REPUBLIC OF THE PHILIPPINES

THE STUDY ON FLOOD CONTROL AND DRAINAGE PROJECT IN METRO MANILA

VOLUME 1
MAIN REPORT

MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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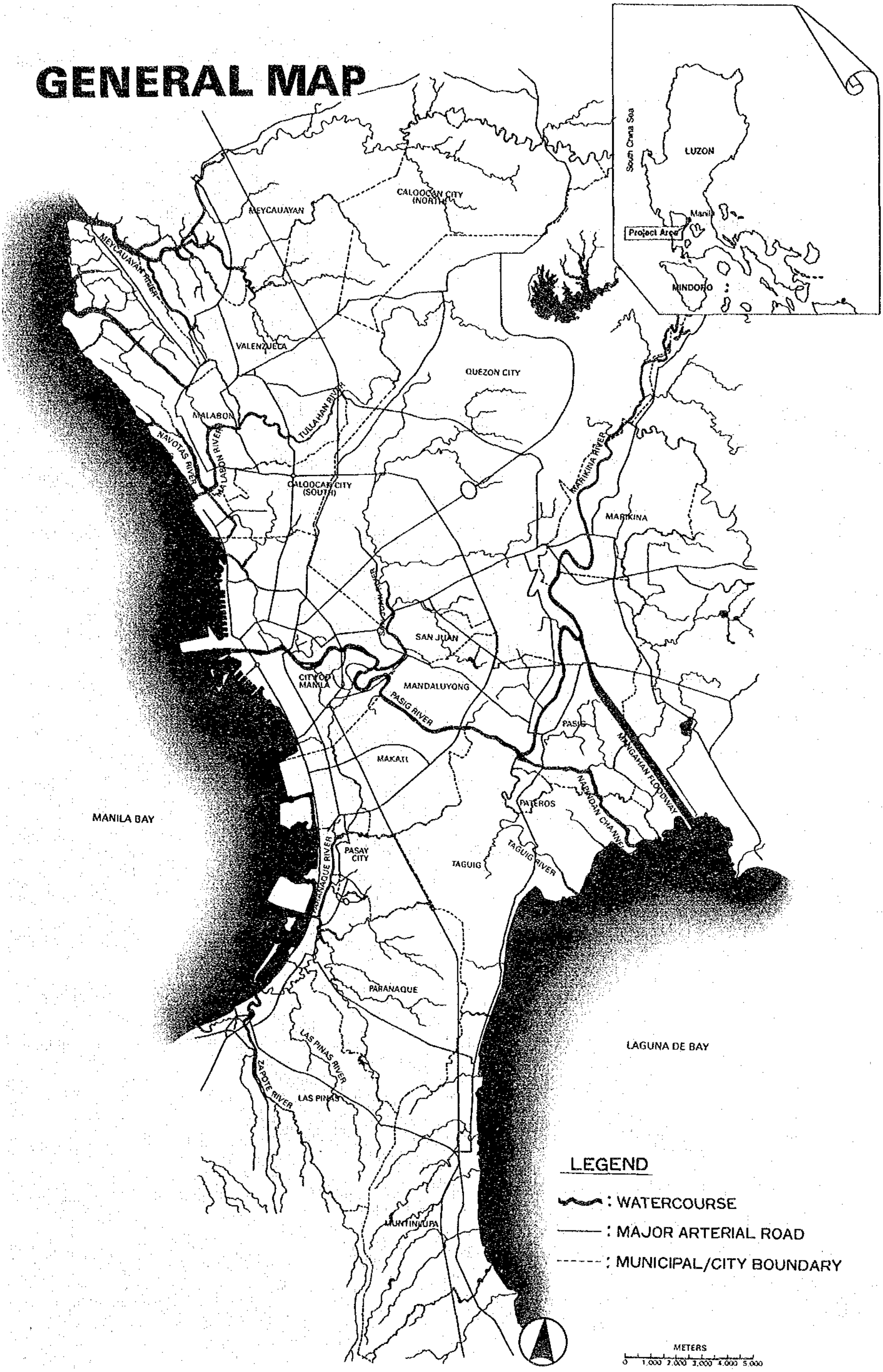
GENERAL MAP


South China Sea
LUZON
Manila
Project Area
MINDORO
MEYCAUAYAN
CALOOCAN CITY (NORTH)
MEYCAUAYAN RIVER
VALENZUELA
QUEZON CITY
MALABON
TULLAHAN RIVER
NAVOTAS RIVER
MALABON RIVER
CALOOCAN CITY (SOUTH)
MARIKINA RIVER
MARIKINA
SAN JUAN
CITY OF MANILA
MANDALUYONG
PASIG RIVER
PASIG
MANGAHAN FLOODWAY
MAKATI
NAPINDAN CHANNEL
PATEROS
MANILA BAY
PARANAQUE RIVER
PASAY CITY
TAGUIG
TAGUIG RIVER
PARANAQUE
LAGUNA DE BAY
LAS PINAS RIVER
ZAPOTE RIVER
LAS PINAS
MUNTINLUPA
LEGEND
: WATERCOURSE
: MAJOR ARTERIAL ROAD
: MUNICIPAL/CITY BOUNDARY
METERS
0 1,000 2,000 3,000 4,000 5,000

SUMMARY

1. INTRODUCTION

1.1 Study Area and Objectives

The study area for this project is the Metro Manila and related areas covering approximately 981 km^2.

The objectives of the study are to prepare the Master Plan for flood control and drainage improvement in Metro Manila with the target year of 2020, as well as the Framework Plan which presents the future comprehensive flood plain management plan, and to carry out a Feasibility Study on the Priority Project Areas selected on the basis of the results of the Master Plan Study.

1.2 Existing Flood and Drainage Control Practice

Metro Manila which encompasses four (4) cities and thirteen (13) municipalities with the population of over 6.0 million is the economic and political core of the Philippines. One of the most serious problems in the area is habitual flooding.

A flood control plan of the Pasig-Marikina River including the Metro Manila area was formulated in 1954 with the Marikina River Multipurpose Project, followed by several studies on flood control of the Pasig-Marikina-Laguna Lake Basin. The Mangahan Floodway, Napindan Hydraulic Control Structure and the improvement works of the Pasig River, consisting mainly of river wall and dredging of the channel, have been constructed in line with the flood control plan of the Pasig-Marikina River.

As for the storm drainage in Metro Manila, the drainage program by the construction of pumping stations in central Manila was started in 1974. Initiated by the Drainage Master Plan Study in 1952, ten (10) pumping stations were constructed. In parts of other areas of Metro Manila, embankment and drainage gates have been constructed as urgent countermeasures for flood inundation.

Notwithstanding the continuous efforts and big investments on flood control and drainage works, several development projects and the rapid urbanization achieved in the past years have worsened the flooding conditions. Metro Manila is still facing the menace of flood damage caused by the poor flow capacity of Pasig-Marikina River and other rivers, and also the insufficient capacity of drainage channels and facilities in the low-lying areas.

Considering the above situation, it is expected that immediate action to mitigate flood and inundation damage in the object area be taken at the earliest possible opportunity.

1.3 Flood Damage

Metro Manila suffered from serious flood damage in 1948, 1966, 1967, 1970, 1972, 1977, 1986 and 1988. Floods were caused by overtopping of the main rivers, as well as inland water.

Flooding in 1986 caused by Typhoon Miding, inflicted the most serious damage in recent years to Metro Manila. The flood area in Metro Manila reached 86.7 km^2, 14.5% of Metro Manila. When the flooded area of Cainta and Taytay located in the Marikina Valley are included, the total flooded area was 103.6 km^2.

Flooding in 1988 caused by Typhoon Unsang also inflicted serious damage in the Marikina River Basin and in the low-lying shoreline area of the Laguna Lake because of the overflowing flood water of the Marikina River and the incremental high lake stage, respectively. The Provident Subdivision located at the right bank side in the lower reach of Sto. Niño received tremendous damage because of the destruction of the river wall by the flood flow.

2. FORMULATION OF FRAMEWORK PLAN

2.1 Planning Conditions

The Framework Plan has been studied on the basis of the following conditions.

Target Completion Year

The target completion year for the Framework Plan is not specified, because this plan presents the outline of the far future comprehensive flood plain management for Metro Manila and some of its neighboring areas after full urbanization has been attained.

Safety Degree

The following design return periods were adopted as the safety degree of proposed structures and facilities.

- River System : 100-year return period
- Drainage System : 10-year return period
- Laguna Lakeshore Area (East and West of Mangahan): Recorded Maximum High Water Stage (40-year return period)

2.2 Proposed Plan

River System

For the improvement of the Pasig-Marikina River, the comparative study was made from the economic and social aspects. Proposed are the plans comprising river improvement works for the Pasig, Marikina and San Juan rivers, MCGS construction works for diversion, and the Marikina Dam for discharge regulation.

The area along the Malabon-Tullahan River has been well developed and it is practically difficult to acquire an area for the construction of flood regulation facilities. Proposed are thus the river improvement works in the whole stretch.

As for the Buli, Baho and Mahaba rivers, channel improvement by expanding the existing channel width together with excavation/dredging is the most and only viable measure for the upper and middle reaches. In this case, a shortcut from the Baho River to the Buli River is employed because of the apparent lesser construction cost and house evacuation than the improvement work of the Baho River. In the lower reach, backwater dike to connect with the laguna Lake is constructed.

