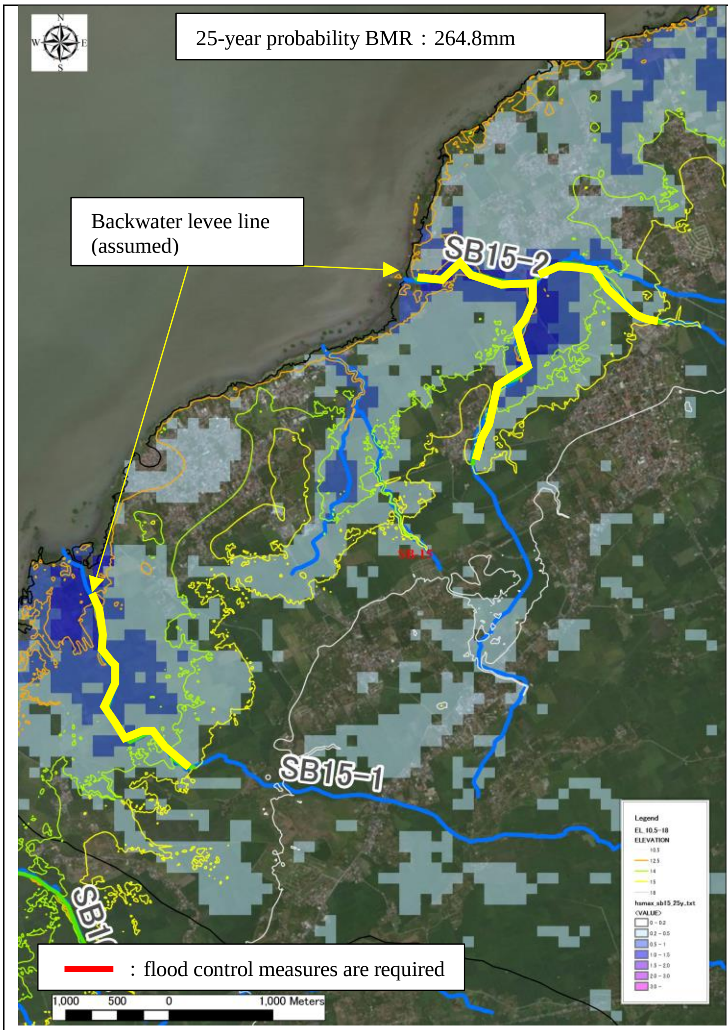
- Low-lying land of 14 m or less widely spread, and residential areas are distributed.
- With the rise of lake water level, individual measures such as land raising and relocation ofresidents are required in affected areas (14m or less).

(12) Pila Basin (SB-15)

The total area of Pila Basin is 89.3km² and some rivers exist. The results of inundation analysis of Bancabanca River, which is a major river with the design scale of 25-year, are shown in Figure 4.6.14. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.13 Outline of Pila Basin (SB-15)

River ID	River Name	Basin Area (km²)	River (km)	Design Scale (Year Probability)	Design Discharge (m³/s)	River Improvement Extension (km)
SB-15-1	Bancabanca	31.2	12.3	25	380	—
SB-15-2	Pira	31.5	5.2	25	380	—
Sub-total		62.7				
Total Basin (Remaining Basin)		89.3 (26.6)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.14 Inundation Area of 25-year (SB-15, Pila)

＜Basin Mean Rainfall :BMR＞

- 25-year BMR：264.8 mm
- 15-year BMR：231.7mm

＜Flood Prone Area＞

- Lowlands where elevation is 14m or less widely spread and inundation in low-lying areas is confirmed.

＜Assumed Flood Countermeasure＞

SB-15-1～15-2

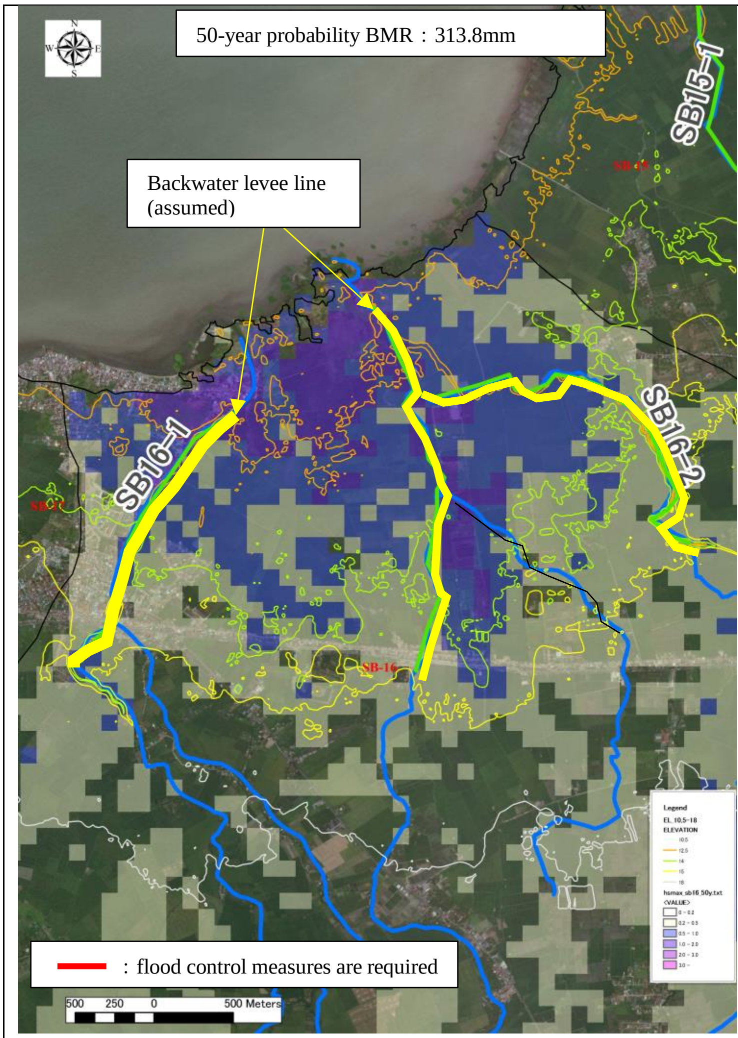
- Countermeasure for overflow inundation is unnecessary.
- This area l
- Lakeshore dike is proposed and backwater levee will be constructed due to lakeshore dike construction. The yellow line in the figure indicate the assumed backwater levee line.

(13) Calauan Basin (SB-16)

The total area of Calauan Basin is 154.5km^2 and some rivers exist. The results of inundation analysis of Bay River, which is a major river with the design scale of 50-year, are shown in Figure 4.6.15. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.14 Outline of Calauan Basin (SB-16)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-16-1	Bay	64.7	31.2	50	800	—
SB-16-2	Punongcaian	49.9	25.6	50	700	—
Sub-total		114.6				
Total Basin (Remaining Basin)		154.5 (39.9)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.15 Inundation Area of 50-year (SB-16, Calauan)

＜Basin Mean Rainfall :BMR＞

- 50-year BMR：296.1mm
- 25-year BMR：278.3mm

＜Flood Prone Area＞

- Lowlands where elevation is 14m or less spread widely and it is possible to confirm the inundation for areas with low altitude.

＜Assumed Flood Countermeasure＞

SB-16-1～16-2

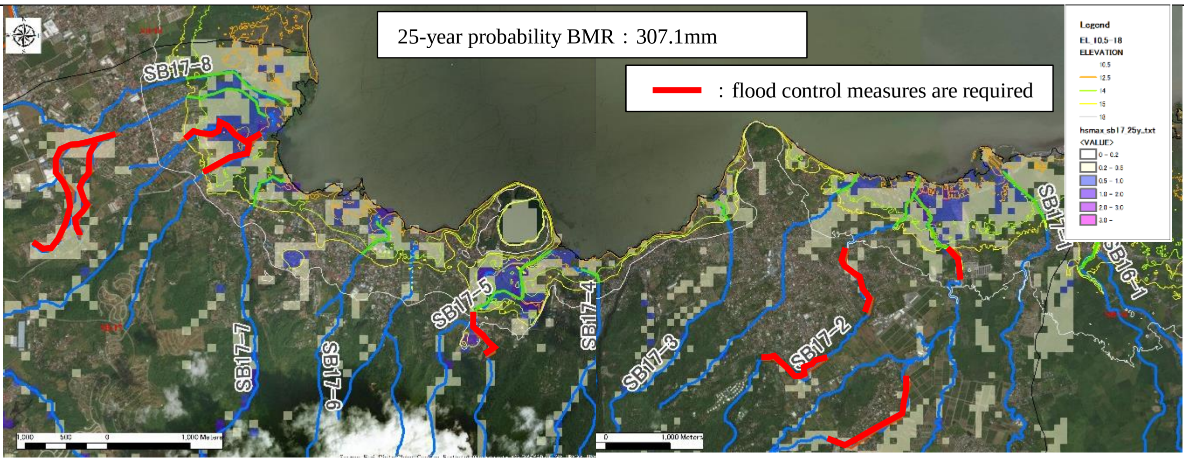
- Countermeasure for overflow inundation is unnecessary.
- Lakeshore dike is proposed in this area and backwater levee will be constructed due to lakeshore dike construction. The yellow line in the figure indicates the assumed backwater levee line.

(14) Los Baños Basin (SB-17)

Total area of Los Baños Basin is 102.1km² and some rivers exist. The results of inundation analysis of Maulauen River, which is a major river with the design scale of 25-year, are shown in Figure 4.6.16. Inundation areas as the result of analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.15 Outline of Los Baños Basin (SB-17)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-17-1	Colo	20.3	9.3	25	300	—
SB-17-2	Maulauen	25.8	4.1	25	430	5.0
SB-17-3	Saran	2.8	6.4	15	50	—
SB-17-4	Dampalia	5.5	5.6	15	90	—
SB-17-5	Unknown	12.5	6.3	25	210	1.0
SB-17-6	Pansol	3.3	12.7	15	50	—
SB-17-7	unknown	7.6	6.0	15	130	—
SB-17-8	unknown	11.6	10.7	25	200	3.5
Sub-total		89.4				
Total Basin (Remaining Basin)		102.1 (12.7)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.16 Inundation Area of 25-year (SB-17, Los Baños)

＜Flood Prone Area＞

- Lowlands where elevation is 14m or less are widely distributed, and the inundation of areas with low altitudes is confirmed.
- Flood prone area are confirmed along some rivers.

＜Assumed Flood Countermeasure＞

Backwater Levee

- Lakeshore dike is proposed, and backwater levee will be constructed due to lakeshore dike construction. The backwater levee height will be 15m.

Flood countermeasures excluding Backwater Levee

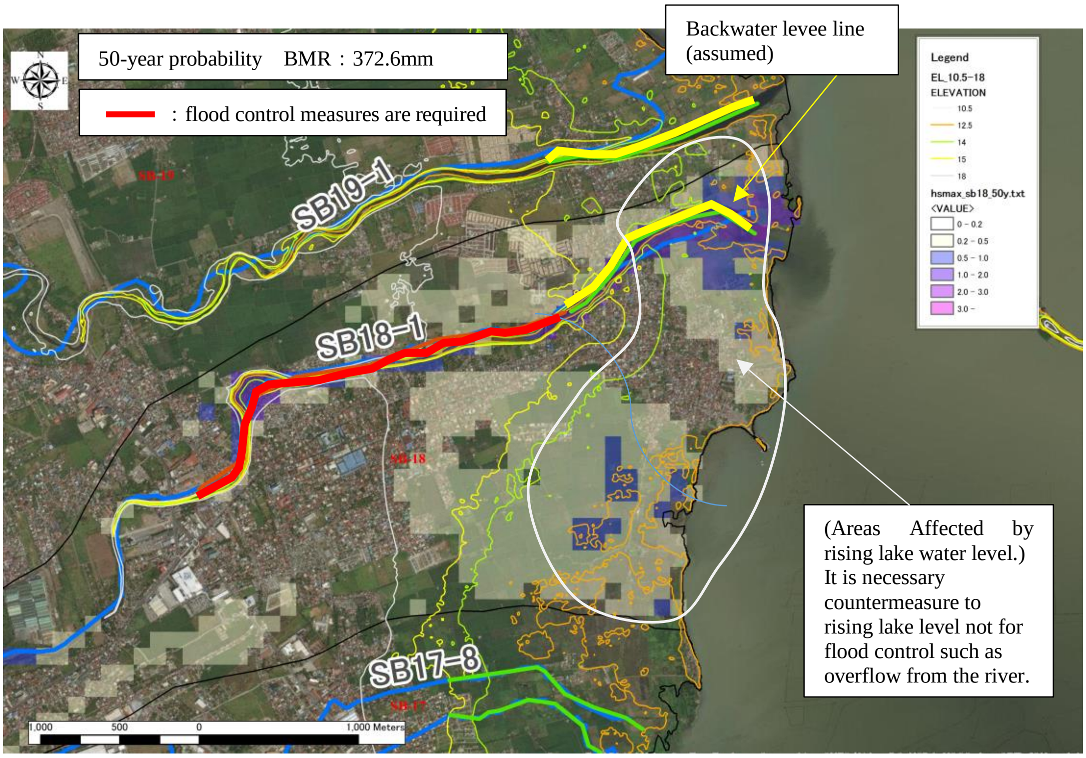
- Residential areas are distributed at the middle part of river. Residential areas along the river where flooding is confirmed require countermeasures for overflow inundation.
- River Improvement (River widening, Excavation)
- Dike

(15) San Juan Basin (SB-18)

The total area of San Juan Basin is 191.7 km^2 and some rivers exist. The results of inundation analysis of San Juan River, which is a major river with the design scale of 50-years, are shown in Figure 4.6.17. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.16 Outline of San Juan Basin (SB-18)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-18-1	San Juan	175.3	43.0	50	2,400	2.7
Sub-total		175.3				
Total Basin (Remaining Basin)		191.7 (16.4)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.17 Inundation Area of 50-year SB-18 San Juan

＜Flood Prone Area＞

- Lowlands where elevation is 14m or less spread widely and it is possible to confirm the inundation for low-lying areas with low altitudes.
- Flood prone area can be confirmed along San Juan River.

＜Assumed Flood Countermeasure＞

<u>Backwater Levee</u>

- Lakeshore dike is proposed, and backwater levee will be constructed due to lakeshore dike construction. The backwater levee height will be 15m.

<u>Flood countermeasures excluding Backwater Levee</u>

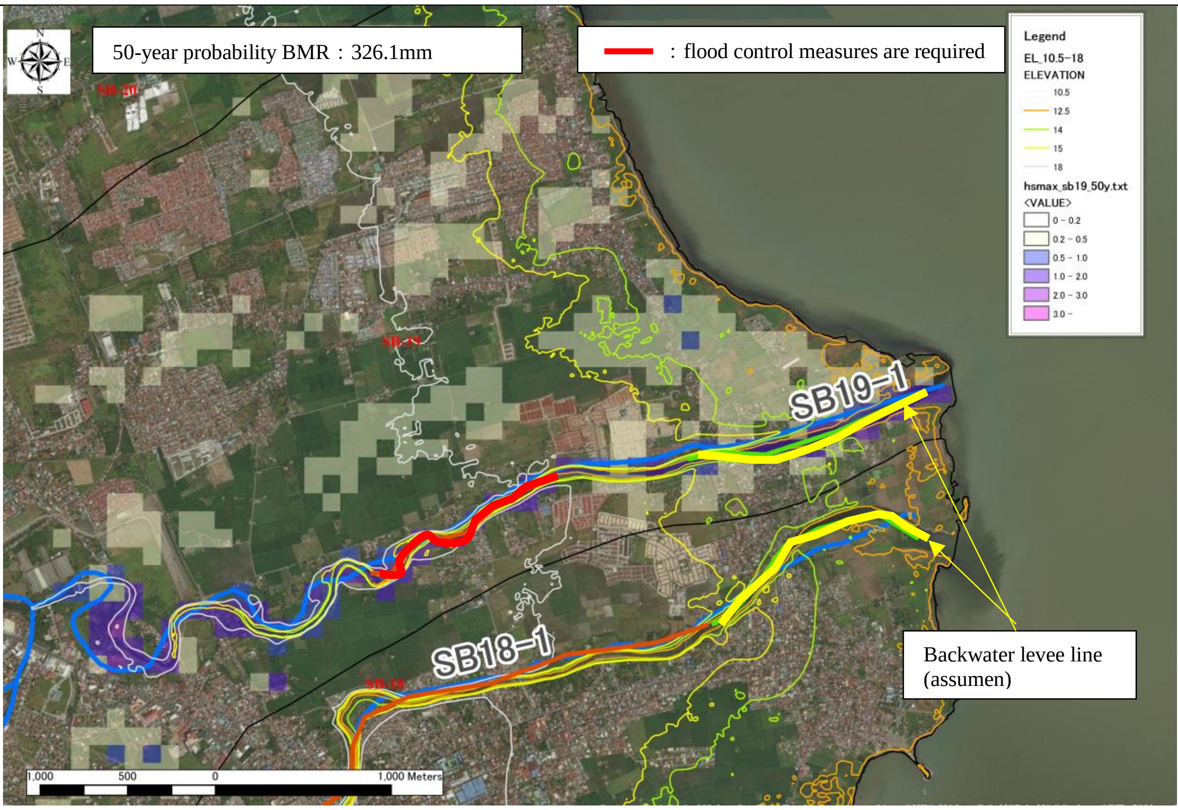
- Residential areas are distributed particularly on the right bank side, and flooding is confirmed in some residential areas along the rivers. Hence, overflow countermeasures are needed.
- River Improvement (River widening, Excavation), Dike

(16) San Cristobal Basin (SB-19)

The total area of San Cristobal Basin is 140.6km^2 and some rivers exist. The results of inundation analysis of San Cristobal River, which is a major river with the design scale of 50-year, are shown in Figure 4.6.18. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.17 Outline of San Cristobal Basin (SB-19)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-19-1	San Cristobal	123.7	36.2	50	1,600	1.2
Sub-total		123.7				
Total Basin (Remaining Basin)		140.6 (16.9)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.18 Inundation Area of 50-year (SB-19, San Cristobal)

＜Flood Prone Area＞

- Low-lying lands where elevation is 14m or less spread widely and inundation in areas with low altitude are confirmed.
- Flood prone area are confirmed along San Cristobal River.

＜Assumed Flood Countermeasure＞

Backwater Levee

- Lakeshore dike is proposed in this area and backwater levee will be constructed due to lakeshore dike construction. The backwater levee height will be 15m.

Flood countermeasures excluding Backwater Levee

- Residential areas are distributed at the middle part of river. The residential area along the river would require countermeasures for overflow inundation.
- River Improvement (River widening, Excavation), Dike

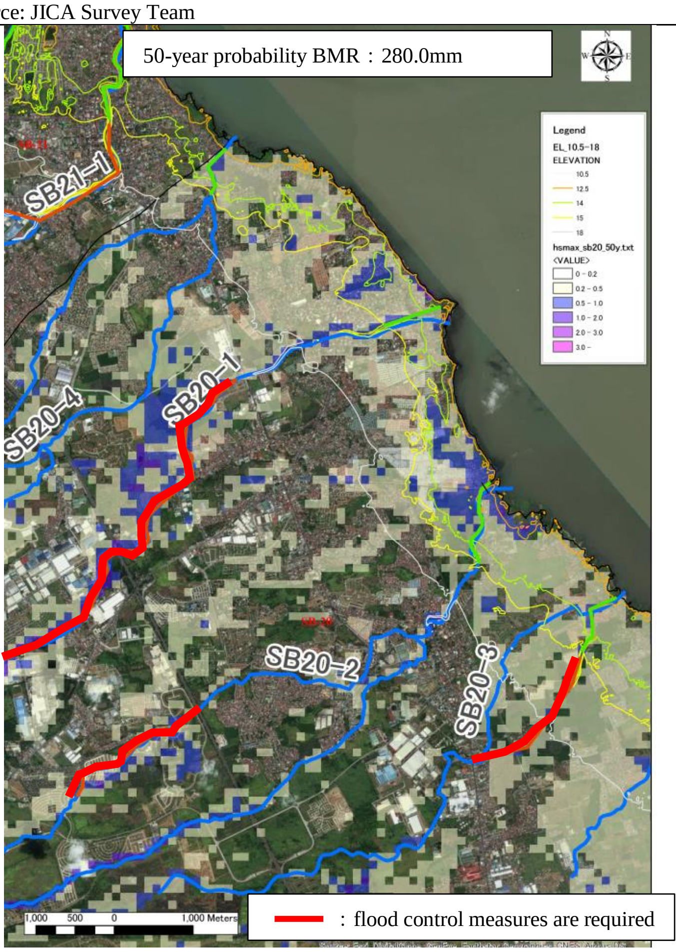
(17) Sta. Rosa Basin (SB-20)

Then total area of Sta. Rosa Basin is 119.8 km^2 and some rivers exist. The results of inundation analysis of Sta. Rosa River, which is a major river with the design scale of 50-year, are shown in Figure 4.6.19. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.18 Outline of Sta. Rosa Basin (SB-20)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-20-1	Sta. Rosa	44.1	30.2	50	520	6.0
SB-20-2	Cabuyao	19.2	9.7	25	200	2.0
SB-20-3	Niugan	16.0	9.1	25	170	2.0
SB-20-4	unknown	15.6	11.0	25	160	—
Sub-total		94.9				
Total Basin (Remaining Basin)		119.8 (24.9)				

Source: JICA Survey Team



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.19 Inundation Area of 50-year (SB-20, Sta. Rosa)

＜Basin Mean Rainfall :BMR＞

- 50-year BMR：280.1mm
- 25-year BMR：246.4mm

＜Flood Prone Area＞

- Inundation is confirmed in lowland at altitudes of 14 m or less.
- Several sections of the river channel inundate in the middle part.

＜Assumed Flood Countermeasure＞

Backwater Levee

- Lakeshore dike is proposed in this area and backwater levee will be constructed due to lakeshore dike construction. The backwater levee height will be 15m.

Flood countermeasures excluding Backwater Levee

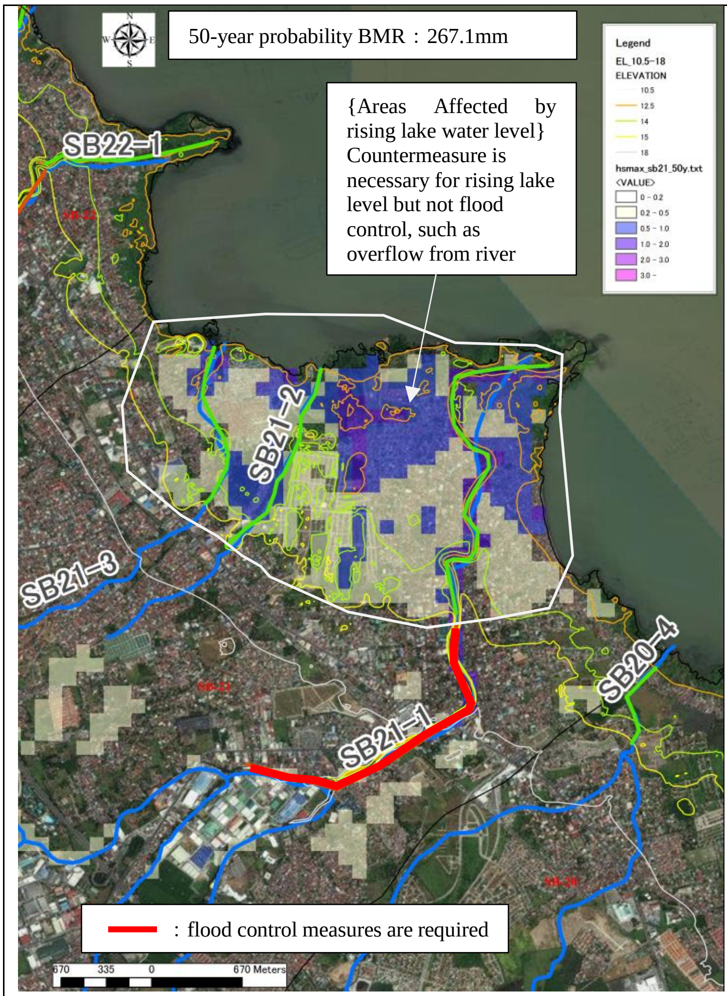
- Residential areas are widely distributed and flooded due to the influence of lake level at lowland area.
- Overflow countermeasure is necessary for middle section where flooding occurs and houses are dense.
- River Improvement (River widening, Excavation)
- Dike

(18) Biñan Basin (SB-21)

The total area of Biñan Basin is $84.8km^2$ and some rivers exist. The results of inundation analysis of Biñan River, which is a major river with the design scale of 50-year, are shown in Figure 4.6.20. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.19 Outline of Biñan Basin (SB-21)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-21-1	Biñan	67.7	36.0	50	700	2.5
Sub-total		67.7				
Total Basin (Remaining Basin)		84.8 (17.1)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.20 Inundation Area of 50-year (SB-21, Biñan)

＜Basin Mean Rainfall (BMR)＞

- 50-year BMR：267.1mm
- 25-year BMR：235.7mm

＜Flood Prone Area＞

- Inundation is confirmed in a lowland with an altitude of 14 m or less.
- The middle part of channel of several rivers inundate.

＜Assumed Flood Countermeasure＞

Backwater Levee

- Lakeshore dike is proposed in this area and backwater levee will be constructed due to lakeshore dike construction. The backwater levee height will be 15m.

Flood countermeasures excluding Backwater Levee

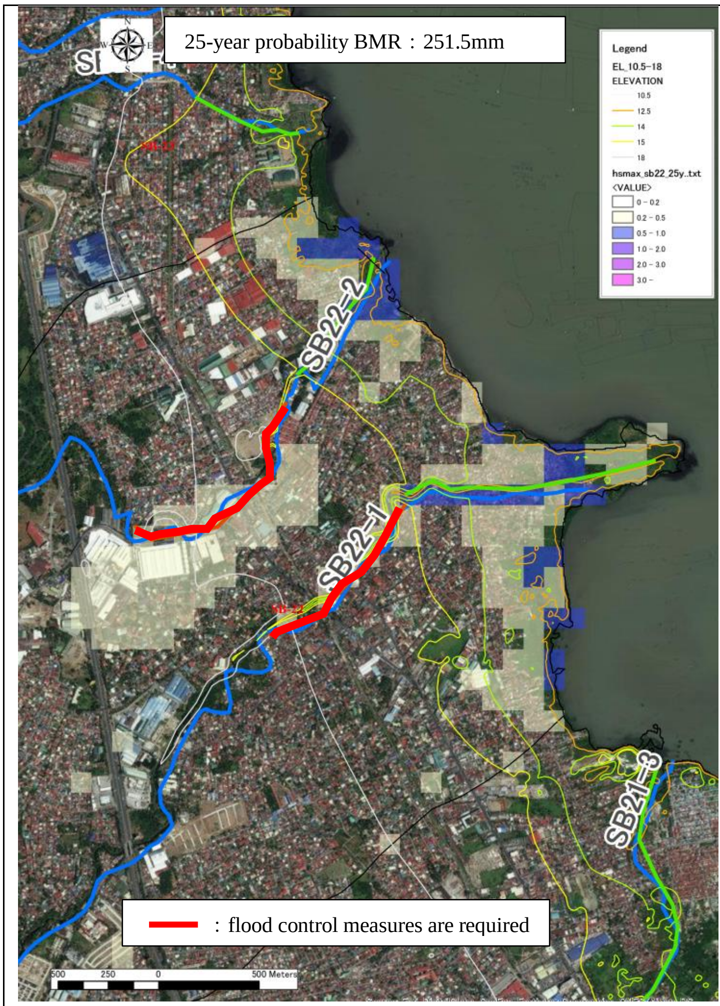
- In the middle part of SB-21-1, measures against overflow flooding are necessary.
- River Improvement (River widening, Excavation)
- Dike

(19) San Pedro Basin (SB-22)

The total area of San Pedro Basin is 46.0 km^2 and some rivers exist. The results of inundation analysis of San Pedro River, which is a major river with the design scale of 25-year, are shown in Figure 4.6.21. Inundation areas as the result of inundation analysis, and the assumed flood (river water) countermeasures are as follows.

Table 4.6.20 Outline of San Pedro Basin (SB-22)

River ID	River Name	Basin Area (km^2)	River km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-22-1	San Pedro	29.3	36.8	25	290	1.0
SB-22-2	Tunasan River	6.1	9.6	15	60	1.2
Sub-total		67.7				
Total Basin (Remaining Basin)		84.8 (17.1)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.21 Inundation Area of 25-year (SB-22, San Pedro)

＜Basin Mean Rainfall (BMR)＞

- 25-year BMR：251.5 mm
- 15-year BMR：220.3 mm

＜Flood Prone Area＞

- Inundation is confirmed in a lowland with altitude of 14 m or less.
- The middle part of several river channels inundate.

＜Assumed Flood Countermeasure＞

<u>Backwater Levee</u>

- Lakeshore dike is proposed in this area and backwater levee will be constructed due to lakeshore dike construction. The backwater levee height will be 15m.

<u>Flood countermeasures excluding Backwater Levee</u>

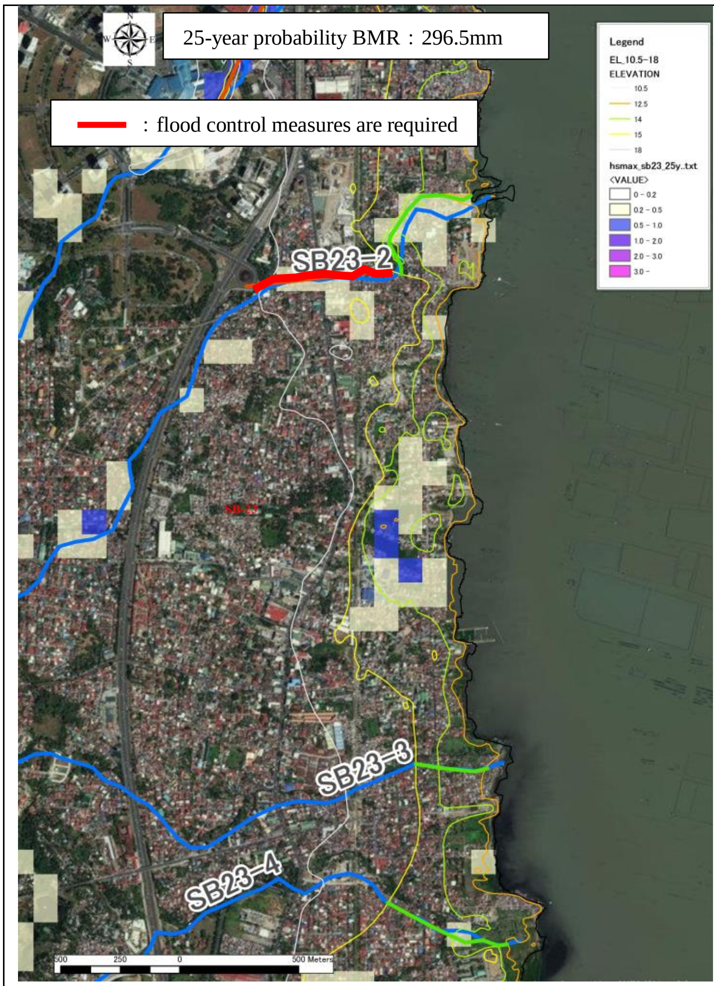
- In the middle parts of SB-22-1 and SB22-2, due to flooding from the river, measures against overflow flooding are necessary.
- River Improvement (River widening, Excavation)
- Dike

(20) Muntinlupa Basin (SB-23)

The total area of Muntinlupa Basin is 44.1km^2 and some rivers exist. The result of inundation analysis of Pasong Diablo River, which is a major river with the design scale of 25-year, are shown in Figure 4.6.22. Inundation areas as the result of inundation analysis, and the assumed flood (river water) are as follows.

Table 4.6.21 Outline of Muntinlupa Basin (SB-23)

River ID	River Name	Basin Area (km^2)	River (km)	Design Scale (Year Probability)	Design Discharge (m^3/s)	River Improvement Extension (km)
SB-23-1	Pasong Diablo	10.6	6.60	25	170	4.0
SB-23-2	Bayanan Creek	4.5	6.49	15	60	0.5
SB-23-3	Poblacion	5.7	8.23	15	80	—
SB-23-4	Magdaong	4.5	6.34	15	60	—
SB-23-5	Sucat	3.4	3.73	15	50	2.5
SB-23-6	unknown	0.4	1.07	15	10	—
SB-23-7	unknown	1.8	1.52	15	30	1.0
Sub-total		30.9				
Total Basin (Remaining Basin)		44.1 (13.2)				



Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.22 Inundation Area of 25-year (SB-23, Muntinlupa, 1/2)

＜Basin Mean Rainfall (BMR)＞

- 25-year BMR：296.5mm
- 15-year BMR：234.3mm

＜Flood Prone Area＞

- Inundation is confirmed in a lowland with an altitude of 14 m or less.
- The middle part of several river channels inundate.

＜Assumed Flood Countermeasure＞

Backwater Levee

- Lakeshore dike is proposed in this area and backwater levee will be constructed due to lakeshore dike construction. The backwater levee height will be 15m.

Flood countermeasures excluding Backwater Levee

- Above elevation 15m of SB-23-2, due to flooding from the river, measures against overflow flooding are necessary.
- River Improvement
  (River widening, Excavation)
- Dike

Source: Google Earth, Digital Globe, arranged by JICA Survey Team

Figure 4.6.23 Inundation Area of 25-year (SB-23, Muntinlupa, 2/2)

4.6.2 River Basins Requiring Priority Flood Countermeasures for Overflow Flooding

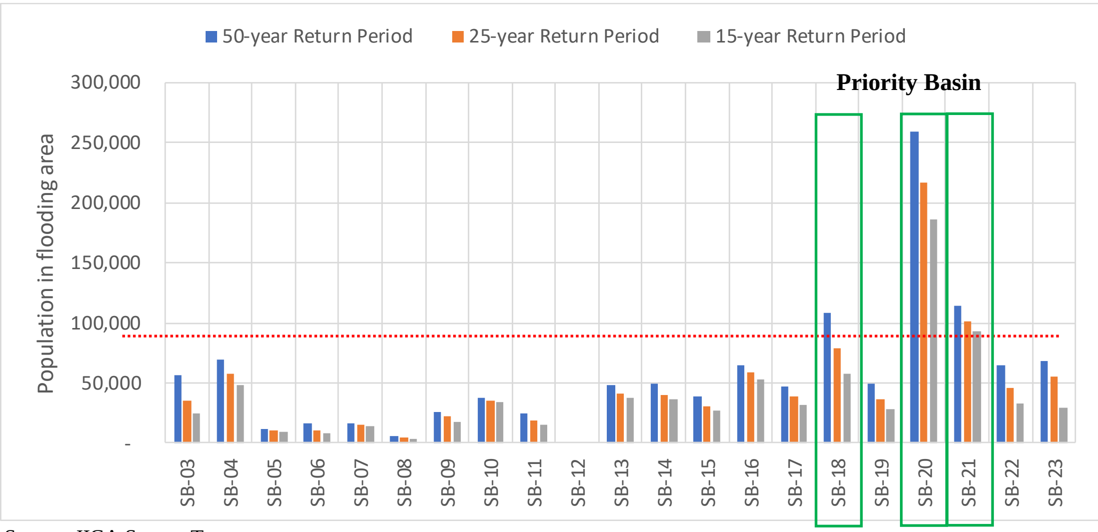
The selection of priority basins eligible to receive flood countermeasures was based on the results of Runoff-Inundation Analysis. Inundation areas are calculated according to their basin population probability as well as population affected by flooding. River basins where affected population is more than 100,000 are proposed as priority basins.

Inundation areas and affected population are shown in Table 4.6.22. Based on these results, three basins, "SB-18 San Juan", "SB-20 Sta. Rosa" and "SB-21 Biñan", are selected as priority basins for flood countermeasures.

Table 4.6.22 Inundation Area and Affected Population Based on Probability

Sub-Basin ID	Sub-Basin Name	Sub-Basin Area km^2	Population in Sub-Basin	50-year Return Period		25-year Return Period		15-year Return Period	
				Inundation Area km^2	Population in flooding area	Inundation Area km^2	Population in flooding area	Inundation Area km^2	Population in flooding area
SB-03	Angono	86.60	427,916	9.61	56,420	6.53	34,595	4.56	25,101
SB-04	Morong	95.90	276,289	23.34	69,464	19.69	57,307	17.44	48,160
SB-05	Baras	21.70	30,710	3.18	12,084	2.41	10,050	1.95	8,668
SB-06	Tanay	52.20	45,091	7.92	15,867	6.11	10,323	5.36	8,203
SB-07	Pililla	40.40	50,411	5.66	15,822	4.86	14,891	4.22	13,820
SB-08	Jala-jala	70.60	60,941	5.36	5,513	3.26	3,938	2.14	2,801
SB-09	Sta. Maria	202.20	69,120	35.93	25,639	30.31	21,600	26.40	17,219
SB-10	Siniloan	71.70	55,274	17.19	36,973	15.06	35,003	13.39	33,502
SB-11	Pangil	50.10	36,740	10.52	24,629	8.73	19,174	7.27	15,467
SB-12	Caliraya	128.80	-	-	-	-	-	-	-
SB-13	Pagsanjan	301.20	166,744	48.88	47,931	39.62	41,554	33.54	37,684
SB-14	Sta. Cruz	146.70	206,362	18.56	49,731	14.03	40,322	11.28	36,199
SB-15	Pila	89.30	123,308	27.37	39,269	20.50	30,600	17.63	26,988
SB-16	Calauan	154.50	150,901	46.46	64,561	41.31	58,426	36.81	52,851
SB-17	Los Banos	102.10	223,840	19.00	47,166	14.92	39,007	12.46	32,009
SB-18	San Juan	191.70	438,646	44.56	108,670	34.10	78,360	27.36	57,842
SB-19	San Cristobal	140.60	390,420	15.27	49,535	10.77	36,468	7.98	27,516
SB-20	Sta. Rosa	119.80	659,121	41.04	259,047	34.54	216,869	29.77	186,105
SB-21	Binan	84.80	599,468	8.35	113,852	6.86	100,924	5.95	92,660
SB-22	San Pedro	46.00	386,193	5.15	64,614	3.58	45,854	2.53	33,005
SB-23	Muntinlupa	44.10	761,017	4.45	68,529	3.69	55,266	2.10	29,431

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.6.24 Population Affected in Flooding Areas

4.6.3 Recommendations for Consideration of Flood (overflow) Measures in Priority Basin

The number of observation points and observation frequency of hydrological data (rainfall, water level, flow rate) in the Laguna de Bay Basin are not sufficient to examine the potential flood (overflow) countermeasures for the Basin. Since no river survey data were available in the study, cross-sectional survey, etc., shall be conducted.

Despite the lack of a more detailed data, flood analyses were carried out by using the RRI model, which is a distributed Rainfall-Runoff-Inundation model that enables flood runoff analysis using rainfall data and topographical data (DEM) as input. The framework of measures against overflow flooding was examined by using the results.

In river basins where flood (overflow flooding) countermeasures are absolutely necessary in the future, it is necessary to examine the scale and scope of flood countermeasures for flood. Vertical cross-sectional survey of rivers shall be carried out and evaluated by the hydraulic and hydrological analysis model to appropriately reflect the river characteristics.

4.7 Study on Non-structural Measures

4.7.1 Existing Non-structural Measures

(1) Present Condition of Lake Management of the Laguna de Bay

The Laguna Lake Development Authority (LLDA) and the local government units (LGUs) composed of provinces, cities and municipalities relate to the management of the Laguna de Bay and the Laguna Lake Basin.

LLDA belongs to the Department of Environment and Natural Resources (DENR). Based on Republic Act No. 4850 of 1966, in order to promote a well-balanced socio-economic growth, LLDA was established for conserving and developing resources of the Laguna de Bay. After that, due to the rapid expansion of urban areas in Metro Manila, increasing water use by industry and irrigation, deterioration of lake water quality by the inflow of wastewater from the urban areas and agricultural areas into the Lake, and the flooding problems in Metro Manila as well as the Lakeshore areas, LLDA’s mandate was amended under Presidential Decree PD No. 813 in 1975. After this, LLDA’s mandate was further amended based on Executive Order (EO) No. 927 in 1983 by mainly focusing on wastewater management.

In the RA No. 4850 and PD No. 813, lands of the Laguna de Bay below El. 12.50m, which is the average annual maximum lake level, is defined as public lands to be managed by LLDA.

In terms of flood control for the Laguna de Bay lakeshore area and for the inflowing rivers, LLDA had conducted limited works such as bank protection, etc. Full-blown flood control will be the responsibility of DPWH with the cooperation of LLDA.

Current responsibilities of LLDA are as follows:

a) To make comprehensive survey on socio-economy, hydrological conditions, hydropower potential, scenery, tourism resources, and natural environment resources, and based on the survey results, to formulate conservation and development plan for the Area.

b) To approve or disapprove the development plans and programs proposed by the local governments, public corporations, private sector (including resettlement of people, if necessary).

c) To plan, finance, and undertake infrastructural development projects related to river, flood control, sewerage, road, port, irrigation, housing and others.

d) If necessary, to undertake reclamation in a portion in the Lake.

e) To approve or disapprove using lake water in the Laguna de Bay (navigation, fish culture, etc.), and to monitor their activities and collect fees.

f) To develop water supply from groundwater or lake water for urban, agricultural and industrial water supply.

g) To establish water quality standard of municipal, industrial and agricultural wastewater discharged to the Laguna de Bay through coordination with the existing government agency (DENR). Then, to apply the standards and collect penalty in case of not compliance with the standard through cooperation of the above agency or separately by LLDA.

h) To conserve the Laguna de Bay and Laguna Lake Basin.

i) To study on water quality improvement of the Laguna de Bay and to formulate a water quality management plan.

Problem and Issues of Lake Management for the Laguna de Bay:

The lakeshore meant by LLDA is the land below El. 12.50m to the average of annual minimum water level (El. 10.00m). Land above El. 12.50m is under the responsibility of the local government units (LGUs). Hence, LLDA does not conduct management in the real meaning of the entire lakeshore [Example of lakeshore: from the bank height (El. 12.50m + Wave run-up height + α) to the bottom of the Lake]. The land above El. 12.50m is managed differently by the LGUs. Easement zones for not allowing building construction have not been set along the lakeshore. Therefore, consistent management of the land including easement zones along the lakeshore are not conducted, which is a problem. Due to the above condition, many formal and informal houses exist in the low-lying areas, including the lakeshore affected by the lake’s water level and waves. The condition of the densely existing houses has become worse, especially in the areas along the lakeshore at the western side of the Laguna de Bay. There are also some areas below El. 12.50m, where formal and informal houses exist.

It is noted that during the 1988 Flood in the Laguna de Bay with the highest water level of El. 13.55m, in the western side of the Laguna de Bay, houses only existed beside the road along the lakeshore, and almost no house existed below the road. Hence, it can be understood that the inhabitants in those years lived on some higher lands, where they were not affected significantly by floods. This is based on the experience of site investigation by one of the members of this JICA Study Team on the flooding condition of the Laguna de Bay in 1988.

- There is an issue on the development of Lake Management System and its implementation.

  Lack of Lake Management (management of land lower than the real meaning of lakeshore with certain constant width of Easement Zone along the lakeshore) is one of the core problems to enhance the living condition in the low-lying flood vulnerable areas, and this is a serious issue. Development of a feasible Lake Management System and its implementation is, therefore, very necessary.

(2) Present Condition of Disaster Risk Reduction and Management System for the Laguna Lake Basin including the Low-lying Areas in the Laguna de Bay Lakeshore Areas

The current Disaster Risk Reduction and Management System (DRRM System) in the Philippines is based on Republic Act No. 10121. RA No. 10121 stipulates the direction of mainstreaming disaster risk reduction and climate change adaptation in the formulation process of policy and socio-economic development plans, and budgeting and politics. Based on this direction, different levels of DRRM Systems [National, Regional, Provincial, City, Municipality and Community (Barangay) are strengthened.

In addition, based on RA No. 10121, 5% of the annual budget of each LGU can be utilized for DRRM. Furthermore, 30% among the 5% is to be reserved for Emergency Response, and the rest (70%) can be utilized for the preparation before the occurrence of disasters (Prevention & Mitigation and Preparedness). Around the Laguna de Bay, there are LGUs which utilize the above fund for preparation against disasters such as widening; dredging and bank protection of rivers; installing rainfall and water level gauges; purchasing vehicles, heavy equipment and boats; preparing relief goods and so on. In addition, there are LGUs which utilize the Community Development Fund based on the Property Fund for constructing river bank protection works, etc. (e.g., Muntinlupa City).

In the National Level, there is the National Disaster Risk Reduction and Management Council (NDRRMC) chaired by the Secretary of the Department of National Defense (DND) with the Secretary of other departments as members.

NDRRMC has the responsibility of policy formulation for the four areas of the DRRM cycle (Preparedness, Response, Recovery & Rehabilitation and Prevention & Mitigation), coordination and integration among the related agencies, formulation of the National Disaster Risk Reduction and Management Framework (NDRRMF), establishing the National Early Warning and Emergency Alert System, implementation of the National Disaster Risk Reduction and Management Fund and monitoring of these implementations.

Similar councils exist in regions, provinces, cities and municipalities. The Office of Civil Defense (OCD) is the Secretariat of the NDRRMC, and has the role of leading disaster risk reduction and management programs. OCD has roles of leading DRRM and formulating the National Disaster Risk Reduction and

Management Plan (NDRRMP). In addition to the headquarters of OCD, OCD has regional offices as well.

According to OCD Region IV-A, their major activities are education and training of staff of the Local Disaster Risk Reduction and Management Office (LDRRMO), mainly focusing on emergency response. In addition, LGUs and the related agencies have started discussion on developing a warning and alert system covering the whole Region IV-A. The DRRMP of each LGU has been formulated or being updated. OCD Region IV-A is now assessing the DRRMPs as to whether or not they are complying with the Assessment Guideline prepared by the technical cooperation project of JICA on disaster risk reduction and management of the Disaster Risk Reduction and Management Capacity Enhancement Project (DRRM CEP).

Problems and Issues on the Disaster Risk Reduction and Management System in the Laguna de Bay Area:

- There is an issue in implementing the DRRM System including Prevention and Mitigation.

  DRRM covers all the disaster risk reduction and management cycle. However, actual activities of the OCD and the DRRM System are mainly on Preparedness and Response. There is an issue on developing the DRRM System for implementing Prevention and Mitigation such as structural measures and non-structural measures through coordination and cooperation of the related agencies. This issue is the same for the Laguna de Bay Area.

- There is an issue on consistent implementation of DRRM in the whole Laguna Lake Basin through vertical and horizontal cooperation

  The Laguna Lake Basin is under the jurisdiction of the National Capital Region (NCR) and Region IV-A. In terms of provinces, there are the Laguna Province and the Rizal Province, and many cities and municipalities exist in these administration areas. In addition, various agencies such as LLDA, MMDA, DPWH and DENR relate to the Area. Hence, each LGU and each agency tends to formulate plans and conduct activities related to DRRM based on their different points of view, and vertical and horizontal coordination and cooperation is one of the problems and issues on DRRM. Therefore, there is an issue on implementing a consistent DRRM based on the DRRMP for the whole Laguna Lake Basin through vertical and horizontal coordination and cooperation between the related agencies and the LGUs.

(3) Present Condition of Land Use Management in the Laguna de Bay Lakeshore Areas

Land use management for lands in the Laguna de Bay Lakeshore above El. 12.50m is under the responsibility of the local government units (LGUs) composed of provinces, cities and municipalities.

There are cases of living on lands below EL 12.50m since the olden times. Also, there are cases of settling informally, or development of residential subdivisions by private land developers. For these cases, in principle, LLDA should fulfil its responsibility of management. In reality, however, the LGUs manage these lands. In addition, the management responsibility for agricultural lands with elevation above

EL 12.50m are under the LGUs.

In accordance with the guidelines of the Housing and Land Use Regulatory Board (HLURB), each LGU has to formulate a Comprehensive Land Use Plan (CLUP) and a Comprehensive Development Plan (CDP) within its administration area. Furthermore, it is required to mainstream climate change and disaster risk, and also required to formulate the CLUP by focusing on climate change adaptation (CCA) and disaster risk reduction (DRR)*. Each LGU has to enforce its Zoning Ordinance based on the CLUP and to start conducting land use management.

(HLURB; "CLUP Guidebook: Supplemental Guideline on Mainstreaming Climate Change and Disaster Risks in the Comprehensive Land Use Plan", 2014)*

Table 4.7.1 show the results of interview with several LGUs on land use management plans for the lakeshore and related conditions of resettlement of inhabitants. This table also shows the preference of LGUs on flood protection methods for the lakeshore. Following are the land use management activities and concepts of land use management of the interviewed LGUs, in general.

