DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE REPUBLIC OF THE PHILIPPINES

JAPAN INTERNATIONAL COOPERATION AGENCY

DATA COLLECTION SURVEY ON DRAINAGE SYSTEM IN METRO MANILA IN THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT

(Summary)

DECEMBER 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

CTI ENGINEERING INTERNATIONAL CO., LTD.
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LOCATION MAP

PROJECT TITLE

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ABBREVIATIONS AND ACRONYMS

AASHTO: American Association of State Highway and Transportation Official
ADB: Asian Development Bank
AO: Administrative Order
BOD: Biochemical Oxygen Demand
CCEP: Construction Contractor's Environmental Program
CCP: Cultural Center of the Philippines
CNC: Certificate of Non-Coverage
CMP: Community Mortgage Program
C/S: Construction Supervision
DAO: DENR Administrative Order
DENR: Department of Environment and Natural Resources
DILG: Department of the Interior and Local Government
DO: Dissolved Oxygen
DPWH: Department of Public Works and Highways
DOF: Department of Finance
DOH: Department of Health:
DOT: Department of Tourism
DOTC: Department of Transportation and Communications
DSWD: Department of Social Welfare and Development
DWO: Drainage and Waterways Operation, MMDA
ECC: Environmental Compliance Certificate
EFCOS: Effective Flood Control Operation and Warning System
ECA: Environmentally Critical Area
ECC: Environmental Compliance Certificate
ECP: Environmentally Critical Project
EDSA: Epifanio de Los Santos Avenue
EIA: Environmental Impact Assessment
EIS: Environmental Impact Statement
EMB: Environmental Management Bureau
FCSM: Flood Control and Sewerage Management Office, MMDA
FCSEC: Flood Control and Sabo Engineering Center
GDP: Gross Domestic Product
GIS: Geographic Information System
GOJ: Government of Japan
GOP: Government of Republic of the Philippines
GNP: Gross National Product
GPS: Global Positioning System
GRDP: Gross Regional Domestic Product

GSIS:	Government Service Insurance System
IBRD:	International Bank for Reconstruction and Development (World Bank)
IEE:	Initial Environmental Examination
IFS	Informal Settle Families
JICA:	Japan International Cooperation Agency
LARRIPP:	Land Acquisition, Resettlement, Rehabilitation and Indigenous Peoples Policy
LGC:	Local Government Code
LGU:	Local Government Unit
LGU-Makati:	Local Government Unit Makati City
LGU-Manila:	Local Government Unit City of Manila
LGU-Pasay:	Local Government Unit Pasay City
LiDAR Data:	Light Detection and Ranging Data
LRT:	Light Rail Transit
MC:	Memorandum Circular
MLLW:	Mean Lower Low Water Level
MMDA:	Metropolitan Manila Development Authority
MNH:	Manila North Harbor
MRT:	Metro Rail Transit
MSH:	Manila South Harbor
MSL:	Mean Sea Level
NAIA:	Ninoy Aquino International Airport
NAMRIA:	National Mapping and Resources Information Authority
NCM:	Normal Cubic Meter
NCR:	National Capital Region, DPWH
NHA:	National Housing Authority
NCSO:	National Census and Statistics Office
NDRRMC:	National Disaster Risk Reduction Management Council
NEDA:	National Economic and Development Authority
NGO:	Non-Government Organization
NHA:	National Housing Authority
NAMRIA:	National Mapping & Resources Information Authority
North Manila:	North or right bank of the Pasig River
NSO:	National Statistics Office
NWRB:	National Water Resources Board
NWSS:	Manila Waterworks and Sewerage System
OCD:	Office of Civil Defense
PAGASA:	Philippines Atmospheric, Geophysical & Astronomical Services Administration
PAP:	Project Affected Person/People
PD:	Presidential Decree
PD:	Project Description

PEISS: Philippine Environmental Impact Statement System
PRA: Philippine Reclamation Authority
PRRC: Pasig River Rehabilitation Commission
PPA: Philippine Port Authority
PNP: Philippine National Police
PSFO: Pumping Stations and Floodgates Operation, MMDA
PNR: Philippine National Railway
RA: Republic Act
ROW: Right-Of-Way
SHFC: Social Housing Finance Corporation
South Manila: South or left bank of the Pasig River
TSP: Total Suspended Particulates
TBM: Tunnel Boring Machine
UDHA: Urban Development and Housing Act
UPMO: Unified Project Management Office
TBM: Tunnel Boring Machine
TWG: Technical Working Group
UDHA: Urban Development and Housing Act
UN-OCHA: United Nations Office for the Coordination of Humanitarian Affaires
UTM: Universal Transverse Mercator Projection
UP: University of Philippine
WB: World Bank
WHO: World Health Organization

CHAPTER 1. BACKGROUND

1.1 Background

This Survey is carried out in response to the request of the Government of Philippines in accordance with the Terms of Reference (TOR) for the Data Collection Survey on Drainage System in Metro Manila (herein after referred as "the Survey"), which was agreed between the Department of Public Works and Highways (hereinafter referred to as "DPWH") and Japan International Cooperation Agency (hereinafter referred to as "JICA") on July 30, 2015.

The Survey area is the same as the DPWH Survey that covers the core area of Metro Manila (Buendia-Maricaban-NAIA-Parañaque and España-UST) and rivers in the surrounding area (Zapote-Las Pinas, Tullahan and San Juan) shown in the Location Map. DPWH has set a new target for flood and drainage projects to attain a safety level of 25-year return period (RP) or 50-year RP.

In the Core Area of Metropolitan Manila the drainage improvement works have been conducted through many years. The 2005 JICA M/P proposed to recover and strength the drainage capacities to attain the safety level of 10-year RP with 2-day rainfall. However in the surrounding area of Metropolitan Manila only the Pasig River is now under improvement, but the other rivers have not been improved yet. The DPWH Survey has proposed for the five rivers to conduct river improvement works (2015-2020) and urgent works (2015-2018), and planned to commence urgent works in 2015.

However, DPWH is facing many difficulties for the implementation of new drainage facilities which require an extensive construction period resulting in strong social impact caused by prolonged traffic congestion, presence of underground utilities which might be affected by its construction, disruption of social and economic activities, among others. The DPWH is considering that the Japanese deep tunnel technology could be a suitable solution to the drainage situation in Metro Manila and sent an official letter to the Embassy of Japan requesting to conduct a survey on the possible short construction period project of utilizing Japanese underground tunnel technologies to the drainage system in Metro Manila.

1.2 Objective of the Survey

The Survey aims to collect information on the Drainage System in Metro Manila and examine the applicability of the Japanese underground tunnel technologies (shield tunnel, micro tunnel, etc.) as solution for the drainage improvement problems in Metro Manila as well as to examine the effective assistance approaches of JICA in the sector.

The Counterpart Agency is the Department of Public Works and Highways (DPWH) and the office in charge is the Unified Project Management Office-Flood Control Management Cluster. Members of the counterpart team and the Survey team are listed and shown in Annex 1.

Currently DPWH is conducting following projects:

- The Study on Drainage Improvement in the Core Area of Metropolitan Manila (DICAMM 2005 / 2005 JICA-MP)
- The Master Plan for Flood Management in Metro Manila and Surrounding Areas (2012 WB-MP)
- Consulting Services for the Review and Detailed Engineering Design of Comprehensive River Management for San Juan River and Review and Updating of Feasibility Studies and Detailed Engineering Design of Various Urgent Flood Control Projects in Metro Manila, on-going, DPWH (DPWH Survey)

Annex-1 Counterpart and JICA Survey Team Member

1. DPWH: Unified Project Management Office Flood Control Management Cluster

	Name of Personnel	Designation
1	Angelina C. Forcadilla	Project Manager II
2	Leonila R. Mercado	Engineer V
3	Lydia C. Aguilar	Engineer III

2. JICA Survey Team

	Name of Personnel	Assignment
1	Hajime TANAKA	Team Leader/Urban Drainage Measures
2	Makoto MITSUKURA	Deputy Team Leader/Urban Drainage Plan
3	Masanori SUZUKI	Flood Analysis
4	Masaru IIJIMA	Procurement/Construction Plan and Cost Estimation (1)
5	Tamotsu KIYUNA	Procurement/Construction plan and Cost Estimation (2)
6	Hiroshi NISHIMAKI	Economic/Financial Analysis and Project Evaluation
7	Takeshi OKAMURA	Operation and Maintenance Planning
8	Hitoshi SAKAI	Environment and Social Consideration

CHAPTER 2. FLOOD AND ISSUES IN THE CORE AREA

The 2005 JICA M/P divided the Core Area of Metro Manila into two areas: the left bank of the Pasig River: the "North Manila" (28.78 km²) five drainage blocks and the right bank of the Pasig River: the "South Manila" (43.80 km²) six drainage blocks. The flood conditions are explained as follows:

2.1 Flood Prone Area

In the North Manila the flood - prone areas are Aviles and Sampalock under the drainage block of Quiapo–Aviles pumping stations and also include the major trunk road of España which is affected by floods yearly.

In the South Manila the flood - prone areas are the drainage areas of Zober Roxas, PNR canal and Calatagan Creek-1, and San Isidro, San Antonio and Pio del Pilar located at the east side of PNR, which are located in the drainage block of Libertad – Tripa de Gallina Pumping Stations. The major trunk road of Osmenia HWY is yearly affected by floods. During Typhoon Ondoy in 2009, four drainage pumping stations of Makati, Paco, Pandacan and Sta. Clara were inundated and stopped operation.

2.2 Management of Drainage Facilities in Metro Manila

The core area of Metro Manila is low-lying and about 70% (52 km²) of the area depends on the pump drainage system.

The O&M of drainage facilities were handed over from DPWH to MMDA in 2002 due to the Republic Act (RA) 7924 (July 9, 2002) and the responsibilities for O&M of drainage facilities are belonged to MMDA, but the responsibilities for construction of new drainage facilities (major drainage channels and drainage pumping stations) are belonged to DPWH. The O&M works such as dredging of esteros/creeks, cleaning of wastes, relocation of ISF and rehabilitation of pumping stations are conducted by MMDA.

The premise of the 2005 JICA M/P is that the existing open channels were assumed to have conveyance capacities of more than 10 - year return period, but they had lost their discharge capacities because of the heavy deposits of sand/gravel, dumped solid wastes (estimated amount: 920,000 m³), and the presence of ISF (estimated: 6,000 families) in the open channels. The discharge capacity of the drainage system was estimated to be reduced to less than 60% of the original capacity and assessed at the level of 2 to 3 year return period.

2.3 DICAMM 2005

The DICAMM 2005 proposed to improve the drainage capacity of to attain the drainage capacity of 10-year return period by recovering the original drainage capacities and construction of additional drainage facilities like new interceptors and drainage channels.

As for the drainage pumping stations, the DICAMM 2005 has proposed the rehabilitation of 12 pumping stations that were installed from 1970s to 1980s.

MMDA has started working on the recovery of drainage capacities of drainage channels by dredging/cleaning channels and relocating of Informal Settler Families (ISF) along channels and rehabilitating major pumping stations according to the DICAMM 2005, and DPWH has just recently started working on the strength of drainage capacities of the drainage system by constructing new drainage channels like Blumentrit Interceptor, Constancia interceptor and Earnshaw Main Drainage

The drainage improvement projects conducted by DPWH and MMDA are shown in Figure 2.3.1.

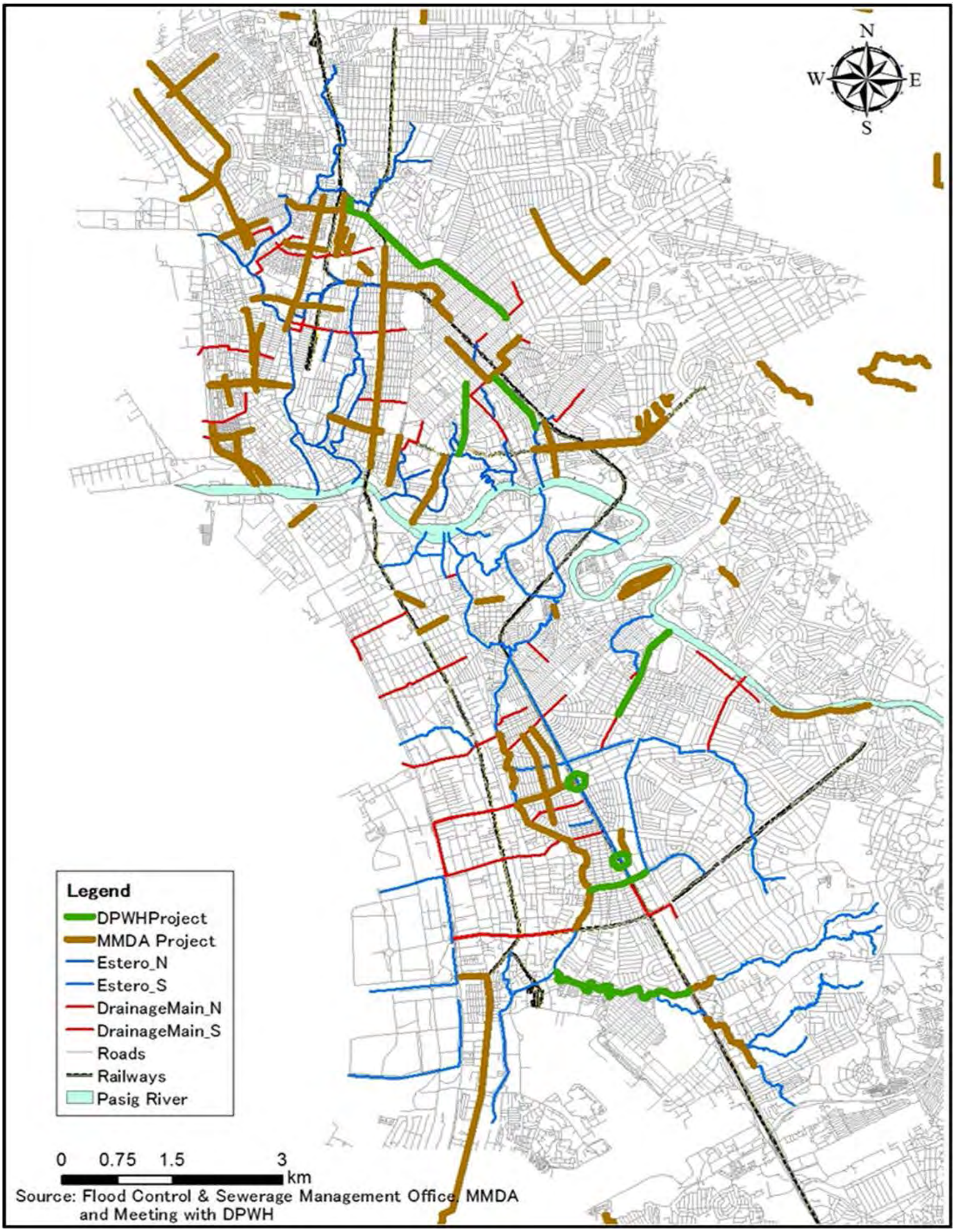


Figure 2.3.1 Location Map of DPWH/MMDA Projects

2.4 DPWH Survey

The DPWH Survey took into consideration the flood control plan composed of the river improvement works (2015~2020) and the urgent works (2015~2018) of the 2005 JICA M/P and the 2012 World Bank M/P. It validated the status of implemented projects. The total cost of each plan is Php 86 Billion and Urgent works Php 22 Billion respectively. As of 2015 some of urgent works for Espania-UST are planned to commence.