As for the South Parañaque and Las Piñas rivers, the optimum way is to drain the runoff discharge from the upstream hilly land or mountain area into the Manila Bay directly by channel improvement.

Drainage System

For all of the drainage areas, the proposed drainage system basically consists of mechanical drainage by the construction of a pumping station together with the improvement of a drainage channel. In this case, backwater dike was provided in the lower reach which is affected by the high water stage of the sea, lake and rivers. Other measures such as ring dike and cut-off channel were adopted in accordance with the topographic characteristics of the respective drainage areas.

In Manila and suburbs, further improvement works such as extension/construction of pumping stations, improvement of the capacity of esteros and installation of drainage mains were proposed.

Malabon-Navotas area was proposed to be drained of inundation water by the construction of ring dikes together with pumping stations, since this area is low-lying and inundation is more attributed to high tide rather than the river flood.

The inundation of the east and west areas of Mangahan Floodway is attributed not only to inland water but also to incremental high stage of the Laguna Lake. The construction of the Parañaque Spillway will enable to lower the recorded maximum lake stage of 14.03 m to 12.50 m. Thus, the lakeshore dike was proposed to be constructed with a top elevation of 14.20 m along the shoreline, providing the regulation pond in addition to the basic measures such as pumping stations, drainage channels and backwater dike.

In Parañaque-Las Piñas, since the water discharged from the Tripa de Gallina Pumping Station worsens the flood situation along the Parañaque River, the construction of cut-off channel was proposed to drain directly to the Manila Bay.

Flooding in Valenzuela is also attributed to the high tide of the Manila Bay, and ring dike is thus considered to be the optimum way for improvement.

Other drainage areas are improved only by the combination of basic measures such as pumping stations, drainage channels and backwater dike.

2.3 Constuction Cost

The construction cost of the Framework Plan is estimated at 21,860 million pesos at the price level of October 1988, excluding price contingency; 8,205 million pesos for the river improvement, 4,000 million pesos for the Parañaque Spillway, and 9,655 million pesos for the drainage improvement works.

3. FORMULATION OF MASTER PLAN

3.1 Planning Condition

The conditions for the Master Plan Study are as follows.

Target Completion Year

The target completion year for the Master Plan is set up at the year of 2020.

Premises for Structural Application

The Framework Plan was formulated without considering financial restrictions. On the contrary, the Master Plan is to formulate the flood control and drainage project that could be realized by the year 2020 within the financial availability up to that year. Since the Parañaque Spillway which will require a huge amount of funds is considered to be practically difficult to realize within the year 2020, the spillway is excluded in the formulation of the Master Plan.

3.2 Proposed Plan

River System

In the Pasig-Marikina River and San Juan River, proposed are quite the same as the Framework Plan. In the other rivers such as Marabon-Tullahan River, Buli-Baho-Mahaba rivers and South Parañaque-Las Piñas rivers, only the scale of works was reduced to cope with floods of a 30-year return period, and the work component is the same as the Framwork Plan.

In addition to the above structural measures, the flood warning system was introduced as the non-structural measure in the PasigMarikina River.

Drainage System

Since Manila and suburbs are at present secured to drain the inundated water of a more than 5-year return period, the safety degree of the drainage system with about 10-year return period will be attained by the completion of the on-going projects under foreign finance.

East of Mangahan, West of Mangahan and Malabon-Navotas are proposed to be secured with a 5-year return period of flood. In Dagat-Dagatan area, which is included in Malabon-Navotas, no measures are planned in this study because the area is, in the existing condition, provided with sufficient facilites against the flood of more than a 5-year return period.

Other areas were proposed to be secured with a 3-year return period of flood. For all of the above areas, the component of work is the same as that proposed in the Framework Plan.

3.3 Implementation Schedule and Construction Cost

Implementation Schedule

The implementation schedule for the Master Plan spans a long period of 30 years from 1991 to 2020. The construction works are proposed to be implemented in three phases as follows.

Phase	Drainage Area	River System
Phase I (1991-2000)	° East and West of Mangahan ° Malabon and Navotas (First Stage)	° Pasig-Marikina downstream of Mangahan
Phase II (2001-2010)	° San Juan ° Mandaluyong and Pasig ° Marikina ° Parañaque and Las Piñas ° Valenzuela ° Malabon and Navotas (remaining area)	° Pasig-Marikina upstream of Mangahan
Phase III (2011-2020)	- None -	° Baho, Buli and Mahaba ° Malabon and Tullahan ° South Parañaque and Las Piñas ° San Juan ° Marikina Dam

Construction Cost

The construction cost of the Master Plan is estimated at 13,523 million pesos at the price level of October 1988, excluding price contingency. This cost consists of 7,390 million pesos for the river improvement works and 6,133 million pesos for the drainage improvement works.

3.4 Project Evaluation

Annual Average Benefit

The annual average benefit, defined as the reduction of probable damage under the with- and the without-the-project situations, was thus estimated for the proposed plan, i.e., 2.78 billion pesos in total.

Economic Evaluation

In this project, the optimum plan shows a high economic viability of 17.3% in IRR.

Financial Evaluation

Required construction cost of this proposed plan which is estimated at 13,523 million pesos is less than the accumulated amount of public investment (14,060 million pesos) on the flood control and drainage sector by the year 2020 that could be attained by the potential economic growth rate of 4% in the future Philippine economy. Therefore, the proposed Master Plan is financially affordable.

Environmental Assessment

(1) Flood Control Works

The proposed flood control plan consisting mainly of river improvement works will contribute much to the scenery by providing the revetment and low wall/parapet along the river, and may aslo enhance river water quality with the increase of flow capacity. Accessibility to the river channels may be hampered, but the adverse influence is small, judging from the present river utilization.

Large scale construction such as the Marikina Control Gate Structure (MCGS) and the Marikina Dam are included in the plan for the Pasig-Marikina River. The conceivable problem caused by the MCGS is lake stage rising, but this would be resolved by the improvement of the Pasig River and the Napindan River.

As for the Marikina Dam, a concrete gravity type was proposed for flood control purpose to store water only in flood time, but the resettlement of about 600 households is required.

(2) Drainage Improvement Works

Drainage improvement plan consists of channel improvement works, construction of ring dikes and installation of pumping station and gates. The construction of ring dikes may cause the inconvenience of access to the shore. However, betterment of water quality is expected by the smooth and speedy drainage with these improvement works, and the scenery may be improved by the construction of revetment. Under these circumstances, the environmental condition will be much improved by the proposed works in comparison with the situation before construction.

4. FORMULATION OF PRIORITY PROJECTS

Feasibility study was made for the following three priority projects selected through the Master Plan Study.

- Drainage system improvement in East and West of Mangahan
- Drainage system improvement in Malabon-Navotas
- River Improvement of the Pasig River

4.1 Drainage System Improvement in East and West of Mangahan

4.1.1 Proposed Plan

Lakeshore Dike

The lakeshore dike is provided to secure the inland area for the recorded maximum lake stage which corresponds to a 40-year return period. The alignment of the lakeshore dike was determined to protect the area of which the ground elevation is higher than 11.5 m, by the economic justification based on the present and future land use. The dike is made of borrow materials, providing the revetment on the lake side slope to protect against waves.

The dike will not close the wide channels such as Napindan, Mangahan Floodway, Mangahan Diversion and Lower Bicutan, but bridges will be installed over these channels for maintenance and transportation. Sluice gates will be installed åt small channels.

River Improvement

Dredging and diking will be carried out for the Napindan Channel in a bottom width of about 80 m (almost equal to the existing) to assure the flow of lakewater from the Laguna Lake to the Pasig River. Earth dikes will be constructed on lakeside portions of the Napindan Channel, while a concrete structure such as a parapet wall is proposed on densely populated areas along the Napindan Channel near the Pasig River. The elevation of the earth dike and parapet wall is 14.6 m.

Baho, Buli and Mahaba rivers will be provided with only backwater dikes with the river width determined from a 30-year return period flood. Mangahan diversion channel will be newly constructed along the Mangahan Floodway to drain the flood water of these three rivers.

Drainage System

Drainage system is improved with 5-year return period. Channel improvement will be carried out for the Taquig, Tipas and Antipolo rivers in a total length of 35,000 m. A number of open and closed drainage channels will be newly constructed in a total length of 18,000 and 1,500 m.

Nine pumping stations are also proposed and six of them are provided with a regulation pond. In addition to the floodgates along the lakeshore dike, nine sluice gates will be placed at the pump stations and the junction of rivers.

4.1.2 Implementation Schedule and Construction Cost

Implementation Schedule

The implementation schedule was proposed basically in accordance with that of the Master Plan, of which the construction period including the lakeshore dike, river improvement and drainage system improvement will be done for four years.

Construction Cost

The construction cost is estimated at 2,812 million pesos or 132.0 million U.S. dollars, consisting of 2,058 million pesos or 96.6 million U.S. dollars for the foreign currency portion and 754 million pesos or 35.4 million U.S. dollars for the local currency portion.

4.1.3 Economic Evaluation

Annual Average Benefit

For the calculation of the annual average benefit in the Feasibility Study, the present land use conditions as of 1986 were employed as the basic flood damage estimation under the with- and without-the-project. The estimated annual average benefit, defined as the reduction of the probable damages, was 430 million pesos.

