E. DRAINAGE FACILITY PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

E.1 GENERAL

The total catchment area of the drainage system in the core area is about 73 km2. Within the catchments, there are esteros / creeks and drainage mains with total length of about 73 km and 34 km, respectively and 15 major drainage pumping stations. The drainage system in the core area is geographically divided by the Pasig River into two areas: South Manila (south or left bank of Pasig River) and North Manila (north or right bank of Pasig River).

A flood control and drainage improvement works in Metropolitan Manila were initiated by the then BPW (Bureau of Public Works, presently DPWH) in the 1940s. A drainage improvement master plan was originally formulated by BPW in 1954. In line with the said plans, BPW and/or DPWH carried out various construction works of drainage channels, dredging of river channels and construction of other related works in Metropolitan Manila by own fund.

Subsequently, the construction of Mangahan floodway and 10 major drainage pumping stations were completed by 1984 and 5 more major drainage pumping stations were completed in 1997. Accordingly, the floods from the Pasig River and inundation problems in the core area have been reduced significantly. However, it was observed during the 1999 floods that there remained severe inundation areas regionally and locally. Such floods and inundations caused heavy traffic congestion, and disturbed commercial activities and urban living in the core area. The further drainage improvement is one of major tasks in the core area of Metropolitan Manila.

In this supporting report of Drainage Facility Plan, the present conditions of drainage facilities and pumping stations, and formulated drainage improvement master plan for coping with the above problems and constraints involved in the core area of Metropolitan Manila are described.

Major investigation and study results on the present conditions of drainage facilities and pumping stations are firstly described covering previous studies and planned projects, completed and ongoing flood control and drainage improvement project and drainage conditions of drainage system and catchments, and problems and constraints in the drainage sector.

Subsequently, study results of drainage improvement master plan are explained. The description of this item consists of basic concept for formulating drainage improvement plan, improvement plan of drainage channels and pumping stations, non-structural measures, supporting measures, phasing of structural measures and priority projects subject to a feasibility study.

E.2 PREVIOUS STUDIES AND PLANNED PROJECTS OF FLOOD CONTROL AND DRAINAGE IMPROVEMENT

E.2.1 GENERAL

The Bureau of Public Works (BPW, presently DPWH) initiated flood control and drainage improvement in what is now known as Metropolitan Manila in the 1940s. Since then, flood control and drainage improvement works have been constructed so far. Owing to the implementation of such improvement works, flood control and drainage situations in Metropolitan Manila have been so much improved, although frequent flood damage still remains. In this section, major previous studies and planned projects are discussed below.

E.2.2 PREVIOUS FLOOD CONTROL AND DRAINAGE IMPROVEMENT PLANS

The flood control and drainage plan, from time to time, has been reviewed and restructured to keep up with changes in flow patterns and other hydrological circumstantial requirements of natural and social causes. Major studies and planned projects made so far are summarized in *Table E.2.1*.

Table E.2.1 Major Studies and Planned Projects

Year	*Study and Project*
1952	*Plan for the Drainage of Manila and Suburbs (BPW)*
1954	*Marikina River Multipurpose Project (BPW)*
1963	*Review of the above Plan and Project (BPW/WB and WHO)*
1984	*Metro Manila Integrated Urban Drainage and Flood Control (DPWH/WB)*
1986	*Drainage Improvement Plans of Estero de Vitas and Other Catchment Areas in Metro Manila Drainage System Rehabilitation Project (DPWH/OECF)*
1990	*Study on Flood Control and Drainage Project in Metro Manila (DPWH/JICA)*
1990	*Manila Metropolitan Region Environment Improvement Study (DENR/ADB)*
1995	*Study on Updated Drainage Plan for Libertad Reclamation Area, Pasay City and Paranaque, Metro Manila (Public Estates Authority)*
1996	*Study on Water Supply and Sewerage Master Plan of Metro Manila (MWSS/JICA)*
1998	*Study on Flood Control and Drainage System Improvement for KAMANAVA Area (DPWH)*
1999	*Feasibility Study on Metro Manila Drainage System Rehabilitation Project (Phase II) in Republic of the Philippines (Japan Consulting Institute)*
2000	*Study on the Existing Laterals in Metro Manila in the Republic of the Philippines (DPWH/MMDA/JICA)*
2002	*Detailed Engineering Design for Pasig-Marikina River Flood Control Project*

The following three flood control and drainage master plans in Metropolitan Manila are introduced: 1) 1952 Plan for the Drainage of Manila and Suburbs, 2) 1984 Metro Manila Integrated Urban Drainage and Flood Control Master Plan and 3) 1990 Study on Flood Control and Drainage Project in Metropolitan Manila. Subsequently, the following study and engineering design directly related to drainage improvement in the core area is explained: 1) 2000 Study on Existing Laterals in Metro Manila in the Republic of the Philippines, and 2) 2002 Detailed Engineering Design for Pasig-Marikina River Flood Control Project.

(1) 1952 Plan for the Drainage of Manila and Suburbs[1]

In 1952, the BPW formulated a drainage improvement master plan in Metro Manila. The details of the plan are described in Plan for the Drainage of Manila and Suburbs prepared by River Control Section, 1952 and outlined hereunder.

The objective area for the plan is around 50.8 km^2 consisting of 21.7 km^2 in North Manila and 29.1 km^2 in South Manila. North Manila is divided into 7 divisions of Bay Front, Estero de la Reina, Antipolo mains, Quezon City slope, Estero de Quiapo, Estero de Sampaloc and Estero de Valencia. Meanwhile, South Manila is divided into 10 divisions of Nielson Airfield, Buendia, Pasay Bay front, Makati, Sta. Ana, Malate-Ermita, Intramuros, Singalong, Paco and Pandacan. The drainage improvement plan is designed for 10-year return period. The following are the major proposed works in the plan.

- Land filling
- Construction of outfall and drainage channels
- Construction of interceptor
- Construction of drainage pumping stations of Quiapo, Sampaloc, Valencia, Paco, and Pandacan

(2) 1984 Metro Manila Integrated Urban Drainage and Flood Control Master Plan[2]

Subsequently, in March 1984, the then Ministry of Public Works and Highways (MPWH) formulated the World Bank-assisted Final Alternative Master Plan Strategy in the Report on the Metro Manila Integrated Urban Drainage and Flood Control Master Plan by Engineering-Science, Inc., USA in association with Basic Technology and Management Corporation, Philippines. The objective area of this master plan strategy covers 661 km^2 with four cities and 13 municipalities making up Metro Manila including Marikina area east of Mangahan Floodway.

In this study, various alternatives for urban drainage and flood control were examined and finally a prioritized master plan framework was recommended. The master plan framework consists of 40 priority projects as listed in *Table E.2.2*. Major priority projects are as follows.

- Establish and enforce flood proofing regulations for newly developing area
- Deferred maintenance on mechanical equipment including pumps and floodgates
- San Juan River improvement
- Estero de Tripa de Gallina improvement
- Estero de Vitas improvement
- Malabon River improvement
- Marikina/Mangahan area drainage improvement

Table E.2.2 Master Plan Framework Priority Projects

Priority Order	Action Plans	Total Capital Cost (Pesos million)
1.	Establish and enforce floodproofing regulations for newly developing areas (probably 20-y return period plus 0.5 m)	Administrative costs to be borne by METROFLOODS
2.	Deferred maintenance on mechanical equipment, including pumps and floodgates	Expected to be funded by the Japanese Government loan.
3.	San Juan River dredging - IAP Contract 1	39.5
4.	Estero Tripa de Gallina: estero dredging IAP Contract 2. (part)	20.6
5.	Malabon River dredging-IAP Contract 2 (part)	17.1
6.	Estero de Vitas: estero dredging - IAP Contract 2 (part)	10.9
7.	Parañaque River dredging - IAP Contract 2 (part)	12.6
8.	San Andres Bukid Drainage - IAP Contract 3	16.8
9.	Estero Tripa de Gallina: culvert rehabilitation - IAP Contract 4 (part	1.3
10	Parañaque: culvert rehabilitation - IAP Contract 4 (part	5.2
11	Estero de Vitas: culvert rehabilitation -IAP Contract 4 (part)	11.3
12.	Establish and enforce floodproofing regulations for new construction throughout Metro-Manila	_a
13.	Establish and enforce floodroofing regulations for substantial additions, remodeling or reconstruction throughout Metro-Mani	_a
14.	San Juan River dredging eight tributaries of San Juan river to 100-y return period flooded area (Buhangin, Maytunas, Salapan, Mariablo, Diliman, Talayan, Dario and Culiat Creeks) and construction of Buhangin Creek pump station and floodgate	29.5
15.	Marikina/Mangahan: dredging creeks north of Mangahan Floodway (Buli, Baho, Long and Concepcion Creeks	16.3
16.	Estero Tripa de Gallina: construction of EsteroTripa de Gallina (north of Zobel Raoxas Ave.) and estero de Pandaca	44.0
17.	Estero Tripa de Gallina: culvert rehabilitation of Buendia outfall, Libertad outfall and EDSA mai	16.4
18.	Estero Tripa de Gallina: dredging of Kalatagan/Camachile Creek, Bangkal Creek, Makati diversion channel and PNR open channel, and culvert rehabilitation of Zobel Roxas main, Pasong Tamo main, and Delores main outfall and EDSA main	9.6
19.	Estero Tripa de Gallina: construction of estero walls along Estero de Pacc	58.1
20.	Estero Tripa de Gallina: construction of estero walls along Estero de Concordia	18.8
21.	Estero Tripa de Gallina: construction of estero walls along Estero Tripa de Gallina (south of Zobel Roxas ave.	28.3
22.	Malabon: dredging of Muzon- Dampalit River, Pinagkabalian River, Tugatuog Creek, Navotas River, Marala River, Chunkang River, Panghulo River and Estero de Saluysc	47.8
23.	San Juan River: rehabilitation of street (local) drains within 100-y return peiod flooded are	17.6
24.	Marikina/Mangahan: rehabilitation of street (local) drains within 100-y return period flooded are	88.3
25.	Estero Tripa de Gallina: rehabilitation of street (local) drains within 100-y return period flooded are	37.7
26.	Malabon: rehabilitation of street (local) drains within 100-y rreturn period floode are	24.4
27.	Estero de vitas: construction of estero walls along Estero de Vitas, Estero de Sunog Apog, Estero de Maypajo (downstream of Blumentritt interceptor) and Casili Creek (downstream of PNR bridge)	95.4
28.	Estero de Vitas: dredging of Estero de Maypajo and Casili Creek, and rehabilitation of Kanlaon Piy Margal main and South Antipolo ma	4.3
29.	Estero de vitas: rehabilitation of street (local) drains within 100-y return period flooded are	34.4
30.	South of Pasig River: culvert rehabilitation of Padre Faura outfall, Remedios outfall and San Antonio Abad main, and dredging of Estero de Bale	8.6
31.	South of Pasig River: culvert rehabilitation of Masukol main, Zorbel Orbit outfall and Makati Headraces I and II and dredging of Estero de santa Clara, Balisampan Creek and Pinagkaisahan Creek	6.7
32.	Estero de Binondo: dredging of Estero de la Reina, Estero de Magdalena, Estero San Lazaro and Estero de Binond	6.8
33.	North of Pasig River: dredging of Estero de Quiapo, Estero de San Miguel, Estero de Sampaloc, Estero de Balic Balic, Estero de Uli Uli and Estero de Aviles, and culvert rehabilitation of Pacheo outfall, Lakandula outfall, Zurbaran main, Reyes-Severino mai	12.9
34.	Marikina River dredging	49.1
35.	South of Mangahan Floodway: dredging of Pateros River, Tipas River, Santa Ana River, Taguig River, Tipas Daang Paa River and Tipas Labasan Cree	35.4
36.	Parañaque River: dreging of Parañaque River (south), Dongalo River, Kay Boboy Creek and Sapang Buway	38.8
37.	All areas: rehabilitation of all other street (local) drains	197.5
38.	San Juan River: dredging of six tributaries beyond 100-y return period flooded area (Mariablo Creek, Diliman Creek, talayan Creek, Dario Creek, Culiat Creek, and Arayat Cree	20.8
39.	Estero Tripa de Galllina: dredging of san Isidro Creek, Ayala Creek, San Lorenzo Creek and San jose Creel	13.9
40.	Estero Tripa de Gallina: dredging of Dilain/ Maribacan Creel	10.8
		1107.5

Source: World Bank-assisted Final Alternative Master Plan Strategy in the Report on the Metro Manila Integrated Urban Drainage and Flood Control Master Plan by Engineering-Science, Inc., USA in association with Basic Technology and Management Corporation,

(3) 1990 Study on Flood Control and Drainage Project in Metro Manila[3]

In line with the recommendations made by Metro Manila Integrated Urban Drainage and Flood Control Master Plan in 1984, the Department of Public Works and Highways (DPWH) conducted the JICA-assisted Study on Flood Control and Drainage Project in Metro Manila in 1990. The plan consists of framework plan, master plan and priority projects for urgent implementation aiming at target year of 2020.

For drainage countermeasures in the core area of Metro Manila, the concept developed by BPW in 1952 and World Bank in 1984 has been followed in the plan. In this section, 4 proposed priority projects other than drainage in the core area are introduced below.

1) Drainage Improvement in East and West of Mangahan

Lakeshore/backwater dikes are designed for EL 15.5 m with 40-year return period and drainage facilities, 5-year return period, respectively.

- Construction of lakeshore dike (L=10.7 km)
- Construction of backwater dikes (6 rivers)
- Construction/improvement of drainage channel (L=55 km)
- Construction of drainage pumping stations (9 stations with total capacity of 111 m^3/s)

2) Drainage Improvement in Malabon-Navotas (North of Malabon River)

Coastal dike is designed for EL 13.5 m and river/ring dikes, EL12.5-13.5 m, respectively. Drainage facilities are designed for 5-year return period.

- Construction of coastal, river and ring dikes (L=15.9 km)
- Construction/ improvement of drainage channel (L=1.6 km)
- Construction of drainage pumping stations (3 stations with total capacity of 25 m^3/s)

3) Drainage Improvement in Malabon-Navotas (South of Malabon River)

Coastal dike and parapet wall are designed for EL 13.5 m and river/ring dikes, EL12.5-13.5 m, respectively. Drainage facilities are designed for 5-year return period.

- Construction of coastal and river dikes (L=4.7 km)
- Construction of parapet wall (8.5 km)
- Construction/improvement of drainage channel (L=1.6 km)
- Construction of drainage pumping stations (3 stations with total capacity of 10 m^3/s)

4) Pasig-Marikina River Improvement

A 30-year design flood is applied in the Pasig-Marikina River improvement.

- Channel improvement of Pasig-Marikina River (L=26.4 km)
- Construction of Marikina Control Gate Structure
- Reconstruction of Pandacan Bridge

(4) 2000 Study on Existing Laterals in Metro Manila[4]

The Study on Existing Laterals in Metro Manila was conducted under Local Development Study Program assisted by JICA in cooperation with DPWH and MMDA in 2000. Objectives of the study are as follows.

- To ascertain the present condition of existing drainage laterals,

- To establish a database of drainage laterals, and
- To analyze problems in the laterals of drainage system.

The following are outlines of the study based on the above report of Study on Existing Laterals in Metro Manila.

1) Field Survey of Existing Drainage Laterals and Inundation Conditions

Surveyed manholes and drainage channels are 7,178 manholes and 209 cross-sections in 19 open channels, respectively. Total length of channels surveyed is as follows.

- Esteros: about 26 km,
- Drainage mains and outfalls: 33 km, and
- Drainage laterals: 55 km

An inundation survey was made for the 1999 floods to evaluate the performance of existing drainage system. Also, interviews were conducted for 1,756 residents in the core area of Metro Manila to acquire a full appreciation of the 1999 floods. Based on the field survey results, flood problems are identified and analyzed as follows.

2) Identification and Analysis of Flooding Problems

Runoff and flow capacity estimation was made against 2-year and 10-year return periods. According to the above calculation, it can be said that almost all drainage laterals and a number of drainage mains and esteros have limited flow capacity against both the 2-year and 10-year return periods.

Flooding areas were categorized into two types of regional flooding and local flooding by size of area to be affected. The most seriously affected areas as regional one were eastern portions in North Manila from Sta. Mesa Heights to Sampaloc and Quiapo. In Sampaloc and Quiapo areas, flooding depth exceeded 0.5 m in many places. In some places, it reached 1.3 m. Average duration was 20 to 30 hours. In South Manila, the seriously affected areas classified as regional flooding were San Andres Bukid, San Antonio Village, Metropolitan Subdivision, Palanan, San Isidro and Bangkal (regional flooding). Average depth reached 1.0 m on the streets of Coral, Zobel-Roxas Avenue and exceeded 0.5 m in many places. The average duration ranges from 3 to 4 hours.

3) Establishment of Database

For the above-mentioned data, the database system was designed to facilitate the retrieval of necessary information to support the drainage system operation, maintenance rehabilitation and improvement programs of responsible agencies. The database system consists of the following 5 primary ones:

- Hardware and software composition,
- Digital location maps with 1/10,000 scale,
- Database of drainage channels and manholes
- Lateral database, and
- Flood condition database.

4) Conclusion and Recommendations

To cope with the above situation and problems, it is recommended that a comprehensive drainage plan through master plan study be undertaken. Areas identified for the master plan study are the Sampaloc area of North Manila and the San Antonio-Palanan-Pio del Pilar-San

Isidro (areas along Estero de Tripa de Gallina system) of South Manila.

In connection with conducting the above master plan study, the following are further recommended.

- Implementation of Urgent Works
- Strengthening of Inter-agency Coordination
- Management of Database System
- Follow-up Study on the Flooding Problem in Metropolitan Manila

(5) 2002 Planned Project for Pasig-Marikina River Flood Control[5]

The Pasig-Marikina River Channel Improvement was proposed as an urgent project through the feasibility study in the JICA Study conducted in the period from 1988 to 1990. For this urgent project, OECF (now called JBIC) extended its financial support and executed Special Assistance for Project Formation (SAPROF) in 1998. Subsequently, OECF extended its loan for implementation of the urgent project under the 23rd loan package in June 1999. Thus the detailed engineering design was carried out for Pasig-Marikina River Channel Improvement Project from Oct. 2000 to Mar. 2002. The construction works are scheduled to commence in the year of 2004, but it has not commenced yet. The project features are outlined below, referring to Detailed Engineering Design of Pasig-Marikina River Channel Improvement Project, Main Report, Vol. II, DPWH, March. 2002.

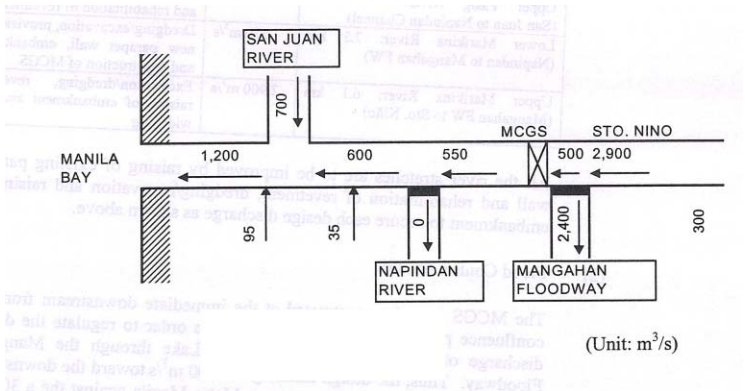
1) Basic Conditions of Flood Control

Objective river length to be improved is around 30.3 km in total as divided below.

Pasig River: River mouth (Del Pan Bridge) to Napindan gate (17.1 km)

Marikina River: Napindan gate to Marikina Bridge (13.2 km)

The design discharge distribution for the river channel improvement against the 30-year return period is shown in *Figure E.2.1*. *Figure E.2.2* presents a proposed longitudinal profile of Pasig River.



Source: Detailed Engineering Design of Pasig-Marikina River Channel Improvement Project, Main Report, Vol. II, DPWH, March. 2002.

Figure E.2.1 Design Discharge Distribution of Pasig-Marikina River

2) Basic Conditions of Drainage Improvement

Objective area of drainage is 3,600 ha having 139 sub-catchments directly drained to the Pasig-Marikina River, consisting of 72 sub-catchments into Pasig River and 67 sub-catchments into Marikina River as shown in *Figure E.2.3*. A 10-year return period is adopted for the drainage improvement in the sub-catchment.

3) Planned Works

The proposed works consist of:

- River Channel Improvement of the Pasig-Marikina River,
- Construction of Marikina Control Gate Structure (MCGS) in the lower Marikina River and
- Drainage Improvement in the catchment along the Pasig-Marikina River.

On the other hand, drainage structures are to be constructed in line with the scheme as shown in *Figure E.2.4*. They are reinforced concrete pipe and box culvert, curb inlet, flap gate, slide gate, etc.

4) Proposed Phasing and Construction Schedule

The construction works are divided into 3 phases consisting of 5 packages and scheduled as follows.