The projects proposed in the DPWH Survey are shown in Table 2.4.1 and Figure 2.4.1.

Table 2.4.1 Construction Cost and Tasks to be Work Out for Projects by DPWH Survey

No	River and Drainage Block	Master Plan (2015~2020)	Urgent or Priority Project (2015~2018)	Outline of Evaluation
1	Tullahan River	18,712	4,804	Design cross-section、ROW・Relocation of people are tasks
2	San Juan River	25,260	10,728	ROW・relocation of people・Raised River bed、relation with the Pasig River are major tasks.
3	Espana - UST	6,840	3,802	Width of road, width of proposed culvert、pumping station、slope etc. there are many tasks and seem difficult for implementation
4	Buendia	6,757	29	Draining to the Pasig river, slope etc. there are many tasks and difficulty for implementation.
5	Maricaban	2,031	206	River improvement and construction of flood ways, there are many tasks and difficulty for implementation.
6	NAIA	6,540	395	Small task and possible river improvement
7	Paranaque River	2,246	363	Small task and possible river improvement
8	Las Pinas	4.997	1,689	ROW is task
9	Zapote River	12,373	-	ROW is task
TOTAL		85,756	22,016	

Source: Presentation of DPWH Survey "Consulting Services for the Review and Detailed Engineering Design of Comprehensive River Management for San Juan River and Review and Updating of Feasibility Studies and Detailed Engineering Design of various Urgent Flood Control Projects in Metro Manila" DPWH 2015

Table 2.4.1 is culled from the presentation material of Woodfields Engineers Company (WEC) that was submitted to the DPWH (reference material 2-2)

River improvement works are formulated for rivers in Metropolitan Manila to attain the safety level of 50-year return period, involving dredging, Embankment/Revetment, replacement of bridges, and drainage improvement works are formulated for the core area to attain the safety level of 25-year return period.

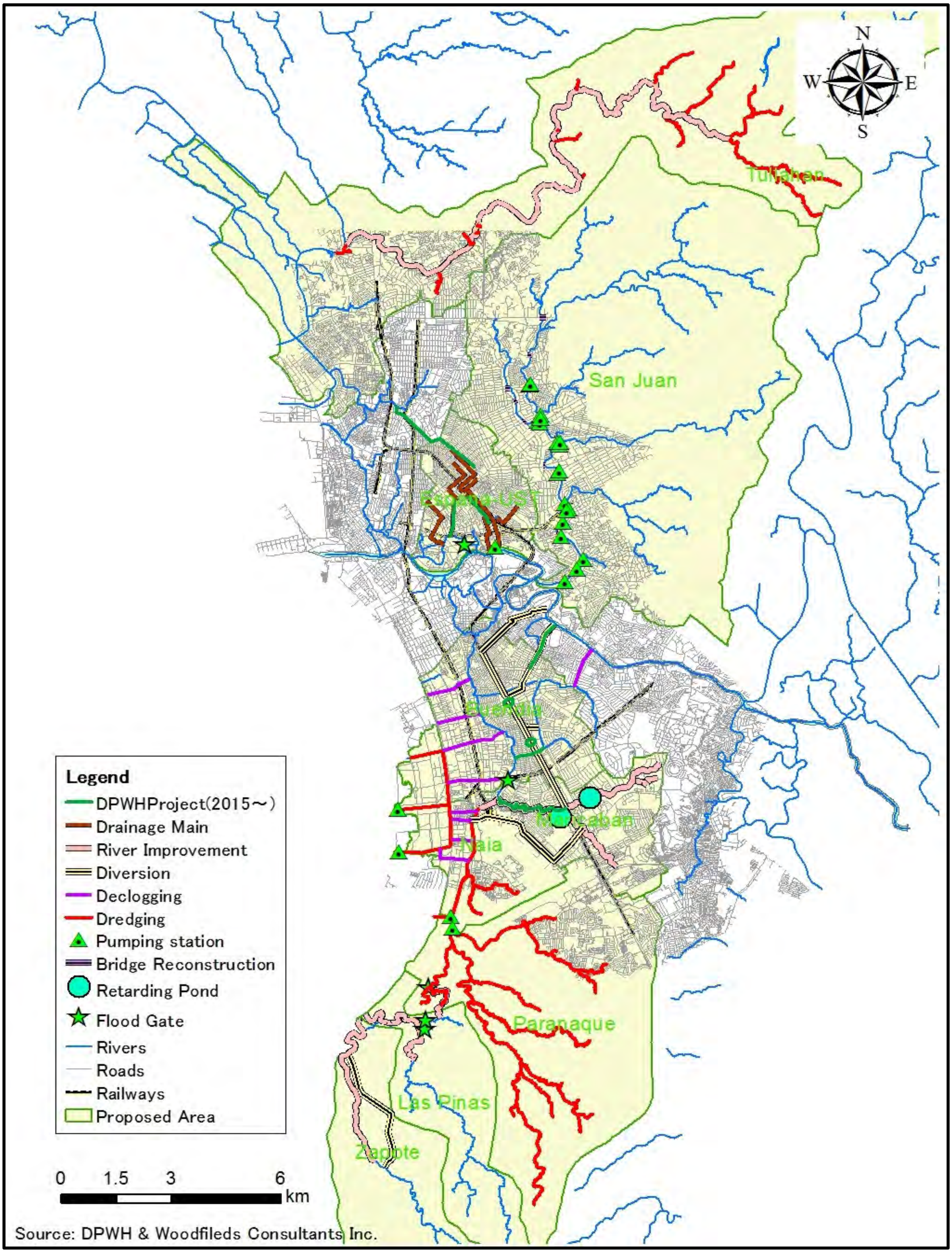


Figure 2.4.1 Projects proposed in the DPWH Survey

CHAPTER 3. DRAINAGE PLAN

3.1 Hydrological Analysis

3.1.1 Collection of Rainfall Data

The rainfall data observed at three observation stations (Port Area, NAIA and Science Garden) located in the target study area and the surrounding area from 1961 to 2014, the annual maximum basin average one-day rainfall and two-day rainfall were calculated by applying the Thiessen Method.

The probability distribution and 10-year RP, 25-year RP and 50-year RP 2-day rainfall amounts are 401.1 mm, 517.4 mm and 612.9 mm respectively.

3.2 Issues and Constraints on drainage improvement in Metro Manila

3.2.1 Current Conditions of Drainage Channel and Drainage Pumping Station

(1) Evaluation in the DICAMM 2005

- The existing drainage channels were designed to able to convey 10-year RP rainfall amounts, but mostly their capacities were decreased and assessed as below 2-year RP.
- The existing drainage channels are necessary to recover their drainage capacities.
- It is necessary for the drainage system to increase the drainage capacity with additional facilities.

(2) Drainage pumping stations

There are 54 pumping stations including relief stations with small capacity in Metro Manila. MMDA has been undertaking repairs and rehabilitation of 12 pumping stations to attain a higher drainage capacity than the proposed capacity by the DICAMM 2005.

The Operation Records of 10 pumping stations have been collected and studied in order to confirm the flow capacity of existing drainage channels. The target floods are those from Monsoon Habagat in August 2012, Typhoon Maring in August 2013 and Typhoon Ondoy in September 2009, regarding the flow capacity of the drainage channel, it can convey flood water to each pumping station. The pumping stations were working well in general.

3.2.2 Issues for Drainage Improvement Works

Required tasks and constraints related to drainage improvement in Metro Manila are summarized below:

- Issue 1: Difficulties on Land Acquisition
- Issue 2:Tedious coordination with different and various private and semi-government agencies handling underground utilities
- Issue 3: Limited area that can be used during project construction (narrow road, etc.)
- Issue 4: Difficulties due to heavy traffic and will aggravate traffic jam by construction
- Issue 5: Solution is additional pumping station, but limited land for acquisition.
- Issue 6: Need for additional pumping stations as well as Storage Facilities

3.2.3 Effectivity of Underground Tunnelling Technology

The effectivity of underground tunnelling technology for drainage improvement in Metro Manila is summarized below.

➢ Construction will be short and fast avoiding usual constraints of open-cut (Avoiding Issue1,2)

- Minimal coordination with underground utility administrator
- Minimal arrangement with Land Acquisition only for shaft area
- Low possibility of delayed progress of the project

➢ Required construction space is minimal (Avoiding Issue1,3)
  - Less difficulties in project implementation (no above-ground land acquisition along road, etc.)
  - Lower risk of delays in implementation or limited impact

➢ Tunnel allows the optimized arrangement of pumping station (Avoiding Issue5)
  - Several small drainage area can be connected to the tunnel and drained from one pumping station
  - Solution to catching flood water from low-lying area

➢ Storage facilities are available underground（to cope with Issue6）

➢ Lighter negative impact to traffic condition（Avoiding Issue4）

3.3 Selection of Prioritized Area

3.3.1 Preparation of Criteria to Select Priority Area

The following criteria were formulated to show the importance of each area. These criteria serve as a simple 'checklist' of what is found in each nominated area.

1 Properties to be protected from floods

1-1 Population Density: Large investments/properties and human life to be protected from flood.

1-2 Inundated Vital Facilities: Airport, Hospitals, City Hall, Government headquarters such as National Police are expected.

1-3 Inundated Major Road Network: Roads considered as core network of Metro Manila that need to be protected.

2 Flood Risk

2-1 Inundation Area: the extent of inundation in the area that will be considered as flood risk

2-2 Population in the inundation area: the number of people exposed to the flood risk

2-3 Geographical Aspect: Determine where the drainage improvement is not easy due to its topography

2-4 Damages of Past Flood: area that has the most damages recorded

3.3.2 Classification of Area Based on the Criteria

Evaluation of each area using the above-mentioned criteria is shown in Table 3.3.1. As a result, San Juan, Espana-UST and Buendia are the top prioritized area.

Table 3.3.1 Selection of Priority Area based on the Criteria

	Tullahan	San Juan	Espana-UST	Buendia	Maricaban	NAIA	Pranaque	Las Pinas	Zapote
1-1		○	○	○					
1-2						○			
1-3	○	○	○	○		○	○	○	○
2-1	○	○	○	◎		○		○	
2-2	○	◎	◎	○					
2-3			○	○	○	○			
2-4	○	○					○		

*: ○ for one indicator meets, ◎ for two indicator meet

3.4 Selection of Candidate Areas for Japanese Underground Tunnel Technologies

3.4.1 Basic Policy Basic Policy on Underground Tunnel River in Japan

Based on the “Technical Criteria for River Works – Practical Guide for Planning”, a tunnel river should not be installed unless it is unavoidable in the light of topographic features or for other special reasons in view of following the aspects;

- Negative effects against flow debris during flood
- Difficulties in increasing the flow capacity
- Difficulties in channel maintenance such as cross-section occlusion caused by falling objects during floods

Moreover, according to the “Guide for urban river planning - three dimensional river facilities”, the planning policy is that the “Tunnel River shall be planned only if there are other particularly compelling reason” because tunnel river should be avoided as much as possible.

3.4.2 Criteria Preparation on Selection of Candidate Areas for Japanese Underground Tunnel Technologies

In the above mentioned policy, underground tunnel is not an alternative but a final approach. Therefore, it is necessary to select the area where underground tunnel is the only solution. The selection criteria developed with the DPWH are:

1 Great improvement effect is expected (Core Manila): The project site should be in the Core of Manila

2 Necessity of Emergency onset of the measures

2-1 The project area will consider a lot of ROWs for an open-cut/excavation construction method.