Economic Evaluation

The propsed project shows a high viability of 16.8% in IRR.

4.1.4 Environmental and Socioeconomic Impacts

Environmental Impact

The construction of the lakeshore dike may reduce by about 1.5% the surface area of the Laguna Lake at the elevation of 12.50 m. Though the water volume from this decreased area corresponds to only 0.8 cm, the improvement of the Napindan River is planned to be simultaneously implemented, so that rising of the lake stage will be reduced. Therefore, no significant rising of the lake stage is expected to occur. Fish pens are seen in the lake but these will not be affected by the lake dike, because they are located below elevation 9.5 m and the lake dike, on the other hand, is constructed on the ground with an elevation of 11.5 m.

Socioeconomic Impact

The north shore dike to be constructed in this project will be used as a new road of 10.7 km connecting Bicutan and Taytay. This new road will improve the transportation condition in the area, and land value in a wide area is expected to increase because of the location close the the city center of Manila.

4.2 Drainage System Improvement in Malabon-Navotas

4.2.1 Proposed Plan

Ring Dike

Ring dike at the north bank of the Malabon River which consists of the earth dike with revetment along the coastline in a length of 5,700 m, the earth dike with revetment along the Malabon River in a length of 3,500 m, and the earth dike without revetment between Obando and the shoreline in a length of 6,700 m, is constructed to protect the area from high tide, providing a sluice gate at the intersection with river/channel.

At the south bank of the Malabon River, a river dike 3,600 m long along the Malabon River and a coastal dike 1,100 m long along the seashore line and the river course near the estuary of the Malabon River are proposed, providing the same shapes as in the north bank of the Malabon River. Since there is no adequate open space for diking along the Navotas River and Estero Marala, a parapet wall with 8,500 m in total length is provided at both sides of the water courses.

Drainage System

Drainage system in this area is improved for 5-year return period flood. Proposed are the six pumping stations of which the sumbersible type was adopted from the economical verification, providing the drainage channels to collect the inland water.

Navigation Lock

Navigation lock was proposed at the estuary of the Navotas River near Tanza, aiming that one thousand dead weight ton class vessel can pass. Two roller type gates with 20 m span are provided.

4.2.2 Implementation Schedule and Construction Cost

Implementation Schedule

The implementation schedule was prepared basically in accordance with that of the Master Plan, of which the construction period of this priority project will be done for four years.

Construction Cost

The construction cost was estimated at 1,115 million pesos or 52.4 million U.S. dollars, consisting of 762 million pesos or 35.8 million U.S. dollars for the local currency portion and 353 million pesos or 16.6 million U.S. dollars for the local currency portion.

4.2.3 Economic Evaluation

Annual Average Benefit

The estimated annual average benefit, defined as the reduction of the probable damages, was 159 million pesos.

Economic Evaluation

The project shows a high economic viability of 15.9% in IRR.

4.2.4 Environmental and Socioeconomic Impact

Environmental Impact

The major environmental problems that may be caused by the proposed ring dike in Malabon-Navotas are the hampering of navigation and deterioration of water quality as discussed in the Master Plan. As for navigation, however, the gates to be constructed in the ring dike are usually opened and even during flood time the proposed locks can be opened. Water quality will be little deteriorated by related works because the water flow will not be prevented by the usual opening of gates.

Socioeconomic Impact

The Malabon-Navotas area is partially utilized as fishponds, and the low-lying land is deemed inappropriate for other purposes. With the implementation of drainage improvement, land use diversification into residential and agricultural land is expected.

4.3 River Improvement of Pasig River

4.3.1 Proposed Plan

Channel Improvement

The Pasig River is improved for 30-year return period of flood. Since the riverine of the Pasig River is highly developed and densely populated it is impractical to widen the channel width. Thus, the alignment was set following the existing alignment without expanding the channel width, providing the embankment in the upper stretches of MCGS, about 2.0 km, where the backwater by MCGS is affected.

High water level was set in almost equal elevation as the existing ground elevation, paying careful attention to the river utilization condition and the related reparian structures. Design bed was set not to change the present profile so steeply, setting the bed elevation of the river mouth at 5.0 m

Design cross section was, in principle, set as a trapezoidal type with 1:1 side slope, providing the concrete revetment and parapet wall/river wall for all stretches.

Marikina Control Gate Structure

Marikina Control Gate Structure (MCGS) is constructed in the downstream of the diversion point of Mangahan Floodway to divert the originally designed discharge at 2,400 m^3/s, providing two roller type gates of which each span length is 17.5 m.

4.3.2 Implementation Schedule and Construction Cost

Implementation Schedule

The implementation schedule was prepared basically in accordance with that of the Master Plan, of which the construction period of this priority project will be done for five years.

Construction Cost

The construction cost was estimated at 1,401 million pesos or 65.8 million U.S. dollars, consisting of 927 million pesos or 43.5 million U.S. dollars for the foreign currency portion and 474 million pesos or 22.3 million U.S. dollars for the local currency portion.

4.3.3 Economic Evaluation

Annual Average Benefit

The annual average benefit, defined as the reduction of the probable damages, was 198 million pesos.

Economic Evaluation

The project shows a high economic viability of 16.1% in IRR.

4.3.4 Environmental and Socioeconomic Impacts

Environmental Impact

The major components of the proposed flood control works in the Pasig-Marikina River are the river improvement works such as excavation, revetment and parapet wall, and the Marikina Control Gate Structure (MCGS).

No significant effect will be caused by the proposed works of the MCGS. As for the river improvement, it will contribute not only to the reduction of flood damage but also to the scenery by providing a continuous revetment and a parapet wall. Also, water quality of the river is expected by the smooth flow of the channel, contributing to the improvement of the environment in the riverine. Therefore, it is considered that the proposed schemes will be acceptable from the environmental viewpoint.

Socioeconomic Impact

The lower reaches of the Pasig River is the very core of the nation as well as Metro Manila, and crucial offices/facilities which are influential politically and economically to the whole nation are concentrated. In this situation, flood control in this area may give invaluable favorable impact to the nationwide economic activities as well as to people's living.

PROJECT FEATURES

I. FRAMEWORK PLAN AND MASTER PLAN

A. FLOOD CONTROL WORKS

(1) Pasig-Marikina River System

a. River Works

River Stretch	Stretch Length (m)	Framework Plan (100-Yr.)		Master Plan (100-Yr.)	
		Design Discharge (m^3/s)	Proposed Works	Design Discharge (m^3/s)	Proposed Works
Pasig River	18,495	1,150 -500	Dredging Rehabilitation	Same as Framework Plan	
Lower Marikina River	6,790	500	-ditto-	-ditto-	
Upper Marikina River	20,565	2,900	Dredging Diking	-ditto-	
San Juan River (Tributary)	10,653	900	Dredging	-ditto-	

b. Construction of Structures

Structure	Framework Plan (100-Yr.)	Master Plan (100-Yr.)
Marikina Control Gate Structure	Roller gate type 10.1 m (height) x 17.5 m (width) x 2 units	Same as Framework Plan
Marikina Dam	Concrete gravity type of 70 m high with orifice spillway	-ditto-
Pandacan Bridge (Reconstruction)	Steel plate girder 137.6 m (length) x 5.4 m (width)	-ditto-

(2) Malabon-Tullahan River System

River Stretch	Stretch Length (m)	Framework Plan (100-Yr.)		Master Plan (30-Yr.)	
		Design Discharge (m^3/s)	Proposed Works	Design Discharge (m^3/s)	Proposed Works
Malabon River	5,430	570-520	Dredging Rehabilitation Diking	500-450	Same as Framework Plan
Tullahan River	20,500	480-240	Dredging Diking	420-210	-ditto-

(3) Buli, Baho and Mahaba River Systems

River Stretch	Stretch Length (m)	Framework Plan (100-Yr.)		Master Plan (30-Yr.)	
		Design Discharge (m^3/s)	Proposed Works	Design Discharge (m^3/s)	Proposed Works
Buli River (incl. tributaries)	19,900	330-80	Dredging Diking	270-50	Same as Framework Plan
Baho River	7,450	335-280	-ditto-	275-230	-ditto-
Mahaba River	5,000	190	-ditto-	160	-ditto-
Mangahan Diversion	3,800	570-340	-ditto-	470-280	-ditto-

(4) South Parañaque and Las Piñas River Systems

River Stretch	Stretch Length (m)	Framework Plan (100-Yr.)		Master Plan (30-Yr.)	
		Design Discharge (m^3/s)	Proposed Works	Design Discharge (m^3/s)	Proposed Works
S. Parañaque River (incl. Dongalo River)	6,500	630-200	Dredging Diking	520-170	Dredging Diking
Las Piñas River	6,395	250-220	-ditto-	210-180	-ditto-

(5) Laguna Lake System

Proposed Structure	Stretch Length (m)	Framework Plan	Master Plan
Napindan Channel Improvement	5,242	Dredging Diking (HWL: 12.5 m Top of dike: EL 13.3 m)	Dredging Diking (HWL: 13.8 m Top of dike: EL 14.6 m)
Lakeshore Dike	10,700	Diking (HWL: 12.5 m Top of dike: EL 14.2 m)	Diking (HWL: 13.8 m Top of dike: EL 15.5 m)
Parañaque Spillway	9,200	Dredging Channel Bottom: 60 m in width	-