- The cities interviewed try to resettle inhabitants living in flood risk areas along the lakeshore to resettlement areas in those cities as much as possible. The resettlement areas are prepared by the cities or the National Housing Authority (NHA). Currently, several cities are implementing the resettlement of ISFs (Informal Settler Families). However, the cities are thinking to resettle formal settlers who own land titles in low-lying lands in the future and are now identifying these inhabitants.
- All of the interviewed cities and municipality desire to improve and develop the lakeshore as eco-tourism area by conserving the scenery and natural environment of the Lake. For reference, Figure 4.7.1 and Figure 4.7.2 show development images for the Lakeshore prepared by San Pedro City in the western side and Cabuyao City in the west-southern side of the Laguna de Bay.
- All of the interviewed cities and municipality think that conservation of fishing activities including fish culture by fishermen in the Laguna de Bay is very important.
- Several interviewed cities think that traffic jam along the Lakeshore is a problem.
- In terms of protection method for the Lakeshore against flood, the LGUs think that land-raising in the Lakeshore areas is more preferable than the lakeshore dike. The LGUs are thinking about the possibility of improving and developing eco-tourism areas in the Lakeshore, the possibility that inhabitants can return to their original places of abode after temporary resettlement, and the possibility that fishermen can continue their fishing activities. Also, these LGUs expect the development of roads in the raised lands. In addition, the LGUs expect that the national government conducts land-raising stretch by stretch even if it takes a long time.
- The LGUs in rural areas along the Laguna de Bay (example: Pila Municipality) expects countermeasures for floods which fit nature, including floods, instead of flood protection by artificial ways. For example, Pila Municipality expects a wide and a little higher evacuation places where inhabitants can evacuate

with their livestock for 4 to 6 months, as well as the installation of evacuation buildings. They are not expecting lakeshore dike construction.

Table 4.7.1 Hearing Results from LGUs on Land Use Management in the Laguna de Bay Lakeshore

LGU	Flood Problem	Land Use Management in Lakeshore Area & Resettlement from the Lakeshore Area	Improvement & Development in Lakeshore Area	LGU's Opinion on Preferable Lakeshore Flood Protection
Laguna Provincial Government	Rivers and Laguna de Bay	• Buffer zone above El. 12.50m will be set for no buildings. • Province supports cities/ municipalities in resettlement.	• Eco-tourism development. • Conservation of fishermen's accessibility to the Lake.	Land raising along the Lakeshore (West to Southwest Lakeshore)
Muntinlupa City (NCR)	Mainly Laguna de Bay	• 20m buffer zone above El. 12.50m for no buildings. • House basement height to be 0.6m above the existing road along the Lakeshore. • Resettled 10,527 Informal Settler Families (ISFs) from the Lakeshore and rivers to San Pedro and Biñan. • Identifying families in flood risk areas.	• Wetland parks, eco-tourism area including road development. • Conservation of fishermen's accessibility to the Lake.	Land raising along the Lakeshore
San Pedro City (Laguna Province)	River and Laguna de Bay	• Restriction of building construction. • Resettlement areas (RAs) in the City are being acquired. • Resettlement of ISFs from Lakeshore will be conducted from now on.	• Eco-tourism areas development. • Conservation of fishermen's accessibility to the Lake.	Land raising along the Lakeshore
Biñan City (Laguna Province)	River and Laguna de Bay	• Resettled 7,000 ISFs from rivers and Lakeshore to NHA's RA in the City.	• Same as above.	Land raising along the Lakeshore
Santa Rosa City (Laguna Province)	River and Laguna de Bay	• Mainly doing works for the rivers, and no works for the Lakeshore yet.	• Same as above.	Land raising along the Lakeshore
Cabuyao City (Laguna Province)	River and Laguna de Bay	• Lakeshore will be protected areas for not allowing buildings. • Purchasing low-lying Lakeshore areas from private landowners.	• Same as above.	Land raising along the Lakeshore
Calamba City (Laguna Province)	River and Laguna de Bay	• Regulation for not building houses in the Lakeshore. • Acquiring RAs in the City. • Resettled of ISFs from the rivers and lakeshore to RAs in City.	• Same as above.	Depending on the National Government flood control plan and its implementation.
Pila Municipality (Laguna Province)	Laguna de Bay and river	• Not done land use management yet.	• Same as above.	Wide and higher evacuation land with evacuation building
Rizal Provincial Government	River and Laguna de Bay	• Barangay officials have identified families in flood risk areas.	• Same as above.	Land raising along the Lakeshore except existing West Mangahan Dike

Note: Flood protection measures by land raising will enhance the scenery in the Laguna de Bay lakeshore, and will ensure accessibility of fishermen to the Lake. Families in lakeshore flood risk areas need temporary resettlement, but can come back to the raised land areas for living in the permanent resettlement houses. The raised land areas can be developed as eco-tourism areas.

Source: San Pedro City

Figure 4.7.1 Images of Improvement and Development of the Laguna de Bay Lakeshore (San Pedro City)

Source: Cabuyao City

Figure 4.7.2 Image of Improvement and Development of the Laguna de Bay Lakeshore (Cabuyao City)

Problem and Issue of Land Use Management in the Low-lying Lakeshore Areas of the Laguna de Bay:

- There is an issue on resettlement of inhabitants living in flood risk areas along the Laguna de Bay Lakeshore to resettlements areas in cities or nearby lands.

  Taking the western area of the Laguna de Bay for example, due to the trend of urbanization with a high density of population, houses densely exist in the low-lying areas along the lakeshore. In these areas, there are problems that improvement of land use and provision of flood control measures have not progressed so much. During the 2009 Flood and 2011 Flood, long lasting inundation with the duration of 4 months occurred in these lands. The LGUs are gradually implementing resettlement of ISFs to safer grounds in the cities, etc., to spare them from floods. There is, however, an issue on the implementation of further resettlement of ISFs as well as resettlement of formal inhabitants.

- There is an issue of flood protection considering scenery, nature, and fishery of the Laguna de Bay as well as improvement and development of the Lakeshore.

  The LGUs along the Laguna de Bay Lakeshore think that it is important to conserve the scenery and natural environment of the Laguna de Bay as well as the fishing activities of fishermen in the Lake. Moreover, the LGUs desire improvement of the Lakeshore and development of eco-tourism utilizing the scenery and natural environment, etc. In reality, however, there is a problem on the wide difference between the desired ideal condition and the actual condition with many houses existing in flood inundation areas along the Lakeshore. In formulating the flood control plan and for its implementation in the Lakeshore, not only protection of the lakeshore areas against floods is necessary, but also conservation of the scenery, natural environment and fishery of the Laguna de Bay as much as possible, including the formulation of a flood control plan with stage-wise implementation by stretches. Solution of this issue will contribute to the improvement and development of the Lakeshore in the future.

(4) Present Condition of Flood Warning and Evacuation System in the Laguna de Bay Area

Flood Warning, Alert and Evacuation System:

During the flooding of the Laguna de Bay in 2009 and 2012, flood warning and alert information was announced to the inhabitants in the high flood risk areas from the Local Disaster Risk Reduction and Management Offices (LDRRMO) and Barangay Disaster Risk Reduction and Management Committee (BDRRMC). Many people evacuated to elementary schools, churches and municipal buildings, etc., during 4 to 6 months until the floodwaters have subsided. In this case, flood warning, alert and evacuation at LGU and community levels were conducted.

Flood Forecasting and Warning System:

In terms of flood forecasting and warning system in the Pasig-Marikina River Basin, there is the Effective Flood Control Operation System (EFCOS), established in 1993, for operating the Mangahan Floodway and warning to the inhabitants along the Floodway about the release of floodwater through the Floodway. The EFCOS is being managed by the Metropolitan Manila Development Authority (MMDA) and it is equipped with radio telemetric rain gauges, radio telemetric water level gauges (float type) for the rivers and radio telemetric water level gauge in the northern part of the Laguna de Bay (float type). In addition, there are radio and SMS telemetric rain gauges and water level gauges (ultrasonic type above water surface) installed in 2012 by the Korea International Cooperation Agency (KOICA), and they are currently managed by the Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) (see Figure 4.7.3). In addition, all of the observed data of EFCOS, KOICA and the GMMA Ready Project described below are transmitted to PAGASA, and utilized for flood forecasting and warning. According to PAGASA, the transmission of observed data by SMS is frequently disconnected during typhoons or storm rainfall. Hence, PAGASA put more reliability on radio telemetric data.

In addition, as for the flood forecasting and warning system (FFWS) in the Laguna Lake Basin connected to the FFWS of PAGASA, there is only the SMS telemetric system with rain gauges and water level gauges covering the north-eastern part of the Laguna de Bay including the Tanay River Basin. This system was installed by the Ready Project of the United Nations Development Program (UNDP) with the Australian Agency for International Development (AusAID). Hence, basically, there is no flood forecasting and warning system with a wide coverage in the Laguna Lake Basin.

Hydrological Observation Facilities owned by LGUs themselves:

Many LGUs in the Laguna Lake Basin have installed manual, automatic or telemetric (may be SMS) rain gauges, water level gauges in the rivers and in the Laguna de Bay, and utilize the observed data for dispatching warning, alert and evacuation information to inhabitants (see Figure 4.7.4). However, there are LGUs which do not have such kinds of observation station.

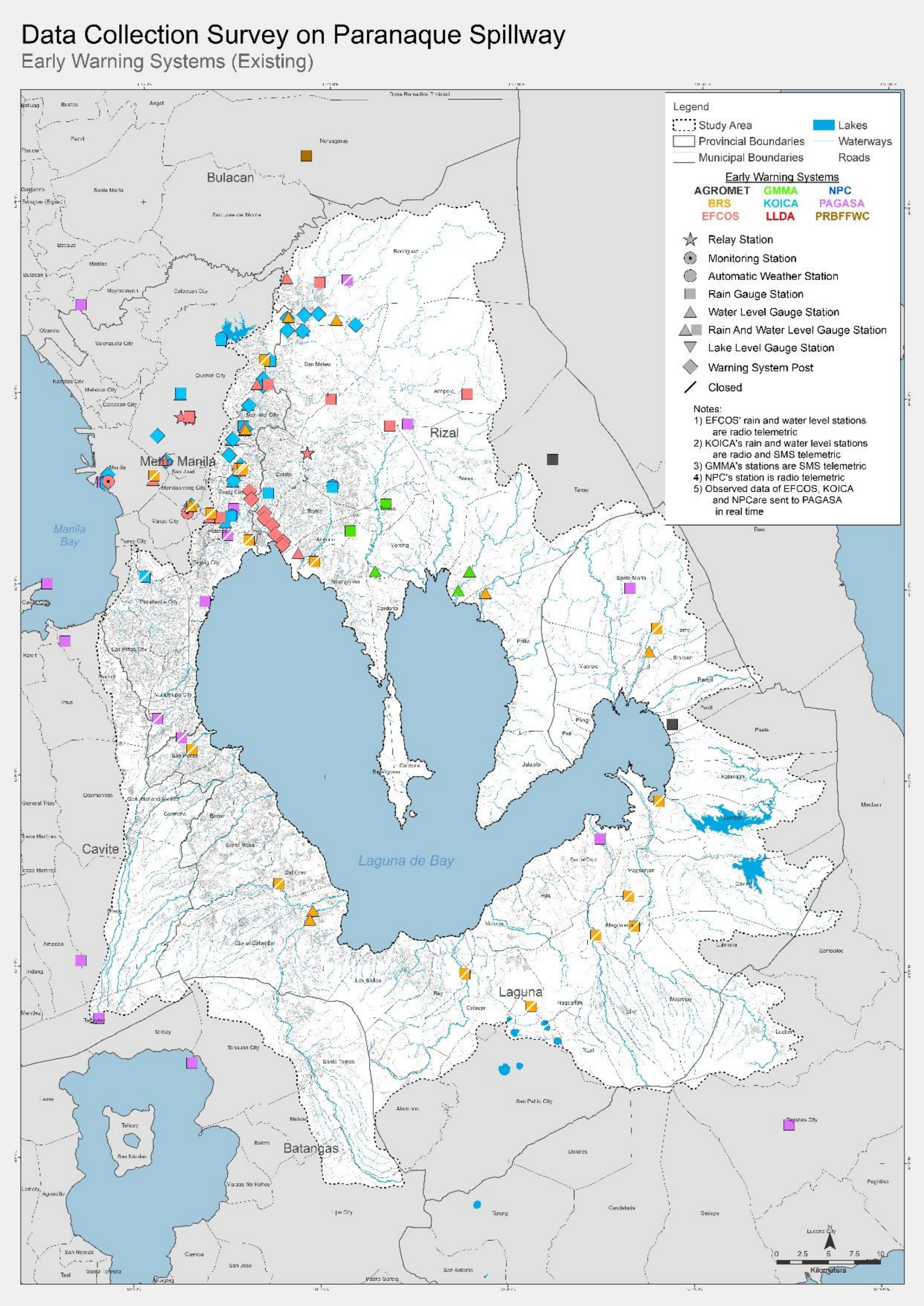
Radar Rain Gauges of PAGASA:

PAGASA owns radar rain gauge systems covering the whole country which are composed of nine (9) S-band radars with observation radius of about 400km and four (4) C-band radars with observation radius of about 120km. Among them, the C-band radar in Tagaytay is the nearest to the Laguna Lake Basin (see Figure 4.7.5). In addition, PAGASA purchased three (3) units of mobile X-band radars with observation radius of 50 to 80km from Japan with Philippine funds, and it is going to install six (6) units of fixed X-band radars with Philippine funds. However, there is no plan for X-band radar related to the Laguna Lake Basin. There is information that the National Power Corporation (NPC) will install an X-band radar in the Angat River Basin, but the details are unknown (Source of information: PAGASA).

Issues on Flood Forecasting and Warning System in the Laguna de Bay Area:

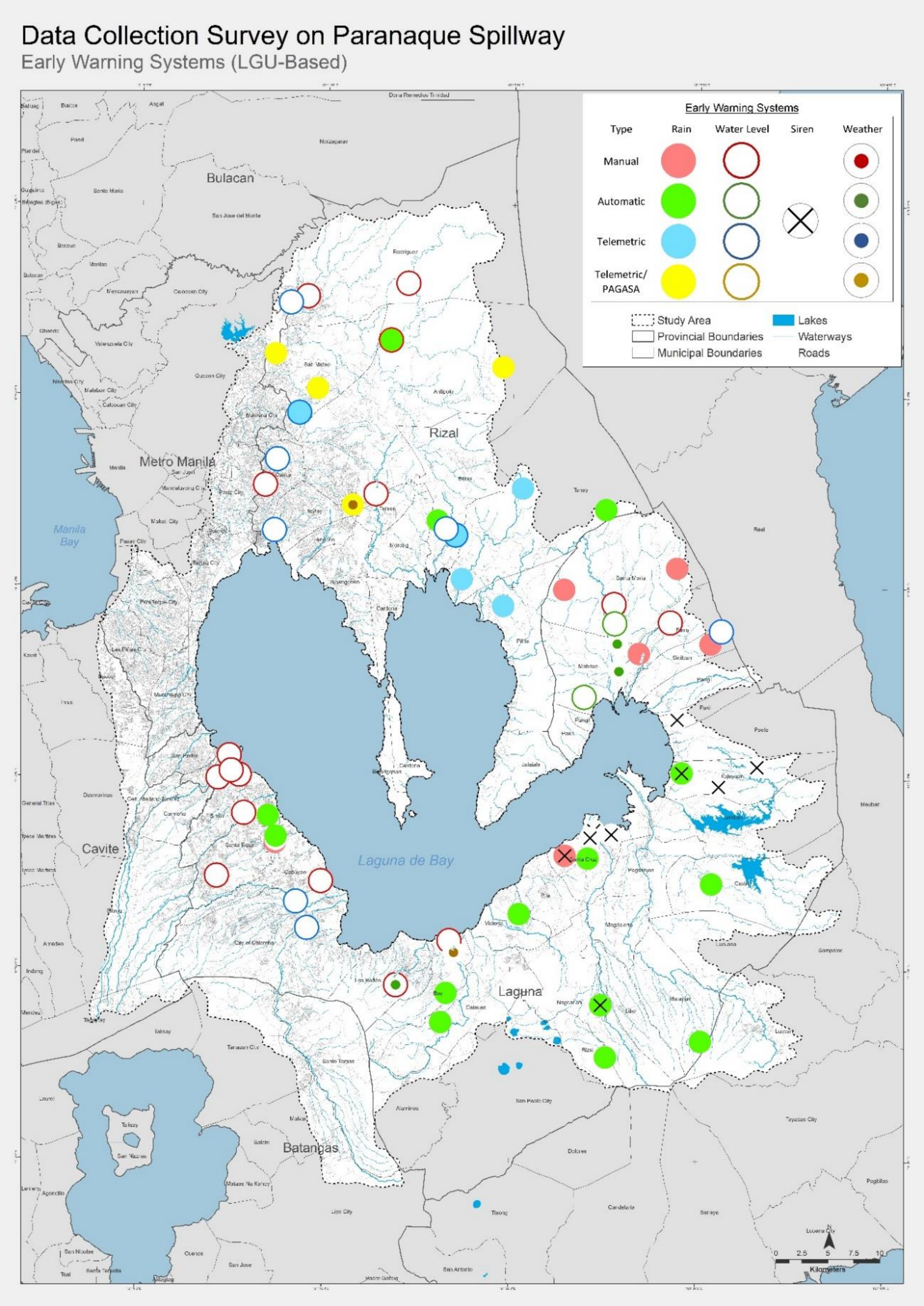
- There is an issue on developing flood forecasting and warning system covering the whole Laguna Lake Basin

  The installation of radio telemetric rain gauges covering the whole Laguna Lake Basin and radio telemetric water level gauges in the rivers and the Lake is one of the issues. In this regard, it is preferable to install the X-band radar rain gauge in the inflow river basin with a flash flood problem. The installation of radar rain gauge is also one of the issues. It is noted that KOICA submitted a proposal to PAGASA on the installation of telemetric rain and water level gauges including installation of X-band radar in the Laguna Lake Basin.



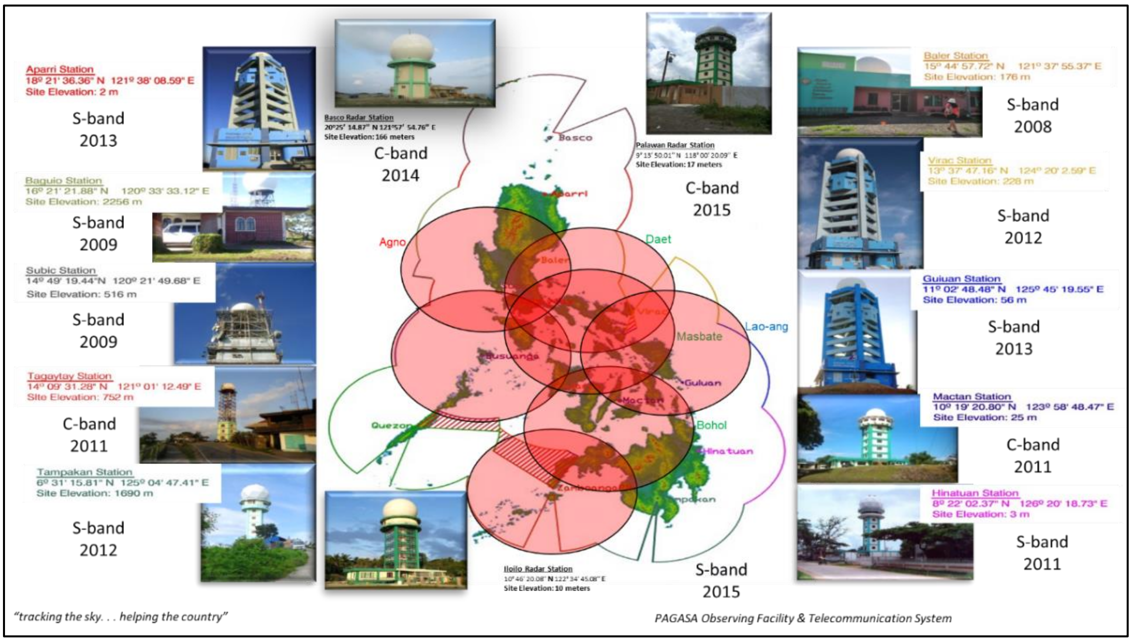
Source: PAGASA, EFCOS, LLDA, BRS and NPC

Figure 4.7.3 Existing Flood Warning and Hydrological Observation Systems in Laguna Lake Basin, Pasig-Marikina River Basin and Surrounding Areas



Source: DRRMPs of Rizal Province and Laguna Province

Figure 4.7.4 Existing Hydrological Observation Stations owned by the LGUs of Rizal Province and Laguna Province around the Laguna de Bay



Source: PAGASA

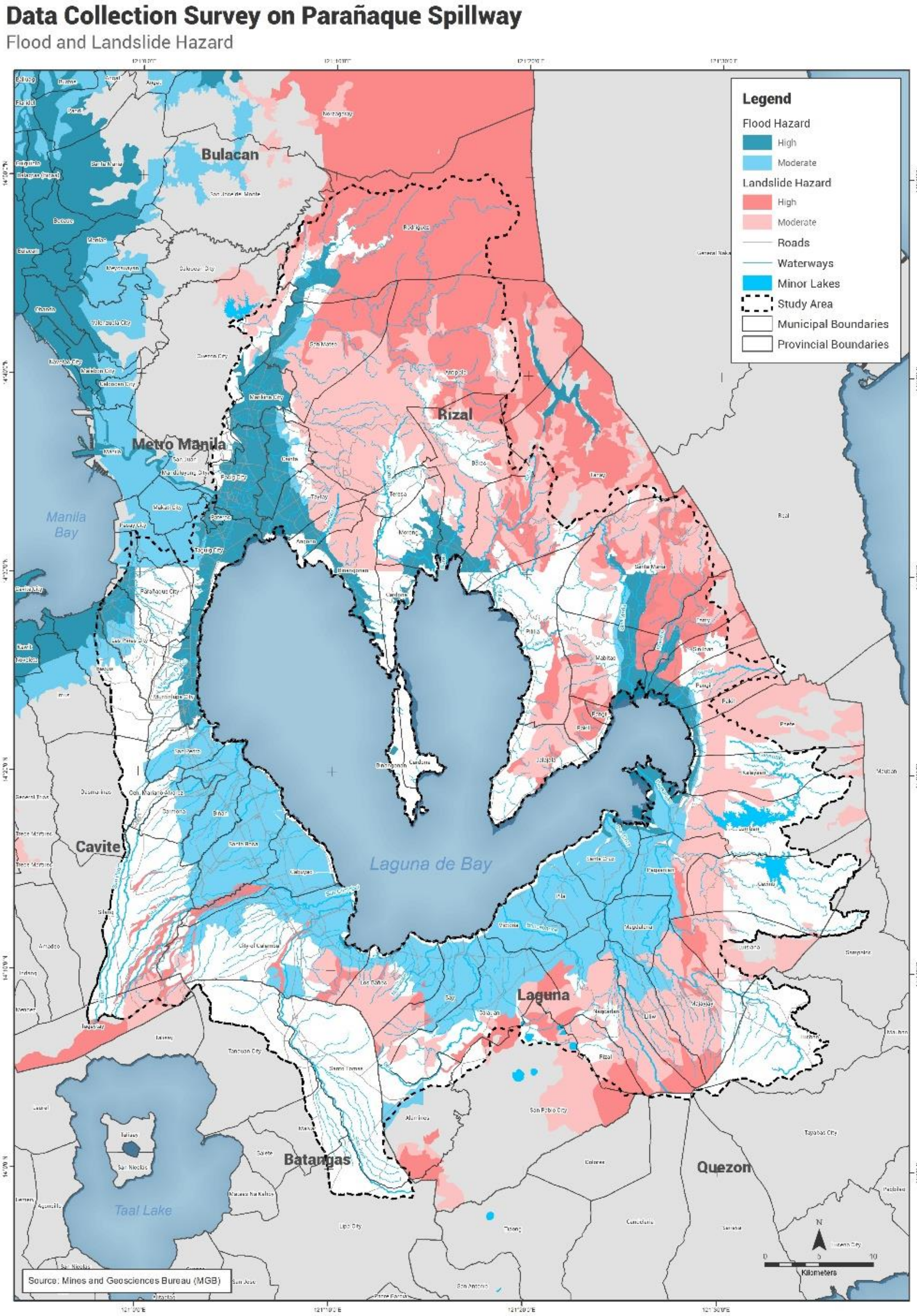
Figure 4.7.5 Existing Radar Rain Gauges of PAGASA for the Whole Philippines

(5) Present Condition of Flood Hazard and Risk Maps for the Low-lying Areas in the Laguna de Bay Lakeshore

The Mines and Geosciences Bureau (MGB) of the Department of Environment and Natural Resources (DENR) prepares flood with landslide hazard maps for the whole country, and publishes them in their Webpage. The flood hazard maps of MGB are made based on-site investigation and questionnaire to people and they are like general hazard maps. It is noted that the digital elevation model (DEM) for making hazard maps has topographic accuracy of around 1 to 10,000 (with accuracy of around plus or minus 1m) based on the IFSAR (Interferometric synthetic aperture radar). Figure 4.7.6 shows the flood hazard map of MGB for the Laguna de Bay Area.

The World Bank study called "Master Plan for Flood Management in Metro Manila and Surrounding Area" in 2011 to 2012, prepared flood maps for the Pasig-Marikina River Basin and the Laguna Lake Basin by conducting flood questionnaire survey and flood simulations. Based on these, the WB MP Study prepared Flood Risk Maps on Danger of Casualty for the target-rivers and the Laguna de Bay considering damage to people by different inundation water depths. Furthermore, based on the damage rate by inundation depth, the WB-MP prepared Flood Risk Map of Annual Damage Rate for Residential Assets. Based on the Flood Risk Map on Danger of Casualty made by the WB-MP Study, most of the inundation areas belong to the medium risk level with inundation depths of 0.5 to 2.0m. However, since these areas have experienced long lasting inundation of about 4 months, and people had to live in the evacuation centers or on the second floor of their houses during these periods, the actual flood risk level of these areas is assumed to be higher than the medium risk level.

In addition, by the AusAID's project, the "Enhancing Risk Analysis Capacities for Flood, Tropical Cyclone Severe Wind and Earthquake for the Greater Metro Manila Area", an inundation map was prepared for the Pasig-Marikina River Basin and the western side of the Laguna de Bay area within the range of available Lidar data.



Source: MGB

Figure 4.7.6 Flood Hazard Map of the Laguna de Bay Area

Issues on the Hazard Maps of the Low-lying Areas of the Laguna de Bay Lakeshore Area:

➢ There is an issue on enhancing accuracy of topographic elevation as basis of flood hazard maps.

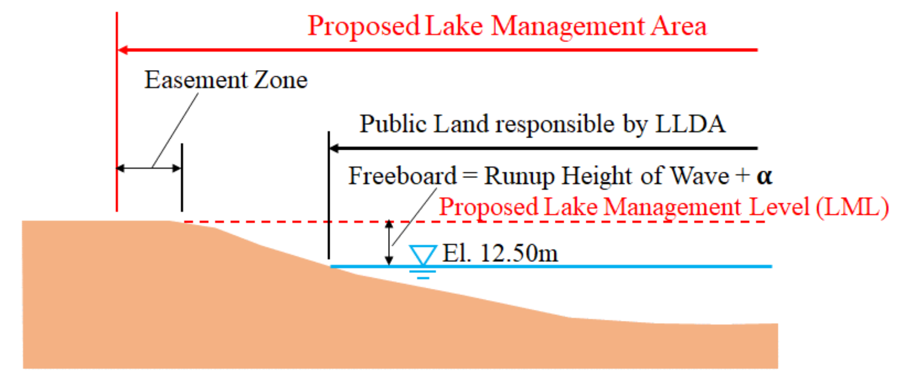
It is necessary to prepare flood hazard and risk maps covering the whole Laguna Lake Basin based on DEM with higher accuracy of elevation, and this is one of the issues.

It is noted that the accuracy of topographic elevation of DEM has been upgraded based on the NAMRIA's IFSAR data covering the whole Laguna Lake Basin. However, in the low-lying areas along the Laguna de Bay lakeshore areas, small differences of elevation become difference of inundation areas. Therefore, it is necessary to conduct further improvement of the accuracy of elevation of the DEM.

4.7.2 Proposed Non-structural Measures

(1) Proposal of Lake Management for the Laguna de Bay

Based on RA No. 4850 of 1966, the water body and land (bottom and lakeshore) below El. 12.50m are under the responsibility of LLDA. However, for the management of the Lake, as described in Subsection 3.4.1(1), it is necessary to set real lakeshore elevation (Lake Management Level: LML) based on El. 12.50m plus wave run-up height plus some allowance. The Easement Zone shall be set from the real lakeshore elevation with 3m for urban area and 20m for agricultural area. The concept of Easement Zone is based on the Philippine Water Code (PD No. 1067). Then, the Lake Management Area is to be set from the Easement Zone to the inside of the lake. Figure 4.7.7 shows the concept of setting the Lake Management Area. Basically, it is necessary to implement Lake Management so that houses are not allowed within the Lake Management Area.



Notes:
1) Lake water level of El. 12.50m is average annual maximum lake level elevation (based on the RA No. 4850 and PD No. 813)
2) Easement zone: 3 m for urban area and 20 m for agricultural area (based on the PD No. 1067: Water Code)
3) Freeboard example: 0.7m (about half of the freeboard of the West Manggahan Dike of 1.20m)

Source: JICA Study Team

Figure 4.7.7 Image of Proposed Lake Management Area for the Laguna de Bay

- It is proposed to legalize the above concept and direction of Lake Management. LLDA is proposed to be the responsible agency on Lake Management. However, since many houses exist inside the Easement Zone and within the Lake Management area below LML, land use management including resettlement of houses is necessary to be conducted by LLDA with the cooperation of the LGUs and the related agencies.

(2) Proposed Improvement of the Disaster Risk Management System of the Laguna Lake Basin including the Low-lying Areas along the Laguna de Bay Lakeshore

The Laguna de Bay Area, including the Lake, belongs to NCR and Region IV-A, and many LGUs belong to these two regions. In addition, there are many government agencies such as LLDA, MMDA, DPWH and DENR related to the Laguna de Bay Area. In order to strengthen and enhance DRRM in the whole Laguna de Bay Area, it is necessary to formulate a comprehensive master plan covering the four (4) areas of DRRM, and to implement a well-balanced DRRM for the whole Laguna de Bay Area based on the Master Plan. Especially, for the Area of Prevention & Mitigation and the Area of Preparedness, it is preferable to implement and strengthen them before the occurrence of disasters as much as possible.

In order to proceed with a well-balanced DRRM in the Laguna de Bay Area, it is necessary to implement DRRM based on horizontal and vertical coordination and cooperation among the many LGUs as well as among the related agencies. For this, the following two items are proposed.

- Proposal on coordination, cooperation and monitoring by NDRRMC on the whole DRRM in the Laguna de Bay Area.

  The National Disaster Risk Reduction and Management Council (NDRRMC) will have the central role of vertical and horizontal coordination and cooperation between the national governmental agencies and the LGUs. Under the vertical and horizontal coordination and cooperation, the related agencies and LGUs shall have the same targets, and jointly implement a well-balanced DRRM including climate change adaptation (CCA) for the entire Laguna de Bay Area. Furthermore, the NDRRMC shall monitor the progress of DRRM, and, if there is any problem, shall make discussion on measures for improving the situation. It is noted that the same was also proposed in the World Bank Master Plan on the Flood Management for the Metro Manila and Surrounding Areas in 2012.

- Proposal on implementation of DRRM based on DRRM Master Plan for the whole Laguna de Bay Area

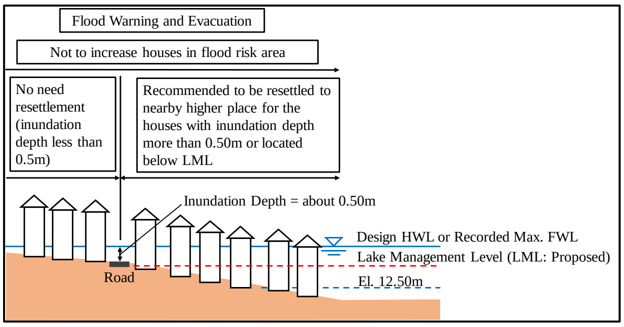
  A master plan for comprehensive DRRM, which will be the basis of proceeding with the well-balanced DRRM in the whole Laguna de Bay Area, shall be formulated. In the Master Plan, especially for the proactive approach before occurrence of disasters, disaster Prevention and Mitigation and Flood Forecasting and Warning Systems will be focused. Then, implementation of these for the entire Laguna de Bay Area will be promoted. It is noted that a flood risk management master plan for the Laguna Lake Basin was formulated by the World Bank Study in 2012. In this JICA Study, by focusing on Prevention and Mitigation, an master plan will be formulated.

(3) Proposal on Non-structural Measures focusing on Land Use Management in the Low-lying Areas along the Laguna de Bay Lakeshore Areas

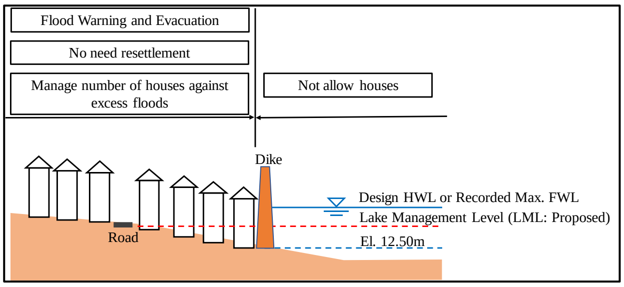
Prevention & Mitigation by land use management in combination with flood warning and evacuation is proposed for the low-lying areas with flood risk along the Laguna de Bay Lakeshore. For proposing them, by assuming various cases of possible flood control facilities made by public and private concerns, patterns of non-structural measures for these cases are studied (see Figure 4.7.8). Following table shows the proposed non-structural measures.

Table 4.7.2 Proposed Non-structural Measures of Mainly Land Use Management for the Low-lying Areas in the Laguna de Bay Lakeshore

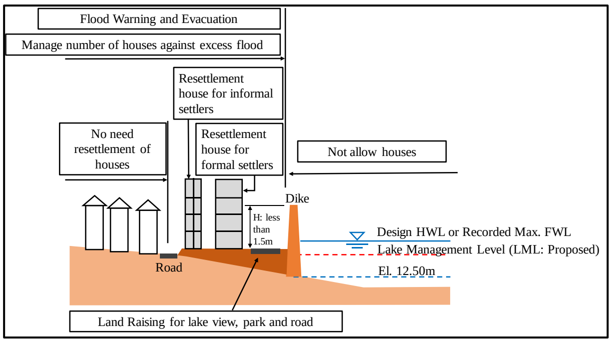
Non-structural Measures	Contents
1. Resettlement of Inhabitants from Flood Risk Areas	Inhabitants living in low elevation land below the Lake Management Level (LML) are recommended to be resettled to nearby land with less flood risks.
2. Control for Not Increasing Houses in Flood Risk Areas	For both cases of without and with flood protection facilities, in order to prevent increasing density of houses in the low-lying areas with flood risks, building of houses will be regulated based on the monitoring of distribution of houses. Considering occurrence of excess floods, building of houses will be regulated even in the case of with flood protection facilities.
3. Setting Evacuation Places and Evacuation Buildings (Shelters)	Especially for rural areas located in wide low-lying lakeshore areas, it is preferable to set higher and wider evacuation places where people and their livestock will evacuate from floods of long duration. In addition, evacuation buildings (shelters) shall be built on the evacuation places where people can evacuate for several months.
4. Development of Flood Forecasting and Warning System	In order to monitor flash floods of the inflow rivers and lake water level change and to announce flood warning, flood forecasting and warning system shall be developed [described in 3.4.2(4)].



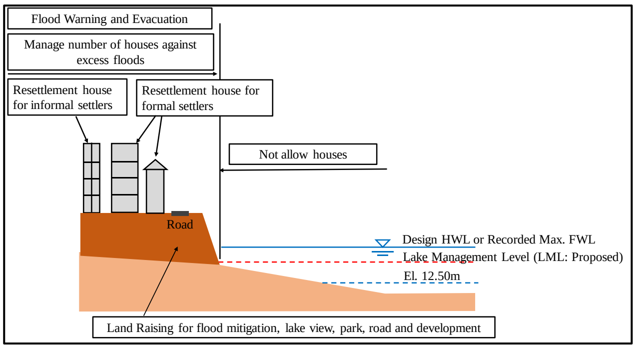
Case-1: Non-structural Measures in the West Lakeshore Area of the Laguna de Bay without Flood Prevention and Mitigation Measures



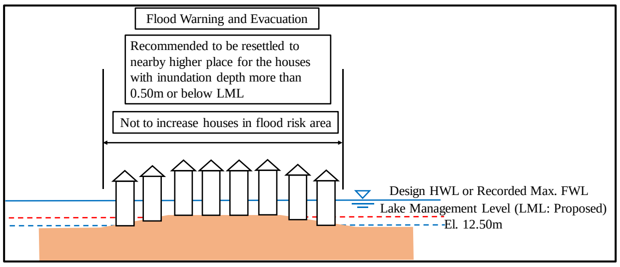
Case-2: Non-structural Measures in the West Lakeshore Area of the Laguna de Bay with Flood Protection Dike



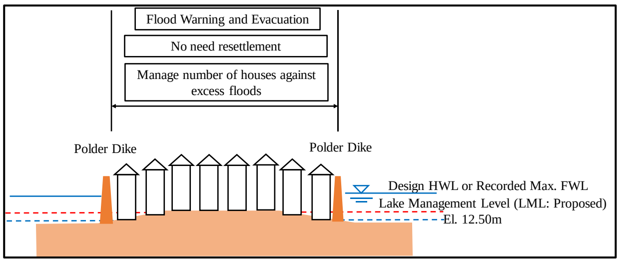
Case-3: Non-structural Measures in the West Lakeshore Area of the Laguna de Bay with Flood Protection Dike and Land Raising for Lake View



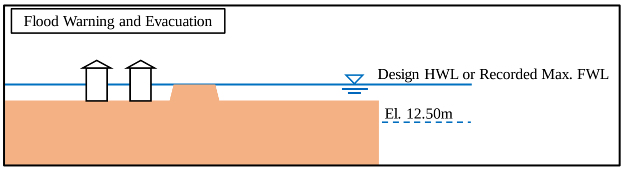
Case-4: Non-structural Measures in the West Lakeshore Area of the Laguna de Bay with Land Raising above LML



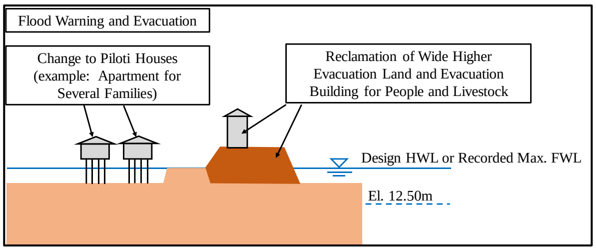
Case-5: Non-structural Measures in the Wide Flat Low-lying Area without Flood Prevention and Mitigation Measures



Case-6: Non-structural Measures in the Wide Flat Low-lying Area with Polder Dikes



Case-7: Non-structural Measures in the Wide Flat Low-lying Rural Area with Small Density of Houses



Case-8: Non-structural Measures in the Wide Flat Low-lying Rural Area with Small Density of Houses and Evacuation Facility and "Piloti" Houses

Source: JICA Study Team

Figure 4.7.8 Proposed Non-structural Measures by Mainly Land Use Management in the Laguna Lakeshore

(4) Proposed Flood Warning System for the Laguna Lake Basin including the Lakeshore

Following are the proposed flood forecasting and warning systems covering the whole Laguna Lake Basin (see Figure 4.7.9).

- Strengthening rainfall and water level observation systems for the flood forecasting and warning system in the Laguna Lake Basin

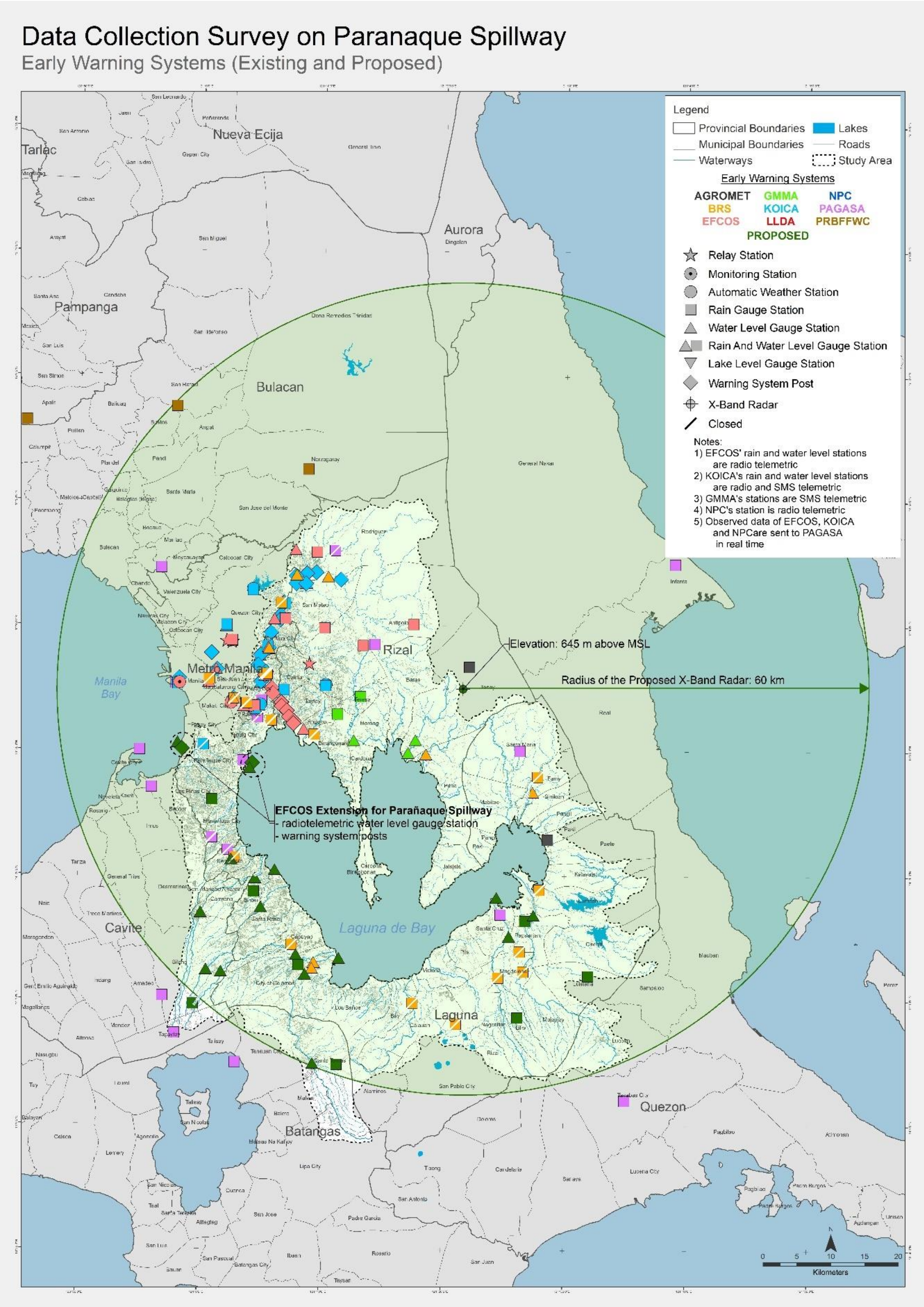
  Radio telemetric rainfall and float type water level gauges shall be installed in the Laguna de Bay and in the inflow rivers. In addition, one unit of X-band radar is proposed to be installed for facilitating forecasting and warning of flash floods from the inflow-rivers. Observed data shall be sent to PAGASA in real-time to utilize the data for flood forecasting and warning information by PAGASA.

- Installation of rainfall and water level observation facilities and conduct of observation by all of the LGUs around the Laguna de Bay

  Many of the LGUs around the Laguna de Bay are already conducting rainfall and water level observations in the inflow-rivers as well as in the Lake by themselves. The observed data are utilized for announcing flood warning and alert information to inhabitants. It is proposed to conduct this kind of rainfall and water level observation by all of the LGUs around the Laguna de Bay. Through this, warning and evacuation in all of the LGUs around the Laguna de Bay will be strengthened.

- Water level observation for Parañaque Spillway and conduct of warning to inhabitants on water through the Spillway

  In case of construction of Parañaque Spillway, MMDA may conduct the operation and maintenance of spillway facilities. In case of discharging water from the Laguna de Bay to the Manila Bay, it will be necessary to warn people around the Spillway. To make sure that the water is released properly, it is proposed to install radio telemetric water level gauges at the inlet and outlet points of the Spillway. Furthermore, in order to announce warning to people about the release of water, sirens are proposed to be installed at each inlet and outlet of the Spillway.



Source: JICA Study Team

Figure 4.7.9 Proposed Flood Forecasting and Warning System for the Laguna Lake Basin

CHAPTER 5. COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR LAGUNA DE BAY LAKESHORE AREA

5.1 Formulation of Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area

5.1.1 Combination of Flood Management Measures Selected in the First Step

The full menu proposed in the Section 4.1.3 was preliminary evaluated in terms of the flood management and the feasibility of the measures and the candidates of the primary measures were selected. In addition, further study was conducted in order to select the most efficient and feasible measures and listed as follows.

Table 5.1.1 Flood Management Measures (First Step)

Control and Prevention of Water Level Rise	Mitigation of Inundation Damage	Non-Structural Measure
・ Construction of Parañaque Spillway	・ Construction of Lakeshore Diking System at the Priority Area	・ Implementation of the lakeshore management ・ Establishment of the committee for the Laguna de Bay Basin ・ Land use regulation ・ Implementation of warning system ・ Inundation hazard map

Source: JICA Survey Team

Above mentioned and selected flood management measures in the first step, following single or combined structural measure/s were studied. Since covering the entire lakeshore area with the structural measure is not feasible in aspects of the implementation period and financial resources, the non-structural measure was proposed at the area as a part of flood management plan, where the structural measure could not cover.

Table 5.1.2 Proposed Combination of the Flood Management Menu

Case	Target	Structural Measure	Non-Structural Measure
A	Prevention of Flood Damage	・ Construction of Lakeshore Diking System at the Priority Area	・ Implementation of the lakeshore management ・ Establishment of the committee for the Laguna de Bay Basin ・ Land use regulation ・ Implementation of warning system ・ Inundation hazard map
B	Mitigation of Flood Damage	・ Construction of Parañaque Spillway	(same as above)
C	Prevention of Flood Damage	・ Construction of Lakeshore Diking System at the Priority Area ・ Construction of Parañaque Spillway	(same as above)

Source: JICA Survey Team

Case A: Priority Area will be protected by the structural measure to the 100-year probable lake water level. Flood damage at the residual area will be reduced by a warning system.

Case B: Although total protection to the flood caused by 100-year probable lake water level cannot be provided, flood mitigation such as reduction of the inundation depth and period can be made.

Case C: Priority Area will be protected by the structural measure to the 100-year probable lake water level. With combining the construction of the Parañaque Spillway, the height of the lakeshore dike can be lowered considering the water level drawdown by the Parañaque Spillway. This effect of drawdown goes to the entire lakeshore area.

5.1.2 Evaluation of the Structural Measure Combination and Formulation of Comprehensive Flood Management Plan of Laguna De Bay Lakeshore Area (Secondary Step)

Referring to the evaluation criterion proposed in the Section 4.1.2, the previously mentioned combinations of the structural measures were evaluated. The score is ◎: 10 (20), ○: 7 (14), △: 4 (8), ×: 1 (2). The results of the evaluation were summarized in Table 5.1.3. Besides, the river improvement at the selected rivers are not included in this evaluation.