2-2 Highly urbanized land use and high level of economic activities (or expected in near future):

3 Minimal to None Effect on Traffic condition

3-1 Heavy Traffic:

3-2 No detour route

4 Land Development

4-1 Difficulties on road-widening works for the planned drainage channel:

4-2 No space for the additional pumping station to be enhanced:

For these criteria, the 1)Espana-UST area, 2)Buendia area and 3)Maricaban area were selected as shown below.

Table 3.4.1 Selection by Criteria for Japanese Underground Technology

	Tullahan	San Juan	Espana-UST	Buendia	Maricaban	NAIA	Pranaque	Las Pinas	Zapote
1	-	-	○	○	○	○	-	-	-
2-1	○	○	-	○	○	-	-	○	○
2-2	○	○	○	○	○	-	-	○	-
3-1	-	-	○	○	○	-	-	○	○
3-2	-	-	○	-	○	-	-	-	○
4-1	-	-	○	○	-	-	-	-	○
4-2	-	-	-	○	○	-	-	-	-

Note : ○ for meet

For this criteria, the 1) Espana-UST area, 2) Buendia area and 3) Maricaban area were selected.

3.5 Proposed Drainage Improvement Plan in the Selected Area

3.5.1 Plan for Espana-UST

(1) Tunnel Route

The points with yellow pin are selected as candidate areas for vertical shafts. As shown in Figure 3.5.1, the vacant lots on the north side of SM City San Lazaro and on the west side of Valencia Pumping station are selected for vertical shafts. The pink line is the tunnel alignment of 3.5km in length.

Figure 3.5.1 Proposed Tunnel Route in España-UST

(2) Drainage Area and Tunnel Volume

As shown in Figure 3.5.2, northeast area from the Lacson Avenue is the drainage area.

The drainage area is divided into two areas: Area (1) and Area (2). Area (1) is the original drainage area. Blumentritt interceptor is proposed in Area (2) to drain 10-yr flood water; any excess water will come down to the tunnel.

Tunnel volume is computed at 446,000 m^3 as described below.

(i) Store excess run-off water then pump up after flood

Tunnel volume is calculated as follows.

- Total drainage area: 7.42km^2 (Area (1) 5.86km^2 and Area (2) 1.56km^2)
- Tunnel Length: 3.5km
- Runoff coefficient: 0.8
- Rainfall (difference between 10-yr and 25-yr): 116.3mm

- Total runoff (Tunnel Volume): 690,357m^3
- 48 hours pumping capacity: 4.0m^3/sec

(ii) Pumping start during flood

The tunnel volume reduction is examined by earlier start running pump because large volume and huge cost are required if the storage pipe impound all runoff.

The inflow to the tunnel is computed by runoff simulation model (unit hydrograph method) developed by the DICAMM 2005. The inflow hydrograph is calculated by the difference between 25-yr hydrograph and 10-yr hydrograph.

- Using the drainage pump of 4.0m^3/s not only after flood but also during flood
- Tunnel storage volume: 445,557m^3

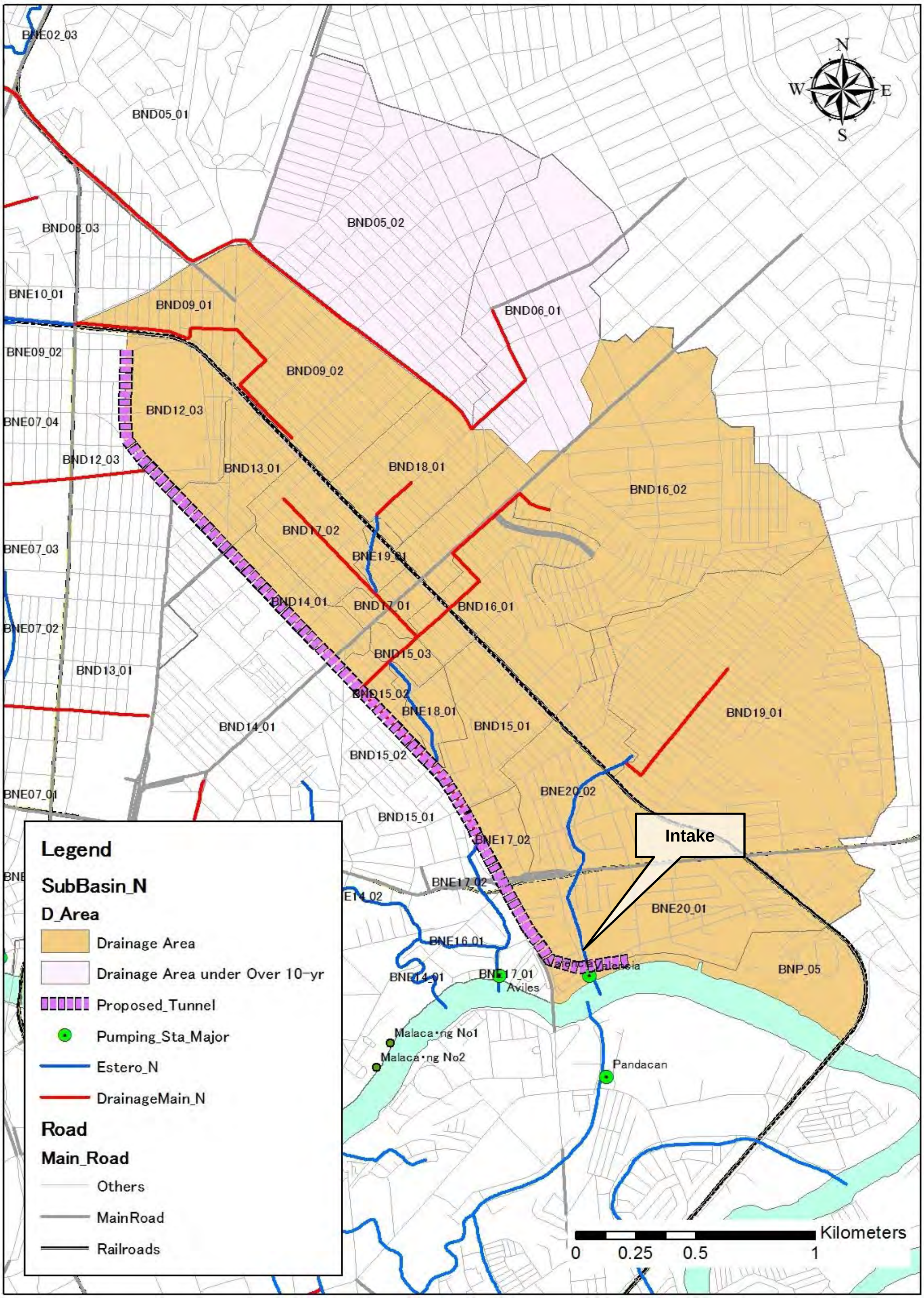


Figure 3.5.1 Drainage Area in España-UST

3.5.2 Buendia-Maricaban

(1) Tunnel Route

Gil Puyat Ave. (Buendia Ave.) has enough width for underground tunnel. But it will be a challenge for the shield machine to turn at the corner of Gil Puyat and Osmena Highway within the area of the intersection. It is assumed that the machine can turn without passing under private lot in this planning stage. As for the vertical shaft and pumping station, there is open space in the seacoast area as shown in Figure 3.5.2.

Route 1: Osmeña Highway - Mataas na Lupa St. - Quirino Ave.:8.2km

Route 2: Osmeña Highway - Ocampo St. - Pedro Bukaneg St.:7.7km

Route 3: Osmeña Highway – Senator Gil Puyat Ave. (Buendia Ave.): 7.2km

Source: JICA Survey Team

Figure 3.5.2 Candidate Route for Tunnel in Buendia-Maricaban

(2) Drainage Area and Tunnel Volume

The drainage area of the proposed tunnel is along Osmena Highway from Nichols station until Quirino Ave. as shown in Figure 3.5.3.

Tunnel volume is computed to be 844,000 m^3 as described below.

(i) Store excess run-off water then pump up after flood

Store excess run-off water then pump up after flood

Tunnel volume is calculated as follows.

- Drainage Area 15.00km^2
- Tunnel Length: 7.2km
- Runoff coefficient: 0.75

- Rainfall (difference between 10-yr and 25-yr): 116.3mm
- Total runoff (Tunnel Volume): 1,308,375m3
- 48 hours pumping capacity: 7.6m3/sec

(ii) Pumping start during flood

The tunnel volume reduction is examined by earlier start running pump because large volume and huge cost are required if the storage pipe impound all runoff.

The inflow to the tunnel is computed by runoff simulation model (unit hydrograph method) developed by the DICAMM 2005. The inflow hydrograph is calculated by the difference between 25-yr hydrograph and 10-yr hydrograph.

- Using the drainage pump of 7.6 m^3/s
- Tunnel storage volume: 843,845 m^3

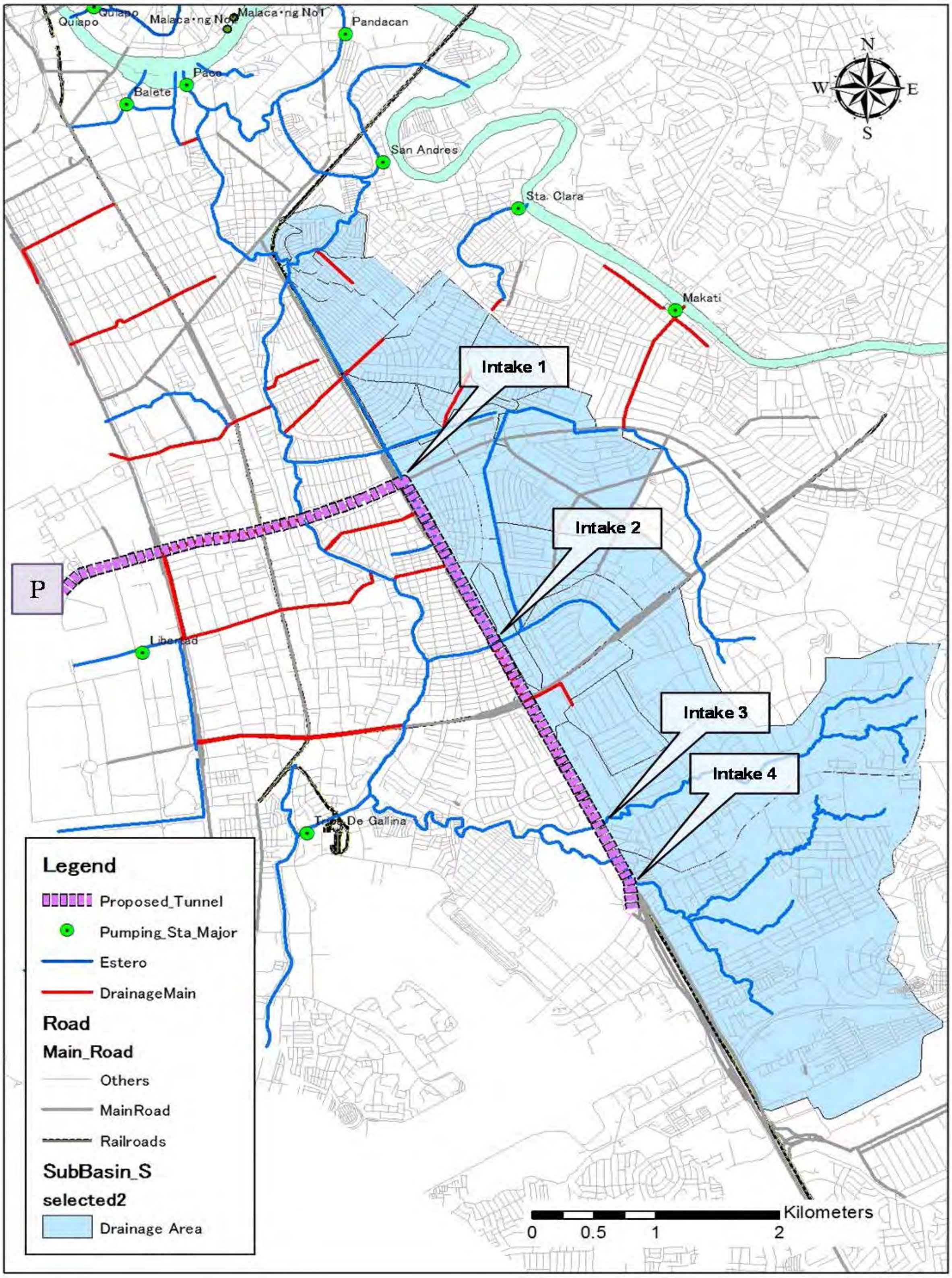


Figure 3.5.4 Drainage Area in Buendia-Maricaban Area

3.6 Effect of Underground Tunnel Storage

3.6.1 Results of Inundation Analysis

(1) Calculation case

The calculation case of Inundation Analysis was shown in Table 3.6.1.

Table 3.6.1 List of Calculation Case

Branch Condition	Rainfall					
	Tyhoon Ondoy Reproduction	5-yr	10-yr	25-yr	50-yr	100yr
Present Condition	✓	✓	✓	✓	✓	✓
Present Condition with TUNNEL	–	✓	✓	✓	✓	✓
With TUNNEL + DICAMM2005	–	–	–	✓	–	–

Souse: JICA Study Team

(2) Inundation Map

(a) Pattern of Typhoon Ondoy (2009)

The reproduction calculation of Typhoon Ondoy (September 2009) was conducted.

Figure 3.6.3Figure 3.6.3 shows the results of the reproduction calculation with overlaying the damage survey conducted by Woodfield Engineering Company (WEC). However, the damage survey of the WEC does not cover the whole core area of Metro Manila, the Figure cannot show the overall comparison. In the comparison of inundation depth, although the results of flood damage survey were slightly larger than the results of the reproduction calculation at some area, it is generally agreed.