B. DRAINAGE IMPROVEMENT

(1) Manila (Framework Plan only)

Structure	Quantity	Design Discharge (m^3/s)
Pump Station (new)	4 sites	20.8
Sluice Gate	3 sites	-
Channel Improvement	14,600 m	59-12
Closed Channel Const.	5,750 m	15-5

(2) Malabon-Navotas

Structure	Quantity	Design Discharge (m^3/s)	
		Framework Plan (10-Yr.)	Master Plan (5-Yr.)
Ring Dike	22,000 m	-	-
Pump Station	8 sties	76.1	62.1
Channel Improvement	5,100 m	33-15	30-13
Open Channel Const.	5,600 m	38-15	34-13
Closed Channel Const.	800 m	14	12
Navigation Lock	1 site	-	-
Sluice Gate	15 sites	-	-

(3) East of Mangahan

Structure	Quantity	Design Discharge (m^3/s)	
		Framework Plan (10-Yr.)	Master Plan (5-Yr.)
Pump Station	4 sites	31.1	27.0
Sluice Gate	4 sites	-	-
Channel Improvement	1,100 m	18-13	17-11
Open Channel Const.	7,300 m	20-8	18-7
Regulation Pond	2 sites	60,300 m^3	51,000 m^3

(4) West of Mangahan

Structure	Quantity	Design Discharge (m^3/s)	
		Framework Plan (10-Yr.)	Master Plan (5-Yr.)
Pump Station	5 sites	147.6	129.0
Sluice Gate	10 sites	-	-
Channel Improvement	34,100 m	102-5	91-5
Open Channel Const.	11,000 m	23-10	21-9
Closed Channel Const.	1,450 m	21-13	19-12
Regulation Pond	4 sites	775,500 m^3	642,000 m^3

(5) San Juan

Structure	Quantity	Design Discharge (m^3/s)	
		Framework Plan (10-Yr.)	Master Plan (3-Yr.)
Pump Station	9 sties	52.7	31.0
Sluice Gate	13 sites	-	-
Channel Improvement	1,300 m	21	17
Closed Channel Const.	12,300 m	44-7	36-6
Backwater Dike	3,400 m	-	-

(6) Mandaluyong-Pasig

Structure	Quantity	Design Discharge (m^3/s)	
		Framework Plan (10-Yr.)	Master Plan (3-Yr.)
Pump Station	3 sites	23.0	14.5
Sluice Gate	3 sites	-	-
Channel Improvement	2,500 m	78-45	63-37
Closed Channel Const.	8,800 m	24-8	19-7

(7) Marikina

Structure	Quantity	Design Discharge (m^3/s)	
		Framework Plan (10-Yr.)	Master Plan (3-Yr.)
Sluice Gate	1 site	-	-
Open Channel Const.	1,000 m	14	11
Closed Channel Const.	2,600 m	29-16	23-13

(8) Parañaque-Las Piñas

Structure	Quantity	Design Discharge (m^3/s)	
		Framework Plan (10-Yr.)	Master Plan (3-Yr.)
Pump Station	2 stles	19.8	12.5
Sluice Gate	8 sites	-	-
Channel Improvement	4,800 m	52-24	42-19
Open Channel Const.	150 m	39	39
Cut-off Channel	500 m	59	59

(9) Valenzuela

Structure	Quantity	Design Discharge (m^3/s)	
		Framework Plan (10-Yr.)	Master Plan (3-Yr.)
Pump Station	3 sites	10.9	0
Sluice Gate	1 site	-	-
Ring Dike	8,000 m	-	-
Channel Improvement	12,900 m	51-12	41-10
Open Channel Const.	500 m	2	0

II. PRIORITY PROJECTS (FEASIBILITY STUDY)

A. DRAINAGE IMPROVEMENT IN EAST AND WEST OF MANGAHAN

(1) Lakeshore Dike

Structure	Quantity	Remarks
Earth Dike (with revetment)	10,700 m	EL 15.5 m, 9.1 m in width, 4.0 m in height
Sluice Gate	5 sites	Appurtenant to pump station
Maintenance Bridge	4 bridges	240 m - 30 m in length

(2) River Improvement (Backwater Dike)

Structure	Stretch Length	Remarks
Napindan Channel (dredging/diking)	5,242 m	Parapet wall 2,494 m, earth dike 2,747 m in length
Buli River (diking)	1,600 m	
Baho River (diking)	1,800 m	
Mahaba River (diking)	2,400 m	
Mangahan Diversion (dredging/diking)	3,800 m	
Lower Bicutan River (dredging/diking)	800 m	

(3) Drainage System

Structure	Quantity	Remarks
Channel Improvement	35,200 m	46 m - 5 m in width
Open Channel Const.	18,300 m	20 m - 5 m in width
Closed Channel Const.	1,450 m	3 m in width x 2 or 3 units
Sluice Gate	9 sites	4 sites appurtenant to pump station, 5 sites independent
Regulation Pond	6 sites	693,000 m^3 in total storage capacity
Pump Station	9 sties	111 m^3/s in total pump capacity

B. DRAINAGE IMPROVEMENT IN MALABON-NAVOTAS

(1) North of Malabon River

Structure	Quantity	Remarks
Coastal Dike (with revetment)	5,700 m	EL 13.5 m, 3 m in width, 2.5 m in height
River Dike (with revetment)	3,500 m	EL 12.5 m - 13.5 m, 3 m in width, 1.0 m raising of existing dike
Ring Dike (without revetment)	6,700 m	EL 12.5 m, 3 m in width, 1.0 m raising of existing dike
Channel Improvement	600 m	12 m in width
Open Channel Const.	1,000 m	12 m in width
Pump station	3 sites	25 m^3/s in total pump capacity
Sluice Gate	7 sites	2 sites appurtenant to pump station
Navigation Lock	1 site	20 m in width, 180 m in length

(2) South of Malabon River

Structure	Quantity	Remarks
Coastal Dike (with revetment)	1,100 m	EL 13.5 m, 3 m in width, 2.5 m in height
River Dike (with revetment)	3,600 m	EL 12.5 m - 13.5 m, 3 m in width, 1.0 m raising of existing dike
Parapet Wall	8,500 m	EL 13. 5 m
Channel Improvement	700 m	12-18 m in width
Open Channel Const.	900 m	13 m in width
Closed Channel Const.	800 m	2.7 m in width x 3 units
Pump Station	3 sites	10 m^3/s in total pump capacity
Sluice Gate	5 sites	3 sites appurtenant to pump station, 2 sites independent

C. PASIG-MARIKINA RIVER IMPROVEMENT

(1) River Improvement Works

River Stretch	Stretch Length (m)	Design Discharge (m^3/s)	Improvement Pattern
River Mouth/ San Juan	8,735	1,150	Dredging, raising of existing river wall or parapet wall and rehabilitation of bank protection. Design bed width 450 m - 75 m, Trapezoidal section with 1:1 side slope.
San Juan/ Napindan	9,760	500	Raising of existing river wall or parapet wall and rehabilitation of bank protection.
Napindan/ MCGS	5,580	500	Principally no improvement and river wall or parapet wall for low elevation only.
MCGS/Mangahan Floodway	1,210	500	Dredging, providing new parapet wall or river wall and new bank protection. Design bed width 75 m, Trapezoidal section with 1:1 side slope.
Upstream of Mangahan Floodway	1,050	2,900	Dreding, providing new parapet wall or river wall and new bank protection. Design bed width 114 m, Trapezoidal section with 1:1 side slope.

(2) Construction of Marikina Control Gate Structure (MCGS)

Location	:	Downstream of confluence with Mangahan Floodway (Marikina River Sta. 5+425)
Gate	:	Roller type 10.1 m (height) x 17.5 m (width) x 2 units

(3) Reconstruction of Pandacan Bridge (PNR)

Location	:	Pasig River (Sta. 7+990)
Type	:	Steel plate girder 137.6 m (length) x 5.4 m (width)

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GLOSSARY OF TERMS AND ABBREVIATIONS

1. Agencies, Institutions and Organizations

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BCGS	Bureau of Coast and Geodetic Survey
BDCC	Barangay Disaster Coordinating Council
BPW	Bureau of Public Works
BTr-DOF	Bureau of Treasury, Department of Finance
CB/CBP	Central Bank of the Philippines
CDCC	City Disaster Coordinating Council
DBM	Department of Budget and Management
DCC	Disaster Coordinating Council
DND	Department of National Defense
DPWH	Department of Public Works and Highways
DSWD	Department of Social Welfare and Development
GCMCC	Government Corporate Monitoring and Coordinating Committee
GOJ	Government of Japan
GOP	Government of the Philippines
IBRD	International Bank for Reconstruction and Development
IMF	International Monetary Fund
INP	Integrated National Police
JICA	Japan International Cooperation Agency
LLDA	Laguna Lake Development Authority
MMC	Metro Manila Commission
MMDCC	Metro Manila Disaster Coordinating Council
MMINUTE	Metro Manila Infrastructure, Utilities and Engineering
MND	Ministry of National Defense
MWSP	Manila Water Supply Project
MWSS	Metropolitan Waterworks and Sewerage System
NCR	National Capital Region, DPWH
NCSO	National Census and Statistics Office
NDCC	National Disaster Coordinating Council
NEDA	National Economic and Development Authority
NHA	National Housing Authority
NPC	National Power Corporation
NPCC	National Pollution Control Committee
NWRB	National Water Resources Board
OCD	Office of Civil Defense
ODA	Overseas Economic Assistance
OECF	Overseas Economic Cooperation Fund
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PNRC	Philippine National Red Cross
PDCC	Provincial Disaster Coordinating Council
PREMIUMED	Program for Essential Municipal Infrastructure, Utilities, Maintenance and Engineering Development
PROGRESS	Program to Reduce and Eliminate Sewerage from Streets