Table 5.1.3 Evaluation of the Structural Measure Combination

No.	Criteria	Index	Case A	Case B	Case C
			Lakeshore Diking System at the Priority Area	Parañaque Spillway	Lakeshore Diking System at the Priority Area and Parañaque Spillway
	Design Level		100-year Probability	100-year Probability	100-year Probability
	Design High Lake Water Level		EL. 14.3 m	EL. 14.0 m (by the effect of the Parañaque Spillway)	EL. 14.0 m (by the effect of the Parañaque Spillway)
	Parañaque Spillway		-	Route A and D were considered. As tunneling method, Shield Tunneling Method and NATM were considered. As cheapest case, Route A + NATM was studied, and as most expensive case, Route D + Shield Tunneling Method was studied.	Same as Case B
1	Mitigation and Management of Disaster Risk	(1) Lake water drawdown	No lake water drawdown effect	・By 0.3m from EL 14.3 m (100-year) to EL. 14.0 m ・By 0.1 m to 0.3 m for the cases with 50-year, 30-year, 20-year, 10-year, 5-year and 2-year probability ・By 0.55 m from EL 13.85 m in the case in 2009 ・By 0.3 m from EL 13.89 m in the case in 2012	Same as Case B
		(2) Reduction of inundated area	・Phase 1 Agriculture: 50ha Resident: 520ha ・Phase 2 Agriculture: 550ha Resident: 940ha ・Phase 3 Agriculture: 2040ha Resident: 540ha ・Total Agriculture: 2640ha Resident: 2000ha	・Although this method cannot prevent the flood damage at 100%, following flood damage mitigation can be achieved ・Total Agriculture: 5080ha Resident: 2640ha	・After completion of he Parañaque Spillway and before completion of the lakeshore dike, benefit by the spillway can be counted. ・After completion of the lakeshore dike, following benefit by the lakeshore dike is additionally counted.

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Criteria</th><th rowspan="2">Index</th><th>Case A</th><th>Case B</th><th>Case C</th></tr>
<tr><th>Lakeshore Diking System at the Priority Area</th><th>Parañaque Spillway</th><th>Lakeshore Diking System at the Priority Area and Parañaque Spillway</th></tr>
<tr><td></td><td></td><td>(3) Reduction of affected people</td><td>・Phase 1 : 145,000
・Phase 2 : 257,000
・Phase 3 : 91,000
・Total 493,000</td><td>・Although 100% of reduction cannot be expected, flood damage mitigation is expected for the following people.
・Total : 624,000</td><td>・After completion of he Parañaque Spillway and before completion of the lakeshore dike, benefit by the spillway can be counted.
・After completion of the lakeshore dike, following benefit by the lakeshore dike is additionally counted.</td></tr>
<tr><td></td><td></td><td>(4) Reduction of inundation period</td><td>No inundation after the completion of the lakeshore dike</td><td>・The inundated days with the lake water level of EL 12.5 m or above can be shortened from 124 days to 79 days (64%)
・Reduction ratio of inundated days with the lake water level of EL 12.5 m or above is from 30% to 60% for the cases with 50-year, 30-year, 20-year, 10-year, 5-year and 2-year probability
・from 110 days to 46 days (43%) in the case in 2009 (at above EL 12.5 m)
・from 108 days to 63 days (60%) in the case in 2012 (at above EL 12.5 m)</td><td>・Same as Case B after completion of the Parañaque Spillway and before completion of the lakeshore dike,
・After completion of the lakeshore dike, benefit of the spillway and the lakeshore dike is counted.</td></tr>
<tr><td></td><td></td><td>Score (10)</td><td>○ (7)</td><td>△ (4)</td><td>◎ (10)</td></tr>
<tr><td>2</td><td>Technical Difficulty</td><td>(1) Difficulty of design</td><td>No difficulty on designing since it is mainly composed of earth dike.</td><td>Although it is a large scaled tunnel and an underground structure at 50 m or deeper with technical difficulties, it is feasible with know-how and experiences in Japan.</td><td>Same as the evaluation in Case A and B</td></tr>
<tr><td></td><td></td><td>(2) Difficulty of administration process before construction</td><td>・This case results in constructing the wall with a little less than 3 m high and it will limit the access to the lake from the land side. It is expected that it takes time for negotiation and consensus building with fishermen and residents.
・Land acquisition and relocation will be required.
(Details are described in “4. Natural Environment” and “5. Social Environment” in this table.)</td><td>・Less social impact such as relocation and consensus building since it is designed deep underground at 50 m
・Relocation and consensus building will be required at the inlet and outlet of the spillway.
(Details are described in “7. Natural Environment” and “8. Social Environment” in this table.)</td><td>It is realistic that the spillway which has relatively less difficulty on administration processes is commenced first, then the lakeshore dike which requires more time for those is commenced later.</td></tr>
</table>

No.	Criteria	Index	Case A Lakeshore Diking System at the Priority Area	Case B Parañaque Spillway	Case C Lakeshore Diking System at the Priority Area and Parañaque Spillway
		(3) Difficulty of construction	・No difficulty on constructing since it is mainly composed of earth dike. ・Acquisition of the earth dike material is an issue.	Although it is a large scaled tunnel and an underground structure at 50 m or deeper with technical difficulties, it is feasible with know-how and experiences in Japan.	Same as the evaluation in Case A and B
		(4) Year of completion	・Phase 1 : yr 2029 ・Phase 2 : yr 2039 ・Phase 3 : yr 2049	Yr 2030	Same as the evaluation in Case A and B
		(5) Influence to the existing structures and plan for flood management	・Design high lake water level is EL. 14.3 m, crest elevation of the lakeshore dike is EL 15.3 m, crown elevation of the dikes of Mangahan Floodway at the lake side is EL. 15m. ・Dike at Mangahan Floodway needs to be elevated by 30 cm. ・The crest elevation of the west Mangahan lakeshore dike is also EL 15.0 m and needs to be elevated by 30 cm. ・High water level of Napindan Channel is 13.8m, crest elevation of parapet wall is EL. 14.1 m. Parapet wall of Channel need to be elevated by 50 cm.	・Design high lake water level is EL. 14.0 m, crest elevation of the lakeshore dike is EL 15.0 m. ・Except for Napindan Channel, no influence on the existing structure and plan ・High water level of Napindan Channel is 13.8m, crest elevation of parapet wall is EL. 14.1 m. Parapet wall of Channel needs to be elevated by 20 cm	・Design high lake water level is EL. 14.0 m, crest elevation of the lakeshore dike is EL 15.0 m. ・Except for Napindan Channel, no influence on the existing structure and plan ・High water level of Napindan Channel is 13.8m, crest elevation of parapet wall is EL. 14.1 m. Parapet wall of Channel needs to be elevated by 20 cm
		Score (10)	× (1)	◎ (10)	◎ (10)
3	Flood Exceeding Design Scale, Climate Change Adaptation	(1) Adaptation to flood exceeding design scale	The free board of the lakeshore dike is utilized for the lake water level rise.	・The spillway shows the effect to the flood exceeding design scale. ・The spillway lowers the water level of 14.7 m in 200-year probability by 0.4m and reduces the inundation period with water level at EL. 12.0 and above from 141 days to 93 days (66%).	Sufficient effect can be expected with the lake water level lowering effect by the spillway and the free board of the lakeshore dike.
		(2) Adaptation to climate change	The free board of the lakeshore dike is utilized for the lake water level rise and heavier rainfall.	It is estimated that the water level rises to 14.6m from 14.3m. The spillway can lower the water level under this environment by 0.4 m.	Sufficient effect can be expected with the lake water level lowering effect by the spillway and the free board of the lakeshore dike.
		Score (10)	△ (4)	○ (7)	◎ (10)
4	Natural Environment	(1) Water quality	No direct effect caused by construction of the lakeshore dike is expected.	The water quality in Laguna de Bay is better than the one in Manila Bay. Hence no negative impact in aspect of the water quality is expected.	・Same as the evaluation in Case A and B

No.	Criteria	Index	Case A Lakeshore Diking System at the Priority Area	Case B Parañaque Spillway	Case C Lakeshore Diking System at the Priority Area and Parañaque Spillway
		(2) Lakeshore landscape preservation	This case results in constructing the wall with a little less than 3 m high and it will limit the access to the lake from the land side. Some disturbance on the landscape can be expected.	No significant impact due to the construction of inlet of the spillway at the lake side.	・Same as the evaluation in Case A and B
		Score (10)	△ (4)	◎ (10)	△ (4)
5	Social Environment	(1) Nos of relocated people	・Although the lakeshore dike will be constructed at the lower area than EL 12.5 m, there are some relocation. ・Lakeshore Dike: 7,200 ・Backwater Levee: 4,400	Some minor relocation will be required at the inlet and the outlet of the spillway	・Same as the evaluation in Case A and B
		(2) Area of land acquisition	・Although the lakeshore dike will be constructed at the lower area than EL 12.5 m, there are some relocation. ・Lakeshore Dike: 1,100 ha ・Backwater Levee: 120 ha.	Some land acquisition will be required at the inlet and the outlet of the spillway	・Same as the evaluation in Case A and B
		(3) Influence of construction	A large amount of earth material will be transported, and it may cause the traffic congestion.	・Transport method of the excavated material for the tunneling and finding dump site are the issues. ・Excavated material can be utilized for embankment.	・Same as the evaluation in Case A and B
		(4) Influence to local area	・This case results in constructing the wall with a little less than 3 m high and it will limit the access to the lake from the land side. It is expected that it takes time for negotiation and consensus building with fishermen and residents. This could be an issue during the operation.	・Operation rule will be required for the flood at the connected river at the outlet side. ・River improvement at the outlet side will be also required.	・Same as the evaluation in Case A and B
		Score (20)	× (2)	○ (14)	△ (8)
6	O/M Difficulty (refer to Table 5.1.20 for the details)	Difficulty of operation and maintenance, O/M Cost	・General structure. No special concern on maintenance. ・O/M Cost: PHP 286 mil.	・Although it is a large scaled tunnel and an underground structure at 50 m or deeper with technical difficulties, it is feasible with know-how and experiences in Japan. ・O/M Cost: PHP 211 to 278 mil.	・Same as the evaluation in Case A and B ・Lakeshore dike: PHP 265 mil. ・Spillway: PHP 211 to 278 mil. ・Total: 476 to 545 mil.
		Score (10)	○ (7)	△ (4)	△ (4)
7	Financial Feasibility (refer to Table 5.1.8 to Table 5.1.11 for the details)	(1) Construction Cost	Construction Cost: PHP 45.69 bln.	Construction Cost: PHP 36.15 to 49.12 bln.	・Lakeshore dike: PHP 42.07 bln. ・Spillway: PHP 36.15 to 49.12 bln. ・Total: PHP 78.22 to 91.19 bln.

No.	Criteria	Index	Case A Lakeshore Diking System at the Priority Area	Case B Parañaque Spillway	Case C Lakeshore Diking System at the Priority Area and Parañaque Spillway
		(2) Project Cost	Project Cost: PHP 94.16 bln.	Project Cost: PHP 55.41 to 74.58 bln.	Project Cost: PHP 143.1 to 162.3 bln.
		Score (10)	○ (7)	○ (7)	△ (4)
8	Economics	(1) Reduction of flood damage	・Yearly average flood damage reduction ・Phase 1 : PHP 1.48 bln. ・Phase 2 : PHP 1.80 bln. ・Phase 3 : PHP 1.07 bln. ・Total : PHP 4.35 bln.	・Yearly average flood damage reduction ・Total : PHP 3.23 bln.	・After completion of the Parañaque Spillway and before completion of the lakeshore dike, benefit by the spillway can be counted. ・After completion of the lakeshore dike, following benefit by the lakeshore dike is additionally counted.
		(2) Benefit except for flood sector (Road)	Yearly average benefit by road ・Phase 1 : PHP 0.30 bln. ・Phase 2 : PHP 0.58 bln. ・Phase 3 : PHP 0.27 bln. ・Total : PHP 1.15 bln.	No benefit except for the flood sector	After completion of the lakeshore dike, same as Case A
		(3) Increase of land price	Value of 50% of land protected by lakeshore dike is considered to increase by 15% during first 5 years	Value of 50% of land protected by spillway is considered to increase by 15% during first 10 years	・Same as the evaluation in Case A and B
		(4) EIRR	・Flood control: EIRR: 13.5% ・Flood control + Road EIRR: 15.9 %	EIRR: 8.2% to 10.3%	EIRR: 8.8% to 10.7%
		(5) B/C	・Flood control: B/C: 1.36 ・Flood control + Road B/C: 1.65	B/C: 0.78 to 1.04	B/C: 0.86 to 1.08
		(6) NPV	・Flood control: NPV: PHP 5.5 bln. ・Flood control + Road ・NPV: PHP 9.8 bln.	PHP -6.8 bln. ~ PHP 0.8 bln.	PHP -6.2 bln. ~ PHP 2.8 bln.
		Score (20)	◎ (20)	△ (8)	○ (14)
	Total Score		**52**	**64**	**64**

Note: the values for the inundation area, inundated population, land acquisition area and relocated persons are roughly estimated by the JICA Survey Team

Source: JICA Survey Team

The Lakeshore diking system requires a large number of relocation of local people and land acquisition with the influence on the fishery at Laguna de Bay. It also requires a long period of construction such as 20 years to 30 years. On the other hand, the Parañaque Spillway has a feature to provide the flood mitigation effect to the entire lakeshore area evenly. In addition, the construction period is about 10 years or so, so that the early mitigation effect can be expected. Hence, it is presently considered to be appropriate to construct the Parañaque Spillway as the priority project and then to implement the lakeshore diking system with the drawdown water level effect of the Parañaque Spillway as the long-term project.

Based on the evaluation result, "Case C: Construction of the Lakeshore Diking System at the Priority Area, River Improvement at the Selected Rivers and Construction of the Parañaque Spillway" was selected as the target structure measures for secondary step, in other words, as a composition of "Comprehensive Flood Management Plan of Laguna de Bay Lakeshore Area."

5.1.3 Selection of Priority Project

(1) Selection of Priority Project (Structural Measure)

The comprehensive flood management plan with the structural measures were proposed in the Section 5.1.2. Among these structural components of the flood management plan, "Construction of the Parañaque Spillway" was selected from the following view pints.

- Inundation depth and period will be reduced at the entire Laguna de Bay Basin.
- The beneficial effects in terms of the reduction of the inundation depth and the flooding period caused by Laguna de Bay provided by the Parañaque Spillway are expected relatively early (such as within 10 years) and at wider area comparing to the ones by the Lakeshore Diking System.
- The Parañaque Spillway will be the early mitigation measure to the negative impact caused by the diverted flow from Marikina River through the Mangahan Floodway.
- It can be the responsiveness to the social impact which will be caused by the implementation of Marikina Control Gate Structure planned in Pasig-Marikina River Improvement Project Phase IV and can be expected to promote the Phase IV project.
- DPWH can take the governmental responsibility for flood management at the entire Laguna de Bay Basin with the Parañaque Spillway.

(2) Selection of Priority Project (Non-Structural Measure)

The structural measures previously proposed takes a role of the first step of the flood mitigation and will not cover the entire Laguna de Bay Basin. In the view of saving the life of people and avoiding the flood risk, the non-structural measures as the priority project were selected. In addition, it is important to raise the awareness to disaster risks that will deeply related with evacuation activities. Hence, preparation of the inundation hazard map and implementation of hydrological observation equipment.

Table 5.1.4 Non Structural Measure Component for Priority Project

Type of Measure	Criteria	Component
Non Structural Measures	Avoidance of Flood Risk	Expansion of installation of hydrological observation equipment and monitoring structures
	Awareness of Flood Risk	Preparation and distribution of inundation hazard map, campaign

Source: JICA Survey Team

5.1.4 Implementation Schedule

(1) Concept

The comprehensive flood management plan is a large-scale project and is expected to require a long period for the implementation. Hence, Total of 30 years for the project implementation is proposed which is composed of the target years of 10 years for the Short-Term Project, of 20 years for the Middle-Term Project and of 30 years for the Long-Term Project.

Table 5.1.5 Proposed Implementation Schedule for the Comprehensive Flood Management Plan of Laguna de Bay Lakeshore Area

No.		Component	Implementation Period: 30 years		
			Shot-term (10 years)	Middle-term (10 years)	Long-term (10 years)
I	Structural Measure				
	1)	Construction of Parañaque Spillway and Heightening of Parapet Wall of Napindan Channel			
	2)	Construction of Lakeshore Diking System at the Priority Area			
II	Non-structural measure				
	1)	Implementation of the lakeshore management			
	2)	Establishment and inauguration of the committee for the Laguna de Bay Basin			
	3)	Land use regulation			
	4)	Implementation and management of warning system			
	5)	Preparation and distribution of the Inundation hazard map, campaign			

Source: JICA Survey Team

(2) Planning Condition

As stated below, the implementation schedule is considered in three phases, i.e., short-term program for the 1st phase, middle-term program for the 2nd phase and long-term program for the 3rd phase, during 30 years from 2020 to 2049.

【Preparation】: 2018 to 2019

- F/S (1.5 years), ICC application and fund arrangement from the second half of F/S

【Phase 1】: January 2020 to December 2029

- Procurement of Consultant in parallel with STEP D/D (Parañaque Spillway), after approval of ICC, signing Exchange of Notes (E/N), Loan Agreement (L/A), selection of contractor in 2021
- Detailed Design (D/D): January 2025 to December 2026 (Phase 2)
- Construction Project
  a. Parañaque Spillway (Route A: L=7.8 km, Route D: L=9.6 km)

     Option 1: Route A, Shield Tunneling Method: January 2022 to June 2029

     Option 2: Route A, NATM: January 2022 to March 2031

     Option 3: Route D, Shield Tunneling Method: January 2022 to November 2029

     Option 4: Route D, NATM: January 2022 to December 2031

b. Lakeshore Diking Systems (L=17.0 km) (Inclusive of Pumping Stations, Bridges, Sluice Gates and Backwater levees)

c. Expansion of EFCOS

【Phase 2】: January 2030 to December 2039

- Detailed Design (D/D), Tendering: January 2035 to December 2036 (Phase 3)
- Construction Project

d. Lakeshore Diking Systems (L=32.8km) (Inclusive of Pumping Stations, Bridges, Sluice Gates and Backwater levees)

【Phase 3】: January 2040 to December 2049

- Construction Project

e. Lakeshore Diking Systems (L=32.9km) (Inclusive of Pumping Stations, Bridges, Sluice Gates and Backwater levees)

(3) Implementation Schedule

The implementation schedules based on the above conditions are shown in Figure 5.1.1 (Route A) and Figure 5.1.2 (Route D), respectively. As stated above, there are four (4) options for Parañaque Spillway, and the schedules for two options in each route are shown in the said Figures.

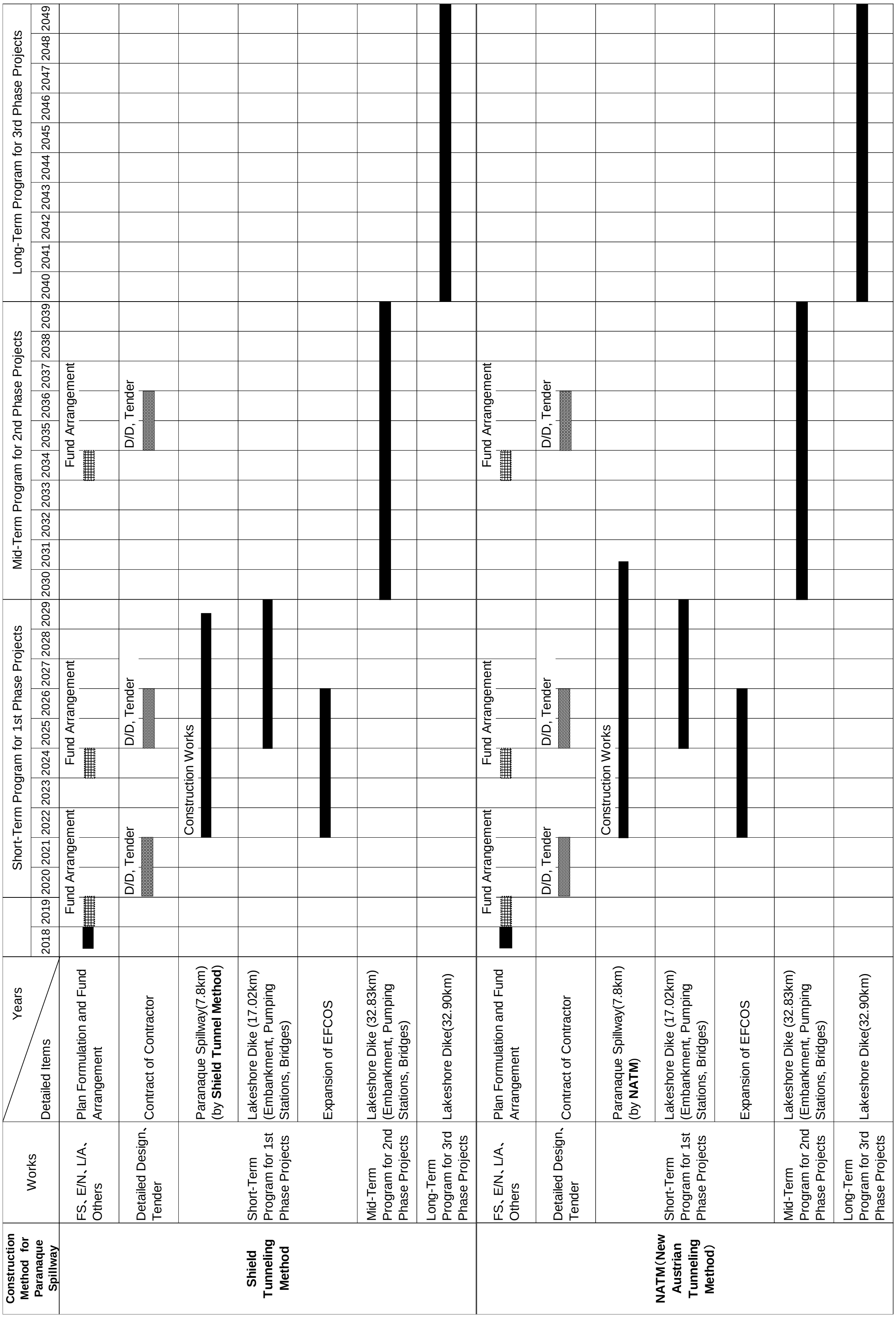


Figure 5.1.1 Implementation Schedule (Parañaque Spillway: Route A)

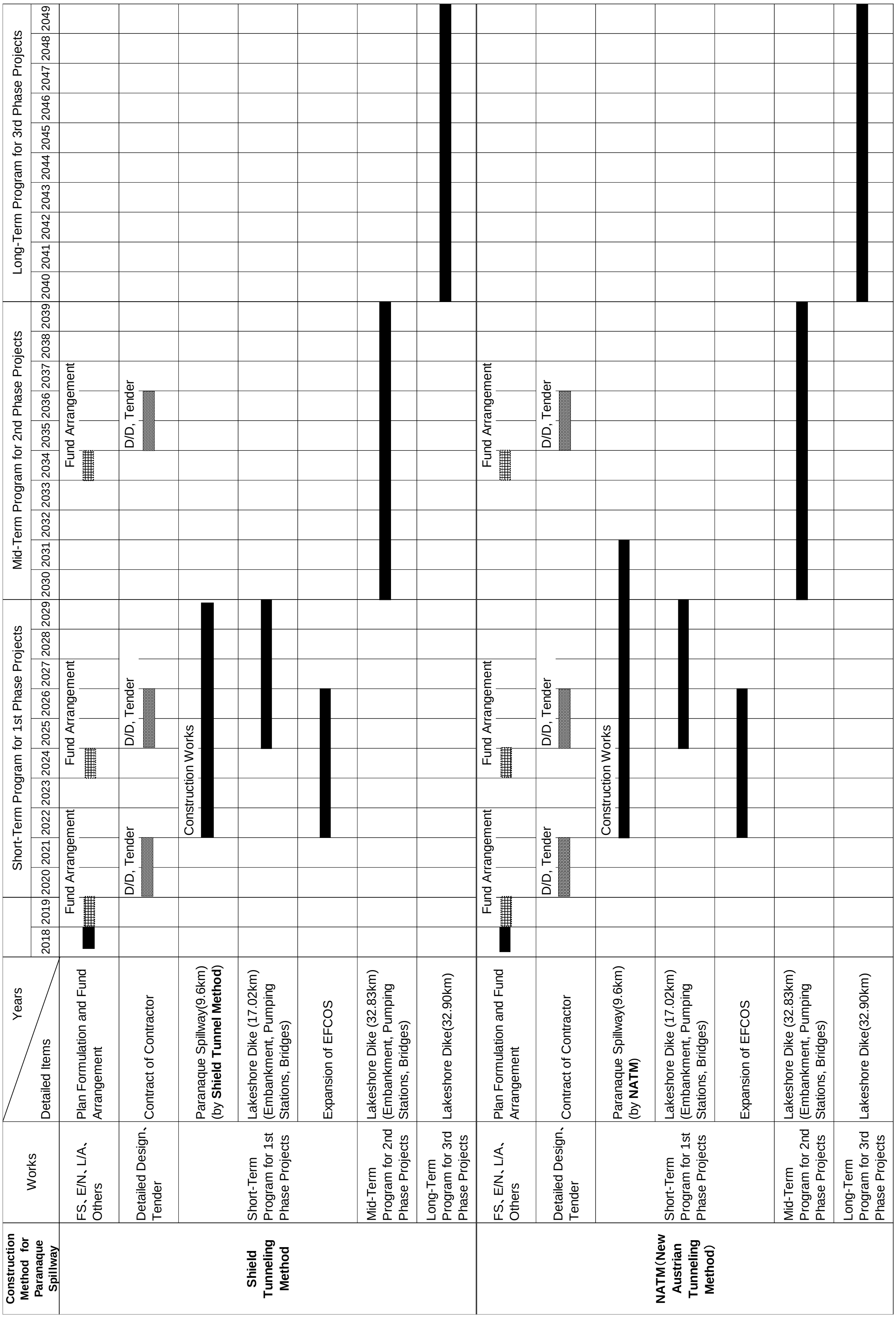


Figure 5.1.2 Implementation Schedule (Parañaque Spillway: Route D)

5.1.5 Preliminary Cost Estimate

(1) Project Cost Items

The project cost items are as follows:

- Construction Cost
- Engineering Cost (the cost for consulting services)
- Price Escalation
- Contingency

The following are non-eligible loan items:

- Land acquisition and compensation
- Project administration cost by project implementation body
- TAX (VAT)

(2) The policy on the calculation of construction cost

The construction cost, which is based on the calculation of project cost, is roughly calculated by the policy stated in the following table.

Table 5.1.6 The Policy on the Calculation of Construction Cost

Construction Project	Policy on Cost Estimate
Parañaque Spillway	There are no past experiences on big tunneling projects in the Philippines. Therefore, cost estimation will be done assuming the implementation of tunneling project in Philippines in reference to the examples in other countries including Japan and information obtained by hearing from Japanese Contractors and Specialist Contractors.
Lakeshore Diking Systems (Inclusive of Pumping Stations, Bridges, etc.)	Base unit costs are considered in reference to past projects such as "Metro Manila Flood Control Project – West of Mangahan Floodway" (Tender Year: 2000) and also adjusted by the price escalation up to base year of cost estimate, i.e., September 2017.
Expansion of EFCOS	Cost estimate for concerned project is based on the information by hearing from PAGASA.

(3) Calculation Condition of Project Cost

The following conditions are applied to calculate Project Cost.

Table 5.1.7 Calculation Condition of Project Cost

Items	Conditions	Remarks
Base Year of Cost Estimate	September 2017	
Exchange Rate	1USD=110.96JPY; 1USD=50.84PHP、1PHP=2.183JPY	Refer to data on Exchange Rates in IMF homepage (Average rate from July 2017 to September 2017)
Engineering Cost	10% of Construction Cost	

Items	Conditions	Remarks
Price Escalation	Price Escalation regarding Construction Cost, Engineering Cost F/C 0.8%、L/C 1.8%	Refer to “World Economy Outlook” published in the IMF homepage
Contingency	10% of total amount for construction cost, engineering cost and price escalation	
Land Acquisition, Compensation	Detailed calculation for land acquisition and compensation for building removal (Inclusive of price escalation 1.8% for LC and also contingency 10%)	
Project Administration Cost for project implementation body	**2**% of total amount of construction cost, engineering cost and the cost for land acquisition and compensation	
VAT	12.0%	

(4) Calculation of Project Cost

Project Costs based on the above policy and conditions are shown in Table 5.1.8 to Table 5.1.11.

As stated in the planning condition of implementation schedules, the following four (4) options for Parañaque Spillway are applied for the construction cost which is the basis of project cost.

Option 1: Parañaque Spillway (Route A, Shield Tunneling Method), Lakeshore Diking Systems, Expansion of EFCOS

Option 2: Parañaque Spillway (Route A, NATM), Lakeshore Diking Systems, Expansion of EFCOS

Option 3: Parañaque Spillway (Route D, Shield Tunneling Method), Lakeshore Diking Systems, Expansion of EFCOS

Option 4: Parañaque Spillway (Route D, NATM), Lakeshore Diking Systems, Expansion of EFCOS

Table 5.1.8 Project Cost (Option 1)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route A, Shield Tunneling Method)	13,000	32,876	45,876
	Lakeshore Diking Systems	8,415	33,658	42,073
	Expansion of EFCOS	80	34	114
	Sub-Total	21,494	66,568	88,063
Engineering Cost		4,403	4,403	8,806
Price Escalation		2,829	8,903	11,732
Contingency		2,394	18,054	20,449
Land Acquisition, Compensation		0	8,786	8,786
Administration Cost		0	2,757	2,757
VAT		0	16,540	16,540
Total (million PHP)		31,121	126,012	157,133

Table 5.1.9 Project Cost (Option 2)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route A, NATM)	9,460	26,688	36,148
	Lakeshore Diking Systems	8,415	33,658	42,073
	Expansion of EFCOS	80	34	114
	Sub-Total	17,955	60,380	78,335
Engineering Cost		3,917	3,917	7,833
Price Escalation		2,413	8,198	10,611
Contingency		2,257	17,687	19,944
Land Acquisition, Compensation		0	8,786	8,786
Administration Cost		0	2,510	2,510
VAT		0	15,061	15,061
Total (million PHP)		26,541	116,541	143,082

Table 5.1.10 Project Cost (Option 3)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route D、Shield Tunneling Method)	13,889	35,233	49,121
	Lakeshore Diking Systems	8,415	33,658	42,073
	Expansion of EFCOS	80	34	114
	Sub-Total	22,383	68,925	91,308
Engineering Cost		4,565	4,565	9,131
Price Escalation		2,942	9,198	12,140
Contingency		2,470	18,493	20,964
Land Acquisition, Compensation		0	8,786	8,786
Administration Cost		0	2,847	2,847
VAT		0	17,080	17,080
Total (million PHP)		32,360	129,895	162,255

Table 5.1.11 Project Cost (Option 4)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route D, NATM)	10,499	27,153	37,653
	Lakeshore Diking Systems	8,415	33,658	42,073
	Expansion of EFCOS	80	34	114
	Sub-total	18,994	60,846	79,840
Engineering Cost		3,992	3,992	7,984
Price Escalation		2,536	8,290	10,826
Contingency		2,374	18,062	20,435
Land Acquisition, Compensation		0	8,786	8,786
Administration Cost		0	2,557	2,557
VAT		0	15,345	15,345
Total (million PHP)		27,895	117,878	145,773

(5) Cost Disbursement Schedule

Cost Disbursement Schedules are considered based on the implementation schedule (four options) from 2020.

Table 5.1.12 Cost Disbursement Schedule (Option 1, Breakdown of Construction Cost)

(Unit: Million of PHP)

Phase	Year	Paranaque Spillway (Route A Shield)			Lakeshore Diking Systems (Inclusive of Backwater Levees, Pumping			Expansion of EFCOS			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2020	0	0	0	0	0	0	0	0	0	0	0	0
	2021	0	0	0	0	0	0	0	0	0	0	0	0
	2022	1,733	4,383	6,117	0	0	0	16	7	23	1,749	4,390	6,140
	2023	1,733	4,383	6,117	0	0	0	16	7	23	1,749	4,390	6,140
	2024	1,733	4,383	6,117	0	0	0	16	7	23	1,749	4,390	6,140
	2025	1,733	4,383	6,117	337	1,346	1,683	16	7	23	2,086	5,737	7,822
	2026	1,733	4,383	6,117	337	1,346	1,683	16	7	23	2,086	5,737	7,822
	2027	1,733	4,383	6,117	337	1,346	1,683	0	0	0	2,070	5,730	7,800
	2028	1,733	4,383	6,117	337	1,346	1,683	0	0	0	2,070	5,730	7,800
	2029	867	2,192	3,058	337	1,346	1,683	0	0	0	1,203	3,538	4,741
2	2030	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2031	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2032	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2033	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2034	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2035	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2036	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2037	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2038	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2039	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
3	2040	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2041	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2042	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2043	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2044	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2045	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2046	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2047	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2048	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2049	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
Total Cost		13,000	32,876	45,876	8,415	33,658	42,073	80	34	114	**21,494**	**66,568**	**88,063**

Table 5.1.13 Cost Disbursement Schedule (Option 1)

(Unit: Million of PHP)

Phase	Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
	2020	0	0	0	308	308	616	31	31	62	2	6	8	0	0	0	0	14	14	0	82	82	342	441	783
	2021	0	0	0	308	308	616	31	32	63	5	11	16	0	639	639	0	27	27	0	160	160	344	1,177	1,521
	2022	1,749	4,390	6,140	230	230	460	203	487	690	48	254	302	0	616	616	0	164	164	0	985	985	2,230	7,127	9,357
	2023	1,749	4,390	6,140	230	230	460	204	496	701	64	342	406	0	616	616	0	166	166	0	999	999	2,248	7,240	9,488
1	2024	1,749	4,390	6,140	230	230	460	206	505	711	80	431	512	0	616	616	0	169	169	0	1,013	1,013	2,266	7,354	9,620
	2025	2,086	5,737	7,822	308	308	616	251	673	924	117	683	800	0	0	0	0	203	203	0	1,219	1,219	2,762	8,823	11,585
	2026	2,086	5,737	7,822	308	308	616	253	685	938	137	804	941	0	698	698	0	220	220	0	1,322	1,322	2,784	9,774	12,558
	2027	2,070	5,730	7,800	308	308	616	253	696	950	157	926	1,083	0	711	711	0	223	223	0	1,339	1,339	2,788	9,933	12,721
	2028	2,070	5,730	7,800	307	307	615	255	709	964	177	1,051	1,228	0	724	724	0	227	227	0	1,360	1,360	2,809	10,107	12,917
	2029	1,203	3,538	4,741	307	307	615	164	460	623	125	751	876	0	737	737	0	152	152	0	911	911	1,799	6,855	8,655
	2030	337	1,346	1,683	78	78	156	45	173	219	38	309	347	0	0	0	0	48	48	0	288	288	498	2,243	2,741
	2031	337	1,346	1,683	78	78	156	46	176	222	42	340	382	0	0	0	0	49	49	0	293	293	502	2,283	2,784
	2032	337	1,346	1,683	78	78	156	46	180	226	45	372	417	0	0	0	0	50	50	0	298	298	506	2,323	2,829
	2033	337	1,346	1,683	78	78	156	46	183	229	49	404	453	0	0	0	0	50	50	0	303	303	510	2,364	2,874
	2034	337	1,346	1,683	78	78	156	47	186	233	53	437	490	0	0	0	0	51	51	0	307	307	514	2,406	2,920
2	2035	337	1,346	1,683	78	78	156	47	189	237	56	470	527	0	0	0	0	52	52	0	312	312	518	2,449	2,966
	2036	337	1,346	1,683	78	78	156	47	193	240	60	505	565	0	835	835	0	70	70	0	417	417	522	3,443	3,965
	2037	337	1,346	1,683	78	78	156	48	196	244	64	539	603	0	850	850	0	71	71	0	424	424	526	3,505	4,031
	2038	337	1,346	1,683	78	78	156	48	200	248	68	575	642	0	865	865	0	72	72	0	431	431	530	3,567	4,097
	2039	337	1,346	1,683	78	78	156	49	203	252	72	611	682	0	881	881	0	73	73	0	438	438	535	3,630	4,165
	2040	337	1,346	1,683	78	78	156	49	207	256	75	647	723	0	0	0	0	56	56	0	338	338	539	2,673	3,212
	2041	337	1,346	1,683	78	78	156	49	211	260	79	685	764	0	0	0	0	57	57	0	344	344	543	2,721	3,264
	2042	337	1,346	1,683	78	78	156	50	215	264	83	723	806	0	0	0	0	58	58	0	349	349	548	2,769	3,316
	2043	337	1,346	1,683	78	78	156	50	219	269	87	761	849	0	0	0	0	59	59	0	355	355	552	2,818	3,370
3	2044	337	1,346	1,683	78	78	156	51	222	273	91	800	892	0	0	0	0	60	60	0	360	360	556	2,868	3,424
	2045	337	1,346	1,683	78	78	156	51	226	277	95	841	936	0	0	0	0	61	61	0	366	366	561	2,919	3,479
	2046	337	1,346	1,683	78	78	156	51	231	282	99	881	981	0	0	0	0	62	62	0	372	372	565	2,970	3,536
	2047	337	1,346	1,683	78	78	156	52	235	287	104	923	1,026	0	0	0	0	63	63	0	378	378	570	3,023	3,593
	2048	337	1,346	1,683	78	78	156	52	239	291	108	965	1,073	0	0	0	0	64	64	0	384	384	574	3,077	3,651
	2049	337	1,346	1,683	78	78	156	53	243	296	112	1,008	1,120	0	0	0	0	65	65	0	391	391	579	3,131	3,710
Total Cost		21,494	66,568	88,063	4,403	4,403	8,806	2,829	8,903	11,732	2,394	18,054	20,449	0	8,786	8,786	0	2,757	2,757	0	16,540	16,540	**31,121**	**126,012**	**157,133**

Table 5.1.14 Cost Disbursement Schedule (Option 2, Breakdown of Construction Cost)

(Unit: Million of PHP)

Phase	Year	Paranaque Spillway (Route A NATM)			Lakeshore Diking Systems (Inclusive of Backwater Levees, Pumping Stations, Bridges)			Expansion of EFCOS			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2020	0	0	0	0	0	0	0	0	0	0	0	0
	2021	0	0	0	0	0	0	0	0	0	0	0	0
	2022	1,051	2,965	4,016	0	0	0	16	7	23	1,067	2,972	4,039
	2023	1,051	2,965	4,016	0	0	0	16	7	23	1,067	2,972	4,039
	2024	1,051	2,965	4,016	0	0	0	16	7	23	1,067	2,972	4,039
	2025	1,051	2,965	4,016	337	1,346	1,683	16	7	23	1,404	4,318	5,722
	2026	1,051	2,965	4,016	337	1,346	1,683	16	7	23	1,404	4,318	5,722
	2027	1,051	2,965	4,016	337	1,346	1,683	0	0	0	1,388	4,312	5,699
	2028	1,051	2,965	4,016	337	1,346	1,683	0	0	0	1,388	4,312	5,699
	2029	1,051	2,965	4,016	337	1,346	1,683	0	0	0	1,388	4,312	5,699
2	2030	1,051	2,965	4,016	337	1,346	1,683	0	0	0	1,388	4,312	5,699
	2031	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2032	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2033	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2034	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2035	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2036	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2037	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2038	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2039	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
3	2040	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2041	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2042	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2043	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2044	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2045	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2046	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2047	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2048	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2049	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
Total Cost		9,460	26,688	36,148	8,415	33,658	42,073	80	34	114	**17,955**	**60,380**	**78,335**

Table 5.1.15 Cost Disbursement Schedule (Option 2)

(Unit: Million of PHP)

Phase	Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2020	0	0	0	243	243	486	24	25	49	2	4	6	0	0	0	0	11	11	0	65	65	269	348	617
	2021	0	0	0	243	243	486	25	25	50	4	9	13	0	639	639	0	24	24	0	142	142	272	1,082	1,353
	2022	1,067	2,972	4,039	165	165	330	126	331	457	30	172	202	0	616	616	0	113	113	0	677	677	1,388	5,047	6,435
	2023	1,067	2,972	4,039	165	165	330	127	337	464	40	232	272	0	616	616	0	114	114	0	687	687	1,399	5,123	6,523
	2024	1,067	2,972	4,039	165	165	330	128	343	471	50	293	343	0	616	616	0	116	116	0	696	696	1,410	5,201	6,611
	2025	1,404	4,318	5,722	243	243	486	173	508	680	81	515	596	0	0	0	0	150	150	0	898	898	1,900	6,632	8,532
	2026	1,404	4,318	5,722	243	243	486	174	517	691	94	607	701	0	698	698	0	166	166	0	996	996	1,915	7,545	9,460
	2027	1,388	4,312	5,699	243	243	486	174	525	699	107	699	806	0	711	711	0	168	168	0	1,008	1,008	1,912	7,666	9,577
	2028	1,388	4,312	5,699	242	242	484	175	535	710	121	793	914	0	724	724	0	171	171	0	1,024	1,024	1,926	7,800	9,726
	2029	1,388	4,312	5,699	242	242	484	177	544	721	135	889	1,025	0	737	737	0	173	173	0	1,040	1,040	1,942	7,937	9,879
2	2030	1,388	4,312	5,699	242	242	484	178	554	732	149	987	1,137	0	0	0	0	161	161	0	966	966	1,957	7,223	9,180
	2031	337	1,346	1,683	78	78	156	46	176	222	42	340	382	0	0	0	0	49	49	0	293	293	502	2,283	2,784
	2032	337	1,346	1,683	78	78	156	46	180	226	45	372	417	0	0	0	0	50	50	0	298	298	506	2,323	2,829
	2033	337	1,346	1,683	78	78	156	46	183	229	49	404	453	0	0	0	0	50	50	0	303	303	510	2,364	2,874
	2034	337	1,346	1,683	78	78	156	47	186	233	53	437	490	0	0	0	0	51	51	0	307	307	514	2,406	2,920
	2035	337	1,346	1,683	78	78	156	47	189	237	56	470	527	0	0	0	0	52	52	0	312	312	518	2,449	2,966
	2036	337	1,346	1,683	78	78	156	47	193	240	60	505	565	0	835	835	0	70	70	0	417	417	522	3,443	3,965
	2037	337	1,346	1,683	78	78	156	48	196	244	64	539	603	0	850	850	0	71	71	0	424	424	526	3,505	4,031
	2038	337	1,346	1,683	78	78	156	48	200	248	68	575	642	0	865	865	0	72	72	0	431	431	530	3,567	4,097
	2039	337	1,346	1,683	78	78	156	49	203	252	72	611	682	0	881	881	0	73	73	0	438	438	535	3,630	4,165
3	2040	337	1,346	1,683	78	78	156	49	207	256	75	647	723	0	0	0	0	56	56	0	338	338	539	2,673	3,212
	2041	337	1,346	1,683	78	78	156	49	211	260	79	685	764	0	0	0	0	57	57	0	344	344	543	2,721	3,264
	2042	337	1,346	1,683	78	78	156	50	215	264	83	723	806	0	0	0	0	58	58	0	349	349	548	2,769	3,316
	2043	337	1,346	1,683	78	78	156	50	219	269	87	761	849	0	0	0	0	59	59	0	355	355	552	2,818	3,370
	2044	337	1,346	1,683	78	78	156	51	222	273	91	800	892	0	0	0	0	60	60	0	360	360	556	2,868	3,424
	2045	337	1,346	1,683	78	78	156	51	226	277	95	841	936	0	0	0	0	61	61	0	366	366	561	2,919	3,479
	2046	337	1,346	1,683	78	78	156	51	231	282	99	881	981	0	0	0	0	62	62	0	372	372	565	2,970	3,536
	2047	337	1,346	1,683	78	78	156	52	235	287	104	923	1,026	0	0	0	0	63	63	0	378	378	570	3,023	3,593
	2048	337	1,346	1,683	78	78	156	52	239	291	108	965	1,073	0	0	0	0	64	64	0	384	384	574	3,077	3,651
	2049	337	1,346	1,683	78	78	156	53	243	296	112	1,008	1,120	0	0	0	0	65	65	0	391	391	579	3,131	3,710
Total Cost		17,955	60,380	78,335	3,917	3,917	7,833	2,413	8,198	10,611	2,257	17,687	19,944	0	8,786	8,786	0	2,510	2,510	0	15,061	15,061	**26,541**	**116,541**	**143,082**

Table 5.1.16 Cost Disbursement Schedule (Option 3, Breakdown of Construction Cost)

(Unit: Million of PHP)

Phase	Year	Paranaque Spillway (Routed Shield)			Lakeshore Diking Systems (Inclusive of Backwater Levees, Pumping Stations, Bridges)			Expansion of EFCOS			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2020	0	0	0	0	0	0	0	0	0	0	0	0
	2021	0	0	0	0	0	0	0	0	0	0	0	0
	2022	1,754	4,450	6,205	0	0	0	16	7	23	1,770	4,457	6,228
	2023	1,754	4,450	6,205	0	0	0	16	7	23	1,770	4,457	6,228
	2024	1,754	4,450	6,205	0	0	0	16	7	23	1,770	4,457	6,228
	2025	1,754	4,450	6,205	337	1,346	1,683	16	7	23	2,107	5,804	7,910
	2026	1,754	4,450	6,205	337	1,346	1,683	16	7	23	2,107	5,804	7,910
	2027	1,754	4,450	6,205	337	1,346	1,683	0	0	0	2,091	5,797	7,888
	2028	1,754	4,450	6,205	337	1,346	1,683	0	0	0	2,091	5,797	7,888
	2029	1,608	4,080	5,688	337	1,346	1,683	0	0	0	1,945	5,426	7,371
2	2030	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2031	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2032	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2033	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2034	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2035	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2036	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2037	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2038	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2039	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
3	2040	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2041	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2042	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2043	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2044	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2045	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2046	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2047	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2048	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2049	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
Total Cost		13,889	35,233	49,121	8,415	33,658	42,073	80	34	114	**22,383**	**68,925**	**91,308**

Table 5.1.17 Cost Disbursement Schedule (Option 3)

(Unit: Million of PHP)

Phase	Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2020	0	0	0	324	324	648	33	33	66	3	6	8	0	0	0	0	14	14	0	87	87	360	464	824
	2021	0	0	0	324	324	648	33	34	67	5	12	17	0	639	639	0	27	27	0	164	164	362	1,200	1,563
	2022	1,770	4,457	6,228	246	246	493	207	496	703	49	259	307	0	616	616	0	167	167	0	1,002	1,002	2,272	7,243	9,515
	2023	1,770	4,457	6,228	246	246	493	208	505	713	65	348	413	0	616	616	0	169	169	0	1,016	1,016	2,290	7,358	9,648
	2024	1,770	4,457	6,228	246	246	493	210	514	724	82	439	521	0	616	616	0	172	172	0	1,030	1,030	2,308	7,474	9,783
	2025	2,107	5,804	7,910	324	324	648	255	682	937	119	692	811	0	0	0	0	206	206	0	1,237	1,237	2,805	8,945	11,750
	2026	2,107	5,804	7,910	324	324	648	257	694	951	139	815	955	0	698	698	0	223	223	0	1,340	1,340	2,828	9,898	12,726
	2027	2,091	5,797	7,888	324	324	648	257	706	963	159	939	1,098	0	711	711	0	226	226	0	1,357	1,357	2,832	10,060	12,892
	2028	2,091	5,797	7,888	324	324	647	259	719	978	180	1,066	1,245	0	724	724	0	230	230	0	1,378	1,378	2,853	10,236	13,089
	2029	1,945	5,426	7,371	324	324	647	246	687	933	188	1,123	1,311	0	737	737	0	220	220	0	1,320	1,320	2,702	9,836	12,538
2	2030	337	1,346	1,683	78	78	156	45	173	219	38	309	347	0	0	0	0	48	48	0	288	288	498	2,243	2,741
	2031	337	1,346	1,683	78	78	156	46	176	222	42	340	382	0	0	0	0	49	49	0	293	293	502	2,283	2,784
	2032	337	1,346	1,683	78	78	156	46	180	226	45	372	417	0	0	0	0	50	50	0	298	298	506	2,323	2,829
	2033	337	1,346	1,683	78	78	156	46	183	229	49	404	453	0	0	0	0	50	50	0	303	303	510	2,364	2,874
	2034	337	1,346	1,683	78	78	156	47	186	233	53	437	490	0	0	0	0	51	51	0	307	307	514	2,406	2,920
	2035	337	1,346	1,683	78	78	156	47	189	237	56	470	527	0	0	0	0	52	52	0	312	312	518	2,449	2,966
	2036	337	1,346	1,683	78	78	156	47	193	240	60	505	565	0	835	835	0	70	70	0	417	417	522	3,443	3,965
	2037	337	1,346	1,683	78	78	156	48	196	244	64	539	603	0	850	850	0	71	71	0	424	424	526	3,505	4,031
	2038	337	1,346	1,683	78	78	156	48	200	248	68	575	642	0	865	865	0	72	72	0	431	431	530	3,567	4,097
	2039	337	1,346	1,683	78	78	156	49	203	252	72	611	682	0	881	881	0	73	73	0	438	438	535	3,630	4,165
3	2040	337	1,346	1,683	78	78	156	49	207	256	75	647	723	0	0	0	0	56	56	0	338	338	539	2,673	3,212
	2041	337	1,346	1,683	78	78	156	49	211	260	79	685	764	0	0	0	0	57	57	0	344	344	543	2,721	3,264
	2042	337	1,346	1,683	78	78	156	50	215	264	83	723	806	0	0	0	0	58	58	0	349	349	548	2,769	3,316
	2043	337	1,346	1,683	78	78	156	50	219	269	87	761	849	0	0	0	0	59	59	0	355	355	552	2,818	3,370
	2044	337	1,346	1,683	78	78	156	51	222	273	91	800	892	0	0	0	0	60	60	0	360	360	556	2,868	3,424
	2045	337	1,346	1,683	78	78	156	51	226	277	95	841	936	0	0	0	0	61	61	0	366	366	561	2,919	3,479
	2046	337	1,346	1,683	78	78	156	51	231	282	99	881	981	0	0	0	0	62	62	0	372	372	565	2,970	3,536
	2047	337	1,346	1,683	78	78	156	52	235	287	104	923	1,026	0	0	0	0	63	63	0	378	378	570	3,023	3,593
	2048	337	1,346	1,683	78	78	156	52	239	291	108	965	1,073	0	0	0	0	64	64	0	384	384	574	3,077	3,651
	2049	337	1,346	1,683	78	78	156	53	243	296	112	1,008	1,120	0	0	0	0	65	65	0	391	391	579	3,131	3,710
Total Cost		22,383	68,925	91,308	4,565	4,565	9,131	2,942	9,198	12,140	2,470	18,493	20,964	0	8,786	8,786	0	2,847	2,847	0	17,080	17,080	**32,360**	**129,895**	**162,255**