(b) 25-yr Return Period

The result of inundation analysis was compared. The compared cases is “present condition”, “Present Condition with Tunnel", and “With Tunnel and DICAMM Project”.

A Comparison of "present condition" and "present condition + Tunnel" shown that both of inundation area and depth has been greatly reduced. In particular, inundation depth has been reduced in the range indicated by the red circle in Figure 3.6.4, the effect of the tunnel can be confirmed visually.

(3) Estimated Flood Inundation Area and Volume

In the calculation of the flood damage in the economic evaluation, the occurrence of such house and building damage was assumed in the case of more than inundation depth of 0.15m. If this project is implemented, the estimated flood inundation area, which is more inundation depth of 0.15m in return period 25-yr, is reduced from 4.47km^2 to 3.52km^2 in España-UST, and from 8.09km2 to 6.97km^2 in Buendia - Marikaban.

The inundation volume is estimated 1.60 MCM in España-UST and 3.54 MCM in Buendia-Maricaban at the maximum inundation depth. If the project is implemented, the estimated flood inundation volume is reduced to 1.05 MCM (Reduction 35%) in España-UST and to 2.48 MCM (Reduction 30%) in Buendia-Maricaban. As the result of computation the average inundation depth each basin, the average inundation depth is reduced 0.36m to 0.16m in España-UST and 0.44m to 0.18m in Buendia-Maricaban.

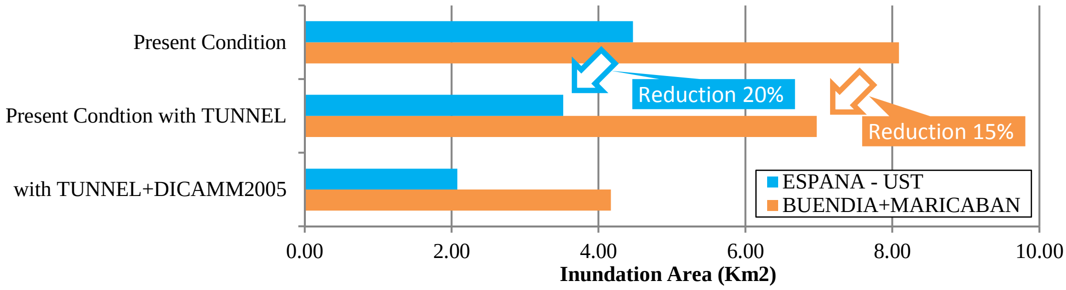
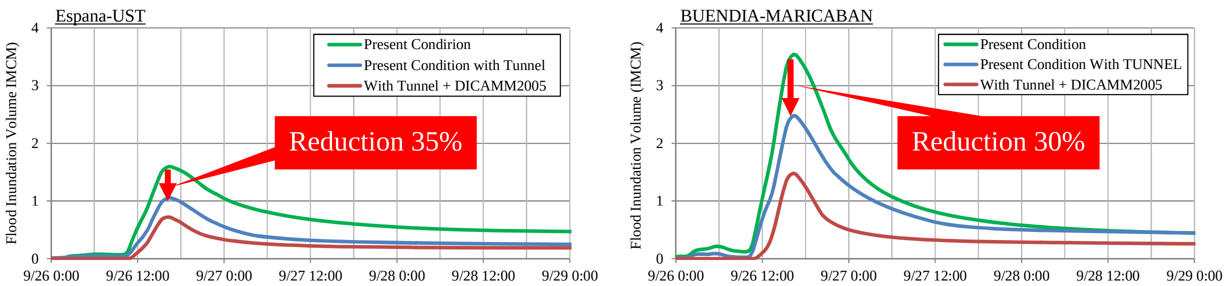


Figure 3.6.1 Estimated Reduction Flood Inundation Areas (Return Period 25-yr)

Table 3.6.2 Estimated Flood Inundation Area

Inundation Depth (m)	Inundation Area (km2) (25-yr)					
	ESPAÑA - UST			BUENDIA+MARICABAN		
	Present Condition	Present with Tunnel	w Tunnel and DICAMM2005	Present Condition	Present with Tunnel	w Tunnel and DICAMM2005
0.15m - 0.49m	3.70	3.32	1.92	5.22	4.48	3.26
0.50m - 0.99m	0.76	0.20	0.16	2.56	2.30	0.82
1.00m - 1.99m	0.01	0.00	0.00	0.31	0.20	0.09
2.00m - 2.99m	0.00	0.00	0.00	0.00	0.00	0.00
More than 3.0m	0.00	0.00	0.00	0.00	0.00	0.00
Total	4.47	3.52	2.08	8.09	6.97	4.17

Source: JICA Survey Team



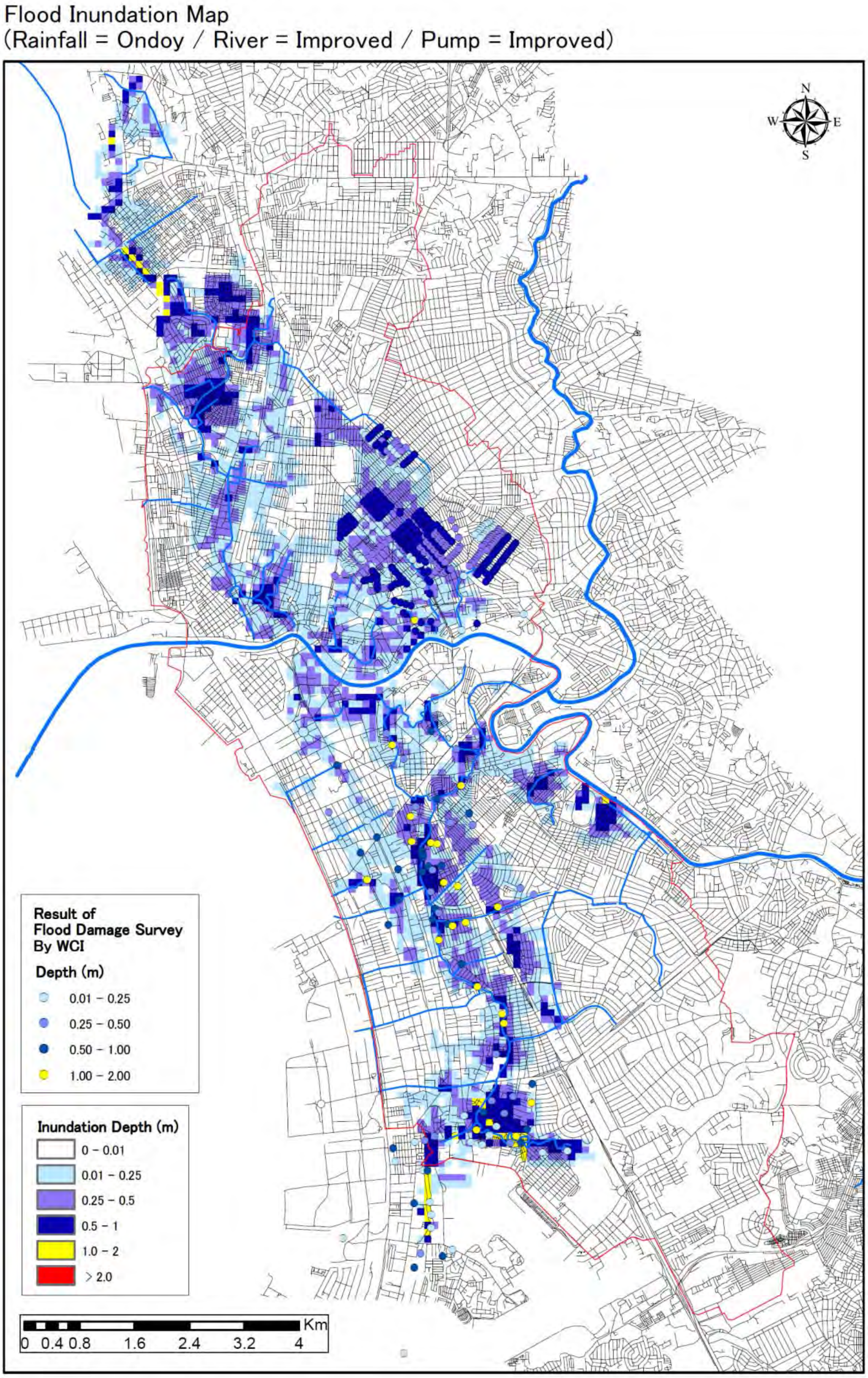
Source: JICA Survey Team

Figure 3.6.2 Transition of Inundation volume in the each Basin

Table 3.6.3 Estimated Population in Inundation Area

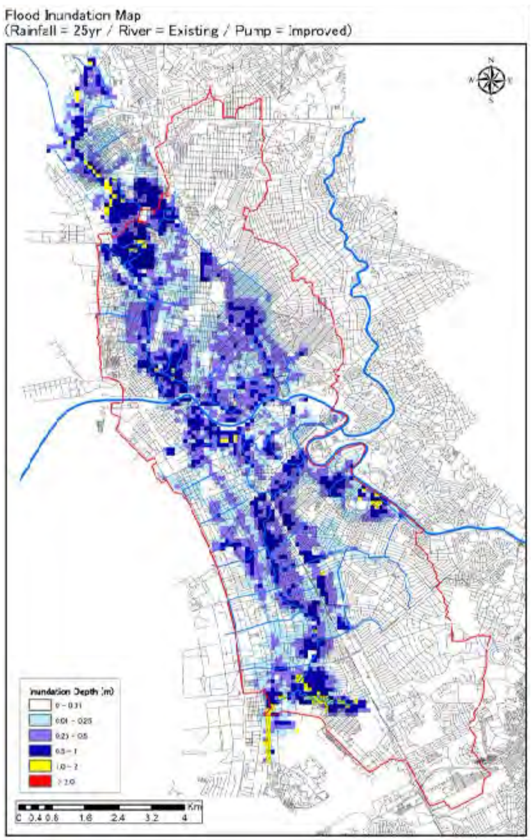
Area	Maximum Inundation Area (25-yr) (km2)	Present Condition		With Tunnel		With Tunnel + DICAMM2005	
		Maximum Volume (MCM)	Average Depth (m)	Maximum Volume (MCM)	Average Depth (m)	Maximum Volume (MCM)	Average Depth (m)
España-UST	4.47	1.60	0.36	1.05 (-35%)	0.24	0.72	0.16
Buendia-Maricaban	8.09	3.54	0.44	2.48 (-30%)	0.31	1.48	0.18

Source: JICA Survey Team

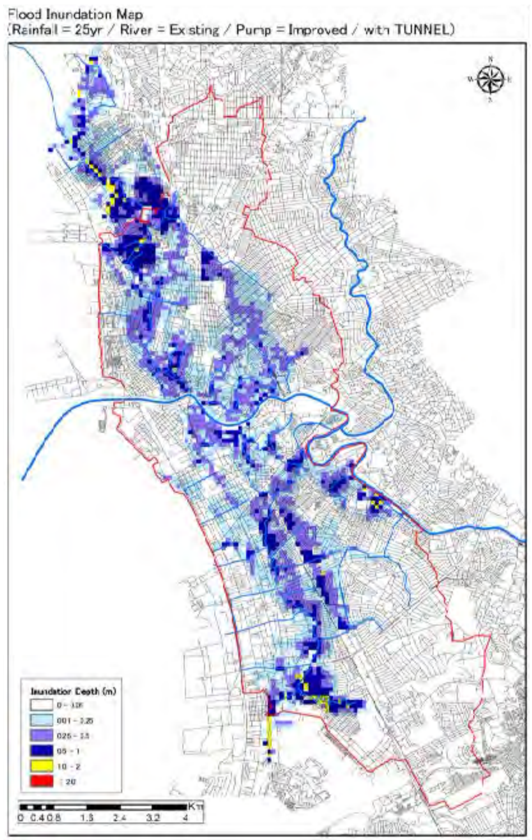


Source: JICA Study Team

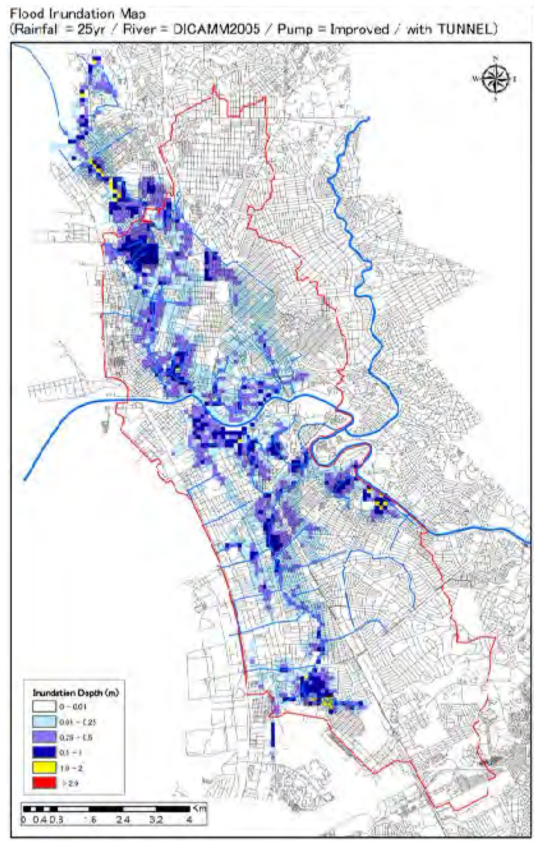
Figure 3.6.3 The Results of Inundation Analysis (The Reproduction of Typhoon Ondoy, 2009)