2. Length

mm	millimeter
cm	centimeter
m	meter
km	kilometer

3. Area, Volume and Weight

cm^2, sq.cm.	square centimeter
m^2, sq.m.	square meter
km^2, sq.km.	square kilometer
m^3, cum	cubic meter
10^6 m^3	million cubic meters (also MCM)
l, ltr	liter
Ml	million liters
kg	kilogram
t	ton

4. Derived Measures

kg/m^2	kilogram per square meter
m^3/s	cubic meter per second (also cumecs)
m^3/day	cubic meter per day
m/s	meter per second
m/hr	meter per hour
km/hr	kilometer per hour

5. Currency

₱	Philippine Peso
¥	Japanese Yen
$	United States Dollar (US$)

6. Other Terms

BM	Bench Mark
BOD	Biochemical Oxygen Demand
DO	Dissolved Oxygen
EL	Elevation above MSL
MSL	Mean Sea Level
GDP	Gross Domestic Product
GNP	Gross National Product
GRDP	Gross Regional Domestic Product
MANAVA	Malabon, Navotas and Valenzuela municipalities
PAMPS	Preliminary Alternative Master Plan Strategy (for the Metro Manila Integrated Urban Drainage)
PD	Presidential Decree
pH	Degree of acidity
X-sec	Cross Section
DL	Datum Line
CHB	Concrete Hollow Block
RC	Reinforced Concrete
PC	Prestressed Concrete
MCGS	Marikina Control Gate Structure
NHCS	Napindan Hydraulic Control Structure
EIA	Environmental Impact Assessment

CHAPTER 1. INTRODUCTION

1.1 General Description

Metro Manila which encompasses four (4) cities and thirteen (13) municipalities with the population of over 6.0 million is the economic and political core of the Philippines. One of the most serious problems in the area is habitual flooding.

Flooding in Metro Manila is brought about by two main causes: overbanking water of the Pasig-Marikina River and other rivers and the poor capacity of the drainage system. The former takes place less frequently than the latter, but it may bring more destructive damage. It has been reported that the specific areas habitually and seriously damaged by flooding are the Manila city area and its vicinity, the MANAVA (Malabon, Navotas and Valenzuela) area, the east and west areas of the Mangahan Floodway, the areas along the San Juan River, the Upper Marikina River areas, and the Parañaque city area.

According to the previous survey done by BPW, 1943's flood was the biggest with 10,950 ha inundated in Metro Manila. The floods in 1966, 1967, 1970, 1972, 1977, 1978, 1986 and 1988 have also resulted in serious damages. Out of these floods, the 1986 flood which is the recent biggest inundation caused by Typhoon Miding inflicted tremendous damage to areas in Metro Manila. The 1988 flood caused by Typoon Unsang also inflicted serious damage, especially in the Marikina Valley and the low-lying shoreline area of the Laguna Lake.

A flood control plan of the Pasig-Marikina River including the Metro Manila area was formulated in 1954 with the Marikina River Multipurpose Project, followed by several studies on flood control of the Pasig-Marikina-Laguna Lake Basin. The Mangahan Floodway, Napindan Hydraulic Control Structure and the improvement works of the Pasig River, consisting mainly of river wall and dredging of the channel, have been constructed in line with the flood control plan of the Pasig-Marikina River.

As for the storm drainage in Metro Manila, the drainage program by the construction of pumping stations in central Manila was started in

1974. Initiated by the Drainage Master Plan Study in 1952, ten (10) pumping stations were constructed. In parts of other areas of Metro Manila, embankment and drainage gates have been constructed as urgent countermeasures for flood.

Notwithstanding the continuous efforts and big investments on flood control and drainage works, several development projects and the rapid urbanization achieved in the past years have worsened the flooding conditions. Metro Manila is still facing the menace of flood damage caused by the poor flow capacity of the Pasig-Marikina River, the Tullahan River and other rivers, and also the insufficient capacity of drainage channels and facilities in the low-lying areas.

Under this situation, the Government of the Republic of the Philippines had requested the Government of Japan to provide technical assistance for flood prevention in Metro Manila. In response to the request, the Study on Flood Control and Drainage Project in Metro Manila had been conducted by the Japan International Cooperation Agency (JICA).

1.2 Outline of the Study

1.2.1 Study Area

The study area for this project is the Metro Manila area and related areas which covers approximately 981 km^2.

1.2.2 Objective of the Study

The objectives of the study are to prepare the Master Plan for flood control and drainage improvement in Metro Manila with the target completion year of 2020, as well as the Framework Plan which presents the future comprehensive flood plain management plan, and to carry out a Feasibility Study on the Priority Project Areas selected on the basis of the results of the Master Plan Study.

1.2.3 Study and Staffing Schedule

The study has been carried out for about two years and three months from December 1987, as shown in Fig. 1.1-1, by the Study Team consisting of fourteen (14) experts recruited from CTI Engineering Co., Ltd. and Nippon Koei, both of Japan, with the CTI Engineering Co., Ltd. acting as the leading firm. The members of the Study Team are shown in Table 1.1-1, together with the members of the Advisory Committee which was organized for the study.

CHAPTER 2. PROJECT BACKGROUND

2.1 National and Regional Development Policies

Upon the assumption of duty of the new leadership in February 1986, the government buckled down to the crucial task of producing the Medium-Term Development Plan for 1987-1992 which shall serve as the framework of development policy-making in the next six years. The plan articulates national goals, specifies socioeconomic targets, and sets forth a package of economic and social policies. It also presents the regional and physical dimensions of national development.

National Development Goals

The national development goals for 1987-92 is principally directed towards the following:

- Alleviation of Poverty

- Generation of More Productive Employment

- Promotion of Equity and Social Justice

- Attainment of Sustainable Economic Growth

The sustained economic growth during the 1987-92 period is indispensable to the attainment of these goals, and will be aided by a favorable world economic environment which will be spurred mainly by the relative stability of oil prices and real interest rates, and moderate inflation. Real Gross National Product (GNP) is targeted to increase by 6.8 percent on the average (see Table 2.1-1).

Development Goals of National Capital Region

To cope with the rapid population growth and explosive urbanization of the National Capital Region (NCR), the general direction of development for the area during the 1987-92 period is directed towards achieving the following goals and objectives:

- Alleviation of Poverty

- Generation of Productive Employment

- Promotion of a Desirable Metropolitan Environment

2.2 Organization and Administration

National Context

The sociopolitical change brought about by the February 1986 revolution made the government strengthen organizational and administrative policies. Although the clear-cut output of the reorganization plan is not still made public, a tentative picture of the government organizational chart is presented in Fig. 2.2-1. The conversion of ministries into departments was implemented in the political framework. Some agencies (ministries) were abolished and adopted as departments from support offices. Various types of government corporations are in operation as attached corporations under respective government agencies. As to the management of corporations, a great emphasis is given to flexibility plus autonomy in operation, and financial viability.

Decentralization aims at upgrading management ability of public works and social services by transfer of personnel, and strengthening financial position in local governments by transfer of increasing allotments from the central government. Provincial governments shall be empowered to consolidate municipal and barangay units. Decentralization also aims at delegating more substantive power to regional offices of central government agencies in order to improve the efficiency of natural development programs. Nevertheless, the clear demarcation of public works and social service programs between regional offices and local governments is of vital importance for the effective operation of them.

National Capital Region

Among the twelve (12) administrative regions of the Philippines, the National Capital Region (NCR) known as Metro Manila is composed of four cities and thirteen municipalities. The government agencies and local governments have been involved in various kinds of physical works and social programs for achieving the region's development goals.

The government has put substantial emphasis on flood control and drainage works in the NCR in the past, since the frequent occurrence of flooding is one of the major constraints to social and economic activities in the region. Flood control and drainage works are exclusively handled by the Department of Public Works and Highways (DPWH), one of the government agencies. The DPWH has a regional office in the NCR under which are seven district offices, project management offices responsible for special projects, and a regional equipment center. A growing concern to urban sanitation issues gives a significant status to the Metro Manila Infrastructure, Utilities and Engineering (MMINUTE) which is a special office under the DPWH. The MMINUTE's engagement in minor improvement works of infrastructures is important, since its area of responsibility extends to the level of barangays in municipalities and cities.

The creation of the Metro Manila Commission in 1975 reflects regionalization policy where development policy and planning is solely determined by the MMC in place of local governments. Though the MMC is not vested with powers as implementing authority, the major practical works are garbage collection, sanitation improvement, and minor cleaning works inside various types of drainage channels.

