社会開発調査部報告書

No. 60

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF THE PHILIPPINES

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

METROPOLITAN MANILA DEVELOPMENT AUTHORITY

STUDY ON THE EXISTING DRAINAGE LATERALS IN METRO MANILA IN THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT

MAIN REPORT

NOVEMBER 2000

WOODFIELDS CONSULTANTS, INC.

IN JOINT VENTURE WITH

BASIC TECHNOLOGY AND MANAGEMENT CORPORATION

ADVISOR :

CTI ENGINEERING INTERNATIONAL CO., LTD.

STUDY ON THE EXISTING DRAINAGE LATERALS

IN METRO MANILA

IN THE REPUBLIC OF THE PHILIPPINES

MAIN REPORT

Woodfields Consultants, Inc. (WCI)
in joint venture with Basic Technology and Management Corp.
and advised by CTI Engineering International Co., Ltd.

November 2000

1161182 (9)

WOODFIELDS CONSULTANTS, INC
PLANNERS, ARCHITECTS, ENGINEERS, CONSTRUCTION MANAGERS AND ENVIRONMENTALISTS
3/F 153 Kamias Road, Kamias, Quezon City 1102, Philippines Tel: (632)436 7360; (632)925 3621
Fax: (632)436 7372: E-mail: woodf@ibahn.net

in joint venture with

BASIC TECHNOLOGY AND MANAGEMENT CORPORATION
2/F PRUDENTIAL BANK BLDG., 1377 A. MABINI ST., ERMITA, MANILA 1000 PHILIPPINES
TELEPHONE NOS.: 523-8184 TO 87 FAX: 521-0618 E-MAIL : basictm@globe.com.ph

01 December 2000

Mr. HIDEO ONO
Resident Representative
Japan International Cooperation Agency (JICA)
Philippine Office
12th Floor Pacific Star Bldg.
Makati Ave., Makati City

Subject: **Final Report of the Study on the Existing Drainage Laterals in Metro Manila in the Republic of the Philippines**

Sir:

We are pleased to submit herewith seventy (70) copies of the final report of the "Study on the Existing Drainage Laterals in Metro Manila in the Republic of the Philippines."

This report is the culmination of survey and inventory activities conducted by Woodfields Consultants, Inc. between February 2000 to November 2000, in joint venture with Basic Technology and Management Corp. and with CTIE as advisor for JICA. It presents an analysis of the flooding problem of Manila and Suburbs in relation to the conditions of present drainage laterals and forwards recommendations too on how more lasting solutions to the flooding problem of the metropolis may be had.

The final report consists of two volumes. The first is the Main Report which describes the conduct of the study, its survey program's results, the database system that was developed during the course of the study, and the analysis and recommendations arising therefrom. The second is the Data Book which contains the maps of the drainage mains, channels (with flow direction indicated), surveyed manholes, and other related drainage data and information.

Allow us at this point to express our sincere and deep gratitude to the Japan International Cooperation Agency for giving us the opportunity to undertake this study and for its continuing support to projects in the Philippines.

Very truly yours,

ENRICO G. GREGORIO
Study Team Leader

ACKNOWLEDGEMENTS

The joint venture of Woodfields Consultants, Inc. (WCI) and Basic Technology and Management Corporation (Basicteam) would like to acknowledge the support received in the preparation of this study from the Department of Public Works and Highways (DPWH), particularly its Major Flood Control Project – Project Management Office (MFCP – PMO) and its National Capital Region Office and the various district engineering offices under it, the Metropolitan Manila Development Authority (MMDA), and the different local government units in Metro Manila without whose cooperation completion of this study would not have been possible.

TABLE OF CONTENTS

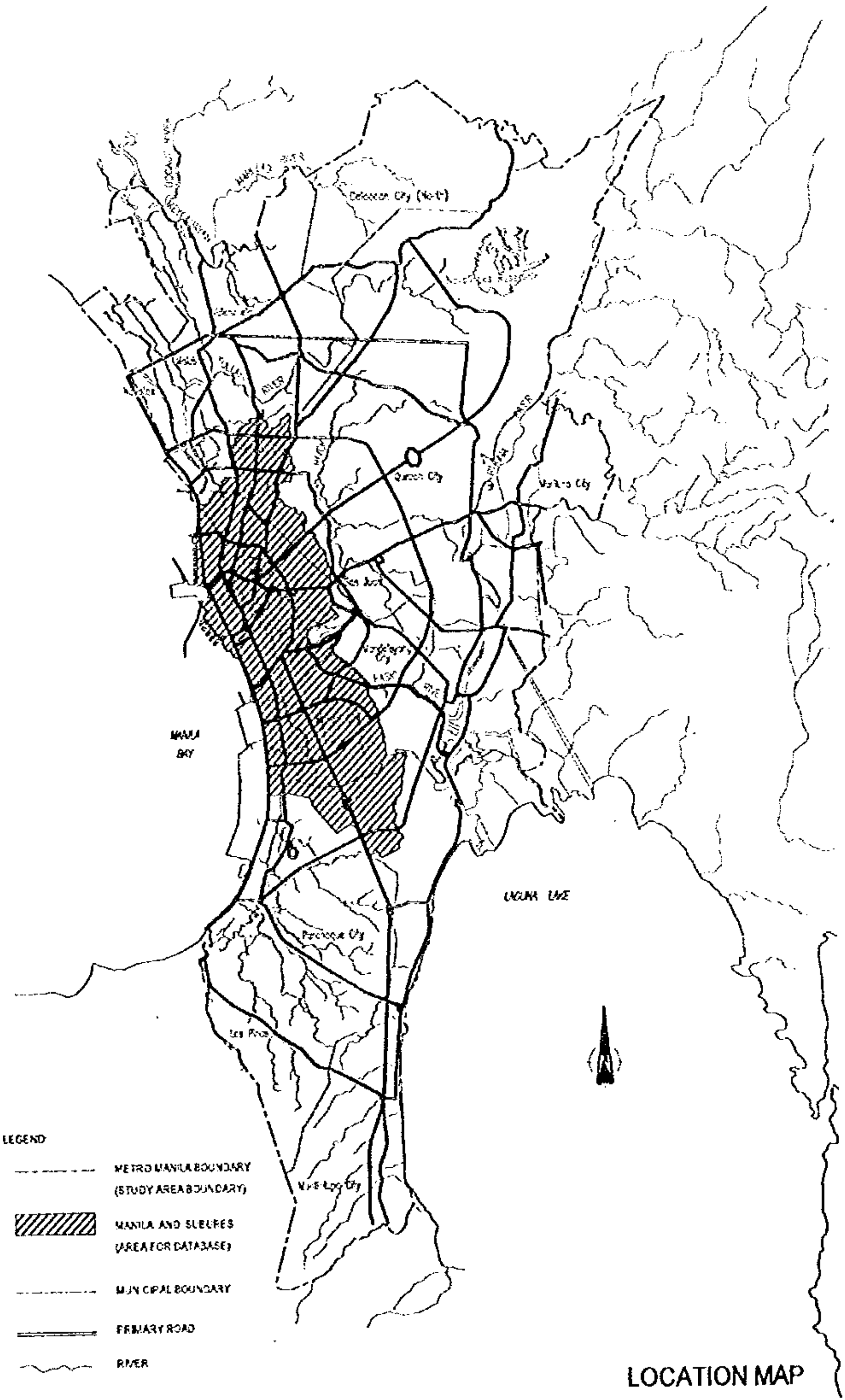
List of Tables

List of Figures

List of Photos

Abbreviations

BPW	:	Bureau of Public Works
BOD	:	Bureau of Design, DPWH
DPWH	:	Department of Public Works and Highways
EXIM Bank	:	Export – Import Bank
GOJ	:	Government of Japan
GOP	:	Government of the Philippines
JICA	:	Japan International Cooperation Agency
LGU	:	Local Government Unit
MMDA	:	Metropolitan Manila Development Authority
MPWH	:	Ministry of Public Works and Highways
NAMRIA	:	National Mapping & Resource Information Authority
NAIA	:	Ninoy Aquino International Airport
NMED	:	North Manila Engineering District, DPWH
OECF	:	Overseas Economic Cooperation Fund
PAGASA	:	Philippine Atmospheric Geophysical and Astronomical Services Administration
PNR	:	Philippine National Railways
BM	:	Benchmark
CAD	:	Computer Aided Design
DA	:	Drainage Area
DM	:	Drainage Main
IEC	:	Information Education Campaign
KAMANAVA	:	Kalookan – Malabon – Navotas – Valenzuela
LAN	:	Local Area Network
LPA	:	Low Pressure Area
MCM	:	Mercator Converter Model
MLLW	:	Mean Lower Low Water
MSL	:	Mean Sea Level
NL	:	North Lateral
NR	:	No Record
SL	:	South Lateral
TD	:	Tropical Depression
TWC	:	Technical Working Committee
C	:	Runoff Coefficient
El.	:	Elevation
EST	:	Estero



LOCATION MAP

Executive Summary

EXECUTIVE SUMMARY

The problem of flooding in Metro Manila has long engaged the attention of the Government of the Philippines (GOP). Various flood control and drainage improvement projects have been implemented in the metropolis in the last two decades, but little seems to have been gained because the flooding problem persists, as evidenced by the flooding events of September 1999 and July 2000 which had even enlarged the area inundated and wrought greater damage than had been experienced in floods of previous years.

Flood control and drainage in Metro Manila has yet to effectively address the inadequate capacity of existing drainage channels for conveying storm water to the pumping stations, or to Manila Bay and Pasig River. While possible solutions have been identified to correct the deficiencies of the system, the formulation of drainage improvement measures has been hampered by the very limited information on the present conditions of existing drainage channels.

Appreciating this information need, the GOP decided to conduct the "Study on the Existing Drainage Laterals in Metro Manila" and requested the Government of Japan (GOJ) in 1999 for technical assistance. The Japanese government acceded to this request and entrusted the delivery of technical assistance to the Japan International Cooperation Agency (JICA) under the latter's Local Development Study Program. JICA organized a Study Team led by Woodfields Consultants, Inc. (WCI) to undertake the study and engaged the services of CTI Engineering International Co. Limited as project advisor. To ensure the smooth implementation of the study, the Department of Public Works and Highways (DPWH) and the Metro Manila Development Authority (MMDA) acted as counterpart agencies to the JICA Study Team. The study commenced in February 2000 and was completed in November 2000.

The objectives of the study as agreed upon in the Implementing Arrangement (I/A) signed in November 1999 between and among JICA, DPWH and MMDA are:

- To ascertain the present conditions of existing drainage laterals;
- To establish a database of drainage laterals that can be used as guide in the operation, maintenance, rehabilitation and/or improvement of drainage facilities; and
- To analyze problems in the laterals of the drainage system of Metro Manila.

In pursuit of the above objectives, the Study Team implemented a field survey program aimed at generating primary data on the existing drainage channels. The program involved the establishment of a benchmark network, conducting survey of manholes for drainage mains and laterals, cross-sectional survey for open channels, and inundation survey. Except for the inundation survey which covered the whole study area of Metro Manila, the area concentrated on by the field survey activities was Manila and Suburbs (i.e. the City of Manila and portions of Malabon, Kalookan, Quezon, Makati, Pasay, Paranaque and Taguig). Data obtained through the field survey program were inputted into the LATERAL database developed by the Study Team during the course of study. These were also plotted in sufficient detail on digital location maps of the drainage system.

The digital location maps of the drainage system and the information generated by the database system were used together as bases for the analysis of the existing conditions of drainage laterals and drainage blocks in Manila and Suburbs. The flood condition database and the inundation maps, on the other hand, formed the bases for identification and analysis of flood problems in various flood-prone areas of Metro Manila.