Phase 1 works in the Pasig River (2003 to 2008 by JBIC 26th Loan)

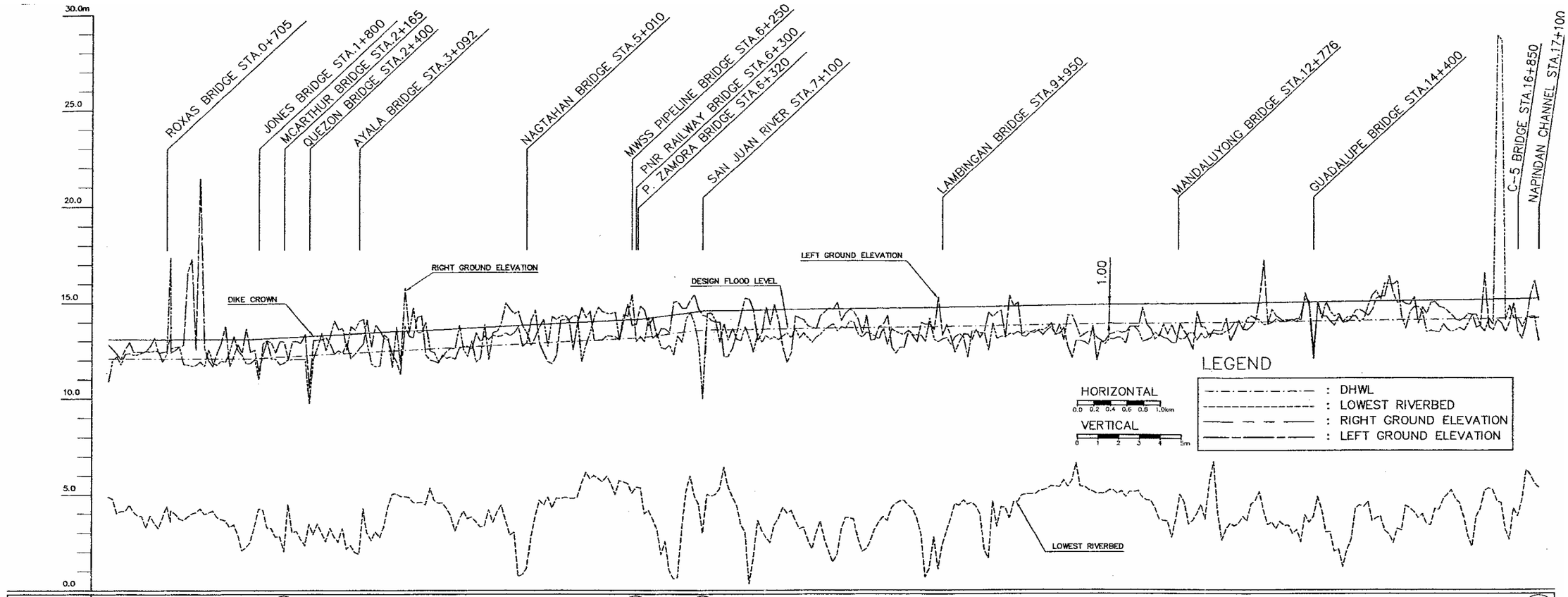
- Del Pan bridge to Lambingan bridge (9.2 km)
- Lambingan bridge to confluence with Napindan channel (7.2 km)

Phase 2 works in the Lower Marikina River (2004 to 2009)

- MCGS and its vicinity (1.2 km)
- Confluence with Napindan channel to MCGS (6.0 km)

Phase 3 works in the upper Marikina River (2005 to 2010)

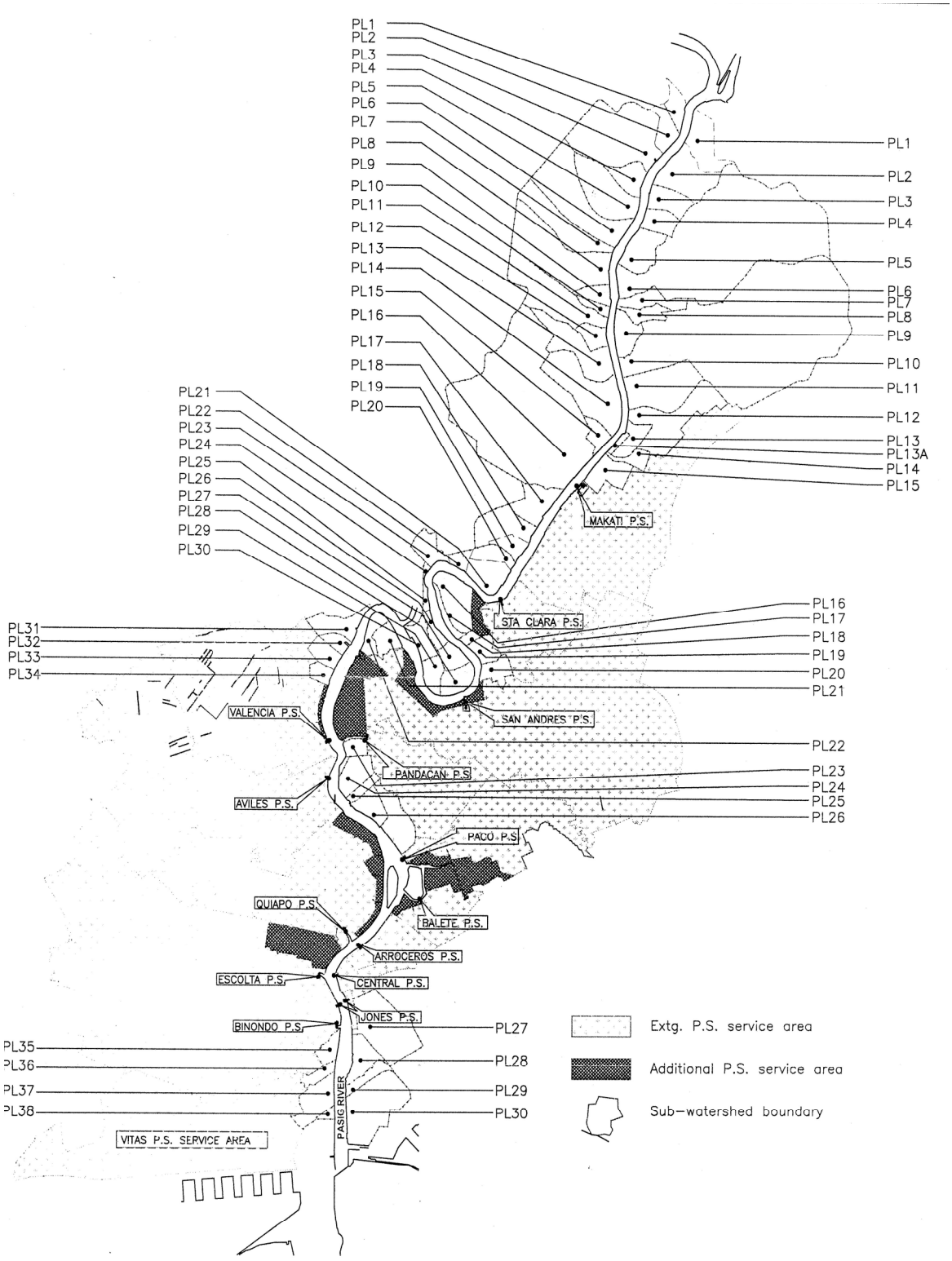
- MCGS to Marikina bridge (6.1 km)



STATION NUMBER	PARTIAL DISTANCE (Km)	ACCUMU-LATIVE DIST. (km)	ELEVETION – METERS: LOWEST RIVER BED	MEAN RIVER BED	LEFT GROUND ELEV.	RIGHT GROUND ELEV.	DESIGN RIVER BED	D.F.L.	DESIGN DIKE CROWN	DESIGN RIVER BED SLOPE	DESIGN D.F.L. SLOPE
0.000	0	0	4.891		12.820	10.937		12.100	13.100		LEVEL L=1.700km
0.200	0.200	0.200	4.141		12.611	12.351		12.100	13.100		
0.400	0.200	0.400	3.881		12.100	12.407		12.100	13.100		
0.600	0.200	0.600	3.251		12.100	12.491		12.100	13.100		
0.800	0.200	0.800	4.011		12.701	12.541		12.100	13.100		
1.000	0.200	1.000	4.011		17.311	11.731		12.100	13.100		
1.200	0.200	1.200	4.081		12.011	12.591		12.100	13.100		
1.400	0.200	1.400	3.661		13.791	11.931		12.100	13.100		
1.600	0.200	1.600	2.091		12.381	12.271		12.100	13.100		
1.800	0.200	1.800	4.261		11.41	11.010		12.100	13.119		
2.000	0.200	2.000	2.791		12.411	12.081		12.100	13.166		
2.200	0.200	2.200	3.031		12.991	12.061		12.109	13.212		
2.400	0.200	2.400	3.451		10.561	9.791		12.150	13.259		
2.600	0.200	2.600	2.561		13.191	12.521		12.192	13.305		
2.800	0.200	2.800	3.241		12.381	13.701		12.234	13.352		
3.000	0.200	3.000	1.901		12.611	14.081		12.275	13.398		
3.200	0.200	3.200	3.081		13.861	11.681		12.317	13.445		
3.400	0.200	3.400	5.051		12.311	11.611		12.359	13.491		
3.600	0.200	3.600	4.861		13.261	13.451		12.400	13.538		
3.800	0.200	3.800	4.471		12.291	14.031		12.442	13.584		
4.000	0.200	4.000	4.564		12.279	12.179		12.484	13.631		
4.200	0.200	4.200	3.689		12.637	13.843		12.525	13.677		
4.400	0.200	4.400	3.589		13.434	11.919		12.567	13.724		
4.600	0.200	4.600	3.552		13.315	13.448		12.609	13.770		
4.800	0.200	4.800	2.888		13.303	14.093		12.650	13.817		
5.000	0.200	5.000	1.151		12.911	13.451		12.863	13.863		
5.200	0.200	5.200	4.456		12.363	14.148		12.734	13.910		
5.400	0.200	5.400	4.794		14.116	14.340		12.775	13.956		
5.600	0.200	5.600	4.861		13.945	14.361		12.817	14.003		
5.800	0.200	5.800	6.022		13.051	14.277		12.859	14.049		
6.000	0.200	6.000	5.589		13.251	14.474		12.900	14.095		
6.200	0.200	6.200	5.603		14.945	14.330		12.942	14.142		
6.400	0.200	6.400	3.997		14.651	12.991		13.003	14.555		
6.600	0.200	6.600	1.866		13.700	12.859		13.123	14.567		
6.800	0.200	6.800	0.659		15.098	13.284		13.242	14.579		
7.000	0.200	7.000	4.919		15.471	13.938		13.361	14.591		
7.200	0.200	7.200	4.909		14.114	14.499		13.453	14.604		
7.400	0.200	7.400	5.438		12.199	13.061		13.465	14.616		
7.600	0.200	7.600	3.051		15.265	13.779		13.477	14.628		
7.800	0.200	7.800	3.093		13.452	12.933		13.489	14.640		
8.000	0.200	8.000	3.755		14.104	13.065		13.500	14.652		
8.200	0.200	8.200	3.651		14.326	13.679		13.512	14.664		
8.400	0.200	8.400	2.158		13.731	12.923		13.524	14.676		
8.600	0.200	8.600	2.062		14.730	13.771		13.536	14.688		
8.800	0.200	8.800	3.777		14.481	13.683		13.548	14.700		
9.000	0.200	9.000	2.033		13.391	13.199		13.559	14.713		
9.200	0.200	9.200	3.581		13.759	13.093		13.571	14.725		
9.400	0.200	9.400	4.524		12.353	13.499		13.583	14.737		
9.600	0.200	9.600	4.239		13.252	13.302		13.595	14.749		
9.800	0.200	9.800	1.150		13.903	14.212		13.806	14.761		
10.000	0.200	10.000	3.062		13.887	13.175		13.618	14.773		
10.200	0.200	10.200	4.700		14.351	13.199		13.830	14.785		
10.400	0.200	10.400	3.956		13.162	13.401		13.642	14.797		
10.600	0.200	10.600	3.321		14.499	13.116		13.653	14.810		
10.800	0.200	10.800	4.589		14.829	13.334		13.665	14.822		
11.000	0.200	11.000	5.045		13.447	13.436		13.677	14.834		
11.200	0.200	11.200	5.302		13.570	13.693		13.689	14.846		
11.400	0.200	11.400	5.751		13.898	13.028		13.700	14.858		
11.600	0.200	11.600	5.411		12.988	13.180		13.712	14.870		
11.800	0.200	11.800	5.040		11.983	13.133		13.724	14.882		
12.000	0.200	12.000	5.221		13.371	13.071		13.736	14.894		
12.200	0.200	12.200	5.161		13.781	13.766		13.748	14.907		
12.400	0.200	12.400	4.681		13.871	13.021		13.759	14.919		
12.600	0.200	12.600	3.821		13.161	13.901		13.771	14.931		
12.800	0.200	12.800	4.991		13.921	13.091		13.781	14.943		
13.000	0.200	13.000	3.971		14.551	13.391		13.795	14.955		
13.200	0.200	13.200	6.701		13.581	13.391		13.806	14.967		
13.400	0.200	13.400	3.471		12.971	13.841		13.818	14.979		
13.600	0.200	13.600	3.601		13.591	14.191		13.830	14.991		
13.800	0.200	13.800	4.101		17.271	13.871		13.842	15.004		
14.000	0.200	14.000	3.571		14.181	14.051		13.853	15.016		
14.200	0.200	14.200	3.151		14.181	13.981		13.865	15.028		
14.400	0.200	14.400	3.831		12.081	12.391		13.877	15.040		
14.600	0.200	14.600	3.041		14.051	14.561		13.889	15.052		
14.800	0.200	14.800	2.101		14.001	14.261		13.900	15.064		
15.000	0.200	15.000	4.341		14.911	14.191		13.912	15.076		
15.200	0.200	15.200	3.851		15.341	15.171		13.924	15.088		
15.400	0.200	15.400	3.201		14.991	16.141		13.936	15.100		
15.600	0.200	15.600	4.071		15.301	14.791		13.948	15.113		
15.800	0.200	15.800	3.381		15.011	13.561		13.959	15.125		
16.000	0.200	16.000	5.011		14.561	13.601		13.971	15.137		
16.200	0.200	16.200	3.781		14.201	13.561		13.983	15.149		
16.400	0.200	16.400	4.221		13.811	13.761		13.995	15.161		
16.600	0.200	16.600	4.627		14.107	28.865		14.006	15.173		
16.800	0.200	16.800	4.241		14.941	14.181		14.018	15.185		
17.000	0.200	17.000	6.037		15.394	14.272		14.030	15.197		
17.100	0.100	17.100	5.354		15.096	12.976		14.036	15.204		

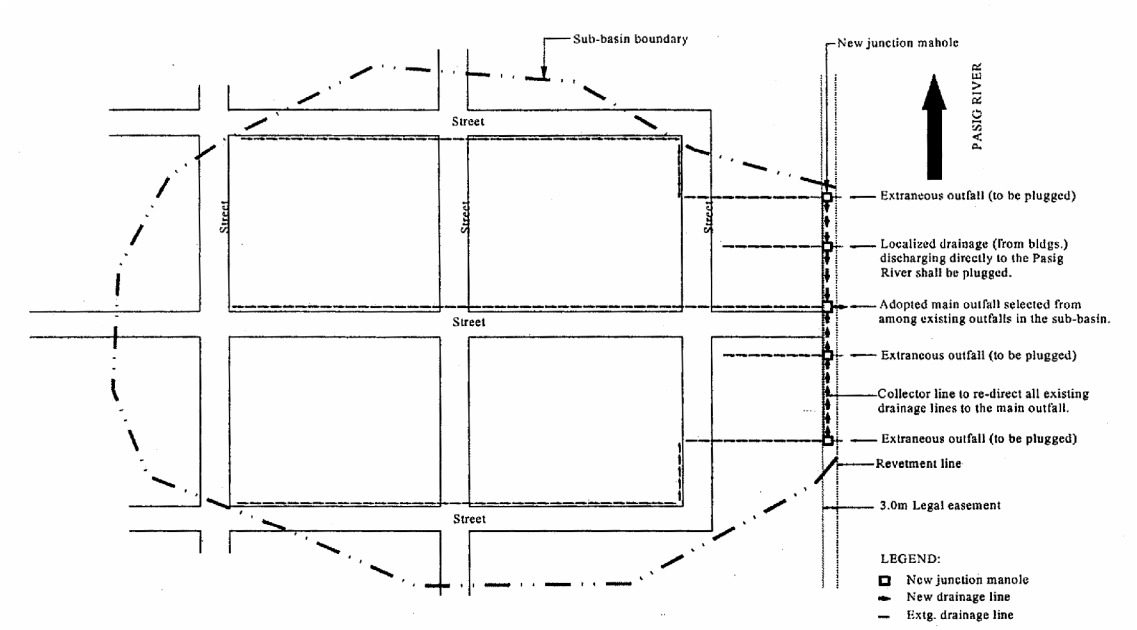
Source: Detailed Engineering Design of Pasig-Marikina River Channel Improvement Project, Main Report, Vol. II, DPWH, March. 2002.

Figure E.2.2 Longitudinal Profile of Pasig River



Source: Detailed Engineering Design of Pasig-Marikina River Channel Improvement Project, Main Report, Vol. II, DPWH, March. 2002.

Figure E.2.3 Sub Catchment Areas Directly Drained to Pasig River



Typical Drainage Scheme

Source: Source: Detailed Engineering Design of Pasig-Marikina River Channel Improvement Project, Main Report, Vol. II, DPWH, March. 2002.

Figure E.2.4 Concept of Drainage Improvement

E.2.3 CURRENT STUDIES RELATED TO DRAINAGE IMPROVEMENT IN THE CORE AREA

The following 3 plans related to drainage in the core area of Metropolitan Manila are briefly explained below. They are 1) Study on Water Supply and Sewerage Master Plan of Metro Manila in the Republic of the Philippines, 2) Earthquake Impact Reduction Study for Metropolitan Manila, Republic of the Philippines and 3) Manila Metropolitan Region Environment Improvement Study.

(1) 1990 Manila Metropolitan Region Environment Improvement Study[6]

The Environmental Management Bureau of the Department of Environment and Natural Resources (DENR) conducted this study assisted by Asian Development Bank in 1990. An objective of the study is to prepare an integrated environmental improvement program and consequent action plan to alleviate problems of environmental degradation in Metropolitan Manila.

The proposed integrated environmental improvement program consists of 2 major components. The first component is an environmental management program consisting of various non-engineering elements to support successful implementation of physical improvement projects. The second one consists of physical improvement projects that address the most serious problems and improve the quality of life in Metropolitan Manila.

In line with the above program, the following 5 action plans are proposed with a 5 years implementation period.

- Environmental management and monitoring program
- Integrated solid waste management program
- Flood control and drainage program
- Water quality management program
- Industrial pollution control program

Among the above 5 plans, the flood control and drainage program covers 1) East-West Mangahan drainage and flood control project, 2) Navotas-Malabon drainage and flood control project, 3) Pasig-Marikina River flood control project, and 4) Upgrading and realignment of informal settlers in the above 3 projects.

(2) 1996 Study on Water Supply and Sewerage Master Plan of Metro Manila[7]

In February 1996, the Metropolitan Waterworks and Sewerage System (MWSS) formulated a JICA-assisted master plan for water supply and sewerage including sanitation. In this sub section, outline of the master plan is briefly explained below, referring to the said report.

The master plan area covers 15,588 ha consisting of 5 systems of West Mangahan, South Manila, Ayala, Central Manila and North Manila, having a total population of 5.1 million. Direct objectives of the study are to establish development strategy on expansion of service areas and quality improvement of sewerage and sanitation. Throughout the study, the following respective 8 sewerage projects and 15 sanitation projects are formulated and planned to implement dividing into 2 phases of phase 1(up to 2010) and phase 2 (2009 to 2015).

Table E.2.3 Planned Sewerage Projects

Sewerage Project Name	*Project Type*	*Implementation*
Ayala sewerage treatment plant rehabilitation	*Rehabilitation*	*Phase 1*
Ayala sewerage system rehabilitation	*Rehabilitation*	*Phase 1*
Central Manila sewerage system rehabilitation	*Rehabilitation*	*Phase 1*
South Manila sewerage system rehabilitation	*Rehabilitation*	*Phase 2*
Central Manila sewerage system expansion	*Expansion*	*Phase 2*
North Manila sewerage system expansion	*Expansion*	*Phase 2*
West Mangahan sewerage system expansion	*Expansion*	*Phase 2*
Ayala sewerage treatment plant rehabilitation	*Rehabilitation*	*Phase 2*

Source: Study on Water Supply and Sewerage Master Plan of Metro Manila, Final Report, Vol. I, Main Report

Table E.2.4 Planned Sanitation Projects

Sanitation Project Name	*Project Type*	*Implementation*
Septage collection and hauling	*Management*	*Phase 1*
Barging of septage for sea dumping	*Management*	*Phase 2*
Barge loading station 1st stage construction	*Management*	*Phase 1*
Barge loading station 2nd stage construction	*Management*	*Phase 2*
Dagat-Dagatan septage treatment plant (STP) 1st stage construction	*Management*	*Phase 1*
Supply of laboratory equipment, vacuum car etc.	*Management*	*Phase 1*
Dagat-Dagatan STP 2nd stage construction	*Management*	*Phase 2*
Dagat-Dagatan STP 3rd stage construction	*Management*	*Phase 2*
Quezon city STP 1st stage construction	*Management*	*Phase 2*
Quezon city STP 2nd stage construction	*Management*	*Phase 2*
Quezon city STP 3rd stage construction	*Management*	*Phase 2*
Taguig STP construction	*Management*	*Phase 2*
Paranaque STP 1st stage construction	*Management*	*Phase 2*
Paranaque STP 2nd stage construction	*Management*	*Phase 2*
Binangonan STP construction	*Management*	*Phase 2*

Source: Study on Water Supply and Sewerage Master Plan of Metro Manila, Final Report, Vol. I, Main Report

(3) 2004 Earthquake Impact Reduction Study for Metropolitan Manila[8]

MMDA and Philippine Institute of Volcanology and Seismology (PHIVOLCS) assisted by JICA conducted an Earthquake Impact Reduction Study for Metropolitan Manila in 2004. The objective of the study is to set forth basic policy and direction in pursuit of the vision of a safer Metropolitan Manila for earthquake impact. This plan is a road map to achieve the vision and structure of the plan.

The following are goals to attain the vision.

- To develop national system resistant to earthquake impact
- To improve Metropolitan Manila's urban structure resistance to earthquake
- To enhance effective risk management system
- To increase community resilience
- To formulate reconstruction system
- To propel research and technology development for earthquake impact reduction measures

As seen in *Table E.2.5*, the goals have 10 objectives, and then the objectives are broken down into 34 frameworks in total. The frameworks represent main policies and strategies to achieve goals and objectives. The frameworks contain 100 action plans to put in practice of the policies and strategies.

Table E.2.5 Structure of the Disater Management Plan for Metro Manila

Vision	Goals	Objectives		Frameworks
A safer Metropolitan Manila for earthquake impact	To develop national system resistant to earthquake impact	To increase social and community sustainability	NSD-1	Protectr stability of national government function
			NSD-2	Protect stability ofsocio-economic system
	To improve metropolitan Manila`s urban structue resistant to earthquake	To increas resistance of Metropolitan manila`s vulnerable areas	USI-1	Promote earthquake resistant urban development
			USI-2	Promote flameless urban development
			USI-3	Promote spacial urban development
		To increase resistance of Metro Manila`s buildings	USI-4	Promote earthquake resistant buildings
			USI-5	Promote earthquake resistant public facilities
		To increase resistance of Metro Manila`s buildings	USI-6	Promote earthquake resistant infrastracture
			USI-7	Promote earthquake resistant lifeline
	To enhance effective risk management system	To prevent secondary effects and damages	RMS-1	Promote fire preparedness and mitigation including hazardous materials
			RMS-2	Take measures against tsunami
		To strenghthen disaster management system	RMS-3	Enhance resistance basis for disaster management
			RMS-4	Strenghthen institutional capacity for implementing preparedness and mitigation measures
		To improve disaster response capability	RMS-5	Stenghthen inter-institutional coordination
			RMS-6	Strenghthen institutional disaster response capability
			RMS-7	Develop operation systems and procedures
			RMS-8	Enhance capability of fire suppression and hazardous material abatement
			RMS-9	Secure evacuation route and evacuation site
			RMS-10	Secure water,food and other necessaries
			RMS-11	Enhance emergency health and medical response system
			RMS-12	Establish emergency transportation system
			RMS-13	Establish search and rescue system
		To ensure access to critical information	RMS-14	Establish information and communication system
			RMS-15	Establish geographic information system
			RMS-16	Manage emergency public information
	To increase community resilience	To establish disaster management mechanism through enhancement of social capital	CRI-1	Enhance self reliant and mutual help risk management capacity
			CRI-2	Inculcate disaster culture in future generation
	To formulate reconsruction system	To improve community recovery capability	RSF-1	Supply temporary refugee housings
			RSF-2	Prepare emergency assistance for everyday life
			RSF-3	Estalish debris clearance and management system
			RSF-4	Restore public and social services
			RSF-5	Establish post-disater reconstruction system of the damaged area
			RSF-6	Enhance institutional aspect
	To propel research and technology development for earthquake impact reduction measures	To sustain research and effective transfer of technology	R&D-1	Promote sustained research and development on earthquake

E.3 COMPLETED AND ONGOING FLOOD CONTROL AND DRAINAGE IMPROVEMENT PROJECTS IN THE CORE AREA

E.3.1 GENERAL

A flood control and drainage improvement works in Metropolitan Manila were initiated by the then BPW in the 1940s. A drainage improvement master plan was originally formulated by BPW in 1954. In line with the said plans, BPW and/or DPWH carried out various construction works of drainage channels, dredging of river channels and construction of other related works in Metropolitan Manila by own fund. Flood and drainage situations in Metropolitan Manila were so much improved. However, wide vulnerable areas to inundation are still remaining because of lack of adequate drainage facilities, lack of flow capacity of drainage channel, occupation of informal settlers in and along drainage channels, etc. To cope with such serious situations, systematic flood control and drainage improvement projects were one after the other started in the 1970s.