The Metropolitan Waterworks and Sewerage System (MWSS) is one of the government corporations attached to the DPWH. The principal work of the MWSS is the construction and maintenance of water supply and sewerage system in Metro Manila. Currently, the MWSS collaborates with the MMINUTE in undertaking minor drainage schemes called Program to Reduce and Eliminate Sewerage from Streets (PROGRESS).

The Philippine Atmospheric, Geophysical and Astronomical Services Administration known as PAGASA, an agency attached to the Department of

Science and Technology (DST), has been engaged in flood forecasting and warning systems in major river basins, except for the Metro Manila Area, and also for dam operation.

Cities supported by the favorable fiscal position and skilled personnel have expanded administrative services for physical and social services. On the other hand, municipal governments are not in a position to conduct self-decisive planning and implementation of various works. As far as flood control and drainage works are concerned, the participation of local governments in such works is still negligible though the growing importance of local governments for the implementation of regional public works is fully recognized.

2.3 Population and Labor Force

During the postwar period from 1948 to 1980 the total population of the NCR had increased by almost 3.8 times and amounted to 5,926,000 in 1980. Table 2.3-1 is the results of the censuses during the period. A remarkable increase of nearly 2,000,000 was recorded in the decade from 1970 to 1980, but it might be noticeable that the population growth rate had already shown a tendency to decline from 25.3% in 1970-1975 to 19.2% in 1975-1980.

It is clear that the population growth of the NCR has a radial pattern. This point can be traced by a closer look at the highest average annual growth rate of each city/municipality all through the postwar period. The gross population density of the NCR in 1980 was 99 persons/ha, while the net population density was 249 persons/ha.

The labor force participation rate, defined as the ratio (in percentage) of the total number of persons in the labor force to the total population 15 years old and over, averages at 56 percent in NCR during the period of 1980-86. This is 6.4 points lower than the national level of 62.4 percent, presenting less willingness to participate in labor among the school-going people and housewives. However, the rate in the NCR fluctuated much during this period, although this rate exceeded considerably its average in 1984 and 1985, showing 60.0 percent and 59.9 percent, respectively. (See Table 2.3-2.)

The labor force in NCR has increased at an average annual growth rate of 3.8 percent during 1980-86, greater than 3.5 percent increase in household population 15 years old and over. This signifies that a majority, especially those of school-going age, are more inclined in earning a living. In 1984 when drastic changes in the economy occurred, as indicated by the substantial decrease in GRDP by 9.2 percent, the labor force increased by 14.1 percent, remarkably higher than the average of 3.8 percent, while the number of the employed increased at only 6.6 percent in the same year. More noticeable is the abnormal increase in the number of the unemployed by 68.4 percent in the same year.

2.4 Topography and Geology

The Island of Luzon, the largest in the Philippine Archipelago, is roughly divided into three physiographic regions, Northern Luzon, Central Luzon and Southeast Luzon (Bicol and Bondoc Peninsula). Central Luzon is divided into three structural regions, namely the Zambales Range in the west, the Central Valley in the center and the southern extension of the Sierra Madre in the east.

The Central Valley, extending from the Lingayen Gulf to Manila Bay, is the southern continuation of the Cagayan Valley covered by the thick alluvial deposits. The Metropolitan Manila Area occupies integral parts of the southern extension of the Central Valley (which includes the Manila Deltaic Plan, Guadalupe Formation Lowland, as well as the Marikina Valley Alluvial Plain) and the southern extension of the Sierra Madre Range.

The withdrawal of the sea from the Central Valley isolated the Laguna de Bay from the sea in the Quaternary Period. At a much later period, the Pasig River captured the stretch to the sea and altered the downstream course of the Marikina River. This is said to cause the sediments being washed by the Marikina River from the Sierra Madre Range to form the Manila Deltaic Plain.

The topography and geology of the Study Area is as follows (see Figs. 2.4-1 and 2.4-2).

<u>Manila Deltaic Plain</u>

The area is almost flat and the elevation ranges from more than one (1) meter near Manila Bay to five (5) meters in Sta. Mesa and Makati. The thickness of delta materials which consists of sand, pebbly gravel, silt and clay of various colors and plasticity is over seventy (70) meters near the coast and thins out eastward in the Sta. Mesa and Marikina area.

<u>Guadalupe Formation Lowland</u>

The Guadalupe Formation Lowland, a thick sequence of tuff and tuffaceous clastics, is the bedrock of the Manila Deltaic Plain and the Marikina Valley Alluvial Plain and exposes between the two plains as a plateau-like lowland. The elevation of the lowland is five (5) to thirty (30) meters at Parañaque; around forty (40) meters from Guadalupe to near Camp General Emilio Aquinaldo; between fifty (50) to seventy (70) meters from Quezon City to Novaliches.

<u>Marikina Valley Alluvial Plain</u>

The Marikina Valley Alluvial Plain occupies the area between the Guadalupe Formation Lowland and the Sierra Madre Range and it widens and extends southward to the Laguna Lake. The thickness of the alluvial deposits which have similar components as the Manila deltaic materials varies erratically from one hundred twenty (120) meters in the northern portion of Montalban, around fifteen (15) meters at Marikina, between thirty (30) and forty (40) meters at Pasig, and more than one hundred thirty (130) meters at the southernmost portion.

<u>Southern Extension of Sierra Madre Range</u>

The prominent feature of the range is Mt. Droid (EL 1,171 m) to the south. The geology of the area is complex and Cretaceous to Tertiary rocks such as limestone, tuffaceous clastics and some igneous rocks are distributed in the range.

2.5 Meteohydrology

General Condition of Weather

The meteohydrological characteristics over the Philippines are mainly governed by seasonal dominant monsoons, trade winds, tropical cyclones, and combinations of them.

Typhoon, the strongest wind type among the four (4) classifications of tropical cyclones by PAGASA (see Table 2.5-1), is the most influential to floods in the Study Area. Due to seasonal interaction, the Philippines may be classified into four (4) climatological regions as presented in Fig. 2.5-1. The annual mean tropical cyclones that pass near the Philippines is 19.6 in number. For Central Luzon where the Study Area is located, the landing rate of tropical cyclones counts for 16 percent.

Meteohydrological Condition in the Study Area

The study area belongs to the first climatological region of the four Philippine climatological regions. The first climatological region may be characterized by a dominant rainy season from May to October and a dominant dry season for the rest of the months.

(1) Rainfall

The annual rainfall distribution presented in Fig. 2.5-2 shows the annual rainfall of more or less 3,000 mm over the high Sierra Madre mountain range where the headwaters of the Marikina River are located. On the other hand, the annual rainfall of approximately 2,000 mm spreads over the rainfall zone of the Manila Bay area to the Laguna Lake basin.

The monthly rainfall distribution, except the western area of the Laguna Lake, accords with that of the first climatological region and have high rainfall months from May to October. The total rainfall of the months counts for about 80 percent of the annual rainfall, and it is brought mainly by the wet southwest monsoon, plus the occasional typhoons. The monthly rainfall distribution over the western area of the Laguna Lake has a longer rainy season up to December. This is because of the influence of the northeast monsoon which invades the area across the low terrain of the Sierra Madre ranges bordering the first and the second climatological zones.

(2) Temperature

The monthly temperature distribution in the study area is presented in Fig. 2.5-3. The temperature rises to as high as 30°C in May, the bordering month between dry and wet seasons, and takes the lowest in December, as low as 25°C. This indicates no severe temperature change throughout the year.

(3) Relative Humidity

The relative humidity observed in the study area is presented in Fig. 2.5-3. It takes the maximum in the mid-months of the rainy season from August to September, and drops to the minimum during the months of March to April. The difference between the maximum and the minimum is 20 percent, and the annual difference is not large.

(4) Evaporation

Evaporation records measured by a Class A pan at the gauge located in the hilly San Juan River Basin and the low-lying Laguna basin are presented in Fig. 2.5-3. The two records show annual evaporations of 1,469 mm for the San Juan area and 1,942 mm for the Laguna area.

2.6 Infrastructures

In contract to the rapid population growth during the past few decades, the present situation of infrastructures in the NCR seems to be far behind in supply adequate to the basic needs of inhabitants. The following is a summary of the major items of physical infrastructures.

Road Network

The total length of roads in the NCR in 1985 was about 4,912.4 km including national roads of 719.8 km and provincial roads of 182.2 km. Besides the natinal and provincial roads, there are privately developed subdivision roads and it is remarkable that their share is more than one-third of the total length of roads. The ratio of pavement is generally high, though the ratio of subdivision roads is unknown.

The major road network pattern of the NCR consists of partially completed four beltways and ten radial roads. However, hierarchical road networks are few and the areas outside the beltway (EDSA) do not enjoy network connections because of indiscriminate development of subdivisions.

Water Supply

In June 1987, MWSS completed the Manila Water Supply Project II (MWSP II) and the supply of water rose to 2,500 mld. The objectives of the project are the full development of the existing major water sources of the Angat River and the realization of rehabilitation and extension of the water distribution system. As a result, MWSS serves about 5.3 million residents of its service area and 39.1% of the population of the NCR. Since the target in 1992 is to cover 67% of the population with water supply, the accomplishment in 1987 was 58%.

The Manila Water Supply Rehabilitation Project is under way to reduce the non-revenue water in 56 zones (9,541 ha) of the MWSS service area. Another ongoing water supply project is the Metropolitan Manila Water Distribution Project (MMWDP). This is to make the fullest possible use of the increased water supply capacity in accordance with the completion of the Manila Water Supply Project II.