Analysis of the present conditions of drainage laterals in Manila and Suburbs was made considering the runoff and flow capacity of existing drainage channels, flow direction in the drainage laterals, interconnectivity within each drainage block, and topography of the catchment area. Analysis results show the discharge and flow capacity of most of the drainage laterals in Manila and Suburbs to be inadequate for a 10-year flood. Estimates of runoff and flow capacity of drainage mains and open channels similarly showed the inadequacy of several channels for both 2-year and 10-year floods.

Because of the inadequate capacity for draining storm water of most of the drainage laterals, drainage mains and open channels, the low-lying areas of Manila and Suburbs such as Sampaloc (north of the Pasig River) and San Antonio-Palanan-Pio del Pilar (south of Pasig River) become prone to flooding. The limited flow capacity of drainage channels was found to be caused by one or several combinations of the following: undersized drainage channels; unevenly laid slope of the conduit; irregular channel profile; inconsistent drain size; clogged manholes; sediment deposits along the drainage channel; overflowing of esteros; floodwater spilling to neighboring drainage areas; and submerged crown elevation at the outlet. Also contributing to a significant reduction of their carrying capacity, and thereby aggravating the problem of flooding in most parts of Manila and Suburbs, are: the encroachment of esteros and waterways by informal settlers; uncoordinated infrastructure development activities by various public utility agencies; indiscriminate disposal of garbage; and increased run-off resulting from rapid urban development.

Given the present conditions obtaining in the drainage system of Manila and Suburbs as ascertained by the study, some immediate and long-term measures may be recommended. These are discussed as follows.

<u>Formulation of Master Plan and Feasibility Study</u>

Considering that the flooding problem is regional in scope and involves several closely connected drainage blocks, drainage mains, esteros, and pumping stations, it is necessary that comprehensive drainage planning be undertaken through a master plan study. Candidate areas identified for the master plan study are the *Sampaloc area of North Manila* and the *San Antonio-Palanan-Pio del Pilar-San Isidro area of South Manila*.

With a view towards formulating long-term solutions to the flooding problem, the master plan should come up with a balanced mix of both structural and nonstructural measures. The structural ones should include: construction of additional drainage channels; improvement of esteros; rehabilitation and improvement of existing drainage mains; rerouting of flows to less stressed lines; compartmentalization of drainage blocks to reduce problem areas into manageable levels; or possibly, redesign or reconstruction of the whole drainage system.

Nonstructural measures should include IEC and advocacy programs aimed at promoting proper solid waste management and discouraging informal settlements in drainage channels and waterways.

For purposes of determining the technical, institutional, financial, social and environmental aspects of proposed drainage improvement measures, feasibility studies should be conducted for projects identified as priorities in the master plan.

Implementation of Urgent Works

In the immediate term, the Study Team recommends that urgent measures be implemented to improve the flow capacity of some important channels. These measures are detailed as follows:

North Manila Watershed: Regional

CHANNEL CODE	NAME	MEASURES
DM01	**Blumentritt Interceptor**	
NL041	Amoranto/Mayon/ Calamba (Right Side)	▪ Increase lateral/main capacity, reduce run-off peak or provide additional line if space allows ▪ Desilting/Declogging of drainage channel ▪ Develop/implement solid waste management plan to include non-structural measures like IEC and advocacy programs ▪ Inclusion in the overall master planning
NL039	Andres Bonifacio	▪ Increase lateral/main capacity, or provide additional line if space allows ▪ Declog/dredge drainage main (DM01) and declog manholes ▪ Inclusion in the overall master planning, being contributor to large scale flooding of Sampaloc area (*diversion channel can be considered in the master planning*).
NL043	Piy Margal (Mayon/M. Cuenco)	▪ Increase lateral/main capacity, or provide additional line if space allows (*flooding problem covers a large area and several drainage areas interact*) ▪ Develop/implement solid waste management plan to include non-structural measures like IEC and advocacy programs ▪ Inclusion in the overall master planning
DM06	**N. Reyes –Severino**	
NL031	Laong-Laan/ Gov. Forbes/España	▪ Increase lateral/main capacity, or provide additional line if space allows ▪ Develop guidelines to improve drainage planning, design, construction, operation and maintenance. ▪ Undertake overall master planning and include this lateral (*the drainage basin lies in low-lying area and also involves other interdependent drainage basins*)
NL032	Dimasalang/Gov. Forbes/España	▪ Increase lateral/main capacity, or provide additional line if space allows ▪ Clean/declog NL032. ▪ Develop proper drainage planning, design, construction, and operation guidelines so as to put more emphasis on the hydraulic aspect of the problem ▪ Develop/implement solid waste management plan to include non-structural measures like IEC and advocacy programs ▪ Undertake comprehensive drainage master planning and include this lateral for it is part of the large scale flooding of the Sampaloc area.

DM07	**Josefina - Lepanto**	
NL036	España Right Side)	▪ Increase lateral/main capacity, or provide additional line if space allows ▪ Develop guidelines on proper drainage planning, design, construction, and operation, with emphasis on the hydraulic aspect of the flooding problem. ▪ Develop/implement solid waste management plan to include non-structural measures like IEC and advocacy programs ▪ Undertake comprehensive drainage master planning (*This lateral involves a number of interdependent drainage basins including those in low-lying areas.)*
DM08	**Economia**	
NL034 NL035	España (Right Side) España (Left Side)	▪ Increase capacity of NL034 , or provide additional line if space allows ▪ Undertake comprehensive drainage master planning *(The laterals' drainage basin lies in a low-lying area and involves also a number of interdependent drainage basins. Due consideration should be given to the fact that the drainage main (DM08), NL034 and NL035 are in the interior of a large basin.)*
NL033	M. Earnshaw/ España	▪ Increase lateral/main capacity, or provide additional line if space allows ▪ Clean clogged manholes from ii15C4064 to ii15C4071. ▪ Enlarge drain size at manhole ii5C4075 ▪ Develop guidelines on proper drainage planning, design, construction and operation, with emphasis on the hydraulic aspect of the flooding problem. ▪ Develop/implement solid waste management plan to include non-structural measures like IEC and advocacy programs ▪ As this is part of the large scale flooding of the Sampaloc area, it should be included in the overall master planning study.
NL029 NL030	M.V. delos Santos (Right Side) M.V. de los Santos (Left Side)	▪ Increase lateral capacity, or provide additional line if space allows ▪ Develop guidelines on proper drainage planning, design, construction, and operation, with emphasis on the hydraulic aspect of the flooding problem. ▪ Undertake comprehensive drainage master planning as this involves a number of interdependent drainage basins and also because these laterals' drainage basin lies in a low-lying area.
DM 28	**South Antipolo Main**	
NL055	F. Huertas	▪ Increase lateral/main capacity, or provide additional line if space allows ▪ Dredge South Antipolo Main. ▪ Include in a small basin-wide drainage improvement study (say north Sta. Cruz area).
DM02	**Solis-Tecson**	
NL016 NL017	J. Abad Santos (Right Side) J. Abad Santos (Left Side)	▪ Increase lateral/main capacity, or provide additional line if space allows ▪ Declog/desilt NL016 & NL017. ▪ Develop guidelines on proper drainage planning, design, construction, and operation, with emphasis on the hydraulic aspect of the flooding problem ▪ Improve carrying capacity of DM02, preferably through a study on improvement of drainage laterals for small drainage area.

DM29	**Tayuman**	
NL025	Oroquieta	▪ Increase lateral/main capacity, or provide additional line if space allows ▪ Develop guidelines on proper drainage planning, design, construction, and operation, with emphasis on the hydraulic aspect of the flooding problem ▪ Declog manholes and dredge Tayuman Main. ▪ Include in a small basin-wide drainage improvement study (say north Sta. Cruz area).
NL018 NL019	S. Herrerra Tayabas	▪ Increase lateral/main capacity, or provide additional line if space allows ▪ Declog/dredge Estero de Magdalena for immediate impact, ▪ For long range planning, conduct a drainage improvement study of Estero de Magdalena from South Antipolo to Tayuman. It may include the improvement of the drainage laterals under a small basin wide study.

North Manila Watershed: Local

CHANNEL CODE	NAME	MEASURES
NL049	Luzon/Negros	▪ Desilt/declog lateral and manhole iii11A4197. ▪ Improve slope of lateral and check inlet to NL049 from Luzon. ▪ Develop proper drainage planning design, construction, and operation guidelines so as to put more emphasis on the hydraulic aspect of the problem
NL010	Claro M.Recto (Left Side)	▪ Increase lateral capacity, or provide additional drain line, if space allows ▪ Develop proper drainage planning, design, construction, and operation guidelines so as to put more emphasis on the hydraulic aspect of the problem
NL026	P. Guevarra	▪ Increase lateral capacity, or provide additional drain line, if space allows ▪ Declog drainage lateral (NL026). ▪ Develop proper drainage planning, design, construction, and operation guidelines so as to put more emphasis on the hydraulic aspect of the problem.
NL004	Moriones/Nolasco/ Morga	▪ Increase lateral capacity, or provide additional drain line, if space allows ▪ Declog drainage lateral NL004. ▪ Develop proper drainage planning, design, construction, and operation guidelines so as to put more emphasis on the hydraulic aspect of the problem
NL020	North Antipolo Creek (T. Bugallon – Antipolo)	▪ Declog/clean NL020. ▪ Improve downstream of drainage laterals. ▪ Improve flow capacity of North Antipolo Creek. ▪ Include in a small basin-wide drainage improvement study (say north Sta. Cruz area).
NL044	Cordillera/Quezon Ave./D.Tuazon /Data/Matimyas	▪ Study the possibility of replacing drainage lateral from iii11A3186 to iii11A3121 to get rid of the choke. ▪ Develop proper drainage planning, design, construction, and operation guidelines with more emphasis on the hydraulic aspect of the problem ▪ *Design channel with appropriate gradient and flow capacity.*

NL028	C. Palanca/ Padilla/ Nepomuceno	▪ Declog manhole ii20C1025. ▪ Improve drainage profile through proper planning.
NL054	Old Sta. Mesa/ Albina/Altura/ R. Magsaysay/ Hipodromo/Anonas	▪ Declog manhole. ▪ Revise drainage profile through proper drainage planning. ▪ Develop proper drainage planning design, construction, and operation guidelines with more emphasis on the hydraulic aspect of the problem.
NL045 NL046	Matimyas (Right Side) Matimyas (Left Side)	▪ Declog NL045.and desilt NL046 ▪ Improve drainage lateral through proper planning.