Table 5.1.18 Cost Disbursement Schedule (Option 4, Breakdown of Construction Cost)

(Unit: Million of PHP)

Phase	Year	Paranaque Spillway (Route D NATM)			Lakeshore Diking Systems (Inclusive of Backwater Levees, Pumping			Expansion of EFCOS			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2020	0	0	0	0	0	0	0	0	0	0	0	0
	2021	0	0	0	0	0	0	0	0	0	0	0	0
	2022	1,050	2,715	3,765	0	0	0	16	7	23	1,066	2,722	3,788
	2023	1,050	2,715	3,765	0	0	0	16	7	23	1,066	2,722	3,788
	2024	1,050	2,715	3,765	0	0	0	16	7	23	1,066	2,722	3,788
	2025	1,050	2,715	3,765	337	1,346	1,683	16	7	23	1,402	4,068	5,471
	2026	1,050	2,715	3,765	337	1,346	1,683	16	7	23	1,402	4,068	5,471
	2027	1,050	2,715	3,765	337	1,346	1,683	0	0	0	1,387	4,062	5,448
	2028	1,050	2,715	3,765	337	1,346	1,683	0	0	0	1,387	4,062	5,448
	2029	1,050	2,715	3,765	337	1,346	1,683	0	0	0	1,387	4,062	5,448
2	2030	1,050	2,715	3,765	337	1,346	1,683	0	0	0	1,387	4,062	5,448
	2031	1,050	2,715	3,765	337	1,346	1,683	0	0	0	1,387	4,062	5,448
	2032	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2033	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2034	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2035	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2036	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2037	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2038	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2039	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
3	2040	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2041	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2042	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2043	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2044	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2045	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2046	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2047	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2048	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
	2049	0	0	0	337	1,346	1,683	0	0	0	337	1,346	1,683
Total Cost		10,499	27,153	37,653	8,415	33,658	42,073	80	34	114	**18,994**	**60,846**	**79,840**

Table 5.1.19 Cost Disbursement Schedule (Option 4)

(Unit: Million of PHP)

Phase	Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2020	0	0	0	236	236	471	24	24	48	2	4	6	0	0	0	0	10	10	0	63	63	261	337	598
	2021	0	0	0	236	236	471	24	24	48	4	9	12	0	639	639	0	23	23	0	140	140	263	1,071	1,334
	2022	1,066	2,722	3,788	158	158	315	125	304	429	30	158	188	0	616	616	0	107	107	0	640	640	1,378	4,705	6,084
	2023	1,066	2,722	3,788	158	158	315	126	309	436	40	213	253	0	616	616	0	108	108	0	649	649	1,389	4,775	6,165
	2024	1,066	2,722	3,788	158	158	315	127	315	442	50	269	318	0	616	616	0	110	110	0	658	658	1,401	4,847	6,247
	2025	1,402	4,068	5,471	236	236	471	172	479	651	80	486	566	0	0	0	0	143	143	0	859	859	1,890	6,272	8,162
	2026	1,402	4,068	5,471	236	236	471	173	488	661	94	572	666	0	698	698	0	159	159	0	956	956	1,905	7,178	9,083
	2027	1,387	4,062	5,448	236	236	471	173	496	669	107	659	766	0	711	711	0	161	161	0	968	968	1,902	7,292	9,194
	2028	1,387	4,062	5,448	235	235	470	174	504	679	121	748	869	0	724	724	0	164	164	0	983	983	1,916	7,419	9,335
	2029	1,387	4,062	5,448	235	235	470	176	514	689	134	839	974	0	737	737	0	166	166	0	998	998	1,931	7,550	9,482
2	2030	1,387	4,062	5,448	235	235	470	177	523	700	149	932	1,080	0	0	0	0	154	154	0	924	924	1,947	6,828	8,775
	2031	1,387	4,062	5,448	235	235	470	178	532	711	163	1,026	1,188	0	0	0	0	156	156	0	938	938	1,962	6,949	8,911
	2032	337	1,346	1,683	78	78	156	46	180	226	45	372	417	0	0	0	0	50	50	0	298	298	506	2,323	2,829
	2033	337	1,346	1,683	78	78	156	46	183	229	49	404	453	0	0	0	0	50	50	0	303	303	510	2,364	2,874
	2034	337	1,346	1,683	78	78	156	47	186	233	53	437	490	0	0	0	0	51	51	0	307	307	514	2,406	2,920
	2035	337	1,346	1,683	78	78	156	47	189	237	56	470	527	0	0	0	0	52	52	0	312	312	518	2,449	2,966
	2036	337	1,346	1,683	78	78	156	47	193	240	60	505	565	0	835	835	0	70	70	0	417	417	522	3,443	3,965
	2037	337	1,346	1,683	78	78	156	48	196	244	64	539	603	0	850	850	0	71	71	0	424	424	526	3,505	4,031
	2038	337	1,346	1,683	78	78	156	48	200	248	68	575	642	0	865	865	0	72	72	0	431	431	530	3,567	4,097
	2039	337	1,346	1,683	78	78	156	49	203	252	72	611	682	0	881	881	0	73	73	0	438	438	535	3,630	4,165
3	2040	337	1,346	1,683	78	78	156	49	207	256	75	647	723	0	0	0	0	56	56	0	338	338	539	2,673	3,212
	2041	337	1,346	1,683	78	78	156	49	211	260	79	685	764	0	0	0	0	57	57	0	344	344	543	2,721	3,264
	2042	337	1,346	1,683	78	78	156	50	215	264	83	723	806	0	0	0	0	58	58	0	349	349	548	2,769	3,316
	2043	337	1,346	1,683	78	78	156	50	219	269	87	761	849	0	0	0	0	59	59	0	355	355	552	2,818	3,370
	2044	337	1,346	1,683	78	78	156	51	222	273	91	800	892	0	0	0	0	60	60	0	360	360	556	2,868	3,424
	2045	337	1,346	1,683	78	78	156	51	226	277	95	841	936	0	0	0	0	61	61	0	366	366	561	2,919	3,479
	2046	337	1,346	1,683	78	78	156	51	231	282	99	881	981	0	0	0	0	62	62	0	372	372	565	2,970	3,536
	2047	337	1,346	1,683	78	78	156	52	235	287	104	923	1,026	0	0	0	0	63	63	0	378	378	570	3,023	3,593
	2048	337	1,346	1,683	78	78	156	52	239	291	108	965	1,073	0	0	0	0	64	64	0	384	384	574	3,077	3,651
	2049	337	1,346	1,683	78	78	156	53	243	296	112	1,008	1,120	0	0	0	0	65	65	0	391	391	579	3,131	3,710
Total Cost		18,994	60,846	79,840	3,992	3,992	7,984	2,536	8,290	10,826	2,374	18,062	20,435	0	8,786	8,786	0	2,557	2,557	0	15,345	15,345	**27,895**	**117,878**	**145,773**

(6) Operation and Maintenance Cost

Operation and maintenance cost of the proposed Parañaque Spillway, which is composed of operation cost for drainage pumps (fuel, manpower), maintenance cost of hydromechanical facilities (repair and replacement), and maintenance cost of underground tunnels (inspection and repairs). These are estimated at 0.5% of construction cost and 1.0% of procurement cost of hydromechanical facilities. Costs for sediment removal from tunnels and cleaning of tunnels are added, referring to the actual costs for operation and maintenance in tunnel spillways in Japan.

Operation and maintenance cost for lakeshore diking system is estimated at 0.5% of civil works such as construction of earth dikes and drainage and 1.0% of procurement cost of electrical and mechanical equipment.

Table 5.1.20 Operation and Maintenance Cost for Comprehensive Flood Control in Laguna de Bay

Project Component	Items	O&M Cost (million PHP)
Parañaque Spillway	Operation cost of drainage pump, maintenance cost of hydromechanical facilities, maintenance cost of underground tunnels	200.2～265.1
	Sediment removal and cleaning of spillway tunnel	10.5～13.2
	Sub-Total	210.7～278.3
Lakeshore Diking System	O&M of Civil Works	155.3
	O&M of Electrical and Mechanical Equipment	110.2
	Sub-Total	265.4
Expansion of EFCOS	O&M of Electrical and Mechanical Equipment	1.1

5.1.6 Economic Analysis

(1) General Assumptions of Economic Analysis

General Assumptions for the economic analysis are as follows.

- Project Period : Construction period + 50 years
- Standard Conversion Factor: 0.84
- Shadow Wage Rate : Skilled labor 0.93, Un-skilled labor 0.6
- Target EIRR : 10%

(2) Outline of Quantified Costs and Benefits

Quantified Costs and Benefits are summarized in Table 5.1.21

Table 5.1.21 Economic Costs and Economic Benefits

Project Cost	Economic Benefits
(1) Initial Construction Cost (2) O&M Cost (3) Major Rehabilitation Cost	(1) Reduced Economic Damage induced by Inundation (household assets, commercial/industrial assets, infrastructure, agriculture crops, suspension of economic activities) (2) Improvement of Transportation (3) Increase of Land Price

Source: JICA Survey Team

The annual average value of “reduced economic damage induced by inundation” is calculated by multiplying the “avoided damage of assets/human life under different return period cases (2, 3, 5, 10, 20, 30, 50, 100 years)” and “occurrence rate of each cases per year”.

(3) Method of Quantifying Economic Benefits

(a) Reduced Economic Damage induced by Inundation

(i) Damage of Household Assets

Damage of household assets are defined in the Survey as follows.

- “Number of Affected Household (affected population / average household size)” x “Value of Household Assets” x “Damage Rate” x 1.3 (including indirect damage)

Parameters for damages on household asset and its data sources are summarized in Table 5.1.22.

Table 5.1.22 Parameter and Data Source for Evaluating Damage of Household Asset

Parameter	Data Source
Number of Affected Household	To be estimated by analyzing geographical data and population data per barangay (NSO, 2015). Number of houses are calculated by population and average household size.
Value of Household Assets	156,000 - 437,000 PHP/household per province (Consumer Finance Survey, Bangko Sentral ng Pilipinas, 2014)
Damage Rate	0.092 (0.15 m - 0.5 m), 0.119 (0.5 - 1.0m), 0.266 (1.0 m - 2.0 m), 0.58 (2.0 - 3.0 m), 0.834 (> 3.0 m) (Manual for Economic Analysis for Flood Control Project in Japan, Ministry of Infrastructure, Land and Transportation, 2005)

Source: JICA Survey Team

(ii) Damage of Commercial and Industrial Assets

Damage of commercial and industrial assets are defined in the Survey as follows.

- Number of Affected Enterprises” x “Value of Commercial Assets” x “Damage Rate” x 1.3 (including indirect damage)

Parameters for evaluation of damages on commercial and industrial asset and its data sources are summarized in Table 5.1.23.

Table 5.1.23 Parameter and Data Source for Evaluating Damage of Commercial and Industrial Asset

Parameter	Data Source
Number of affected enterprises	Estimated by analyzing geographical data and numbers of business units per LGU (Annual Survey of Philippine Business and Industry, NSO, 2015)
Value of fixed asset and inventories	Average value of tangible assets and inventory stocks per unit in each sector is used (Annual Survey of Philippine Business and Industry, NSO). The data used in World Bank study is converted into 2017 price using GDP increase rate.
Damage rate	0.092 (0.15 m - 0.5 m), 0.119 (0.5 - 1.0 m), 0.266 (1.0 m - 2.0 m), 0.58 (2.0 - 3.0 m), 0.834 (> 3.0 m)

Source: JICA Survey Team

(iii) Damage of Agricultural Crops (Paddy, Maize, commercial crops)

Damage of agricultural crops are defined in the Survey as follows.

- "Affected Area of Crops" x "Economic Value of Agricultural Crops per hectare" x "Damage Rate"

Parameters for evaluation of damages on agricultural crops and its data sources are summarized in Table 5.1.24.

Table 5.1.24 Parameter and Data Source for Evaluating Damage of Agricultural Crops

Parameter	Data Source
Number of affected household	Estimated by geographical analysis (affected area). Area per crops are estimated by census data in 2016 (PSA).
Economic value of crops	Economic Values of paddy and maize are estimated based on the crop price forecast of World Bank until 2040. The economic value becomes 10.5PHP/kg (Paddy) and 9.3PHP/kg (Maize). Farmgate price obtained from PSA data in 2016 was used for other commercial crops. In conclusion, economic value of agricultural land per province becomes PHP 2.59 – 5.29/m^2.
Damage rate	1.0

Source: JICA Survey Team

(iv) Avoided Economic Cost of Suspended Business Activities

Avoided economic cost of suspended business activities is defined for each return period cases in the Survey as follows.

- "Number of Affected Enterprises" x "Reduced Period of Suspension" x "Average Daily Added Value per Enterprise"

Parameters for evaluation of economic cost of suspended business and its data sources are summarized in Table 5.1.25.

Table 5.1.25 Parameter and Data Source for Evaluating Economic Cost of Suspended Business

Parameter	Data Source
Number of Affected Enterprises per Category	Affected numbers of enterprises per LGU, under several water level cases of 12.5 m, 13.0 m, 13.5 m and 14.0 m, were estimated by GIS analysis and the census data of total number of enterprises per LGU (Annual Survey of Philippine Business and Industry, NSO, 2015)
Reduced Period of Suspension	Move of water level of Laguna de Bay was predicted under several return period cases. Suspended period of land over 12.5 m. 13.0 m, 13.5 m and 14.0 m under with-project and without-project cases compared to have the difference.
Average Daily Added Value per Sector	3,900 – 5,653,000 PHP/day depending on sector. The data used in World Bank report was quoted and converted into 2017 price reflecting GDP increase rate.

Source: JICA Survey Team

(b) Benefit of Improvement of Transportation

Community road will be installed on the dike constructed around the Laguna de Bay (one lane on one side, refer to Figure 4.5.5 for road section). Benefit of improvement of transportation is estimated by VOC method and VOT method used for the evaluation of road projects in the Philippines. The latest "unit cost of VOC" was obtained from the planning section in DPWH.

VOC (Value of Operating Cost) method

- Operating cost under with-project and without-project cases were compared, and the saved cost is considered as the benefit.
- Operating cost = “Unit cost of VOC per vehicle category (PHP/km)” x “Total Distance per vehicle category (km)”

Table 5.1.26 Parameter and Data Source for Evaluating VOC Method

Parameter	Data Source
Unit Cost of VOC per vehicle category	Unit cost in 2017 was obtained from DPWH. The vehicles were categorized into car, jeepney, bus and truck. The unit cost varies from PHP 8.6-69.2/km-vehicle.
Total Distance per vehicle category	Demand of transportation was assumed as 1/4 of present traffic at the surrounding national road which was provided from DPWH.

Source: JICA Survey Team

VOT (Value of Time) method

- Value of saved time was calculated under with project case.
- “Total Saved Time” x “Value of Saved Time”

Table 5.1.27 Parameter and Data Source for Evaluating VOT Method

Parameter	Data Source
Total Saved Time	Estimated by the traffic volume and estimated speed of vehicles
Value of Saved Time	Economic value of 1 hours was calculated dividing “GDP per capita” by “average working duration (240 days x 8 hours)”. As considering the opportunity of working, half of the estimated value was used for calculation.

Source: JICA Survey Team

(c) Benefit of Increase of Land Price

Future land price increase caused by the Project implementation was predicted as follows.

- “Influenced Area” x “Current Market Value of Land” x “Increase Rate of Land Value”

Table 5.1.28 Parameter and Data Source for Evaluating Benefit of Increase of Land Price

Parameter	Data Source
Influenced Area	Considered by predicted inundation area and opinions of real states companies
Current Market Value of Land	Market value is estimated at 120% of average Zonal Value. Average Zonal Values in Laguna, Rizal and NCR in target area, are 1,514, 1,223 and 25,740 PHP/m^2 referring to Zonal Value data of Bureau of Internal Revenue (BIR)
Increase Rate of Land Value	Considering the opinion of real estate companies and assumptions of the past report of World Bank, value of 50% of land protected by lakeshore dike is considered to increase by 15% during first 5 years, and value of 50% of land protected by Parañaque spillway is considered to increase by 15% during first 10 years.

Source: JICA Study Team

(4) Results of Economic Analysis

EIRR was calculated for the comprehensive flood management plan for Laguna de Bay lakeshore area. Results of economic analysis are shown in Table 5.1.29.

Table 5.1.29 Economic Analysis of Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area.

Item	Economic Cost (million PHP)	EIRR	B/C	NPV (PHP million)
Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area (Parañaque Spillway) + (Lakeshore Diking System) + (Non-structural Measure)	110,306～ 127,279	8.8% ~ 10.7%	0.86 ~ 1.08	-6,232 ~ 2,820

Source: JICA Study Team

5.2 Proposed Organization for Project Implementation/Operation, Maintenance and Management

5.2.1 Related Law and Act for Operation and Maintenance

Main laws and acts related to operation and maintenance of the proposed project are presented as described below.

(1) Water Code

There is the Water Code of the Philippines as Presidential Decree No. 1067 on December 31, 1976. The Water Code is a water resources oriented code, instituting a water code and consolidation of laws governing ownership, appropriation, utilization, exploitation, development, conservation and protection of water resources.

Pursuant to the Water Code, Implementing Rules and Regulations were promulgated in 1979 vesting upon the National Water Resources Management Board (NWBA) the administration and enforcement of the provisions thereof. It provides 88 sections under three (3) rules.

(2) National Water Security Act

Amendment of the Water Code into the National Water Security Act has been proposed. The proposed act includes the Amended Implementing Rules and Regulation incorporating the principles of integrated water resources management and climate change adaptation, institutionalization of the river-basin approach in water resource management, and incorporating the Public Service Law concerning regulation of water service providers and sewerage system operators.

(3) Related Law and Act for DPWH

The organizational structure of the Department of Public Works and Highways is pursuant to Executive Order No. 124 dated 30 January 1987. The authorities and areas of responsibilities are based on the Department Orders No. 114, 127 and 149, Series of 2003.

(4) Related Law and Act for MMDA

On 24 July 1994, through RA No. 9724, "An Act Creating the Metropolitan Manila Development Authority, Defining its Powers and Functions, Providing Funding therefor and for Other Purposes", the former Metro Manila Authority (MMA) was replaced by the Metro Manila Development Authority (MMDA).

Through the Memorandum of Agreement (MoA) signed in 2002, DPWH turned over to the Metro Manila Development Authority (MMDA) all functions and responsibilities on flood control management in Metro Manila, including all relevant programs, projects and activities, personnel, funds, equipment, facilities, records, assets and liabilities.

(5) Related Law and Act for LLDA

LLDA was organized in 1966 under Republic Act No. 4850 as a quasi-government agency with powers, functions and duties, providing funds therefor. Through Presidential Decree No. 813 in 1975 and Executive Order No. 927 in 1983, its powers and functions were further strengthened to include environmental protection and jurisdiction over surface waters of the lake basin. In 1993, the Administrative Supervision over LLDA was transferred to the DENR through Executive Order No. 149.

RA 4850 in 1966 states that the area of Laguna de Bay below El. 12.50 m is public land.

(6) Related Law and Act for LGUs

RA No. 7160 in 1991, known as an Act providing for a Local Government Code, declares a system of decentralization whereby local government units shall be given more powers, authority, responsibilities, and resources from the state government.

Through RA No. 10121 in 2010, the legal framework related to the institutional setup and budgetary arrangement for disaster risk reduction and management (DRRM) in the Philippines was established. The Local Disaster Risk Reduction and Management Office (LDRRMO) was established as the execution body at each level of region, province, city/municipality and barangay. The LDRRMOs coordinate implementation and development of flood-related disaster risk reduction and management projects in each level.

5.2.2 Organization of Operation, Maintenance and Management (Organization, Institution, Human Resources)

(1) Approach to the Study for Organization of Operation, Maintenance and Management

DPWH oversees planning, designing and construction of large-scale flood control projects in the Metro Manila area. In principle, the completed flood control facilities are transferred to MMDA, which also conducts operation and maintenance of the facilities.

The target area of this Project is located in the extended area which covers the parts of Metro Manila under the jurisdiction of MMDA and the provinces of Laguna and Rizal that are outside of the MMDA's jurisdiction. Therefore, the responsibility for operation and maintenance is going to be shared among several organizations in the regular case, although this is not effective to manage. In addition, since the measures to be proposed are for large-scale structures, it is appropriate to establish a project implementation/operation and maintenance system by positioning DPWH at the center.

In this Survey, the project implementation/operation and maintenance system is studied in accordance with this policy in order to establish a satisfactory implementation system that organizations such as DPWH, MMDA and LLDA could agree.

(2) Present Condition of Organization for Operation, Maintenance and Management

Present conditions on the project implementation/operation, maintenance and management system are studied and analyzed considering adaptation to the comprehensive flood control plan in the Laguna de Bay Lakeshore areas.

(a) Related Organizations

The organizations involved in the comprehensive flood control plan for the whole Laguna de Bay area are basically categorized into project implementation organizations, project related organizations and the Local Government Units (LGUs). The roles and responsibilities of each are summarized in Table 5.2.1 below.

Table 5.2.1 Roles and Organizations Related to Comprehensive Flood Control Plan in Whole Laguna de Bay Area

Category	Related Department/Agency/Organization		Roles in the Proposed Plan
Project Implementation	Department of Public Works and Highways (DPWH)	UPMO	Plans, designs, constructs and implements O&M of infrastructures including large-scale flood control, water supply and sanitation projects.
		Regional Offices / District Engineering Offices (RO/DEO)	Plans, designs, constructs and implements O&M of infrastructure projects in the regions and districts.
	Metro Manila Development Authority (MMDA)	FCSM	Operation, maintenance and management of drainage channels and drainage pump stations in Metro Manila.
	Laguna Lake Development Authority (DENR-LLDA)		Environmental management and development in Laguna de Bay lakeshore areas.
Related Agency (Planning, Regulation and Approval)	National Economic and Development Authority (NEDA)		Through the inter-lateral department agency of the Investment Coordination Committee (ICC), evaluates and approves plans and programs on feasibility, effectiveness and integration to the national development plan
	Department of Budget and Management (DBM)		Promotes sound, efficient and effective use of government resources, and allocates related budget to DPWH and LGUs.
	Department of Finance (DOF)		Responsible for national fiscal policy, and decides on the acceptance of ODA loans.
Related Agency (Non structural measures)	Department of the Interior and Local Governments (DILG)		Promotes peace and order, ensures public safety and strengthens local government capability to effectively deliver basic social services to the citizenry.

Category	Related Department/Agency/Organization		Roles in the Proposed Plan
	Department of National Defense (DND)	OCD-NDRRMC/ DRRMCs	Disaster risk reduction and management at national and regional levels through policy-making, coordinating, and capacity building for risk reduction.
	Department of Science and Technology (DOST)	PAGASA	Observation of hydro-meteorology, forecasts weather and provides flood warning.
Related Agency (Environment, water use)	Department of Environment and Natural Resources (DENR)	NWRB/RBCO	Controls the watershed and river basin plan, manages the river and other water sources, and coordinates water related projects from the aspects of river basin management.
		NAMRIA	Creation and management of national topographic maps, management of national benchmarks, tidal water level
	Department of Agriculture (DA)	NIA	Development, operation, maintenance and management of irrigation systems
	Water Supply	Maynilad Water Service Inc. / Manila Water Company	Water supply services in developing, operating, maintenance of related facilities
Local Governments	Provincial	4 provinces: Cavite, Laguna, Rizal and Quezon, and barangays	Prepares the Provincial Development and Physical Framework Plan (PDPFP), and manages DRRMO for effective response to disasters.
	City and Municipality	35 cities/ municipalities	Prepares the CLUP and zoning plan, manages DRRMO for effective response to disasters, implements evacuation of dwellers, relocation and resettlement relating to the projects.

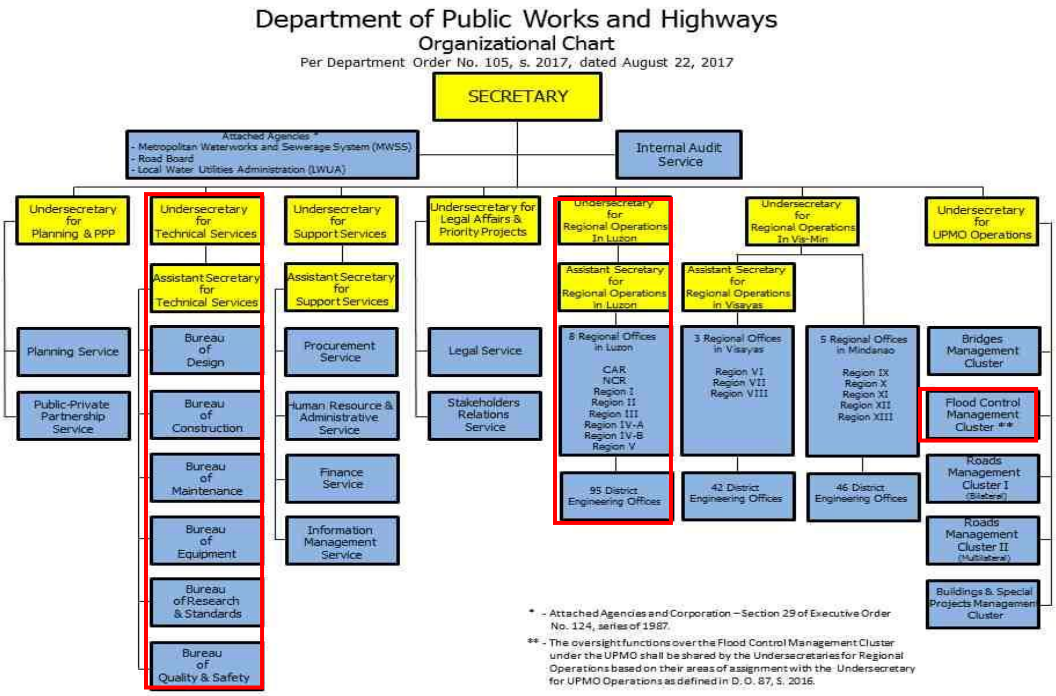
Source: JICA Survey Team

(b) Department of Public Works and Highways (DPWH)

The organizational chart of the DPWH Head Office in Department Order (DO) No. 105, 2017, is shown in Figure 5.2.1 and the number of staff is presented in Table 5.2.2.

The DPWH acts as the engineering and construction arm of the government. The department structure is divided into project implementation horizontally. UPMO-DCMC (Flood Management Authority) is assumed to be the main counterpart (C/P) in this Project; however, the full menu and the underground spillway proposed in this project are the related works of the planning, designing and construction departments belonging to the DPWH Head Office as well as the regional offices of related areas (National Capital Region and Region IV A).

To implement the project, it is necessary to strengthen the DPWH’s capacity; and the involvement of staff from each relevant department is essential.



Source: DPWH (DO 105, 2017)

Figure 5.2.1 Organizational Chart of DPWH

Table 5.2.2 Number of Staff of DPWH (As of June 30, 2017)

Office		Main Staff: Number of Staff	Main Staff: Average Age	Number of Job Order Personnel
Central Office	Department Proper	88	39	40
	Pooled Field Positions	378	56	0
	Services (9)	736	42	413
	Bureaus (6)	637	39	221
	UPMOs (5)	261	49	637
	Sub-Total	2,100	45	1,311
Field Office	NCR	843	45	3,440
	Region IV-A	1,194	40	2,131
	Others	13,535	-	33,855
	Sub-Total	15,572	43	39,426
Total		17,672	43	40,737

Source: DPWH

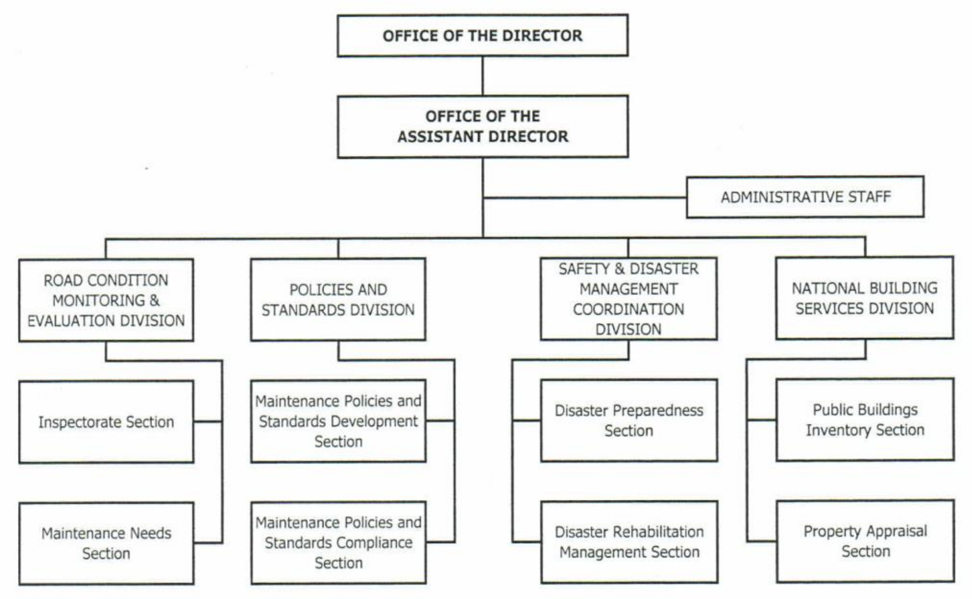
The outline of main offices which will have important roles and responsibilities in project implementation, operation, maintenance and management are given below.

(i) Unified Project Management Office (UPMO)

The Unified Project Management Office (UPMO) under the Office of the Undersecretary for UPMO Operations is in charge of the implementation of foreign funded projects from both multilateral and bilateral donors. There are five (5) clusters including the Flood Control Management Cluster (FCMC) which is in charge of flood control projects. The UPMO conducts operation and maintenance works of flood control facilities constructed with financial assistance from the Government of Japan.

(ii) Technical Services

Technical Services consists of six (6) bureaus which manage design, construction, maintenance, equipment, research and standard, and quality and safety. Following three (3) bureaus have specific functions for operation, maintenance and management of flood control facilities. The Bureau of Design (BOD) supervises and evaluates the design, specifications, estimates, tender and contract documents mainly in pre-construction stage. The Bureau of Construction (BOC) reviews the project costing and construction schedule of the project. The Bureau of Maintenance (BOM) is responsible for maintenance of flood control structures (revetment, spur dike, earth dike, drainage facilities) and conduct regular inspection of the said structures. The organizational chart of BOM is presented in Figure 5.2.2. The BOM consists of four (4) divisions which work for monitoring and inspection of road and bridge conditions, developing maintenance policy and standard, managing and coordinating safety and disaster, and managing inventory and asset of national buildings.



Source: DPWH-BOM

Figure 5.2.2 Organizational Chart of DPWH-BOM

(iii) RO/DO

DPWH has 16 regional offices (RO) and 180 district engineering offices (DEO). ROs and DEOs are distributed nationwide aiming at the construction and operation and maintenance of infrastructures at regional and district levels using the financial source of domestic budget.

The Study area belongs to the DPWH NCR and Region IV A.

(c) MMDA

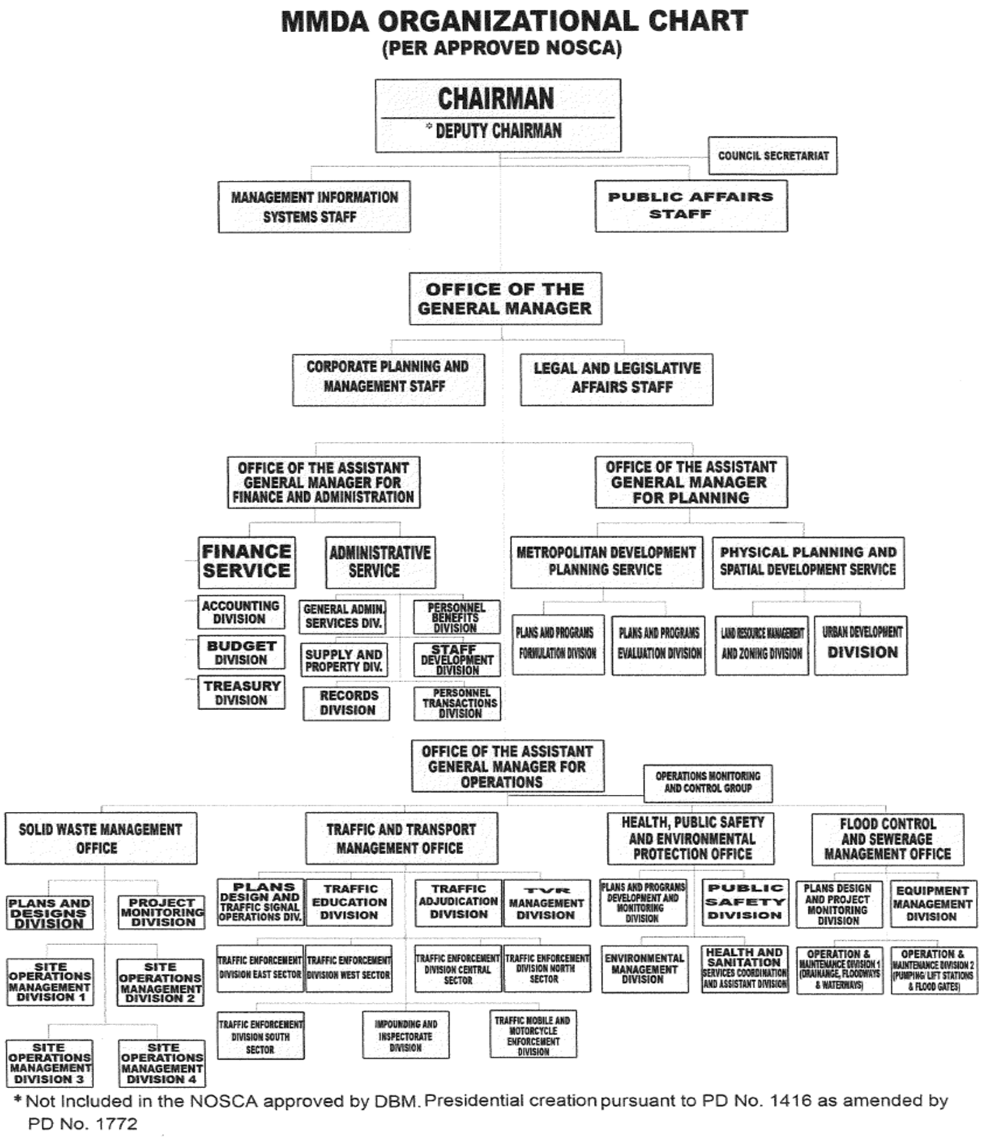
Under the law, the MMDA shall perform planning, monitoring and coordinative functions, and in the process exercise regulatory and supervisory authority over the delivery of metro-wide services within

Metro Manila without diminution of the autonomy of local government units concerning purely local matters. Tasks to perform are as follows:

(a) Preparation of Development Plan
(b) Transportation and Traffic Management
(c) Solid Waste Disposal and Management
(d) Flood Control and Sewerage Management
(e) Urban Renewal, Zoning and Land Use Planning, and Shelter Services
(f) Health and Sanitation, Urban and Pollution Control
(g) Public Safety

As the governing board and policy-making body of the MMDA, Metro Manila Council is placed, composed of the mayors of thirteen (13) cities and four (4) municipalities, and the representatives from DOTC, DPWH, DOT, DBM, HUDCC and PNP as non-voting members.

The Organizational Chart of MMDA is presented in Figure 5.2.3 below. As mentioned above, in August 2002, the operation and maintenance work for all flood control structures and facilities were turned over from DPWH to MMDA. In the MMDA, the Flood Control and Sewerage Management Office (FCSMO) undertakes the operation and maintenance works. FCSMO is composed of four divisions. The Flood Control and Drainage Division, consisting of 11 FC operation districts, is in charge of the improvement, operation and maintenance of waterways, esteros, drainage laterals and interceptors. The Pumping Station and Floodgates Division handles the operation of 23 large pumping stations and 17 relief pumping stations and floodgates.



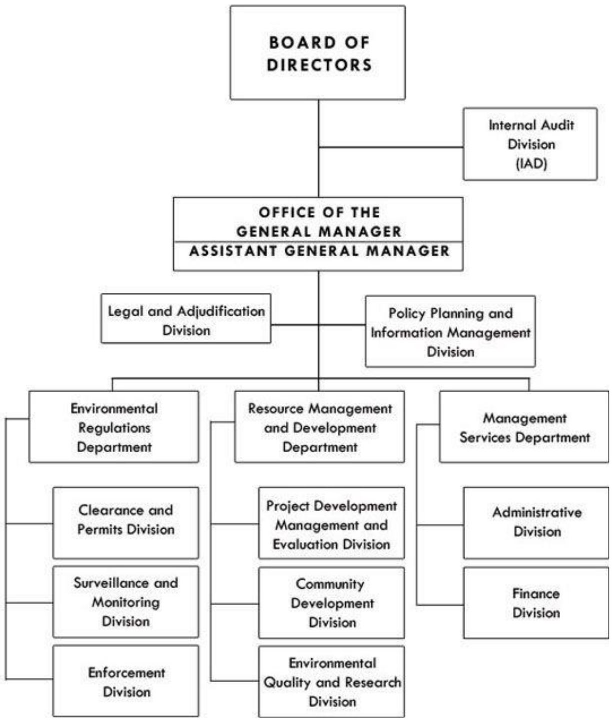
Source: MMDA

Figure 5.2.3 Organizational Chart of MMDA

(d) LLDA

As aforementioned, the LLDA was created in 1966 under Republic Act No. 4850, and was transferred to the DENR in 1993. LLDA has responsibility for the preservation, development and sustainability of the Laguna de Bay.

The mandate of LLDA is to promote and accelerate the development and balanced growth of areas of the Laguna Lake and its 21 major tributary rivers, as well as the surrounding provinces, cities and towns within the context of the national and regional plans and policies for social and economic development. LLDA carries out the development of the Laguna Lake region with due regard and adequate provisions for environmental management and control, preservation of the quality of human life and ecological systems, and the prevention of undue ecological disturbances, deterioration and pollution. The Organizational Chart of LLDA is presented in Figure 5.2.4 below.

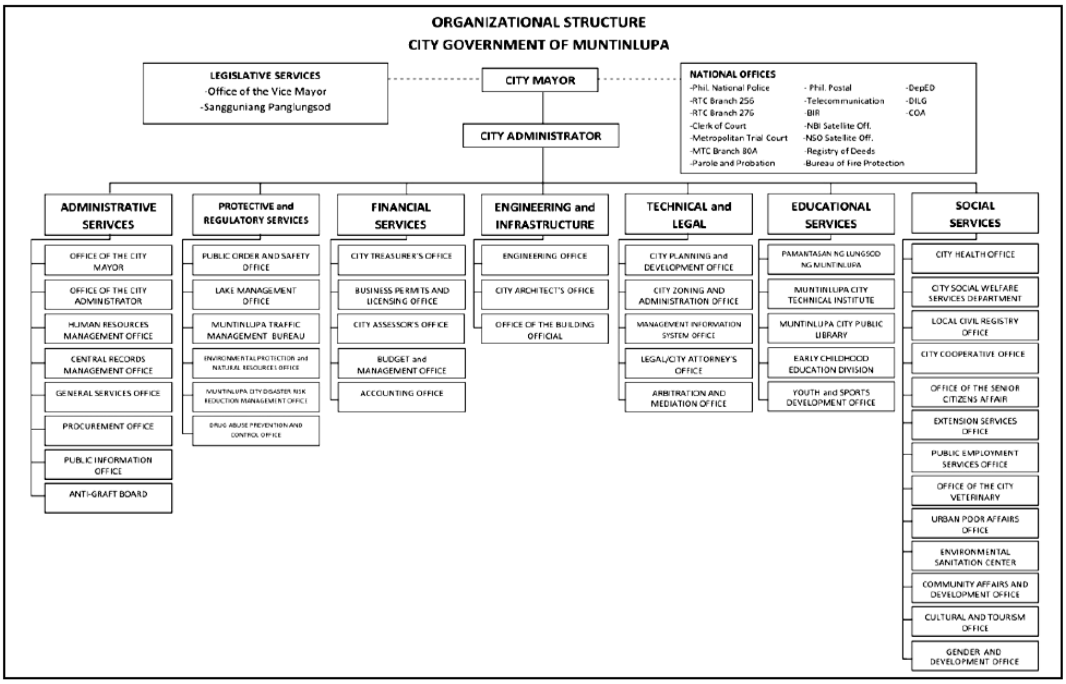


Source: LLDA

Figure 5.2.4 Organizational Chart of LLDA

(e) LGUs

There are five (5) provincial governments and 35 cities and municipalities in the Study Area. Organizational structures are different from each other, but the basic structures are similar. As the example of organization of city governments, the organizational structure of the City of Muntinlupa is given in Figure 5.2.5.



Source: City of Muntinlupa

Figure 5.2.5 Example of Organizational Chart of City Governments (City of Muntinlupa)

There are four (4) main offices related to the flood control projects in LGUs, namely; the Planning and Development Office (PDO), the Engineering Office (EO), the Environment and Natural Resources Office (ENRO) and the Disaster Risk Reduction Management Office (DRRMO). In addition, some LGUs located at the lakeshore of the Laguna de Bay had established a Lake Management offices.

PDO is responsible for the conduct of feasibility studies, as well as monitoring and evaluation of essential development projects, including flood management. The EO is tasked with designing, preparing tender documents and supervising construction works for basic infrastructure projects including flood control. ENRO has tasks related to flood management, including (i) development and implementation of solid waste management; (ii) maintaining infrastructures under their responsibility; (iii) conducting cleaning and clogging activities in rivers and drainage channels; (iv) serving notices to dismantle illegal structures and to relocate informal settlers; and (v) monitoring and surveying of rivers in the provinces. DRRMO designs and coordinates disaster risk reduction and management activities in the area following the guidelines set by the agencies concerned.

Table 5.2.3 shows the number of permanent employees of the said 4 offices in major LGUs in the study area. The number of employees for the implementation, operation, maintenance and management of flood control project is around 150 to 380 in total.

Table 5.2.3 Example of Number of Staff of LGUs

Name of Province	Name of LGUs	Total	PDO	EO	ENRO	DRRMO
NCR	City of Las Piñas				1,284	17
NCR	City of Muntinlupa	369	20	260	19	70
NCR	City of Parañaque					
Laguna	Provincial Government	279	24	159	19	77
Cavite	Provincial Government					
Quezon	Provincial Government	450	29	371	34	16
Rizal	Provincial Government	227	29	163	15	20

PDO: Planning and Development Office
EO: Engineering Office
ENRO: Environment and Natural Resources Office
DRRMO: Disaster Risk Reduction Management Office

5.2.3 Financial Conditions

(1) DPWH

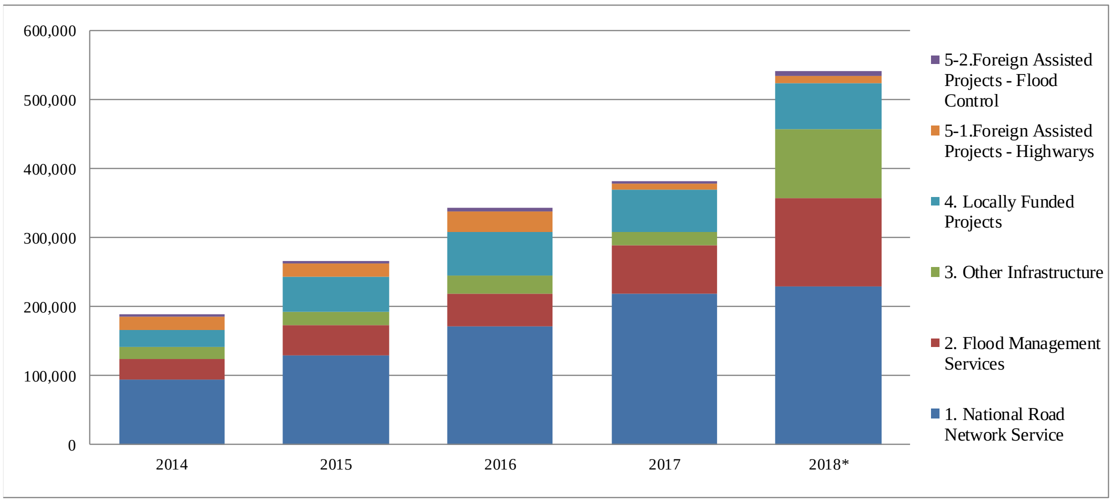
(a) Total Investment Budget

The trends of budget allocation for investments in each category from 2014 to 2018 are summarized in Figure 5.2.6. The total amount of investment budget has significantly increased as influenced by the higher prioritization of the government policy on basic infrastructures. The total budget for 2018 is PHP 54.1 billion, which is around 2.8 times bigger than that in 2014.

(million PHP)

	2014	2015	2016	2017	2018*	Total	Share
1. National Road Network Service	94,286	129,765	170,446	218,581	229,181	842,259	49.0%
2. Flood Management Services	30,201	42,283	47,200	69,843	128,233	**317,760**	**18.5%**
3. Other Infrastructure	16,790	20,626	26,987	19,708	100,033	184,144	10.7%
4. Locally Funded Projects	24,518	50,079	63,638	61,642	65,832	265,709	15.5%
5-1.Foreign Assisted Projects - Highwarys	19,510	19,336	29,033	8,876	10,748	87,503	5.1%
5-2.Foreign Assisted Projects - Flood Control	3,619	3,611	5,236	2,227	7,439	**22,132**	**1.3%**
Total	**188,924**	**265,700**	**342,540**	**380,877**	**541,466**	**1,719,507**	**100%**
Total Budget for Flood Management ("2"+"5-2")	33,820	45,894	52,436	72,070	135,672	**339,892**	
Share of Flood Management Sector	17.9%	17.3%	15.3%	18.9%	25.1%	**19.8%**	

* Catergorization of Budget Item was changed in the fiscal year 2018. Therefore the amount per sector shown above does not exactly match to the other fiscal years.



Source: DPWH

Figure 5.2.6 Annual Budget of DPWH (2014-2018)

(b) Budget for Flood Management Sector

Figure 5.2.6 shows that the budget for each sector is mainly divided into two: one is for the road network sector which takes a half of the total budget, and the other is for the flood management sector which takes around 19% of the total. The share of the total budget of the flood management sector is increasing year by year, and it is 25.1% (PHP 13.5 Billion) in 2018. Regarding the financial source of the flood control sector, around 1.5% of the total budget is provided by international donors, and 18.5% of the total budget is sourced from the national budget in the past average.

(c) Budget for Operation and Maintenance

There are two kinds of budget for the operation and maintenance works in DPWH. One is sourced from the regular budget to be used for the operation and maintenance works undertaken by ROs and DEOs. Another is the special operation and maintenance fund provided from the planning office.

Based on the data provided by the BOM, the regular annual budget for operation and maintenance works is PHP 12.7 Billion in 2017. Out of this, PHP 1.85 Billion is allocated for flood and drainage facilities.

Table 5.2.4 Regular Annual Budget for Operation and Maintenance Works of DPWH

Unit: Billion Peso

Sector	2012	2013	2014	2015	2016	2017
Road & Bridge	4.000	4.000	6.580	6.700	8.500	10.000
Flood/Drainage	1.509	1.734	1.500	1.400	1.650	1.850
Other	0.297	0.276	0.326	0.500	0.650	0.850
Total	5.806	6.010	8.406	8.600	10.800	12.700

Source: DPWH-BOM

On the other hand, the special operation and maintenance fund is allocated for the large flood control structures constructed under the foreign-assisted projects. Table 5.2.5 below shows the trend of the special funds of the 11 foreign-assisted projects from 2012 to 2017. The total budget in 2017 is PHP 588 Million, while the KAMANAVA Flood Control Project, which had similar project components as the proposed Parañaque Spillway, was PHP 200 Million. The special fund is increasing year by year; the amount of budget in 2017 is around 3.8 times that in 2012.