Rainfall: 25-yr / River: Present Condition/
Pump: Improved



Rainfall: 25-yr / River: Present Condition/
Pump: Improved/ with Tunnel



Rainfall: 25-yr / River: DICAMM 2005/
Pump: Improved/ with Tunnel

Figure 3.6.4 Inundation Map

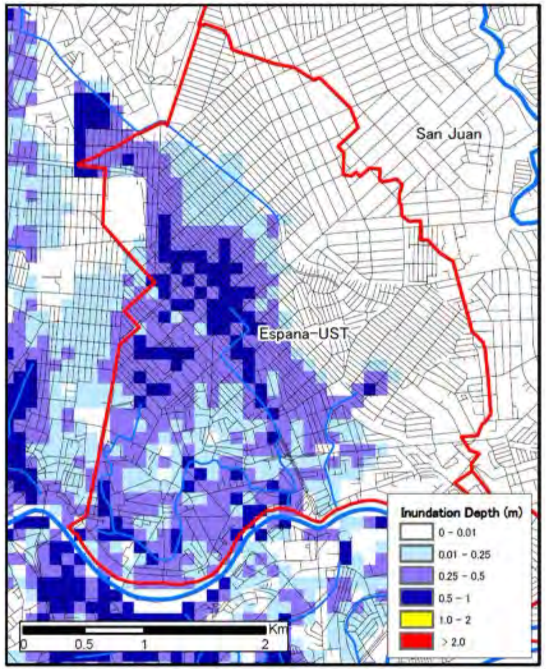
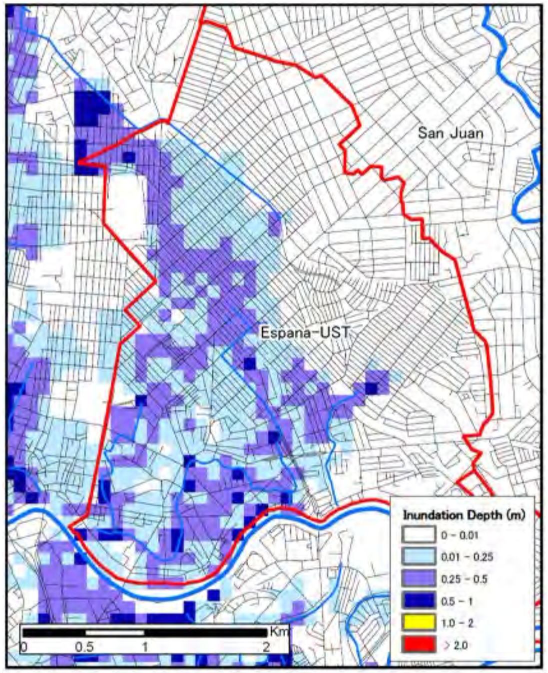
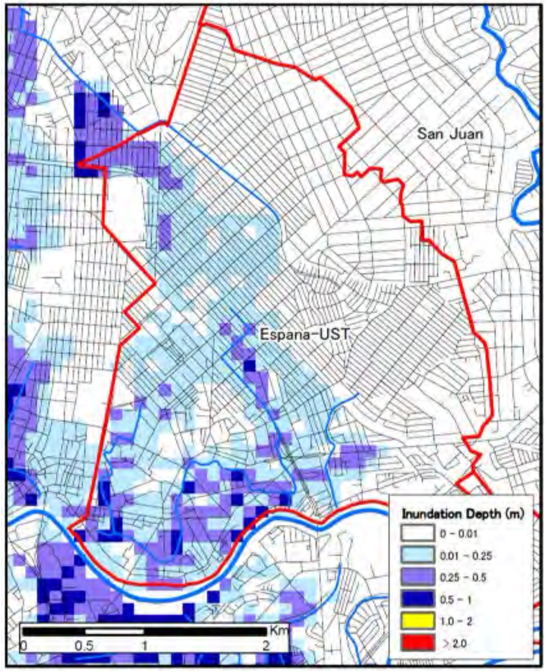
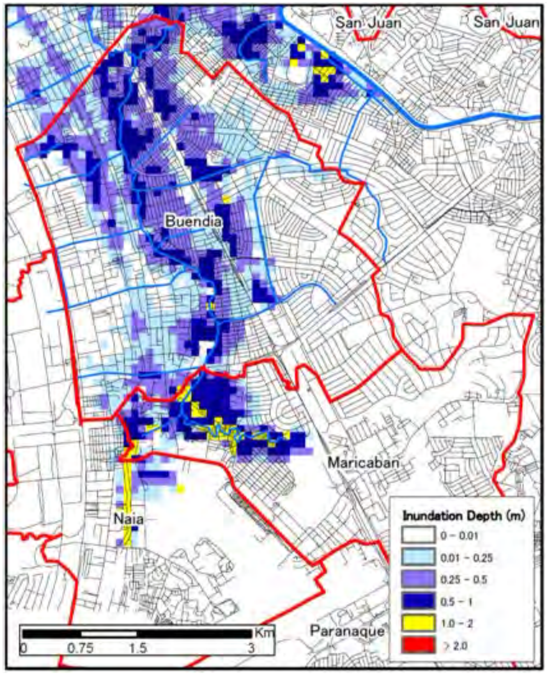
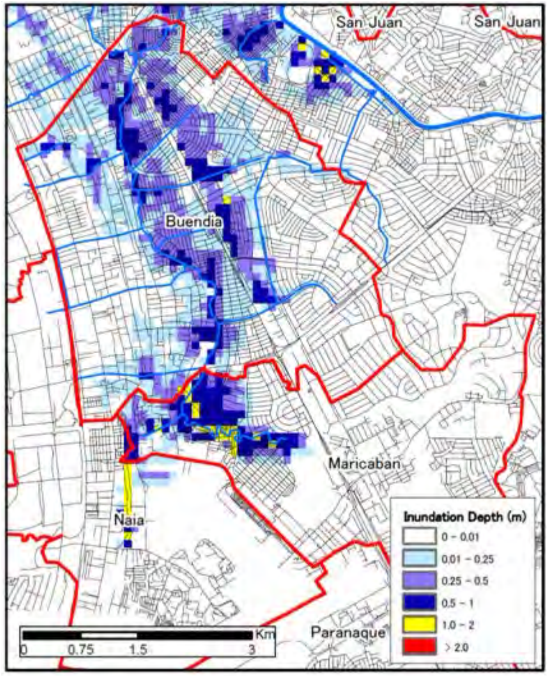
ESPANA-UST		
Present Condition	**Present Condition with Tunnel**	With Tunnel + DICAMM2005
		

Figure 3.6.5 Inundation Map (Larger Version)

BUENDIA-MARICABAN

Present Condition	Present Condition with Tunnel	With Tunnel + DICAMM2005





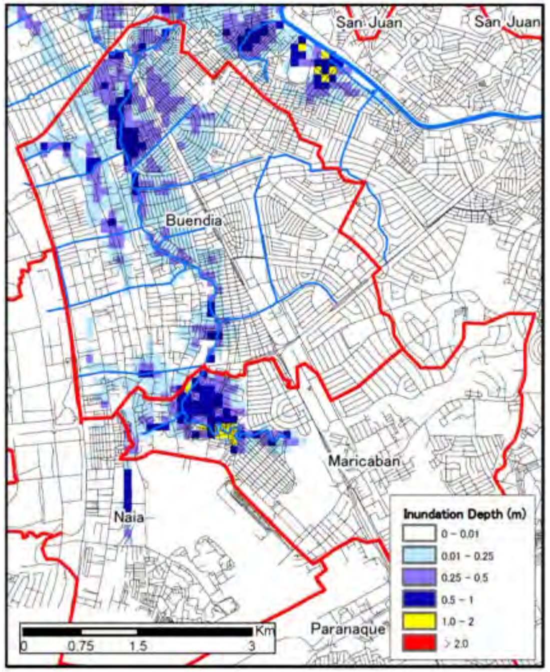


Figure 3.6.6 Inundation Map (Larger Version)

CHAPTER 4. DRANAGE FACILITY PLAN

4.1 Underground Tunnel Technology

The role of the tunnel is for flood control in Metro Manila. In Metro Manila, the condition of tunnel construction is location and tunnel scale (cross section and length). In case of Tunnel Method, Flood control measures are possible. Moreover, the traffic jam for the construction at the Metro Manila is small compared to the construction of cut and cover method.

The main structure is underground storage pipe and underground connection pipe. The features of these facilities are as follows. The construction method of these facilities is adequate for the Shield Tunnel Method and Micro Tunnel Method from the flood control plan.

- Underground storage pipe: Large-scale, Long distance
- Connect Pipe: Small, Medium-scale, short distance

Furthermore, the construction method of storage pipe and connection pipe is a Shield Tunnel Method and Micro Tunnel Method. The basis for the selection is the applicable geology and inner diameter.

The applicability to the underground storage pipe is high because the shield tunneling method can be applied to the inner diameter 1.35 m-14 m and a large section, and the applicability to the connect pipe is high because the Micro tunneling method can be applied to the inner diameter 0.2 m- 3m. The feature of the two tunneling method is curve construction along road alignment.

When using the shield tunneling method and micro tunneling method, a deep shaft is not necessary to a joint of the underground storage pipe and the connecting pipe.

Shield Tunneling Method and Micro Tunneling Method both need a shaft. The purpose of the shaft is the import and export of the machine. Construction method of shaft is Cut and Cover Method. Japanese underground tunnel technology can be used for construction for a shaft. As the typical method of construction adopted by large-scale tunnel construction, there are 1) Diaphragm wall, 2) Open caisson method, and 3) Pneumatic caisson method.

4.2 Drainage Facility Development Plan in each Candidate Area

Brief examinations were made on the following candidate areas:

- Espana-UST candidate area
- Buendia-Maricaban candidate area

The probable flood discharges for the planning were assumed as below:

(1) The ongoing flood countermeasures, dredging and rehabilitation of the existing drainage channel by DPWH will accomplish the development level for a ten-year probable flood.

(2) The proposed drainage facility development plan will be able to cope with a 25-year probable flood which is planned by DPWH, and also has expandability to cope with 50-year probable flood in the future. Further, the following points ware taken care of for outline examination.

(3) The development plan was formulated based on the available information (the existing structures, geological information, land ownership etc.) at this moment.

(4) In case alternatives are considered, multiple candidates were indicated which were considered technically and financially executable, and also items were indicated which needs to be considered in detail in the next stage.

Bearing in mind the abovementioned assumptions and items to be taken care of, the following items were roughly examined and the development plans for the candidate areas where formulated.

4.3 Development Plan in Espana-UST Candidate Area

The following examinations were made on underground storage pipe based on the indicated base plan in Chapter 3 Drainage Plan.

A plan for Espana-UST underground storage pipe is as indicated in Figure 4.3.1. For underground storage pipe examination, in view of construction with shield tunnelling method, layouts were examined with the assumption that the required lands for both the departing and arrival vertical shaft could be secured. The result of the examination and as one of the possible layout, the underground storage pipe is designed to be installed along Lacson Avenue besides the campus of Sto. Thomas University (UST) in the northern part of Manila City.

In concrete, a vertical shaft is to be constructed on the site located in the northern part of SM City San Lazaro (the land is currently used as material stockyard for hotel construction) and the underground storage pipe is to be constructed by shield tunnelling method southeast ward along the Lacson Avenue. The length of the storage pipe will be 3.5 km at maximum. The arrival vertical shaft is to be constructed in the eastern side (upstream side) of the existing Valencia Pumping Station that is located on the right bank of the Pasig River. Drainage facilities to drain the water in the storage pipe are to be installed in the arrival vertical shaft in order to be utilized as a pumping station. In the pumping station, a staff is needed to monitor each facility of the drainage facilities.