South Manila Watershed: Regional

CHANNEL CODE	NAME	MEASURES
	Estero de Tripa de Gallina	▪ Improve channel capacity of Calatagan Creek and Tripa de Gallina.
DM 23	**Zobel Roxas**	
SL001	Primo de Rivera	▪ Re-design SL001 and rectify longitudinal slope. *Constant slope must be maintained throughout the whole length. Verify availability of head from upper end of line to junction with SL044 (Vito Cruz), to DM23 (Zobel Roxas) and ultimately at Tripa de Gallina.*
SL002	Vito Cruz Extension	▪ Do the same for SL002 (north segment of Mayapis).
		▪ Provide auxillary pump at the Tripa de Gallina inlet of Vito Cruz outlfall (DM14). Forced pumping is necessary. ▪ Another alternative is to completely redesign/ reconstruct the drainage system of San Antonio Village. *Compartmentalize the area by providing floodgates on Tripa de Gallina area for the Libertad to prevent external flows. This will ensure a definite influence area for the Libertad Pumping Station plus a new auxiliary force pump which should be provided at inlet of Vito Cruz outfall.*
SL032	Sen. Gil Puyat Dian-DM22	▪ Increase lateral capacity, or provide additional line if space allows
SL033	Finlandia-Edison-Morse-EST25	▪ Increase lateral capacity, or provide additional line if space allows
SL037	Hen. A. Ricarte	▪ Increase lateral capacity, or provide additional line if space allows ▪ Declog/desilt drainage lateral.
SL039	Cabrera Protacio Extension	▪ Increase lateral capacity, or provide additional line if space allows ▪ Reconstruct pipe sections to gradual slope. ▪ Declog/clean manhole iii21A1042 and downstream sections.
SL031	Dayap-Dian-Calatagan Creek	▪ Improve capacity of lateral and Calatagan Creek, or provide additional line if space allows
SL030	Dian (Outfall)	▪ Improve capacity of lateral and Calatagan Creek, or provide additional line if space allows
DM33	**Pasong Tamo**	
SL055	Lumbayao and St. Paul	▪ Increase lateral capacity, or provide additional line if space allows

SL022	Mayapis	▪ Increase lateral capacity, or provide additional line if space allows ▪ Declog whole length of drainage lateral
	PNR Open Channel	▪ Dredge PNR open canal.
SL020	Dagonoy	▪ Improve capacity of lateral including the receiving PNR open canal or provide additional line if space allows. ▪ Clean manhole iii16A3158 of sediment deposit.
SL021	Estrada A	▪ Declog/clean the PNR open canal and the drainage lateral as well. ▪ Undertake improvement of the drainage laterals for San Andres Bukid; this can be studied in detail using a small basin-wide approach.
SL054	Estrada B	▪ Do the same for SL054.

South Manila Watershed: Local

CHANNEL CODE	NAME	MEASURES
SL010	Paz Mendoza Guanzon	▪ Reconstruct SL010 and rectify slope. *Verify size of drain line.* ▪ Flatness of the existing terrain may require closer spacing of street/curb inlets. ▪ *Drain size must be smaller at the upper end, becoming progressively larger at the lower end.*
SL035	Rockefeller/Ford/ Tripa de Gallina	▪ Declog manhole inlets. ▪ Provide additional curb inlets. ▪ Clean SL035.
SL047	Victoria	▪ Redesign and reconstruct segment 0 to 893 for a steeper slope.
SL041	Donada/DM14	▪ Redesign whole segment and replace with larger RCPs. ▪ Clean SL041. ▪ Develop proper drainage planning, design, construction, and operation guidelines with more emphasis on the hydraulic aspect of the problem
SL045	Rodriquez/Apelo Cruz/ C. Jose	▪ Reconstruct SL045 and rectify slope ▪ Desilt/declog the whole pipe system. ▪ Clean inlets. If necessary, provide additional inlets. ▪ Develop proper drainage planning, design, construction, and operation guidelines so as to put more emphasis on the hydraulic aspect of the problem
SL008	T.M. Kalaw/Taft	▪ Replace SL008 with one that has a bigger capacity or provide additional parallel line if space is available ▪ Recalculate to determine proper drain size. ▪ Rectify longitudinal slope from 0 to 103. ▪ Clean inlets. ▪ Develop proper drainage planning, design, construction, and operation guidelines with more emphasis on the hydraulic aspect of the problem
SL009	San Marcelino	▪ Provide flap gate or check gate at outfall.
SL032 SL033	Sen. Gil Puyat/Dian/ DM22 Finlandia/Edison/ Morse/Tripa de Gallina	▪ Reconstruct SL032 and SL033 and rectify slope ▪ Desilt/declog manholes ▪ Develop guidelines for proper drainage planning, design, construction, and operation, with emphasis on the hydraulic aspect of the problem
SL029	Herrera	▪ Clean/clear of sediment deposits the whole length of drainage lateral

SL019	E. Pascua	▪ Redesign and reconstruct SL019 from 0 to 167 ▪ Raise outfall invert to El. 11.50 ▪ Desilt/declog SL019
SL014	Road 9	▪ Reconstruct segment from 0 to 50 and raise outfall invert to El. 12. ▪ Increase channel capacity of Tripa de Gallina.
SL015	Road 16/Pedro Gil	▪ Redesign and reconstruct segment from 0 to 328. ▪ Rectify longitudinal slope. ▪ Drain size must progressively become larger as the lower end is approached. ▪ Increase channel capacity of Tripa de Gallina.

The Study Team also recommends the following areas for *pilot projects* as requested for joint implementation by DPWH, MMDA and LGUs:

- Sta. Mesa Heights in Quezon City, involving NL039 (A. Bonifacio), NL041 (Amoranto-Mayon-Calamba), NL043 (Piy Margal, Mayon-M. Cuenco) and DM01 (Blumentritt Interceptor)
- Sta. Cruz, Manila, involving Tayuman Main (DM29), NL018 (S. Herrera), NL019 (Tayabas), NL025 (Oroquieta)
- Metropolitan Subdivision in Makati City, involving SL001 (Primo de Vera), SL002 (Vito Cruz Extension) and DM23 (Zobel-Roxas)
- Manila City Hall, involving SL056 (Arroceros) and SL057 (Concepcion)

Strengthening of Inter-agency Coordination

A requisite for the effective operation, maintenance, rehabilitation and improvement of drainage facilities is the close coordination between and among the DPWH, the MMDA and the concerned LGUs within Metro Manila. It is suggested that a Technical Working Committee (TWC) composed of representatives of DPWH, MMDA and the different LGUs be created. With a view towards ensuring the effective utilization of the outputs of the present study and improving the management of drainage laterals, the TWC will be responsible for the following:

- Firming up of post-project (study) implementation arrangements particularly in regard to the operation and maintenance of the database system for drainage laterals;

- Coordinating the implementation of pilot projects recommended under this study. These projects are aimed at providing immediate structural and non-structural solutions to the recurrent flood problems;

- Design and implementation of a capacity-building program for concerned staff of member-agencies on drainage system planning, design, construction, operation and maintenance;

- Evaluation of the current practice of planning drainage systems, to include updating of drainage design criteria in coordination with the Bureau of Design of the DPWH; and

- Exploring the possibility of replicating the study, particularly the development of database system for drainage laterals in other critical areas of Metro Manila and in other key urban centers of the country such as Metro Cebu, Metro Davao, Metro Surigao, Butuan City, Naga City, and other urban centers.

Management of Database System

The potential benefits from the database system for drainage laterals that was developed as part of the study can only be realized through proper system management. This requires that an appropriate agency within the TWC be designated to operate and maintain the database system. This agency should be able to provide a full-time staff and allocate an adequate budget for database system operation and maintenance. Specifically, the designated agency will be involved in:

- Coordination with the other agencies within the TWC as regards the use and updating of database information;

- Conduct of capacity-building and skills transfer activities for concerned personnel of member-agencies of the TWC for them to be able to establish and manage a database system for drainage laterals on their own;

- Preparation of post-project monitoring reports on the utilization status of the database system including the status of equipment and materials acquired through the study for submission to JICA.

Follow-up Study on the Flooding Problem in Metro Manila

A follow-up study focused on existing government policies on flood control and anchored on addressing policy and institutional aspects of the problem of flooding in the metropolis needs to be undertaken. The proposed follow-up study should, among others, examine the existing policies on flood control including the allocation of financial resources; review the present roles and functions of various government organizations involved in flood control; and recommend appropriate policy and institutional arrangements to mitigate the problem of flooding. The results of the said study could then serve as basis for initiating future executive and legislative actions for providing a long-term solution to the recurrent and worsening floods in Metro Manila.

Chapter 1

Introduction

CHAPTER 1
INTRODUCTION

1.1 Background

Finding appropriate solutions to the recurrent floods in Metro Manila -- the country's economic, political and cultural center with an area of 636 square kilometers -- has occupied the Philippine government's attention since several administrations back. With foresight the national government in 1952 prepared a "Plan for the Drainage of Manila and Suburbs," a master plan formulated by the former Bureau of Public Works (BPW). Drainage system improvement projects have been implemented since then, the greater number of which were concentrated in Manila and Suburbs (the core area of Metro Manila, covering the City of Manila and its adjacent cities and municipalities), in consideration of this area's national importance. The flooding problem, however, has remained. Year by year the metropolis is wrought great damage, with even an increase in inundation spread.

One major cause of the persistence of the flooding problem in Metro Manila has been identified to be the insufficient capacity of the drainage system to drain local inland water. Addressing this requires the availability of reliable data on drainage channels, but available information on the present condition of drainage channels or laterals in the metropolis is very limited. Drainage maps or as-built plans of the drainage system facilities (such as location of channels, sizes, elevation, among others) are not even available. Neither integrated nor complementarily established too are information about drainage facilities installed and maintained by the DPWH (along national roads) and those installed by local government units (along city or municipal roads). Without reliable data, it is extremely difficult, if not impossible, to analyze causes of and evaluate measures against recurrent flooding.

Appreciating the significance of the above problem, the GOP requested the Government of Japan (GOJ) in 1999 for assistance in the conduct of the "Study on the Existing Drainage Laterals in Metro Manila". Based on this request, the GOJ decided to support the study and entrusted the delivery of assistance to Japan International Cooperation Agency (JICA) under the latter's Local Development Study Program. Representatives of both parties signed the Implementing Arrangement (I/A) of the project cooperation in November 1999. The study commenced in February 2000 and was completed in November 2000.

1.2 Objectives and Scope of Work

The study primarily aims to achieve the following:

a) To ascertain the present conditions of existing drainage laterals;

b) To establish a database of drainage laterals that can be used as guide in the operation, maintenance, rehabilitation and/or improvement of these facilities; and

c) To analyze problems in the laterals of the drainage system of Metro Manila.

To achieve the objectives of the study in consonance with the Terms of Reference of the Contract with JICA, the following activities were undertaken:

a) Collection of existing data and information on drainage system and plans related to above Study;

b) Inventory survey of existing drainage laterals;

c) Cross-section and longitudinal survey of drainage laterals;

d) Study of inundation areas;

e) Study of drainage area;

f) Establishment of database; and

g) Identification and analysis of problems in drainage laterals.

1.3 Implementation Arrangements

The Study was undertaken by JICA through a Study Team led by Woodfields Consultants, Inc.(WCI) in joint venture with Basic Technology and Management Corporation (Basicteam) and with CTI Engineering Consultants as project advisor.

The DPWH acted as the lead counterpart agency of the Study Team while the Metro Manila Development Authority (MMDA) served as the co-counterpart agency. To ensure the smooth implementation of the study, both the DPWH and the MMDA took on the task of coordinating with other relevant organizations, including local government units and particularly those covered by the survey activities.

1.4 Study Area

The study area (**Figure 1.1**) embraces Metro Manila. However, the survey/inventory of manholes and establishment of corresponding database are limited to the City of Manila, portions of Malabon, Kalookan City, Quezon City, Makati City , Pasay City, Parañaque City and Taguig (**Figure 1.2**), which taken together comprise an area of approximately 73 square kilometers or 11.5 percent of the total area of Metro Manila. These specific areas also represent the referred-to "Manila and Suburbs" in the 1952 "Plan for Drainage of Manila and Suburbs."

1.5 Organization of the Report

The final report of the study on drainage laterals is divided into two parts. This report constitutes the Main Report and is where the conduct of the study, the results of the survey program carried out, and the analysis of findings and recommendations arising therefrom, are presented. The second part is the Data Book which contains the maps of drainage mains, laterals, manholes, pumping stations, flood gates, drainage divide, benchmarks and flow directions, and other related information.