Sewerage System

Two sewerage systems are working in the NCR. One is the Central Manila Sewerage System constructed before 1909 with the original overload capacity to serve 450,000 people. Presently the system covers 1,850 ha, serving 530,000 people with the total length of 240 km. The other system is for Quezon City and Makati: isolated systems mostly in subdivisions and commercial areas service 350,000 people with the total length of 140 km. The rest of the NCR discharges its wastewater either into storm drains, septic tanks or directly into the esteros.

The Metro Manila Sewerage and Sanitation Project (METROSS) has, at present, three construction stages: firstly, to rehabilitate the existing Central Manila Sewerage System together with slight expansion and other improvements; secondly, to expand the sewerage system to the south with the direct service area of 3,000 ha; and, finally, to the north covering 3,400 ha. Furthermore, METROSS will have additional two stages to cover most of the NCR and the western portion of Rizal Province. It is estimated that the accomplishment of METROSS in 1987 reached the 79.6% level.

Power

Electric power related to the NCR is generated by the National Power Corporation (NPC) in the wider frame called Luzon Grid. The components of the generated power in 1986 are coal or oil thermal (68.9%), hydropower (14.4%) and geothermal (16.7%).

About 80% of the generated power is supplied at 115 kV or 230 kV to the Manila Electric Company (MERALCO) which distributes power over a total area of 8,813 km^2 covering the whole NCR. The total amount of electricity sales in 1986 was about 7.9 billion kWh, and the share was 30.2% for industry, 33.4% for the commercial sector, and 35.4% for residential customers. Industrial and commercial consumption grew by 1.1% each over the previous year, but residential sales decreased by 1.3% in spite of the increase in the number of residential customers by 11.0%. This fact is attributed to the effect of the subsidy reduction program in February 1986.

2.7 Regional Economy

Gross Regional Domestic Product

The gross regional domestic product (GRDP) of NCR during 1980 to 1986 averages at 29,437 million pesos at the constant price of 1972. It was recorded highest in 1983 at 32,231 million pesos and lowest in 1985 at 26,618 million pesos. The average growth rate figures at minus 1.4 percent due to the substantial negative growth rates of minus 9.32 percent from 1983 to 1984 and minus 9.02 percent from 1984 to 1985, which may be called an economic crisis. (See Table 2.7-1.)

The NCR's contribution to the gross national domestic product averages as much as 31 percent on average for the 1980-86 period. This primarily shows the critical situation of NCR in terms of setting the trend of national economy.

Economic Framework

The sectoral breakdown of GRDP gives credence to the dominance of industry and services sectors in all three economic areas in the NCR, giving 51.7 percent and 48.3 percent on the average, respectively, during the 1980-86 period. Meanwhile, the agriculture sector plays a negligible minor role on the economy of the NCR according to the statistical data.

Under the industry sector, the subsector of manufacturing contributes dominantly to the GRDP averaging 42.0 percent, and the subsector "other services" gives an average contribution of 20.9 percent. These are the major subsectors which neutralized and reverted the negative trend of the 1986 GRDP (see Table 2.7-2).

Income and Its Distribution

The average annual income of NCR families has improved by about 15 percent in real terms from 1975 to 1985. According to the results of survey on family income and expenditure in 1985, the 1985's family income reached 57,193 pesos on average, and the poorest 40 percent of NCR families received only 16 percent of the total income or 12.0 billion pesos while the richest 20 percent obtained 49.6 percent or 37.2 billion pesos.

A majority comprising more than 70 percent of the total number of families live below the NCR average income of 57,193 pesos, and 13.4 percent belonging to the classes under 19,999 pesos are earning average incomes which are lower than their respective average expenditure. Meanwhile, only 28.1 percent belong to the classes above 50,000 pesos, although the average income falls in this range. In other words, the average income is subject not to the majority but to the income level of the extremely rich people.

CHAPTER 3. BASIC STUDY AND ANALYSIS

3.1 Existing and Future Land Use

Land use in the study area is one of the most important factors for the runoff calculation and flood damage estimation. The study covers the conditions at present and the conditions at the year 2020, which are required for the formulation of the Priority Project and the Framework/Master plans, respectively, as discussed in Chapters 5, 6 and 7. In both cases, land use is classified into the following categories.

- Residential/Commercial (Built-up Area)
  - ° Low Density
  - ° Middle Density
  - ° High Density
- Industrial
- Open Space
- Agricultural
- Fishpond/Paddy Field/Marsh
- Forest

The land use analysis of the present conditions was based on the 1:10,000 contour maps (BCGS & JICA, 1986). Future land use at the year 2020 was prepared on the basis of the official land use plan with some adjustments to accord with the present land use. The present and future land use conditions in the study area are summarized in the following table.

Land Use	Present (km^2)	Year 2020 (km^2)
Residential/Commercial	268 (22.4%)	444 (37.2%)
- Low Density	159 (13.3%)	241 (20.1%)
- Middle Density	59 (5.0%)	126 (10.5%)
- High Density	49 (4.1%)	78 (6.5%)
Industrial	46 (3.9%)	68 (5.7%)
Open Space	149 (12.4%)	66 (5.6%)
Agricultural	14 (1.1%)	4 (0.3%)
Fishpond/Paddy Field/Marsh	129 (10.8%)	67 (5.6%)
Forest	589 (49.3%)	546 (45.7%)
Total	1,195 (100.0%)	1,195 (100.0%)

Note: Figures may not add up to the total due to rounding.

For the hydrological study, the study area was divided into 80 sub-basins, as indicated in Fig. 3.1-1. The present and future land use conditions in each sub-basin are presented in Tables 3.1-1 and 3.1-2, respectively. The present and future land use maps are shown in Figs. 3.1-2 and 3.1-3, respectively.

3.2 Applicable Non-Structural Measures

To mitigate flood damage in river basins, structural flood control measures such as the improvement of river channels and construction of dams, diversion channels, etc., have been conventionally employed. In areas where urbanization has been attained or in progress, however, runoff retention and storage functions have deteriorated and peak discharge has increased. The urbanization of flood prone areas has increased flood damage potential due to the concentration of population and property at such areas.

The structural measures are the principal ones to mitigate flood damage, but their completion requires a considerable time and enormous funds. Therefore, the applicability of non-structural measures for Metro Manila was studied considering the effectiveness of such measures.

There are various non-structural measures, as shown in Fig. 3.2-1. The conservation of areas to preserve natural retarding function and the restriction of urbanization in flood prone areas through the enactment of land use regulations are judged to be difficult to apply in Metro Manila because almost all parts of the area are already designated as residential area in accordance with the zoning ordinance enacted in 1982. The implementation of land use regulation and/or conservation may call for the revision of the existing zoning ordinance and land value may decrease.

Flood insurance which is to enable an individual property owner to spread an uncertain but potentially large loss uniformly over a long period of time, is deemed too early to apply. This is because the application of this method requires the fundamental data on flood frequency and damage amount in the subject area to be precise, and the inhabitants in the highly flood prone area which is usually the low land area, are not inclined to spend for insurance.

In view of the foregoing, the following three measures are recommended; namely, the publication of a flood risk map and the introduction of flood-proofing as measures for flood plain management, and the enforcement of emergency activities.

Publication of Flood Risk Map

Flood risk map is recommended to be published and disseminated to the inhabitants and governmental agencies concerned. The publication of flood risk map is expected to have the following effects.

- Inhabitants will know the flood risk of their locality.
- Inhabitants will be prepared for the flood with the establishment of evacuation routes and evacuation areas.
- Inhabitants will have a greater understanding on the significance of flood control and their cooperation is enhanced.
- New occupancy in flood prone areas will be discouraged.

Introduction of Flood Proofing

Flood proofing measures are considered so as to reduce the damage potential and the most applicable ones proposed are the raising of building foundations or the floor elevation and the installation of bulkheads over low doors or windows.

Enforcement of Emergency Activities

Emergency activities include flood warning, flood fighting and evacuation/rescue activities. These activities are to reduce potential losses and relieve the distress of flood victims.

3.3 Land Subsidence

The main causes of land subsidence seem to be the settlement of soil due to added load and excessive groundwater utilization, and the latter appears to be the more general factor. Since local land subsidence can be related closely with the drawdown of groundwater table, the records on groundwater, as well as the ground elevation survey record, was utilized in this study to evaluate the occurrence of land subsidence.

Ground Water Level Survey

The ground water level records of 1955, 1967 and 1981 and the measurements of ground water level in June 1988 were studied. According to the available ground water level data of the Manila Bay Aquifer System given by H.P. Quiazon of the Bureau of Mines, as well as those from the MWSS (1981), the ground water level in the project area had continued to subside since 1955, except in Manila where the ground water level recovered between 1967 and 1981 as a result of the reduced pumpage and abandonment of wells due to saline water intrusion. By 1981, new centers of the pumpage were Sucat, Parañaque, Makati and Quezon City.

Measurement of the ground water level was carried out at six wells in June, 1988. The water level of the wells had been almost unchanged or recovering since 1981 (refer to Fig. 3.3-1).

Ground Elevation Survey

The existing data obtained in 1979 and results of the topographic survey carried out in 1988 were studied. Since the primary bench mark level of 1979's survey is unknown, the results of the survey carried out in 1979 and 1988 are incomparable in the same level.