E.3.2 COMPLETED PROJECTS

(1) Drainage Improvement Project

Major drainage improvement projects in Metropolitan Manila were started in the beginning of 1970s in line with the then master plan. More than 20 drainage pumping stations have been constructed within the core area of Metropolitan Manila so far, mainly by financial assistance of foreign countries, whereas DPWH-NCR, LGUs and private developers also undertook small-scale drainage projects by national or own funds. Among those are outlined below.

Table E.3.1 Drainage Improvement Project

Year	*Project*
1973	*Improvement Works of Drainage Facilities (BPW)*
1975	*Pasig River Flood Control Project (BPW/WB)*
1983	*Manila and Suburbs Flood Control and Drainage Project (DPWH, OECF 1st loan)*
1985	*Planning and Detailed Engineering Design for Flood Control and Drainage Project (DPWH)*
1987	*Metro Manila Drainage System Rehabilitation Project (DPWH, OECF 12th loan*
1988	*Pasig River (Mangahan Floodway) Flood Control Project (DPWH, OECF 4th loan)*
1989	*Retrieval of Flood Prone Area in Metro Manila (DPWH, JICA)*
1992	*Retrieval of Flood Prone Area in Metro Manila (II) (DPWH, JICA)*
1993	*Pasig River Rehabilitation Project (PRRP and DSWPR) (DPWH, Danish/Belgian)*
1996	*North Laguna Flood Control Project (DPWH, OECF 16th loan)*
1998	*Metro Manila Flood Control Project (II) (DPWH, OECF 14th loan)*
2001	*Rehabilitation of Flood Control Operation and Warning System in Metro Manila (PAGASA/JICA)*
2002	*Dredging and Sanitation Works for Pasig River Area (Belgian Government)*

Major completed projects in the core area of Metropolitan Manila are explained in the following.

1) Manila and Suburbs Flood Control and Drainage Project by OECF 1st Loan (1973 to 1983)

The following 10 drainage pumping stations having each a drainage capacity against a 10 year-design storm were constructed in the core area of Metropolitan Manila.

Table E.3.2 Features of Constructed Drainage Pumping Stations (1/3)

Name	*Location*	*Completion Year*	*Pump Capacity (m^3/s)*	*Project Cost (Php)*
Pandacan	*Pandacan, Manila*	*April 1976*	*4.4*	*8,431,000*
Aviles	*Sampaloc, Manila*	*June 1976*	*15.6*	*18,468,000*
Quiapo	*Quiapo, Manila*	*June 1976*	*9.5*	*18,243,000*
Valencia	*Sta. Mesa, Manila*	*June 1976*	*10.5*	*14,640,000*
Tripa de Gallina	*Pasay*	*July 1977*	*56.0*	*73,694,000*
Sta. Clara	*Sta. Ana, Manila*	*May 1977*	*5.3*	*10,898,000*
Paco	*Paco, Manila*	*May 1977*	*7.6*	*19,479,000*
Libertad	*Pasay*	*May 1982*	*42.0*	*62,934,900*
Makati	*Makati*	*July 1984*	*7.0*	*10,620,000*
Binondo	*Binondo, Manila*	*July 1985*	*11.6*	*22,686,000*

Source: Brief Information on the NCR-DPWH Pumping Stations and Floodgates Project, MMDA, 1999.

In connection with the above projects, the following independent floodgates were constructed at Balete, Pandacan and Sta. Banez (3 floodgates) in 1978 and at Escolta, Binondo and Vitas (3 floodgates) in 1983, respectively. The above Binondo and Vitas floodgates were integrated in one location beside the Binondo Pumping Station due to design changes of the Binondo Pumping Station scheme. Accordingly, there exist 5 independent floodgates along the Pasig River.

2) Expansion of Tripa de Gallina Pump Station and Procurement of Pump Equipment Project by EXIM Bank of Japan (1978)

In this project, appurtenant equipment to pump for Libertad, Makati and Binondo was procured and repaired, and pump capacity of Tripa de Gallina was expanded by 15 m^3/s.

3) Metro Manila Drainage System Rehabilitation Project by OECF 12th Loan (1984 to 1987)

In this project, the following 2 drainage pump stations as shown in *Figure E.3.3* were constructed and also some repair and rehabilitation works for the above explained 10 drainage pumping stations were made. On the other hand, the then drainage improvement plan was reviewed based on the recommendations by Final Alternative Master Plan Strategy Report for the Metro Manila Integrated Urban Drainage and Flood Control Master Plan (Phase 1) and changing natural and social conditions in and around Metro Manila.

Table E.3.3 Features of Constructed Drainage Pumping Stations (2/3)

Name	*Location*	*Completion Year*	*Pump Capacity (m^3/s)*	*Project Cost (Php)*
Balete	*Ermita, Manila*	*Oct. 1989*	*2.5*	*7,890,000*
Escolta	*Sta. Cruz, Manila*	*1991*	*1.5*	*9,552,000*

Source: Brief Information on the NCR-DPWH Pumping Stations and Floodgates Project, MMDA, 1999.

4) Metro Manila Flood Control Project II by 14th OECF Loan (1988 to 1998)

Based on the above reviewed plan, this project constructed the following 3 drainage pumping stations as shown in *Figure E.3.4* and improved major esteros.

Table E.3.4 Features of Constructed Drainage Pumping Stations (3/3)

Name	*Location*	*Completion Year*	*Pump Capacity (m^3/s)*	*Project Cost (Php)*
Vitas	*Tondo, Manila*	*1997*	*32.0*	*456,552,000*
Balut	*Tondo, Manila*	*1997*	*2.0*	*81,954,000*
San Andres	*Pandacan, Manila*	*1998*	*19.0*	*339,492,000*

Source: Brief Information on the NCR-DPWH Pumping Stations and Floodgates Project, MMDA, 1999.

5) Construction of Drainage Pumping Stations financed by National Fund

Aside from the above foreign-assisted projects, the following 8 locally funded small pumping stations projects were implemented in the core area of Metropolitan Manila as shown in *Table E.3.5*.

Table E.3.5 Small Pumping Stations

Name	*Total Drainage Capacity (m^3/s)*
Malacanang P.S. No.1	0.66
Malacanang P.S. No.2	0.76
Arroceros P.S.	*0.66*
Luneta Park P.S.	*0.42*
Central Post Office P.S.	*0.56*
Jones Bridge Underpass P.S. No.1	*0.26*
Jones Bridge Underpass P.S. No.2	*0.36*
Sta.Banez P.S.	*0.318*

6) Retrieval of Flood-Prone Area, Improvement of Drainage Channels and Others in Metropolitan Manila financed by National Fund

Dredging equipment and appurtenant tools for operation and maintenance of drainage channel in Metropolitan Manila were provided to DPWH/MMDA through Japanese Grant Aid in 1989 and 1992, respectively. They are clamshells, barge, dump trucks, cranes, vacuum cars, etc. By using this equipment and tools, dredging and cleaning of major esteros in Metro Manila were carried out by Metro Manila Flood Control Project. Such equipment is presently working in the site effectively.

Aside from the above, small-scale drainage improvement works have been implemented so

far by the respective agencies of DPWH-NCR, MMDA and LGUs. Major ones are improvement of drainage mains and laterals, dredging of esteros, constructions of outfall, etc. In addition, a land reclamation plan is now at the stage of implementation in Manila Bay along Roxas Boulevard by Public Estates Authority (PEA). Among planned reclamation areas, two blocks directly related to the Study have been completed.

(2) Flood Control Project

As already explained in the above, flood control of the Pasig and Marikina Rivers was initiated by the BPW in the 1940s. The major projects completed so far in and around the study area are explained below.

1) Pasig River Flood Control Project by World Bank and OECF 4th Loan (1975 to 1988)

In this project, Mangahan Floodway was constructed to divert floodwater from the upper Marikina River to Laguna de Bay. Major dimensions of the floodway and structures are as follows.

- Design discharge: 2,400 m^3/s (100-year design flood)
- Floodway length and average river width: 9,000 m and 250 m
- Rosario weir: 9 vertical roller gates

2) Effective Flood Control and Operation System (EFCOS) by OECF Loan and JICA (1993, 1999-2002)

The EFCOS was completed in 1993 as a non-structural measure to observe and analyze information on rainfall and water level with the objective of using the information to operate river structures for flood mitigation in the Pasig-Marikina River basin. EFCOS office is located at Rosario Master Control Station in the compound of Rosario weir.

However, the system is deficient for the monitoring of flooding conditions because the observation network does not keep up with the urbanization. In addition, the system is not able to meet the requirements for small and middle-sized floods resulting in progress of urbanization.

Taking the above into consideration, DPWH subsequently formulated a project to improve and enhance the overall function of EFCOS and made a request to the Government of Japan for its implementation under Japan's Grant Aid. The project started in 1999 and completed in 2002. Major works performed are as follows.

- Improvement of hydrological observation network
- Improvement of telecommunication system
- Rehabilitation of data processing system

3) Dredging and Sanitation Works for Pasig River Area assisted by Belgian Government (2000~2002)

This project is the dredging and sanitation works for Pasig River that is a component of Pasig River Rehabilitation Projects by Pasig River Rehabilitation Commission (PRRC) directed by DPWH. This project is fund-assisted by a concessional loan extended to the Government of the Philippines by the Belgian Government. PRRC was established for the immediate interventions required for the improvement of environmental conditions in and along the Pasig River.

The objective river length covered was 4.5 km long from river mouth of Pasig River to Jones Bridge. Major works are dredging, wreck removal, relocation of informal settlers residing in the river area, etc. The total dredging volume was 676,000 m^3 consisting of non-contaminated of 395,000 m^3 and contaminated of 281,000 m^3.

E.3.3 ONGOING PROJECTS

There are various ongoing flood control and drainage projects in Metropolitan Manila as shown in *Figure E.3.1*. Major projects related to this study are Project for the Enhancement of Capabilities in Flood Control and Sabo Engineering of the DPWH, Linear Parks Development along the Pasig River, Pasig River Environment Management and Rehabilitation Sector Development Project, local drainage improvement works, etc. Aside from the above, Metro Manila Flood Control Project-West Mangahan Floodway Project and KAMANAVA (Kaloocan-Malabon-Navotas-Valenzuela) Area Flood Control & Drainage System Improvement Project are underway in the outside of the core area of Metropolitan Manila. Those of related projects are briefly explained below.

(1) Project ENCA: Project for the Enhancement of Capabilities in Flood Control and Sabo Engineering of the DPWH, Stage I assisted by JICA (2000~)

The Project ENCA is different from those projects that do not refer to any type of construction at all; it rather aims for nationwide human resources development and institutional development through the Project Type Technical Cooperation by JICA. An objective of the project is to enhance capability of DPWH in planning and design of flood control and Sabo facilities in order to cope with water-induced disasters. For this purpose, DPWH established PMO-FCSEC (Flood Control and Sabo Engineering Center, located at Napindan Hydraulic Control Structure Compound) as implementing body of the project. According to BRIEF NOTE ON PROJECT ENCA, DPWH and JICA, outputs through the project will be as follows.

- Basic functions, organizations and institutions of the FCSEC will be established and secured for sustainable activities,
- The technical standards in the field of flood control and Sabo will be upgraded and made available for use,
- Sufficient number of personnel of the DPWH will be trained,
- Basic Information System for profiling damages occurred on disaster prevention structures will be established, and
- The DPWH will form an internal system to extend the technical standards and other outputs of the project throughout all relevant offices of the DPWH for effective implementation of services.

(2) Linear Parks Development Project along the Pasig River assisted by ADB Loan (2000~)

This project is to create linear parks within the 10 m easements to be created along the both banks of the Pasig River from its river mouth to the confluence of Napindan channel. The linear parks development project is being implemented under Pasig River Rehabilitation Commission (PRRC) assisted by ADB Loan.

As a first batch, a total of 15 linear parks were identified and are in various stages of development from planning, design, construction, and operation and maintenance. Further, 12 linear parks have been proposed to construct as a second batch.

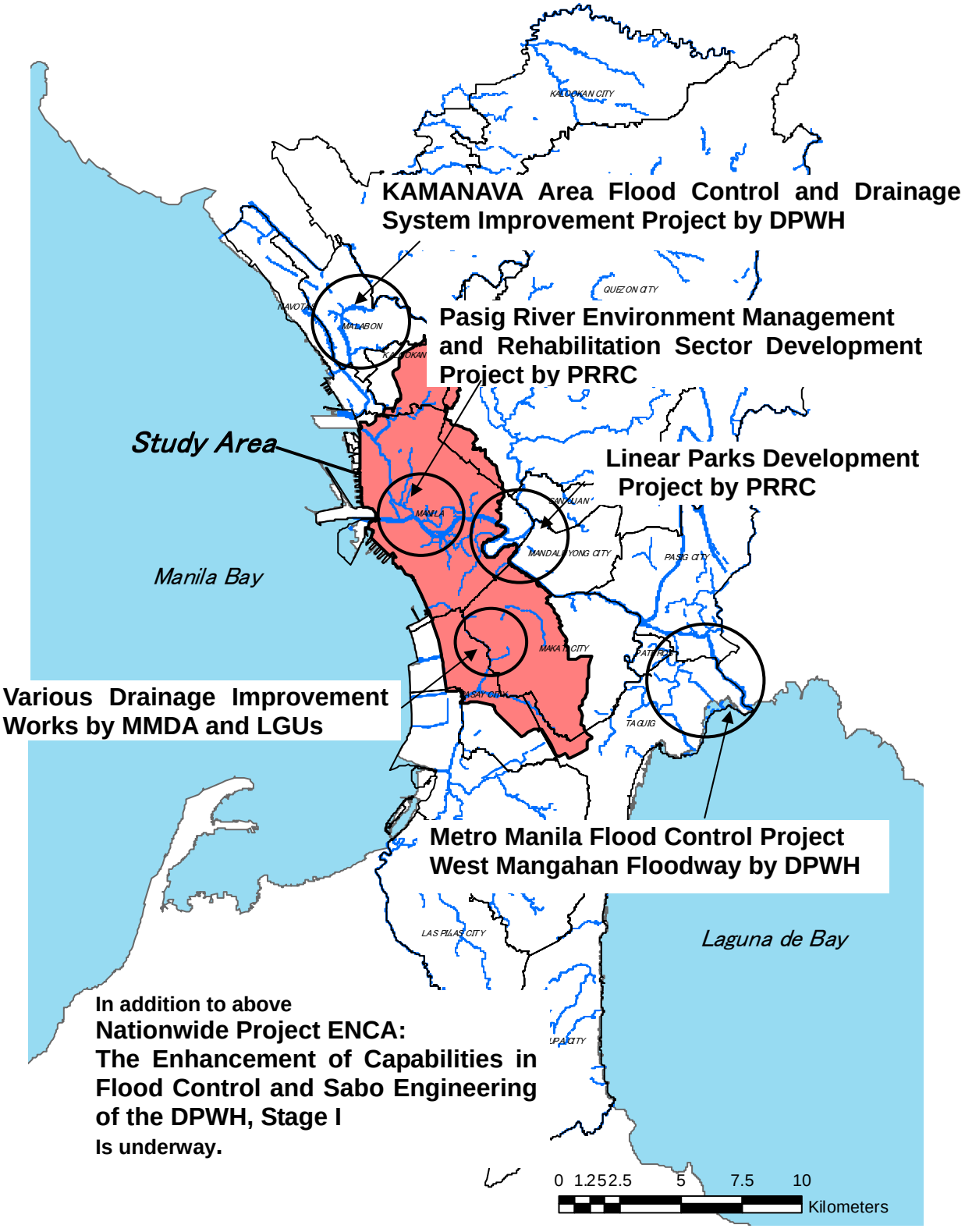


Figure E.3.1 Location of Major Ongoing Flood Control and Drainage Improvement Projects in Metropolitan Manila

(3) The Pasig River Environment Management and Rehabilitation Sector Development Project assisted by ADB (2001~)

This project is being implemented in line with an updated and integrated Pasig River Rehabilitation Master Plan formulated by PRRC with ADB financial assistance. PRRC was established in Jan. 1999 and consolidates the various government offices in charge of aspects of Pasig River rehabilitation into a single body. A goal of the project or program is to bring life back to the Pasig River so that people could reclaim it for leisure and livelihood. The Pasig River Program by said master plan includes an area approximately 500 m from the riverbank on both sides of the Pasig River.

These programs consist of 5 major programs of 1) environmental management, 2) urban renewal and rehabilitation, 3) housing and resettlement, 4) flood control and 5) information and advocacy. Also, it includes the final phase of the DANIDA assistance to the Pasig River Rehabilitation consisting of capacity building support to PMO, environment awareness, information campaigns and waste management. The programs are in various stages of development from planning, design, construction, and operation and maintenance.

(4) Metro Manila Flood Control Project-West Mangahan Floodway by OECF 21st Loan (1997~)

The project site is located in the respective administration areas of Taguig, Pateros and Pasig in Metropolitan Manila, and Cainta in Rizal Province. Major construction works with a loan period from March 1997 to June 2006 are as follows (Data source: PMO, DPWH).

- Lakeshore dike: 8.5 km
- Parapet wall: 5.8 km
- Drainage pumping stations: 4 pumping stations with a total drainage capacity of 36 m^3/s
- Regulation ponds: 4 ponds
- Floodgates: 9 floodgates
- Bridges: 2 bridges

(5) KAMANAVA (Kaloocan-Malabon-Navotas-Valenzuela) Area Flood Control and Drainage System Improvement Project by 24th JBIC Loan (1999~)

The project site is located at KAMANAVA area in Metropolitan Manila. The following are the major works of the KAMANAVA Area Flood Control and Drainage Project (Data source: PMO, DPWH).

Northern Area of Malabon River;

- Polder dike: 8.6 km
- Raising of river wall: 4.4 km
- FloodgatE.3 gates
- Control gate: 1 gate
- Drainage pumping station: 2 sites with a total drainage capacity of 10.5 m^3/s

Southern Area of Malabon River;

- Raising of river wall: 2.4 km
- Pumping drainage station: 4 sites with a total drainage capacity of 34.5 m^3/s

- Drainage channel (improvement): 6 km
- Drainage channel (construction): 2.7 km

(6) Other Drainage Improvement Works by National Fund

There are various drainage improvement works being made by MMDA and LGUs. Those of MMDA in 2004 are declogging of drainage laterals, desilting of drainage mains, dredging of esteros, etc. On the other hand, various local drainage improvements along local roads are undertaken by the respective LGUs.

E.4 DRAINAGE CONDITIONS

E.4.1 DRAINAGE SYSTEM IN THE CORE AREA

(1) Definition of Drainage Channels and Facilities

The drainage system in the core area consists of innumerable drainage channels and facilities, namely esteros/creeks, outfalls, drainage mains, laterals, road gutters, drainage pumping stations, floodgates, flood wall, etc. The terminology of the drainage channels and facilities has been defined in the present study as shown in *Table E.4.1*.

Table E.4.1 Definition of Drainage Channels and Facilities

Esteros / Creeks	*Open channels*
Drainage mains	*Closed channels consisting of one or two box culverts mostly connected to esteros*
Outfalls	*Drainage mains directly connected to Manila Bay or the Pasig River*
Laterals	*Small drainage channels other than above*
Drainage pumping stations	*Drainage facilities that drain storm water mechanically*
Floodgates	*Gate to control discharging storm water from esteros to the Pasig River when the water level at the Pasig River is lower than those in esteros*
Control gates	*Gate that controls the flow direction in esteros as boundary of drainage block*
Control walls	*Earth or concrete dike that controls flow direction in esteros as boundary of drainage block*
Detention ponds	*Pond that retards storm water for drainage pumping stations*
Interceptors	*Man-made channel that intercepts and drains storm water into esteros, the Pasig River and Manila Bay*

(2) Drainage System

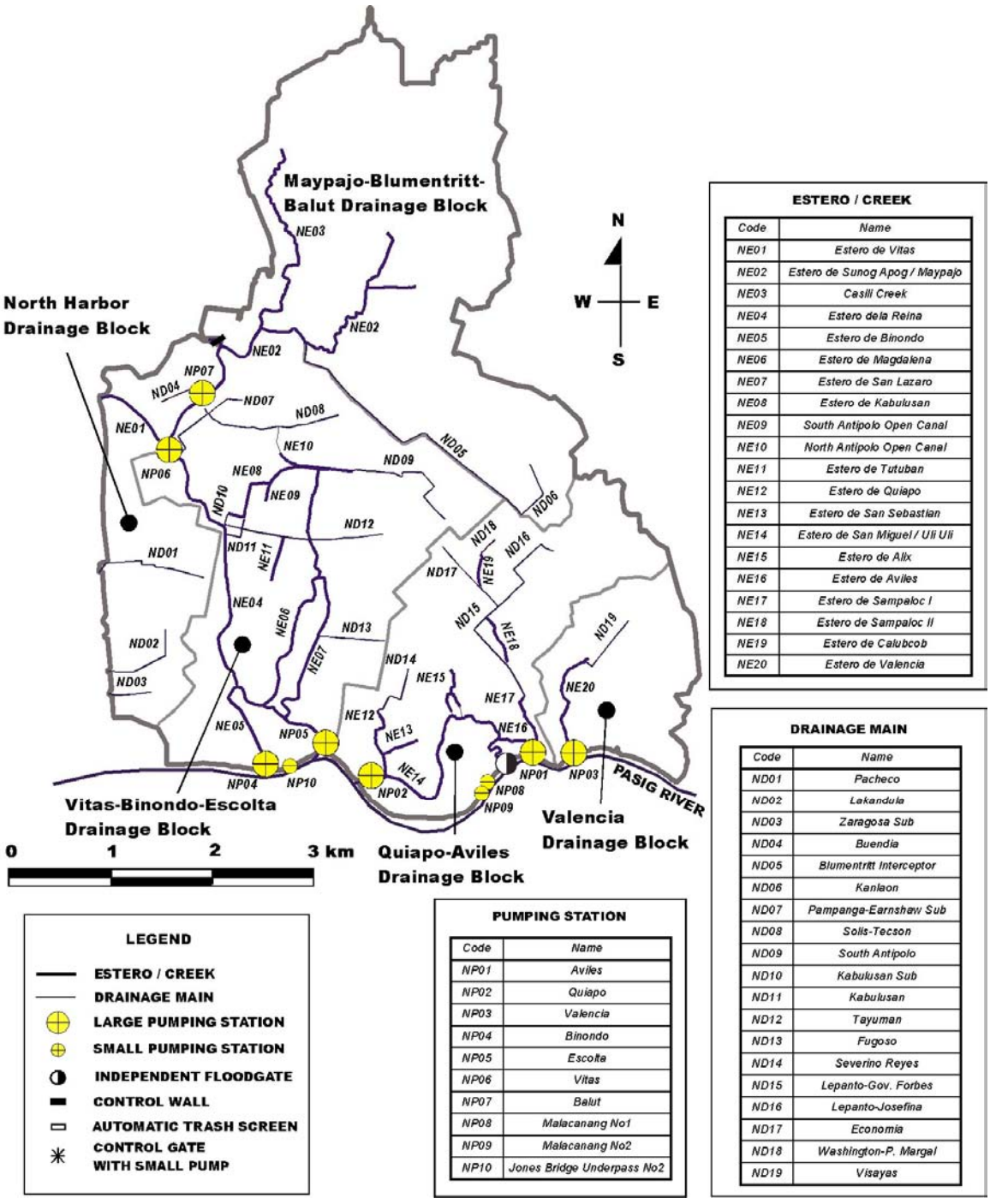
The total catchment area of the drainage system in the core area is about 73 km^2. Within the catchment, there are esteros / creeks and drainage mains with total length of about 74 km and 35 km, respectively. Density of drainage in the core area is thereby 1.0 km^{-1} for esteros / creeks, and 1.5 km^{-1} for both estreos / creeks and drainage mains. The drainage system in the core area is geographically divided by the Pasig River into two areas: South Manila (south or left bank of Pasig River) and North Manila (north or right bank of Pasig River).