Chapter 2
Field Survey

CHAPTER 2
FIELD SURVEY

Primary data and information on drainage laterals in Manila and Suburbs were generated through a field survey program consisting of establishment of a benchmark network, manhole survey for drainage mains and laterals, cross-sectional survey for open channels, and inundation survey. All data generated in this field survey program were entered in the database system as will be discussed in *Chapter 3*. The sections below describe the field survey program conducted.

2.1 Benchmark Network

To have a coherent and consistent vertical control of manhole top elevations, cross-section leveling and road profiling, a benchmark network was established in Manila and Suburbs.

A reconnaissance survey was done to select potential benchmarks from existing benchmarks of the National Mapping & Resource Information Authority (NAMRIA). Nineteen (19) benchmarks were selected from the NAMRIA. An additional twenty-four (24) new benchmarks were also established.

A benchmark leveling circuit was conducted and in such manner that the difference of the double run leveling of two neighboring benchmarks does not exceed the allowable ± 5 mm $\times$ $S^{0.50}$, where S is distance in km. Ten (10) leveling circuits were laid over the study area as exhibited in **Figure 2.1**. The corresponding benchmark network for the project is shown in **Figure 2.2**. The datum for the leveling is referred to DPWH datum, which is 10 m below Mean Lower Low Water (MLLW). BM 66 is used as reference benchmark. It has an elevation of 12.310 m above DPWH datum or 1.832 m above Mean Sea Level (MSL), based on observed tide series of 1951-1969 in Manila Bay. **Table 2.1** presents the elevation of 43 benchmarks.

2.2 Manhole Survey for Drainage Mains and Laterals

The drainage channels in Manila and Suburbs consist of open channels and closed channels. Open channels are referred to as "esteros" or "creeks" and have widths of a few meters to 70 meters. Closed channels are classified into primary drainage channels called "drainage mains" or "outfalls" and secondary/tertiary drainage channels called "drainage laterals."

Drainage mains and outfalls are normally box culverts that have widths of from 2.0 to 5.0 meters and depth of about 3.0 meters. Outfalls are special "drainage mains" connected to Manila Bay or Pasig River. Most drainage laterals are made up of pipes, but there are some which are made up of box culverts.

The DPWH maintains the drainage mains/outfalls and drainage laterals installed under national roads. LGUs on the other hand maintain those drainage laterals in city/municipal roads and most of those in private villages. Some private agencies are also involved in maintaining drainage laterals, like the Ayala Property Management

Corporation which handle those laterals in six (6) upscale villages, namely Magallanes, Dasmariñas, Forbes Park, San Lorenzo, Bel-Air and Urdaneta.

Primary data on drainage mains and laterals in Manila and Suburbs were generated, as said before, through a manhole survey. The data obtained were encoded in the database system for drainage laterals. Though parts of Parañaque and Taguig are within the watershed limits of Manila and Suburbs, limited inventory work was undertaken there since their drainage system is less developed at the moment. The procedures used are described as follows.

Based on a joint reconnaissance of the study area by the drainage engineer and surveyor, manholes due for opening and inventory are first identified. The distances between manholes to be surveyed normally are taken between 50 to 100 meters, preferably at road intersections. The manhole surveys afterward proceed by opening the manhole and recording the physical features of the manhole, inlet and outlet channels. To exactly locate the manhole, the address of the nearest house or establishment is noted in the data sheet.

Photo 1 shows a survey team opening a drainage lateral manhole using equipment the study team developed. Larger lifting equipment is used for the larger and heavier manhole covers of drainage mains. Such equipment when needed is provided the Study Team by engineering district offices of the DPWH - NCR

The data gathered from the surveyed manhole are recorded in the data sheet as shown in **Figure 2.3.** Parameters are measured and recorded as per schematic diagram attached in the data sheet. The format of the data sheet is very much similar to the data input form of the manhole database. The location of the manhole is clearly marked on the 1:2,500 scale location maps.

To establish the top elevation of the manhole, a cross mark is painted on top of its cover. The marking is placed on the frame of manhole cover (i.e. near hinge for circular cover and corner for rectangular or square cover). A leveling is run and is tied up with the established benchmark network.

Each drainage channel is then described by the connectivity of the surveyed manhole and prevailing flow directions. Several manholes are opened to check the interconnection with the nearby and neighboring manholes. This is typical at road intersections. In critical areas, additional manholes are opened to verify the interconnection and flow directions in nearby manholes. Where efforts to locate nearby manholes proved nil, residents are interviewed to check the flow direction, drainage inlets or outlets.

Photos of manholes are taken to obtain a visual documentation of their present condition. For easy identification, each manhole is photographed together with its code number or address.

Ten survey teams under the direction of drainage engineers undertook simultaneously the manhole survey from 01 March to 15 July 2000. Their efforts resulted in 7,178 manholes getting surveyed and documented, complete with data sheets for database encoding.

2.3 Cross-sectional Survey for Open Channels

Because open channels play a vital role in the drainage system, for they serve as linkage between the drainage laterals and the Pasig River or Manila Bay, their cross-sectional survey was made as part of the study, which originally was not part of the study plan. Their cross-sectional survey was also embarked on because of the data it can provide for establishing the adequacy of their flow capacity, which is useful in analyzing the flood problems in the study area.

Nineteen open channels (shown in **Figure 2.4**) were selected from among the more important open channels in Manila and Suburbs. This selection considered, too, their having been missed in the survey implemented by the DPWH when the JICA-assisted "Study on Flood Control and Drainage Project in Metro Manila" was conducted in 1990.

A total of 209 cross-sections were made. They were taken at roughly 200-m intervals including bridge/road crossings and accomplished by having a line stretched across the stream from bank to bank, taking soundings at different points along this line and measuring distances of sounding locations from one end to one end. The water depth and bed elevations are determined using sounding pole or lead line. Two (2) teams were assigned to undertake the cross-section survey.

2.4 Inundation Survey

To acquire a full appreciation of the September 1999 flood (the most serious flooding in Metro Manila in recent years) and evaluate the performance of existing drainage systems, a flood survey was conducted in flood-prone areas in Metro Manila. After the target areas were identified, an interview survey of affected residents was undertaken using a questionnaire format that includes such items as depth, duration, flow direction and causes of flooding in the affected area. The questionnaire form is shown in **Figure 2.5**.

One thousand seven hundred fifty-six (1,756) respondents were interviewed. Of these respondents, most were from the low-lying areas of Manila and Suburbs, particularly those residents of the Sampaloc area north of Manila and those living in the San Antonio area south of Manila. Interviews were also conducted in other parts of Metro Manila such as San Juan, Mandaluyong, Parañaque City, Pasay City and the KAMANAVA area. Documents on flood-prone areas in Metro Manila were also secured from engineering district offices of DPWH-NCR, MMDA, and various Metro Manila LGUs.

In consideration of the big flood that occurred in July when this study was being conducted, which flood brought serious damage to KAMANAVA and the San Juan River basin, an inundation survey was also conducted in these areas. The collected data involved the interview of two hundred forty-eight (248) respondents.

Chapter 3
Database System

CHAPTER 3
DATABASE SYSTEM

One major purpose of the "Study on the Existing Drainage Laterals in Metro Manila in the Republic of the Philippines" is to establish a database system for existing drainage laterals which can be interfaced to support the drainage system operation, maintenance, rehabilitation and improvement programs of agencies such as the DPWH, MMDA and the different LGUs in Manila and Suburbs.

At present the available data on drainage mains and laterals at the DPWH, MMDA, Metro Manila LGUs, and the Ayala Property Management Corporation are limited only to the length and cross-section of said facilities, and the names of streets where they are located. These drainage mains and laterals, normally, can be found installed under city and national roads.

As discussed in *Chapter 2*, the necessary data on existing drainage channels and manholes were obtained in this study by opening 7,178 manholes in Manila and Suburbs and recording the field data. The survey data obtained were afterwards entered in the database system developed by the study team and plotted in sufficient detail on digital location maps of the drainage system. In *Chapter 4*, such data sets are used collectively as basis for the delineation of catchment area and estimation of runoff discharge, determination of how drainage channels are interconnected, their elevations, and computation of the flow capacity of drainage channels.

The database system is designed to facilitate the retrieval of necessary information from five primary databases and facilitate as well the entry of data directly from the source document (data sheet) into the computer. The system includes the databases of the existing drainage channels and manholes and the digital location maps of the drainage system.

3.1 Hardware and Software Composition

The study team assigned eight (8) sets of computers for AutoCAD tasks and four (4) sets for database tasks. All these pieces of equipment necessary to the establishment of the database system were provided by the Japan International Cooperation Agency (JICA). The details of the system components are as follows.

3.1.1 Hardware

The database system requires the following hardware:

a) Twelve (12) units of Intel Pentium III – 500 MHz Desktop PC with 64 MB SDRAM, 12 GB hard disk drive and 1.44 Floppy Disk Drive
b) Eight (8) units of 17" Color Monitor for AutoCAD-tasked computers
c) Four (4) units of 14" Color Monitor for Database-tasked computers
d) Two (2) units of HP Desk Jet 1120C Printer (color, A3 size)
e) One (1) unit of HP Design Jet 450C Plotter (color, A1 size)

f) One (1) unit of HP 6300 Series Scanner
g) Three (3) units of APC UPS
h) Two (2) units of Iomega 100MB Zip Drive
i) One (1) unit of D-Link 10Base-T/100Base-TX Dual Speed Hub for Local Area Network

The twelve (12) computers, two (2) Zip Drives, two (2) printers and one (1) plotter are connected via a LAN (Local Area Network) so as to have easy access and sharing of data and information, and enable multi-tasking activities as well as shared printing (**Figure 3.1**).

The plotter is used for printing A-1 size base maps of 1/2,500 scale. The printer can print out 1/2,500 maps (accomplished by first subdividing the base map into A3 size sections) or print out one A3-size base map (accomplished by first reducing the base map to 1/5,000 scale).

The Zip Drive is used for back up and data exchange with computers not connected to the LAN, since the capacity of floppy diskettes cannot accomodate the file size of a typical base map and a database file, which, respectively, amount to 30 MB and 42 MB.

3.1.2 Softwares

The database system requires the following softwares:

a) Twelve (12) sets of Microsoft Windows 98 for all computers
b) One (1) set of AutoCAD 2000 for AutoCAD-tasked computers
c) Seven (7) sets of AutoCAD LT/14 for AutoCAD-tasked computers
d) Four (4) sets of Microsoft Office Professional (includes Access, Excel, etc.) for database-tasked computers
e) Eight (8) sets of Microsoft Office Standard (includes Access, Excel, etc.) for AutoCAD-tasked computers

The database system utilizes AutoCAD 2000 and AutoCAD LT in encoding and plotting manholes, cross-sections, pumping stations, floodgates, drainage divides, benchmarks and flow directions on the digital location maps. It also uses AutoCAD 2000 to process manhole coordinates and distances between manholes for automatic input into the Access databases. Access is applied for data input, data processing for drainage channel profiling and sequencing of manholes, and report generation. Excel is used by the system to generate discharge tables and graph drainage channel profiles.

3.2 Digital Location Maps

To cover the whole study area, digital maps from 1:10,000 scale NAMRIA maps were obtained for Valenzuela (3130-ii-10), Manila North (3130-ii-15), Manila South (3130-ii-20), Baclaran (3130-ii-25), Tandang Sora (3230-iii-6), Kamuning (3230-iii-11), Mandaluyong (3230-iii-16) and Malibay (3230-iii-21). These eight digital base maps were assembled using a consistent coordinate system to form a unified map for the whole study area. The grid coordinate system was set at 121° 00' 00" North and 14° 36' 00" East or 1,614,550.815 North and 500,000 East as referred to PRS-92 PTM. Coordinates of adjacent base maps were adjusted using the Mercator Converter Model. The unified map was first subdivided into 12 location maps and further subdivided to yield forty-eight (48) digital location maps (see Index Map **Figure 3.2**) to encompass the whole study area.