Considering the consolidated condition of the Guadalupe Formation as mentioned above, and the recovering ground water level in the formation since 1981, the ground level of the hill consisting the Guadalupe Formation appears to be stable and able to be regarded as the primary bench mark during the time between 1981 and 1988. Based on this concept, the results of the topographic survey show that the ground level in the alluvial deposits is almost unchanged or has somewhat risen since 1979.

Findings on Land Subsidence

As shown in Table 3.3-1, Ground Water and Land Subsidence, which summarizes the above conditions, all the data appear to indicate that the land subsidence of the alluvial deposit area is presumed to have ceased since 1981. No more subsidence is expected, when the ground water utilization continues to decline in the future.

3.4 Hydrology and Hydraulics

The study on hydrology and hydraulics covers the whole area of Metropolitan Manila (Metro Manila), as shown in Fig. 3.4-1, and the Laguna Lake.

3.4.1 Rainfall Analysis

Design Hyetograph

Two kinds of design hyetograph were prepared for the runoff analysis of the river basins and drainage areas, as follows.

(1) Design Hyetograph for River Basin

(a) Probable Basin Mean Rainfall

The basin mean rainfall in two days as the basic data for frequency analysis was estimated by the Thiessen Method. The Thiessen Polygon network was established utilizing the rain gauges with reliable data. The basic data for the basin mean rainfall estimation were selected from the 2-day rainfall records for several heavy rainfalls recorded at the rain gauges after 1972.

The frequency analysis was conducted based upon the annual maximum basin mean 2-day rainfall, assuming the Log-Normal Distribution and using the Thomas Plotting Formula. The estimated probable 2-day rainfall of the respective river basins are shown in Table 3.4-1.

(b) Estimated Model Hyetograph

The hourly rainfall observations are not sufficient for setting up the design hyetographs for river basins, and only the data of the Port Area Gauge is available. Therefore, standard model hyetographs were constructed on the basis of the rainfall records of the Port Area gauge. The standard model hyetographs corresponding to 20, 50 and 100-year return periods are presented in Fig. 3.4-2.

(2) Design Hyetograph for Drainage Area

The nine drainage areas shown in Fig. 3.1-1 were further divided into subdrainage areas, considering topography, micro land forms, drainage system, land use and inundation condition. A subdrainage area is the unit of inland inundation calculation aiming to determine pump capacity, as well as to estimate flood damage. Fig. 3.4-3 is a schematization of subdrainage areas for the nine drainage areas.

The design hyetograhs of 2-year, 3-year, 5-year, 10-year, 30-year, 50-year and 100-year return periods were prepared for each subdrainage area using point rainfall data, because the size of a subdrainage area is far smaller than river basins and thus mean rainfall is judged to be nearly equal to point rainfall. The used point rainfall data are those recorded at the Port Area Gauge, only which provide available data of short duration in Metro Manila.

The design hyetograph was set using the rainfall intensity curve at the Port Area Gauge. Since the rational formula was applied to obtain the hydrograph, the time distribution of rainfall is of the same type used for the river basin, while the time interval of rainfall was given at runoff concentration time of each subdrainage area.

3.4.2 Runoff Analysis

The analysis was followed by the design hydrograph computation for the river basins and the drainage areas in compliance with the design hyetographs.

Probable Discharge for River Basin

(1) Probable Peak Discharge at Sto. Niño Estimated by Observed Discharge

The annual peak flood stage and discharge at the Sto. Niño Gauge are compiled in Table 3.4-2. The frequency of the annual peak discharge has been evaluated by assuming the Log-Normal Distribution and applying the Thomas Plotting Formula. The results are compiled in the following table.

Return Period (year)	Sto. Niño Discharge (m^3/s)
100	3,500
50	3,100
20	2,500
10	2,200
5	1,800
2	1,350

Based mainly on the Sto. Niño stream records, the 100-year discharge was estimated at 3,300 m^3/s in the previous study. Since that time, the stream records have increased in number, and the peak discharge of the 1986 flood has been the largest on record.

In view of the increased number of stream records, a new estimation should have a higher reliability than the previous one. Hence, the 100-year flood peak discharge is proposed to be modified into a 3,500 m^3/s.

(2) Probable Flood Discharge Estimated by Runoff Calculation

The river basins may be classified into two (2) kinds. One kind comprises the Upper Marikina River Basin and the other kind comprises the rest of the river basins.

(a) Probable Discharge of Upper Marikina River Basin

The Marikina River Basin has a larger catchment and its upper reaches have steep mountainous areas which may not be urbanized even in the far future. To set the flood routing model in the Marikina River Basin, the storage function flood runoff method was applied to the sub-basins upstream of Sto. Niño, considering the conditions of the river basin.

To know the peak discharge and flood hydrograph at the important sites in the river basin, a basin-river model was set up. It consists of three sub-basins and one river model between Montalban and Sto. Niño.

The probable flood discharge of a 100-year return period at Sto. Niño was computed at 3,500 m^3/s. Its hydrograph is given in Fig. 3.4-4.

(b) Probable Flood Discharge of Other River Basins Except Upper Marikina

The peak discharge and discharge hydrographs of the river basins were estimated by the Quasi-Linear runoff method under the land use conditions at the year 2020, as well as the conditions at present. The model was developed to estimate the runoff increment due to the catchment's urbanization, and utilized extensively for the flood analysis of small to medium-sized catchments to formulate a flood mitigation program considering the future urbanized conditions. The runoff coefficients for the land use classified into nine categories are assumed values which are presented in Table 3.4-3.

The Quasi-Linear runoff method may calculate the peak discharge and the hydrograph at the points concerned in a basin by integrating the sub-basin and river models. The sub-basin model generates flood in the sub-basin and the river model expresses the flood peak change and the delay of the peak time due to flood travel in the main river channel.

The design hydrograph computation for 2020 and 1986 land use conditions was carried out for the respective river basins under 2-year, 5-year, 10-year, 20-year, 30-year, 50-year and 100-year design hyetographs. The results for 2020 and 1986 are shown in Figs. 3.4-5 and 3.4-6, respectively.

<u>Probable Discharge for Drainage Areas</u>

The discharge hydrographs for the respective subdrainage areas under the land use conditions at 2020 and for the priority drainage areas under the present land use conditions were estimated by the rational formula, which has been applied to design the drainage system in Manila and Suburbs including pump capacity since the formulation of its Master Plan in 1952. The runoff coefficient of each subdrainage area was computed by multiplying the ratio of land use classification, obtained from Tables 3.1-1 and 3.1-2, with the corresponding runoff coefficient in Table 3.4-3.

Based on the runoff coefficient and the design hyetograph explained before, the design hydrographs were obtained with 2-year, 3-year, 5-year, 10-year, 30-year, 50-year and 100-year return periods. Table 3.4-4 shows the catchment area, runoff coefficient and probable discharge of the respective subdrainage areas under the land use conditions at 2020, while Table 3.4-5 shows those of the priority drainage areas under the present land use conditions.

3.4.3 Probable Laguna Lake Peak Stage

The annual maximum lake stage record between 1946 and 1987 is presented in Table 3.4-6. Lake stage frequency was evaluated by assuming the Gumbel Distribution and applying the Thomas Plotting Formula. In the annual maximum record, the highest took place in 1972 (EL 14.03 m) followed by 1978 (EL 13.58). These high lake stages correspond to 40 and 20-year return periods, respectively.

Return Period (year)	Probable Lake Stage (EL m)
200	14.89
100	14.50
50	14.12
20	13.60
10	13.20
5	12.80
2	12.14

3.4.4 Manila Bay Tide

Tide in the Manila Bay is currently being observed by a tide gauge located at Pier 15 of the Manila South Harbor which is about 1.7 km southwest of the Pasig River mouth. Tide gauging is under the responsibility of the Bureau of Coast and Geodetic Survey (BCGS).

The tide measured as a height above gauge zero of a staff gauge referred to as TS (1901) datum is recorded on the tide automatic recording chart. Based on the records, BCGS had compiled the hourly, monthly high and low extremes, monthly mean tide, and annual mean sea level, which are available since 1948.

The datum plane for the Study is the one shown in the following table.

Tide Component	Height (EL m)
Observed Highest Tide	11.770
Mean Spring High Tide	11.300
Mean Higher High Water (MHHW)	10.980
Mean High Water (MHW)	10.838
Mean Sea Level (MSL)	10.462
Mean Low Water (MLW)	10.101
Mean Lower Low Water (MLLW)	10.000
Datum Line (DL)	0.000

Note: Primary Bench Mark (BM4b) = EL 13.247 m

3.5 River and Drainage Systems

3.5.1 Watersheds

The objective area is divided into the following basins and/or areas in accordance with the topographical characteristics and the river and channel system. The areal divisions and catchment areas are as shown in Fig. 3.4-1.

- Pasig-Marikina River Basin including San Juan River Basin
- Malabon-Tullahan River Basin
- Buli-Baho-Mahaba River Basin
- South Parañaque-Las Piñas River Basin
- Other Remaining Basins such as the drainage areas of East and West of Mangahan, Malabon-Navotas-Valenzuela, Parañaque-Las Piñas, and Manila and Suburbs, where inundation waters drain directly into the sea or the lake.