For the operation and maintenance cost of the Parañaque Spillway, it should be allocated separately under the special fund, because of the huge budgetary requirement.

Table 5.2.5 Special Operation and Maintenance Fund of Completed Foreign-Assisted Projects

MAINTENANCE FUNDS OF THE COMPLETED FOREIGN-ASSISTED PROJECTS

Project Name	Years						Total
	2012	2013	2014	2015	2016	2017	
1 Lower Agusan Flood Control Structures	7,000,000.00	10,000,000.00	10,000,000.00	20,000,000.00	20,000,000.00	30,000,000.00	97,000,000.00
2 Agno River Flood Control Structures	16,000,000.00	32,000,000.00	32,000,000.00	32,000,000.00	50,000,000.00	50,000,000.00	212,000,000.00
3 Laoag River Flood Control Structures	16,000,000.00	16,000,000.00	21,320,000.00	50,000,000.00	50,000,000.00	50,000,000.00	203,320,000.00
4 Pampanga Delta Flood Control Structures.	23,000,000.00	23,000,000.00	23,000,000.00	23,000,000.00	23,000,000.00	23,000,000.00	138,000,000.00
5 Iloilo Flood Control Structures		10,000,000.00	50,000,000.00	45,000,000.00	50,000,000.00	100,000,000.00	255,000,000.00
6 KAMANAVA Flood Control Structures	40,000,000.00	40,000,000.00	70,000,000.00	100,000,000.00	70,000,000.00	200,000,000.00	520,000,000.00
7 East and West of Mangahan Flood Control Structures	35,000,000.00	35,000,000.00	50,000,000.00	50,000,000.00	30,000,000.00	50,000,000.00	250,000,000.00
8 Flood Control and Sabo Engineering Center	17,480,000.00	17,480,000.00	19,000,000.00	30,000,000.00	5,000,000.00	5,000,000.00	93,960,000.00
9 Ormoc Flood Control Structures		10,000,000.00	10,000,000.00	10,000,000.00	10,000,000.00	-	40,000,000.00
10 Pasig-Marikina River Channel (Phases I and II)				50,000,000.00	50,000,000.00	50,000,000.00	150,000,000.00
11 Post Ondoy and Pepeng Short Term Infrastructure Project						30,000,000.00	30,000,000.00
TOTAL	154,480,000.00	193,480,000.00	285,320,000.00	410,000,000.00	358,000,000.00	588,000,000.00	**1,989,280,000.00**

Source: DPWH-UPMO

(2) MMDA

(a) Budget for the Flood Management Sector

The trend of the annual budget of the MMDA-FCSMO from 2012 to 2014 is presented in Table 5.2.6. The annual budget varies from PHP 580 Million to PHP 710 Million a year. The budget is allocated into three (3) items, namely; salaries and wages, maintenance costs, and project costs. The share of these items is around 25%, 36% and 39%, respectively. Annual operation and maintenance costs consists of supply and materials costs, utility expenses including fuel costs, other professional services and repair and maintenance costs. It is around PHP 210 Million to PHP 250 Million a year.

Table 5.2.6 Annual Budget of MMDA-FCSMO from 2012 to 2016

Item	2012	2013	2014	2015	2016	Average
1. Salaries and Wages	***152,886,108***	***156,400,089***	***155,692,695***	***170,013,024***	***167,345,364***	***160,467,456***
2. Maintenance & Other Operating Expenses						
Supplies and Materials	92,615,285	85,713,308	74,390,799	51,939,682	55,491,491	*72,030,113*
Utility Expenses	27,504,323	29,726,387	36,058,592	41,030,882	60,899,859	*39,044,009*
Other Professional Services	19,070,637	63,335,991	48,601,530	48,395,971	56,393,129	*47,159,451*
General Services	17,414,880	17,534,160	18,719,008	18,846,240	17,806,600	*18,064,178*
Repairs and Maintenance						
- Infrastructure Assets	38,878,232	12,919,669	17,600,807	38,425,217	18,056,562	*25,176,097*
- Building & Other Structures	0	0	0	0	0	*0*
- Machinery and Equipment	11,562,585	20,192,522	20,694,986	15,917,021	18,594,142	*17,392,251*
- Transportation Equipment	1,254,388	3,039,449	6,310,554	6,624,885	9,731,687	*5,392,193*
Other Mode	3,956,670	2,371,353	6,055,910	21,703,579	11,844,733	*9,186,449*
Sub Total of 2.	***212,257,000***	***234,832,839***	***228,432,188***	***242,883,477***	***248,818,203***	***233,444,741***
3. Public Infrastructures (Dredging, Drainage Improvement, Riprapping, etc.)						
Total Project Costs	**222,680,960**	**276,094,789**	**250,628,768**	**296,344,988**	**218,818,546**	***252,913,610***
(The number of projects)	*49*	*62*	*84*	*82*	*66*	
Ground Total	**587,824,068**	**667,327,717**	**634,753,651**	**709,241,490**	**634,982,113**	***646,825,808***

Source: MMDA-FCSMO

(b) Operation and Maintenance Costs for Drainage Pump Stations

MMDA has 35 flood control facilities composed of drainage pump stations, floodgates and warehouses in Metro Manila. The annual budget for operation and maintenance of these facilities from 2014 to 2017 (only 6 months from January to June for 2017) is given in Table 5.2.7. This budget is included in the budget of the MMDA-SCSMO as mentioned above.

The annual budgets in the past 4 years were kept at almost the same amount of around 100 Million Peso to 120 Million Peso. The major pay items are fuel cost, electricity cost and costs for labor/manpower. The share of these items in the total cost is 21%, 26% and 47%, respectively.

Table 5.2.7 Annual Budget for Existing Pumping Stations of MMDA (2014-2017)

Year	2014	2015	2016	2017.1-6	Average(2014-2016)	
Operating Hour (hour)	23,045	13,421	18,472	3,896	18,313	
Fuel Consumption (ltr)	928,105	537,055	435,968	69,621	633,709	
Cost (PHP)						
Fuel	39,878,540	18,956,680	13,691,488	2,218,341	24,175,569	21.9%
Electricity	15,595,996	25,006,306	45,954,338	17,061,832	28,852,213	26.2%
Water service	3,102,130	3,553,912	3,706,934	1,344,384	3,454,325	3.1%
Telephon	101,531	101,531	101,531	69,097	101,531	0.1%
Labor/Manpower	49,995,156	51,754,937	52,729,491	28,727,213	51,493,194	46.7%
Micellaneous	1,889,817	1,281,567	3,115,101	2,046,550	2,095,495	1.9%
Total	**110,563,170**	**100,654,933**	**119,298,882**	**51,467,417**	**110,172,328**	100.0%

Source: MMDA-FCSMO

(3) LGUs

The actual income and expenditure of local government units in the study area from 2013 to 2016 is summarized in Table 5.2.8. A majority of the income of local governments comes from the Internal Revenue Allotment (IRA) which is provided by the national government based on the formula calculated by the population and land size of each local government unit. Though there is some variation, the rate of IRA out of the total income is 63% in average. The rest is collected from their independent revenue sources.

Among the expenditure items of the related offices in the provincial governments, cost for manpower is the highest at more than 50%, and maintenance and operation cost is around 20-30%.

As shown in the trend of income and expenditure in the past 4 years, both are increasing. For the financial balance between income and expenditure, almost all LGUs have kept their income bigger in a balanced condition.

As for the IRA budget, its usage is guided by Memorandum and Republic Act as shown below. These budgets are utilized for investment, development, and disaster risk management.

- Guidelines related to disaster risk reduction management tasks of LGUs to allocate not less than 20% of IRA for their development projects of any infrastructure sector [Memorandum Circular (MC) 2011-1, DILG/DBM]

- To utilize not less than 5% of the IRA for the Local Disaster Risk Reduction and Management Fund (LDRRMF) for the quick response or stand-by fund for relief and recovery programs of man-made and natural disasters. (Philippine Disaster Risk Reduction and Management Act of 2010, and MC 2012-73, DILG)

The budget of LGUs is not sufficient for the construction of large-scale flood control structures and the operation and maintenance works. In general, the budget is allocated for the implementation of small-scale flood control projects and for the procurement of related equipment, cleaning and repair as well as maintenance of the structures and facilities.

Table 5.2.8 Actual Income and Expenditure of Local Government Units (2013-2016)

Unit: Million Pesos

	LGU NAME	in Study Area	2013			2014			2015			2016		
			Total Income	Total Expenses	Balance	Total Income	Total Expenses	Balance	Total Income	Total Expenses	Balance	Total Income	Total Expenses	Balance
Province	REGION IV-A													
	BATANGAS	o	2,397	2,130	267	2,758	2,356	402	3,019	2,642	377	7,868	5,133	2,734
	CAVITE	o	2,534	2,172	363	2,804	1,935	869	3,181	2,051	1,130	6,665	4,686	1,979
	LAGUNA	o	2,135	2,292	-157	2,299	2,375	-75	2,542	2,568	-26	4,218	1,928	2,290
	QUEZON	o	2,082	1,605	477	2,399	1,574	826	2,948	1,773	1,175	7,637	4,400	3,238
	RIZAL	o	2,279	2,002	277	2,342	1,782	560	3,024	2,072	952	6,817	3,948	2,869
City	NATIONAL CAPITAL REGION (NCR)													
	LAS PINAS CITY	o	1,776	1,747	29	2,268	2,030	238	2,613	2,098	515	3,826	1,570	2,256
	MAKATI CITY	o	12,494	7,918	4,576	12,656	8,425	4,231	13,762	8,031	5,731	25,668	12,987	12,682
	MARIKINA CITY	o	1,974	1,708	267	1,911	1,806	105	2,212	1,656	557	3,899	1,757	2,142
	MUNTINLUPA CITY	o	2,842	2,153	689	3,272	2,482	791	3,819	3,377	442	5,275	3,810	1,466
	PARANAQUE CITY	o	3,666	3,404	263	3,776	2,976	800	3,445	2,360	1,086	7,315	2,454	4,861
	PASAY CITY	o	4,209	3,734	475	4,870	3,170	1,701	4,503	2,766	1,737	7,499	2,831	4,668
	PASIG CITY	o	7,016	10,427	-3,411	7,451	7,449	2	9,074	4,950	4,125	16,250	8,198	8,052
	QUEZON CITY	o	13,785	7,822	5,963	16,052	13,577	2,475	20,912	13,444	7,468	37,008	16,588	20,420
	TAGUIG CITY	o	3,758	3,138	620	4,737	2,799	1,938	6,054	3,582	2,471	8,941	2,799	6,142
	REGION IV-A													
	ANTIPOLO CITY	o	1,243	821	422	2,328	1,595	733	3,082	2,012	1,070	4,431	3,400	1,031
	BACOOR CITY	o	1,720	1,450	270	1,355	1,219	136	1,497	1,244	253	3,317	1,732	1,585
	CALAMBA CITY	o	318	295	24	2,501	2,050	452	3,071	2,054	1,018	5,955	2,286	3,669
	DASMARINAS CITY	o	921	839	82	1,550	918	632	1,872	1,024	848	2,915	1,783	1,132
	IMUS CITY	o	1,361	833	528	1,202	904	298	1,213	1,030	183	2,152	1,351	801
	LIPA CITY	o	980	873	107	1,200	1,083	117	1,611	1,131	480	1,811	1,319	492
	SAN PABLO CITY	o	770	775	-5	866	874	-9	969	968	1	1,161	954	207
	SAN PEDRO CITY	o	754	753	0	827	588	239	967	909	58	1,735	1,008	728
	SANTA ROSA CITY	o	578	582	-4	2,542	1,974	568	2,668	1,987	681	3,880	2,185	1,695
	TAGAYTAY CITY	o	2,396	1,879	517	984	864	120	980	941	39	2,153	1,079	1,074
	TANAUAN CITY	o	1,084	1,362	-278	1,059	964	95	1,080	999	81	2,136	976	1,160
	TAYABAS CITY	o	360	222	138	408	275	133	459	152	308	1,018	482	536
Municipality	BATANGAS													
	MALVAR	o	147	105	42	159	121	39	185	136	50			
	SANTO TOMAS	o	435	343	92	462	382	80	563	410	153			
	TALISAY	o	99	99	-0	131	153	-22	184	174	9			
	CAVITE													
	CARMONA	o	471	334	137	491	320	172	534	368	166			
	GENERAL MARIANO ALVAREZ	o	220	210	10	271	258	13	304	276	28			
	SILANG	o	407	363	44	486	336	151	555	441	114			
	LAGUNA													
	ALAMINOS	o	91	67	25	104	76	29	113	90	23			
	BAY	o	103	96	6	117	106	11	132	135	-3			
	CALAUAN	o	126	68	59	136	74	62	157	83	74			
	CAVINTI	o	95	91	4	103	93	11	109	93	16			
	FAMY	o	41	35	5	45	41	4	51	45	6			
	KALAYAAN	o	66	64	2	68	68	0	84	79	6			
	LILIW	o	64	64	1	74	56	19	81	74	8			
	LOS BANOS	o	202	181	22	227	204	24	247	192	55			
	LUISIANA	o	64	76	-12	64	60	3	71	64	6			
	LUMBAN	o	75	76	-1	82	68	14	95	91	4			
	MABITAC	o	46	44	1	54	49	5	59	51	8			
	MAGDALENA	o	61	53	7	67	58	8	74	68	6			
	MAJAYJAY	o	59	48	11	63	53	10	71	61	10			
	NAGCARLAN	o	106	99	7	119	96	23	137	106	31			
	PAETE	o	52	49	4	63	58	5	66	60	6			
	PAGSANJAN	o	92	83	9	102	88	14	108	69	39			
	PAKIL	o	67	75	-8	55	53	2	61	53	8			
	PANGIL	o	61	58	4	66	61	5	73	64	9			
	PILA	o	88	75	12	96	85	11	101	90	12			
	RIZAL	o	41	39	2	47	38	9	51	42	9			
	SANTA CRUZ	o	214	212	2	250	239	11	264	236	28			
	SANTA MARIA	o	64	60	5	82	66	16	78	78	-0			
	SINILOAN	o	85	82	4	117	105	12	143	123	20			
	VICTORIA	o	60	60	-0	136	60	77	77	68	9			
	QUEZON													
	CANDELARIA	o	133	89	44	204	170	34	292	242	50			
	DOLORES	o	56	52	4	63	58	5	72	53	19			
	LUCBAN	o	112	82	30	119	94	26	137	81	56			
	REAL	o	113	87	25	124	82	42	142	97	45			
	SAMPALOC	o	47	49	-2	52	46	5	66	48	17			
	SARIAYA	o	212	202	10	242	188	53	274	190	84			
	RIZAL													
	ANGONO	o	219	204	15	244	209	35	307	242	65			
	BARAS	o	67	67	-0	78	69	9	97	87	10			
	CAINTA	o	956	587	370	1,252	681	571	1,102	716	386			
	JALA-JALA	o	55	49	6	68	31	37	74	31	44			
	MORONG	o	49	47	2	131	98	32	120	111	9			
	PILILIA	o	93	81	12	115	114	1	129	107	22			
	RODRIGUEZ (MONTALBAN)	o	473	416	57	483	447	36	519	461	58			
	SAN MATEO	o	352	353	-2	381	313	68	428	325	103			
	TANAY	o	220	214	6	262	200	62	293	233	61			
	TAYTAY	o	414	377	36	576	571	5	650	605	45			
	TERESA	o	119	112	7	142	118	24	126	122	4			

Source: Statement of Receipts and Expenditures, DBM

5.2.4 Proposed Organization for Project Implementation/Operation and Maintenance

DPWH oversees the planning, designing and construction of large-scale flood control projects in the Metro Manila area. The completed flood control facilities are later transferred to MMDA which also conducts the operation and maintenance.

The target area of this project covers the Metro Manila area under the jurisdiction of MMDA and the provinces of Laguna and Rizal outside of the MMDA's jurisdiction. Therefore, the responsibility for operation and maintenance is shared among several organizations, which is not always effective. In addition, since the proposed measures are large-scale structures, it is but appropriate to establish the project implementation/operation and maintenance system by positioning DPWH at the center.

Based on the existing condition of organizations, institutions, and financial and human resources as mentioned above, an outline of the conceivable organization for the operation, maintenance and management of the comprehensive food control works in the Laguna de Bay area (Parañaque Spillway, Laguna Lakeshore Dike, pumping stations, river improvement works) is proposed as shown in Table 5.2.9.

Table 5.2.9 Proposed Organization for Project Implementation, Operation, Maintenance and Management of the Comprehensive Flood Control Works in Laguna de Bay

Flood Control Works	Outline	Implementation	Operation and Maintenance
Spillway	Underground tunnel spillway (L7.8-9.8km, drainage pump facilities)	DPWH-UPMO	・ DPWH-UPMO/MMDA
Lake Dike	Crest EL.14.0m, total length 83km	DPWH-UPMO	・ MMDA-FCSMO (in Metro Manila) ・ DPWH-RO/DEOs or LGUs (other areas) ・ Land management for related structures by LLDA/LGUs
Pump Station	28 pump stations in low-lying lake dike areas	DPWH-UPMO	
River Improvement	Major tributaries in construction areas of lake dike	DPWH-UPMO	

Source: JICA Survey Team

Since the proposed spillway is a large-scale underground tunnel facility it will require advanced intake/outlet operation and a large amount of budget for maintenance works (drainage and sediment removal from tunnel), it is but appropriate that the DPWH and MMDA will collaborate in the operation and maintenance of the spillway and facilities, utilizing the special operation and maintenance fund.

On the other hand, after construction of the proposed lake dike flood control facilities, pump stations and river improvement work in the surrounding area of the Laguna de Bay, they will be handed over to the DPWH regional offices concerned (NCR, Region IV-A and related district engineering offices), or to the MMDA in case the facilities are located within Metro Mania.

LGUs will generally conduct the monitoring and cleaning of small scale flood control facilities concerned. The roles and responsibilities on operation and maintenance works of the LGUs shall be identified through a Memorandum of Agreement (MOA).

CHAPTER 6. PRELIMINARY ENVIRONMENTAL AND SOCIAL ANALYSIS

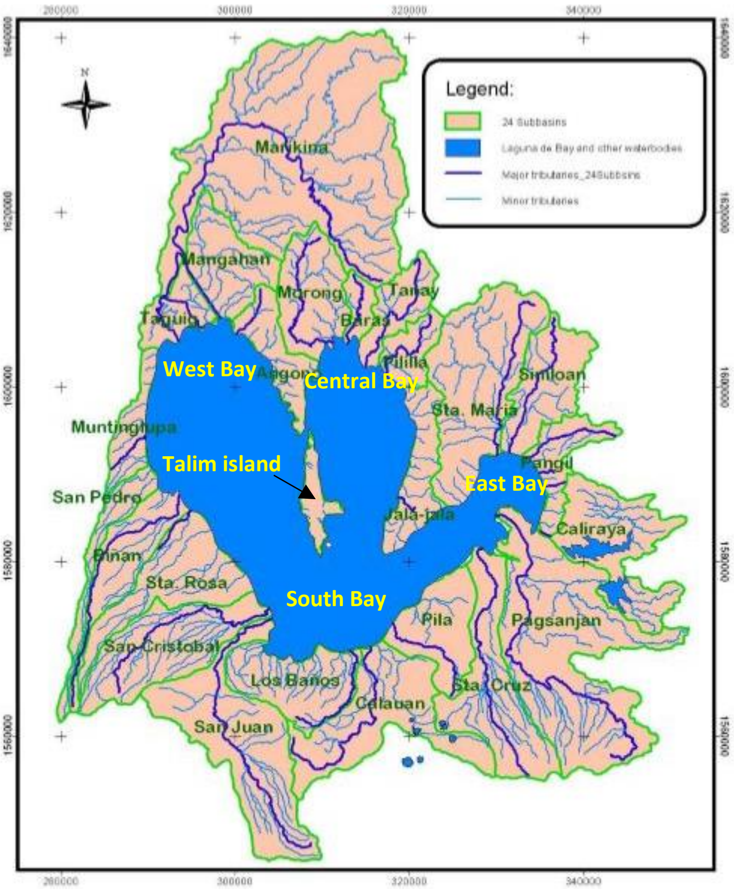
6.1 Existing Conditions of Target Areas

6.1.1 Natural Environment

(1) Ecosystem in Laguna Lake

(a) Overview

Laguna Lake is the largest lake in the Philippines with an area of approx. 900km^2. It is the third largest in South-East Asia following the largest, Toba Lake in Indonesia, and the second largest Songkhla Lake in Thailand. Average depth of the lake is shallow, namely, 2.5m, but the volume/capacity is 3.2 billion m3 and the length of lakeshore line amounts up to 220km. Laguna Lake is bounded by Laguna Province at west, south and east shore, bounded by Rizal Province at north-east and north shore, and bounded by Metro Manila at north-west shore. The lake is divided into four areas: West Bay, Central Bay, East Bay and South Bay (Figure 3.5.4). Around 100 rivers and streams drain into the lake, of which 22 are significant river systems. The whole catchment area of the lake watershed is approx. 2,980km^2. On the other hand, there is only one outlet, the Napindan Channel, which drains lakewaters through the Pasig River into the Manila Bay. (Website of LLDA)



Source：Annual Water Quality Report on the Laguna de Bay and its Tributary Rivers (2009-2012)

Figure 6.1.1 Laguna Lake and Its Watershed

(b) Biodiversity

Laguna Lake is endowed with rich natural resources and has a variety of organisms that comprise its biodiversity pool. Of note are the 31 species of fishes belonging to 16 families and 19 genera, the most dominant and important species were ayungin (*Therapon plumbeus*) and white goby (*Glossogobius giurus*), 154 species of phytoplankton, 36 species of zooplankton, and 24 species of macrophytes. Other organisms thriving in the lake include different species of mollusks, crustaceans, and birds that feed on the lake's resources. Commercially important fishes include white goby (*Glossogobius giurus*), mudfish (*Ophicephalus striatus*), ayungin (*Therapon plumbeus*), milkfish (*Chanos chanos*), catfish (*Clarias sp.*), kanduli (*Tilapia mossambica*), tilapias (*T. nilotica*), common carp (*Cyprinus carpio*), and plasalit (*Trichogaster sp.*). (Website of LLDA)

The freshwater prawn (*Macrobrachium sp.*) is also harvested commercially. A wide variety of waterfowl occur: the common species of which include yellow bittern (*Ixobrychus sinensis*), cinnamon bittern (*Ixobrychu*s cinnamomeus), grey heron (*Ardea cinerea*), luzon rail (*Rallus mirificus*) (a species endemic to the Philippines), purple swamphen (*Porphyrio porphynio*), *fulica ama*, black-winged stilt (*Himantopus himantopu*s) and little tern (*Sterna albitrons*). Laguna Lake comprises a stopover for migratory birds, thanks to its rich ecosystem. (Website of LLDA)

(c) Degree of Ecosystem Health of Laguna Lake

Water quality and aquatic ecosystem in Laguna Lake is characterized by a Laguna de Bay ecosystem health report card developed based on the water quality data of 2013. The ecosystem health report card was developed aiming at facilitating the understanding of ecosystem and water quality in the lake in collaboration with relevant organizations funded by UNEP and GEF.

Specifically, the ecosystem health of the lake is to be evaluated based on DENR environmental standards of water quality given to Laguna Lake (Class C) focusing on representative Water Quality Indicators: WQI (DO, BOD, Nitrate, Total Coliform, Phosphate, and Chlorophyll a) and Fisheries Indicators: FI (Native fish species, Zooplankton, and Catch per unit effort). Result of the evaluation is shown in Table 6.1.1, revealing that water quality of the lake is evaluated to the levels of water quality C to D (degree of conformance: 70 to 83%)[1], and fisheries indicators of F (degree of conformance: 0 to less than 70%). It is concluded that ecosystem health is evaluated as high in terms of water quality but not high in terms of fisheries indicators.

[1] Of the water quality parameters, DO, BOD, Nitrate and Total Coliform conformed with the environmental standard, but Phosphate showed a wide range of conformance degree and Chlorophyll failed to conform with the standard at all areas.

Table 6.1.1 Degree of Ecosystem Health of Laguna Lake (2013)

Section	WQI		FI	
	Score (%)	Evaluation	Score (%)	Evaluation
West Bay	76	C	55	F
Central Bay	71	D	65	F
East Bay	81	C	28	F
South Bay	77	C	43	F
Laguna de Bay (the whole area)	76	C	48	F

Note: Score and evaluation based on consistency with DENR standard (Class C:
A: 91 – 100%, B: 83 – 91%, C: 75 – 83%, D: 70 – 74%, F: 0 – 70%
Source: Laguna de Bay 2013 Ecosystem Health Report Card
http://ian.umces.edu/pdfs/ian_report_card_500.pdf#search=%272013+Ecosystem+Health+report%27

(2) Ecosystem of Manila Bay (LPPCHEA)

As described in 3.5.3 (4), Parañaque Spillway is not likely to pose an impact on the whole bay. Hence, the list of flora and fauna in and around LPPCHEA was collected to check the existence of endangered species, because it locates near the outfalls of the Parañaque and Zapote rivers, which are candidates for the spillway's outlet. The flora and fauna is described below.

(a) Avian Species

In LPPCHEA, there are around 82 wild bird species including migratory ones. In addition, endemic Philippine Duck and Chinese Egret were spotted. It is important not to affect them.

Philippines Duck

Chinese Egret

Source: Wikipedia

Figure 6.1.2 Endemic Avian Species in LPPCHEA

(b) Plant Species

LPPCHEA has the thickest and most diverse mangrove forest among the remaining mangrove areas in Manila Bay. Mangrove forests are critical spawning grounds, nursery, feeding and temporary shelter areas not only for fishes but for other wild life species as well. Major mangrove species in that area are, Avicennia marina, Lumnitzera racemosa, Sonneratia alba and Rhizophora spp.

(c) Macro-invertebrate and Fish Species

Mollusc including bivalves and gastropods is the most abundant macro-invertebrate around LPPCHEA. Eight species of juvenile to sub-adult sized fishes such as milkfish are also found. This shows the importance of mangrove forest as a spawning ground and nursery. No endemic specie is included among them.

(3) Water Quality

The water quality of Manila Bay, Laguna de Bay and the tributaries is explained in this section. The data of Manila Bay monitored along the shores of the City of Navotas to the City of Las Piñas were used, because the area is near the planned outlet location of the Parañaque Spillway. Water quality was evaluated based on the water quality guideline in DAO 2016-08 (refer to Section 3.5.2).

(a) Manila Bay

The water of Manila Bay is contaminated with human waste, sewage and industrial effluent, according to the water quality reports from the Department of Environment and Natural Resources (DENR) and the Bureau of Fisheries and Aquatic Resources. The latest water quality data were recorded in the first half of 2017. The average water quality of 2016 and 2017 are shown in the table below. Dissolved oxygen, fecal coliform, oil and grease, chromium and lead do not meet the Class SC standard in DAO 2016-08. Class SC is the standard for commercial fishing and mangrove areas declared as wildlife sanctuaries.

Table 6.1.2 Water Quality of Manila Bay (2016, first half of 2017)

Parameters (units)	2016 Annual Ave.	2017 First Half-year Ave.	Class SC Standard
Dissolved oxygen (mg/l)	**0.73**	**2.71**	> 5
Total suspended solids (mg/l)	13	16	< 80
Color (TCU)	12.64	16.33	< 75
Phosphate-phosphorus (mg/l)	**1.6**	0.18	< 0.5
Nitrate Nitrogen (mg/l)	1.34	1.26	< 10
Fecal Coliform (MPN*1/100ml)	**290 Million**	**2 Billion**	< 200
Oil and Grease (mg/l)	-	**3.5***2	< 2
Chromium (mg/l)	-	**0.036***2	< 0.01
Cadmium (mg/l)	-	< 0.003*2	< 0.005
Mercury (mg/l)	-	< 0.0001*2	< 0.002
Lead (mg/l)	-	**0.27***2	< 0.05

*1 Most Probable Number
*2 Observed in May 2017 only
Source: JICA Survey Team

The number of fecal coliforms is considerably large. It is more than 1 million times larger than the standard, and is near to untreated wastewater. The contamination is attributed to the coastal urban area and the informal settlers along rivers and beaches who directly dispose their waste into rivers or Manila Bay. The low Dissolved Oxygen (DO) is also not suitable for fishes. In addition, toxic substances oil and grease, Chromium and lead exceeded the standard according to the survey in May 2017, which is attributed to industrial effluent. Moreover, DENR's report shows that the sediment of Manila Bay is also contaminated with toxic substances. The coastal area and outfalls smelled bad like sulfur when the Survey Team visited the site. It is expected that organic substances in the sediment are biodegraded by anaerobic bacteria, because Biochemical Oxygen Demand (BOD) is high and DO is almost 0. The coast and river were full of urban waste.

LPPCHEA from Coast

Zapote River Left Bank near Outfall

Source: JICA Survey Team

Figure 6.1.3 Gumbel, GEV and LN2LN Distributions and Observed Annual Maximum

For the reasons mentioned above, water quality of the Manila Bay near the coast from City of Navotas to the City of Las Piñas is not suitable for fishery or any recreational activity. The marine products are considered at risk for contamination with toxic substances lead, chromium, etc.

(b) Laguna de Bay and Tributaries

(i) Laguna de Bay

Most water quality parameters of Laguna de Bay pass the Class C standard, although some tributaries in urban areas fail, according to LLDA’s water quality reports. Class C standard is the standard for freshwater. Water which meets Class C is suitable for fishery, boating, fishing, agriculture and livestock watering. The measurement results in 2017 and 2016 is shown in the table below. DO is enough for fishes and phosphate-phosphorus and nitrate meet Class C. Among them, only ammonia fails Class C. Human waste that enters through tributaries in the urban area on the west and north-west side of the lake is thought to be the major cause of high ammonia concentration of the lake. However, ammonia also exceeds the standard in the rural areas except for some tributaries on the east side, though the exceedance is about one-tenth of that of urban areas. The exceedance in the rural areas is attributed to human waste and livestock waste.

Table 6.1.3 Water Quality of Laguna de Bay (2016 and First Quarter of 2017)

Parameters (units)	2016 Annual Ave.	2017 First Half-Year Ave.	Class SC Standard
Dissolved Oxygen (mg/l)	8.1	8.36	> 5
Biochemical Oxygen Demand (mg/l)	2	1.4	< 7
pH	8.54	8.16	6.5 – 9.0
Phosphate-Phosphorus (mg/l)	0.13	0.18	< 0.5
Nitrate Nitrogen (mg/l)	0.2	1.26	< 7
Total Coliform (MPN/100ml)	482	154	< 5000*
Ammonia (mg/l)	**0.077**	**0.08**	< 0.05

*DAO No. 34 standard (DAO 2016-08 does not have standards)

Source: JICA Survey Team

(ii) Tributaries

The water quality of tributaries was also monitored by LLDA. The tributaries in the west and north-west sides are highly contaminated with sewage. DO, BOD, phosphate phosphorus, total coliform and ammonia far exceed the Class C standard. On the other hand, regarding the tributaries in the south, east and north side where population density is low, DO, BOD, phosphate phosphorus and nitrate satisfy Class C, but ammonia and total coliform fail. Exceedance is one-tenth less than that of the west and northwest sides because of far lower population density.

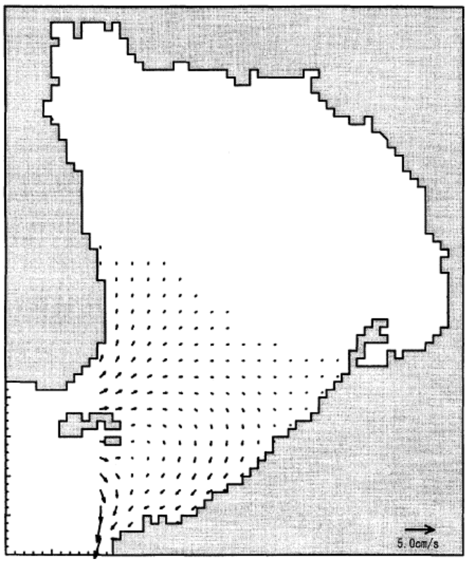
(c) Current in Manila Bay

There asioxdrive forces of ocean current:

- Wind
- Density difference
- Tide
- River flow
- Large scale ocean current (ex. Kuroshio Current)

In inner bays, large scale ocean current is not a driving force, and the effect of tide is small with exception of the mouth of bays. The outfall of Parañaque and Zapote River, which are the candidate of the outlet of Parañaque Spillway, located in head of Manila Bay, and the effect of the tides to the current is thought to be small there. Fujiie (2002)2, simulated the tide induced current in Manila Bay. The simulation result is shown in Figure 6.1.4. The tide induced residual current for 30 days is less than 1 cm/s with the exception of 5 cm/s at the mouth of the bay.

Thus, wind, density difference, and river flow take a large part of the current near the outfalls of the Parañaque and Zapote rivers. Wind and river flow induced current are described below. Density difference induced current is not mentioned because it is not clear without simulation.



Source: Tide, Tidal Current and Sediment Transport in Manila Bay, 2002
(Only the flow velocities larger than 0.5 cm/s are shown.)

Figure 6.1.4 Tide Induced Residual Current in a Month

[2] Tide, Tidal Current and Sediment Transport in Manila Bay by Wataru Fujiie, Tetsuo Yanagi and Fernando P. SIRIGAN, 2002

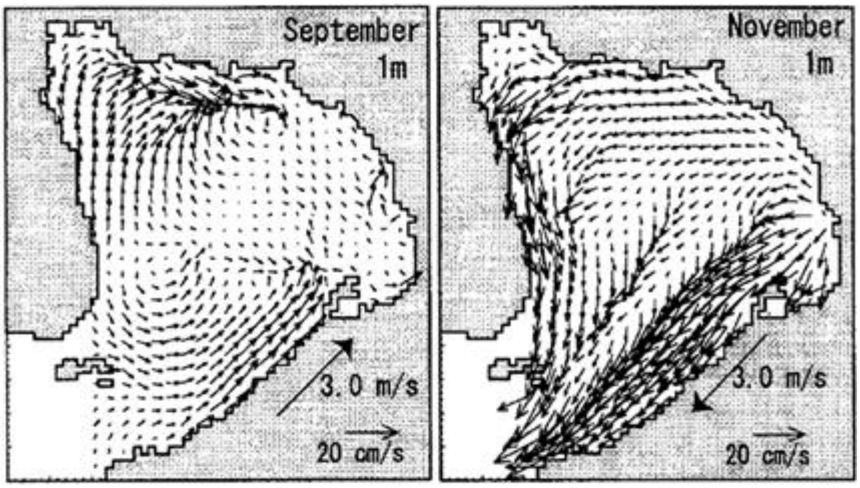
(i) River Flow Induced Current

Manila Bay is drained by two major river systems, the Pampanga and Pasig river systems. The Pampanga River contributes about 50% of all freshwater that enters the bay. The inflow from the Pampanga River causes southward current from its outfall. The Pasig River also creates westward current from its river mouth.

(ii) Wind Induced Current

Wind pushes against the sea surface and sets up a current in the down-wind direction which decreases with depth. The wind direction of Manila Bay is under the influence of monsoon. A monsoon is a seasonal prevailing wind in the region of South and SE Asia. In the Philippines, it blows from the southwest or west between May and September bringing rain (the wet monsoon), and from the northeast or north between October and April (the dry monsoon).

Between May and September, southwest or west winds make ocean current toward the head of the bay, while between October and April, northeast or north winds make ocean current toward the mouth of the bay. Fujiie (2002) also simulated the wind and density driven current. The simulation result at the depth of 1 m is shown in the figure below for reference. The wind induced current under the dry and wet monsoons is shown.



Source: Tide, Tidal Current and Sediment Transport in Manila Bay, 2002

Figure 6.1.5 Wind and Density Induced Current in Manila Bay

(4) Terrestrial Flora and Fauna, and Ecosystem

(a) Biodiversity, Endemism and Protected Species

According to the Fourth National Biodiversity Strategy and Action Plan (2009), the Philippines is in the 5th place in the number of plant species and maintains 5% of the world's flora. Species endemism is very high, covering at least 25 genera of plants and 49% of terrestrial wildlife. It also ranks 4th in bird endemism. In terms of fishes, there are 121 endemic species. It is also recognized that the natural environment such as forests, mangrove and coral reefs are rapidly being devastated and the whole nation was designated as a hotspot in 1992. Thus, early conservation of ecosystem is required to be done.

Table 6.1.4 shows the number of species of flora and fauna identified as well as endemic species in the Philippines. The characteristics of Philippine biota are, high diversity and extremely high ratio of endemism.

Table 6.1.4 Biodiversity in the Philippines and Endemism

Category		Number of identified species	Number of endemic species	Ratio of endemic species (%)
Flora		9,253	6,091	65.8
Fauna	Mammals	167	102	61.1
	Birds	535	186	34.8
	Reptiles	237	160	67.5
	Amphibians	89	76	85.4
	Freshwater Fishes	281	67	23.8

Source：Conservation International (2007)

Threatened species are designated in the Philippines as protected species under DAO No. 2004-15 for wildlife and DAO No. 2007-01 for plants depending on the degree of threatening as Critically Endangered: CE, Endangered: EN, Vulnerable: VU, and Other Threatened: OT (refer to Table 6.1.5 and Table 6.1.6). The number of protected species is 207 for faunal species and 526 for plants.

In this regard, the number of protected species is not specified by region or area, so there is no clear information on the number of protected species in the survey area.

Table 6.1.5 Number of Protected Wildlife designated by Domestic Law (DAO No. 2004-15)

Group	Critically Endangered (CE)	Endangered (EN)	Vulnerable (VU)	Other Threatened (VU)	Total
Mammals	8	12	17	5	42
Birds	15	59	53	0	127
Reptiles	5	11	4	4	24
Amphibians	0	4	10	0	14
Total	28	86	84	9	207

Note: As of 2013
Source: DENR-BMB

Table 6.1.6 Number of Protected Plants designated by Domestic Law (DAO No. 2007-01)

Category	Number of Threatened Species
Critically Endangered (CE)	99
Endangered (EN)	187
Vulnerable (VU)	176
Other Threatened (VU)	64
Total	526

Note: As of 2013
Source: DENR-BMB

(b) Land Cover

Table 6.1.7 shows land cover in the three provinces (Metro Manila, Laguna and Rizal) where the project area is located and the whole country. It should be noted that these three provinces are the most urbanized area and therefore, the ratio of built-up is high, especially 86.7% in Metro Manila. Those of

Laguna and Rizal Province are 10.7% and 13.8%, respectively, which are much higher compared with 2.3% in the whole country. The ratio of forest lands, on the contrary, is low: the ratio of forest lands, even if combining with “Other Wooded Land,” is 5.8% in Metro Manila and 24.4% in Laguna. On the other hand, the ratio of “Inland Water” is extremely high, 36.0% owing to the existence of Laguna Lake. Ecosystem in the survey area is made up based on these land covers as habitat of wildlife and plants, which shows dynamic changes through action and reaction with human activities.

Table 6.1.7 Land Cover Status in the Survey Area

Land Cover Classification		Metro Manila		Laguna Province		Rizal Province		Philippines	
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Forest	Closed	-	0.0	1,234	0.5	4,139	3.3	1,934,032	6.5
	Open	2008	3.4	15,193	5.8	12,682	10.2	4,595,154	15.5
	Mangrove	115	0.2	-	0.0	-	0.0	310,531	1.1
Other Wooded Land	Fallow	-	0.0	-	0.0	-	0.0	7,247	0.0
	Shrubs	346	0.6	37,727	14.4	32,926	26.4	3,355,180	11.4
	Wooded grassland	962	1.6	9,612	3.7	25,424	20.4	3,829,046	13.0
Agricultural	Annual crop	655	1.1	31,990	12.2	8,071	6.5	6,275,993	21.2
	Perennial crop	26	0.0	39,800	15.2	8,432	6.8	6,168,360	20.9
Fishpond		1,090	1.8	51	0.0	25	0.0	244,968	0.8
Other natural land		1,506	2.5	4767	1.8	15017	12.0	1666144	5.6
Built-up area		51,618	86.7	27,954	10.7	17,238	13.8	692,079	2.3
Inland water		1,231	2.1	94,222	36.0	820	0.7	481,421	1.6
Grand Total		59,556	100.0	261,550	100.0	124,774	100.0	29,554,156	100.0

Source：Compendium of Philippine of Environmental Statistics, 2014

(c) Terrestrial Ecosystem in the Survey Area

There is no massive forest but only built-up in the area of Taguig and Muntinlupa City along the west lakeshore of Laguna Lake. Vegetation cover is only seen in parks, subdivisions, or in woods along the lake. Lakeshore is densely covered by water hyacinth (*Eichhornia crassipes*) and kangkong (*Ipomoea aquatica*) (Photos 1 and 2, Figure 6.1.6). This situation is seen over the municipalities of San Pedro, Biñan and Santa Rosa.

Vast agricultural lands (paddy and dry field) cover the area along the Laguna Lake from the municipality of Cabuyao toward southern LGUs, which forms agricultural ecosystem. In the municipality of Los Baños, natural ecosystem under vast forest lands of Mt. Makiling Forest Reserve prevails until the lakeshore (Photos 3 and 4, Figure 6.1.6). Existing tree species include sampaloc (*Tamarindus indica*), langka (*Artocarpus heterophyllus*), talisai (*Terminalia catappa*), santol (*Sandoricum koetjape*), mangga (*Mangifera indica*), camachile (*Pithecellobium dulce*), coconut (*Cocos rucifera*), bamboo (*Bambusa spp.*), banana (*Musa spp.*), and papaya (*Carica papaya*), most of which are common in tropical area.

The ratio of built-up becomes smaller in the eastern side of Laguna Lake. The lakeshore lands from the municipality of Victoria to Mabitac through Santa Cruz, a provincial capital, municipalities of Lumban and Kalayaan, establish a marsh ecosystem on a vast wetland including paddy and dry fields (Photos 5 and 6, Figure 6.1.6). The common plants in it include buffalo grass (*Brachiaria mutica)*, rice flatsedge (*Cyperus iria*), and windmill grass (*Chloris barbata*).

In the northern area along Laguna Lake, consisting of two peninsulas and Talim Island, there is a few built-up but vase forest lands and dry fields. Low land along the lakeshore is only limited in narrow area, which forms an agricultural ecosystem. There is a vast wetland along the northernmost area in Laguna Lake where water hyacinth (*Eichhornia crassipes*) and kangkong (*Ipomoea aquatica*) covers until the western side of the lake (Photos 7 and 8, Figure 6.1.6).

Photo 1: Western Side of Laguna Lake (1)
(Southern area from Taguig Lakeshore Hall)

Photo 2: Western Side of Laguna Lake (2)
(Southern area from Sucat People's Park)

Photo 3: Southern Side of Laguna Lake (1)
(Wetland along San Juan River and Mt. Makiling)

Photo 4: Southern Side of Laguna Lake (2)
(Western area of Los Baños)

Photo 5: Eastern Side of Laguna Lake (1)
(Dry Field around Pagsanjan River)

Photo 6: Eastern Side of Laguna Lake (2)
(Wetland around Pagsanjan River)

Photo 7: Northern Side of Laguna Lake (1) (Wetland near Angono River)

Photo 8: Northern Side of Laguna Lake (2) (Wetland along Mangahan Floodway)

Source: JICA Survey Team

Figure 6.1.6 Vegetation Cover around Laguna Lake

(5) Protected Areas

Protection of important ecosystems in the Philippines is stipulated by the National Integrated Protected Areas System Act (NIPAS Act), 1992, and its IRR (implementation rules and regulations). According to the NIPAS Act, the categories of protected areas are as shown in the table below:

Table 6.1.8 Categories of Protected Areas according to the NIPAS Act

No.	Protected Areas	Definition
1	Strict Nature Reserve	An area possessing some outstanding ecosystem, features and/or species of flora and fauna of national scientific importance maintained to protect nature and maintain processes in an undisturbed state in order to have ecologically representative examples of the natural environment available for scientific study, environmental monitoring, education, and for the maintenance of genetic resources in a dynamic and evolutionary state.
2	Natural Park	A relatively large area not materially altered by human activity where extractive resource uses are not allowed and maintained to protect outstanding natural and scenic areas of national or international significance for scientific, educational and recreational use.
3	Natural Monuments	A relatively small area focused on protection of small features to protect or preserve nationally significant natural features on account of their special interest or unique characteristic.
4	Wildlife Sanctuary	An area which assures the natural conditions necessary to protect nationally significant species, groups of species, biotic communities or physical features of the environment where these may require specific human manipulations for their perpetuation.
5	Protected Landscapes and Seascapes	Areas of national significance which are characterized by the harmonious interaction of man and land while providing opportunities for public enjoyment through the recreation and tourism within the normal lifestyle and economic activity of these areas.
6	Resource Reserve	An extensive and relatively isolated and uninhabited area normally with difficult access designated as such to protect natural resources of the area for future use and prevent or contain development activities that could affect the resource pending the establishment of objectives which are based upon appropriate knowledge and planning.
7	Natural Biotic Area	An area set aside to allow the way of life of societies living in harmony with the environment to adapt to modern technology at their pace.
8	Other categories established by law, conventions or international agreements which the Philippine Government is a signatory.	Conservation Areas established by law, conventions or international agreements (Ramsar Site, World Heritage Site, etc.)

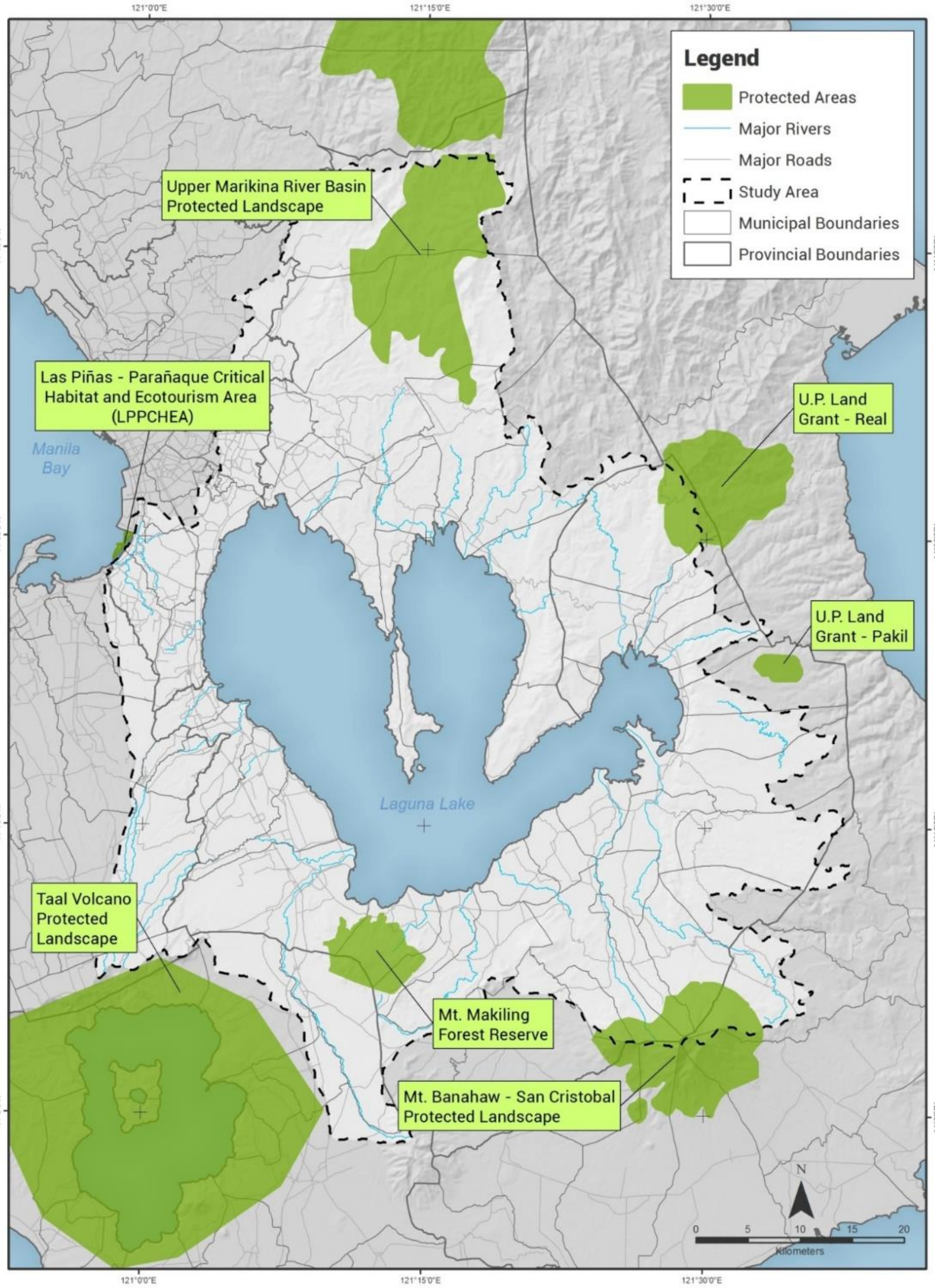
Source: National Integrated Protected Areas System Act (NIPAS Act), 1992

Protected areas located in the survey area include Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA) which is designated as Samsar site, Upper Marikina River Basin Protected Landscape, Mounts Banahaw–San Cristobal Protected Landscape and Taal Volcano Protected Landscape, which are located in or close to the survey area. In addition, there are Mt. Makiling Forest Reserve and UP Land Grants (Pakil and Real), both of which are not designated by NIPAS Act but are designated as biodiversity reserve. Features and locations of these protected areas are shown in Table 6.1.9 and Figure 6.1.7.