(3) Drainage Block in North Manila

The drainage area in North Manila is divided into 5 drainage blocks with a total catchment area estimated at 28.78 km^2 as shown in *Figure E.4.1*. Major dimensions of each drainage block are summarized in *Table E.4.2*.

Table E.4.2 Major Dimensions of Each Drainage Block in North Manila

ID	*Name of Drainage Block*	*Area (km^2)*	*Total Length of Esteros /Creeks (km)*	*Total Length of Drainage Mains (km)*
N01	*Vitas-Binondo-Escolta*	*8.55*	*13.14*	*6.62*
N02	*Quiapo-Aviles*	*5.58*	*6.77*	*3.90*
N03	*Valencia*	*2.37*	*1.22*	*0.67*
N04	*Maypajo-Blumentritt-Balut*	*9.91*	*6.65*	*4.13*
N05	*North Harbor*	*2.37*	*0.00*	*2.46*
	Total	*28.78*	*27.78*	*17.78*



ESTERO / CREEK

Code	Name
NE01	Estero de Vitas
NE02	Estero de Sunog Apog / Maypajo
NE03	Casili Creek
NE04	Estero dela Reina
NE05	Estero de Binondo
NE06	Estero de Magdalena
NE07	Estero de San Lazaro
NE08	Estero de Kabulusan
NE09	South Antipolo Open Canal
NE10	North Antipolo Open Canal
NE11	Estero de Tutuban
NE12	Estero de Quiapo
NE13	Estero de San Sebastian
NE14	Estero de San Miguel / Uli Uli
NE15	Estero de Alix
NE16	Estero de Aviles
NE17	Estero de Sampaloc I
NE18	Estero de Sampaloc II
NE19	Estero de Calubcob
NE20	Estero de Valencia

DRAINAGE MAIN

Code	Name
ND01	Pacheco
ND02	Lakandula
ND03	Zaragosa Sub
ND04	Buendia
ND05	Blumentritt Interceptor
ND06	Kanlaon
ND07	Pampanga-Earnshaw Sub
ND08	Solis-Tecson
ND09	South Antipolo
ND10	Kabulusan Sub
ND11	Kabulusan
ND12	Tayuman
ND13	Fugoso
ND14	Severino Reyes
ND15	Lepanto-Gov. Forbes
ND16	Lepanto-Josefina
ND17	Economia
ND18	Washington-P. Margal
ND19	Visayas

PUMPING STATION

Code	Name
NP01	Aviles
NP02	Quiapo
NP03	Valencia
NP04	Binondo
NP05	Escolta
NP06	Vitas
NP07	Balut
NP08	Malacanang No1
NP09	Malacanang No2
NP10	Jones Bridge Underpass No2

Figure E.4.1 Drainage System in North Manila

1) Vitas- Binondo- Escolta Drainage Block

The total catchment area is 8.55 km^2. The stormwater is drained by three drainage pumping stations: Vitas, Binondo and Escolta, having a total drainage capacity of 45.1 m^3/s. Those drainage pumping stations are connected through major esteros of Vitas, de la Reina, and Binondo. Stormwater in the block is collected into the above major esteros directly or through the following secondary esteros.

- Kabulusan
- South Antipolo Open Canal
- North Antipolo Open Canal
- Magdalena
- San Lazaro etc

At the middle reach of the South Antipolo Open Canal, there exists a control gate with small drainage pump equipment.

2) Quiapo-Aviles Drainage Block

Two drainage pumping stations: Quiapo and Aviles, having a total drainage capacity of 26.4 m^3/s, drain stormwater in this block. The total catchment area is 5.58 km^2. These stations are connected by esteros of San Miguel / Uli-Uli and Aviles. Stormwater in the block is collected into the above esteros directly or through the following esteros.

- Quiapo
- San Sebastian
- Sampaloc I
- Sampaloc II
- Calubcob

Quiapo and Aviles drainage block is one of the remaining severely inundated areas in the core area.

3) Valencia Drainage Block

The total catchment area of this block is 2.37 km^2. The stormwater is drained by Valencia drainage pumping station that has a total drainage capacity of 11.8 m^3/s. Major collecting channels are Estero de Valencia and Visayas Drainage Main.

4) Maypajo-Blumentritt-Balut Drainage Block

This block is mainly drained by gravity drainage system consisting of the following esteros, which has a total catchment area of 9.91 km^2.

- Sunog Apog
- Casili Creek
- Maypajo

The Estero de Maypajo receives the stromwater from the Blumentritt interceptor that collects runoff in the hilly area in the northeast of Blumentritt Street. The area around the street and in the southwest of the street is suffering from severe inundation. On the other side, at the upper end of the lower Estero de Maypajo, control wall exists. Accordingly, stormwater coming from the middle and upper Estero de Maypajo is completely discharged through Estero de Sunog Apog. Balut pumping station with a total drainage capacity of

2.0 m³/s drains stormwater in the right bank of the Estero de Sunog Apog through drainage main of Buendia.

5) North Harbor Drainage Block

North harbor and other independent drainage areas along the Pasig River are basically drained by gravity system. Total catchment area of this block is 2.37 km^2. The stormwater in the block is mainly drained by the following drainage mains.

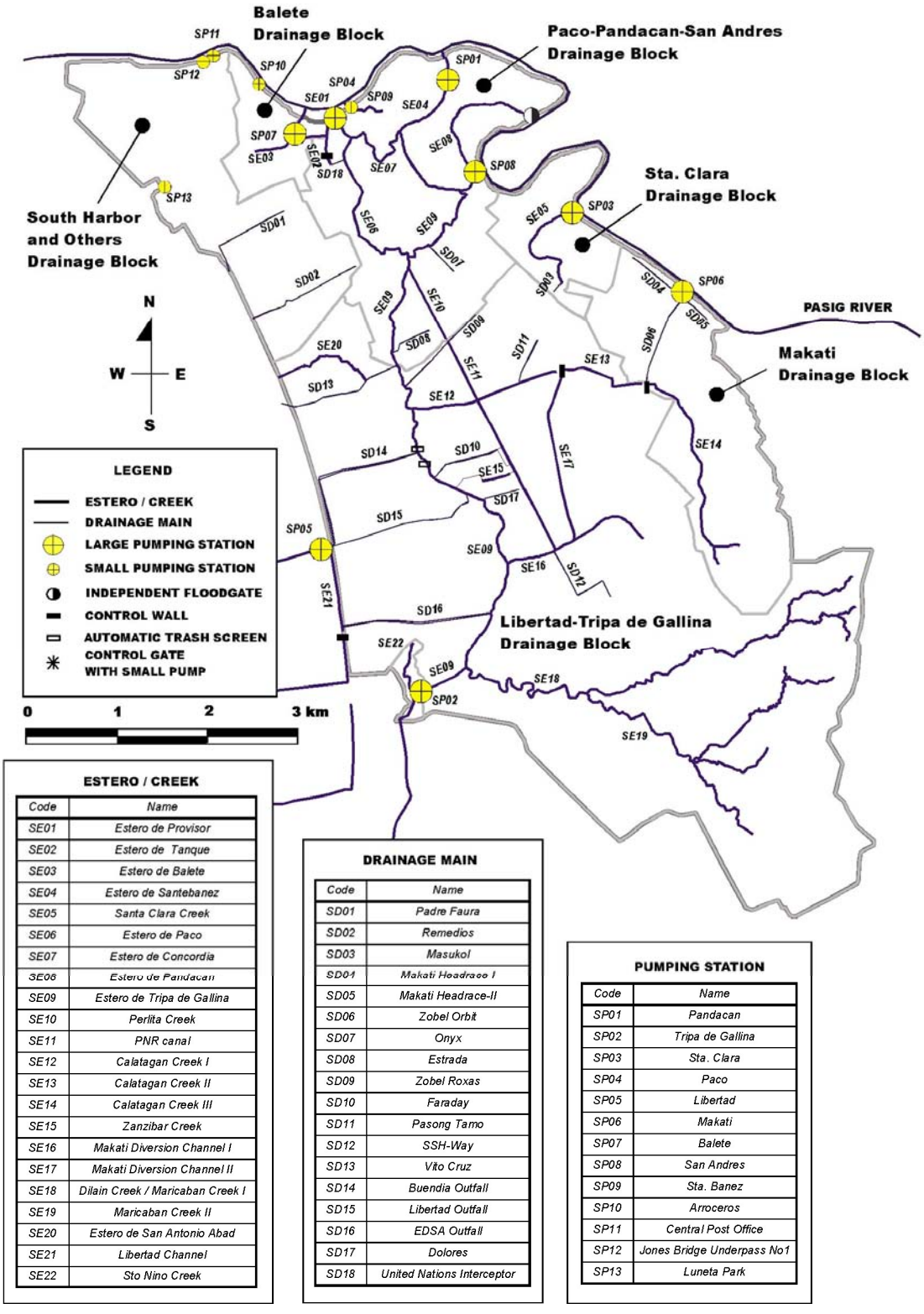
- Pacheco
- Lakandula
- Zaragosa sub-main

(4) Drainage Block in South Manila

The drainage area in the south Manila area is divided into 6 drainage blocks as shown in *Figure E.4.2*, with a total catchment area estimated at 43.80 km^2. Major dimensions of each drainage block are summarized in *Table E.4.3*.

Table E.4.3 Major Dimensions of Each Drainage Block in South Manila

ID	*Name of Drainage Block*	*Area (km^2)*	*Total Length of Esteros /Creeks (km)*	*Total Length of Drainage Mains (km)*
S01	*Libertad-Tripa de Gallina*	*25.96*	*29.80*	*11.02*
S02	*Balete*	*0.94*	*0.55*	*0.00*
S03	*Paco-Pandacan-San Andres*	*6.12*	*10.59*	*1.10*
S04	*Sta. Clara*	*1.57*	*1.49*	*0.13*
S05	*Makati*	*4.31*	*2.56*	*2.24*
S06	*South Harbor and Others*	*4.90*	*0.73*	*2.51*
	Total	*43.80*	*45.72*	*17.00*



ESTERO / CREEK

Code	Name
SE01	Estero de Provisor
SE02	Estero de Tanque
SE03	Estero de Balete
SE04	Estero de Santebanez
SE05	Santa Clara Creek
SE06	Estero de Paco
SE07	Estero de Concordia
SE08	Estero de Pandacan
SE09	Estero de Tripa de Gallina
SE10	Perlita Creek
SE11	PNR canal
SE12	Calatagan Creek I
SE13	Calatagan Creek II
SE14	Calatagan Creek III
SE15	Zanzibar Creek
SE16	Makati Diversion Channel I
SE17	Makati Diversion Channel II
SE18	Dilain Creek / Maricaban Creek I
SE19	Maricaban Creek II
SE20	Estero de San Antonio Abad
SE21	Libertad Channel
SE22	Sto Nino Creek

DRAINAGE MAIN

Code	Name
SD01	Padre Faura
SD02	Remedios
SD03	Masukol
SD04	Makati Headrace I
SD05	Makati Headrace-II
SD06	Zobel Orbit
SD07	Onyx
SD08	Estrada
SD09	Zobel Roxas
SD10	Faraday
SD11	Pasong Tamo
SD12	SSH-Way
SD13	Vito Cruz
SD14	Buendia Outfall
SD15	Libertad Outfall
SD16	EDSA Outfall
SD17	Dolores
SD18	United Nations Interceptor

PUMPING STATION

Code	Name
SP01	Pandacan
SP02	Tripa de Gallina
SP03	Sta. Clara
SP04	Paco
SP05	Libertad
SP06	Makati
SP07	Balete
SP08	San Andres
SP09	Sta. Banez
SP10	Arroceros
SP11	Central Post Office
SP12	Jones Bridge Underpass No1
SP13	Luneta Park

Figure E.4.2 Drainage System in South Manila

1) Libertad-Tripa de Gallina Drainage Block

The total catchment area of this block is 25.96 km^2. The stormwater in the block is drained mainly by two drainage pumping stations of Libertad and Tripa de Gallina, which have a total drainage capacity of 99 m^3/s consisting of 42 m^3/s at Libertad and 57 m^3/s at Tripa de Gallina. Main drainage channel in the block is the Estero de Tripa de Gallina. Stormwater in the Southern part of Tripa de Gallina is collected by the following esteros and drainage mains.

- Calatagan Creek I
- Calatagan Creek II
- Makati Diversion Channel
- Dilain Creek / Maricaban Creek I
- Maricaban Creek II
- PNR Canal
- Zobel-Roxas Drainage Main
- Faraday Drainage Main
- Pasong Tamo Drainage Main
- SSH-Way Drainage Main
- Dolores Drainage Main

The riverine areas of Tripa de Gallina, especially catchment areas of Zobel-Roxas Drainage Main, Calatagan Creek I, PNR Canal, are one of the most severely inundated areas in Metropolitan Manila. Collected stormwater through the esteros and drainage mains into the Estero de Tripa de Gallina is finally drained by the following three systems into Manila Bay.

- By Libertad drainage pumping station collecting through outfalls of Buendia, Libertad and EDSA
- By Tripa de Gallina drainage pumping station
- By gravity system through outfall of Vito Cruz and Estero de San Antonio Abad

This drainage block is systematically connected to the adjoining Paco-Pandacan-San Andres Drainage Block. Further, the upper catchment of the original Calatagan Creek (Calatagan Creek III) has been completely transferred into the adjoining Makati Drainage Block through Zobel-Orbit Drainage Main.

2) Paco-Pandacan-San Andres Drainage Block

The stormwater in this block is drained by three drainage pumping stations of Paco, Pandacan and San Andres, having a total drainage capacity of 31.0 m^3/s against the total catchment area of 6.12 km^2. These pumping stations are connected through the following esteros.

- Paco
- Concordia
- Pandacan
- Tripa de Gallina

Estero de Santebanez and Estero de Pandacan are connected with the Pasig River through floodgate of Santebanez and Pandacan, respectively.

3) Sta. Clara Drainage Block

The total catchment area of this block is 1.57 km^2 and the stormwater is drained by Sta. Clara drainage pumping station that has a total drainage capacity of 5.3 m^3/s. Major collecting channels are Estero de Sta. Clara and Masukol Drainage Main.

4) Makati Drainage Block

The total catchment area of this block is 4.31 km^2. The stormwater in the area neighboring the Pasig River is drained by Makati drainage pumping station that has a total drainage capacity of 7.0 m^3/s. On the other hand, the stormwater gathered by the upper Calatagan Creek is directly flowing into the Pasig River through Zobel-Orbit Drainage Main. Major collecting channels in the drainage block are as follows.

- Calatagan Creek III
- Zobel-Orbit Drainage Main
- Makati Headrace I Drainage Main
- Makati Headrace II Drainage Mains

5) South Harbor and Others Drainage Block

Gravity system or small pumping stations drain the storm water in south harbor along Manila Bay and other independent drainage areas along the Pasig River. The storm water gathered by the following drainage mains is drained by gravity system. .

- Padre Faura Drainage Main
- Remedios Drainage Main

Total catchment area of the block is 4.90 km^2.

E.4.2 DRAINAGE FACILITIES

(1) General

The drainage method in the core area of Metropolitan Manila can be basically categorized into two types of gravity drainage and forced drainage by pumping station. Since a major portion of the core area of Metropolitan Manila is low-lying land, the tidal effect gives rise to one of the primary and most difficult flooding problems. Accordingly, storm water is drained mostly by means of pumping stations covering about 52 km^2 (71 %) of the total area of 73 km^2. *Figure E.4.3* shows the drainage area that is drained by pumping stations. In this section, present conditions of drainage facilities and related ones in the core area of Metropolitan Manila are summarized based on the site reconnaissance and analysis of data collected.

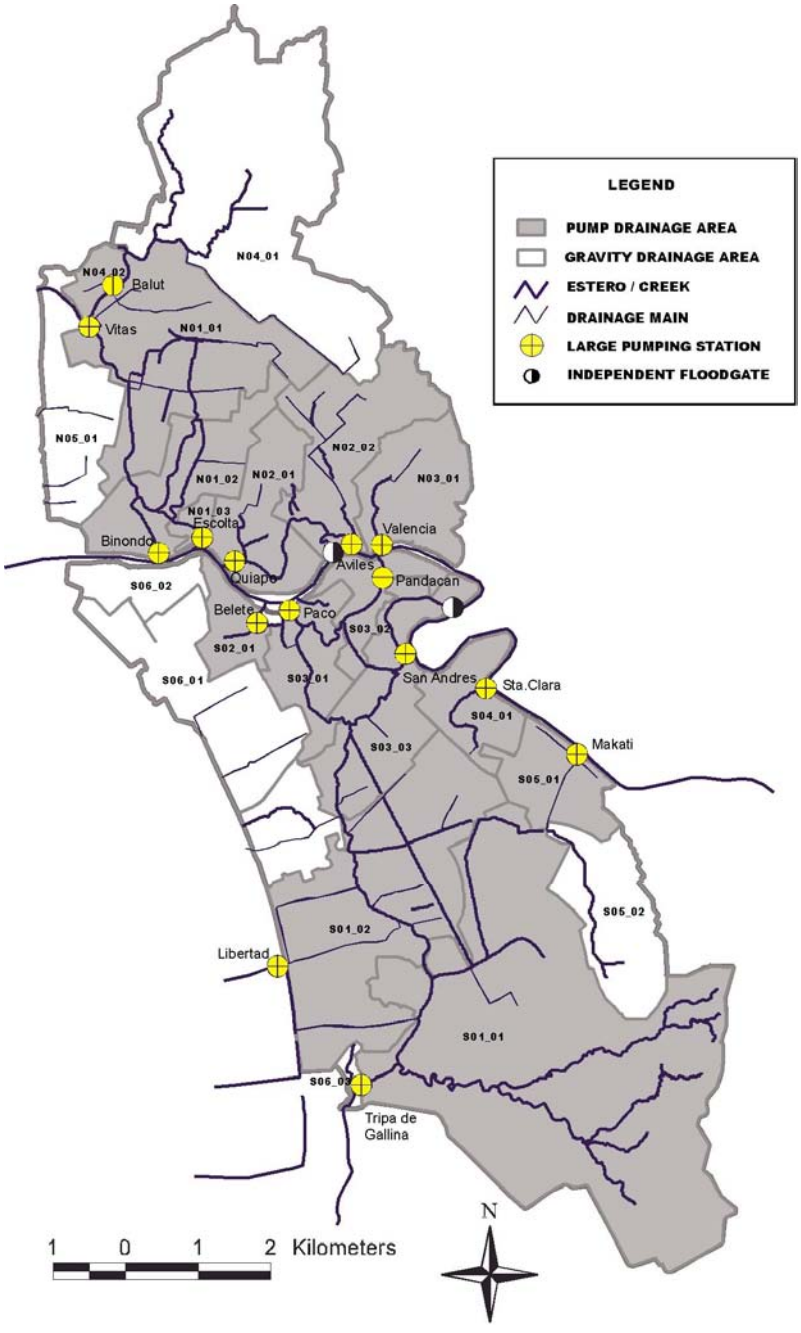


Figure E.4.3 Drainage Area Drained by Pumping Stations

(2) Drainage Pumping Stations and Floodgates

1) Large Drainage Pumping Stations

There exist 15 large drainage pumping stations in the core area of Metropolitan Manila. To specify the boundary of drainage basin of each pumping station is quite difficult, because the boundary can vary actually depending on flow condition, rainfall pattern and so on. Therefore, overall basin boundary was firstly specified based on the original plan, then, small modification was made based on available information for topography and existing drainage laterals. The areas of each drainage basin are shown in *Table E.4.4* together with capacity of pumping stations.

Among those, 7 stations were constructed in the 1970s, 4 stations in the 1980s and 4 stations in the 1990s. The detailed design dimensions provided by MMDA are summarized in *Table E.4.5*.

Table E.4.4 Total Drainage Capacity and Area of Drainage Basin for Large Pumping Stations

Basin_ID	*Name of Pumping Station*	*Drainage Area*[*1] *(km^2)*	*Capacity (m^3/s)*	*Specific Discharge ($m^3/s/km^2$)*
N01_01	*Vitas*	*5.56*	*32.0*	*5.76*
N01_02	*Binondo*	*2.69*	*11.6*	*4.31*
N01_03	*Escolta*	*0.30*	*1.5*	*5.07*
N02_01	*Quiapo*	*2.29*	*10.8*	*4.71*
N02_02	*Aviles*	*3.28*	*15.6*	*4.75*
N03_01	*Valencia*	*2.37*	*11.8*	*4.98*
N04_02	*Balut*	*0.49*	*2.0*	*4.05*
S01_01	*Tripa de Gallina*[*2]	*17.05*	*57.0*	*3.34*
S01_02	*Libertad*[*2]	*7.48*	*42.0*	*5.61*
S02_01	*Balete*	*0.94*	*3.0*	*3.19*
S03_01	*Paco*	*1.74*	*7.6*	*4.37*
S03_02	*Pandacan*	*1.15*	*4.4*	*3.84*
S03_03	*San Andres*	*3.23*	*19.0*	*5.88*
S04_01	*Sta. Clara*	*1.57*	*5.3*	*3.38*
S05_01	*Makati*	*1.65*	*7.0*	*4.24*

Note: [*1] Based upon the review by JICA Study Team

[*2] Drainage boundary of Tripa de Gallina and Libertad is quite unclear. Storm water in these drainage areas is actually drained by cooperation work of the two pumping stations.