Manholes, cross-sections, pumping stations, floodgates, drainage divides, benchmarks and flow directions are plotted on the digital location maps utilizing AutoCAD LT, as mentioned above. A set of legends used in representing the features of the drainage system is shown in **Figure 3.3**.

On the digital location maps, contour lines of 2.0, 2.5, and 3.0 meters in the low-lying areas are redrawn using the top elevations of surveyed manholes and the spot elevations along roadways. Values of elevation are tied up to the benchmark network. Flood-prone areas are afterwards delineated using the contour lines.

The definition of a drainage channel on the location maps is made by connecting neighboring manholes that have consistent flow direction and topography. That some manholes may be noted to be not connected or were left hanging on the location maps were due to some constraints faced by the study team in establishing flow directions. These constraints may be due to one or a combination of the following:

a) Manhole covers are so tightly shut that their hooks or attachments snap when lifted. There are even cases where lifting hooks are not provided.
b) There are no available manholes upstream or downstream over long stretches of roadway.
c) Manholes are laid with thick asphalt or covered with pavement.
d) Encroachments in esteros make it difficult to access the outfalls.
e) Accessibility to some districts or villages is restricted and requires additional permits other than issued by DPWH and MMDA.
f) There is an on-going drainage improvement project; manhole data, however, are not available.

3.3 Database of Drainage Channels and Manholes

The database is a computer-based system for the storage, retrieval and analysis of drainage channel and manhole data. It aims to provide a systematic and more efficient means of data accumulation and dissemination.

3.3.1 Tables

The database system is composed of five (5) primary databases or tables, namely:

Table Name	Description	Contents
MH_DATA	Manhole properties	Manhole code, location, water level, clogging condition, etc. (See database structure in **Table 3.1**)

INLET	Properties of upstream channels of a manhole	Channel size, shape, invert elevation, etc. (See database structure in **Table 3.2**)
OUTLET	Properties of downstream channels of a manhole	Channel size, shape, invert elevation, etc. (See database structure in **Table 3.3**)
CHANNEL	Manhole sequence of drainage line	Channel code, inlet manhole code, outlet manhole code, etc. (See database structure in **Table 3.4**)
NAMES	Names of drainage lines	Channel code and channel name (See database structure in **Table 3.5**)

3.3.2 LATERAL Database

To enable encoding, retrieval and analysis of data from the five primary databases, the database system has a menu-driven database called LATERAL. After running Microsoft Access® and opening *"Lateral.mdb"* file, the "Main Menu" will be displayed onscreen as shown in **Figure 3.4**. Each command/submenu is explained as follows:

(1) Add/Edit Record

Selecting this button will display the first record (**Figure 3.5**) which format on-screen is like the data sheet used during the field survey. This format is designed to make encoding easy.

This navigation button will move and display the next record.

This navigation button will move and display the previous record.

This button will prompt the user to key-in the manhole code for the manhole record being sought (**Figure 3.6**).

This button will navigate to the last empty record of the database and the user can already add a new record.

All records displayed onscreen are already in Edit Mode. Any alteration and deletion of the data will automatically update the database. Other Microsoft Access® Standard menus and toolbars displayed on top of the screen can also be used to modify and delete the data and the data entry form itself.

(2) Print Single Data Sheet

This will prompt the user to enter a manhole code (**Figure 3.7**) in order to locate and preview a desired manhole record (**Figure 3.8**). Select the toolbar from Microsoft Access® Standard Toolbar or the "File...Print..." menu from Microsoft Access® Standard Menu.

The printout of this report is configured in "A4" paper size in landscape mode. If the printer is set to a different paper size and mode, the user must first configure its page setup by selecting "File...Page Setup...select A4 paper size and landscape options" of Microsoft Access® Standard menus before printing.

(3) Print Summary Table by Map Code

This will prompt the user to enter a map code (**Figure 3.9**) in order to gather, tabulate and display (**Figure 3.10**) in ascending order all manholes included in the map code. Select the toolbar from Microsoft Access® Standard Toolbar or the "File...Print..." menu from Microsoft Access® Standard Menu.

The printout of this report is configured in "A3" paper size in landscape mode. If the printer is set to a different paper size and mode, the user must first configure its page setup by selecting "File...Page Setup...select A3 paper size and landscape options" of Microsoft Access® Standard menus before printing.

(4) Arrange Manhole Sequence

This command/submenu allows the user to obtain channel profile information for further processing under command/submenu (6). When command/submenu (4) is chosen, the input/edit form shown in **Figure 3.11** appears onscreen.

a. Encode channel code and manhole codes in sequence

The user enters first the channel code and then enters in sequence the manhole codes along the channel. If the channel code is correctly entered and has been registered in the Channel Code Table, its channel name appears below the channel code.

The user can sequence the manholes of the channel by entering the manhole codes one by one, starting from the first manhole upstream up to the last manhole of the drainage line. After typing a manhole code, the user clicks the "**Add**" button. When all the manhole codes have been encoded, the user clicks the "**OK**" button, and the system does the following: (1) the channel code and name are encoded in the Channel Names Table (**Table 3.5**); (2) every manhole code is stored in the Manhole Sequence Table (**Table 3.7**) together with the corresponding channel code and inlet manhole code and outlet manhole code; and (3) the "**Main Menu**" (**Figure 3.4**) finally appears.

A sample of the Drainage Channel Names Table is shown in **Table 3.6**. It lists the channel codes and names. **Table 3.7** presents a sample of the Manhole Sequence Table. It contains manhole codes and their corresponding channel codes, inlet and outlet manhole codes. If the same sequence cannot be established in the Drainage Channel Table, Error Manhole Sequence Table (**Table 3.8**) appears onscreen. Blank spaces are displayed for data that have to be corrected. For checking or verification, the user can print out this table by clicking the "**Print**" button.

When an error occurs, the user modifies the channel name and code and clicks "**OK**" button in this command/submenu. The system revises then the sequence of manhole data in the Manhole Sequence Table (**Table 3.7**).

When the user clicks the "**Cancel**" button, the "**Main Menu**" appears onscreen. The input/edit form is disregarded and no change is made to the related tables.

b. Edit Manhole Sequence

If an error is found in the sequence of manholes, the user can enter the correction using this input/edit form. After selecting the channel code, the user enters the manhole code and clicks the "**Delete**" button to remove the wrong manhole code. The user enters the correct manhole code by clicking the "**Add/Edit**" button and then the "**OK**" button to rectify the whole manhole sequence.

(5) <u>Print Summary Table by Channel Code</u>

This will prompt the user to select a channel code (**Figure 3.12**) in order to gather, tabulate and display (**Figure 3.13**) all manholes included in the channel code as arranged in Task no. (4) – 'Arrange Manhole Sequence'. Select the toolbar from Microsoft Access® Standard Toolbar or the "File...Print..." menu from Microsoft Access® Standard Menu.

The printout of this report is configured in "A3" paper size in landscape mode. If the printer is set to a different paper size and mode, the user must first configure its page setup by selecting "File...Page Setup...select A3 paper size and landscape options" of Microsoft Access® Standard menus before printing.

(6) <u>Generate Profile Data</u>

This will prompt the user to select a channel code (**Figure 3.12**) in order to gather, process, tabulate and display (**Figure 3.14**) all manholes included in the channel code as arrange in Task no. (4) – 'Arrange Manhole Sequence'. The profile of drainage channel as shown in **Figure 3.15** can be done by copying these data to Microsoft Excel® file (*Profile.xls*) which is pre-formatted for chart generation.

(7) Generate Percent of Deposition (by Street Name)

This will prompt the user to select a street name (**Figure 3.16**) in order to gather, process, tabulate and display (**Figure 3.17**) all manholes included in the street name.

3.4 Flood Condition Database

A separate database stores the data gathered from the inundation survey. A code number is assigned to each location point. The data and information in the database include: a) address, b) district, c) city, d) flood duration, e) flood depth, and f) causes of flooding, which may be overbanking of waterway or estero, clogged manholes, insufficient flow capacity, and other flooding causes.

Table 3.9 shows the data file structure for both year-1999 and year-2000 flood condition databases. The number of location points with data encoded is 1,756 for the year-1999 flood and 248 for the year-2000 flood.

Inundation maps for the study area that were generated through the inundation survey are discussed in *Chapter 5*.

Chapter 4

Existing Conditions of Drainage Laterals

CHAPTER 4
EXISTING CONDITIONS OF DRAINAGE LATERALS

4.1 Background of the Existing Drainage System

The existing drainage system in Manila and Suburbs (the core area of Metro Manila and includes the City of Manila and its adjacent cities/municipalities) is composed of closed principal channels called "drainage mains" or "outfalls," open channels called "esteros" or "creeks," secondary or tertiary drainage channels called "drainage laterals," and pumping stations. Initial drainage construction works were based on the "Plan for the Drainage of Manila and Suburbs," a master plan prepared in 1952 by the former Bureau of Public Works (BPW). Subsequent system improvements were based on later revisions of the 1952 master plan. One of such revisions was made in 1978 under the "Manila and Suburbs Flood Control Project." Another was made in 1984 under the "Metro Manila Integrated Urban Drainage and Flood Control Master Plan" of the then Ministry of Public Works and Highways, now the Department of Public Works and Highways (DPWH).

The DPWH today is in-charge of the installation and maintenance of drainage facilities located along national roads. The local government units (LGUs), on the other hand, are responsible for the construction and maintenance of drainage facilities located along city or municipal roads. The DPWH has installed 35 drainage mains (or outfalls) along the national roads of Manila and Suburbs, which altogether have a total length of 34 kilometers. There is no consolidated data on drainage facilities constructed by the various LGUs but most of the roads within Manila and Suburbs have drainage laterals installed.

Manila and Suburbs is being serviced by 15 pumping stations for draining the storm water to the Pasig River or Manila Bay. All these stations are operated and maintained by the DPWH and all were designed for draining storm water of a 10-year return period. Of these pumping stations, seven (7) were completed and became operational between 1976 and 1977 through the financial assistance of the Overseas Economic Cooperation Fund (OECF). These seven stations are: Valencia, Quiapo, Pandacan, Aviles-Sampaloc, Paco, Sta. Clara, and Tripa de Gallina.

Procurement of the required equipment for three (3) of the 15 stations, namely, Libertad, Binondo and Makati pumping stations, was individually undertaken starting 1979 through 1985. The Export-Import Bank (EXIM Bank) of Japan financed the equipment procurement. The construction of the five (5) remaining stations, namely Vitas, Balut, Escolta, San Andres, and Balete, was made possible through the financial loan assistance from the OECF-Japan. Construction started in 1994 and was completed in 1998.

To address the increasing accumulation of sediment and garbage in drainage channels, the DPWH carried out "The Project for Retrieval of Flood Prone Areas in Metro Manila." Phase I of the project was implemented in 1990 and Phase II in 1994. For this project, which was also meant to complement the gains made in other flood control projects, the GOP sought and obtained GOJ's help in getting the necessary equipment through GOJ's General Grant Aid Program.

Given this background, the present conditions of drainage laterals in Manila and Suburbs were ascertained through the field survey described in *Chapter 2*. The various data sets generated from the survey were entered in the LATERAL database. Together with the location maps, they collectively form the basis for the analysis of existing conditions of drainage laterals and drainage blocks in Manila and Suburbs, as discussed below.