Table 6.1.9 Protected Area and Biodiversity Reserve located in the Survey Area

Category	Name	Feature
Protected Area	Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA)	LPPCHEA is one of the six Ramsar sites in the Philippines, which was registered in UNESCO in 2013. It is located along Manila-Cavite Expressway at 0.5 to 1.0 km offshore with an area of 175 ha, composed of two islands, Freedom Island and Long Island. It was designated as Critical Habitat by NIPAS Act in 2007. This protected area is characterized by the location close to the metropolitan area. Before 2010, 5,000 wild birds at least were identified, including 47 species of migratory birds. The number has been decreasing afterwards due to development activities around there.
	Upper Marikina River Basin Protected Landscape	Upper Marikina River Basin Protected Landscape, located in the upper basin area of the Marikina River flowing down Metro Manila area, has an area of 26.125.64 ha, proclaimed in 2011. It is administratively located in Rizal Province and is approx. 15km far in the north from Laguna Lake.
	Mounts Banahaw–San Cristobal Protected Landscape	Mounts Banahaw–San Cristobal Protected Landscape, registered in 2003, is located across both Laguna and Rizal provinces with an area of 10,900.59 ha. It is located approx. 20km north from Laguna Lake, composed of two dormant volcanos, Mt. Banahaw and Mt. San Cristobal, and covered by dipterocarp forests.
	Taal Volcano Protected Landscape	Taal Volcano Protected Landscape, located approx. 55km south of Manila with an area of 62,292.14ha, was designated in 1996. Most parts of the protected area belong to Batangas Province while the municipality of Tagaytay, which is situated at the top of ridge around Taal Lake, the third largest lake in the country, belongs to Cavite Province. Taal Volcano, located within the lake, has a continuing volcanic activity.
Biodiversity Reserve	Mt. Makiling Forest Reserve (MMRR)	Mt. Makiling Forest Reserve (MMRR) is located south of Laguna Lake, with an area of 4,244.37ha. MMFR is also designated as ASEAN Heritage Park and famous for resort area utilizing the efficacy of hot spring. Further in ecological point of view, it is designated as one of the 18 plant biodiversity reserves.
	UP Land Grants (Pakil and Real)	UP Land Grants (Pakil and Real) is designated as one of the priority biodiversity reserve, located across three provinces, Laguna, Quezon and Rizal. It is, with an area of 22,635ha, located approx. 10km in the east divided into two areas.

Source：National Integrated Protected Areas System Act (NIPAS Act), 1992



Source：Manila Bay Environmental Atlas, 2nd Edition, 2015

Figure 6.1.7 Location Map of Protected Areas and Biodiversity Reserves in the Survey Area

(6) Air Quality

National air quality status reports (2008-2015) published by DENR show the monitoring results of air quality in the country based on the General Ambient and Roadside Ambient Air Quality Monitoring Program. Monitored parameters in NCR and Region 4A where the survey area is located include TSP, PM10, PM2.5 SO2, NO2 and O3. Monitoring results are shown in Table 6.1.10 to Table 6.1.13 (refer to Figure 6.1.8 for monitoring locations).

TSP shows the suspended particulate matters with the diameter of less than 100μm in the air, and its concentration has been monitored from the earliest times among others. Monitoring results show that TSP concentration exceeds the environmental standard value (NAAQGV) at many locations, and that there is a decreasing trend after 2010.

PM10 is the suspended particulate matters with the diameter of less than 10μm in the air. It can enter the lung due to its small size and therefore, it is an indicator on threat to human health. Monitoring results show that PM10 concentration exceeds the environmental standard value at many locations, same as TSP, and that there is a decreasing trend year by year.

PM2.5 is further small-sized particulate matters than PM10. Since it can reach deep into the lung, it is also an indicator on bigger threat to human health. Monitoring results at four stations show that there are the data exceeding the environmental standard value.

SO2 and NO2 are harmful substances produced in the process of burning of fossil fuel. Monitoring results show SO2 concentration exceeds the environmental standard value at one station although three others are far below the standard value. NO2 shows that all the data exceed the standard value except for one station (DLSU, Taft). O3 shows that all the data exceed the standard value at all stations.

Table 6.1.10 Secondary Data on Air Quality (TSP Annual Average)

Unit: μg/NCM

Region	Station	2008	2009	2010	2011	2012	2013	2014	2015	Ave.
NCR	Makati Bureau of Fire Cmpd. , Makati City	**134**	**145**	**160**	**128**	**135**	-	**130**	**111**	**135**
	Vallenzuela Municipal Hall, Valenzuela City	**156**	**164**	**162**	**121**	**123**	**143**	**122**	86	**135**
	EDSA East Avenue BFD Cmpd., Quezon City	**107**	90	**105**	74	72	**92**	**96**	**97**	**92**
	NCR-EDSA National Printing Ofc., Quezon City	**144**	89	**152**	**103**	**96**	**112**	**97**	-	**113**
	Ateneo de Manila University, Quezon City	74	62	79	58	62	70	50	48	63
	Mandaluyong City Hall, Mandaluyong City	**125**	**104**	**138**	**136**	**148**		**143**	**158**	**136**
	Dept. of Health, Manila City	**103**	**103**	**132**	**101**	**114**	**115**	**105**	**109**	**110**
	LLDA Cmpd. Pasig City	85	**126**	-	-	-	-	-	-	**106**
	Marikina Sports Complex, Marikina City	-	-	**125**	**125**	**108**	**97**	81	104	**107**
	MRT-Taft Ave. Rotonda Sta., Pasay City	**282**	**283**	**294**	**219**	**213**	**197**	**216**	-	**243**
Region IV-A	Brgy. Bolbok, Batangas	50	19	22	-	-	-	-	-	30
Average		**126**	**119**	**137**	**118**	**119**	**118**	**116**	**102**	**115**

Environmental Standard: NAAQGV (National Ambient Air Quality Guideline Value): 90 μg/NCM (annual average)
Source：National Air Quality Status Report (2008－2015)

Table 6.1.11 Secondary Data on Air Quality (PM10 Annual Average)

Unit: μg/NCM

Region	Station	2012	2013	2014	Average
NCR	NCR-EDSA National Printing Office, Quezon City	**61**	**73**	**89**	**74**
	Marikina Sports Complex, Marikina City	**67**	**62**	47	59
	Dept. of Health, Manila City	51	**69**	-	60
	MMDA Building Compound, Makati City	54	**67**	52	58
	MRT-Taft Ave. Rotonda Sta., Pasay City	**110**	**105**	-	**108**
	National Bilibid Prison, Muntilupa City	-	25	36	31
	Monumento, Caloocan City	**151**	**150**	-	**151**
	Commonwealth Ave., Quezon City	-	-	57	57
	DLSU, Taft, Manila City	-	29	27	28
	DPWH, Timog-EDSA, Quezon City	-	44	**66**	55
	Vallenzuela Municipal Hall, Valenzuela City	-	-	33	33
	Ateneo de Manila University, Quezon City	38	50	-	44
	Radio ng Bayan, Valenzuela City	58	**74**	53	**62**
	NAMRIA, Taguig City	43	54	-	49
Region IV-A	Cavite State University, Cavite	-	32	-	32
	Brgy. Bolbok, Batangas	-	29	-	29
Average		**70**	**62**	51	**62**

Environmental Standard: NAAQGV (National Ambient Air Quality Guideline Value): 60 μg/NCM (annual average)
Source：National Air Quality Status Report (2008-2015), DENR

Table 6.1.12 Secondary Data on Air Quality (PM2.5 Annual Average)

Unit: μg/NCM

Station	2013	2014	Average
Commonwealth Avenue, Quezon City	-	**50**	**50**
DLSU, Taft, Manila City	21	19	20
DPWH, Timog-EDSA, Quezon City	**36**	**43**	**40**
Valenzuela Municipal Hall, Valenzuela City	29	29	29
Average	29	35	35

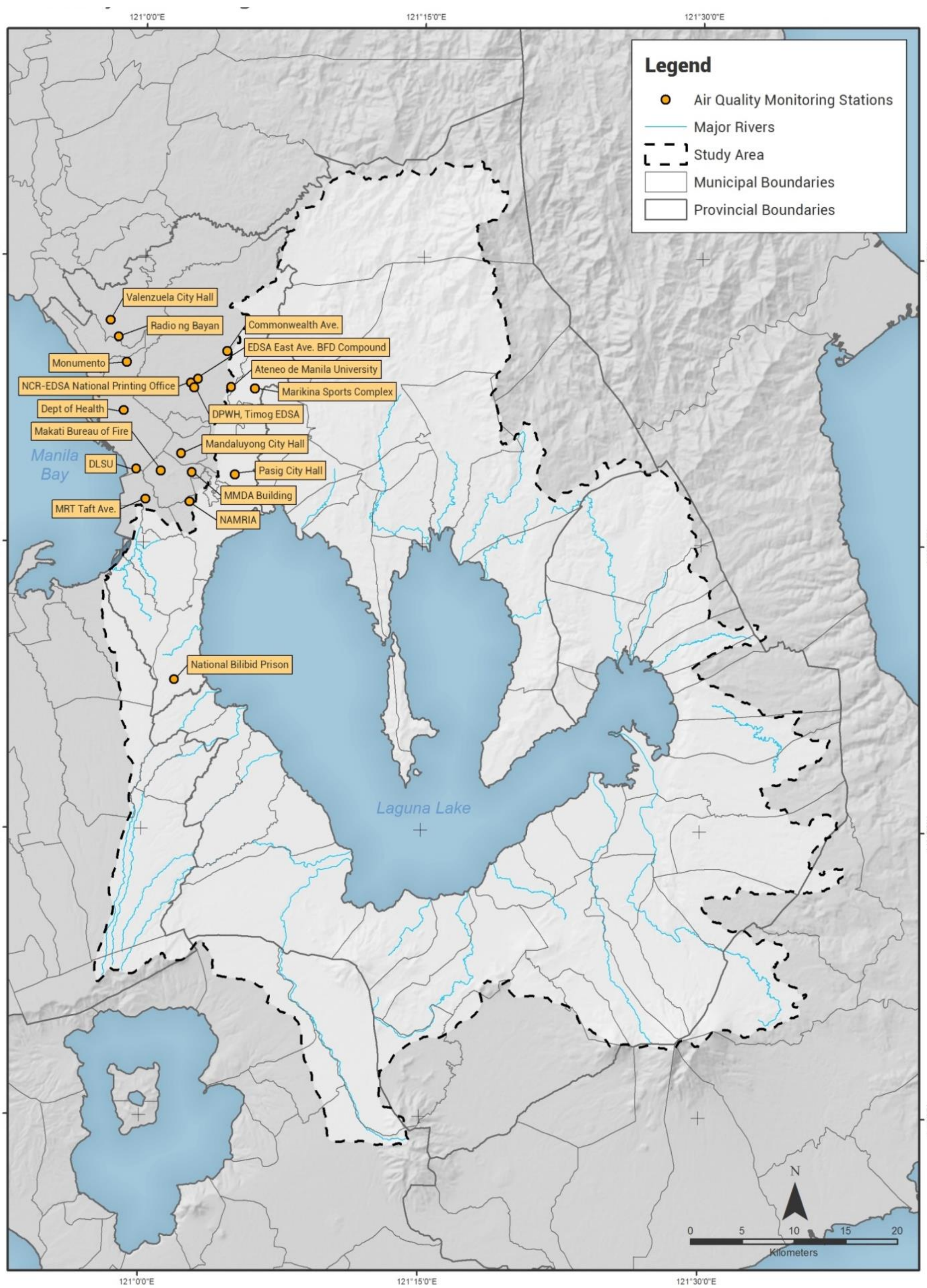
Environmental Standard: NAAQGV (National Ambient Air Quality Guideline Value): 35 μg/NCM (annual average)
Source: National Air Quality Status Report (2008－2015)

Table 6.1.13 Secondary Data on Air Quality (SO2, NO2 and O3）

Unit: μg/NCM

Station	SO2（24-hour value）		NO2（24-hour value）		O3（8-hour value）	
	Ave.	Max.	Ave.	Max.	Ave.	Max.
Commonwealth Avenue, Quezon City	27	143	128	**436**	**-**	**-**
DLSU, Taft, Manila City	12	35	49	94	52	**225**
DPWH, Timog-EDSA, Quezon City	27	73	106	**195**	40	**148**
Valenzuela Municipal Hall, Valenzuela City	**86**	**268**	63	**185**	98	**282**
Environmental standard: NAAQGV	80	180	-	150	-	60

Source：National Air Quality Status Report (2008-2015)



Source：National Air Quality Status Report (2008－2015), DENR

Figure 6.1.8 Location Map of Air Quality Monitoring Stations of DENR

There are monitoring data on air quality along the west side of the Laguna Lake, which is the target of the Project, obtained in the EIA Study for LLED (Laguna Lakeshore Express Dike) Project. The monitoring results shown in Table 6.1.14 indicate that all the monitored parameters, SO2, NO2 and PM10, are almost below the environmental standard value (NAAQGV), which suggests there is no pollution issue in ambient air quality around the Laguna Lake.

Table 6.1.14 Secondary Data on Air Quality (Laguna Lakeshore Express Dike (LLED) Project)

Unit: µg/NCM

No.	Station	City/Municipality	Monitoring date (monitoring time)	SO2	NO2	PM10
1	Hagonoy	Taguig	Feb. 09, 2014 (1 hour)	2.21	2.93	49
2	Sucat	Muntinlupa	Feb. 09, 2014 (1 hour)	0.73	4.76	36
3	Alabang	Muntinlupa	Feb. 09-10, 2014 (24 hour)	0.18	13.86	31
4	Sinalhan	Sta. Rosa	Feb. 08, 2014 (1 hour)	5.18	0.27	33
5	Marinig	Cabuyao	Feb. 08, 2014 (1 hour)	< 0.04	2.51	18
6	Bucal	Calamba	Feb. 08, 2014 (1 hour)	< 0.04	2.53	79
7	Maahas	Los Baños	Feb. 08, 2014 (1 hour)	< 0.04	1.69	52
NAAQGV (National Ambient Air Quality Guideline Value) for 24 hours average				180	150	150

Source：Environmental Impact Statement for the Laguna Lakeshore Express Dike Project (2014), DENR

(7) Noise

No monitoring on noise pollution is conducted by government agencies including DENR, and there is no data on ambient noise over time but only ad hoc data obtained on project basis. Monitoring results of ambient noise from 2008 to 2017 under the Pasig-Marikina River Channel Improvement Project (Phase II and III) are among such project cases, showing that the ambient noise level in residential areas along the rivers exceeds the environmental standard values at most of the monitoring stations. The LLED Project also monitored the noise level under its EIA Study along the west side of Laguna Lake. Table 6.1.15 shows the monitoring results, showing that the noise level data at five stations exceed the environmental standard out of seven stations.

These secondary data on ambient noise suggest that ambient noise level in the survey area is estimated to be higher than the environmental standard value.

Table 6.1.15 Secondary Data on Ambient Noise Level (LLED Project)

No.	Station,	City/Municipality	Monitoring date	Noise Level（dB (A)）			
				Morning	Daytime	Evening	Night time
1	Hagonoy	Taguig	Feb. 09, 2014	-	**70.5**	-	-
2	Sucat	Muntinlupa	Feb. 09, 2014	-	67.7	-	-
3	Alabang	Muntinlupa	Feb. 09-10, 2014	**76.7**	**74.7**	**78.7**	**71.3**
4	Sinalhan	Sta. Rosa	Feb. 08, 2014	-	**74.2**	-	-
5	Marinig	Cabuyao	Feb. 08, 2014	-	59.6	-	-
6	Bucal	Calamba	Feb. 08, 2014	-	**77.1**	-	-
7	Maahas	Los Baños	Feb. 08, 2014	-	**71.8**	-	-
Noise Level Standards in General Areas (NPCC, 1980), Class C: Section primarily reserved as a light industrial area				65	70	65	60

Source：Environmental Impact Statement for the Laguna Lakeshore Express Dike Project (2014), DENR

(8) Waste Management

(a) Overview of Waste Management in the Philippines

In the Philippines, the volume of municipal solid waste has been increasing along with economic development. In urban areas, especially in Metro Manila, the issue on solid waste management becomes a threat. The Ecological Solid Waste Management Act of 2001 provides the framework of collection, transport and disposal of municipal waste in the country. In reality, however, the disposal site development is not well accomplished but delayed due to insufficient skill and budget. Statistical data on the generation volume of solid waste or recycling is not provided well, and thus, information on waste management is not altogether available at the moment. (Environmental and Social Consideration Profile of the Philippines, JICA, 2011)

(b) Basic Laws on Waste Management

There are two basic laws on waste management in the Philippines:

The Ecological Solid Waste Management Act (Republic Act No. 9003), 2001: This act is the basic law on municipal solid waste management in the country, in which efforts for systematic and comprehensive solid waste management program as a national policy is declared. In addition, the responsibility of various levels of LGUs on solid waste management is stipulated. Specifically, barangays are responsible for the segregation of waste, collection of biodegradable, reusable and recyclable wastes, and for installation of Material Recovery Facility (MRF). On the other hand, cities and municipalities are in charge of non-biodegradable wastes, hazardous waste and development of disposal sites. In this regard, the development of final disposal sites in Metro Manila is the responsibility of MMDA (Metro Manila Development Authority).

Toxic Substances, Hazardous and Nuclear Wastes Control Act (RA No. 6969), 1990: This act is the basic law covering the importation, manufacture, processing, handling, storage, transportation, sale, distribution, use and disposal of all unregulated chemical substances and mixtures in the Philippines.

(c) Waste Management Facilities

Table 6.1.16 shows the number of solid waste management facilities in the survey area. This table shows that there are a substantial number of open dumping sites even in 2012 which is prohibited under the Ecological Solid Waste Management Act (2001). The number of open dumping sites is estimated to be 606 in the whole country, and 59 in Region 4A where the survey area is located. On the other hand, the number of controlled dump sites or sanitary landfill is relatively few. In this connection, no open dumping site is reported in Metro Manila. Even though interest on recycling of solid waste has been growing in recent years in the Philippines, the recycling rate is still low. It was estimated to be 13 % as of 2000 in Metro Manila. Recycling methods of solid waste are composed of composting, recovery of reusable/recyclable materials, etc., and the number of material recovery facilities (MRFs) has increased to 935 in NCR and 659 in Region 4A as of 2012.

Table 6.1.16 Number of Waste Disposal Sites and Material Recovery Facilities (2012)

Region	Open Dump	Controlled Dump	Material Recovery Facility (MRF)	Sanitary Landfill
NCR	0	0	935	2
Region 4A	59	45	659	9
Philippines	606	339	7,713	44

Note: Open dump refers to a disposal area where solid wastes are indiscriminately thrown or disposed without due planning and conservation to meet environmental and health standards.
Controlled dump refers to a disposal site at which solid waste is deposited in accordance with the minimum prescribed standards of site operation.
Source: National Statistics Office (2010)

(d) Waste Management Facilities

Hazardous wastes are classified into the following 13 categories based on DENR Administrative Order No. 2013-22: A. Wastes with Cyanide; B. Acid Wastes; C. Alkali Wastes; D. Wastes with Inorganic Chemicals; E. Reactive Chemical Wastes; F. Inks/Dyes/Pigments/Paint/Resins/Latex/Adhesives /Organic Sludge; G. Waste Organic Solvent; H. Putrescible/Organic Wastes; I. Oil; J. Containers; K. Stabilized Waste; L. Organic Chemicals; M: Miscellaneous Wastes. Waste generators are responsible for proper storage, transport and treatment/disposal based on RA No. 6969 and its IRR (DAO No. 92-29). The materials to be generated in the Project such as excavated materials and waste concrete are not listed as hazardous wastes. However, they are to be categorized as hazardous ones if harmful substances with concentrations beyond the limit value stipulated in DAO No. 2013-22 exist, and thus, they shall be properly treated and disposed pursuant to law.

(e) Waste Management in Laguna de Bay Region

(i) Existing Status of Waste Management and Challenges

According to the Laguna Lake Master Plan (2016), it is estimated that per capita generation volume of solid waste is 0.46 to 0.70 kg/day. If per capita waste generation is 0.5kg/day and the total population in Laguna de Bay Region is 15 million, the annual waste generation in the region is 2.7 million tons per year. Further if 30% of solid waste is recycled and the remaining 70% is disposed in the disposal sites, the required capacity of disposal sites is 1.89 million tons annually.

It is estimated that 6,700 tons of solid waste is generated every day in Metro Manila and approx. 720 tons of which are recycled (ADB, 2004). The approx. 6,000 tons of wastes remaining and supposed to be transported to disposal sites are illegally dumped into private properties or the rivers, or burned causing air pollution. Thus, there are two big challenges in solid waste management: 1) how to manage the huge volume of solid waste; and 2) the insufficient disposal sites. (Laguna de Bay Master Plan, 2016)

(ii) Current Status of Waste Management in Laguna and Rizal Province

The JICA Survey Team has conducted a questionnaire survey with entities responsible for waste management in the Laguna and Rizal provinces to grasp the current status of waste management. Table 6.1.17 summarizes the interview results, suggesting that the two provincial governments are making efforts on proper waste management.

Table 6.1.17 Current Status of Solid Waste Management in Laguna and Rizal Provinces

No.	Questionnaire	Laguna Province	Rizal Province
1	Respondents (Division)	Provincial Environment and Natural Resources Office	Provincial Environment and Natural Resources Office
2	Status of Solid Waste Collection	Collection system is working at 549 barangays (81%) out of all (674) barangays in the province.	Collection ratio of solid waste in LGUs in the province is approx. 100%.
3	Status of Disposal Site	The number of operating disposal sites are as follows: Open Dumping Sites: 4 Controlled Dumping Sites: 9 Sanitary Landfill (LGU): 4 Sanitary Landfill (Private): 2	There are 3 sites of Sanitary Landfill Facility (New San Mateo SLF, Morong Engineering SLF, Green Leap SLF), all of which are operational.
4	Illegal Dumping	No illegal dumping seen	No illegal dumping or complaint reported
5	Status of Recycling of Solid Waste	There are 24 Material Recovery Facilities (MRF) operated by city/ municipality and 276 operated by barangays in the province; No survey on recycling activities conducted.	Recycling is promoted in each LGU under the "YES to Green Program" initiated by Provincial Governor. A training program to support low level income households is provided. There are 93 Material Recovery Facilities (MRF) in the province as of August 2017, which is almost half of the number of barangays in the province. Recycling ratio of solid waste is approx. 32% in the province based on the 10-Year Solid Waste Management Plan of Rizal.
6	Possibility to receive excavated materials to be generated in the Project	Excavated materials can be received in such projects as flood control, recreational park and greening program in three municipalities (Lumban, Sta. Cruz, and Victoria).	There are low-lying areas around Laguna Lake, where backfilling can be done. Provincial Engineering Office has detailed information on it.
7	Status of Liquid Waste Management	Data on liquid waste management is out of management scope of the Division.	Provincial Ordinance No. 2008-08 (Environmental Code of the Province of Rizal) stipulates that all Subdivisions, Condominiums, Commercial Centers, Hotels, Public Buildings, Industrial Complex, etc., shall establish appropriate sewerage system. Cities and municipalities have enacted their own Sewerage and Septage ordinances.

Source: JICA Survey Team

6.1.2 Social Environment

(1) Demography

Table 6.1.18 shows 2015 population and households of LGUs in the survey area.

Population of LGUs in the survey area reflects the distance from Metro Manila. Six cities in Metro Manila have population of more than 400 thousand, especially, Taguig which has the largest of more than 800 thousand. In Laguna Province, LGUs from San Pedro to Calamba located at the west-shore of Laguna Lake have the population of more than 300 thousand. Cities and municipalities located at the south to east shore of the lake have population of less than 100 thousand except for Los Baños and Santa Cruz, provincial capital. In Rizal Province, Cainta and Taytay have the large population of more than 300 thousand except for those located inland including Antipolo, San Mateo and Rodoriquez, and Biñangonan follows them with population of 280 thousand. Others have only population of less than 100 thousand.

Population density has a similar feature to that of population. Six cities in Metro Manila and San Pedro have population density of much more than 100 persons/ha, ranging from 127 to 210 persons/ha. Population density diminishes gradually with distance from central Manila down to 20 persons/ha in Los Baños. Eastern areas of Los Baños have only more or less 10 persons/ha except Pagsanjan and Santa Cruz, the provincial capital. Further in eastern areas, population density is less than 10 persons/ha. Rizal Province has a similar feature. Cainta and Taytay have population density of 75 persons/ha and 82 persons/ha, respectively. In eastern areas, the population density decreases gradually down to less than 10 persons/ha in Baras and eastern LGUs.

Family size per household has a correlation with distance from central Manila, but not as strong as that of population and population density. Six cities in Metro Manila have the size of 4.1 to 4.2 except for Marikina City (4.6). Family size of LGUs from San Pedro to Los Baños which are located in west to south side of Laguna Lake have family size less than 4.0. On the contrary, LGUs located south-east and east side of the lake have the size of more than 4.0 except for Victoria (3.6) and Liliw (3.9).

Table 6.1.18 Demography of LGUs in the Survey Area (2015)

Region/ Province	City / Municipality	Population (No..)	Area (ha)	Population Density (No./ha)	Households (No.)	Family Size (No./HH)
NCR/ Metro Manila	Marikina	450,741	2,152	209.5	98,238	4.6
	Pasig	755,300	4,846	155.9	180,612	4.2
	Taguig	804,915	4,521	178.0	198,256	4.1
	Muntinlupa	504,509	3,975	126.9	122,286	4.1
	Parañaque	588,894	3,269	180.1	141,925	4.1
	Las Piñas	665,822	4,657	143.0	163,074	4.1
Region 4A/ Laguna	San Pedro	325,809	2,405	135.5	73,030	4.5
	Biñan	333,028	4,350	76.6	86,752	3.8
	Santa Rosa	353,767	5,484	64.5	101,385	3.5
	Cabuyao	308,745	4,330	71.3	81,573	3.8
	Calamba	454,486	14,950	30.4	123,071	3.7
	Los Baños	112,008	5,422	20.7	29,020	3.9
	Bay	62,143	4,266	14.6	15,149	4.1
	Alaminos	47,859	5,746	8.3	11,154	4.3
	Calauan	80,453	6,540	12.3	17,669	4.6
	San Pablo	266,068	19,756	13.5	62,289	4.3
	Rizal	17,253	2,790	6.2	4,065	4.2
	Victoria	39,321	2,235	17.6	10,822	3.6
	Pila	50,289	3,120	16.1	11,447	4.4
	Nagcarlan	63,057	7,810	8.1	15,692	4.0
	Santa Cruz	117,605	3,859	30.5	27,982	4.2
	Pagsanjan	42,164	2,636	16.0	9,747	4.3
	Magdalena	25,266	3,488	7.2	5,850	4.3
	Liliw	36,582	3,910	9.4	9,309	3.9
	Majayjay	27,792	6,958	4.0	6,624	4.2
	Luisiana	19,720	7,331	2.7	4,847	4.1
	Cavinti	21,702	20,358	1.1	5,359	4.0
	Lumban	30,652	4,053	7.6	7,350	4.2
	Kalayaan	23,269	4,660	5.0	5,147	4.5
	Paete	25,096	5,502	4.6	5,602	4.5
	Pakil	20,659	4,650	4.4	4,597	4.5
	Pangil	24,274	4,503	5.4	5,492	4.4
	Siniloan	38,067	6,451	5.9	8,489	4.5

Region/ Province	City / Municipality	Population (No..)	Area (ha)	Population Density (No./ha)	Households (No.)	Family Size (No./HH)
	Famy	16,587	5,306	3.1	4,117	4.0
	Mabitac	20,530	8,076	2.5	4,575	4.5
Region 4A/ Rizal	Jala-jala	32,254	4,412	7.3	6,919	4.7
	Pililla	64,812	6,995	9.3	14,734	4.4
	Tanay	117,830	20,000	5.9	25,836	4.6
	Baras	69,300	8,493	8.2	16,706	4.1
	Morong	58,118	3,758	15.5	13,180	4.4
	Teresa	57,755	1,861	31.0	13,457	4.3
	Antipolo	776,386	30,610	25.4	170,523	4.6
	San Mateo	252,527	5,509	45.8	56,379	4.5
	Rodoriquez	369,222	17,265	21.4	82,348	4.5
	Cardona	49,034	2,856	17.2	12,114	4.0
	Binagonan	282,474	6,634	42.6	69,786	4.0
	Angono	113,283	2,622	43.2	25,325	4.5
	Taytay	319,104	3,880	82.2	73,835	4.3
	Cainta	322,128	4,299	74.9	71,463	4.5

Source：Philippine Statistics Authority (2015)

(2) Land Use and Existing Structures and Facilities

Land use and existing facilities and structures were surveyed since they would be affected by the implementation of the Project. The survey was done by means of analysis of Google Earth and plotting the existing facilities and structures on maps and confirmation on site when necessary. Results of the survey were shown in Appendix 4 and summarized in Table 6.1.19.

Table 6.1.19 Land Use and Existing Facilities and Structures in the Survey Area

No.	Area (City/Municipality and *Province*)	Land Use and Existing Facilities and Structures
1	Taguig, Muntinlupa (North), Parañaque, Las Piñas (*Metro Manila*)	Area 1 is located in the southern edge of Metro Manila being densely populated. Transportation facilities include SLEX (South Luzon Expressway) in the north-south direction along Laguna Lake and CAVITEx (Manila-Cavite Expressway) along Manila Bay, and as non-express road, M. Quezon Ave. (north-south direction), Sucat Rd. (east-west direction), Alabang Zapote Rd. (east-west direction), and PNR: Philippine National Railways. There are industrial estates at both sides of SLEX and subdivisions in the east of it. Also, there is business district in the south of this area.
2	Muntinlupa (South) (Metro Manila), San Perdo, Biñan (*Laguna Province*)	Area 2 is located at the border of Metro Manila and Laguna Province being in the transition from densely populated to suburbs. Transportation facilities include SLEX and PNR, as continuation from Area 1 above, and San Guillermo St. and Maharlika Hwy as non-express way. There are only a few industrial estates but many subdivisions with large area are located. Lakeshore of Laguna Lake is dense residential area but less populated in the area of San Pedro being occupied with farmlands and natural areas instead.
3	Santa Rosa, Cabuyao (*Laguna Province*)	Area 3 is located in the suburbs of Metro Manila. There are only a few dense residential areas, but the built-up is a mixture of old town and subdivision. Main transportation facilities are those continued from Area 1 and 2. There are large-scale subdivisions and industrial estates. Old built-up areas are seen along the lakeshore and a vast tract of farm lands are located inside.
4	Calamba, Los Baños (*Laguna Province*)	Area 4 is located at the south shore of Laguna Lake. Subdivision and industrial estate exist in only a limited area until the Calamba City, but none in the area of Los Baños. The road site built-up seen in the area of Cabuyao is no longer seen in this area. Lakeshore line becomes more intricate and comprises a bay. Mt. Makiling Forest Reserve exists near the shoreline. Many hot spring resort facilities are located.

No.	Area (City/Municipality and *Province*)	Land Use and Existing Facilities and Structures
5	Bay, Calauan, Victoria (*Laguna Province*)	Area 5 is a transition from the south to east shore of Laguna Lake. There is no express way anymore in this area but only non-express roads. The size of subdivision becomes small and there are only several ones in the municipality of Bay. The old town of the municipality of Victoria is located near the lakeshore.
6	Pila, Santa Cruz, Pagsanjan (*Laguna Province*)	Area 6, built-up area of Santa Cruz, capital city of Laguna Province, is located along the Sta. Cruz River. The built-up area comprises an old town. There is no subdivision in this area. A vast tract of farm lands is located in the west of Santa Cruz.
7	Lumban, Kalayaan, Paete (*Laguna Province*)	Area 7 is located at the river mouth of the Pagsanjan River which has the largest watershed among all rivers flowing into Laguna Lake. A delta of the Pagsanjan River is formed into the lake and comprises an intricate shoreline. The built-up area of Lumban is located along the river. NGCP (National Grid Corporation of the Philippines) is located at the border of Lumban and Kalayaan. The built-up area continues along J.P. Rizal St. in the northward.
8	Pakil, Pangil, Siniloan, Famy, Mabitac (*Laguna Province*)	Area 8 is located at the north shore of East Bay of Laguna Lake. There are large low-lying plains as delta of three rivers: Pangil, Romero and Sta. Maria, where paddy fields are seen.
9	Pilla, Tanay, Baras, Morong (*Rizal Province*)	Area 9 is located at the north shore of Central Bay of Laguna Lake. There are large low-lying plains as delta of four rivers: Pililla, Tanay, Baras, and Morong, where paddy fields are seen.
10	Biñangonan, Angono, Taytay (*Rizal Province*)	Area 10 is located at the north shore of West Bay of Laguna Lake. This area is featured with a lot of industrial estates and subdivisions. The built-up areas of Biñangonan and Angono are located along the lakeshore. There is only a limited paddy field in the low-lying area and a vast tract of marsh land.

Source: JICA Survey Team

(3) Informal Settler Families (ISFs)

According to the Manila Bay Environmental Atlas (2nd Edition, 2015), Informal Settler Families (ISFs) increased from about the year 2000 in Manila Bay Area including the lakeshore land of Laguna Lake. It has become more conspicuous at dangerous areas and public properties near water bodies. Number of ISFs counted in 2014 are shown in Table 6.1.20.

Table 6.1.20 Number of ISFs in Manila Bay Area (2014)

Region	Area	City	2014*
NCR	Whole Area		65,723
	Study Area	Las Piñas	3,116
		Muntinlupa	3,686
		Parañaque	914
		Taguig	3,672
Region 4A	Study Area	Laguna	11,567
		Rizal	10,541

Note: 2nd quarter of 2014 for Region 4A and 3rd quarter of 2014 for NCR.
Source: Manila Bay Environmental Atlas, 2nd Edition, 2015.

According to the data of the National Housing Authority (NHA), the existing situation of ISFs in the survey area is listed from Table 6.1.21[3]. The number of ISFs in February 2017 is 93,099 in NCR and 91,439 in Region 4A, of which the number of relocated ISFs in NCR are 40,506 accounting for 43.51% while that in Region 4A is 9,491 accounting for 10.38%.

[3] It should be noted that the data on ISF is not always consistent but different depending on the agency surveyed, survey year, survey method, etc.

Table 6.1.21 Number of ISFs and Progress of Relocation in the Survey Area

Region	Adjusted baseline* (as of February 2017)	No. of ISFs Relocated**	% to Target	Balance
NCR	93,099	40,506	43.51	52,593
Region 4A	91,439	9,491	10.38	91,946

Note: Adjusted baseline*: Recounted number at February 2017.
No. of ISFs Relocated**: Total number of relocated ISFs so far.
Source: National Housing Authority (NHA)

In the survey area where four cities (Parañaque, Las Piñas, Taguig and Muntinlupa) are located, the number of ISFs are many in Muntinlupa and Las Piñas, accounting for 33,217 and 10,246, respectively. The number of relocated ISFs is 920 and 1,976, accounting only for 2.77% and 19.29%, respectively (Table 6.1.22).

Table 6.1.22 Number of ISFs and Progress of Relocation in NCR

Province	City / Municipality	Adjusted baseline* (as of February 2017)	No. of ISFs Relocated**	% to Target	Balance***
North	Caloocan	5,680	1,527	26.88	4,153
	Malabon	3,396	1,048	30.86	2,348
	Navotas	8,339	2,440	29.26	5,899
	Valenzuela	5,061	1,506	29.76	3,555
	Sub-total	**22,476**	**6,521**	**29.01**	**15,955**
East	Quezon City	11,434	9,384	82.07	2,050
	Pasig	4,201	1,962	46.70	2,239
	Marikina	161	827	513.66	-666
	Sub-total	**15,796**	**12,173**	**77.06**	**3,623**
West	Manila	53	7,403	13,967.92	-7,350
	San Juan	763	979	128.31	-216
	Mandaluyong	131	391	298.47	-260
	Sub-total	**947**	**8,773**	**926.40**	**-7,826**
South	Pasay	4,200	4,383	104.36	-183
	Parañaque	345	2,475	717.39	-2,130
	Las Piñas	10,246	1,976	19.29	8,270
	Pateros	116	806	694.83	-690
	Makati	4,023	1,891	47.00	2,132
	Taguig	1,733	588	33.93	1,145
	Muntinlupa	33,217	920	2.77	32,297
	Sub-total	**53,880**	**13,039**	**24.20**	**40,841**

Note: Adjusted baseline*: Recounted number at February, 2017.
No. of ISFs Relocated**: Total number of relocated ISFs so far.
Balance***: Minus values mean the number of relocated ISF is larger than original number of ISF due to the increase of ISF during relocation activity.
-: No Report from LGU, NA: Not Applicable,
Source: National Housing Authority (NHA)

In Rizal and Laguna Province, the number of ISFs is 15,088 and 30,115 as of February 2017 and the ratio of relocation is 36.76% and 4.42%, respectively, showing that the relocation of ISFs in Laguna Province is delayed.

Table 6.1.23 Number of ISFs and Progress of Relocation in Region 4A

Province	City / Municipality	Adjusted baseline* (as of February 2017)	No. of ISFs Relocated**	% to Target	Balance
Rizal	Antipolo	5,332	4,726	88.63	606
	Angono	2,850	0	0.00	2,850
	Binagonan	-	-	-	-
	Cainta	106	32	30.19	74
	Rodriguez	429	196	45.69	233
	San Mateo	1,794	0	0.00	1,794
	Taytay	2,458	0	0.00	2,458
	Baras	269	204	75.84	65
	Cardona	136	0	0.00	136
	Jalajala	338	0	0.00	338
	Morong	319	0	0.00	319
	Pililla	335	0	0.00	335
	Tanay	394	389	98.73	5
	Teresa	328	0	0.00	328
	Sub-total	**15,088**	**5,547**	**36.76**	**9,541**
Laguna	Biñan	1,577	0	0.00	1,577
	Cabuyao	727	0	0.00	727
	Calamba	12,025	0	0.00	12,025
	San Pablo	325	9	2.77	316
	Sta. Rosa	3,163	179	5.66	2,984
	Alaminos	233	0	0.00	233
	Bay	-	267	-	-
	Calauan	870	0	0.00	870
	Liliw	108	140	129.63	0
	Los Baños	1,178	0	0.00	1,178
	Nagcarlan	124	0	0.00	124
	Rizal	2	0	0.00	2
	San Pedro City	2,243	0	0.00	2,243
	Victoria	152	0	0.00	152
	Cavinti	231	0	0.00	231
	Famy	10	0	0.00	10
	Kalayaan	1,376	0	0.00	1,376
	Luisiana	0	0	NA	0
	Lumban	1,389	0	0.00	1,389
	Mabitac	1,968	0	0.00	1,968
	Magdalena	46	0	0.00	46
	Majayjay	107	5	4.67	102
	Paete	244	244	100.00	0
	Pagsanjan	1,308	104	7.95	1,204
	Pakil	-	-	-	-
	Pangil	144	7	4.86	137
	Pila	53	0	0.00	53
	Sta. Cruz	434	375	86.41	59
	Siniloan	78	0	0.00	78
	Sta. Maria	0	0	NA	0
	Sub-total	**30,115**	**1,330**	**4.42**	**28,785**

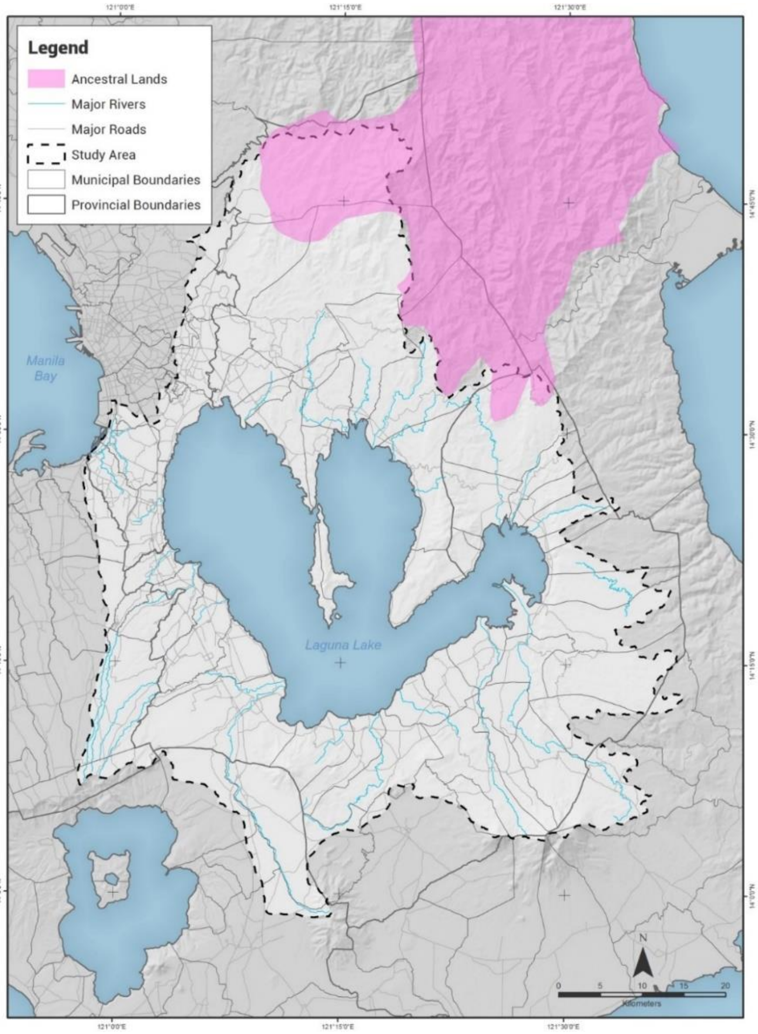
Note: Adjusted baseline*: Recounted number at February 2017.
No. of ISFs Relocated**: Total number of relocated ISFs so far.
-: No Report from LGU, NA: Not Applicable.
Source: National Housing Authority (NHA)

(4) Ethnic Minorities and Indigenous People

There is no exact statistical data on population and distribution of indigenous people in the Philippines. However, NCIP (National Commission for Indigenous People) has estimated the population of indigenous people as 14.18 million, comprising those living in Mindanao: 62.6%, those in Luzon: 359% and those in Visayas: 1.4%. The number of tribes of indigenous people published by NCIP is 110, being ethnographically classified into 7 districts. NCR and Region 4A including the survey area belong to "Rest of Luzon," where tribes of Negrito, Dumagat and Remontado are included. Environmental and Social Consideration Profile of the Philippines, JICA, 2011)

Indigenous people's rights on ancestral domain, culture, tradition and institution are protected by The Philippine Constitution of 1987. Republic Act, No. 8371 (1997), known as Indigenous Peoples Rights Act (IPRA) stipulates that human rights, ancestral lands, culture, tradition and social institution of indigenous people are guaranteed.

Designation of ancestral lands of indigenous people in the surveyed area is shown in Figure 6.1.9. There is no ancestral land in the area around Laguna Lake, cities of Las Piñas, Parañaque, Taguig or Muntinlupa.



Source：Manila Bay Area Environmental Atlas, 2nd Edition, 2015

Figure 6.1.9 Location Map of Ancestral Lands in the Survey Area

(5) Historical and Cultural Heritage

In the Philippines, there are three World Heritage Sites registered in UNESCO (Table 6.1.24), including the Baroque Churches of the Philippines in Metro Manila.

Table 6.1.24 World Heritage Sites in the Philippines

Name	Location	Features	Category	Registration year
Rice Terraces of the Philippines	Ifugao Province, Cordillera Region	The Rice Terraces of the Philippine Cordilleras is an outstanding example of an evolved, living cultural landscape that can be traced as far back as two millennia ago in the pre-colonial Philippines. The terraces are located in the remote areas of the Philippine Cordillera mountain range on the northern island of Luzon, Philippine archipelago.	Cultural Heritage/ Endangered	1995
The Historic Town of Vigan	Ilocos Sur Province, Region I	Vigan is the most intact example in Asia of a planned Spanish colonial town, established in the 16th century. Its architecture reflects the coming together of cultural elements from elsewhere in the Philippines and from China with those of Europe and Mexico to create a unique culture and townscape without parallels anywhere in East and South-East Asia.	Cultural Heritage	1999
Baroque Churches of the Philippines	1) Manila, Metro Manila, NDR, 2) Santa Maria, Ilocos Sur, Region I, 3) Paoay, Ilocos Norte, Region I, 4) Miag-ao, Iloilo, Region VI	The Baroque Churches of the Philippines is a serial inscription consisting of four Roman Catholic churches constructed between the 16th and the 18th centuries in the Spanish period of the Philippines. They are located in separate areas of the Philippine archipelago, two at the northern island of Luzon, one at the heart of Intramuros, Manila, and the other in the central Visayas island of Iloilo.	Cultural Heritage	1993

Source：Website of UNESCO World Heritage Center

Historical and cultural heritage in the Philippines are registered with the National Historical Commission of the Philippines (NHCP)(referred to as “Registered Heritage”). Registered heritage sites are divided into two levels: Level I consists of national historical landmarks, national shrines, national monuments, heritage zones/historical centers and heritage houses, while Level II are the historical markers. Table 6.1.25 shows the number of registered heritage sites, revealing that there are 40 registered heritage sites in the survey area, consisting of 11 Level I heritage sites and 29 Level II heritage sites.

Table 6.1.25 Number of Registered Heritage Sites in the Philippines

Province	Area	City / Municipality	Level I	Level II	Total
Metro Manila	Whole Area		36	106	142
	Survey Area	Marikina	0	2	2
		Pasig	0	2	2
		Las Piñas	0	2	2
		Muntinlupa	0	1	1
		Parañaque	0	2	2
		Taguig	2	1	3
Laguna	Whole Area (Survey Area)		7	11	20
Rizal	Whole Area (Survey Area)		2	8	10
Total	Whole Area		45	127	173
	Survey Area		11	29	40

Source: National Historical Commission of the Philippines (NHCP)

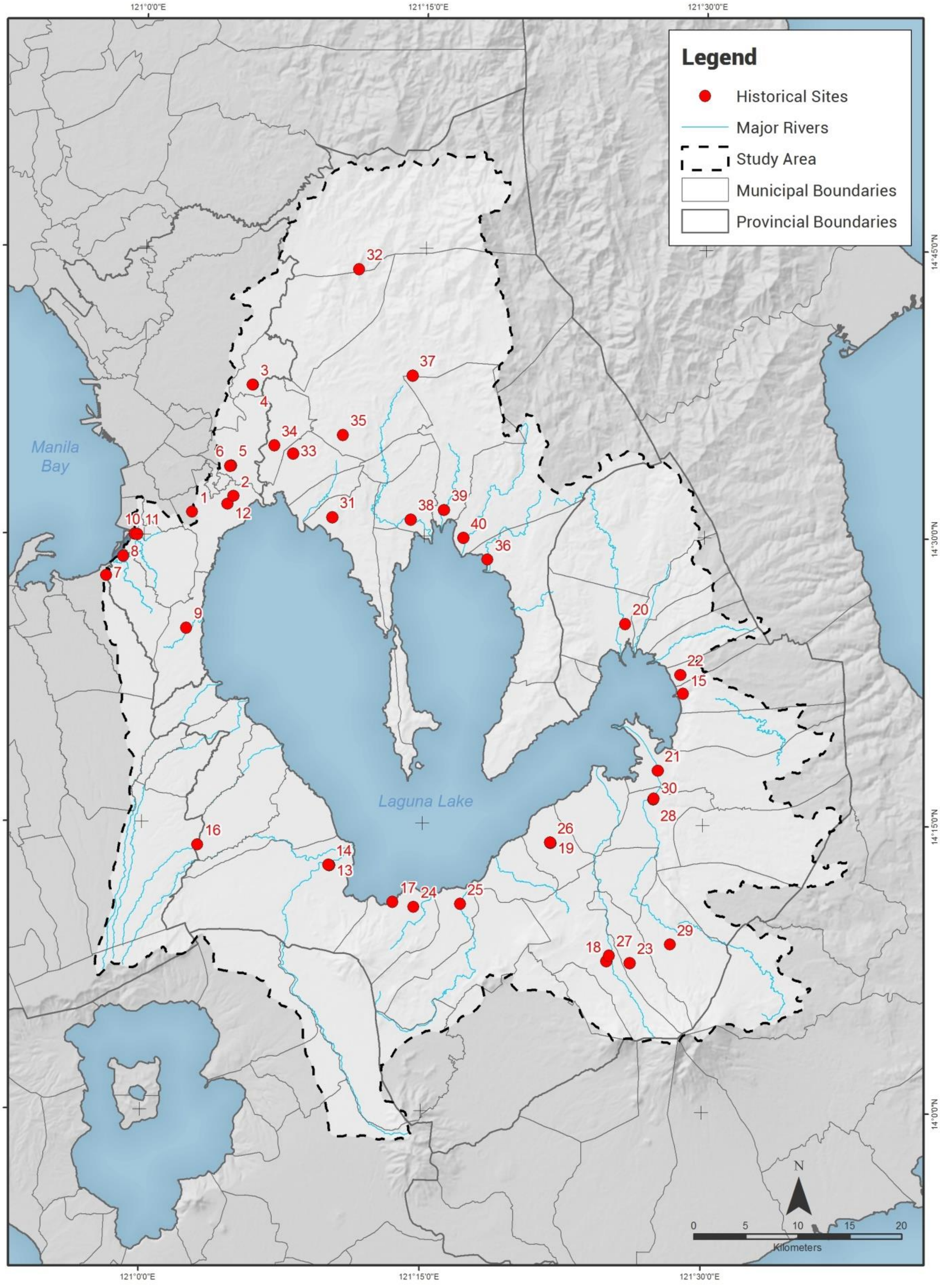
Table 6.1.26 shows details of the registered heritage sites in the survey area. There locations are as indicated in Figure 6.1.10. As shown, there are a number of registered heritage sites around Laguna Lake.