Source: JICA Survey Team

Figure 4.3.1 Drainage Facility Development Plan

Table 4.3.1 Design criteria of Longitudinal Profile and design conditions

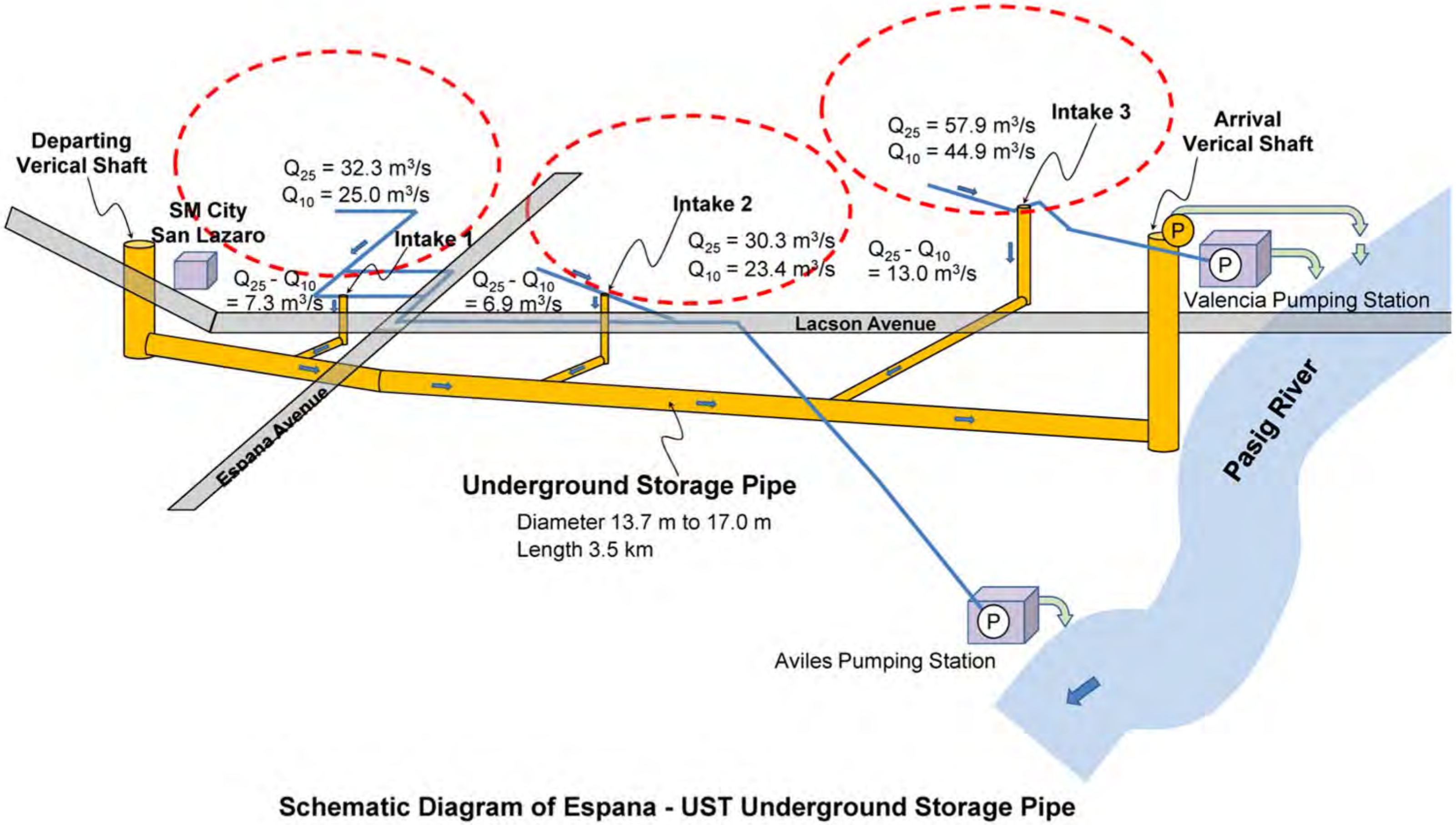
■ Standard gradient	0.1 %
	The role of the facilities once they are completed is to store the flooded water into the tunnel temporarily and release the water to the designated rivers using pumps after the rain. Therefore, it is necessary to have gradient on the side where pumping facility is located, so that the stored water will flow down the slope. The gradient is set 0.1% for this purpose based on the flow to the pumping facility and the accuracy of construction (mm/unit) at the time of shield tunneling. In addition, the range of gradient that the underground structures are not influenced is set for the purpose of reducing the depth of vertical shaft (including cost and construction period reduction)
■ Minimum overburden	1D (D: tunnel outer diameter), 18.540m
	The average minimum overburden of shield tunnel is 1D~1.5D (D: tunnel outer diameter) in general. Therefore, 1D was applied for this project. In Japan, there are many construction cases which apply less than 1D. Reduction of overburden depends on the pumping after the completion of construction and this needs to be reviewed. When reviewing, influence analysis is performed to secure the safety. In this project, when the soil condition is confirmed, the reduction of overburden can be reviewed too.
■ Distance from the foundation of the existing structure	1D (D: tunnel outer diameter), 18.540m from the bottom of the foundation
	Distance from the foundation of the existing structure is taken sufficiently so that the existing structures can maintain the stability. The relationship between longitudinal profile of the tunnel and the horizontal position of the existing structure is important and when 2D (D: tunnel outer diameter) can't be secured, the tunnel has to be constructed within the range that leaves impact on the existing structure. In this project, because of width of roads, location of the existing structures and the diameter of the tunnel, the tunnel will be constructed within the abovementioned range. Therefore, 1D (D: tunnel outer diameter) from the bottom of the foundation is to be secured.

Source: JICA Survey Team

Table 4.3.2 Principal Features of Preliminary Facilities Development Plan at Espana-UST Candidate Area

Name of the Scheme	Alternatives	Total Length of the underground storage pipe (km)	Inner Diameter of the underground storage pipe	Storage Volume (m^3)
Espana-UST Underground Storage Pipe	Storage Plan	3.5	17.0	690,000
	Early Drainage Plan		13.7	446,000

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.3.2 Schematic Diagram of Drainage Facilities for Espana-UST Candidate Area

4.4 Development Plan in Buendia-Maricaban Candidate Area

A plan for Buendia-Maricaban underground storage pipe is as shown in Figure 4.4.1.

The underground storage pipe starts from Nicholas Interchange located northeast of Ninoy Aquino International Airport in Pasay City. The underground storage pipe is to be installed along Osmenia Highway for 4.1 km northward, and turns almost perpendicular to the Osmenia Highway near PNR Buendia station. The underground storage pipe continues along Sen Gil Puyat Avenue for 3.1 km toward Manila Bay to drain the stored water into Manila Bay.

In view of securing wider working spaces, the departing vertical shaft is to be set at Manila Bay side to proceed the underground pipe excavation using shield tunnelling method eastward along Sen Gil Puyat Avenue. The excavation direction changes southward near PNR Buendia station and proceed further excavation toward the arrival vertical shaft at Nicholas Interchange.

The length of the underground storage pipe is 7.2 km. Drainage facilities for draining the stored water in the pipe are to be installed at the departing vertical shaft. The departing vertical shaft is to be used as pumping station and maintenance facilities are to be installed. Through the remote monitoring system, relevant parts of the drainage facilities are to be monitored at this pumping station.

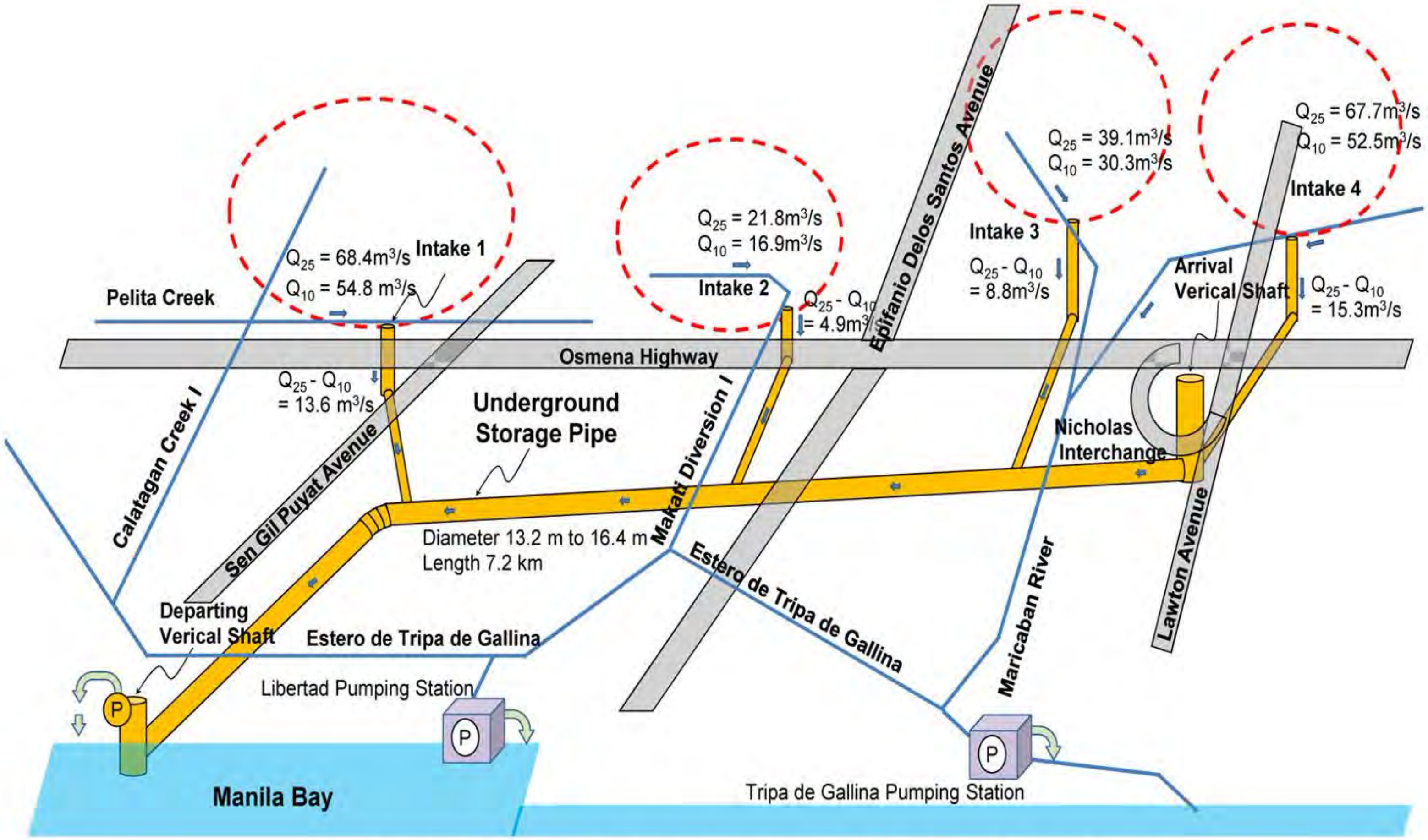
Souece：JICA Survey Team

Figure 4.4.1 Drainage Facility Development Plan

Table 4.4.1 Principal Features of Facilities Development Plan at Buendia-Maricaban Candidate Area

Name of the Scheme	Alternatives	Total Length of the underground storage pipe (km)	Inner Diameter of the underground storage pipe (m)	Storage Volume (m^3)
Buendia-Maricaban Underground Storage Pipe	Storage Plan	7.2	16.4	1,310,000
	Early Drainage Plan		13.2	844,000

Source: JICA Study Team



Schematic Diagram of Buendia - Maricaban Underground Storage Pipe

Source: JICA Survey Team

Figure 4.4.2 Schematic Diagram of Drainage Facilities for Buendia-Maricaban Candidate Area

4.5 Construction Plan for España-UST Area and Buendia-Maricaban Area

4.5.1 General outline

The construction plan is carried out in the schematic process in the case of adopting the shield method for storage. Study results for the general outline of plan are as shown in Table 4.5.1.

Table 4.5.1 General Outline of the Plan

Project Area	Alternative case of Drainage Plan	Storage length （KM）	Inner Diameter （M）	Storage （CBM）
España-UST	Storage all + Pumping after flood	3.5	17.050	690,000
	Pumping Start during flood		13.750	446,000
Buendia-Maricaban	Storage all + Pumping after flood	7.2	16.400	1,310,000
	Pumping Start during flood		13.200	844,000

Source : JICA Study Team

Construction Method

- Underground storage pipe Construction Method: Shield Tunneling Method
- Shaft Construction Method: Pneumatic Caisson Method

4.5.2 Preliminary Construction Schedule

Construction schedule will be created based on the specifications of the drainage facilities maintenance plan shown in Table 4.5.1. Shield construction process is construction capacity in the Philippines is considered to Japanese standard.

Approximate construction schedule is estimated from six (6) years to nine (9) years. The shortest construction period has been shown the case of the Espana-UST which has been estimated at 6.1 years.

Approximate construction schedule are as shown in Figure 4.5.1.

Table 4.5.2 Approximate Construction Schedule

Project Area	Alternative case of Drainage Plan	Storage length （KM）	Inner Diameter (M)	Construction Period (Year)
España-UST	Storage all + Pumping after flood	3.5	17.050	7.3
	Pumping Start during flood		13.750	6.1
Buendia-Maricaban	Storage all + Pumping after flood	7.2	16.400	8.9
	Pumping Start during flood		13.200	7.6

Source : JICA Study Team

Work capacities of shield machine are calculated on the basis of the plan for each schematic design. Average work capacityof shield machine are became 8.0m~10m. Daily and monthly of average work capacities are shown in the Table 4.5.3.