4.2 Runoff and Flow Capacity of Existing Drainage Channels

4.2.1 Hydrologic and Hydraulic Criteria

Runoff

To determine the adequacy of existing drainage mains and laterals in relation to the blocks being drained, the first requirement is to estimate the storm runoff at the point of interest. Runoff may be estimated using the Rational Formula:

$$Q = \frac{CIA}{360}$$

where, Q = discharge (m^3/s); C = runoff coefficient; A = catchment area (ha); and I = rainfall intensity (mm/hr.). Rainfall is obviously the natural cause of flooding of any locality, whether directly caught as it falls on the area or as overflow from other areas. Rainfall intensity is thus an important parameter. Rainfall intensity values of different return periods are shown in **Figure 4.1**.

A 10-year return period is adopted in the study in conformity with the current practice in the planning and design of drainage systems. The rainfall intensity curve was taken from the JICA Metro Manila Flood Control and Drainage Study (1990), together with those for 5-, 3-, 2-year return periods. When for comparison purposes the 10-year curve from the 1952 BPW Master Plan was superimposed on the other curves, it was found to be equivalent only to the 5-year curve of said JICA Study.

Weighing in present urbanization and land use pattern, the present study thus assumed a runoff coefficient of 0.70. Runoff estimates made in the past used values from 0.50 to 0.65, which under present or future conditions are unlikely.

Flow Capacity

Flow calculations under the present study consider the simple case of steady uniform flow and assume that no overflow from neighboring areas or adjacent catchments is present. These calculations further assume that there is no sediment deposit in the drainage channel.

In evaluating the adequacy of drainage channels vis à vis the blocks to be drained, a non-uniform flow is adopted in the calculation of flow capacity. A pressure flow condition is considered in cases where a submerged outfall is likely to occur.

The following assumptions are adopted:

- Roughness coefficient (open channel) = 0.025
- Roughness coefficient (box culvert) = 0.015
- Hydraulic boundary condition:
  - gravity system = El. 11.30 m for Manila Bay tide
  - pumped system = pumping water level

4.2.2 Runoff and Flow Capacity Estimation

Drainage Channel Profile

The channel profiles are prepared using the LATERAL database and by first sequencing the manhole along the drainage channel. From the lateral database, manhole data are retrieved and tabulated, then transferred to MS Excel to plot the longitudinal profile. An accompanying figure reflects the bed elevation, deposition level, water surface level, channel top elevation and ground elevation. Tabulations of drainage profiles are presented in **Tables 4.1** and **4.2,** for drainage mains and drainage laterals, respectively. Flow direction in these profiles is from right to left.

Runoff and Flow Capacity Tables

Discharges for 2-year and 10-year return periods are calculated at the point of interest (i.e., outlets of open channels, drainage mains, and drainage laterals). Calculation points for drainage mains and esteros of North Manila and South Manila are presented in **Figures 4.2** and **4.3**, respectively. For drainage laterals, the calculation points taken were at the exit of the drainage mains, esteros, Pasig River or Manila Bay and redisplayed in **Figures 4.4** and **4.5,** for North Manila and South Manila, respectively.

The summary tables for the discharge and flow capacity of the drainage laterals are shown in **Tables 4.3** and **4.4,** for North Manila and South Manila, respectively. It can clearly be seen from the tables that most of drainage laterals have flow capacities that are inadequate or inappropriate for a 10-year flood.

Two-year and ten-year flood discharges for the drainage mains and open channels are summarized in **Tables 4.5** and **4.6**. For these flood discharges a non-uniform flow calculation of the water surface profile was performed to establish the adequacy of the drainage mains and open channels. Results of the computation are presented in **Figures 4.6** to **4.22,** which also show the inadequacy of many drainage mains and open channels for 2-year and 10-year floods.

4.3 Drainage Block

The delineation of drainage blocks in this study resembles the delineation of DPWH drainage blocks, which is based on the pumping service area. It should be noted here, however, that drainage areas presented in previous studies were **design drainage areas** delineated from old 1:50,000 – scale topographic maps, not from the relatively newer 1:10,000 - scale maps which came out only in the early nineties. Accurate delineation of these drainage areas, which relatively are almost flat, is difficult to achieve using 1:50,000 – scale topographic maps. In this study, the drainage areas for the pumping stations are delineated from the 1:2,500-scale digital location maps discussed in *Section 3.2*. The delineation made considered not only the topography but also the interconnectivity of drainage lines from the farthest point to the pumping station.

The subdivision of North Manila is shown in **Figure 4.23**. The same drainage block divides used by DPWH is assumed in this study, namely: Mendiola Bridge, Juan Luna and the floodwall between Estero de Sunog Apog and Marala Creek.

The delineation of drainage blocks for the South Manila Watershed is shown in **Figure 4.24**. The drainage block division is also based on the same assumption above but the control sections are located at:

- confluence of Estero de Concordia and Estero de Pandacan
- Pres. Quirino Ave. and Estero de Pandacan
- South Superhighway and Estero de Paco (close low sheet pile weir at confluence of Estero de Paco and Estero de Tripa de Gallina)
- floodway across Calatagan Creek at Ayala Ave. Ext
- recently restored 2-meter weir to divert the flow to Zobel-Orbit Main

The table below shows the major drainage blocks in Manila and Suburbs together with their corresponding drainage areas (DAs).

North Manila				*South Manila*			
DB Code	Drainage Block Name	Design DA (ha)	DA per Study (ha)	DB Code	Drainage Block Name	Design DA (ha)	DA per Study (ha)
N01	Valencia	246	215	S01	Balete	52	34
N02	Aviles-Sampaloc	356	307	S02	Paco	182	94
N03	Quiapo	225	198	S03	Pandacan	180	94
N04	Binondo-Escolta	279	312	S04	San Andres	356	391
N05	Vitas	578	493	S05	Sta. Clara	133	89
N06	Balut	49	45	S06	Makati	151	123
N07	Pasig River (North)		79	S07	Tripa de Gallina	1,769	1,771
N08	Manila Bay (North)		242	S08	Libertad	779	567
N09	Sunog-Apog		977	S09	South Manila Bay		630
				S10	South Pasig		223
				S11	Makati Slope (Zobel-Orbit)		321
	TOTAL		2,868		TOTAL		4,337

As shown by this study, the delineation of drainage blocks for a 10-year flood vanishes because the flow capacities of drainage channels for draining the floodwaters to the pumping stations are inadequate. This inadequacy causes floodwaters to spill over to neighboring drainage blocks, thus resulting to wide-scale flooding of low-lying drainage blocks.

4.4 Topography and Drainage System

Surface runoff generally follows the topography and is first collected by a system of street inlets and tertiary roadside drains. It is then conveyed into the drainage mains and laterals to be disposed of to esteros, and ultimately into the Pasig River or Manila Bay either by gravity or by pumping.

As mentioned above, because of the insufficient flow capacity of drainage channels, surface runoff of 10-year flood likewise flows along roadways following the topography from drainage block to drainage block. The flow continues up to the low-lying drainage blocks where two drainage blocks may share the same estero, thus stressing or putting pressure on the pumping station. The tables below present the characteristics of the pumping stations found at the end of esteros.

Whether the capacities of the pumping stations are inadequate or not -- after taking note of the difference between the drainage area determined in this study and the design drainage area used in previous studies -- would require further detailed study.

Large Pumping Stations

Pump Station	Flood Gates No. of Gates × Width (m) × Height (m)	No. of Pumps × Capacity (m^3/s)	Total Capacity (m^3/s)	Head (m)	Pump Type	Drainage Area (ha)
Binondo	1×6.0×4.65	4×2.9	11.6	2.90	vertical/axial	312
Escolta	2×4.0×5.4	3×0.5	1.5	3.50	submersible	
Quiapo	2×4.0×6.30	4×2.375	9.5	2.50	vertical/axial	198
Aviles	2×4.0×6.0	4×3.5	14.0	3.10	vertical/axial	307
Valencia	2×4.0×6.2	4×2.625	10.5	3.30	vertical/axial	215
Vitas	2×4.0×3.65	5×6.4	32.0	3.20	horizontal/axial	493
Balut	1x2.2x2.10	2×1	2.0	3.60	submersible	45
Paco	1×14.0×6.5	3×2.53	7.5	2.80	vertical/axial	94
Pandacan	1×5.0×5.45	2×2.2	4.4	3.10	vertical/axial	94
San Andres	2×3.0×2.0	4×4.75	19.0	4.30	horizontal/mixed	391
Sta. Clara	1×5.0×5.17	2×3.5	7.0	3.50	vertical/axial	89
Makati	1×5.0×5.1	2×3.5	7.0	3.60	vertical/axial	123
Tripa de Gallina	3×8.0×4.25	8×7	56.0	3.20	horizontal/axial	1771
Libertad	3×10.0×5.0	6×7	42.0	2.80	horizontal/axial	567
Balete	2×4.0×4.9	3×0.3,1×1	1.9	8.60	submersible	34

Small Pumping Stations

Pump Station	Flood Gates No. of Gates × Width (m) × Height (m)	Total Capacity (m^3/s)	Drainage Area (ha)
Malacañang P.S. No. 1		0.72	-
Malacañang P.S. No. 2		0.48	-
Arroceros		0.66	27.43
Luneta Park		1.68	56.09
Central Post Office		0.66	12.45
Jones Bridge Underpass (South)		0.52	2.97
Jones Bridge Underpass (North)		0.26	-
Sta. Bañez	1×10.0×5.5	0.32	18.84

Pasig River bisects the Manila and Suburbs area into a North Manila Watershed and a South Manila Watershed, which, respectively, have nine (9) and eleven (11) drainage blocks.

4.4.1 North Manila Watershed

The North Manila Watershed (**Figure 4.25**) is bounded by the Pasig River on the south and extends to as far as Sangandaan and Grace Park in Kalookan City on the north. It is bound on the east by the San Juan River basin and on the west by the Manila Bay. The watershed has an area of 28.68 sq. km.

Sunog Apog Drainage (N09)

Maligaya and Casili creeks are the principal drainageways collecting the surface runoff from the higher elevations (El. 25 m) of the northernmost part of the study area (i.e., Grace Park and Sangandaan, Kalookan City). The runoff collected then flows into Estero de Maypajo, down to Estero de Sunog Apog and eventually to Manila Bay.

The easternmost portion of the watershed has a high terrain (El. 12 to 14 m) at Sta. Mesa Heights and slopes down to the large flat valley in the Sampaloc area. Four concentrated valleys appear at the foot of Sta. Mesa Heights. As planned, the runoff is collected through the Blumentritt Interceptor (DM01) and is drained to Estero de Maypajo, to Estero de Sunog Apog and finally to Manila Bay.

The following table shows the features of the drainage channels:

Name	Channel Type	Size (m)	No. of cells	Length (m)	Drainage Area (ha)	2-year Flood Q (m^3/sec)	10-year Flood Q (m^3/sec)	Remarks
Blumentritt Interceptor (DM01)	Covered channel	W=2.62 to 1.40 D=2.63 to 1.57	2	2,672	275.88	28.34	39.32	Inadequate
Estero de Maypajo (East)	Open channel	W=16.4 to 7.7 D=2.3 to 1.3		1,245	324.69	31.57	43.88	Inadequate
Estero de Sunog Apog	Open channel	W=72 to 16.2 D=4.3 to 1.3		1,800	951.07	72.28	101.19	Adequate for 0-1.0 km Inadequate for 1.0-1.8 km

Quiapo Drainage (N03)

Estero de Quiapo drains the low-lying Sta. Cruz area (El. 2.2 to 2.5 m). This area includes the portion south of San Lazaro Hippodrome down to San Miguel district. The runoff travels in a generally southward direction. Estero de Sulucan, which formerly traversed the University of Santo Tomas compound, has been replaced by the present drainage laterals, but the primary runoff carrier is the N. Reyes-Severino Main (DM06) which conveys the runoff to Estero de Quiapo.