Table 6.1.26 List of Registered Heritage Sites in the Survey Area

Province	No.*	City / Municipality	Name	Level	Category	Type	Status	Marker Date
Metro Manila	1	Taguig	Libingan ng mga Bayani National Shrine	I	Site	Cemetary	National Shrine	-
	2	Taguig	Birthplace of Felix Y. Manalo	I	Site	Site	National Historical Landmark	2007
	3	Marikina City	Simbahan ng Nuestra Señora de Los Desamparados	II	Building	House of Worship	Level II – With Marker	1990
	4	Marikina City	Unang Pagawaan ng Sapatos sa Marikina	II	Building	Government Center	Level II – With Marker	1970
	5	Pasig City	Church of Pasig	II	Building	House of Worship	Level II – With Marker	1937
	6	Pasig City	Colegio De Madres Agustinas	II	Building	School	Level II – With Marker	1937
	7	Las Piñas	Zapote Battlefiled	II	Building/ Structure	Bridge	National Historical Landmark	1952
	8	Las Piñas	Simbanhan ng Las Piñas	II	Building	House of Worship	Level II – With Marker	1995
	9	Muntinlupa	Insular Life	II	Building	Private Company	Level II – With Marker	2010
	10	Parañaque	Church of Parañaque	II	Building	House of Worship	Level II – With Marker	1939
	11	Parañaque	Kapilya ni San Nicolas	II	Building	House of Worship	Level II – With Marker	1995
	12	Taguig	Simbahan ng Taguig	II	Building	House of Worship	Level II – With Marker	1987
Laguna	13	Calamba	Baptistry of the Church of Calamba	I	Building	House of Worship	National Historical Landmark	1960
	14	Calamba	Rizal Shrine Calamba	I	Building	NHCP Museum	National Shrine	-
	15	Paete	Church of Paete	I	Building	House of Worship	National Historical Landmark	1939
	16	Santa Rosa	Cuartel de Santo Domingo	I	Structure	Fortification	National Historical Landmark	2005
	17	Los Baños	Paciano Rizal House	I	Building	House	National Historical Landmark	1983

Province	No.*	City / Municipality	Name	Level	Category	Type	Status	Marker Date
	18	Nagcarlan	Nagcarlan Underground Cemetery Historical Landmark	I	Structure	Cemetery	National Historical Landmark	1981
	19	Pila	Town Center of Pila	I	Historic Center/Heritage Zone	Historic Center	National Historical Landmark	2000
	20	Mabitac	Church of Mabitac	II	Building	House of Worship	Level II – With Marker	1939
	21	Lumbang	Church of Lumbang	II	Building	House of Worship	Level II – With Marker	1939
	22	Pakil	Simbaha ng Pakil	II	Building	House of Worship	Level II – With Marker	1988
	23	Liliw	Church of Lilio	II	Building	House of Worship	Level II – With Marker	1939
	24	Los Baños	Church of Los Baños	II	Building	House of Worship	Level II – With Marker	-
	25	Bay	Simbahan ng Bay	II	Building	House of Worship	Level II – With Marker	1985
	26	Pila	Church of Pila	II	Building	House of Worship	Level II – With Marker	1939
	27	Nagcarlan	Church of Nagcarlan	II	Building	House of Worship	Level II – With Marker	1937
	28	Pagsanjan	Pagsanjan Municipal Building	II	Building	Government Center	Level II – With Marker	1956
	29	Majayjay	Simbahan ng Majayjay	II	Building	House of Worship	Level II – With Marker	1993
	30	Pagsanjan	Church of Pagsanjan	II	Building	House of Worship	Level II – With Marker	1953
Rizal	31	Biñangonan	Vicente Manansala Historical Landmark	I	Building	House	Delisted, National Historical Landmark	1984
	32	Rodriquez	Pamitinan Cave	I	Site	Cave	National Historical Site	-
	33	Taytay	Simbahan ng Taytay	II	Building	House of Worship	Level II – With Marker	1992
	34	Cainta	Simbahan ng Cainta	II	Building	House of Worship	Level II – With Marker	2007
	35	Antipolo	Nuestra Señora De La Paz y Buenviaje	II	Building	House of Worship	Level II – With Marker	1937
	36	Pililla	Simbahan ng Pililla	II	Building	House of Worship	Level II – With Marker	1977
	37	Antipolo	Simbahan ng Boso-Boso	II	Building	House of Worship	Level II – With Marker	2001
	38	Morong	Church of Morong	II	Building	House of Worship	Level II – With Marker	1939
	39	Baras	Church of Baras	II	Building	House of Worship	Level II – With Marker	1939
	40	Tanay	Church of Tanay	II	Building	House of Worship	Level II – With Marker	1939

Note: LEVEL I - Sites and structures declared as National Historical Landmark, National Shrine, National Monument, Heritage Zone/Historic Center, and Heritage House.
LEVEL II - Sites and structures recognized with Historical Markers.
*：The number in Table above conform with that in Figure 6.1.10.
Source: National Historical Commission of the Philippines (NHCP)



Note) The number in Figure above is conformed with that in Table 6.1.26.
Source：JICA Survey Team developed the map based on the information at Web sites of NHCP

Figure 6.1.10 Location Map of Registered Heritage in the Survey Area

6.2 Confirmation of Law and System about Environmental Assessment

(1) Philippine Environmental Impact Statement System (PEISS) and Relevant Institution

(a) Legal Framework of PEISS

The Philippine Environmental Impact Statement System (PEISS) was initially set up under Presidential Decree (PD) No. 1151 in 1977, known as the Philippine Environmental Policy. It stipulates the rationale to prepare an Environmental Impact Statement (EIS) for proposed projects and/or undertakings which might cause significant environmental impacts. In the following year, PD No. 1586 was issued to formalize the EIS System.

Section 4 of PD No. 1586 stipulates that proposed projects that are identified as Environmentally Critical Projects (ECPs) and/or to be located in Environmentally Critical Areas (ECAs), two of which are presumed to have significant impacts on the environment, are required to secure an Environmental Compliance Certificate (ECC).

Meanwhile, to strengthen the implementation of the PEISS, the DENR issued Administrative Order No. 37 in 1996 (DAO No. 96-37), which has been revised to partly simplify the procedures under AO No. 2 (2002) and DAO No. 03-30 (2003). In November 2011, Memorandum Circular 005 (EMB 2011-005) was issued by DENR-EMB to streamline the EIA requirements and include climate change adaptation and disaster risk reduction into the PEISS. In 2014, another Memorandum Circular (2014-005) was issued by DENR-EMB, in which coverage screening and standardized requirements were updated.

(b) Screening

Section 1 of EMB MC 2014-005 provides screening under the PEISS to determine coverage, proposed projects or undertakings that shall be screened according to the following categories:

Category A: Projects or undertakings which are classified as environmentally critical projects (ECPs) under PP No. 2146 (1981) and Proclamation No. 803 (1996);

Category B: Projects or undertakings which are not classified as ECP under **Category A**, but deemed to significantly affect the quality of the environment for being located in an Environmentally Critical Area (ECA);

Category C: Projects or undertakings not falling under **Category A** or **B** which are intended to directly enhance the quality of the environment or directly address existing environmental problems; and

Category D: Projects or undertakings that are deemed unlikely to cause significant adverse impact on the quality of the environment according to the parameters set forth in the screening guidelines.

Proponents of a project falling under Category A or B must secure an Environmental Compliance Certificate (ECC). Proponents who intend to directly enhance the quality of the environment or directly address the existing environmental problems are not required to obtain ECC, but they should submit a Project Description (PD) to DENR-EMB to obtain confirmation that the project falls under Category C, where a Certificate of Non-Coverage (CNC) will be issued by DENR-EMB. If the project, however, is judged by EMB to be Category A or B, an ECC is required. Proponents of Category D projects are not covered by the PEISS and are not required to secure an ECC. However, such non-coverage (CNC) projects shall not be construed as exempted from compliance with other environmental laws and government permit requirements.

ECPs and ECAs are defined and identified in Presidential Proclamation (PP) No. 2146 (1981) and PP No. 803 (1996), respectively, as mentioned earlier. Their technical definitions are stipulated in detail in EMB Memorandum Circular 005-2014 and summarized in Table 6.2.1 and Table 6.2.2.

Table 6.2.1 Summary of Environmentally Critical Projects (ECPs)

Main Categories	Sub-Category
I. Heavy Industries	- Non-Ferrous Metal Industries - Iron and Steel Mills - Petroleum and Petrochemical Industries - Smelting Plants
II. Resource Extractive Industries	- Mining and Quarrying Projects, - Forestry Projects, - Dikes for/and Fishpond Development Projects.
III. Infrastructure Projects	- Dams - Power Plants - Reclamation Projects - Road and Bridges
IV. Golf Course Projects	Golf Course

Source: Revised Guidelines for Coverage Screening and Standardized Requirements under PEISS, EMB Memorandum Circular 005, July 2014

Table 6.2.2 Summary of Environmentally Critical Areas (ECAs)

ECA Categories	Examples
1. Areas declared by law as national parks, watershed reserves, wildlife preserves, and sanctuaries	- Areas declared as such under Republic Act No. 7586 or the National Integrated Protected Areas System (NIPAS) Act. - Areas declared as such through other issuances from pertinent national and local government agencies such as presidential proclamations and executive orders, local ordinances and international commitments and declarations.
2. Areas set aside as aesthetic, potential tourist spots	- Aesthetic potential tourist spots declared and reserved by the LGU, DOT or other appropriate authorities for tourism development. - Class 1 and 2 cases as cited in EMB MC 2014-004 and defined under DENR MC 2012-03 and significant cases as may be determined by BMB and EMB.
3. Areas which constitute the habitat for any endangered or threatened species of indigenous Philippine wildlife (flora and fauna)	- Areas identified as key biodiversity areas (KBAs) by BMB, - Areas declared as Local Conservation Areas (LCA) through issuances from pertinent national and local government agencies such as presidential proclamations and executive orders, local ordinances and international commitments and declarations.
4. Areas of unique historical, archeological, geological, or scientific interests	- All areas declared as historic site under RA 10066 by NHCP, - The whole barangay or municipality, as may be applicable, where archaeological, paleontological and anthropological sites/ reservations are located as proclaimed by the National Museum. - The whole barangay or municipality, as may be applicable, of cultural and scientific significance to be the nation as recognized

ECA Categories	Examples
	through national or local laws or ordinances (e.g. declared geological monuments and scientific research areas and areas with cultural heritage significance as declared by the LGUs or NCCA).
5. Areas which are traditionally occupied by cultural communities or tribes	- Areas issued with Certificate of Ancestral Domain Title (CADT) or Certificate of Ancestral Land Title (CALT) by the National Commission on Indigenous Peoples (NCIP), - Areas issued with Certificate of Ancestral Domain Claim (CADC) or Certificate of Ancestral Land Claim (CALC) by the DENR, - Areas that are historically/traditionally occupied as ancestral lands or ancestral domains by indigenous communities as documented in reputable publications or certified by NCIP.
6. Areas frequently visited and or hard-hit by natural calamities (geologic hazards, floods, typhoons, volcanic activity, etc.	The areas shall be so characterized if any of the following conditions exist: 6.1 Geologic hazard areas: - Areas classified by the MGB as susceptible to landslide; - Areas identified as prone to land subsidence and ground, settling; areas with sinkholes and sags as determined by the MGB or as certified by other competent authorities. 6.2 Flood-prone areas: - Areas with identified or classified by MGB or PAGASA as susceptible or prone to flood. 6.3 Areas frequently visited or hard-hit by typhoons: - For purposes of coverage, depressions, storms and typhoons will be covered in the category; - This shall refer to all provinces affected by a tropical cyclone in the past. 6.4 Areas prone to volcanic activities/ earthquakes: - This refers to all areas around active volcanoes designated by Philippine institute of Volcanology and Seismology (PHIVOLCS) as Permanent Danger Zone, as well as areas delineated to be prone to pyroclastic flow hazard, lava flow hazard, lahar hazard and other volcanic hazard as found applicable per active volcano. - This refers to all areas identified by the Philippine institute of Volcanology and Seismology (PHIVOLCS) to be transected by active faults and their corresponding recommended buffer zones, as well as areas delineated to be prone to ground-shaking hazard, liquefaction hazard, earthquake-triggered landslide hazard and tsunami hazard.
7. Areas with critical slope	This shall refer to all lands with slope of 50% or more as determined from the latest official topographic map from NAMRIA.
8. Areas classified as prime agricultural lands	Prime Agricultural lands shall refer to 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 as determined by DA, NIA or concerned LGU through their zoning ordinance.
9. Recharged areas of aquifers	- Recharge areas of aquifers shall refer to sources of water replenishment where rainwater or seepage actually enters the aquifers. - Areas under this classification shall be limited to all local or non-national watersheds and geothermal reservations.
10. Water bodies	All-natural water bodies (e.g., rivers, lake, bay) that have been classified or not.
11. Mangrove Areas	Mangrove areas as mapped identified by DENR.
12. Coral Reefs	Coral reefs as mapped or identified by DENR and/or DA-BFAR.

Source: Revised Guidelines for Coverage Screening and Standardized Requirements under PEISS, EMB Memorandum Circular 005, July 2014

Among the flood mitigation measures (mitigation menu) proposed in the Project, structures/facilities for which PEISS are to be applied include the construction of spillway, river channel improvement (river structures) and construction of drainage facility (pumping station). Screening for these structures/facilities under PEISS shows that they fall under "3. Infrastructure Projects" in Annex A of EMB MC 2014-005. However, there is no exact conformance between the facilities listed in Annex A and the structure/facilities proposed in the Project.

The JICA Survey Team, therefore, explained these points to DENR-EMB, a competent agency of PEISS, for their opinion on the EIS requirements of the proposed structures/facilities, and eventually obtained the following comment: "The project is considered to be an environment enhancement project, which is, therefore, to be categorized as C. However, based on the project scale and size of the structures/facilities and taking into account that similar projects were required to conduct EIA to secure an ECC, it is natural to require EIA study for the structures/facilities proposed in the Project. It is, therefore, necessary for the Proponent (DPWH) to submit a Project Description (PD) to the competent authority (DENR-EMB) in advance for determination of EIS requirements."

(c) Responsible Institution of PEISS

The responsible institution of PEISS is the DENR-EMB (Central Office) whose organizational chart is as shown in Figure 6.2.1. The administrative process of EIS for issuing an ECC for individual projects is under the responsibility of the regional office of EMB. In such cases, however, that a proposed project is geographically located across plural regions, the central office of EMB is responsible for the EIS and issuance of an ECC.

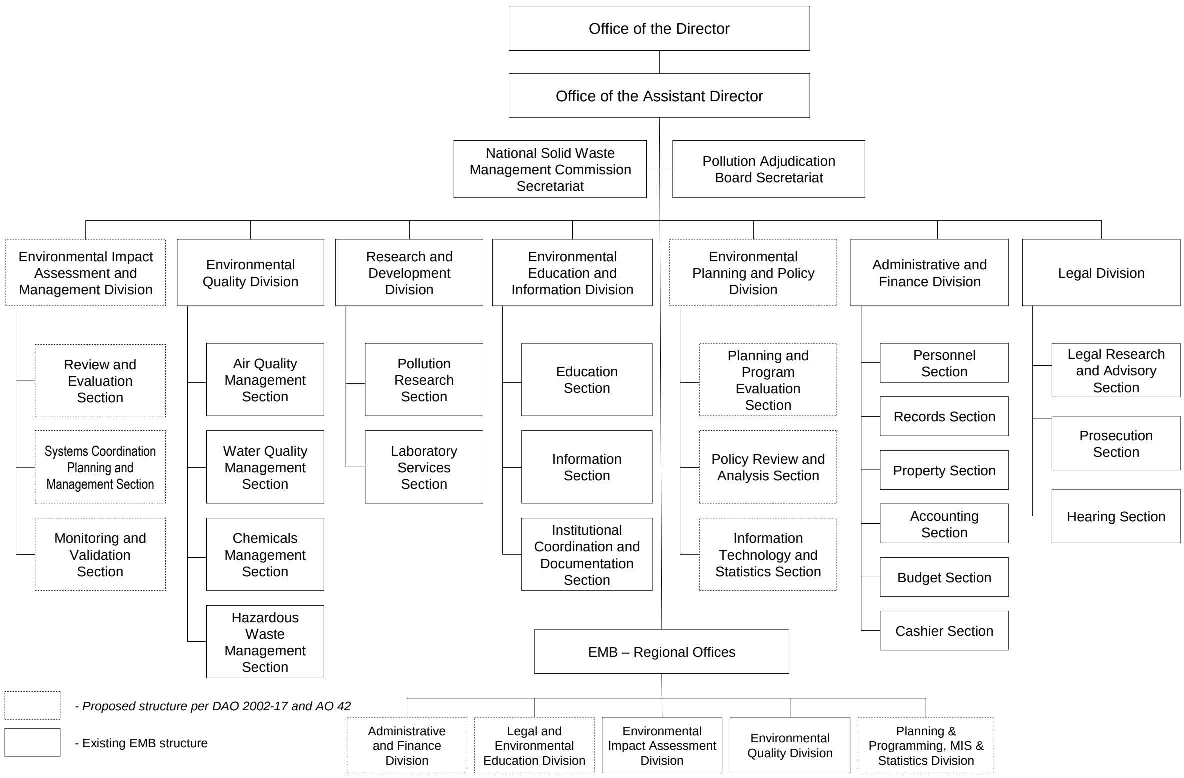


Figure 6.2.1 Organizational Chart of DENR-EMB (Central Office)

(2) Legal Framework on Land Acquisition and Resettlement

Legal framework on land acquisition and resettlement related to projects is summarized below:

(a) The Philippine Constitution (1987)

The basic legal foundation for resettlement policies in the country is enshrined in the following provisions of the 1987 Philippine Constitution:

- Article III, Section 9 - Private property shall not be taken for public use without just compensation;
- Article III, Section 11 - Free access to the courts and quasi-judicial bodies and adequate legal assistance shall not be denied to any person by reason of poverty;
- Article XIII, Section 10 - Urban or rural poor dwellers shall not be evicted nor their dwellings demolished, except in accordance with the law and in a just humane manner. No resettlement of urban or rural dwellers shall be undertaken without adequate consultation with them and the communities where they are to be relocated.

(b) The Water Code of the Philippines (PD 1067, 1976)

The Code administers river areas in Article No. 51 as follows: The banks of rivers and streams and the shores of the seas and lakes throughout their entire length and within a zone of three (3) meters in urban areas, 20m in agricultural areas, and 40m in forest areas along their margins, are subject to the easement of public use. No person shall be allowed to build structures of any kind or to stay in this zone longer than necessary for recreation, navigation, floatage, fishing, or salvage or to build structures of any kind.

Further, Article No. 58 stipulates that when a river or stream suddenly changes its course to traverse private lands, the owners of the land thus affected are not entitled to compensation by the government for any damage sustained thereby.

(c) Urban Development and Housing Act (UDHA) (RA 7279, 1992)

The Act mandates the local governments, with the support of the national government, to undertake urban development and renewal, paying attention to underprivileged and homeless citizens. It also sets the guidelines and the procedures in the eviction of informal settlers and demolition of their dwellings (Section 28) and resettlement (Sections 22, 23 and 29).

(d) An Act Facilitating the Acquisition of Right-Of-Way Site or Location for National Government Infrastructure Projects (RA No.10752) and its IRR (2016)

This Act aims at ensuring that Article III, Section 9 of the Constitution stating that private property shall not be taken for public use without just compensation by guaranteeing that owners of real property acquired for national government infrastructure projects are promptly paid just compensation for the expeditious acquisition of the required right-of-way for the projects. With the promulgation of this Act, Republic Act No. 8974 (2000) was repealed.

Section 5 of the Act stipulates the rules on negotiated sale that the implementing agency shall offer to the property owner concerned, as compensation price, the sum of:

(1) The current market value of the land;

(2) The replacement cost of structures and improvements therein; and

(3) The current market value of crops and trees therein.

To determine the appropriate price offer, the implementing agency may engage the services of a government financial institution with adequate experience in property appraisal, or an independent property appraiser accredited by the Bangko Sentral ng PiliPiñas (BSP) or a professional association of appraisers recognized by the BSP.

Section 4 of the Act (and Section 11 of its IRR) states that when it is necessary to build, construct, or install on the subsurface or subterranean portion of private and government lands owned, occupied, or leased by other persons, such infrastructure as subways, tunnels, underpasses, waterways, floodways, or utility facilities as part of the government's infrastructure and development project, the government or any of its authorized representatives shall not be prevented from entry into and use of the subsurface or subterranean portions of such private and government lands by surface owners or occupants, if such entry and use are made more than fifty (50) meters from the surface.

If the national government project involves underground works within a depth of fifty (50) meters from the surface, the implementing agency may undertake the mode of acquisition in the following order:

a. Negotiate with the property owner a perpetual easement of ROW for the subterranean portions of this property required by the project; and

b. Offer to acquire from the property owner the affected portion of the land, including affected structures, improvements, crops and trees therein in accordance with the provisions of the Act.

The easement price under Section 11a of this IRR shall be twenty percent (20%) of the market price of the land.

(e) DPWH Land Acquisition, Resettlement, Rehabilitation and Indigenous Peoples Policy (LARRIPP) (2007)

The Land Acquisition, Resettlement, Rehabilitation and Indigenous People's Policy (LARRIPP) (3rd edition in April, 2007) embodies the principles and guidelines governing land acquisition and involuntary resettlement caused by DPWH infrastructure projects. Specifically, the LARRIPP prescribes (1) Eligibility, (2) Severity of Impact, (3) Entitlement, and (4) Public Consultation and Participation.

(f) National Government Programs for ISFs

The Philippine government has made efforts to address the ISF issue but has been unable to come up with institutional reforms and interventions that can adequately resolve it. It had developed and implemented a number of housing programs to respond to the challenge, ranging from highly centralized government-led approaches to more market-oriented and participatory strategies, but these have not curbed the increasing informality in urban centers.

President Benigno S. Aquino III at the start of his term in 2010 signed what he called a "Social Contract with the Filipino People," promising, among others, "inclusive urban development where people of varying income levels are integrated in productive, healthy, and safe communities." Among other efforts, his administration accelerated the provision of shelter, particularly for low-income groups and the urban poor. It launched Oplan LIKAS[4]: Lumikas para Iwas Kalamidad at Sakit (Operation Plan: Evacuate to Avoid Calamity and Sickness), a program to relocate more than 104,000 ISFs from danger areas. It allocated PHP 50 billion (approximately USD 1.15 billion) over five years, from 2011 to 2016, to finance land acquisition and housing construction. Taking global and national best practices into account, Oplan LIKAS advocated in-city relocation, to within the vicinity of ISFs' livelihoods, leaving off-city relocation as a last resort. Yet, due to lack of affordability, land constraints, and institutional challenges, among other factors, about 67 percent of the resettlements by the National Housing Authority (NHA) under Oplan LIKAS as of April 2015 were off-city. *(Source: Closing the Gap in Affordable Housing in the Philippines, Policy Paper for the National Summit on Housing and Urban Development)*

(3) Organizations and Regulations to Preserve Laguna Lake

(a) Organization

The Laguna Lake Development Authority (LLDA) was organized as a quasi-government agency in 1966 by virtue of Republic Act No. 4850. As stated in the law, LLDA's mandate is "to promote and accelerate the development and balanced growth of the Laguna de Bay area and the surrounding provinces, cities and town with due regard and adequate provisions for environmental management and control, preservation of the quality of human life and ecological systems, and prevention of undue ecological disturbances, deterioration and pollution." Presidential Decree No. 813 of 1975 further expanded LLDA's mandate to address environmental concerns and conflicts over the lake's jurisdiction and control. This was followed by Executive Order 927 of 1983, which further strengthened the institutional, financial and administrative responsibilities of the authority, including its regulatory function in industrial pollution.

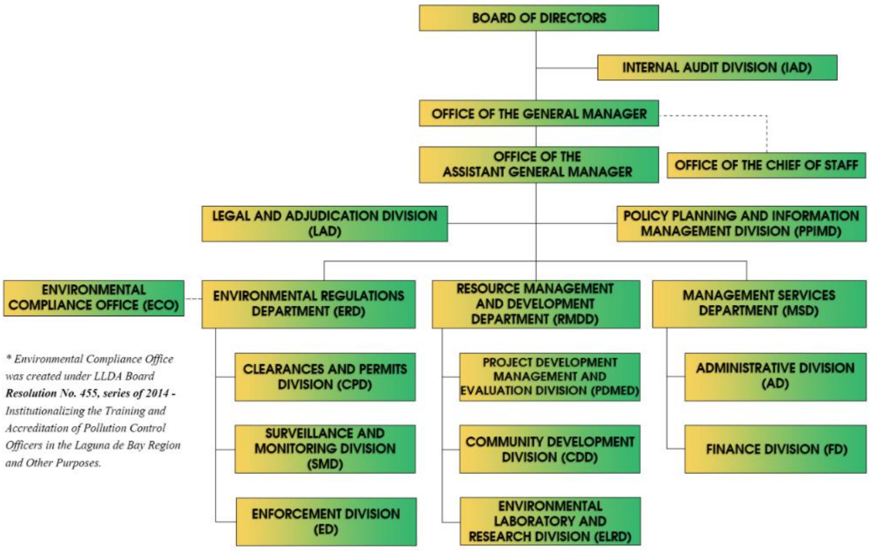
In 1993, LLDA was placed under the administrative supervision of the Department of Environment and Natural Resources (DENR) through Executive Order 149. As such it maintains its separate policy-making functions through the Board of Directors. LLDA decides and acts on policy matters, although not all are elevated to the DENR Secretary for final approval, since the Secretary is an LLDA Board Member.

The Charter of LLDA authorized it to lend or facilitate the extension of financial assistance and/or act as surety or guarantor of worthwhile agricultural, industrial and commercial enterprises. However, this

[4] Oplan LIKAS is a relocation program that began in 2012 and is being implemented by DILG, in conjunction with LGUs, NHA, PCUP (Presidential Commission on the Urban Poor), and DSWD (Department of Social Welfare and Development), involving ISFs residing along identified waterways for priority clean-up in Metro Manila. The national government allocated PHP50 billion for in-city and off-city relocation of the affected ISFs. Some 25,000 ISF had been relocated in 2015-16 to 20 in-city and off-city resettlement sites, mostly administered by NHA. A small number of ISFs are relocating to in-city and near-city sites adopting a "people's plan" approach, with housing finance provided by SHFC.

provision was affected by the issuance of Executive Order 138 in 1999. The LLDA is no longer allowed to engage in providing credit services directly or indirectly to various sectors.

The organizational structure of LLDA is shown in the figure below.



Source: LLDA official Homepage

Figure 6.2.2 Organizational Structure of LLDA

(b) Regulations

(i) EUFS

Environmental User Fee System (EUFS) is a system to reduce pollutant load to Laguna de Bay by charging a fee to liquid waste dischargers for environmental damages caused by their day-to-day operations. In addition, an enterprise must obtain a Discharge Permit, renewable annually, from LLDA. It is a legal authorization to discharge their wastewater. EUFS is meant to cover all water pollution sources from industrial, commercial, domestic and agricultural sources. EUFS is implemented by LLDA.

(ii) PCO

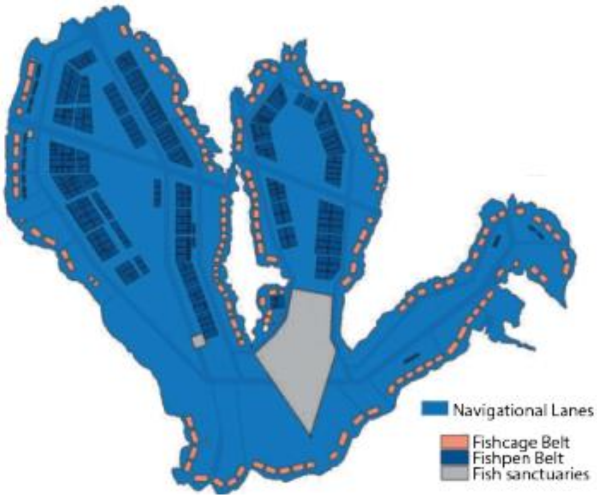
All industrial establishments are required to register with the LLDA. Those with wastewater discharges are also required to have a Pollution Control Officer (PCO) accredited by the LLDA, which has a PCO training program for accreditation purposes, including lectures on such issues as clean technologies.

(iii) Board Resolution No. 10

Board Resolution No. 10 was issued in 1995, asserting the LLDA's authority and exclusive jurisdiction over Laguna de Bay. It bans reclamation projects and disallow any non-environmentally feasible activity for the lake. The guidelines on the lease of the shore land were prepared in 1999.

(iv) ZOMAP

Regulation of aquaculture operation is based on the lake's Zoning and Management Plan (ZOMAP), considered as the most feasible management plan for equitable allocation of the lake's fishery resources. Fish pen belts and fish cage belts are delineated in specified locations in the lake, covering a total area of 100 km^2 and 50 km^2 respectively (Figure below).



Source: LLDA

Figure 6.2.3 Zoning and Management Plan (ZOMAP)

(4) Environmental Conservation of LPPCHEA

(a) LPPCHEA

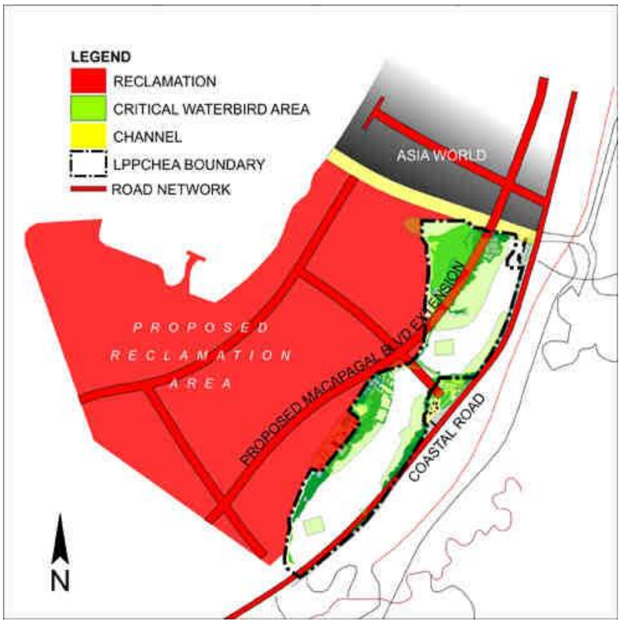
The Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA) was established as the Philippine's first critical habitat through Executive Order 1412 in 2007. "Critical habitat" is defined in Republic Act 9147 as "areas where threatened species are found". The law protects it "from any form of exploitation or destruction which may be detrimental to the survival of the threatened species dependent therein".

LPPCHEA is located on the southern portion of Metro Manila and is part of Manila Bay. It is bounded by Pasay City on the northeast; by Bacoor, Cavite on the southwest. It covers approximately 175 ha and consists of two islands, Free Island and Long Island.

LPPCHEA is known for hosting a diverse variety of wild birds. At present, there are 82 wild bird species found, 47 of which are migratory, and some endemic spices are found (Philippine Duck, Chinese Egret). In addition, it has a mangrove forest known as the thickest and most diverse among the remaining mangrove areas in Manila Bay.

(b) Controversy over Reclamation Plan

There is a controversy between Philippines Reclamation Authority (PRA) and conservation groups over the reclamation project around the LPPCHEA (see Figure 6.2.4). PRA is a government organization which is responsible for the reclamation plan in Manila Bay. The leader of the conservation groups is the Wild Bird Club of the Philippines when it started. Currently, Senator Cynthia Villar is leading the opposition campaign. The history of the controversy is summarized in the table below. To construct Parañaque Spillway, this issue need a closer watch.



Source: The official web site of the Wild Bird Watch Club, Philippines

Figure 6.2.4 Map of Reclamation Area Proposed by PRA

Table 6.2.3 History of Controversy between PRA and Conservation Groups

No.	Date	Events	Source
1	22 April 2007	Established Las Piñas Parañaque Critical Habitat and Ecotourism Area (LPPCHEA)	Executive Order 1412
2	31 January 2008	Amended the Executive Order 1412 to make all relevant departments and instrumentalities cooperate to conserve LPPCHEA.	Executive Order 1412-A
3	24 March 2011	DENR issued Environmental Compliance Certificate(ECC) to the Parañaque and Las Piñas Coastal Bay Project.	ECC-C0-1101-0001
4	25 March 2011	Member of the Interim Manila Bay Critical Habitat Management Council and Technical Working Group (The Council) pretested the above ECC.	Letter of Complaint to DENR Secretary Paje
5	11 May 2011	Philippines Reclamation Authority（PRA） denied to sign Resolution 2011-01 submitted by The Council. The resolution was to make PRA establish a working group which helps The Council preserve LPPCHEA, and prepare maintenance plan for LPPCHEA.	Letter from the Philippine Reclamation Authority
6	17 May 2011	The representative of Wild Bird Club of the Philippines （WBCP） a member of The Council requested DENR to consider not approving the ECC for the reclamation project.	Follow-up letter to DENR Sec. Paje
7	18 May 2011	PRA explained the reason for denying Resolution 2011-01 above.	Letter from the Philippine Reclamation Authority
8	28 May 2011	A group of small scale fisherman challenged supreme court to stop reclamation of LPPCHEA.	All Voices 2011/5/28
9	1 June 2011	WBCP submitted a letter expressing protest to the reclamation of LPPCHEA to Climate Change Commission.	Letter from WBCP
10	2 June 2011	Senate passed the resolution directing a proper senate committee to conduct inquiry to preserve LPPCHEA.	Philippines Senate Resolution # 508.

No.	Date	Events	Source
11	17 July 2011	Philippine Daily Inquirer written an article on birds in LPPCHEA.	Sunday Inquirer of 2011/7/17
12	29 November 2011	The House of Representatives passed the resolution calling for a congressional inquiry on the reclamation project of LPPCHEA.	House Resolution 1952
13	5 December 2011	PRA submitted a letter asking permit for the reclamation to DENR	PRA's letter
14	31 January 2012	Groups of several sectors launched a signature campaign protesting the reclamation.	GMA NEWS 2012/1/31
15	17 March 2012	Former congresswomen Cynthia Villar asked the supreme court to stop the reclamation plan.	Philippine Star 2012/3/17
16	11 April 2012	The supreme court issued a writ against the reclamation without a temporary environmental protection order.	MARK D. MERUEÑAS article 2012/4/11
17	23 April 2012	The representative of PRA declared to LPPCHEA.	WBCP article 2012/4/23
18	12 September 2012	A controversy arose between the bird watching group including WBCP and PRA as to whether the increase in bird strikes in Ninoy Aquino International Airport is attributed to LPPCHEA	Sunstar 2012/9/12
19	3 May 2013	Cynthia Villar's petition asking suspension of the reclamation to the appeals court was denied for lack of merit and prematureness.	Philippine Daily Inquirer 201/5/3
20	26 September 2013	Parañaque City Council passed a resolution to permit the reclamation by SM Land	Parañaque City Council Resolution 13-066
21	10 October 2013	Senate Cynthia Villar challenged anew the Court of Appeals' decision affirming the validity of the ECC for the reclamation project.	INQUIRER.net 2013/10/10

Source: JICA Survey Team; Summarized information in http://www.birdwatch.ph/html/corp/coastal-lagoon.html

(5) Environmental Standards

Environmental standards stipulated in the Philippines for ambient air quality, ambient noise and water quality of water bodies are listed as follows:

Table 6.2.4 National Ambient Air Quality Guideline Values (DAO No. 81 Series of 2000)

Pollutant	Short Term [(a)]			Long Term [(b)]		
-	μg/NCM	ppm	Averaging Time	μg/NCM	ppm	Averaging Time
Suspended Particulate Matter [(c)]- TSP PM-10	230 [(d)] 150 [(f)]		24 hours 24 hours	90 60	90 60	1 year [(e)] 1 year [(e)]
Sulfur Dioxide [(c)]	180	0.07	24 hours	80	0.03	1 year
Nitrogen Dioxide	150	0.08	24 hours	--	--	--
Photochemical Oxidants As Ozone	140 60	0.07 0.03	1 hour 8 hours	-- --	-- --	-- --
Carbon Monoxide	35 mg/NCM 10 mg/NCM	30 9	1 hour 8 hours	-- --	-- --	-- --
Lead [(g)]	1.5	--	3 months [(g)]	1.0	--	1 year

Notes:

1. Pursuant to Section 12 of Republic Act 8749, the initial set of National Ambient Air Quality Guideline Values necessary to protect public health and safety and general welfare shall be as follows:

   [(a)] Maximum limits represented by ninety-eight percentile (98%) values not to exceed more than once a year.

   [(b)] Arithmetic mean

[c] SO_2 and Suspended Particulate are sampled once every six days when using the manual methods. A minimum number of twelve sampling days per quarter or forty-eight sampling days each year is required for these methods. Daily sampling may be done in the future once continuous analyzers are procured and become available.

[d] Limits for Total Suspended Particulate Matter with mass median diameter less than 25-50 µm.

[e] Annual Geometric Mean.

[f] Provisional limits for suspended Particulate Matter with mass median diameter less than 10 µm until sufficient monitoring data are gather to base a proper guideline.

[g] Evaluation of this guideline is carried out for 24-hour averaging time and averaged over three moving calendar months. The monitored average value for any three months shall not exceeded the guideline value.

2. The applicable methods for sampling and measurement of the above pollutants are as follows:

Sulfur Dioxide	Gas Bubbler and Pararosaniline Method (West and Gaeke Method), or Flame Photometric Detector
Nitrogen Dioxide	Gas Bubbler Griess-Saltzman, or Chemiluminescence Method
Ozone	Neutral Buffer Potassium Iodide (NBKI), IChemiluminescence Method
Suspended Particulate Matter	
TSP	High Volume – Gravimetric, USEPA 40 CFR, Part 50, Appendix B
PM-10	High Volume with 10 micron particle-size inlet; Gravimetric, USEPA 40 CFR, Part 50, Appendix J
Sulfur Dioxide	Gas Bubbler and Pararosaniline Method (West and Gaeke Method), or Flame Photometric Detector, USEPA 40CFR, Part 50, Appendix A
Nitrogen Dioxide	Gas Bubbler Griess-Saltzman, or Chemiluminescence Method, USEPA 40 cfr, part 50, Appendix F
Carbon Monoxide	Non- dispersive Infra-red Spectrophotometry (NDIR), USEPA 40 CFR, Par 50, Appendix C
Lead	High Volume and Atomic Absorption Spectrophotometry, USEPA 40 CFR, Part 50, Appendix G

3. An analyzer based on the principles and methods cited above will be considered a reference method only if it has been designated as a reference method in accordance with 40 CFR, Part 53.
4. Other equivalent methods approved by the Department may be adopted.

Table 6.2.5 Noise Level Standards in General Areas (NPCC, 1980)

Category of Area	Daytime	Morning and Evening	Night time
AA	50dB	45dB	40dB
A	55dB	50dB	45dB
B	65dB	60dB	55dB
C	70dB	65dB	60dB
D	75dB	70dB	65dB

Note:
Class AA: refers to a section or contiguous area that requires quietness, such as areas within 100 meters from school sites, nursery, schools, hospitals, and special homes for the aged.
Class A: section of contiguous area, which is primarily used for residential purposes.
Class B: section or contiguous area, which is primarily a commercial area.
Class C: section primarily reserved as a light industrial area.
Class D: section which is primarily reserved as a heavy industrial area.
The standards are applied to the arithmetic mean of at least seven readings at the point of maximum noise level.

Division of the 24-hour period shall be 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.
Night time : 10:00 P.M. to 5:00 P.M.

Table 6.2.6 Water Quality Guidelines for Primary Parameters for Freshwater

Parameter	Unit	Water Body Classification*				
		AA	A	B	C	D
BOD	mg/l	1	3	5	7	15
Chloride	mg/l	250	250	250	350	400
Color	TCU	5	50	50	75	150
Dissolved Oxygen (Minimum)	mg/l	5	5	5	5	2
Fecal Colidorm	MPN/100ml	< 1.1	< 1.1	100	200	400
Nitrate as NO3-N	mg/l	7	7	7	7	15
pH (Range)		6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 9.0	6.5 – 9.0

Parameter	Unit	Water Body Classification*				
		AA	A	B	C	D
Phosphate	mg/l	< 0.003	0.5	0.5	0.5	5
Temperature	mg/l	26 – 30	26 – 30	26 – 30	25 – 31	25 – 32
Total Suspended Solids	mg/l	25	50	65	80	110

Source: DAO No. 2016-08
Note:
MPN/100 ml – Most Probable Number per 100 milliliter
n/a – Not Applicable
TCU – True Color Unit
(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 environment.
*: Classification of Water Bodies and Usage of Freshwater is shown in the table below:

Water Body Classification and Usage of Freshwater

Classification	Intended Beneficial Use
Class AA	Public Water Supply Class I – Intended primarily for waters having watersheds, which are uninhabited and/or otherwise declared as protected areas, and which require only approved disinfection to meet the latest PNSDW.
Class A	Public Water Supply Class II – Intended as sources of water supply that will require conventional treatment (coagulation, sedimentation, filtration and disinfection) in order to meet the PNSDW.
Class B	Recreational water Class I – Intended for primary contact recreation (bathing, swimming, etc.).
Class C	1) Fishery water for the propagation and growth of fish and other aquatic resources. 2) Recreational Water Class II – For boating, fishing or similar activities. 3) For agriculture, irrigation, and livestock watering.
Class D	Navigable Waters.

Table 6.2.7 Water Quality Guidelines for Primary Parameters for Marine Waters

Parameter	Unit	Water Body Classification			
		SA	SB	SC	SD
BOD	mg/l	n/a	n/a	n/a	n/a
Chloride	mg/l	n/a	n/a	n/a	n/a
Color	TCU	5	50	75	150
Dissolved Oxygen (Minimum)	mg/l	6	6	5	2
Fecal Coliform	MPN/100ml	< 1.1	100	200	400
Nitrate as NO3-N	mg/l	10	10	10	15
pH (Range)		7.0 – 8.5	7.0 – 8.5	6.5 – 8.5	6.0 – 9.0
Phosphate	mg/l	0.1	0.5	0.5	5
Temperature	mg/l	26 – 30	26 – 30	25 – 31	25 – 32
Total Suspended Solids	mg/l	25	50	80	110

Source: DAO No.2016-08
Note: Same as those for Freshwater
*: Classification of Water Bodies and Usage of Marine Waters is shown in the table below:

Water Body Classification and Usage of Marine Waters

Classification	Intended Beneficial use
Class SA	1) Protected Waters – Waters designated as national or local marine parks, reserves, sanctuaries, and other areas established by law (presidential Proclamation 1801 and other existing laws) and/or declared as such by appropriate government agency, LGUs, etc. 2) Fishery Water Class I – Suitable for shellfish harvesting for direct human consumption.
Class SB	1) Fishery Water Class II – Water suitable for commercial propagation of shellfish and intended as spawning areas for milkfish (Chanos chanos) and simmila species. 2) Tourism Zones – For ecotourism and recreational activities. 3) Recreational Water Class I – Intended for primary contact recreation (bathing, swimming, skin diving, etc).
Class SC	1) Fishery Water Class III – (For the propagation and growth of fish and other aquatic resources and intended for commercial and sustenance fishing. 2) Recreational water Class II – For boating, fishing, or similar activities. 3) Marshy and /or mangrove areas declared as fish and wildlife sanctuaries.
Class SD	Navigable Waters.

6.3 Environmental Assessment of Parañaque Spillway

(1) Impact of Land Acquisition for Construction of Spillway and Use of Underground Space

(a) Impact of Land Acquisition for Water Intake Facility and Consideration

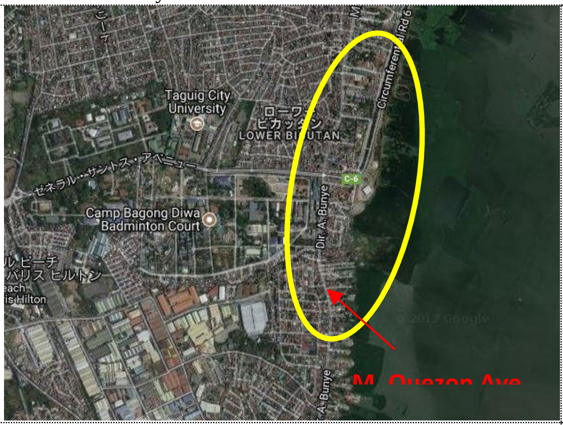
There are four candidate sites (alternatives) for construction of water intake facility. Table 6.3.1 shows the evaluation result of each site from environmental and social points of view:

Table 6.3.1 Baseline Condition of Candidate Sites for Water Intake Facility, Potential Impact and Required Consideration

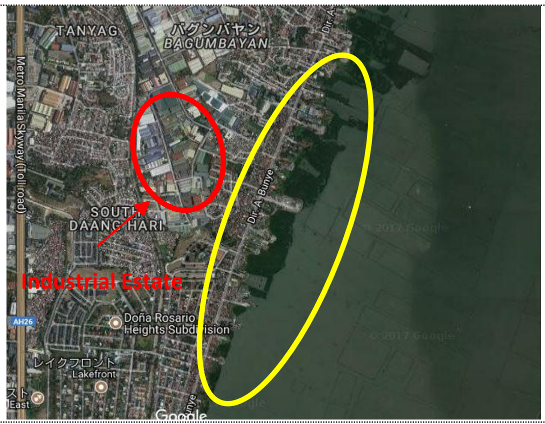
Location	Environmental Baseline / Potential Impacts	Consideration
Water Intake Facility Site ①: Barangay Lower Bicutan, Taguig.	Natural Environment: Terrestrial ecosystem is strongly affected by human activities. Aquatic ecosystem is characterized by marshy vegetation of macrophytes including water hyacinth (*Eichhornia crassipes*) and kangkong (*Ipomea aquatic*) . Traffic Condition: Two-lane road (M. Quezon Ave.) in north-south direction is often overcrowded. Land Use・Existing Facilities: Both sides of M. Quezon Ave. are densely populated (residential area). Land Availability: There is no existing available land (open space) for construction of water intake facility in land side. Water Area Use: Many fish cages are distributed in Laguna Lake at distance of several hundred meters from the shoreline, which would be affected depending on the location of water intake facility. There are mooring facilities at the lakeshore.	Available land for construction of water intake facility is limited on the land. In case of land reclamation at lakeshore, consideration for fish cages, such as mitigation measures for adverse impacts, compensation, etc. will be needed. Temporary road during construction period is necessary.
Water Intake Facility Site ②: Barangay Bagumbayan, Muntinlupa.	Natural Environment: Same as above. Traffic Condition: Same as above. Land Use・Existing Facilities: Both sides of M. Quezon Ave. are densely populated (residential area). Industrial estate, schools and hospital are located. Land Availability: Same as above. Water Area Use: Mooring facilities, restaurants, etc. are located at the lakeshore. Many fish cages are distributed in Laguna Lake at distance of several hundred meters from the shoreline.	Same as above.
Water Intake Facility Site ③: Barangay Sucat, Muntinpula	Natural Environment: Same as above. Traffic Condition: There are M. Quezon Ave., PNR, and SLEX in north-south direction. There is Sucat Road in east-west direction. Land Use・Existing Facilities: Both sides of M. Quezon Ave. are densely populated (residential area). There are subdivisions and industrial estates between PNR and SLEX. Sucat People's Park, Sucat Thermal Power Plant (currently not operated), etc. are located. Land Availability: There is open space between PNR and SLEX, which is large enough for water intake facility. Water Area Use: Many fish cages are distributed in Laguna Lake at distance of several hundred meters from the shoreline.	There is open space which is physically enough size for water intake facility. In case of land reclamation at lakeshore, consideration for fish cages, such as mitigation measures for adverse impacts, compensation, etc. will be needed. Temporary road during construction period is necessary.
Water Intake Facility Site ④: Barangays Buli, Cupag, Alabang, Muntinpula	Natural Environment: Same as above. Traffic Condition: There are M. Quezon Ave., PNR, and SLEX in north-south direction. There is Alabang Zapote Road in east-west direction. Land Use・Existing Facilities: Both sides of M. Quezon Ave. are densely populated (residential area). There are industrial estates, commercial facilities between PNR and SLEX. Sucat People's Park, Sucat Thermal	It is necessary to check if land size is enough for water intake facility. In case of land reclamation at lakeshore, consideration for fish cages, such as mitigation measures for adverse impacts,

Location	Environmental Baseline / Potential Impacts	Consideration
	Power Plant (currently not operated), etc. are located. There are schools near the lakeshore in Brgy. Alabang. Land Availability: There are open spaces, but seems to be not enough for water intake facility. Water Area Use: Same as above.	compensation, etc. will be needed. Temporary road during construction period is necessary.