Major design conditions of the above drainage pumping stations are as follows.

Design flood scale:	10-year storm water
Operating system:	Electric power by MERALCO with diesel engines
Solid waste treatment:	Automatic trash removal equipment
Drainage gate:	Gate for gravity drainage
Total drainage capacity:	230.6 m^3/s
Total service area:	51.80 km^2
Average unit drainage capacity per km^2:	4.45 $m^3/s/km^2$

Table E.4.5 Detailed Design Dimensions of Large Drainage Pumping Stations

Items	Pandacan	Aviles	Quiapo	Valencia	Tripa de Gallina	Sta. Clara	Paco	Libertad	Makati	Binondo	Balete	Escolta	Vitas	Balut	San Andres
Location	Pandacan Manila	Sampaloc Manila	Quiapo Manila	Sta. Mesa Manila	Pasay City	Sta. Ana Manila	Paco Manila	Pasay City	Osmeña Makati	Binondo Manila	Ermita Manila	Nacional Manila	Tondo Manila	Tondo Manila	Sta. Ana Manila
Construction Year	1976	1976	1976	1976	1977	1977	1977	1982	1983	1985	1989	1991	1997	1997	1998
Drainage Area (ha)	180	356	225	246	1769	133	182	779	151	279	52	(*1)	578	49	356
Main Pump Equipment															
Total Pump Capacity (m3/s)	4.4	14.1	9.5	10.5	56.0	5.3	7.6	42.0	7.0	11.6	1.2	1.5	32.0	2.0	19.0
Numbers of pump unit (m3/s x no.)	2.2 x 2	3.53 x. 4	2.37 x 4	2.625 x 4	7.0 x 8	2.65 x 2	2.53 x 3	7.0 x 6	3.5 x 2	2.9 x 4	0.4 x 3	0.5 x 3	6.4 x 5	1.0 x 2	4.75 x 4
Total Pump Head (m)	3.1	3.1	2.5	3.3	3.2	3.5	2.8	2.8	3.6	2.9	3.5	3.5	3.2	3.6	4.3
Pump Start W.L (m)	10.50	10.50	10.50	10.50	9.90	11.20	10.50	9.90	11.30	10.00	10.60	10.00	10.10	9.10	10.50
Pump Stop W.L (m)	10.20	10.30	10.20	10.30	9.60	11.00	10.20	9.60	10.90	9.80	10.50	9.80	9.80	8.90	10.20
Top Revetment at P/S (m)	12.20	12.40	11.60	12.50	13.00	13.10	12.30	13.00	13.90	12.20	13.80	13.30	12.20	12.20	12.50
Type of Pump	VAF	VAF	VAF	VAF	HAF	VAF	VAF	HAF	VAF	VAF	Submer.	Submer.	HAF	Submer.	VMF
Diameter of Pump Bore (mm)	1,000	1,200	1,000	1,000	1,650	1,000	1,000	1,650	1,200	1,000	400	650	1,650	700	1,500
Rehabilitation Year	1988	1988	1988	1988	1988	1988	1988	1988	1988	-	2000	1991	-	-	-
Added Pump Equipment by Rehabilitation Project															
Total Pump Capacity (m3/s)	-	1.5	1.3	1.3	1.0	-	-	-	-	-	1.8	-	-	-	-
Numbers of pump unit (m3/s x no.)		0.5 x 3	0.45 x 3	0.45 x 3	0.5 x 2						0.8 x 1+ 1.0 x 1				
Type of Pump		Submer.	Submer.	Submer.	Submer.						Submer.				
Diameter of Pump Bore (mm)		400	400	400	400						700				
Gate for Gravity Discharge															
Width (m) x Height (m)	4.0 x 4.75	4.0 x 6.0	4.0 x 6.3	4.0 x 6.2	8.0 x 5.3	5.2 x 5.0	14.0 x 6.5	10.0 x 5.0	5.1 x 5.0	6.0 x 4.7	4.0 x 4.9	4.0 x 5.4	10.0 x 4.4	2.2 x 2.2	3.0 x 2.0
Numbers of Gate (no.)	1	2	2	2	3	1	1	3	1	2	2	2	2	1	4

Source: Brief Information on the NCR-DPWH Pumping Stations and Floodgates Project, MMDA, 1999 and interview results

Note: VAF; Vertical shaft axial flow pump, VMF; Vertical shaft mixed flow pump, HAF; Horizontal shaft axial flow pump, Submer; Submersible pump

: *1 included in Binondo Drainage ara

In the course of the Study, the elevations of tide gauges installed in the pumping stations have been checked. The measurement was made for a tide gauge set in estero side. The results are shown in *Table E.4.6*. These indicate that there is possibility of inconsistency between tide gauge reading and actual elevation in some pumping stations.

Table E.4.6 Tide Gauge Elevation

Pumping Station	*Tide Gauge Reading (m)*	*Measured Elevation (m)*
Vitas	*12.00*	*12.005*
Binondo	*12.00*	*12.045*
Escolta	*13.00*	*13.036*
Quiapo	*12.00*	*12.051*
Aviles	*12.00*	*12.021*
Valencia	*12.00*	*12.147*
Balut	*12.00*	*11.908*
Tripa de Gallina	*13.00*	*13.018*
Libertad	*14.00*	*14.145*
Balete	*12.00*	*10.981*
Paco	*12.00*	*11.972*
Pandacan	*12.00*	*11.973*
San Andres	*12.00*	*12.231*
Sta. Clara	*13.00*	*12.995*
Makati	*13.00*	*12.726*

Total operation hours of all units by the pumping stations in the last 10 years are shown in *Table E.4.7* and details including fuel consumption are summarized in *Table E.4.8.*

Table E.4.7 Total Operating Hours of Pumps at Major Stations

(Unit: hour)

Pumping Station	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*
Aviles	*1,953*	*1,995*	*2,019*	*2,033*	*1,100*	*3,133*	*3,759*	*2,093*	*2,462*	*3,026*
Quiapo	*1,257*	*2,321*	*2,119*	*2,534*	*834*	*3,215*	*2,992*	*2,348*	*2,200*	*3,059*
Valencia	*889*	*878*	*1,071*	*1,008*	*589*	*1,675*	*2,208*	*1,458*	*1,471*	*2,132*
Tripa de Gallina	*1,972*	*2,607*	*1,562*	*1,711*	*1,190*	*2,453*	*2,486*	*2,078*	*2,462*	*2,691*
Paco	*1,438*	*1,635*	*1,778*	*1,852*	*446*	*2,315*	*2,425*	*1,583*	*1,450*	*2,108*
Libertad	*3,035*	*4,540*	*4,170*	*4,169*	*1,521*	*4,076*	*4,661*	*3,012*	*2,648*	*3,140*
Binondo	*1,201*	*1,895*	*1,671*	*1,695*	*1,048*	*2,903*	*2,835*	*2,323*	*2,448*	*3,344*
Vitas				*1,192*	*1,242*	*3,710*	*4,635*	*4,848*	*2,169*	*2,557*
San Andres					*330*	*845*	*971*	*766*	*717*	*883*

Source: Flood Control Management Services, MMDA

Table E.4.8 Annual Operating Hours and Fuel Consumption of Drainage Pumping Stations

PUMP STATION	ITEM	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
AVILES	a. Total Operating Hours	1,293	1,667	2,448	2,366	1,997	2,183	2,013	2,382	3,010	1,953	1,995	2,019	2,033	1,100	3,133	3,759	2,093	2,462	3,026
	b. Total fuel consumption	51,045	70,005	87,925	101,685	75,510	27,455	85,090	95,320	107,770	93,810	86,040	91,270	86,615	50,520	130,000	145,020	78,410	91,020	105,238
QUIAPO	a. Total Operating Hours	2,022	2,437	2,647	3,090	2,630	3,018	2,146	2,275	2,174	1,257	2,321	2,119	2,534	834	3,215	2,992	2,348	2,200	3,059
	b. Total fuel consumption	55,890	60,925	66	71,190	68,998	73,065	55,350	56,870	58,870	57,175	58,220	55,170	62,415	34,830	86,380	81,650	63,250	67,180	80,400
VALENCIA	a. Total Operating Hours	817	1,389	1,772	2,026	2,129	3,229	1,916	1,741	2,298	889	878	1,071	1,008	589	1,675	2,208	1,458	1,471	2,132
	b. Total fuel consumption	21,785	33,345	44,310	56,130	56,235	52,500	45,265	45,275	45,310	29,945	27,700	33,380	30,935	21,805	51,170	64,410	35,200	45,780	57,527
BINONDO	a. Total Operating Hours	108	784	1,526	2,018	942	245	1,491	2,014	2,360	1,201	1,895	1,671	1,695	1,048	2,903	2,835	2,323	2,448	3,344
	b. Total fuel consumption	4,145	25,095	45,775	67,090	30,410	7,715	55,655	64,435	71,800	50,985	75,930	65,170	63,825	42,425	104,650	92,245	79,525	79,275	104,835
STA. CLARA	a. Total Operating Hours	415	516	780	864	975	736	585	772	1,097	595	364	134	176	165	551	831	256	465	458
	b. Total fuel consumption	9,065	13,415	17,930	21,725	19,850	19,530	18,960	20,845	24,180	25,350	10,860	3,985	6,920	6,745	21,115	31,580	9,660	15,700	16,705
PANDACAN	a. Total Operating Hours	666	1,146	1,828	2,117	1,021	955	983	775	631	804	454	260	532	366	628	560	164	291	431
	b. Total fuel consumption	16,110	26,365	40,215	50,310	23,595	21,930	19,600	17,860	15,540	25,390	14,950	7,890	19,505	12,170	19,036	17,325	5,525	9,400	13,740
PACO	a. Total Operating Hours	707	1,287	1,942	1,913	2,630	2,492	2,953	1,865	2,734	1,438	1,635	1,778	1,852	446	2,314	2,425	1,584	1,450	2,108
	b. Total fuel consumption	27,345	37,310	48,555	57,650	70,440	62,210	73,610	71,725	70,485	54,865	39,145	43,525	41,480	17,845	52,640	61,210	38,650	36,100	46,708
MAKATI	a. Total Operating Hours	356	412	467	546	537	471	353	342	701	345	388	188	277	142	469	563	384	379	335
	b. Total fuel consumption	16,180	19,345	22,430	27,940	24,625	23,725	17,115	15,940	15,565	16,135	14,430	8,520	10,970	7,470	18,550	27,745	19,910	19,245	17,510
TRIPA de GALLINA	a. Total Operating Hours	817	1,067	2,012	2,879	3,434	2,785	4,815	4,069	3,640	1,972	2,606	1,562	1,711	1,190	2,453	2,486	2,078	2,462	2,691
	b. Total fuel consumption	49,540	61,905	110,645	118,820	177,620	170,955	172,470	150,385	132,220	112,160	20,650	92,450	105,100	80,615	176,040	187,040	150,295	134,345	148,080
LIBERTAD	a. Total Operating Hours	682	1,377	1,928	2,048	1,949	2,197	3,001	4,137	5,038	3,035	4,540	4,170	4,169	1,521	4,076	4,661	3,012	2,648	3,140
	b. Total fuel consumption	57,955	78,515	102,210	173,995	122,005	120,255	156,240	219,350	278,960	287,960	249,460	229,260	233,445	123,590	269,950	308,350	196,270	161,030	174,310
VITAS*	a. Total Operating Hours													1,193	1,242	3,710	4,635	4,848	2,169	2,557
	b. Total fuel consumption													61,720	64,130	172,120	209,560	195,200	136,110	138,670
SAN ANDRES**	a. Total Operating Hours													62	330	845	971	766	717	883
	b. Total fuel consumption													4,155	19,400	44,220	50,835	41,025	36,300	43,550
BALUT***	a. Total Operating Hours													289	157	697	809	2,137	1,794	1,514
	b. Total fuel consumption													9,415	5,015	23,555	30,885	20,985	7,370	4,440
ESCOLTA	a. Total Operating Hours		Not provided with running (operating) hour-meter											230	72	192	227	77	82	188
	b. Total fuel consumption													5,105	1,765	4,765	5,755	2,925	4,535	2,920
BALETE	a. Total Operating Hours																	18	49	333
	b. Total fuel consumption																	441	1,368	3,110
G. TOTAL	a. Total Operating Hours	7,882	12,080	16,948	19,869	18,244	18,311	20,255	21,373	23,684	13,488	17,076	14,971	17,759	9,202	26,861	29,961	23,544	21,086	26,200
	b. Total fuel consumption	309,060	426,225	520,061	746,535	669,288	579,340	699,355	758,005	820,340	753,775	597,385	630,620	741,605	488,325	1,174,191	1,313,610	937,271	844,758	957,743

Source; Flood Control Management Services, MMDA

Unit: operation hour: hour, Fuel consumption: l

Note; Start of operation * in April 1997, ** in Aug. 1997 and *** in April 1997

These drainage pumping stations have been working effectively in improving drainage situation in the core area of Metropolitan Manila. However, almost 30 years have been past since their constructions, especially for 10 pumping stations. Accordingly, also superannuating of pump equipment and its appurtenant facilities has been progressed in some pumping stations. To cope with such situations, the drainage pump equipment was rehabilitated in 1988.

Subsequently in 1999, overhauling of pump equipment was made at five stations of Aviles, Tripa de Gallina, Valencia, Libertad and Quiapo. It was found that remarkable problems are deterioration of casing liner, erosion and corrosion of guide casing, crack of various major parts and units of engine, etc., due to aging, extremely low water quality, clogged and overloaded solid waste, decreasing of cooling effect, etc.

In the dry season from November to April, these pumping stations are frequently utilized for removing dumped solid waste flowing down in the channels towards pumping stations and operating periodically for maintenance of pump equipment.

2) Small Drainage Pumping Stations

There exist eight small drainage pumping stations having total drainage capacities of 4 m^3/s. Their locations and capacities are shown in *Figure E.4.4* and *Table E.4.9*, respectively.

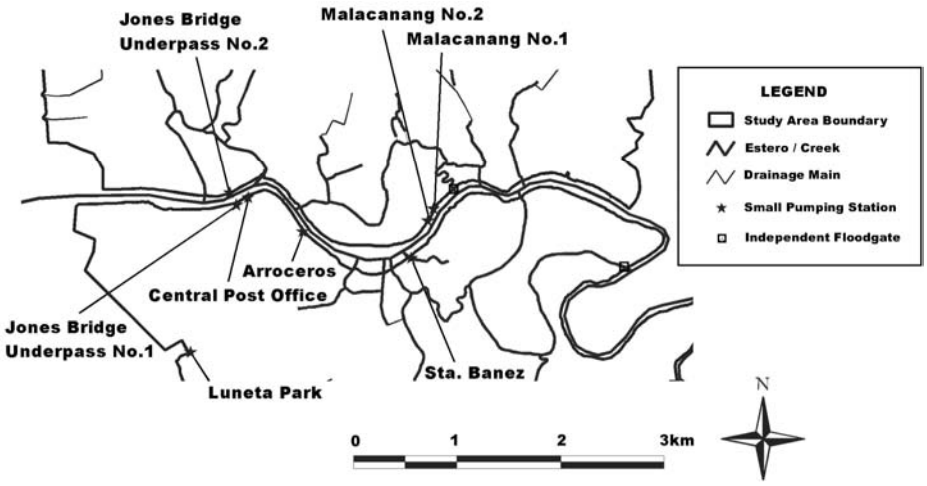


Figure E.4.4 Locations of Small Pumping Stations

Table E.4.9 Capacities of Small Pumping Stations

Name of Pumping Station	*Capacity (m^3/s)*
Malacanang No.1	*0.66*
Malacanang No.2	*0.76*
Arroceros	*0.66*
Luneta Park	*0.42*
Central Post Office	*0.56*
Jones Bridge Underpass No.1 (South)	*0.26*
Jones Bridge Underpass No.2 (North)	*0.36*
Sta.Banez	*0.318*

3) Floodgates and Other Structures

Floodgates and control walls have been constructed at outlets of the esteros or in the esteros, as shown in *Figures E.4.1 and E.4.2*. Objectives of the floodgate are to check return flow from the Pasig River in the high water level and to discharge storm water in the esteros to the Pasig River when the water level at Pasig River is lower than those in the esteros, whereas control wall is to control flow direction by installing wall made by concrete, steel or earth dikes.

There are originally 5 floodgates in total at the respective esteros of Escolta, Uli-Uli, Balete, Sta Banez, and Pandacan. The two floodgates of Uli-Uli and Pandacan are presently independent gates constructed at outlet of each estero, and others are installed jointly with the respective drainage pumping stations of Escolta, Balete and Sta. Banez. Width, height and gate numbers of these floodgates are shown in *Table E.4.10*.

Table E.4.10 Dimensions of Floodgates

Name of Floodgate	*Dimensions*
Escolta	*4 m ×5.4 m ×2 gates*
Uli-Uli	*1 m ×1 m ×4 gates*
Balete	*4 m ×4.9 m ×2 gates*
Sante Banez	*10 m ×5.5 m ×1 gate*
Pandacan	*4 m ×4.8 m ×1 gate*

On the other hand, there exist 5 control walls in the respective esteros of Tanque, Calatagan Creek II and III and Libertad channel in south Manila, and Maypajo in north Manila, as presented in *Figures E.4.1 and E.4.2*.

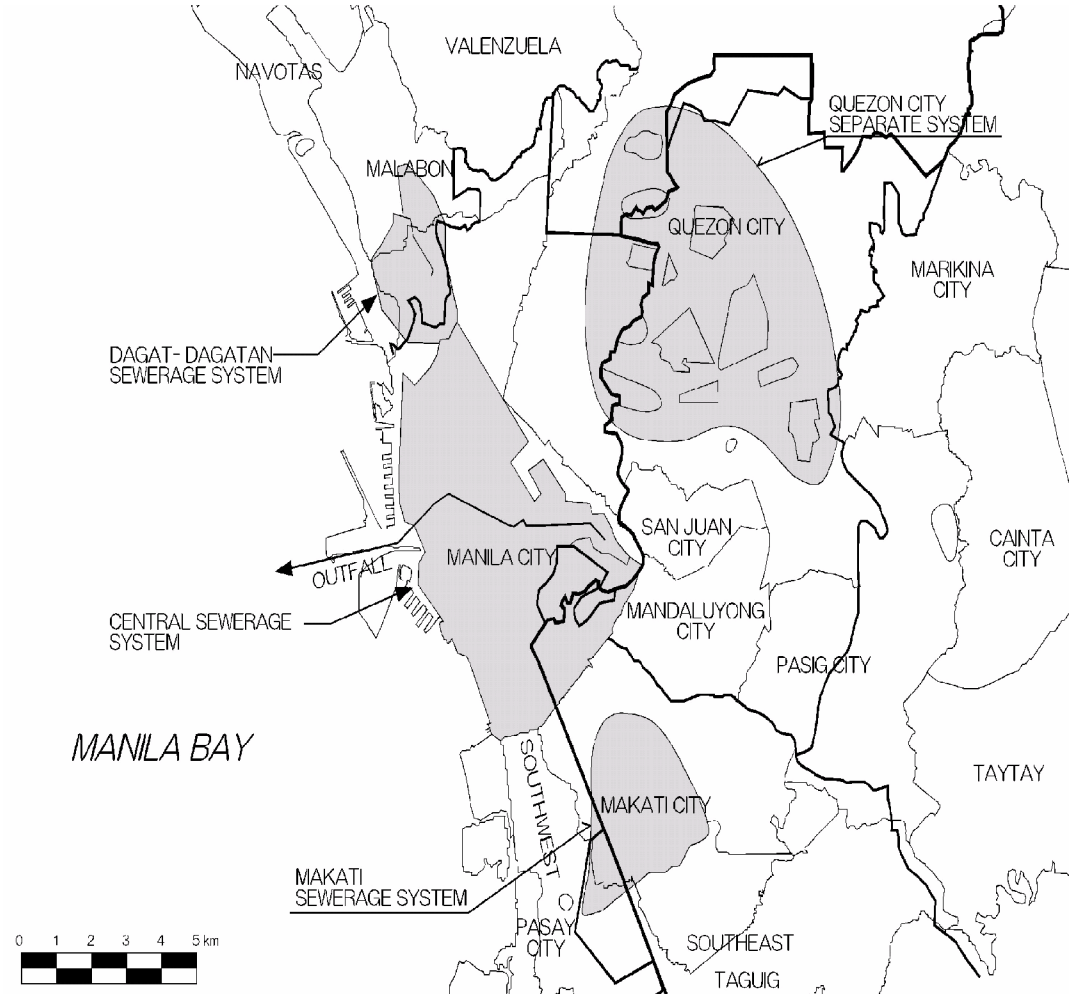
There is a control gate jointly equipped with small drainage pump in the south Antipolo creeks. Trash screens, automatic trash screens, are installed at inlet of outfalls along the Estero de Tripa de Gallina.

(3) Sewerage System

There are.3 sewerage systems in operation in Metropolitan Manila, all of which are separate collection systems under administration of Metropolitan Waterworks and Sewerage System (MWSS). *Figure E.4.5* shows locations of the respective services areas.

In 1997, operation and maintenance of the facilities was transferred to 2 private companies of Manila Water Company, Inc. (MWCI) and Maynilad Water Services, Inc (MWSI) in accordance with a 25-year concession contract. Total service area of the system is 45.6 km^2. The rest of the area not covered discharges its wastewater either to directly existing drainage systems or domestic septic tanks. Major dimensions of the above systems are summarized in *Table E.4.11*.

Aside from the above, there exist small community systems of Makati Pabahay (Makati City, for 480 house units), Valle Valde (Pasig City, 115 house units) and Karangalan Bio Module (Pasig City, 850 house units). The present system of the Central Manila is at the stage of rehabilitation under the Manila Second Sewerage Project assisted by IBRD Loan including Japanese Fund.