The principal features of the main drainage channels are shown below:

Name	Channel Type	Size (m)	No. of cells	Length (m)	Drainage Area (ha)	2-year Flood Q (m^3/sec)	10-year Flood Q (m^3/sec)	Remarks
N. Reyes -Severino (DM06)	Covered channel	W=3.2 to 2.65 D=1.77 to 1.60	1	632	99.02	11.54	15.95	Adequate for 0-0.2 km Inadequate for 0.2~0.6 km
Estero de Quiapo	Open channel	W=26 to 12 D=3.5 to 1.9		875	198	-	-	Functions as impounding basin; no computation made

Estero de Quiapo is connected to Estero de San Miguel. The latter winds through the San Miguel district and the eastern half of Quiapo district. The collected water is disposed of to the Pasig River by the Quiapo pumping station. The pumping station services 198 hectares and has a pumping capacity of 9.50 m^3/s.

Aviles-Sampaloc Drainage (N02)

Estero de Sampaloc starts at Margal and receives runoff from as far as Quezon City. It has several short reaches and is interconnected to drainage mains. Josefina-Lepanto Main (DM07) conveys runoff from the eastern boundary to Estero de Sampaloc and turns westward to Lepanto-Gov. Forbes Main (DM30). The key features of the drainage channels are listed below:

Name	Channel Type	Size (m)	No. of cells	Length (m)	Drainage Area (ha)	2-year Flood Q (m^3/sec)	10-year Flood Q (m^3/sec)	Remarks
Josefina-Lepanto Main (DM07)	Covered channel	W_1=3.4 D_1=2.25	3	882	129.23	15.37	21.23	Adequate
	Covered channel	W_2=2.1 to 2.0 D_2=2.24 to 2.0	2					
	Covered channel	W_3=4.3 to 4.1 D_3=4.3 to 4.1	1					
Lepanto-Gov. Forbes Main (DM30)	Covered channel	W=4.0 to 3.4 D=3.15 to 1.75	3	1,144	253.38	25.40	35.26	Inadequate
Estero de Sampaloc	Open channel	W=16.1 to 9.0 D=3.0 to 1.8		615	307	-	-	Functions as impounding basin; no computation made

Estero de Sampaloc is also connected to Estero de San Miguel and Estero de Aviles. It is assumed that the divide between Estero de Quiapo and Estero de Sampaloc lies close to the Mendiola Bridge. The runoff from the 307-hectare catchment area is disposed of to the Pasig River by the Aviles-Sampaloc pumping station, which has a capacity of 14.0 m^3/s.

Valencia Drainage (N01)

Estero de Valencia serves the southeasternmost portion of the basin, which ridge elevation ranges from El. 9 to 12 m. It collects runoff from the southeastern slopes of Balic-Balic and the lowland slope of the Santol District of Quezon City through the Visayan Avenue Main. The collected water is conveyed to the Estero de Valencia by pumping. The capacity of the Valencia pumping station is 10.5 m^3/s and drains an area of 215 hectares. The features of the main drainage channels are summarized hereunder:

Name	Channel Type	Size (m)	No. of cells	Length (m)	Drainage Area (ha)	2-year Flood Q (m^3/sec)	10-year Flood Q (m^3/sec)	Remarks
Visayan Ave. Main (DM10)	Covered channel	W_1=2.9 D_1=1.60	1	668	105.13	14.73	20.25	Adequate for 0~0.4 km Inadequate for 0.4~0.67 km
	Covered channel	W_2=2.0 to 1.7 D_2=2.0 to 1.7	2					

Vitas Drainage (N05)

The eastern midsection of the watershed is drained westward to Estero de Sunog Apog. Storm runoff of the central and lower western half of the watershed flows to Estero de Vitas, Estero dela Reina, Estero de San Lazaro, and partly to Estero de Magdalena. Most of the storm water from this catchment is drained by Estero de Vitas and disposed of to Manila Bay by pump. The pumping station at Vitas has a capacity of 32 m^3/s and services 493 hectares.

The features of the main drainage channels are summarized hereunder:

Name	Channel Type	Size (m)	No. of cells	Length (m)	Drainage Area (ha)	2-year Flood Q (m^3/sec)	10-year Flood Q (m^3/sec)	Remarks
South Antipolo Main (DM28)	Covered channel	W_1=4.5 to 2.0 D_1=3.0 to 1.85	1	1,326	98.28	11.86	16.38	Adequate for 0~0.3 km Inadequate for 0.3~1.33 km
Solis-Tecson (DM02)	Covered channel	W_1=2.0 to 1.5 D_1=1.53 to 1.0	2	1,355	92.38	12.31	16.95	Inadequate
Tayuman (DM29)	Covered channel	W_1=2.81 to1.85 D_1=2.73 to 1.89	1	1,402	96.99	13.38	18.40	Inadequate
North Antipolo Creek	Open channel	W_1=4.2 to 3.0 D_1=1.3 to 0.8		650	33.64	13.1	18.2	Inadequate
South Antipolo Creek	Open channel	W_1=9.0 to 3.2 D_1=2.1 to 0.7		1,465	33.53	12.4	17.2	Inadequate

Binondo-Escolta Drainage (N04)

Runoff from Sta. Cruz is carried westward through Fugoso main (DM05) to Estero de San Lazaro. The runoff flows southward to Estero de Binondo and Estero de la Reina and finally is pumped out at the Binondo pumping station. This pumping station drains 312 hectares and has a capacity of 11.6 m^3/s. The hydraulic properties of the Fugoso main are tabulated below:

Name	Channel Type	Size (m)	No. of cells	Length (m)	Drainage Area (ha)	2-year Flood Q (m^3/sec)	10-year Flood Q (m^3/sec)	Remarks
Fugoso Main (DM05)	Covered channel	W_1=3.0 to 2.8 D_1=3.0 to 2.8	1	552	76.29	12.33	16.87	Adequate
	Covered channel	W_2=2.2 to 2.0 D_2=2.2 to 2.0	2					

Pumping stations at Vitas, Binondo and Escolta are operated as though they have a common drainage area. It is observed, however, that Juan Luna Bridge serves as a dividing line between the Vitas pumping station catchment area and the Binondo-Escolta pumping station catchment area.

North Manila Bay Drainage (N08)

The floodwaters from areas fronting the Manila Bay, particularly Tondo, is discharged directly to Manila Bay by gravity. The drainage main serving this catchment has the following properties:

Name	Channel Type	Size (m)	No. of cells	Length (m)	Drainage Area (ha)	2-year Flood Q (m^3/sec)	10-year Flood Q (m^3/sec)	Remarks
Lakandula Main (DM04)	Covered channel	W_1=3.0 to 2.8 D_1=3.0 to 2.8	1	552	31.81	4.56	6.26	Adequate

4.4.2 South Manila Watershed

The South Manila Watershed (**Figure 4.26**) is bounded on the north by the Pasig River, on the west by Manila Bay, on the east by a ridge line running along Bel-Air, Forbes Park and Fort Bonifacio down to the Libingan ng mga Bayani, and on the southwest by the NAIA. It has an area of 43.37 sq. km.

Estero de Tripa de Gallina, which ultimately discharges to the Parañaque River, is the principal drainageway of the South Manila Watershed. The 6.20-km estero is linked in the north to Estero de Paco and Estero de Pandacan.

Tripa de Gallina Drainage (S07)

Two principal tributaries of the Estero de Tripa de Gallina drain the eastern block of the watershed, namely, the Maricaban Creek and Calatagan Creek. These natural waterways are supplemented by the Makati Diversion Channel located north of the railroad tracks, the PNR open canal, and the other drainage mains located south of the railroad tracks which drain directly to the Estero de Tripa de Gallina. These are the Estrada Main (DM20), Zobel-Roxas Main (DM23) and Faraday Main (DM22).

The Maricaban Creek watershed is relatively large but is less developed except for the on-going land development at Fort Bonifacio. It starts from a high elevation (El. 30 m) and joins the Estero de Tripa de Gallina at about El.2.0m.

The Calatagan Creek watershed is more developed, catering to the heavily built-up Makati City business district as well as other higher and middle class residential areas.

Surface runoff from the private villages of Forbes (El. 24 m), Urdaneta (El 10 to 12 m), and Makati City business district (El. 8 to 10 m) is collected by the upper Calatagan Creek and is diverted by a low concrete weir to Zobel-Orbit Main (DM21). Further downstream, the flow is again diverted to Makati diversion channel by a concrete floodwall at Ayala Avenue Extension. Accumulated flow from the villages of Legaspi, San Lorenzo and Dasmariñas and the abovementioned areas combines at Pasong Tamo (lower reaches of Makati diversion channel). The flow is then conveyed to Estero de Tripa de Gallina at San Roque District of Pasay City.

An open canal runs parallel to the railroad track of the Philippine National Railways (PNR) and discharges half of the northern flow toward San Andres and the other half to Calatagan Creek.

Data on these drainage mains and waterways are as follows:

Name	Channel Type	Size (m)	No. of cells	Length (m)	Drainage Area (ha)	2-year Flood Q (m^3/sec)	10-year Flood Q (m^3/sec)	Remarks
Estrada Main (DM20)	Covered channel	W_1=2.50 to 2.85 D_1=1.20 to 1.65	1	418	23.98	4.16	5.68	Inadequate for 0~0.2 km Inadequate for 10-year flood 0.2~0.418 km
Zobel-Roxas Main (DM23)	Covered channel	W_1=4.40 to 2.84 D_1=2.60 to 2.10	1	1,157	96.82	13.8	18.98	Adequate for 2-year flood
	Covered channel	Diameter=1.22	1					Adequate for 10-year flood 0~0.52 km Inadequate for 10-year flood 0.52~1.157 km

Faraday Main (DM22)	Covered channel	W_1=2.15 to 0.94 D_1=1.36 to 0.85	1	832	22.78	3.85	5.27	Adequate for 2-year flood 0~0.70 km Inadequate for 2-year flood 0.70~0.832 km
	Covered channel	Dia=0.60 ϕ	2					Adequate for 10-year flood 0~0.540 km Inadequate for 10-year flood 0.540~0.832 km
PNR Canal	Open channel	W_1=3.0 to 4.0 D_1=0,75 to 2.0		3,245	45.29	6.62	9.09	Inadequate
Calatagan Creek	Natural channel	W_1=8.0 to 3.0 D_1=2.0 to 0.8		4,320	47.72	7.95	10.87	Inadequate
Maricaban Creek	Natural channel	W_1=5.0 to 26.0 D_1=1.8 to 2.60		3,790	1032.25	80.08	112.04	Adequate for 0~0.20 km Inadequate for 0.20~1.92 km

The Tripa de Gallina pumping station drains an area of 1,771 hectares with a pumping capacity of 56 m^3/s.

South Manila Bay Drainage (S09)

Areas west of Estero de Tripa de Gallina front the Manila Bay from South Harbor to Intramuros, Malate, and down to Ermita. They are drained by gravity.and disposed of directly to Manila Bay through Padre Faura (DM11), Remedios (DM12), and Vito Cruz (DM14).

These mains are supplemented by laterals that drain areas in the vicinity of Bonifacio Drive particularly Luneta, Intramuros and South Harbor directly either to Manila Bay or the Pasig River.