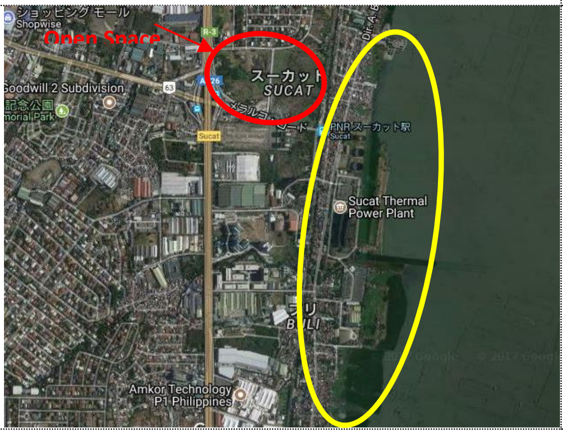
Source：JICA Survey Team



Aero Photo 1: Water Intake Facility Site ①
(Barangay Lower Bicutan, Taguig)



Aero Photo 2: Water Intake Facility Site ②
(Barangay Bagumbayan, Munitnlupa)



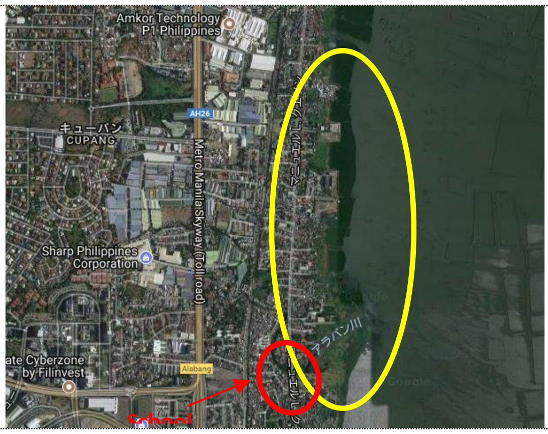


Figure 6.3.1 Location Map of Candidate Sites of Water Intake Facility

Photo 1: Candidate Site ①
(Southward from Taguig Lakehore Hall)

Photo 2: Candidate Site ②
(Southward from Sucat People's Park)

Figure 6.3.2 Existing Condition of Candidate Sites (Lakeshore) for Water Intake Facility

These four candidate sites for water intake facility are already densely populated (residential area) and therefore, available land is limited in the land side. Open spaces scattering in the south of

Barangay Sucat are located with good accessibility from central Manila having an advantage for development. It does not seem to be, therefore, easy for land acquisition. Land reclamation at lakeshore, on the other hand, would be easier than land acquisition although LLDA clearance is required and thus the possibility seems to be higher. Considerations for environmental and social impacts include construction of temporary road as a mitigation measure for minimizing the impact on crowded conditions of existing road. In addition, consideration for schools and hospitals, water area uses such as mooring facilities, water transportation and fish cages will be needed as well.

(b) Impact of Land Acquisition for Water Discharge Facility and Consideration

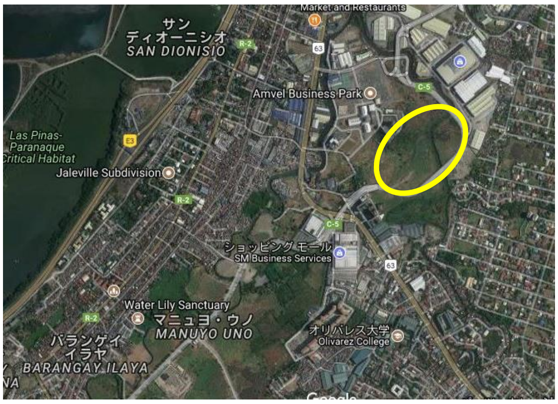
There are four candidate sites (alternatives) for construction of water discharge facility. Table 6.3.2 show the evaluation result of each site from environmental and social points of view:

Table 6.3.2 Baseline Condition of Candidate Sites for Water Discharge Facility, Potential Impact and Required Consideration

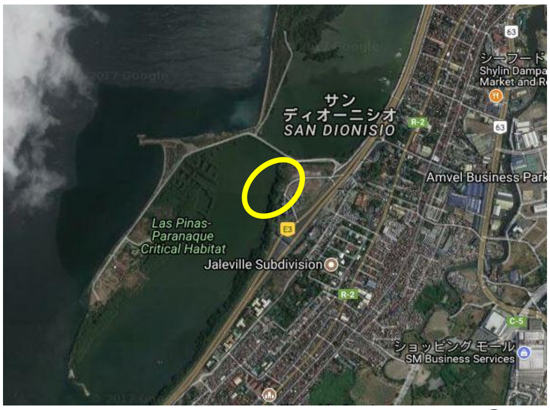
Location	Environmental Baseline / Potential Impacts	Consideration
Water Discharge Facility Site ① : Lower Section of Parañaque River	National Environment: Existing terrestrial ecosystem is strongly affected by human activities. Candidate site is a large open space vegetated with grass/ bush (Photo 1, Figure 6.3.4) Traffic Condition: There is Z. Carlros P. Gracia Ave. (C-5) environing the candidate site. There is Sucat Rd. in east-west direction. Land Use・Existing Facilities: There are business park, church, commercial facility and warehouses. Land Availability: The candidate site is large enough for water discharge facility. Potential Impact on protected area (LPPCHEA): River mouth of Parañaque River is located north of LPPCHEA, so the direct impact on the protected area is avoidable.	Direct impact on LPPCHEA is avoidable but the impacts on aquatic biota in it cannot be always avoided because of outlet point is close to the protected area. Thus, mitigation measures for it should be figured out. Detailed survey on flora and fauna in the candidate site, on which evaluation as habitat, protected species is needed. Mitigation measures to minimize dust, noise, vibration, etc. shall be secured for existing facilities including church during construction period.
Water Discharge Facility Site ② : Tidal land (inside protected area) in LPPCHEA	National Environment: Candidate site is located at tidal land in LPPCHEA (inside the protected area). Traffic Condition: There is CAVITEx. in north-south direction. There is an access road to LPPCHEA. Land Use・Existing Facilities: There is a toll booth of CAVITEx at east side (land side). There are hospital and residential area beyond CAVITEx. Land Availability: There is open space at CAVITEx southbound as candidate site. Potential Impact on protected area (LPPCHEA): Discharge point is facing to LPPCHEA.	Impact of water discharge on LPPCHEA would be large and launching a mitigation measure to minimize it is not easy, which might become a social problem.
Water Discharge Facility Site ③ : Offing (outside of protected area) of LPPCHEA	National Environment: Candidate site is located in the offing (outside of protected area) of LPPCHEA. Traffic Condition: There is CAVITEx in the north-south direction. There is a management road in the area of LPPCHEA. Land Use・Existing Facilities: There is a tool booth of CAVITEx at east side (land side). Land Availability: Land reclamation is needed for securing the land for water discharge facility in Manila Bay. Potential Impact on protected area (LPPCHEA): Direction of water discharge is toward offshore from LPPCHEA.	Direct impact on LPPCHEA is avoidable as the discharge point is located outside of it. Direct impact of water discharge on LPPCHEA is avoidable, but the mitigation measures for such impacts as offensive odor, landscape and noise and those during construction works should be launched. Land reclamation for securing the land for water discharge facility,

Location	Environmental Baseline / Potential Impacts	Consideration
		might cause a generation of opposition campaign.
Water Discharge Facility Site ④ : Outlet of Zapote River	National Environment: Candidate site, located at right bank of the Zapote River, is currently a large open space remained after using as a landfill/disposal site. Left bank of the river is a vast vegetated marsh land. Traffic Condition: There is CAVITEx along Manila Bay. There is Z. Carlros P. Gracia Ave. (C-5) east side. Land Use・Existing Facilities: Right bank of the Zapote River is partly being used as a landfill/disposal site of Las Piñas City. ISFs are dwelling in the candidate site (Photo 2, Figure 6.3.4). Left bank belongs to the area of Bacoor City, Cavite, where a lot of ISFs are dwelling along the river. South side, beyond a tributary of the Zapote River, is occupied with residential area, including hospital, collage, etc. Land Availability: Right bank is a large open space, which is a candidate site for water discharge facility (as mentioned above). Potential Impact on protected area (LPPCHEA): Water discharge point is south of LPPCHEA, and therefore direct impact on it can be avoided.	Impact of water discharge on LPPCHEA is avoidable. But the impact on ISFs cannot be avoided, so relocation of ISFs should be preceded before the implementation of the Project.

Source：JICA Survey Team



Aero Photo 1: Water Discharge Facility Site ①
(Lower Section of Parañaque River)



Aero Photo 2: Water Discharge Facility Site ②
(Tidal land (inside protected area) in LPPCHEA)

Aero Photo 3: Water Discharge Facility Site ③
(Offing (outside of protected area) of LPPCHEA)

Aero Photo 4: Water Discharge Facility Site ④
(Outlet of Zapote River)

Figure 6.3.3 Location Map of Candidate Sites of Water Discharge Facility

	
Photo 1: Candidate Site ① (Open space along the lower section of the Parañaque River)	Photo 2: Candidate Site ④ (Open space along the Zapote River)

Figure 6.3.4 Existing Condition of Candidate Sites for Water Discharge Facility

These four candidate sites are all located near LPPCHEA which is designated as a protected area. Therefore, it is important to avoid/minimize the impacts on LPPCHEA. However, the anticipated impacts of the project cannot be avoided for the cases of candidate sites No. 2 and 3. Taking into account that there was an opposition campaign in the past for the reclamation project in Manila Bay, the eligibility of these two candidate sites are not high. The remaining two sites, No.1 and No.4 have higher eligibility in terms of land availability and environmental point of view. They can avoid direct impacts on LPPCHEA as their discharge points are located at north and south out of the protected area. Thus, these two sites are evaluated as prospective ones. Checking the details, however, impacts on LPPCHEA of the candidate site No.1 is likely to be generated and some mitigation measure should be required in the future since the discharge point of the site No.1 is located rather close to the protected area. With regard to site No.4, since a lot of ISFs are dwelling along river bank of the Zapote River, it should be noted that relocation of the ISFs before the implementation of the Project is a condition for this site.

(c) Impact of Underground Use for Construction of Spillway and Consideration

There are five alternatives in terms of route and depth for construction of spillway. Table 6.3.3 show the evaluation result of each case from environmental and social points of view:

Table 6.3.3 Baseline Condition of Candidate Sites for Underground Spillway, Potential Impact and Required Consideration

Route/ Depth	Environmental Baseline/ Potential Impacts	Consideration
Route A: Connecting Barangay Lower Bicutan, Taguig and Lower Section of the Parañaque River/ Depth: Deeper than 50m below GL.	<u>Land Rights and Compensation:</u> Surface owners' land rights is not effective in case of deeper than 50m below GL. pursuant to RA No. 10752, so compensation is not required. <u>Traffic Condition:</u> Generation of project-related traffic for transportation of construction materials and excavated materials will be large. <u>Existing Underground Structure:</u> Existing underground structures such as foundation of high-rise buildings, expressway, etc., are not estimated to reach 50m below GL. <u>Groundwater Use:</u> Impact on existing groundwater use by deep wells should be avoided.	Impacts of generation of project-related traffic and public pollution such as dust, noise, etc., should be mitigated. Backfill site for excavated materials of more or less one million cubic meters is required (Excavated materials can be used as construction material for lakeshore dike if their construction schedule is synchronized.)

Route/ Depth	Environmental Baseline/ Potential Impacts	Consideration
	Impacts during construction work: Noise, vibration due to construction of vertical shaft, low frequency sound, etc., will be generated during tunneling works.	
Route B: Connecting Barangay Bagumbayan, Muntinlupa and Lower Section of the Parañaque River/ Depth: Deeper than 50m below GL.	Same as the case of Route A.	Same as the case of Route A.
Route C: Connecting Barangay Sucat, Muntinlupa and Lower Section of the Parañaque River under Sucat Road/ Depth: Approx. 30m below GL.	Land Rights and Compensation: Surface owners' land rights is effective in case of shallower than 50m below GL. pursuant to RA No. 10752, so compensation is required. Traffic Condition: Generation of project-related traffic for transportation of construction materials and excavated materials will be large. Existing Underground Structure: Depth of existing underground structures such as foundation of high-rise buildings, expressway, etc. should be confirmed. Groundwater Use: Impact on existing groundwater use by deep wells should be avoided. Impacts during Construction Work: Noise, vibration due to construction of vertical shaft, low frequency sound, etc. will be generated during tunneling works.	Same as the case of Route A.
Route D: Connecting Barangay Sucat, Muntinlupa and Lower most section of the Zapote River/ Depth: Deeper than 50m below GL.	Same as the case of Route A.	Same as the case of Route A.
Route E: Connecting Barangay Alabang, Muntinlupa and Lower most section of the Zapote River under Alabang Zapote Rd./ Depth: Approx. 30m below GL.	Same as the case of Route A.	Same as the case of Route A.

Source：JICA Survey Team

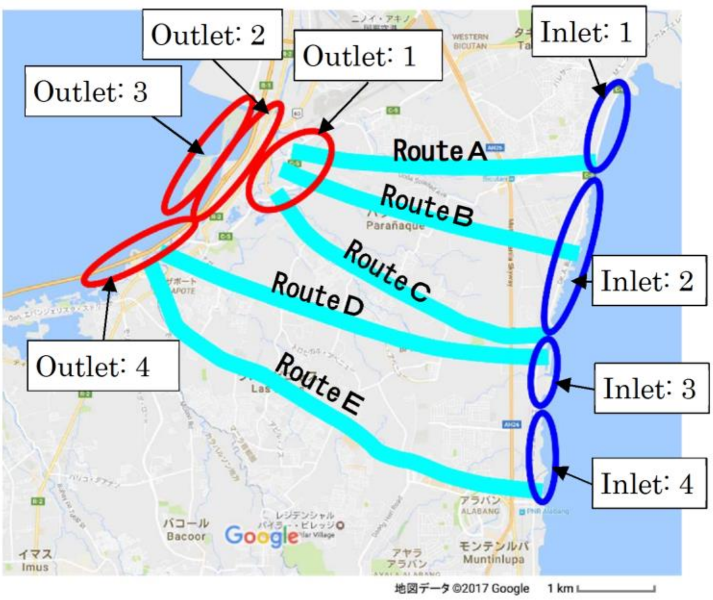


Figure 6.3.5 Location Map of Candidate Construction Routes of Spillway

The differences among the five alternatives are whether the spillway alignment is straight line or the line along the road, and whether the construction depth is deeper than 50m or approx. 30m below GL.

Surface owners' land rights is not effective in case of deeper than 50m below GL. pursuant to RA No. 10752, so compensation for underground use is not required in Cases A, B and D. In terms of this point, it is obvious that the construction cases of these cases will have smaller social impact.

In addition, considering also the evaluation results of water intake facility and discharge facility, the case with no land acquisition for water intake facility and the case of less impact on LPPCHEA for water discharge facility have higher eligibility. Thus, Route D is scored highest from environmental and social points of view, followed by Routes A and B. In this regard, there is a condition that relocation of ISFs' dwellings near the candidate water discharge facility should precede before the implementation of the Protect.

(2) Impacts of Construction Work of Spillway (Public Pollution, Impacts on Traffic, etc.)

(a) Construction Equipment and Materials Necessary for Construction Work

Types of construction work, construction equipment and materials necessary for construction of the spillway are shown in Table 6.3.4. The table shows the necessary information on two cases of tunneling method, Shield and NATM.

Table 6.3.4 Type of Construction Works, Equipment and Materials Necessary for Spillway Construction

Construction work	Construction method	Category	Major equipment and materials
1) Tunneling			
a) Shield	Excavation work Lining work by segment Mucking work, etc.	Materials	Segment, Add-in material, Back-filling material, etc.
		Equipment	Shield machine, Backhoe, Trailer, Dump truck, Crane, Belt conveyor, ventilation blower, vibration sieve, vacuum pump, etc.
b) NATM	Excavation work Lining work by concrete Mucking work, etc.	Materials	Ready-mixed concrete, Lock bolt, Supporting steels, Reinforcing bar, Waterproof sheet, etc.
		Equipment	Wheel Jumbo (Excavator), Breaker, Dump truck, Concrete blower, Concrete mixer truck, Concrete pumping vehicle, etc.
2) Construction work of vertical shaft			
	Excavation work Supporting work Concrete work, etc.	Materials	Reinforcing bar, Ready-mixed concrete, etc.
		Equipment	Excavator for continuous wall, Crawler crane, Backhoe, Trailer, Mud-water treatment equipment, Concrete mixer truck, Concrete pumping vehicle, etc.

Source: JICA Survey Team

(b) Impacts of Construction Work (Public Pollution) and Considerations

Table 6.3.5 lists the anticipated impacts (generation of public pollution) due to construction of the spillway and necessary considerations. Anticipated impacts include groundwater discharge, ground movement, air pollution, noise and vibration, low-frequency sound and water pollution, etc. Necessary consideration for these impacts include investigation of groundwater use through an inventory of existing groundwater wells and launching mitigation measures for minimizing the impacts on groundwater, installation of a sound insulation house, investigation of water area use (fishery, water transportation, water use, etc.) and launching of mitigation measures to minimize/compensate for the impacts.

Table 6.3.5 Environmental Impacts of Construction Work and Necessary Considerations

Construction Work	Potential Impacts	Impact Factor	Considerations
Tunneling (Shield)	Groundwater discharge/ Drawdown of groundwater level	Tunneling by shield machine	Investigation of groundwater use through inventory of existing groundwater wells and launching of mitigation measures for minimizing the impacts on groundwater, etc.
	Ground movements	Tunneling by shield machine	Enough supporting work
	Low-frequency sound	Operation of ventilation blower, vibration sieve to be used at slurry treatment, vacuum pump, etc.	Installation of a sound insulation house, etc.
	Noise and vibration, emission gas, impact on traffic flow and traffic accidents, etc. due to transportation of construction equipment and materials	Transportation by dump truck and trailer, and operation of crane, etc.	General measures to mitigate public pollution in construction works such as introduction of low-noise, low-vibration type construction machine, consideration in operation itme, etc.
Tunneling (NATM)	Same as above, plus water pollution by high-alkali water	Same as above, plus concreting work	Same as above, plus equipment of sediment pond, etc.
Construction of Vertical Shaft	Noise and vibration, emission gas during construction work	Operation of construction equipment (piling machine, crane, backhoe, etc.)	General measures to mitigate public pollution in construction works (same as above)
	Groundwater discharge, drawdown of groundwater level	Excavation work	Investigation of groundwater use through an inventory of existing groundwater wells (same as above)
	Ground movements	Excavation work	Enough supporting work
	Noise and vibration, emission gas, impact on traffic flow and traffic accidents, etc., due to transportation of construction equipment and materials	Transportation by dump truck and trailer, and operation of crane, etc.	General measures to mitigate public pollution in construction works (same as above)
	Oil diffusion	Piling work (operation of piling machine)	Installation of diffusion prevention curtain/fence, etc.
Reclamation in Laguna Lake for Construction of Water Intake Facility	Discharge/diffusion of earth in Laguna Lake, Impacts on fishery (fish pen, fish cage, fish sanctuary), water transportation, and existing water intake facilities)	Reclamation work	Investigation of water area use (fishery, water transportation, water use, etc.) and launching mitigation measures to minimize the impacts, consultation with fisher folks, operators of water transportation, compensation, etc.

Source：JICA Survey Team

(c) Impacts of Construction Work on Traffic and Necessary Considerations

Transportation of construction equipment and materials, mobilization of construction workers, and commuting to construction work site will result in the generation of project-related traffic. One of the major factors of the project-related traffic is the mobilization of segments for shield tunnelling and transportation of excavated materials from the construction of vertical shaft and tunnelling works.

According to the transportation plan of segment in shield tunneling, tunneling work period is estimated to be 23 months. Assuming that segment is to be transported by 27-ton trailer, the necessary number of transportation by the trailer is estimated to be approx. 25,530, which will be 37 per day.

On the other hand, regarding the excavated materials, which will be divided into those from construction of vertical shaft and those from tunneling work, the necessary number of truck transportation is estimated, as shown in the table below, to be 124 per day at maximum for the construction of vertical shaft (Vertical shaft at Manila Bay side), and 743 per day at maximum for the tunneling work (Route D).

Table 6.3.6 Estimation of Generation of Project-Related Traffic for Transportation of Excavated Materials

Type of Work	Case	Volume of excavated materials (m^3)	Number of dump trucks*	
			Total	Number of dump trucks/day
Construction of vertical shaft	Vertical shaft at Laguna Lake side	68,700m^3	13,7000	115
	Vertical shaft at Manila Bay side (Case A/ Case D)	73,500/74,600m^3	14,700/14,900	123/124
Tunneling work	Spillway (Route A) (Length: 7.8km)	1,388,000m^3	277,500	603 **
	Spillway (Route D) (Length: 9.6km)	1,708,000m^3	341,600	743 **

* Assuming that the load capacity of dump truck (10-ton) is 5.0 m^3.
** Assuming that the maximum rate will be 1.5 times of the daily average.
Source: JICA Survey Team

There will be additional traffic to the above, namely; traffic for transportation of construction equipment (heavy machine) and for laborers. As a result, the total number of project-related traffic volume will be much beyond 800/day. This figure is the level of significant impact on the existing traffic condition.

Necessary considerations for the impacts are as shown below. Among others, the first measure is the most important. It is indispensable to carry out a detailed investigation of existing traffic volume of transportation routes prior to the implementation of the Project. Based on the result, it is necessary to formulate a transportation plan of construction equipment and materials and excavated materials, and a traffic management plan to mitigate the impact on existing road traffic.

- Investigation of existing traffic volume and formulation of traffic management plan;
- Consideration in the route of carrying-in and out of construction equipment/materials, and excavated materials;
- Adjustment of time for carrying-in and out;
- Deployment of traffic control personnel;
- Utilization of public transportation by construction workers;
- Notification of dangerous points in terms of traffic accident and its dissemination to drivers of vehicles;
- Public relations by means of mass media regarding construction works of the Project; and
- Dissemination to relevant organizations, LGUs and the general public.

(3) Impact on Manila Bay Environment

Based on the research results, the discharged water through Parañaque Spillway does not seem to affect the environment of Manila Bay for the following reasons:

(a) Amount of Freshwater

Pampanga River contributes approximately 50% of all freshwater that enters Manila Bay. Compared to the water from Pampanga River, the increase in flow rate by the Parañaque Spillway is smaller, and the total amount of freshwater does not change. Therefore, decrease in the density of chloride in Manila Bay is unlikely.

(b) Water Quality

Owning to the control by LLDA, the water quality of Laguna de Bay is better than that of Manila Bay.

(c) Sediment

Sediment concentration of the water discharged through the spillway is expected to be small because Laguna de Bay will work as a settling basin. In addition, the tributaries which are the main sediment sources enter the central and eastern parts of the lake, but the intake of the spillway will be constructed in the western part of the lake. Considering the low current velocity in the lake, the transport of sediment to the intake is also unlikely.

However, a regional and temporal change near the outfalls of the Parañaque or Zapote River will occur. The changes should be evaluated quantitatively in the future because the LPPCHEA is located near the outfalls and it is conceivable that the conservation groups will require explanation about the impact on the LPPCHEA. To evaluate the impact, it is suggested that a 3D simulation of lake water discharge is conducted in collaboration with the LLDA and the Objectives

6.4 Environmental Assessment of Other Structures

Other structures considered in the "full menu" of measures for flood mitigation which would cause environmental and social impacts by the Project are the construction of lakeshore dike along Laguna Lake, river channel improvement works of the major rivers flowing into the lake, and the construction of drainage facilities (pumping stations). Potential impacts caused by the structures/facilities are the following three:

- Land acquisition for the structures/facilities and impacts on existing buildings (houses)
- Impacts during construction work of the structures/facilities (public pollution and impacts on traffic, etc.)
- Impacts on economic activities in Laguna Lake

(1) Land Acquisition for Structures/Facilities and Impacts on Existing Buildings

(a) Land Acquisition for Construction of Lakeshore Dike and Magnitude of Impacts

Land acquisition for construction of the lakeshore dike for flood mitigation and the impacts on existing structures/facilities (buildings) are as estimated in this section. RA No. 4850 (1966), PD No. 813 (1975) and EO No. 927 (1983) stipulate that all lands located at 12.5 meters in elevation and below are considered as public land and are managed and controlled by the LLDA. Nevertheless, there are a lot of residents in areas below 12.5m even before the legal framework mentioned above were enacted. Therefore, it is necessary to compensate for land acquisition even in areas below 12.5m, which are currently public land, for the construction of lakeshore dike. Compensation for affected buildings is required as well.

To estimate the extent of compensation cost for affected lands and buildings, the area of land acquisition and the number of buildings to be affected are calculated using GIS, aero-photographs (Google Earth) and land use maps, specifically, in the following method:

(a) Alignment of lakeshore dike is delineated on Google Earth maps;

(b) Areas located lakeside of the dike alignment is calculated by land use divided into built-up, agricultural, inland water and others (grassland, forests, etc.);

(c) The number of buildings is estimated in the following method: a quadrat (square), 50m x 50m, is set as the unit area over the built-up area in Google Earth, and the number of buildings accommodated are counted. The number of buildings in built-up areas as identified above is estimated as the product of built-up area and the number of buildings in a unit area; and

(d) According to the site reconnaissance, most buildings in the lakeshore area are residential. Assuming that affected buildings are all residential ones, the number of Project-Affected-Persons (PAPs) is estimated as the product of the number of buildings and the average family size cited in demographic statistics.

On the other hand, land acquisition compensation cost to be required for the ROW of public infrastructure projects should be the current market price of the land in question pursuant to RA No. 10752. In case of lakeshore lands of Laguna Lake, however, those located lower than 12.5 m are considered as public land and transaction is basically not made. Therefore, the market price for such land is not given. For this reason, the BIR Zonal Value is used for the estimation of land acquisition compensation cost for the lakeshore dike. In this regard, the target area for compensation is limited only to built-up, and the compensation for affected buildings is the estimated replacement cost based on the statistical data on the average construction cost for residential buildings by the LGU.

The results of estimation of compensation cost for the construction of lakeshore dike is summarized in Table 6.4.1 (Refer to Appendix 2-1 for the details). The results show that the necessary land acquisition is approx. 1,100 hectares and the number of affected buildings is 1,800 in the case of construction of lakeshore dike along the shoreline. On the other hand, the number of PAPs is 7,200 persons. The compensation cost for land is PHP 1,100 million, the compensation cost for buildings is PHP 410 million, and the total compensation cost is PHP 1,530 million. In this regard, the ratio of Informal Settlers (IS) out of the PAPs were not known, since there is no data for the estimation.

Table 6.4.1 Estimation of Compensation Cost for Affected Lands and Buildings Necessary for the Construction of Lakeshore Dike

Province	City/ Municipality	Phase/ Priority	Magnitude of Impacts			Compensation Cost		
			Land acquisition (ha)	Nos. of Building (Households) (No.)	PAPs (No.)	Land (million PHP)	Buildings (million PHP)	Total (million PHP)
Rizal	Angono	1	325.2	92	415	21	14	35
	Taytay	1	83.9	0	0	48	0	48
Metro Manila	Taguig	I	27.0	0	0	0	0	0
	Muntinlupa	I	27.5	75	309	60	33	93
Sub-total		**I**	**463.6**	**168**	**725**	**129**	**47**	**176**
Laguna	San Pedro	II	26.8	25	112	3	5	8
	Binan	II	40.8	249	944	27	54	81
	Santa Rosa	II	28.0	254	889	47	55	102
	Cabuyao	II	85.1	137	520	19	30	49
	Calamba	II	48.8	180	667	77	39	116
Sub-total		**II**	**229.5**	**845**	**3,134**	**174**	**183**	**357**
Laguna	Los Banos	III-2	17.2	426	1,661	69	92	162
	Bay	III-2	28.6	144	592	55	31	86
	Calauan	III-2	16.8	0	0	5	0	5
	Victoria	III-2	61.9	29	104	104	6	110
	Pila	III-2	56.9	53	232	57	11	68
	Santa Cruz	II	223.5	167	703	524	36	561
Sub-total		**III**	**405.0**	**819**	**3,293**	**815**	**177**	**992**
Total for Priority Area		**I+II+III**	**1,098.0**	**1,832**	**7,151**	**1,117**	**408**	**1,525**
Laguna	Pagsanjan,	-	13.8	0	0	35	0	35
	Lumban	-	926.4	8	33	185	2	187
	Kalayaan	-	65.8	33	150	21	7	29
	Paete	-	61.0	0	0	34	0	34
	Pakil	-	112.6	35	158	18	8	25
	Pankil	-	149.7	42	183	67	9	76
	Siniloan	-	62.3	0	0	0	0	0
	Famy	-	27.3	0	0	2	0	2
	Mabitac	-	171.3	6	28	43	1	44
Rizal	Jala-jala	-	123.1	215	1,009	50	46	97
	Pililla	-	150.5	321	1,412	209	50	259
	Tanay	-	71.1	94	433	72	15	87
	Baras	-	129.0	19	76	190	3	193
	Morong	-	280.4	16	73	334	3	337
	Cardona	-	115.2	103	413	11	16	27
	Binagonan	-	428.1	2,024	8,096	346	316	663
Sub-total		**-**	**2,887.5**	**2,916**	**12,064**	**1,617**	**476**	**2,093**
Grand total		**-**	**3,985.5**	**4,748**	**19,216**	**2,734**	**884**	**3,618**

Source：JICA Survey Team

(b) Land Acquisition for River Channel Improvement and Impact on Existing Buildings

In this survey, river channel improvement work is proposed as one of the “full menu” for flood mitigation targeted for major rivers flowing into the Laguna Lake. The section of river channel improvement work is from the elevation of lakeshore dike until 15 0 m, which is the water level at 14.0 m by rain events with 100-year recurrence period considering the drawdown effect of Parañaque Spillway plus 1.0m of freeboard. It is, therefore, necessary to acquire land for river channel improvement and to compensate for the land and the existing structures/buildings on it. Amount of compensation was calculated in the same manner as that in the previous section. The result is shown in Table 6.4.2 (refer to Appendix 2-2 for the details).

Calculation results show that the necessary land acquisition is approx. 120 ha and the number of affected buildings is 1,100. On the other hand, the number of PAPs is 4,400 persons and the amount of land compensation cost for lands is PHP 4,200 million. The results also show that compensation cost for buildings is PHP 280 million, and the total compensation cost is PHP 4,480 million.

Table 6.4.2 Estimation of Compensation Cost for Affected Lands and Buildings Necessary for River Channel Improvement

Province	Target Rivers of Improvement	Phase/ Priority	Magnitude of Impacts			Compensation Cost		
			Land acquisition (ha)	Nos. of Building (Households) (No.)	PAPs (No.)	Land (million PHP)	Buildings (million PHP)	Total (million PHP)
Rizal	Angono River	I	2.69	26	117	31	4	35
Laguna	Magdaong River	I	0.51	22	91	374	10	384
	Alabang River	I	2.45	75	308	787	33	820
	Bayanan River	I	1.38	42	174	444	19	463
	Pblacion River	I	0.80	25	101	258	11	268
	Magdaong River	I	0.95	29	119	304	13	317
	SB-23-5	I	0.85	26	107	274	11	285
	SB-23-6	I	0.52	16	66	167	7	174
	Sub-total	**I**	**10.14**	**262**	**1,083**	**2,640**	**107**	**2,747**
Laguna	San Isidro River	II	3.35	102	458	57	22	79
	Tunasan RIver	II	1.74	53	237	30	11	41
	SB-20-4	II	1.85	37	140	45	8	53
	Binan River	II	6.36	127	482	156	27	183
	Sta. Rosa River	II	2.59	48	168	82	10	92
	SB-20-2	II	1.86	34	120	59	7	66
	SB-20-3	II	2.12	39	137	67	8	75
	San Juan River	II	3.30	27	101	104	6	110
	San Cristobal River	II	3.05	25	93	96	5	102
	SB-17-6	II	0.99	8	30	31	2	33
	SB-17-7	II	1.65	14	50	52	3	55
	SB-17-8	II	4.51	37	137	143	8	151
	Sub-total	**II**	**33.37**	**551**	**2,154**	**923**	**119**	**1,042**
Laguna	Los Banos River	III	6.51	35	136	141	8	149
	SB-17-3	III	0.63	3	13	14	1	14
	SB-17-4	III	0.99	5	21	21	1	23
	SB-17-5	III	2.02	11	42	44	2	46
	Colo River	III	0.75	3	11	6	1	7
	Clauan River	III	7.49	20	93	28	4	32

Province	Target Rivers of Improvement	Phase/ Priority	Magnitude of Impacts			Compensation Cost		
			Land acquisition (ha)	Nos. of Building (Households) (No.)	PAPs (No.)	Land (million PHP)	Buildings (million PHP)	Total (million PHP)
	SB-16-2	III	28.99	78	360	108	17	125
	Pila River	III	8.92	43	155	77	9	86
	SB-15-2	III	14.37	53	232	111	11	122
	Sta. Cruz River	III	2.39	17	73	76	4	80
Sub-total		**III**	**73.04**	**269**	**1,136**	**626**	**58**	**684**
Total for Priority Area		**I+II+III**	**116.54**	**1,081**	**4,373**	**4,188**	**284**	**4,472**

Note: Refer to Section 4.5.2 for the ID of Rivers.
Source: JICA Survey Team

(c) Necessary Land Acquisition for Construction of Drainage Facilities and Impact on Existing Buildings (Houses)

Drainage of inland water behind the lakeshore dike is proposed to be done with the installation of pumping stations in the Project. It is, therefore, necessary to acquire land for the construction of drainage facilities. The location of drainage facilities is not yet fixed, but non-built-up grasslands/bush lands or at least farmlands are most suitable for drainage facilities to minimize compensation necessary for lands and existing structures/facilities. Based on such assumption, the amount of land compensation for drainage facilities was calculated in the same manner as in the previous sections. The results are shown in Table 6.4.3.

Calculation result shows that the necessary land compensation is PHP 730 million based on lands of 70 ha. It should be noted that no compensation for existing structures/facilities is required because the development of drainage facilities is to be done at non-built-up areas.

Table 6.4.3 Estimation of Land Compensation Necessary for Drainage Facilities

Province	ID of Drainage Facility*	City/ Municipality	Land Area			Land Compensation (million PHP)
			Area of Regulation Pond (ha)	Area of Pumping Station (m^2)	Total (ha)	
Metro Manila	SB23-RB1	Taguig	0.9	1,300	0.98	34.3
	SB23-RB2	Muntinlupa	1.2	1,800	1.33	149.2
	SB23-RB3	Muntinlupa	1.4	2,400	1.59	178.4
	SB23-RB4	Muntinlupa	0.5	800	0.58	65.1
	SB23-RB5	Muntinlupa	0.2	500	0.30	33.1
	SB22-RB1	Muntinlupa	0.5	500	0.50	56.1
Laguna	SB22-RB2	San Pedro	1.7	1,800	1.88	11.3
	SB22-RB3	San Pedro	1.2	1,300	1.31	7.8
	SB21-RB1	San Pedro	6.4	7,100	7.12	19.2
	SB21-RB2	Biñan	1.3	1,300	1.38	3.7
	SB20-RB1	Santa Rosa	0.8	1,000	0.90	4.9
	SB20-RB2	Santa Rosa	2.9	3,700	3.27	17.8
	SB20-RB3	Cabuyao	0.9	1,000	1.00	1.6
	SB20-RB4	Cabuyao	7.5	9,400	8.39	13.3
	SB19-RB1	Cabuyao	5.7	7,100	6.36	10.1
	SB18-RB1	Calamba	2.9	3,900	3.24	13.5
	SB17-RB1	Calamba	1.6	3,400	1.98	8.2
	SB17-RB2	Los Baños	1.0	2,100	1.22	4.1
	SB17-RB3	Los Baños	2.9	6,000	3.51	11.9
	SB17-RB4	Los Baños	0.3	500	0.34	1.2
	SB16-RB1	Bay	0.4	500	0.40	0.9
	SB16-RB2	Victoria	0.3	500	0.34	1.0
	SB15-RB1	Victoria	0.8	1,000	0.95	2.9
	SB15-RB2	Victoria	4.4	6,000	5.00	15.2
	SB15-RB3	Santa Cruz	7.1	9,700	8.04	30.8
	SB14-RB1	Santa Cruz	5.9	6,800	6.58	25.2
	SB14-RB2	Santa Cruz	0.7	800	0.78	3.0
Rizal	SB02-RB1	Taytay	1.0	1,600	1.16	1.7
Total			62.0	83,800	70.40	725.7

Note *: Refer to Section 4.5.2 for the ID of drainage facilities.
Source: JICA Survey Team

(2) Impacts of Construction Work (Public Pollution, Impacts on Traffic, etc.)

(a) Construction Equipment and Materials Necessary for Construction Work

Construction of structures/facilities (lakeshore dike, river improvement structures and drainage facilities) include various types of construction works and many kinds of construction equipment and materials as shown in Table 6.4.4.

Table 6.4.4 Types of Construction Works, Equipment and Materials

Construction Work	Construction Method	Category	Major Equipment and Materials
Construction of lakeshore dike	Earth work Excavation work Embankment work Paving work, etc.	Materials	Embankment materials (earth), Riprap, Base course material (crushed stone), Asphalt mixture, etc.
		Equipment	Dump truck, Backhoe, Bulldozer, Road roller, Rammer, Motor grader, Tire roller, Diesel generator, etc.
River channel improvement (construction of river improvement structures)	Earth work Excavation work Dredging work Piling work Bank protection work, etc.	Materials	Embankment materials (earth), Steel (reinforcing bar, sheet pile, H steel), Ready-mixed concrete, Base course material (crushed stone), RC pile (on-site fabrication), etc.
		Equipment	Dump truck, Backhoe, Bulldozer, RC piling machine, Rough-terrain crane, Concrete mixer truck, Concrete pumping vehicle, Diesel generator, etc.
Construction of drainage facilities (Pumping stations)	Earth work Excavation work Piling work, Construction of structures (building), etc.	Materials	Loading materials (earth), Steel (reinforcing bar, sheet pile, H-steel), Ready-mixed concrete, Base course material (crushed stone), RC pile (on-site fabrication), etc.
		Equipment	RC piling machine, Rough-terrain crane, Concrete mixer truck, Concrete pumping vehicle, Vibrator, Diesel generator, etc.

Source：JICA Survey Team

(b) Impacts of Construction Work (Public Pollution) and Considerations

Table 6.4.5 gives a list of the anticipated impacts (generation of public pollution) due to the construction of the proposed structures/facilities and the necessary considerations. Construction of these structures/facilities include earth works, excavation works, paving works, piling works, etc., and, therefore, the potential impacts are similar to each other, such as air pollution, noise and vibration, and water pollution. Necessary considerations for mitigation of these impacts include watering during dry season, considerations on the operation of equipment and driving of vehicles, introduction of low-noise and low-vibration equipment, adjustment of construction work time in a day, installation of sediment ponds and drainage facilities, formulation of safety plan and thorough safe driving, and their continuation.

Table 6.4.5 Environmental Impacts of Construction Work and Necessary Considerations

Construction Work	Potential Impacts	Impact Factor	Consideration
Construction of lakeshore dike, River channel improvement works (construction of river structures), and construction of drainage facilities	Air pollution (dust, gas emission)	Transportation of earth materials, earth work, paving work, etc.	Watering during dry period, thorough maintenance of construction equipment and vehicles, idling stop, consideration in driving and operation of vehicles and equipment, Information, Education & Communication (IEC), etc.
	Noise and vibration	Transportation of earth materials, earth work, piling work, operation of diesel power generator, etc.	Thorough maintenance of construction equipment and vehicles, consideration in driving and operation of vehicles and equipment, introduction of low-noise and low-vibration type equipment, adjustment of working time, IEC, etc.
	Water pollution (generation of turbid water, diffusion of oil, high-alkali water, etc.)	Discharge of earth materials (during rain). Diffusion of oil during piling work; Accidental discharge of excavated materials, oil, cement, etc., during operation	Installation of sediment pond, drainage channel, installation of diffusion prevention curtain/fence, IEC, etc.

Construction Work	Potential Impacts	Impact Factor	Consideration
		of construction equipment	
	Impacts on traffic due to project-related vehicles*	Driving of construction vehicles and vehicles for commuting, etc.	Conduct of a survey on existing traffic volume and formulation of traffic management plan based on the survey result
	Accidents during construction work, and traffic accidents	Driving of construction vehicles and vehicles for commuting; Operation of construction equipment	Formulation of safety plan and thorough safe driving and operation of vehicles and equipment based on the plan, IEC, etc.

* Impact on traffic is described in the following section in detail.
Source: JICA Survey Team

(c) Impacts of Construction Work on Traffic and Necessary Considerations

Transportation of construction equipment and materials, mobilization of construction workers, and commuting to construction work sites will result in the generation of traffic, namely, project-related traffic. One of the major factors of project-related traffic is that for the mobilization of earth materials for construction of the dike body. The estimated extent of transportation of earth materials to be used for the construction of dike body is as shown in the following table.

Table 6.4.6 Estimation of Earth Materials and Traffic Generation for Construction of Lakeshore Dike

Phase	Phase 1	Phase 2	Phase 3	Total	Remarks
Length	Approx. 17km	Approx. 33km	Approx. 33km	Approx. 83km	
Construction period	5 years	10 years	10 years	25 years	Workable months are from November to April, which is during dry season.
Volume of earth materials (for transportation)	1,700,000m^3	3,300,000m^3	3,300,000 m^3	8,300,000m^3	
The number of transportation by dump trucks	340,000 nos.	660,000 nos.	660,000 nos.	1,660,000 nos.	Assuming that the load capacity of dump truck (10-ton) is 5.0m^3.
	Daily maximum number of transportation by dump truck: 450 nos. /day				Maximum value during work period

Source: JICA Survey Team

As shown in the table above, daily maximum number of transportation by dump truck will be 450 per day, based on which hourly maximum number of dump trucks for the construction of lakeshore dike is estimated to be more than 50 per day assuming that working hours per day is eight. It should be noted that there will be other traffic for other construction works in the Project. Thus, the impact of the generation of project-related traffic on the existing traffic is not minor. In addition, there will be a risk of traffic accidents during the transportation of construction equipment and commuting.

Necessary considerations for the impacts on traffic include the investigation of existing traffic volume in the surrounding area of construction work site and formulation of traffic management plan, launching of mitigation measures including installation of temporary construction road and detour, when necessary, deployment of traffic controllers, public relations by means of mass media, etc., and mixture of these measures for maximizing their effectiveness.

(3) Impacts on Economic Activities in Laguna Lake

Major impacts of the implementation of the Project on economic activities such as fishery and water use are the following three. The details of impacts and necessary considerations are shown in Table 6.4.7.

- Impacts on fishery in Laguna Lake
- Impacts on water use (water permits issued for water intake from Laguna Lake)
- Impacts on water transportation

Details of the activities on fishery, water use or water transportation in the lake were not surveyed in this data collection survey because of the limitations. The details should, therefore, be investigated in the next stage of the Project and, based on the results, mitigation measures should be examined in detail.

Table 6.4.7 Potential Impacts on Economic Activity in Laguna Lake and Necessary Considerations

Potential Impact	Description of Impact	Considerations
Impact on fishery	Fishing and aquaculture in Laguna Lake would be affected by the construction of lakeshore dike, specifically, mooring facilities, fish pens and fish cages located along the lakeshore. Fish sanctuaries set in the lake will also be affected by the implementation of the Project.	Investigation on mooring facilities, aquaculture (fish pen and fish cage) and fish sanctuaries should be conducted focusing on those located along the lakeshore including fishing activities. Based on the investigation results, concrete mitigation measures should be formulated. In case of difficulty to avoid or minimize the adverse impact on these economic activities, it is necessary to compensate for the impact upon consultation/coordination with relevant fisher folks, organizations and LGUs.
Impact on water use	A lot of water permits have been issued for water intake from Laguna Lake such as those for irrigation, domestic water supply, hydropower plant, etc. Construction of lakeshore dike would cause impacts on these water intakes.	Detailed investigation on existing water permits should be done based on the inventory data of NWRB and additional data collection focusing on intake points, water taking volume, etc. Based on the actual situation, concrete mitigation measures shall be formulated.
Impact on water transportation	There are navigational routes connecting cities and municipalities in Laguna Lake, as well as water transportation for oil and oil products. These will be affected by the construction of lakeshore dike.	Actual situation of navigation and water transportation in the lake shall be investigated focusing on piers, navigation routes, mooring facilities, time schedule, etc. Based on the results, concrete mitigation measures shall be formulated.

Source：JICA Survey Team

(4) Other Potential Impacts and Necessary Considerations

Other major potential impacts of implementation of the Project include the following ones. Table 6.4.8 shows the details of impacts and necessary considerations.

- Impacts of solid waters to be generated by demolition of existing structures/facilities
- Impacts of change in water regime in Laguna Lake on aquatic ecosystem
- Impacts on historical and cultural heritage located near Laguna Lake
- Impacts of noise and offensive odour generated by drainage facilities (pumping stations)

Table 6.4.8 Other Potential Impacts and Necessary Considerations

Potential Impact	Description of Impact	Consideration
Impacts of waste generation	Solid wastes to be generated by the implementation of the Project include debris of demolished structures/facilities at the construction site of lakeshore dike. The volume of wastes is estimated to be enormous.	Solid wastes shall be treated based on RA No. 9003, which is a basic policy. Reuse and recycle of the demolished structures/facilities should be facilitated in collaboration with LGUs utilizing MRFs through thorough segregation. Harmful wastes shall be properly treated based on RA No. 6969. In addition, disposal site should be developed through coordination with relevant GA (including PRA) and LGUs.
Impacts of change in water regime on aquatic ecosystem	Water regime in Laguna Lake will be changed, specifically, the period of high water level will be shortened after the implementation of the Project. However, such change will not be such a drastic change to cause a significant impact on aquatic ecosystem in the lake.	Although the impact is not anticipated big enough to affect aquatic ecosystem in Laguna Lake, it is necessary to monitor the magnitude of the impacts continuously after implementation of the Project.
Impacts on historical and cultural heritage	Construction works might affect existing historical and cultural heritage in case the work site is located near a heritage site.	It is necessary to consider the alignment of lakeshore dike during design stage. Consideration should also be given on transportation routes of construction equipment and materials, and excavation materials.
Impacts of noise and odor by drainage facilities	Potential impacts include noise from diesel power generator as well as odor from regulation pond during operation period.	Consideration on the construction site of drainage facility is required to make the impacts of noise and odor negligible at nearby residential areas. The location of diesel power generator inside the drainage facility building should be adjusted minimize the impact.

Source：JICA Survey Team