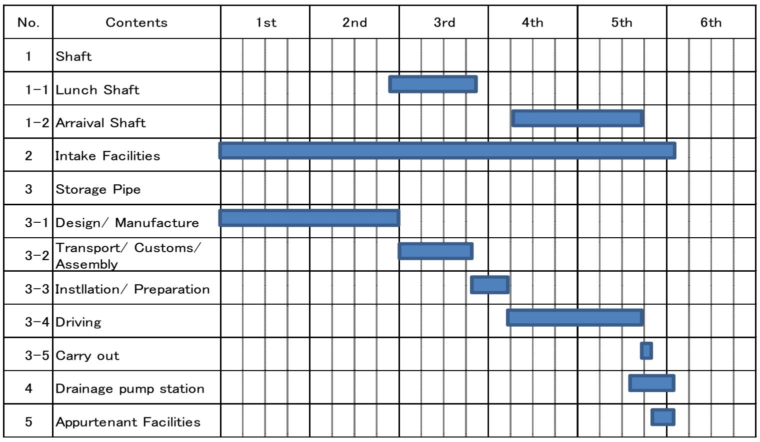
Table 4.5.3 Excavation Speed

Project Area	Alternative case of Drainage Plan	Storage length (KM)	Speed/Day (M/day)	Speed/Month (M/Month)
España-UST	Storage all + Pumping after flood	3.5	17.050	7.3
	Pumping Start during flood		13.750	6.1
Buendia-Maricaban	Storage all + Pumping after flood	7.2	16.400	8.9
	Pumping Start during flood		13.200	7.6

Source : JICA Study Team

(1) Underground Storage Pipe Construction Work Schedule of Españ-UST Area

Pumping Start during flood plan

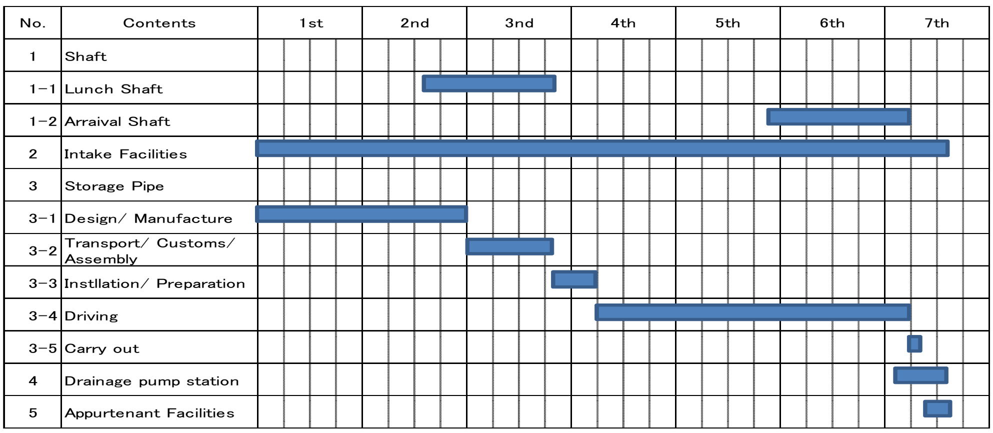


Source: JICA Survey Team

Figure 4.5.1 Construction Work Plan of Pumping Start during flood

(2) Underground storage pipe Construction Work Schedule of Buendia-Maricaban Area

Pumping Start during flood



Source: JICA Study Team

Figure 4.5.2 Construction Work Plan of Pumping Start during flood

4.6 Preliminary Estimation of Construction Cost

Each project cost are estimated by the layout study. Construction Quantity (excavation and concrete) and unit price will be adjusted to the based on the actual achievement of similar construction in Japan.

In addition, construction cost are discounted assume the unit price of the Philippines. The project cost survey is carried out for the actual achievement of similar project in Japan.

(1) Preliminary Estimation of Construction Cost

Preliminary construction costs of each drainage plan are shown in Table 4.6.1 and Table 4.6.2.

Table 4.6.1 Preliminary Estimated Project Cost (Japanese yen)

(Unit: million JPY)

	Philippines Base		Japan Base		Note.
	Early Drainage Plan	Storage Plan	Early Drainage Plan	Storage Plan	
España-UST	56,408	84,179	84,700	131,100	
Buendia-Maricaban	95,103	138,158	160,400	248,900	

Source: JICA Survey Team

Table 4.6.2 Preliminary Estimated Project Cost (Philippine peso)

(Unit: million PHP)

	Philippines Base		Japan Base		Note.
	Early Drainage Plan	Storage Plan	Early Drainage Plan	Storage Plan	
España-UST	22,033	32,880	33,100	51,200	
Buendia-Maricaban	37,147	53,963	62,700	97,200	

Source: JICA Survey Team

(2) Alternative study for Project Cost

Project cost are Construction costs, Non-construction costs (administration, Consultancy services for Detailed design and Supervision, Compensation) , Physical and Price escalation and VAT.

Based on the revised cost levels, in addition to the estimated project costs, non-project costs such as Administration Cost, Consultancy Services Cost and Land Compensation Costs were estimated. Methods and assumptions for estimating the non-project costs are as follows:

1) Administration Cost: Assumed at 3.5% of the construction cost plus consultancy services cost including price and physical contingencies
2) Consultancy Services Cost: 18% of construction cost, consisted of 8% for detailed design and 10% for construction supervision
3) Land Compensation Costs: Estimated based on the required land areas as described in Chapter 7 Environmental Considerations and as summarized in Table 4.6.11.
4) Physical Contingency Cost: 3% of the construction cost and non-construction cost.
5) VAT : 5% of the project cost

Table 4.6.3 Estimated Project Cost for Espana-UST Candidate Area (Storage Plan)

Espana-UST (Storage all + Pumping of after flood) (Unit: million*JPY, million PHP)

Work Item	Total		Equivalent (JPY)	Equivalent (PHP)	Note
	F.C.(JPY)	L.C.(PHP)			
Sub-total I	32,700	9,882	58,000	22,654	
II.Non-construction Cost					
II.1 Administration Cost	---	1,056	2,704	1,056	(I+II.2+III+IV)*3.5%
II.2 Consultancy Services Cost	7,308	1,223	10,440	4,078	8%(D/D), 10%(SV)
II.3 Land Compensation	---	77	197	77	
Sub-total II	7,308	2,356	13,340	5,211	
Sub-total for [I] + [II]	40,008	12,238	71,340	27,865	
Price Escalation Rate					
III.Price Escalation	2,609	1,613	6,740	2,632	
IV.Physical Contingency	1,151	367	2,091	817	
Sub-total for [I] + [II] + [III] + [IV]	43,768	14,219	80,170	31,314	
V.VAT	2,188	711	4,009	1,566	VAT=5%
VI. Project cost ([I] + [II] + [III] + [IV] + [V])	45,956	14,929	84,179	32,880	

Source: JICA Study Team

Table 4.6.4 Estimated Project Cost for Espana-UST Candidate Area (Early Drainage Plan)

Espana-UST (Pumping Start during flood) (Unit: million*JPY, million PHP)

Work Item	Total		Equivalent (JPY)	Equivalent (PHP)	Note
	F.C.(JPY)	L.C.(PHP)			
Sub-total I	22,900	6,445	39,400	15,389	
II.Non-construction Cost					
II.1 Administration Cost	---	707	1,810	707	(I+II.2+III+IV)*3.5%
II.2 Consultancy Services Cost	4,964	831	7,092	2,770	8%(D/D), 10%(SV)
II.3 Land Compensation	---	74	190	74	
Sub-total II	4,964	1,612	9,092	3,551	
Sub-total for [I] + [II]	27,864	8,057	48,492	18,941	
Price Escalation Rate					
III.Price Escalation	1,522	880	3,775	1,475	
IV.Physical Contingency	836	242	1,455	568	
Sub-total for [I] + [II] + [III] + [IV]	30,223	9,179	53,722	20,984	
V.VAT	1,511	459	2,686	1,049	VAT=5%
VI. Project cost ([I] + [II] + [III] + [IV] + [V])	31,734	9,638	56,408	22,033	

Source: JICA Study Team

Table 4.6.5 Estimated Project Cost for Buendia-Maricaban Candidate Area (Storage Plan)

Buendia-Maricaban area (Storage all + Pumping of after flood) (Unit: million*JPY, million PHP)

Work Item	Total		Equivalent (JPY)	Equivalent (PHP)	Note
	F.C.(JPY)	L.C.(PHP)			
I. Construction cost (Direct cost)	43,000	18,983	91,600	35,778	
II.Non-construction Cost					
II.1 Administration Cost	---	1,707	4,370	1,707	(I+II.2+III+IV)*3.5%
II.2 Consultancy Services Cost	11,484	1,922	16,406	6,408	8%(D/D), 10%(SV)
II.3 Land Compensation	---	920	2,355	920	
Sub-total II	11,484	4,549	23,131	9,035	
Sub-total for [I] + [II]	54,484	23,532	114,731	44,813	
Price Escalation Rate					
III.Price Escalation	4,011	2,757	11,070	4,324	
IV.Physical Contingency	1,883	1,521	5,778	2,257	
Sub-total for [I] + [II] + [III] + [IV]	60,378	27,810	131,579	51,394	
V.VAT	3,019	1,391	6,579	2,570	VAT=5%
VI. Project cost ([I] + [II] + [III] + [IV] + [V])	63,397	29,201	138,158	53,963	

Source: JICA Study Team

Table 4.6.6 Estimated Project Cost for Buendia-Maricaban Candidate Area (Early Drainage Plan)

Buendia-Maricaban area (Pumping Start during flood) (Unit: million*JPY, million PHP)

Work Item	Total		Equivalent (JPY)	Equivalent (PHP)	Note
	F.C.(JPY)	L.C.(PHP)			
I. Construction cost (Direct cost)	32,000	12,382	63,700	24,881	
II.Non-construction Cost					
II.1 Administration Cost	---	1,165	2,984	1,165	(I+II.2+III+IV)*3.5%
II.2 Consultancy Services Cost	7,986	1,337	11,409	4,456	8%(D/D), 10%(SV)
II.3 Land Compensation	---	917	2,348	917	
Sub-total II	7,986	3,419	16,739	6,538	
Sub-total for [I] + [II]	39,986	15,801	80,439	31,419	
Price Escalation Rate					
III.Price Escalation	2,711	1,957	7,722	3,016	
IV.Physical Contingency	1,200	474	2,413	943	
Sub-total for [I] + [II] + [III] + [IV]	43,897	18,232	90,575	35,378	
V.VAT	2,195	912	4,529	1,769	VAT=5%
VI. Project cost ([I] + [II] + [III] + [IV] + [V])	46,092	19,144	95,103	37,147	

Source: JICA Study Team

CHAPTER 5. OPERATION AND MANAGEMENT PLAN

5.1 Outlines of Operation and Maintenance (O&M) Plan

5.1.1 Items of Operation and Maintenance (O&M) and Work Flow

In the O&M plan, necessary O&M activities are to be conducted to secure the full functions of the proposed drainage facilities (underground storage pipe). The range of O&M works covers the each intake, the storage pipe and the vertical shafts. The O&M works for the existing drainage channel that is connected to the intake is assumed to be covered by the O&M budget for the usual activities. Required work items are described hereunder for the cases of "during flood" and "normal time."

(1) O&M works during flood

1) Monitoring of smooth inflow conditions from the intake by using remote monitoring system
    a) To confirm the securement of smooth inflow from the existing drainage channel into the storage pipe without any clogging at the intake by floating garbage etc.
2) Drainage of the stored water, ventilation and cleaning
    a) In case of storage plan, the drainage works of the stored water starts after flood, and in case of early start of drainage plan, drainage works starts after the inflow exceeds a certain amount.
    b) After the drainage works, by confirming the recurrence of flood for a moment through meteorological information, ventilation of the storage pipe will start. After securing the sufficient oxygen density inside the storage pipe, a working car will be lowered into the storage pipe to start the cleaning works.
    c) The cleaning works will be conducted by high-pressure washing car for the purpose of cleaning the wall of the storage pipe to remove the adhered floating objects and settled objects to the wall.
    d) The floating and settled objects are collected through the gutter installed on the invert concrete of the storage pipe toward the pit installed at the vertical shaft at the flow end. Liquid will be drained by the drainage pumps and solid objects are to be removed and carried out with container box etc. using the lift in the vertical shaft.

Through the above O&M works after the occurrence of the flood, the preparedness against the coming flood will be arranged.

(2) Normal O&M works

The O&M works and work flow during normal period which is assumed at this moment is as follows:

Descriptions are given hereunder on the check items during normal period (non-flood period) which are important to ensure the full functions of the proposed drainage facilities (underground storage pipe and drainage pumps) against the operations during floods.

1) Check and measurement inside the storage pipe
    a) Visual check will be made for the whole area of the storage pipe to confirm the nonexistence of abnormal conditions such as deformations, cracks and water leakage etc.
    b) In case any abnormal conditions found, detailed measurements and evaluations will be

made to find out the reason for further countermeasures. The detailed procedures will be examined in the next stage.

2) Maintenance and check of the equipment instrument

a) Operation check of equipment instruments such as remote monitoring systems, elevators, drainage pumps are to be conducted to ensure that those equipment instruments have no problems.

b) In case of any problems found, repair and adjustment works are to be conducted and further confirmations will be made.

5.1.2 Conceivable Organization and Budget for O&M

(1) Organization for operation and maintenance

Considering the fact that MMDA is currently in charge of O&M works of drainage channels and pumping stations in Metro Manila, however, it is supposed that neither DPWH nor MMDA has know-how on the O&M activities of the proposed drainage facilities (underground storage pipe), as the facilities are to be introduced to the Philippines for the first time. On the other hand, considering the fact that DPWH would be the main implementation body for the construction of the proposed drainage facilities, and also considering that DPWH has an intension on securing the budget and implementing the future O&M works for the proposed facilities. O&M plan will be considered based on the assumptions that DPWH would be in charge of O&M works.

Further, to make full use of the know-how that MMDA has for the O&M works on the existing drainage channels and pumping stations, it is expected that MMDA should be involved into the implementation of the project by DPWH to enable effective O&M works for both the existing and the proposed facilities. It is hoped during the project implementation stage in the future, that coordination between DPWH and MMDA would be made on the systems of O&M work.

(2) Annual total O&M cost

The abovementioned costs for during flood and normal period can be summarized as follows.

Candidate Area	O&M cost during flood (Required budget for 50 year project period)	O&M cost for normal period (Peso/year)
Espana-UST candidate area	23,911,200	63,445
Buendia-Maricaban candidate area	47,822,400	126,890
Total	71,733,600	190,335

Source: JICA Study Team

CHAPTER 6. ECONOMIC EVALUATION

6.1 Economic Evaluation Method

6.1.1 Evaluation by EIRR

Taking the NEDA policy into consideration, economic evaluation was made according to the following steps for this kind of project:

1) Identify the most likely damaged item.
2) Estimate the basic unit value per unit and/or unit area (amount/unit, or amount/ha) for each damage item.
3) Evaluate the damage by existing floods to be used as the basis of evaluation.
4) Estimate the annual average flood damages by means of probability analysis for each return period under the “With-” and the “Without-Project” concept.
5) Identify the economic benefit as differences of damages in the “With-” and “Without-Project” conditions.
6) Compare the economic benefit with the economic cost of project, and evaluate project feasibility by means of some indices such as the economic internal rate of return (EIRR).