Data on these drainage mains and waterways are as follows:

Name	Channel Type	Size (m)	No. of cells	Length (m)	Drainage Area (ha)	2-year Flood Q (m^3/sec)	10-year Flood Q (m^3/sec)	Remarks
Padre Faura (DM11)	Covered channel	W_1=4.0 to 2.84 D_1=2.5 to 2.10	1	1,085	76.58	10.50	14.45	Adequate for 10-year flood 0~0.43 km Inadequate for 10-year flood 0.43~1.085 km
Remedios Main (DM12)	Covered channel	W_1=1.3 D_1=0.9	2	860	88.54	13.29	18.23	Adequate for 0~0.65 km Inadequate for 0.65~0.86 km
Vito Cruz Main (DM14)	Covered channel	W_1=2.0 to 1.52 D_1=1.63 to 1.3	1	752	91.85	11.69	16.11	Inadequate

Libertad PS Drainage (S08)

The Libertad pumping station drains the southern half of the area from north of Buendia to north of C. Rivera. In addition, the Libertad outfall and Buendia outfall are also connected to Estero de Tripa de Gallina. The pumping station services an area of 567 hectares and has a pumping capacity of 42 m^3/s.

Data on these drainage mains and waterways are as follows:

Name	Channel Type	Size (m)	No. of cells	Length (m)	Drainage Area (ha)	2-year Flood Q (m^3/sec)	10-year Flood Q (m^3/sec)	Remarks
Buendia Outfall (DM15)	Covered channel	W_1=3.8 to 3.5 D_1=3.9 to 2.5	1	2,075	109.60	12.54	17.34	Adequate
Libertad Outfall (DM16)	Covered channel	W_1=4.8 to 3.0 D_1=3.3 to 2.4	1	1,760	99.36	13.89	19.09	Adequate for 10-year flood 0~1.20 km Inadequate for 10-year flood 1.20~1.76 km
EDSA Outfall (DM17)	Covered channel	W_1=4.95 to 4.2 D_1=3.1 to 2.43	2	885	106.74	17.46	23.88	Adequate

Other Areas

Estero de Paco and Estero de Pandacan run through the districts of Paco and Pandacan (low-lying areas, El. 2 to 2.5 m). Paco pumping station (S02) serves an area of 94 hectares with a pumping capacity of 7.5 m^3/s. The Pandacan pumping station (S03) on the other hand serves an area of 94 hectares and has a pumping capacity of 4.4 m^3/s. Estero de Concordia links the two esteros near the outlets.

Storm water from the northern section (San Andres) drains to the PNR open canal (north) and is conveyed northwards to the San Andres pumping station. San Andres pumping station (S04) serves an area of 391 hectares and has a pumping capacity of 19 m^3/s.

Estero de Balete (S01) (DA=34 hectares) and Estero de Sta. Clara (S05) (DA=89 hectares) independently drain their own basins. Estero de Balete (El. 2 to 2.5 m) covers the Ayala Blvd.-Taft Ave. area down to a portion of Paco Park. Estero de Sta. Clara (El. 2.5 to 3 m) covers the large portion of Sta. Ana District and Metropolitan Subdivision. Pumping facilities of both esteros discharge floodwaters directly to Pasig River.

The drainage basin east of Estero de Sta. Clara discharges its storm runoff to the Makati pumping station (S06) which has a capacity of 7.0 m^3/s and serves an area of 123 hectares.

Estero de Provisor and Estero Tanque drains Paco Park by gravity and directly to Pasig River.

Chapter 5

Flooding Conditions

CHAPTER 5
FLOODING CONDITIONS

Metro Manila extends over the low-lying areas along Manila Bay. These low-lying areas are easily inundated mainly because high tides make it hard to drain the surface runoff. Among the flood-prone areas in Metro Manila are the Manila and Suburbs, Mandaluyong City, San Juan town and the KAMANAVA (Kalookan, Malabon, Navotas and Valenzuela) area.

To evaluate the performance of existing drainage systems, an inundation survey was conducted in the abovementioned areas with respect to the September 1999 flood. This flood, which is one of the most serious to hit Metro Manila in recent years, came with a flood-producing rainfall that has a 10-year return period (according to PAGASA), which for purposes of said evaluation is deemed adequate. The survey was also conducted for the flood of July 2000 since it was more severe than the September 1999 flood, particularly in regard to its impact on the KAMANAVA area. For areas which were not covered by the survey, data and information on the flood-prone areas were collected from the DPWH engineering district offices.

5.1 Rainfall Conditions during the September 1999 Flood

In the early morning of 10 September 1999, an active low-pressure area (LPA) was monitored east of Northern Luzon (16.5°N and 124.0°E). When this active LPA was about 200 km east of Baler town, Aurora at 2 PM of the said date, it developed into a tropical depression (TD) with maximum sustained winds of 55 km/hr. During this period, light rains fell over Metro Manila, becoming intense at around 3 PM. The convective cloud band over Metro Manila developed between 2-8 PM of the same date and brought a very high amount of rainfall over Metro Manila.

The table below shows the recorded daily rainfall at Boso-boso, Mt. Oro, Science Garden and Port Area. No records were available for NAIA.

(Unit: mm)

Date	Boso-boso	Mt. Oro	Science Garden	Port Area
9/10/99	9.0	65.0	205.1	84.0
9/11/99	37.0	151.0	76.6	133.0

The succeeding table shows for the September 1999 flood the maximum rainfall for various durations and its corresponding probability. As shown, intense rainfall of short duration came with the September 1999 flood in Metro Manila. The three-hour rainfall at the Science Garden was observed to have a 10-year return period.

Rainfall Duration	Boso-boso	Mt. Oro	Science Garden
Max 1-hour RR	6.0 mm 1500H 9/11	35.0 mm 1900H 9/10	
Max 3-hour RR	15.0 mm 1300H - 1600H 9/11	68.0 mm 1500H- 1800H 9/11	164.4 mm 1400H- 1700H 9/10 10 Years
Max 6-hour RR	26.0 mm 1200H -1800H 9/11	108.0 mm 1200H- 1800H 9/11	192.0 mm 1400H- 2000H 9/10 8 Years
Max 12-hour RR	33.0 mm 0600H- 1800H 9/11	150.0 mm 1000H -2200H 9/11	205.1 mm 1400H 9/10 - 0200H 9/11 < 2 Years
Max Daily RR	37.0 mm 9/11	151.0 mm 9/11	205.1 mm 9/10 3.5 Years

RR: - recorded rainfall

Note: Port Area data was not obtained.

The tidal level fluctuations for the September 1999 and July 2000 floods are shown in **Figure 5.1.**

5.2 Flood-Prone Areas and Flooding Conditions

5.2.1 Manila And Suburbs

Figures 5.2 and 5.3 show the flooding conditions in North Manila and South Manila, respectively, during the September 1999 flood. Except for little portions along Estero de Vitas and Estero de Sunog Apog in the north, and Intramuros and west Sta. Ana in the south, most of the low-lying areas were severely inundated.

The most seriously affected areas were eastern portions of North Manila (east of A. Mendoza), from the Sta. Mesa Heights to Sampaloc and Quiapo. Even in the hilly Sta. Mesa Heights, flooding occurred along steeply sloped streets such as Calamba and Simon. At the corners of Blumentritt and Halcon, flooding continued for 12 hours, with maximum inundation depth of 0.2 m at Blumentritt and 0.4 m at Halcon.

In the Sampaloc - Quiapo area, flooding depth exceeded 0.5 m in many places along streets from Simon to G. Tuason. The deepest was along España, near P. Paredes. In some places, it reached 1.3 m (P. Campa, P. Noval, M. F. Jocson, F. Cayco, etc.). Along España, the flood duration was 28.1 hours. In other places of the Sampaloc - Quiapo area, the average duration was 22.3 hours.

Inundation of areas west of A. Mendoza, on the other hand, and except for some portions, was not as serious (inundation depth was less than 0.3 m). The most seriously affected areas were northern Sta. Cruz, areas to the west of San Lazaro Hippodrome and north of Tayuman Street. In these areas (at 11 location points), maximum inundation depth was equal to or more than 0.5 m, with floodwaters remaining for 21 hours.

In South Manila, the seriously affected areas were San Andres Bukid, San Antonio Village, Metropolitan Subdivision, Palanan, San Isidro and Bangkal. In San Andres Bukid, the most seriously flooded areas were those near the PNR open canal and Zobel-Roxas Avenue. Flood depth reached almost 1.0 m on the streets of Coral, Amatista and Agatha. Average duration was 3.6 hours in places where the maximum inundation depth was 0.5 m and higher.

In San Antonio Village and Metropolitan Subdivision, flooding exceeded 0.5 m in many places, as shown in **Figure 5.3**. Average duration was 4.3 hours for San Antonio Village and 3.1 hours for Metropolitan Subdivision. Palanan and San Isidro, which are located between the PNR open canal and Estero de Tripa de Gallina, were also seriously affected. Average flood duration was 3.0 hours for Palanan and 4.8 hours for San Isidro, with flooding depth not less than 0.5 m. In Bangkal, the most flooded portion was P. Binay (Hen. Ricarte) street along the Estero de Tripa de Gallina. Flooding duration was 2.5 hours for areas where maximum flooding depth was greater than 0.5 m.

5.2.2 Pasay, Mandaluyong and San Juan River

A survey of flooding condition was conducted for areas along Cutcut River in Pasay City, San Francisco drainage channel in Mandaluyong City, and San Juan River. Inundation depth for the areas along Cutcut River is shown in **Figure 5.3**; those for the San Francisco drainage channel and San Juan River are shown in **Figure 5.4**.

For areas along the Cutcut River (five locations), maximum inundation depth was equal to or exceeded 0.5 m. Areas along the San Francisco open canal are also flood-prone. In these latter areas, inundation depths exceeding 0.5 m and 1.0 m were observed in twelve locations and four locations, respectively.. In the 12 locations, duration of flooding was 7.9 hours.

Flooding in areas along the San Juan River and its tributaries exceeded 1.0 m in 28 places, with maximum depth reaching 2.5 m to 3.0 m at A. Juan cor. Tabing Ilog, Don Jose cor. Maria Clara, and Waling-Waling. Flooding duration was about 5 hours.

5.2.3 KAMANAVA

Figures 5.5 and **5.6** indicate inundation depth in the KAMANAVA area during the September 1999 and July 2000 floods, respectively. As shown in **Figure 5.1**, tide level during the July 2000 flood was some 0.5 m higher than that registered during the September 1999 flood, with the former also recording a greater inundation depth.

With respect to inundation spread in the KAMANAVA area, the September 1999 flood left several places relatively free of floodwaters, or where there were floodwaters, inundation depth was less than 30 centimeters. The July 2000 flood, in contrast, inundated most of KAMANAVA, with inundation depth of 1.8 m observed in Dagat Dagatan (Kalookan City), 2.5 m in Paulo Mal 83 (Malabon), 1.6 m in San Andres cor. M. Naval (Navotas), and 2.5 m in Karuhatan and Coloong (Valenzuela). In places where depth was more than 0.5 m, average flooding duration ranged from 74.0 hours (in Kalookan) to 218.9 hours (in Valenzuela). In Navotas and Malabon, average flooding duration was 77.6 hours and 181.5 hours, respectively. Three weeks after the flood had first hit the KAMANAVA area, several places still remain submerged.

5.2.4 Other Areas in Metro Manila

Data and information on flood-prone areas were collected from the DPWH District Engineering Offices in the NCR. These are shown in **Figure 5.7** for Pasig–Marikina, in **Figure 5.8** for the 1st Congressional District of Quezon City, in **Figure 5.9** for the 2nd Congressional District of Quezon City, and in **Figure 5.10** for Muntinlupa.