Source: Basic Study on Sewerage System Improvement in the Philippines, JICA, Sept. 2003

Figure E.4.5 Locations of Existing Sewerage Systems in Metropolitan Manila

Table E.4.11 Outline of Present Sewerage Systems in Metropolitan Manila

System	*Service Area*	*System Covered Area (ha)*	*Population in Service (person)*
Central Manila Sewerage System	*Manila*	*2,620*	*520,000*
Dagat-Dagatan Sewerage System	*Caloocan, Malabon, Navotas, Manila*	*333*	*37,000*
Makati Sewerage System	*Makati*	*600*	*500,000*
Quezon City Separate System	*Quezon*	*1,000*	*200,000*

Source: Basic Study on Sewerage System Improvement in the Philippines, JICA, Sept. 2003

E.4.3 DRAINAGE BASIN

(1) Sub-Basin

The total study area (72.57 km^2) has been divided into 5 drainage blocks for North Manila (28.78 km^2) and 6 drainage blocks for South Manila (43.79 km^2). Each drainage block has again been divided into small drainage basins (pump and gravity drainage basins) and smaller sub-basins based on topography, laterals network, road network, channel connectivity, drainage facility etc. Drainage basin boundary of previous studies and sub-basin boundary of SEDLMM (2000) have been utilized in preparing drainage basin and sub-basin map of this study. In total, there are 7 and 8 pump drainage and 4 and 6 gravity drainage basins in North and South Manila drainage areas, respectively. Total number of sub-basins in North and South drainage areas is 72 and 120, respectively.

In addition, reach basins have been defined as catchment associated with a reach or branch of esteros or drainage mains, which are employed in runoff calculation.

Divisions of drainage blocks, drainage basins, reach basins and sub-basins for North and South Manila drainage areas are shown in *Figure E.4.6* and *Figure E.4.7*, respectively. Characteristics of the drainage blocks, drainage basins and sub-basins are presented in *Table E.4.12* and *Table E.4.13* for north and south drainage areas, respectively.

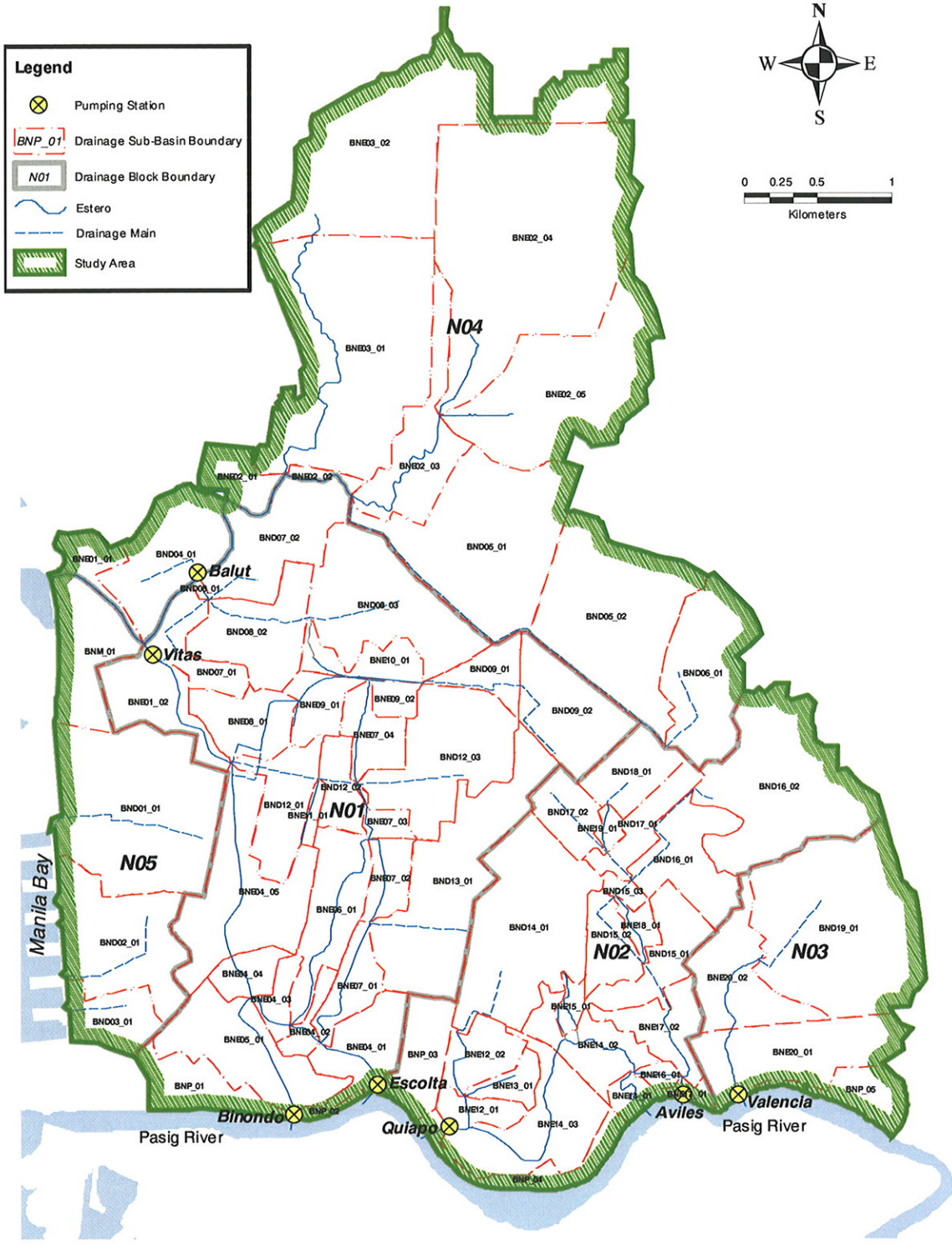


Figure E.4.6 Sub-Basins of North Drainage Area

Figure E.4.7 Sub-Basins of South Drainage Area

Table E.4.12 Sub-Basin for North Drainage Area

Drainage Block				Drainage Basin				Drainage Reach Basin			Drainage Sub-Basin		Sub-Basin Characteristics			
Name	ID	Area (km^2)	RO Coeff. C	Name	ID	Area (km^2)	RO Coeff. C	ID	Area (km^2)	RO Coeff. C	ID	Area (km^2)	Slope (%) Mean	Ground Elevation (EL. m) Minimum	Mean	Maximum
Vitas-Binondo-Escolta	N01	8.55	0.75	Vitas (P.S.)	N01_01	5.56	0.73	RND07_01	0.22	0.69	BND07_01	0.22	0.29	11.28	11.76	12.46
								RND07_02	0.49	0.79	BND07_02	0.49	0.81	11.48	12.37	14.27
								RND08_01	0.44	0.73	BND08_01	0.01	0.00	11.48	11.48	11.48
											BND08_02	0.43	0.24	11.48	12.14	12.68
								RND08_02	0.71	0.74	BND08_03	0.71	0.36	12.08	12.60	15.28
								RND09_01	0.59	0.74	BND09_01	0.16	0.48	12.08	12.64	14.02
											BND09_02	0.43	0.31	12.08	12.67	13.71
								RND12_01	0.47	0.67	BND12_01	0.31	0.25	11.48	12.17	12.75
											BND12_02	0.16	0.25	11.87	12.22	12.48
								RND12_02	0.65	0.64	BND12_03	0.65	0.27	12.08	12.57	13.07
								RNE01_02	0.32	0.82	BNE01_02	0.32	0.60	11.48	12.05	13.28
								RNE04_03	0.70	0.79	BNE04_05	0.70	0.40	11.48	11.97	12.68
								RNE07_02	0.07	0.70	BNE07_03	0.07	0.17	12.08	12.46	12.68
								RNE07_03	0.19	0.74	BNE07_04	0.19	0.13	11.99	12.28	12.51
								RNE08_01	0.27	0.74	BNE08_01	0.27	0.49	11.48	12.23	12.87
								RNE09_01	0.25	0.75	BNE09_01	0.17	0.17	11.68	12.29	12.48
											BNE09_02	0.08	0.29	12.08	12.34	12.64
								RNE10_01	0.18	0.73	BNE10_01	0.18	0.17	12.06	12.34	12.68
								RNE11_01	0.04	0.70	BNE11_01	0.04	0.07	11.87	12.06	12.15
				Binondo (P.S.)	N01_02	2.69	0.77	RND13_01	0.86	0.74	BND13_01	0.86	0.23	11.48	12.22	12.88
								RNE04_02	0.31	0.78	BNE04_02	0.08	0.39	11.48	11.79	12.27
											BNE04_03	0.10	0.53	11.48	11.86	12.37
											BNE04_04	0.13	0.29	11.48	11.72	12.39
								RNE05_01	0.80	0.80	BNE05_01	0.51	0.52	10.48	12.11	13.07
											BNP_01	0.26	1.05	10.48	12.54	13.48
											BNP_02	0.03	2.52	10.48	11.58	13.27
								RNE06_01	0.39	0.74	BNE06_01	0.39	0.34	11.48	12.03	12.68
								RNE07_01	0.33	0.76	BNE07_01	0.18	0.52	11.48	11.77	12.48
											BNE07_02	0.15	0.39	11.48	12.21	12.66
				Escolta (P.S.)	N01_03	0.30	0.79	RNE04_01	0.30	0.79	BNE04_01	0.30	0.46	10.48	11.90	13.48
Quiapo-Aviles	N02	5.58	0.71	Quiapo (P.S.)	N02_01	2.29	0.73	RND14_01	0.93	0.72	BND14_01	0.93	0.31	11.48	12.18	12.97
								RNE12_01	0.76	0.75	BNE12_01	0.11	0.49	10.75	11.91	12.88
											BNE12_02	0.19	0.38	11.48	11.87	12.29
											BNP_03	0.26	0.48	10.48	12.12	13.48
											BNP_04	0.19	0.89	10.48	11.76	12.63
								RNE13_01	0.10	0.71	BNE13_01	0.10	0.46	11.48	11.92	12.67
								RNE14_02	0.51	0.72	BNE14_03	0.51	0.56	10.49	11.88	12.88
				Aviles (P.S.)	N02_02	3.28	0.70	RND15_01	0.51	0.61	BND15_01	0.29	0.27	11.85	12.17	12.62
											BND15_02	0.19	0.23	11.87	12.26	12.68
											BND15_03	0.04	0.24	11.87	12.00	12.22
								RND16_01	0.37	0.69	BND16_01	0.37	1.89	11.87	14.39	18.48
								RND16_02	0.94	0.69	BND16_02	0.94	1.74	12.59	18.59	25.46
								RND17_01	0.38	0.74	BND17_01	0.19	1.05	12.05	13.05	18.79
											BND17_02	0.19	0.23	12.08	12.42	12.88
								RND18_01	0.24	0.74	BND18_01	0.24	0.65	11.88	12.58	14.81
								RNE14_01	0.35	0.74	BNE14_01	0.08	0.34	11.48	11.59	12.08
											BNE14_02	0.28	0.50	11.48	12.06	12.48
								RNE15_01	0.06	0.66	BNE15_01	0.06	0.19	11.85	12.30	12.47
								RNE16_01	0.04	0.76	BNE16_01	0.04	0.55	11.48	11.63	12.48
								RNE17_01	0.28	0.73	BNE17_01	0.04	1.07	11.48	12.21	13.27
											BNE17_02	0.24	0.45	11.48	12.13	12.67
								RNE18_01	0.07	0.74	BNE18_01	0.07	0.31	11.87	12.07	12.30
								RNE19_01	0.04	0.71	BNE19_01	0.04	0.45	11.94	12.62	12.88
Valencia	N03	2.37	0.68	Valencia (P.S.)	N03_01	2.37	0.68	RND19_01	1.21	0.65	BND19_01	1.21	2.67	11.93	16.72	25.48
								RNE20_01	1.16	0.71	BNE20_01	0.56	0.92	11.48	12.90	22.48
											BNE20_02	0.41	1.27	11.48	13.06	18.48
											BNP_05	0.20	1.25	11.48	13.00	15.61
Maypajo-Blumentrit-Balut	N04	9.92	0.69	Maypajo-Blumentrit	N04_01	9.42	0.69	RND05_01	1.06	0.47	BND05_01	1.06	1.73	11.71	18.22	24.48
								RND05_02	0.98	0.70	BND05_02	0.98	1.44	12.48	16.80	22.12
								RND06_01	0.58	0.66	BND06_01	0.58	2.95	12.48	18.53	24.48
								RNE01_01	0.14	0.52	BNE01_01	0.14	7.28	11.48	17.26	45.48
								RNE02_01	0.16	0.98	BNE02_01	0.16	1.01	11.48	12.75	13.48
								RNE02_02	0.04	0.82	BNE02_02	0.04	3.57	11.48	13.49	19.31
								RNE02_03	3.44	0.68	BNE02_03	0.45	3.01	11.48	19.22	25.28
											BNE02_04	1.99	1.10	15.48	27.28	34.48
											BNE02_05	1.01	1.36	15.52	25.18	31.48
								RNE03_01	3.02	0.75	BNE03_01	1.57	1.73	11.48	18.58	25.48
											BNE03_02	1.45	1.08	17.48	26.11	33.91
				Balut (P.S.)	N04_02	0.49	0.79	RND04_01	0.49	0.79	BND04_01	0.49	0.37	11.28	11.70	13.55
North Harbor	N05	2.37	0.80	North Harbor	N05_01	2.37	0.80	RND01_01	1.13	0.83	BND01_01	1.13	0.36	11.56	12.51	13.68
								RND02_01	0.62	0.81	BND02_01	0.62	0.39	11.71	12.64	13.48
								RND03_01	0.23	0.79	BND03_01	0.23	0.41	12.27	12.95	13.48
								RNM_01	0.39	0.68	BNM_01	0.39	0.77	11.48	12.56	15.48
Total		28.78	0.72			28.78	0.72		28.78	0.72		28.78				

Source: 1/5,000 scale GIS map

Table E.4.13 Sub-Basin for South Drainage Area

Drainage Block				Drainage Basin				Drainage Reach Basin			Drainage Sub-Basin		Sub-Basin Characteristics			
Name	ID	Area (km^2)	RO Coeff. C	Name	ID	Area (km^2)	RO Coeff. C	ID	Area (km^2)	RO Coeff. C	ID	Area (km^2)	Slope (%) Mean	Ground Elevation (EL. m) Minimum	Mean	Maximum
Libertad-Tripa de Gallina	S01	25.96	0.66	Tripa de Gallina (P.S.)	S01_01	17.05	0.62	RSD12_01	0.72	0.73	BSD12_01	0.06	0.69	14.28	15.67	16.23
											BSD12_02	0.26	3.05	10.48	17.23	21.90
											BSD12_03	0.39	1.18	17.63	21.05	26.17
								RSE09_01	0.28	0.62	BSE09_01	0.28	0.63	11.48	12.95	13.47
								RSE09_02	0.44	0.72	BSE09_02	0.31	1.00	11.48	13.02	17.27
											BSE09_03	0.13	0.62	11.48	14.25	17.48
								RSE09_03	0.66	0.77	BSE09_04	0.18	0.76	11.48	13.32	15.06
											BSE09_05	0.48	0.35	11.48	13.10	13.48
								RSE13_01	0.72	0.73	BSE13_01	0.72	1.05	14.41	17.60	21.48
								RSE16_01	0.64	0.79	BSE16_01	0.24	0.71	11.48	13.24	14.06
											BSE16_02	0.23	0.88	11.48	13.90	15.61
											BSE16_03	0.18	0.86	11.48	14.51	16.83
								RSE16_02	1.21	0.69	BSE16_04	0.54	2.35	10.48	17.19	24.48
											BSE16_05	0.66	1.49	19.67	25.24	30.48
								RSE17_01	1.55	0.75	BSE17_01	0.09	0.94	11.48	13.88	14.63
											BSE17_02	0.77	1.45	12.22	18.40	29.48
											BSE17_03	0.13	0.69	13.42	14.14	14.67
											BSE17_04	0.55	0.82	14.23	17.30	21.48
								RSE18_01	2.50	0.63	BSE18_01	0.44	0.52	11.48	12.34	13.27
											BSE18_02	0.41	1.52	11.48	14.37	20.30
											BSE18_03	0.55	0.78	11.48	13.90	16.48
											BSE18_04	1.09	1.64	11.48	19.44	28.48
								RSE18_02	2.94	0.56	BSE18_05	0.21	3.53	11.48	15.55	22.37
											BSE18_06	2.72	4.06	15.39	28.10	48.48
								RSE19_01	5.40	0.53	BSE19_01	0.69	2.66	10.48	20.42	30.48
											BSE19_02	4.71	3.89	15.68	29.56	45.48
				Libertad (P.S.)	S01_02	7.48	0.75	RSD09_01	0.22	0.71	BSD09_01	0.22	0.32	12.61	12.97	13.48
								RSD09_02	0.79	0.72	BSD09_02	0.14	0.11	12.68	13.02	13.17
											BSD09_03	0.55	0.12	12.87	13.36	13.66
											BSD09_04	0.10	0.10	13.16	13.49	13.64
								RSD10_01	0.32	0.72	BSD10_01	0.32	0.44	11.48	13.01	13.68
								RSD11_01	0.49	0.69	BSD11_01	0.15	0.20	13.13	13.63	14.96
											BSD11_02	0.34	0.49	13.48	14.52	16.81
								RSD14_01	1.14	0.76	BSD14_01	0.19	0.28	12.48	13.02	13.36
											BSD14_02	0.61	0.32	12.09	13.08	14.23
											BSD14_03	0.34	0.30	12.20	12.94	13.77
								RSD15_01	1.01	0.78	BSD15_01	0.45	0.26	11.48	13.29	13.68
											BSD15_02	0.56	0.12	12.71	13.30	13.48
								RSD16_01	1.38	0.76	BSD16_01	0.98	0.29	11.48	13.21	13.88
											BSD16_02	0.40	0.26	12.27	13.23	13.68
								RSD17_01	0.16	0.79	BSD17_01	0.16	0.31	12.56	13.12	13.81
								RSE09_04	0.19	0.78	BSE09_06	0.19	1.25	11.48	12.99	13.48
								RSE09_05	0.19	0.77	BSE09_07	0.19	0.87	11.48	12.91	13.88
								RSE09_06	0.11	0.69	BSE09_08	0.11	0.30	12.68	12.92	13.84
								RSE09_07	0.11	0.71	BSE09_09	0.11	0.23	12.48	12.73	13.10
								RSE11_01	0.04	0.75	BSE11_01	0.04	0.31	12.75	13.04	13.41
								RSE11_02	0.14	0.80	BSE11_02	0.14	0.33	12.48	13.22	13.68
								RSE11_03	0.50	0.80	BSE11_03	0.50	0.35	11.48	13.45	14.33
								BSE12_01	0.32	0.70	BSE12_01	0.32	0.22	12.68	12.97	13.97
								RSE12_02	0.28	0.74	BSE12_02	0.14	0.23	12.88	13.12	13.47
											BSE12_03	0.14	0.40	13.07	13.79	14.48
								RSE15_01	0.09	0.76	BSE15_01	0.09	0.99	11.48	12.74	13.48
				VitoCruz	S01_03	1.43	0.69	RSD13_01	0.36	0.75	BSD13_01	0.36	0.26	12.48	13.07	13.48
								RSD13_02	0.53	0.71	BSD13_02	0.28	0.28	12.29	12.69	13.08
											BSD13_03	0.25	0.24	12.27	12.50	12.88
								RSE20_01	0.55	0.64	BSE20_01	0.55	0.20	12.27	12.63	13.23
Balete	S02	0.94	0.64	Balete (P.S.)	S02_01	0.94	0.64	RSE03_01	0.94	0.64	BSE03_01	0.25	0.34	10.48	12.25	13.07
											BSE03_02	0.19	0.45	11.48	12.65	14.27
											BSE03_03	0.29	0.47	10.48	12.57	14.07
											BSP_05	0.19	1.05	10.65	12.29	15.28
											BSP_06	0.03	0.88	11.48	11.88	12.63
Paco-Pandacan-San Andres	S03	6.12	0.70	Paco (P.S.)	S03_01	1.74	0.71	RSE02_01	0.21	0.69	BSE02_01	0.13	0.48	12.18	12.70	14.27
											BSP_07	0.08	0.96	12.59	13.21	13.48
								RSE04_01	0.19	0.52	BSP_08	0.19	0.38	11.48	12.88	13.48
								RSE06_01	0.04	0.73	BSE06_01	0.04	1.27	11.48	12.10	12.27
								RSE06_02	1.01	0.75	BSE06_02	0.16	0.51	11.48	12.23	12.59
											BSE06_03	0.10	0.40	11.48	12.44	12.68
											BSE06_04	0.13	0.44	11.48	12.49	13.04
											BSE06_05	0.25	0.65	11.48	12.62	13.58
											BSE06_06	0.16	0.50	11.48	12.95	14.27
											BSE06_07	0.21	0.52	11.48	12.75	13.48
								RSE07_01	0.30	0.69	BSE07_01	0.11	0.30	11.48	12.50	13.27
											BSE07_02	0.19	0.94	11.48	12.17	12.68
				Pandacan (P.S.)	S03_02	1.15	0.63	RSE08_01	0.91	0.60	BSE08_01	0.13	0.96	11.48	12.15	12.48
											BSE08_02	0.09	0.95	11.48	12.27	12.48
											BSE08_03	0.13	0.49	11.48	12.54	13.92
											BSP_09	0.56	0.59	12.27	13.18	14.27
								RSE08_02	0.23	0.74	BSE08_04	0.23	1.01	11.48	12.88	13.41
				San Andres (P.S.)	S03_03	3.23	0.72	RSD07_01	0.23	0.73	BSD07_01	0.23	0.36	11.48	13.45	14.28
								RSD08_01	0.32	0.71	BSD08_01	0.32	0.27	11.48	12.65	14.27
								RSE06_03	0.08	0.76	BSE06_08	0.08	1.44	11.48	12.56	14.48
								RSE08_03	0.24	0.75	BSE08_05	0.24	0.84	12.68	13.38	14.27
								RSE08_04	0.87	0.70	BSE08_06	0.21	1.21	12.27	12.57	13.07
											BSE08_07	0.10	0.72	11.48	13.01	13.88
											BSE08_08	0.12	0.21	11.48	13.04	15.28
											BSE08_09	0.21	0.80	11.48	12.98	13.48
											BSE08_10	0.08	1.12	11.33	12.56	13.44
											BSP_10	0.14	0.61	11.48	12.59	13.20
								RSE09_08	0.47	0.75	BSE09_10	0.40	0.31	12.27	12.70	13.07
											BSE09_11	0.07	0.83	11.48	12.60	13.27
								RSE09_09	0.67	0.71	BSE09_12	0.28	0.76	11.48	12.82	13.27
											BSE09_13	0.26	0.35	12.63	13.43	14.28
											BSE09_14	0.13	1.06	11.48	12.98	13.48
								RSE10_01	0.35	0.70	BSE10_01	0.35	0.30	11.99	12.98	13.68
Sta. Clara	S04	1.57	0.63	Sta. Clara (P.S.)	S04_01	1.57	0.63	RSD03_01	0.09	0.70	BSD03_01	0.09	0.27	13.48	13.83	14.64
								RSE05_01	1.48	0.63	BSE05_01	0.77	0.59	10.48	13.04	13.88
											BSE05_02	0.39	0.32	12.43	13.27	13.88
											BSP_11	0.33	0.93	11.48	13.17	13.68
Makati	S05	4.31	0.63	Makati (P.S.)	S05_01	1.65	0.68	RSD04_01	1.00	0.66	BSD04_01	1.00	1.04	11.48	14.49	19.48
								RSD05_01	0.65	0.72	BSD05_01	0.59	2.00	13.07	19.02	29.48
											BSP_12	0.06	3.38	20.48	31.46	44.48
				Upper Calatagan	S05_02	2.66	0.60	RSE14_01	2.66	0.60	BSE14_01	0.40	1.93	12.48	14.84	20.80
											BSE14_02	0.74	1.57	16.48	24.19	33.48
											BSE14_03	1.52	3.03	18.48	22.31	29.99
South Harbor and Others	S06	4.90	0.64	South Harbor	S06_01	3.66	0.64	RSD01_01	0.93	0.76	BSD01_01	0.48	0.27	11.48	12.90	13.27
											BSD01_02	0.46	0.29	12.48	12.82	13.48
								RSD02_01	0.92	0.74	BSD02_01	0.64	0.46	11.48	12.87	13.68
											BSD02_02	0.28	0.29	12.08	12.67	13.27
								RSM_01	0.53	0.56	BSM_01	0.53	0.30	10.49	12.54	13.52
								RSM_02	0.75	0.47	BSM_02	0.75	1.35	10.48	13.14	18.48
								RSM_03	0.03	0.33	BSM_03	0.03	1.46	10.51	12.07	13.07
								RSM_04	0.21	0.41	BSM_04	0.21	0.80	10.48	12.89	14.27
								RSM_05	0.05	0.71	BSM_05	0.05	0.76	11.43	11.94	12.49
								RSM_06	0.23	0.78	BSM_06	0.23	0.28	11.94	12.73	13.07
				Pasig South	S06_02	1.03	0.58	RSP_01	0.36	0.62	BSP_01	0.36	0.83	10.49	12.54	17.28
								RSP_02	0.51	0.60	BSP_02	0.51	1.68	10.67	13.47	19.28
								RSP_03	0.03	0.66	BSP_03	0.03	2.17	11.49	12.10	13.27
								RSP_04	0.12	0.38	BSP_04	0.12	1.05	11.29	12.60	14.27
				Paranaque	S06_03	0.20	0.78	RSM_07	0.20	0.78	BSM_07	0.20	0.81	11.48	12.99	13.48
Total		43.79	0.66			43.79	0.66		43.79	0.66		43.79				

Source: 1/5,000 scale GIS map

(2) Existing Land Use and Runoff Coefficient

Landuse map prepared by MMEIRS (2004) using aerial photo is the landuse map of 2003 and will be used as existing landuse map by the Study. As presented in *Table E.4.14*, original landuse map of MMEIRS (2004) has been reclassified by the Study to reduce the number of landuse class for ease of analysis. Reclassified landuse map is shown in *Figure E.4.8*. After reviewing previous studies, manuals and books, runoff coefficient by different landuse class has been assigned by this study and is presented in *Table E.4.14*.