6.1.2 With/Without Project

The basic principle of project economic evaluation is to define both economic benefits and costs pertaining exclusively to the domain of influence of the project in question. The costs and benefits of the project are calculated by deriving the incremental differences of each brought by the implementation of the project, i.e. Δ = With Project − Without Project.

6.1.3 Target Project for Economic Evaluation

The target projects are in the Espana-UST Area and the Buendia-Maricaban Area.

6.2 Economic Benefit

6.2.1 Composition of Economic Benefits

The economic benefit arising from flood control are largely composed of two categories of direct and indirect benefits. The direct benefits are composed of 1) reduction in physical damages to building and other facilities; 2) forgone expenditures incurred to provide reliefs to evacuated refugees; and 3) foregone clean-up expenses, whereas the indirect benefits are composed of 1) reduction of traffic congestion and diversion costs, 2) reduction in disruption of economic activities to generate income, and 3) prospective increase in land use values.

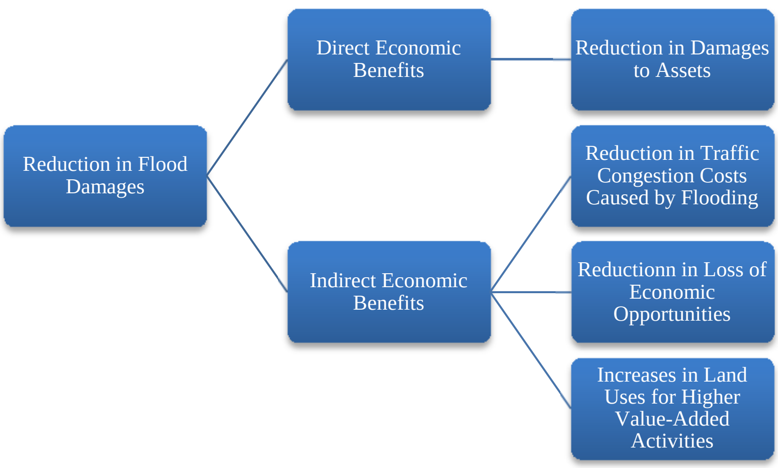


Figure 6.2.1 Economic Benefits to Flood Control Project

6.2.2 Direct Economic Benefits

The basic unit is used for the estimation of economic benefit is the same as the one used in a previous study in Metro Manila the "PMRCIP Phase IV and Phase V"[1].

The flood simulation resulted in the estimated damages and potential reduction with the projects as shown in Table 6.2.1 to calculate the differences between With/Without Projects.

Table 6.2.1 Reduction in Direct Damages to Assets

Espana-UST Area

Return Period	Occurrence Probability	Flood Damage			Average of Damage Reduction	Interval Provability	Annual Average Damage Reduction	Remarks
		Without Project (1)	With Project (2)	Damage Reduction (1)-(2)				
1/3	0.333	0	0	0				
					2,093	0.133	278	
1/5	0.200	7,430	3,243	4,187				
					4,208	0.100	421	
1/10	0.100	10,484	6,256	4,229				
					4,191	0.060	251	
1/25	0.040	14,019	9,865	4,154				
					4,352	0.020	87	
1/50	0.020	17,025	12,475	4,550				
					4,508	0.010	45	
1/100	0.010	20,265	15,799	4,466				
						Annual Benefit :	1,082	million peso

Buendia-Maricaban Area

Return Period	Occurrence Probability	Flood Damage			Average of Damage Reduction	Interval Provability	Annual Average Damage Reduction	Remarks
		Without Project (1)	With Project (2)	Damage Reduction (1)-(2)				
1/3	0.333	0	0	0				
					5,005	0.133	666	
1/5	0.200	25,093	15,083	10,010				
					10,198	0.100	1,020	
1/10	0.100	34,857	24,471	10,386				
					7,461	0.060	448	
1/25	0.040	45,246	40,711	4,535				
					4,154	0.020	83	
1/50	0.020	54,925	51,152	3,772				
					3,604	0.010	36	
1/100	0.010	63,246	59,811	3,435				
						Annual Benefit :	2,253	million peso

Source: JICA Survey Team

[1] Supplemental Agreement No.1 for the Consulting Engineering Services for Assistance to Procurement of Civil Works and Construction Supervision on the JICA-assisted PASIG-MARIKINA River Channel Improvement Project, Phase III (PH-P252) Upper MARIKINA River Channel Improvement Works (PMRCIP PHASE IV AND PHASE V)

6.2.3 Indirect Economic Benefits

(1) Economic Disruption Pricing

Assessment of the economic opportunity costs of flood damages require pricing of economic disruption as well as quantification of damages. Gross domestic product includes in its calculation wages, profits and depreciation, providing a better measure for economic opportunity cost.

In 2014, the Philippines generated the GRDP of 12.6 trillion pesos as a whole while the National Capital Region (NCR) generated approximately 4.7 trillion pesos. The GRDP per worker in NCR is estimated to be 890,000 peso/worker/year.

It is simply presumed on a conservative scale to assign 20% more unit value to the Buendia-Maricaban areas' per worker GRDP and NCR average to the Espana-UST areas' per worker GRDP.

Table 6.2.2 Time Value Pricing

	Unit	Buendia-Maricaban	Espna-UST
Location Adjusted Per Worker GRDP	peso/year/capita	1,068,000	712,000
Economic Price Conversion of Per Worker GRDP	peso/year/capita	892,848	595,232
per day	peso/day/capita	4,464	2,976
per hour	peso/hour/capita	558	372

Source：JICA Survey Team

(2) Reduction in Loss of Economic Opportunities

Annual average of reduction in loss of economic opportunities in the Espana-UST Area and Buendia-Maricaban Area is 111 Million Php and 703 Million Php respectively.

(3) Reduction in Traffic Congestion Costs Caused by Flooding

Annual average of reduction in traffic congestion costs is in the Espana-UST Area and Buendia-Maricaban Area is 514 Million Php and 385 Million Php respectively.

6.3 Preliminary Economic Evaluation

Due to the preliminary nature of the current study, this evaluation is based on the comparison of with the tunnel storage projects and the without projects under the present situation. The EIRRs for Buendia-Maricaban is 14% and for Espana-UST is 12%.

However, possibility of project cost reduction was indicated with a combination of the pump and the storage pipe as above-mentioned. If the cost decreases EIRR will be improved.

CHAPTER 7. ENVIRONMENT AND SOCIAL AWARENESS

7.1 Environmental Settings in the Project Areas of the Proposed Drainage System

España-UST Area is located in the north area of Manila City. Land owners of the proposed project sites (on the ground) are government (one site) and private (four sites). ISFs are not identified in the proposed sites but one of the proposed sites is residential area and therefore land acquisition and displacement of PAPs will be needed.

Buendia-Maricaban Area is located in the cities of Pasay, Makati and Taguig. Land owners of the proposed project sites (on the ground) are government (four sites) and private (two sites). Proposed site of intake No.4 is occupied by ISFs and displacement of them will be needed accordingly.

7.2 Confirmation of Potential Impacts on Natural and Social Environment

The possibility of environmental and social impacts by the implementation of the project area as follows.

- Pre-construction stage: There will be such impacts as conflicts between the proponent and land owners during negotiation for land acquisition, possibility of expropriation, displacement of formal settlers and ISFs (informal settler families), impacts on their livelihood and economic activities, etc.
- Construction stage: There will be such impacts as air pollution by emission gas, noise and vibration due to construction works on the ground, generation of low frequency sound, ground movements and drawdown of groundwater level and impact on groundwater use due to tunnelling works, impacts on road traffic due to transportation of construction materials and excavated materials, impacts due to disposal of the excavated materials, etc.
- Operation stage: There will be such impacts as noise (impulsive sound of water falling at intake facility), noise and offensive odor from pumping station.

7.3 Confirmation of Requirements for the Proposed Drainage System under PEISS

This project will be subject to an Environmental Impact Assessment (EIA) under the Philippine Environmental Impact Statement System (PEISS). According to DENR-EMB, the project is categorized as “flood control project.” EIS requirement of the project is to prepare IEE Checklist since the storage volume of the facility is less than 5 million m^3. The project is, however, regarded as “project that directly addresses existing environmental problem,” under which ECC acquisition is not required. On the other hand, the project includes the components of pumping station and disposal of excavated materials which requires EIA for ECC acquisition. Consequently, it was confirmed from DENR-EMB that EIS requirement is not decided at this moment and that the Proponent (DPWH) is required to submit Project Description (PD) to the competent authority in advance for determination of EIS requirements.”

7.4 Confirmation of Policies and Issues on Land Acquisition and Resettlement

Basic policies for land acquisition and resettlement necessary for public interest are provided in the 1987 Philippine Constitution, under which just compensation for acquisition of private property, adequate legal assistance in its process, and eviction and demolition in accordance with the law and in a just humane manner, etc. are secured. Procedures of land acquisition and resettlement in the DPWH projects shall be executed in accordance with RA 8974 (2000) and LARRIPP (2007). Relocation of ISFs from the dangerous zones along rivers is being implemented under the collaboration of concerned LGUS and government agencies in Metro Manila at present in line with Metro Manila’s Flood Control Master Plan and the Supreme Court Mandamus on Manila Bay Clean-Up (2011). It was confirmed that the relocation activities of ISFs is being conducted in the areas where the project is located.

CHAPTER 8. MAJOR ISSUES AND RECOMMENDATION

8.1 Challenges

<Challenges for the Proposed Projects>

(1) Engineering Aspects

The detailed study, such as 1) development flood simulation model with current data and evaluation of flow capacity of existing drainages/esteros, 2) geological survey along the alignment for designing and planning, 3) survey for shafts and intakes with adequate accuracy, 4) confirmation of tunnel hydraulic condition, 5) environmental impact assessment and 6) proposal including non-structural measures, were not carried out because the Survey is just a preliminary stage and has been expected the result within a short period of time. These items should be considered in the next step.

(2) Project Cost

Possibility of project cost reduction was indicated with a combination of the pump and the storage pipe as mentioned in Chapter 3, 4 and 7. Appropriate project cost should be estimated with above-mentioned engineering surveys in the coming study.

<Present Issued on Drainage Improvement in Metro Manila>

(3) Promotion of Recovery and Improvement of Drainage Capacity of Existing Drainage Systems

The proposed underground tunnels in the Survey cannot function adequately under existing condition being reduced capacity of drainage channels and pumps.

(4) Strengthening of Cooperation between DPWH and MMDA on the Drainage Sector

In Metro Manila the responsibility for management of drainage facilities is devided; i.e., the planning and implementation of drainage facilities are under the DPWH and the Operation and Maintenance (O&M) activities are under the MMDA.

8.2 Activities to the Next Stage

<Further Study for the Proposed Projects>

(1) Required Basic Surveys such as Geological Survey along the Alignment for Designing and Planning
(2) Determination of Layout considering Expandability
(3) Confirmation on Effective and Assured Diversion of the Flood Water
(4) Estimate of Frequency of Facilities Usage and Confirmation of Disappearance of the Inundation Areas through Flood Inundation Analysis
(5) Necessity under the Drainage Improvement Plan to Conduct Necessary Procedures for the Environmental Impact Statement (EIS)
(6) Implementation of Basin Management to the Maricaban River
(7) Necessary Preparation of Laws for Deep Underground Development and Public Use of deep Underground Facilities
(8) Introduction of Operation and Management System for Drainage Facilities using Rainfall and Meteorological Observation and Forecast System

<Activities for Drainage Improvement in Metro Manila>

(1) Promotion of Recovery and Improvement of Drainage Capacities of Existing Drainage Systems
(2) Improvement of Dumping Solid Wastes and of Water Quality in Drainage Channels
(3) Strengthening of Cooperation between DPWH and MMDA on the Drainage Sector
(4) Promotion of Land Use Management and River Basin Management considering Flood Disaster Risk Reduction (DRR)

8.3 Recommendation

The results of the Survey:

The Survey has been carried out for two candidate areas: España-UST and Buendia-Maricaban. A preliminary study on the possibility of applying the deep underground tunnel technologies to their drainage system improvement was also conducted and concluded that they are feasible measures in technical terms.

However, the deep underground tunnel facility should be the final measure to attain the target safety levels of 25-year RP and 50-year RP. The drainage improvement works proposed by the 2005 JICA M/P and the DPWH survey have just been commenced and the results of the works should be assessed and necessary remedial measures to attain the target of 25-year RP and 50-year RP should be identified.

It is necessary for DPWH to conduct a further study on the effects of the works before finalizing the proposed deep underground tunnelling drainage facilities as the final measures to sustain the future development of Metro Manila.

DPWH has set the target safety level of as high as 25-year return period (RP) and 50-year RP for the safety level of flood and drainage projects and require new basis for project evaluation.

In order to realize the proposed deep underground drainage projects it is recommended that DPWH should conduct further studies including the activities in 8.2 as follows:

Further Study:

(1) Consistent implementation and the evaluation of the items mentioned in Section 8.2 should be assessed.
(2) For evaluation and assessment purposes, the on-going and planned drainage improvement works in the core area are to be assessed as to their effects in the disaster risk reduction, and their functions in the short term are to be identified for attaining the target safety levels of 25-year RP and 50-year RP in the Core Area.
(3) Formulation of necessary drainage improvement measures including their O&M measures to attain the target safety levels of 25-year RP and 50-year RP in the Core Area.
(4) Study on the bases of project evaluation for challenging drainage improvement works including adaptation measures against inevitable climate change.

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