Landuse areas by sub-basins have been extracted for north and south drainage areas. Utilizing assigned runoff coefficient by landuse class (*Table E.4.14*), runoff coefficient for each sub-basin has been computed for north and south drainage areas and is presented in *Table E.4.12* and *Table E.4.13*, respectively.

Summary on land use and runoff coefficient for the total study area is presented in *Table E.4.15* and *Table E.4.16*, respectively.

The findings on landuse are as follows:

- Of the total study area, urban area comprises 33% in the north and 47% in the south drainage areas with a total of 80%.
- Of the total study area, non-urban area comprises 6% in the north and 14% in the south drainage areas with a total of 20%.
- Within urban area, residential area comprises 25% in the north and 35% in the south drainage areas with a total of 60%.
- Within urban area, informal settlers comprise 0.7% in the north and 0.5% in the south drainage areas with a total of 1%.
- Within urban area, commercial-industrial-institutional area comprises 16% in the north and 23% in the south drainage areas with a total of 39%.

The findings on runoff coefficient are as follows:

- For the total study area, runoff coefficient is calculated at 0.68. SEDLMM (2000) applied a little bit higher runoff coefficient (0.70) for the entire study area without making any calculation using landuse map.
- Runoff coefficient for the north and south drainage areas are 0.72 and 0.66, respectively.
- Runoff coefficient of the north drainage blocks vary from 0.68 (N03) to 0.80 (N05) and that of the south drainage blocks vary from 0.63 (S04, S05 and S06) to 0.70 (S03).

A comparison has been made between areas and runoff coefficients of pump drainage basins calculated by this study and that of previous studies, which is presented in *Table E.4.17*. There is no big change in pump drainage areas as calculated by this study using GIS database. However, there is increase in runoff coefficient, which is summarized in *Table E.4.18*. In the North Manila drainage area, maximum and minimum increases in runoff coefficient from original (1970s) runoff coefficient are at Balete (23%) and Pandacan (4%) pump drainage basins and that in the South Manila drainage area are at Binondo-Escolta (20%) and Valencia (16%) pump drainage basins.

Table E.4.14 Runoff Coefficient by Landuse

Original Landuse Classification by JICA MMEIRS 2004		Reclassified Landuse by the Present JICA Study, 2004			Applied Runoff Coeff.	Runoff Coefficient used by Other Studies (JICA 2000 Study used uniform Runoff Coefficient of 0.70)					Runoff Coefficient in Manual & Book	
Name	Class	Name	Class	Group	C	DPWH 2002	DPWH 1998	JICA 1990	MPWH 1987	BPW 1974	A.S.C.E.	V.T. C. 1988
Very Low Res Dens 1-2 Storey	VL-1	Very Low Density Residential	VLR	Urban Area	0.35	0.35				0.35	0.25 - 0.40	
Very Low Res Dens 3-4 Storey	VL-2											
Very Low Res Dens >5 Storey	VL-3											
Low Res Dens 1-2 Storey	L-1	Low Density Residential	LR		0.60	0.50	0.60	0.50	0.50	0.40	0.50 -0.80	
Low Res Dens 3-4 Storey	L-2											
Low Res Dens >5 Storey	L-3											
Medium Res Dens 1-2 Storey	M-1	Medium Density Residential	MR		0.70	0.65	0.65	0.65	0.65	0.60	0.25 - 0.75	
Medium Res Dens 3-4 Storey	M-2											
Medium Res Dens >5 Storey	M-3											
High Res Dens 1-2 Storey	H-1	High Density Residential	HR		0.80		0.70	0.80	0.80		0.60 - 0.90	
High Res Dens 3-4 Storey	H-2											
High Res Dens >5 Storey	H-3											
Very High Res Dens 1-2 Storey	V-1	Very High Density Residential	VHR		0.90						0.70 - 0.95	
Very High Res Dens 3-4 Storey	V-2											
Very High Res Dens >5 Storey	V-3											
Informal Settlers	S	Informal Settlers	IS		0.70							
Commercial & Business	2	Commercial & Business	CB		0.80	0.80			0.60, 0.75, 0.90	0.75	0.50 - 0.90	
Industrial	3	Industrial	IN		0.65	0.65	0.65	0.65	0.35, 0.50, 0.65	0.65, 0.75	0.50 - 0.90	
Government & Quasi-Public	4	Government & Quasi-Public	GP		0.70							
Educational & Cultural	5	Educational & Cultural	EC		0.70				0.35, 0.50			
Health & Welfare	6	Health & Welfare	HW		0.70							
Park & Recreational	7	Park & Recreational	PR	Non-Urban Area	0.30	0.05 - 0.25	0.45	0.35	0.35	0.20	0.10 - 0.25	
Religious & Cemetary	8	Religious & Cemetary	RC		0.40		0.45	0.35	0.35 - 0.50	0.20	0.10 - 0.25	
Transport & Service Facilities	9	Transport & Service Facilities	TS		0.30						0.20 -0.40	
Military	10	Military	MI		0.40		0.45	0.35				
Agricultural Land	11	Agricultural Land	AG		0.30		0.10, 0.30	0.10, 0.30				0.31 - 0.36
Grassland	12	Grassland	GR		0.25						0.10 - 0.40	0.25 - 0.30
Forestland	13	Forestland	FO		0.30	0.20 - 0.40						0.22 - 0.36
Open Spaces	15	Open Spaces	OS		0.25	0.10 - 0.30			0.35 - 0.50		0.10 - 0.30	0.10 - 0.30
Water Related	14	Water Body	WB		1.00							
Water Bodies	16											
		Other Impervious Area	IA		0.80	0.75 - 0.85						

JICA MMEIRS 2004: Earthquake Impact Reduction Study for Metropolitan Manila, Republic of the Philippines, 2004
DPWH 2002: Technical Standards and Guidelines for Planning and Design, Volume II, Urban Drainage, 2002
DPWH 1998: The Study on Flood Control and Drainage System Improvement for Kalookan-Malabon-Navotas-Valenzuela KAMANAVA) Areas, 1998
JICA 1990: The Study on Flood Control and Drainage Project in Metro Manila, 1990
MPWH 1987: Drainage Improvement Plans of Estero de Vitas and Other Catchment Areas, Supplementary Study Report of the Vitas Catchment Area Drainage Improvement Plan, 1987
BPW 1974: Technical Report on Engineering Design for Drainage Pumping Stations and Floodgates, 1974

A.S.C.E. : American Society of Civili Engineers
V. T. Chow 1988: Applied Hydrology, McGraw-Hill Book Co., 1988

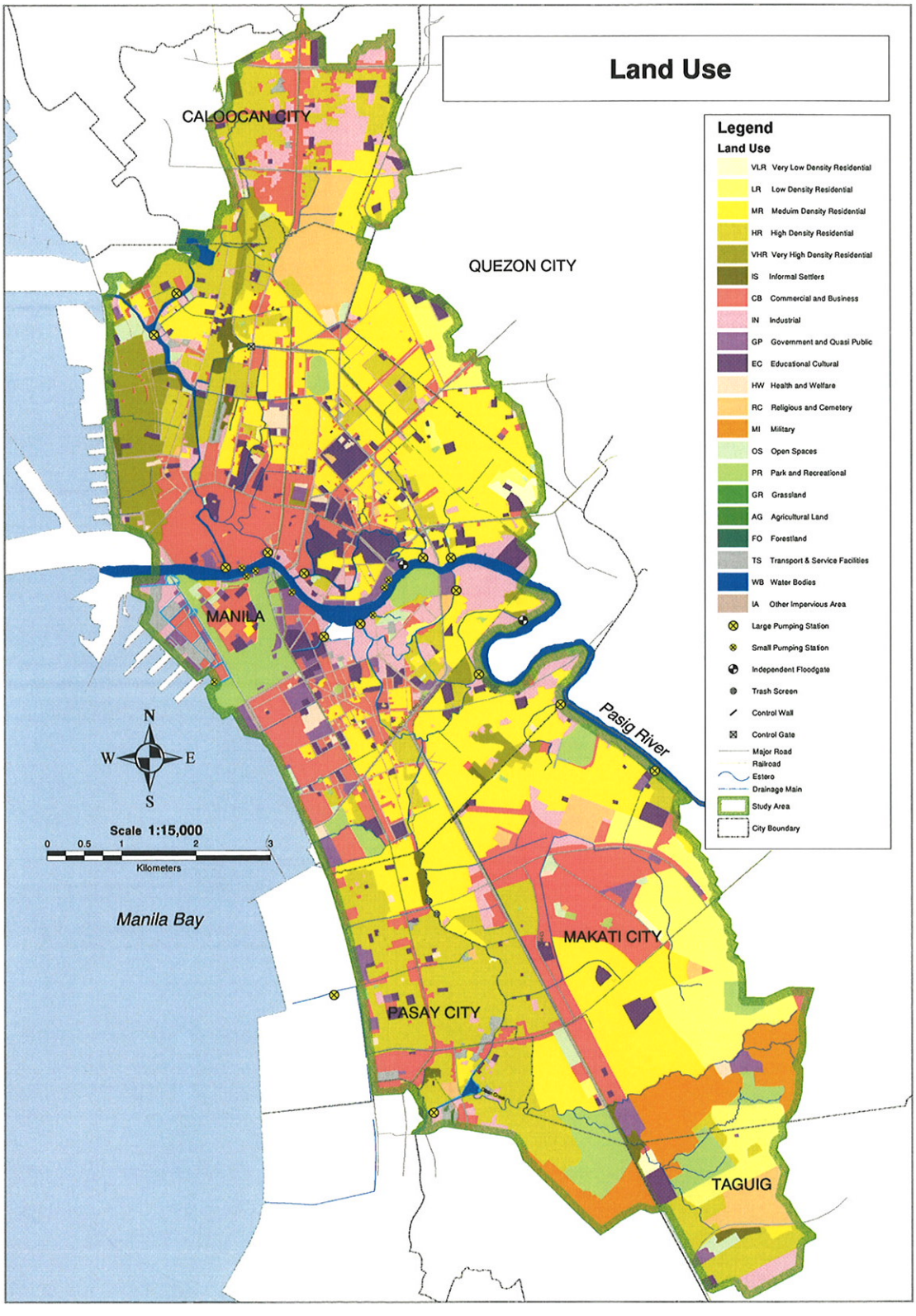


Figure E.4.8 Existing Landuse Map (2003)

Table E.4.15 Summary of Landuse in the Study Area

Group				Sub-Group				Reclassified Landuse by this Study			
Name	Area (km^2)			Name	Area (km^2)			Name	Area (km^2)		
	North Draiange Area	South Draiange Area	Study Area		North Draiange Area	South Draiange Area	Study Area		North Draiange Area	South Draiange Area	Study Area
Urban	24.01	33.79	57.80	Residential	14.43	20.48	34.92	Very Low Density Residential	0.13	0.13	0.26
								Low Density Residential	0.80	3.82	4.61
								Medium Density Residential	7.65	9.10	16.75
								High Density Residential	4.02	7.07	11.09
								Very High Density Residential	1.83	0.37	2.20
				Informal Settlers	0.38	0.30	0.68	Informal Settlers	0.38	0.30	0.68
				Commercial, Industrial & Institutional	9.19	13.01	22.20	Commercial & Business	4.44	7.18	11.63
								Industrial	2.04	2.81	4.85
								Government & Quasi-Public	0.32	1.45	1.76
								Educational & Cultural	2.10	1.37	3.47
								Health & Welfare	0.30	0.20	0.50
Non-Urban	4.78	10.00	14.78					Park & Recreational	0.15	3.33	3.48
								Religious & Cemetary	1.47	1.25	2.72
								Transport & Service Facilities	0.27	0.68	0.95
								Military	0.00	2.54	2.54
								Agricultural Land	0.00	0.00	0.00
								Grassland	0.00	0.00	0.00
								Forestland	0.00	0.02	0.02
								Open Spaces	0.30	0.40	0.71
								Water Body	0.51	0.39	0.89
								Other Impervious Area	2.08	1.39	3.47
Total	28.78	43.79	72.58					21 Classes	28.78	43.79	72.58

Source: Extracted by this Study from JICA MMEIRS 2003 GIS landuse map

Table E.4.16 Summary of Runoff Coefficient of the Study Area

North Drainage Area				South Drainage Area			
Drainage Block		Area	RO Coeff.	Drainage Block		Area	RO Coeff.
Name	ID	(km^2)	C	Name	ID	(km^2)	C
Vitas-Binondo-Escolta	N01	8.55	0.75	Libertad-Tripa de Gallina	S01	25.96	0.66
Quiapo-Aviles	N02	5.58	0.71	Balete	S02	0.94	0.64
Valencia	N03	2.37	0.68	Paco-Pandacan-San Andres	S03	6.12	0.70
Maypajo-Blumentrit-Balut	N04	9.92	0.69	Sta. Clara	S04	1.57	0.63
North Harbor	N05	2.37	0.80	Makati	S05	4.31	0.63
				South Harbor and Others	S06	4.90	0.64
Total		28.78	0.72	Total		43.79	0.66

Source: Estimated using JICA MMEIRS 2003 lnaduse data

Table E.4.17 Comparison of Pump Drainage Basins by Different Studies

Drainage Area		Drainage Block		Pump	Present Study		JICA 2000		JCI 1999		PEA Nov. 1995		PEA Mar. 1995		DPWH 1990		PCI 1988		MPWH 1986*		MPWH 1984		BPW 1978		BPW 1974	
Name	Area (ha)	ID	Area (ha)	Drainage Basin	Area (ha)	Runoff Coeff.	Area (ha)	Runoff Coeff.	Area (ha)	Runoff Coeff.	Area (ha)	Runoff Coeff.	Area (ha)	Runoff Coeff.	Area (ha)	Runoff Coeff.	Area (ha)	Runoff Coeff.	Area (ha)	Runoff Coeff.	Area (ha)	Runoff Coeff.	Area (ha)	Runoff Coeff.	Area (ha)	Runoff Coeff.
North	1,699	N01	855	Vitas	556	0.74	493	0.70							578	0.75	542		542	0.80						
				Binondo	269	0.77	312	0.70	279						292		279	0.64	304	0.86	279		279	0.64	279	0.70
				Escolta	30	0.79																				
		N02	558	Quiapo	229	0.73	198	0.70	225						185		195	0.63	212	0.84	195		225	0.63	225	0.63
				Aviles	328	0.70	307	0.70	356						298		356	0.60	312	0.81	356		356	0.60	356	0.60
		N03	237	Valencia	237	0.68	215	0.70	246						238		246	0.59			246		246	0.59	246	0.59
		N04	49	Balut	49	0.79	45	0.70							49	0.65	31									
South	3,482	S01	2,454	Tripa de Gallina	1,706	0.62	1,771	0.70	1,769		1,769	0.60					1,769	0.60			1,769		1,769	0.60	1,323	0.56
				Libertad	748	0.75	567	0.70	779				779	0.64			779	0.64			779		779	0.64		
		S02	94	Balete	94	0.64	34	0.70									85		85	0.60					52	0.52
		S03	612	Paco	174	0.71	94	0.70	182						228		182	0.64	226	0.83	182		182	0.64	182	0.64
				Pandacan	115	0.63	94	0.70	180						95		180	0.68	104	0.63	180		180	0.68	95	0.68
				San Andres	323	0.72	391	0.70							356	0.72	339									
		S04	157	Sta. Clara	157	0.63	89	0.70	133						133		116	0.56			116		133	0.56	133	0.56
		S05	165	Makati	165	0.68	123	0.70	150								151	0.62			151		151	0.62		

Source of data of Present Study: GIS database of 1/5,000 ccale and landuse map of 2003

JICA 2000: Study on the Existing Drainage Laterals in Metro Manila in the Republic of the Philippines, 2000
JCI 1999: Japan Consulting Institute, Feasibility Study Report on Metro Manila Drainage System Rehabilitation Project (Phase II) in Republic of the Philippines, 1999
PEA Nov. 1995: The Study of and Updated Drainage Plan for Section II of Manila Bay Reclamation Area, Pasay City and Parañaque, Metro Manila, 1995
PEA Mar. 1995: The Study on the Updated Drainage Plan for the Libertad Reclamation Area in Pasay City, Metro Manila, 1995
DPWH 1990: Metro Manila Flood Control Project (II), 1990
PCI 1988: Pacific Consultants International, Metro Manila Drainage System Rehabilitation Project, Study Report, 1988
*MPWH 1986: Drainage Improvement Plans of Estero de Vitas and Other Catchment Areas, 1986 ==> Runoff coefficients were based on projected (future) landuse for year 2000
MPWH 1984: Metro Manila Integrated Urban Drainage and Flood Control Master Plan, 1984
BPW 1978: Technical Report on Engineering Design for Drainage Pumping Stations and Floodgates, 1974
BPW 1974: Technical Report on Engineering Design for Drainage Pumping Stations and Floodgates, 1974

Table E.4.18 Increase in Runoff Coefficients of Pump Drainage Basins

Drainage Area	Pump Drainage Basin	1970s Runoff Coefficient		1980s-1990s Runoff Coefficient		This Study Runoff Coefficient	% Increase from Original Runoff Coefficient
North	Vitas		→	0.75	→	0.74	
	Binondo-Escolta	0.64	→	0.64	→	0.77	20
	Quiapo	0.63	→	0.63	→	0.73	16
	Aviles	0.60	→	0.60	→	0.70	17
	Valencia	0.59	→	0.59	→	0.68	15
	Balut		→	0.65	→	0.79	
South	Tripa de Gallina	0.56	→	0.60	→	0.62	11
	Libertad	0.64	→	0.64	→	0.75	17
	Balete	0.52	→		→	0.64	23
	Paco	0.64	→	0.64	→	0.71	10
	Pandacan	0.68	→	0.68	→	0.63	
	San Andres		→	0.72	→	0.72	0
	Sta. Clara	0.56	→	0.56	→	0.63	13
	Makati	0.62	→	0.62	→	0.68	10

(3) Future (or Planned) Land Use and Runoff Coefficient

Future (or planned) landuse maps for all the cities except the City of Manila have been collected from Local Government Units (LGUs) in Adobe Acrobat Reader (pdf) format. The projected year of planned land use is not known. Unfortunately, future (or planned) landuse map for Manila City has not been authorized as yet, so it is not allowed to use for the present study. The maps have been scanned, digitized using Auto CAD and finally a GIS database on future landuse map has been prepared by this study. *Figure E.4.9* shows the future landuse map without the City of Manila. Based on assigned runoff coefficients by reclassified future landuse classes as shown in *Table E.4.19*, future land use and runoff coefficient by reach basin has been estimated. Since, the map is not complete and also due to difference in legends of land use by LGUs and also due to partial inconsistency of the future landuse map with the existing landuse map, therefore, estimated future runoff coefficient by reach basin has not been directly used in the runoff analysis. Instead, correlations have been developed between increase in runoff coefficient with increase in urbanization (against existing runoff coefficient and urbanization) and between increase in urbanization with existing non-urbanization as shown in *Figure E.4.10*. The correlations (or equations) of *Figure E.4.10* in combination with data on existing urbanization and runoff coefficient were used in estimation of future runoff coefficient by reach basin for north and south drainage areas shown in *Table E.4.20* and *Table E.4.21*, respectively. Averaged runoff coefficient in the entire study area will increase up to 0.70 from the current value of 0.68.

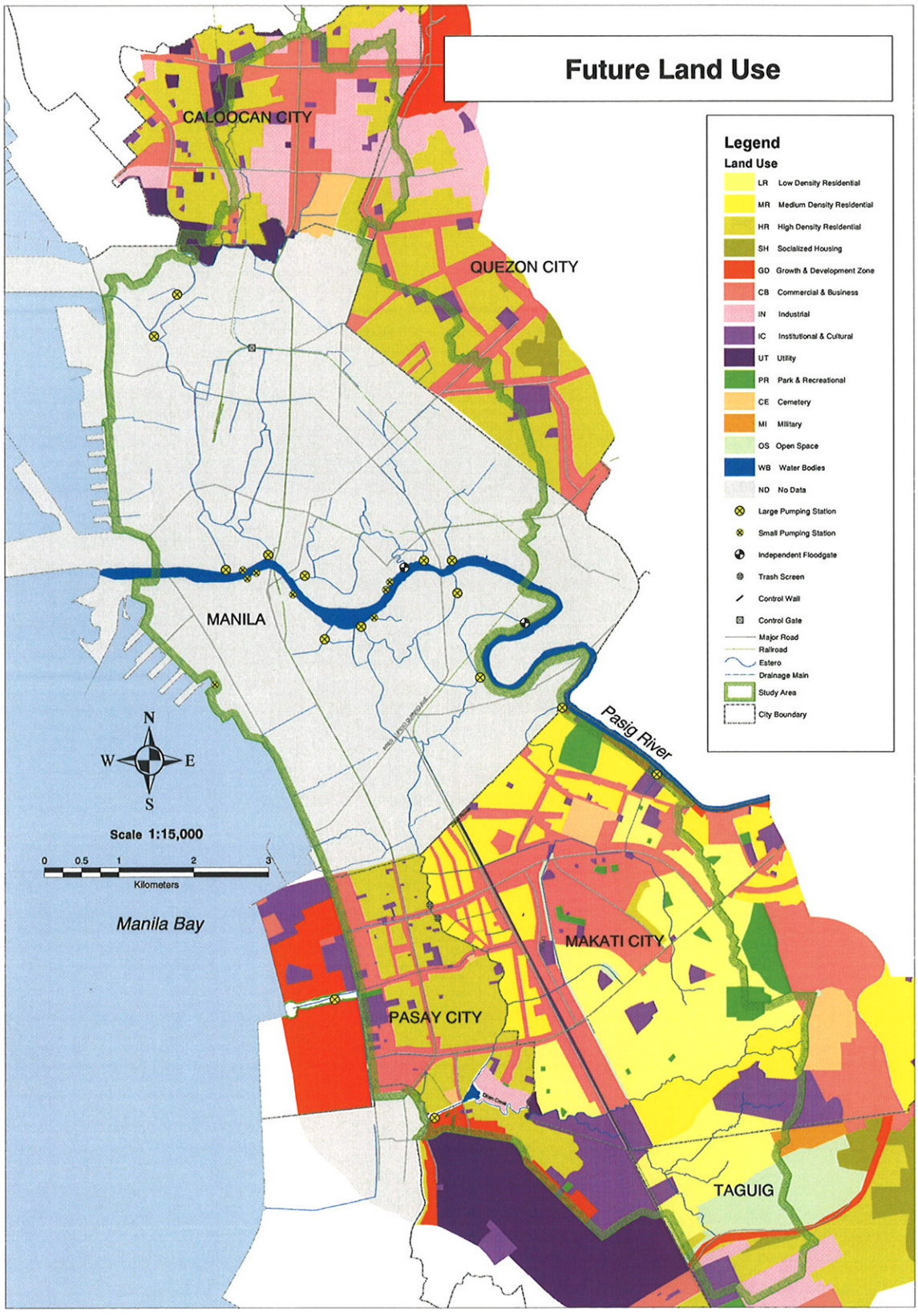
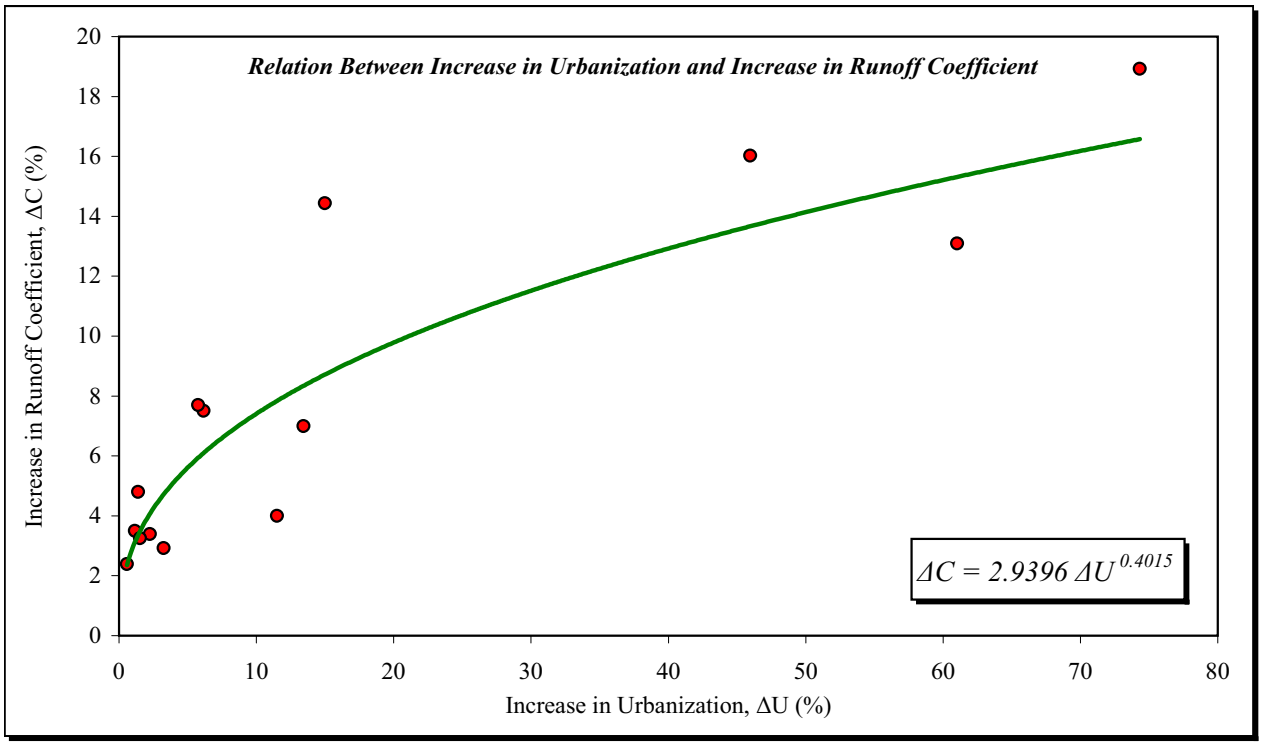
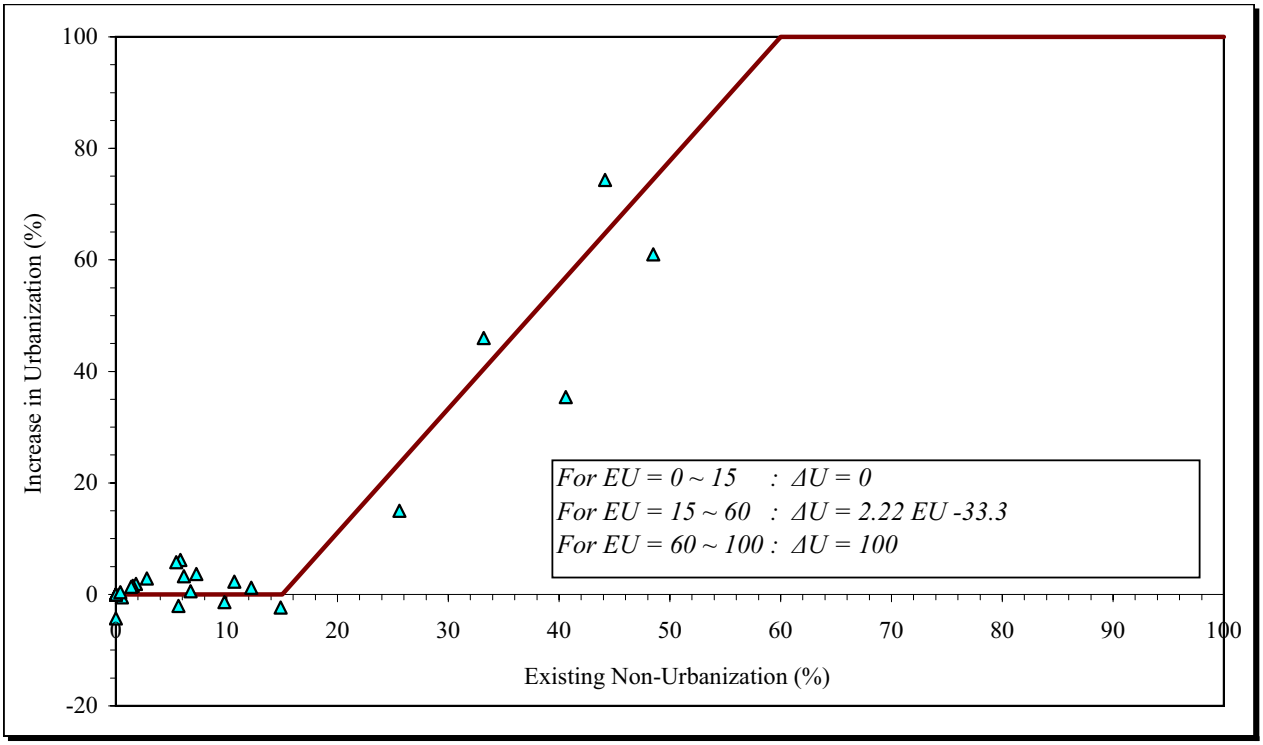


Figure E.4.9 Future (Planned) Landuse Map (Incomplete)

Table E.4.19 Runoff Coefficient by Future (Planned) Landuse

Original Landuse Classification by LGUs		Reclassified Landuse by the Present JICA Study, 2004			Applied Runoff Coeff.
Name	Class	Name	Class	Group	C
Low Density Residential	LR	Low Density Residential	LR	Urban Area	0.60
Low Density Development Area	LDDA				0.60
Medium Density Residential	MR	Medium Density Residential	MR		0.70
Residential 2	R2				0.70
High Density Residential	HR	High Density Residential	HR		0.85
Residential	R				0.85
Residential 1	R1				0.85
Socialized Housing	SH	Socialized Housing	SH		0.70
Riverside Development Zone	RDZ	Growth & Development Zone	GD		0.75
Controlled Growth Corridor	CGC				0.75
Plannd Unit Development	PUD				0.75
Commercial	CO	Commercial & Business	CB		0.80
Low Density Commercial	LC				0.80
Medium Density Commercial	MC				0.80
High Density Commercial	HC				0.80
Central Business District	CBD				0.80
Urban Core Area	UCA				0.80
Industrial	IND	Industrial	IN		0.65
Institutional	I	Institutional & Cultural	IC		0.70
Cultural	CU				0.70
Utility	U	Utility	UT		0.70
Parks and Recreation	PR	Park and Recreational	PR	Non-Urban Area	0.30
Recreation	REC				0.30
Entertainment	E				0.30
Tourism	T				0.30
Cemetery	CE	Cemetery	CE		0.40
Military	M	Military	MI		0.40
Open Space	OS	Open Space	OS		0.25
		Water Body	WB		1.00





Source: Prepared by this Study based on future (planned) landuse maps of the LGUs except Manila city

Figure E.4.10 Effect of Urbanization and Future Landuse Condition on Runoff Coefficient

Table E.4.20 Future (Planned) Runoff Coefficient by Reach Basin for North Manila

Reach		Existing Non-Urban Area			Increase from Existing to Future		Runoff Coefficient	
ID	Area (m^2)	Area (m^2)	w/o Park, Cemetary, Water Body	% of Total Area	Urbanization (%)	Runoff Coefficient (%)	Existing	Future
RND01_01	1,126,563	149,904	137,443	12.20	0.00	0.00	0.83	0.83
RND02_01	618,270	123,175	121,970	19.73	10.50	7.55	0.81	0.85
RND03_01	229,003	69,025	67,865	29.64	32.49	11.89	0.79	0.85
RND04_01	493,903	49,089	21,458	4.34	0.00	0.00	0.79	0.79
RND05_01	1,056,996	887,441	82,402	7.80	0.00	0.00	0.47	0.47
RND05_02	983,480	72,744	71,003	7.22	0.00	0.00	0.70	0.70
RND06_01	579,198	37,555	35,371	6.11	0.00	0.00	0.66	0.66
RND07_01	215,245	72,766	52,276	24.29	20.62	9.91	0.69	0.76
RND07_02	493,944	54,745	37,775	7.65	0.00	0.00	0.79	0.79
RND08_01	435,274	19,095	16,033	3.68	0.00	0.00	0.73	0.73
RND08_02	705,471	68,619	59,345	8.41	0.00	0.00	0.74	0.74
RND09_01	592,048	79,553	77,044	13.01	0.00	0.00	0.74	0.74
RND12_01	468,544	132,146	129,324	27.60	27.97	11.20	0.67	0.75
RND12_02	647,179	204,179	69,378	10.72	0.00	0.00	0.64	0.64
RND13_01	862,851	138,350	134,785	15.62	1.38	3.34	0.74	0.77
RND14_01	926,419	161,719	142,269	15.36	0.79	2.68	0.72	0.74
RND15_01	513,413	67,172	60,923	11.87	0.00	0.00	0.72	0.72
RND16_01	368,765	15,506	7,782	2.11	0.00	0.00	0.69	0.69
RND16_02	942,952	46,159	40,568	4.30	0.00	0.00	0.69	0.69
RND17_01	376,982	43,347	43,347	11.50	0.00	0.00	0.74	0.74
RND18_01	238,400	28,519	23,062	9.67	0.00	0.00	0.74	0.74
RND19_01	1,208,028	40,935	28,871	2.39	0.00	0.00	0.65	0.65
RNE01_01	136,105	70,072	56,460	41.48	58.79	15.09	0.52	0.60
RNE01_02	322,056	102,619	34,632	10.75	0.00	0.00	0.82	0.82
RNE02_01	164,966	152,244	0	0.00	0.00	0.00	0.98	0.85
RNE02_02	39,308	1,094	0	0.00	0.00	0.00	0.82	0.82
RNE02_03	3,444,460	721,545	169,379	4.92	0.00	0.00	0.68	0.68
RNE03_01	3,019,000	190,099	182,473	6.04	0.00	0.00	0.75	0.75
RNE04_01	296,082	26,872	24,085	8.13	0.00	0.00	0.79	0.79
RNE04_02	305,499	28,825	16,024	5.25	0.00	0.00	0.78	0.78
RNE04_03	701,252	106,830	72,508	10.34	0.00	0.00	0.79	0.79
RNE05_01	796,234	92,091	50,640	6.36	0.00	0.00	0.80	0.80
RNE06_01	392,241	47,584	45,926	11.71	0.00	0.00	0.74	0.74
RNE07_01	333,979	24,436	23,858	7.14	0.00	0.00	0.76	0.76
RNE07_02	68,680	2,418	2,418	3.52	0.00	0.00	0.70	0.70
RNE07_03	188,658	11,166	11,166	5.92	0.00	0.00	0.74	0.74
RNE08_01	267,567	30,902	22,050	8.24	0.00	0.00	0.74	0.74
RNE09_01	246,101	32,576	32,070	13.03	0.00	0.00	0.75	0.75
RNE10_01	176,112	32,678	31,790	18.05	6.77	6.34	0.73	0.78
RNE11_01	36,722	221	221	0.60	0.00	0.00	0.70	0.70
RNE12_01	760,775	91,959	68,686	9.03	0.00	0.00	0.75	0.75
RNE13_01	100,304	11,015	7,709	7.69	0.00	0.00	0.71	0.71
RNE14_01	353,996	62,325	47,397	13.39	0.00	0.00	0.74	0.74
RNE14_02	505,337	99,338	72,828	14.41	0.00	0.00	0.72	0.72
RNE15_01	55,682	6,514	6,514	11.70	0.00	0.00	0.74	0.74
RNE16_01	41,768	6,859	1,842	4.41	0.00	0.00	0.76	0.76
RNE17_01	282,565	55,493	42,079	14.89	0.00	0.00	0.73	0.73
RNE18_01	69,360	4,355	1,941	2.80	0.00	0.00	0.74	0.74
RNE19_01	39,934	3,972	3,972	9.95	0.00	0.00	0.71	0.71
RNE20_01	1,161,939	60,736	54,471	4.69	0.00	0.00	0.71	0.71
RNM_01	394,413	140,178	121,511	30.81	35.09	12.27	0.68	0.77
Total	28,784,019	4,778,760	2,664,945				0.72	0.73

Source: Computed by this Study based on existing and future landuse maps

Table E.4.21 Future (Planned) Runoff Coefficient by Reach Basin for South Manila

Reach		Existing Non-Urban Area			Increase from Existing to Future		Runoff Coefficient	
ID	Area (m^2)	Area (m^2)	w/o Park, Cemetary, Water Body	% of Total Area	Urbanization (%)	Runoff Coefficient (%)	Existing	Future
RSD01_01	932,359	171,349	161,601	17.33	5.18	5.69	0.76	0.81
RSD02_01	924,419	192,749	175,351	18.97	8.81	7.04	0.74	0.79
RSD03_01	88,032	0	0	0.00	0.00	0.00	0.70	0.70
RSD04_01	1,001,546	122,369	1,025	0.10	0.00	0.00	0.66	0.66
RSD05_01	649,024	3,513	0	0.00	0.00	0.00	0.71	0.71
RSD07_01	226,110	7,798	0	0.00	0.00	0.00	0.73	0.73
RSD08_01	323,367	19,519	17,967	5.56	0.00	0.00	0.71	0.71
RSD09_01	220,689	14,630	14,630	6.63	0.00	0.00	0.71	0.71
RSD09_02	786,063	8,193	0	0.00	0.00	0.00	0.73	0.73
RSD10_01	319,811	0	0	0.00	0.00	0.00	0.72	0.72
RSD11_01	488,310	82,338	0	0.00	0.00	0.00	0.68	0.68
RSD12_01	715,060	51,939	51,939	7.26	0.00	0.00	0.73	0.73
RSD13_01	356,756	40,693	26,140	7.33	0.00	0.00	0.75	0.75
RSD13_02	527,818	72,169	40,194	7.62	0.00	0.00	0.71	0.71
RSD14_01	1,139,563	66,250	64,066	5.62	0.00	0.00	0.76	0.76
RSD15_01	1,005,893	61,609	31,346	3.12	0.00	0.00	0.77	0.77
RSD16_01	1,380,647	163,559	158,659	11.49	0.00	0.00	0.76	0.76
RSD17_01	158,473	2,897	0	0.00	0.00	0.00	0.79	0.79
RSE02_01	213,281	46,133	29,254	13.72	0.00	0.00	0.68	0.68
RSE03_01	939,005	349,682	156,249	16.64	3.64	4.94	0.64	0.67
RSE04_01	185,788	90,580	59,013	31.76	37.22	12.56	0.52	0.58
RSE05_01	1,481,405	288,911	32,334	2.18	0.00	0.00	0.63	0.63
RSE06_01	36,814	8,633	33	0.09	0.00	0.00	0.73	0.73
RSE06_02	1,004,756	203,669	160,210	15.95	2.10	3.96	0.75	0.78
RSE06_03	84,496	23,648	18,565	21.97	15.48	8.83	0.76	0.83
RSE07_01	299,134	67,954	48,655	16.27	2.81	4.45	0.69	0.72
RSE08_01	914,307	281,493	31,404	3.43	0.00	0.00	0.60	0.60
RSE08_02	232,772	38,136	19,281	8.28	0.00	0.00	0.74	0.74
RSE08_03	239,473	47,354	34,234	14.30	0.00	0.00	0.75	0.75
RSE08_04	868,413	19,262	0	0.00	0.00	0.00	0.70	0.70
RSE09_01	282,676	114,810	61,602	21.79	15.08	8.74	0.62	0.68
RSE09_02	439,260	112,430	64,321	14.64	0.00	0.00	0.72	0.72
RSE09_03	659,979	35,943	35,943	5.45	0.00	0.00	0.77	0.77
RSE09_04	192,231	2,911	0	0.00	0.00	0.00	0.78	0.78
RSE09_05	186,249	0	0	0.00	0.00	0.00	0.77	0.77
RSE09_06	113,846	0	0	0.00	0.00	0.00	0.69	0.69
RSE09_07	113,350	110	58	0.05	0.00	0.00	0.71	0.71
RSE09_08	470,337	71,020	53,172	11.31	0.00	0.00	0.75	0.75
RSE09_09	667,855	15,834	8,179	1.22	0.00	0.00	0.71	0.71
RSE10_01	352,040	47,149	45,733	12.99	0.00	0.00	0.70	0.70
RSE11_01	42,101	21,816	21,816	51.82	80.00	17.08	0.75	0.85
RSE11_02	135,839	10,511	10,511	7.74	0.00	0.00	0.80	0.80
RSE11_03	498,821	65,444	63,335	12.70	0.00	0.00	0.80	0.80
RSE12_01	322,552	4,424	4,424	1.37	0.00	0.00	0.70	0.70
RSE12_02	283,612	29,345	0	0.00	0.00	0.00	0.74	0.74
RSE13_01	723,650	107,761	3,384	0.47	0.00	0.00	0.73	0.73
RSE14_01	2,657,107	179,129	12,185	0.46	0.00	0.00	0.60	0.60
RSE15_01	89,495	0	0	0.00	0.00	0.00	0.76	0.76
RSE16_01	640,841	2,552	592	0.09	0.00	0.00	0.79	0.79
RSE16_02	1,206,874	0	0	0.00	0.00	0.00	0.69	0.69
RSE17_01	1,542,322	87,374	50,166	3.25	0.00	0.00	0.75	0.75
RSE18_01	2,503,124	830,799	527,343	21.07	13.47	8.35	0.63	0.68
RSE18_02	2,935,041	1,295,413	1,194,693	40.70	57.06	14.91	0.56	0.65
RSE19_01	5,401,211	2,619,574	996,464	18.45	7.66	6.66	0.53	0.56
RSE20_01	549,452	198,937	54,620	9.94	0.00	0.00	0.64	0.64
RSM_01	532,665	292,232	243,729	45.76	68.28	16.02	0.56	0.65
RSM_02	752,026	525,358	3,026	0.40	0.00	0.00	0.47	0.47
RSM_03	34,882	34,882	2,032	5.82	0.00	0.00	0.33	0.33
RSM_04	214,173	169,979	12,130	5.66	0.00	0.00	0.41	0.41
RSM_05	46,782	3,434	3,434	7.34	0.00	0.00	0.71	0.71
RSM_06	225,257	51,942	51,942	23.06	17.89	9.36	0.78	0.85
RSM_07	204,636	20,038	75	0.04	0.00	0.00	0.78	0.78
RSP_01	364,753	164,653	106,861	29.30	31.74	11.78	0.62	0.69
RSP_02	508,679	197,083	34,957	6.87	0.00	0.00	0.60	0.60
RSP_03	32,283	16,740	0	0.00	0.00	0.00	0.66	0.66
RSP_04	123,855	103,569	2,715	2.19	0.00	0.00	0.38	0.38
Total	43,793,439	9,980,225	5,001,591				0.66	0.68

Source: Computed by this Study based no existing and future landuse maps