REPUBLIC OF THE PHILIPPINES

METROPOLITAN WATERWORKS AND SEWERAGE SYSTEM

THE FEASIBILITY STUDY

ON

THE BALARA WATER TREATMENT PLANT REHABILITATION PROJECT

VOLUME II

MAIN REPORT

MARCH 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct THE FEASIBILITY STUDY ON THE BALARA WATER TREATMENT PLANT REHABILITATION PROJECT and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a study team headed by Mr. Satoshi Kachi, Nippon Jogesuido Sekkei Co., Ltd, 2 times between August 1991 and February 1992.

The team held discussions with the officials concerned of the Government of the Philippine, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

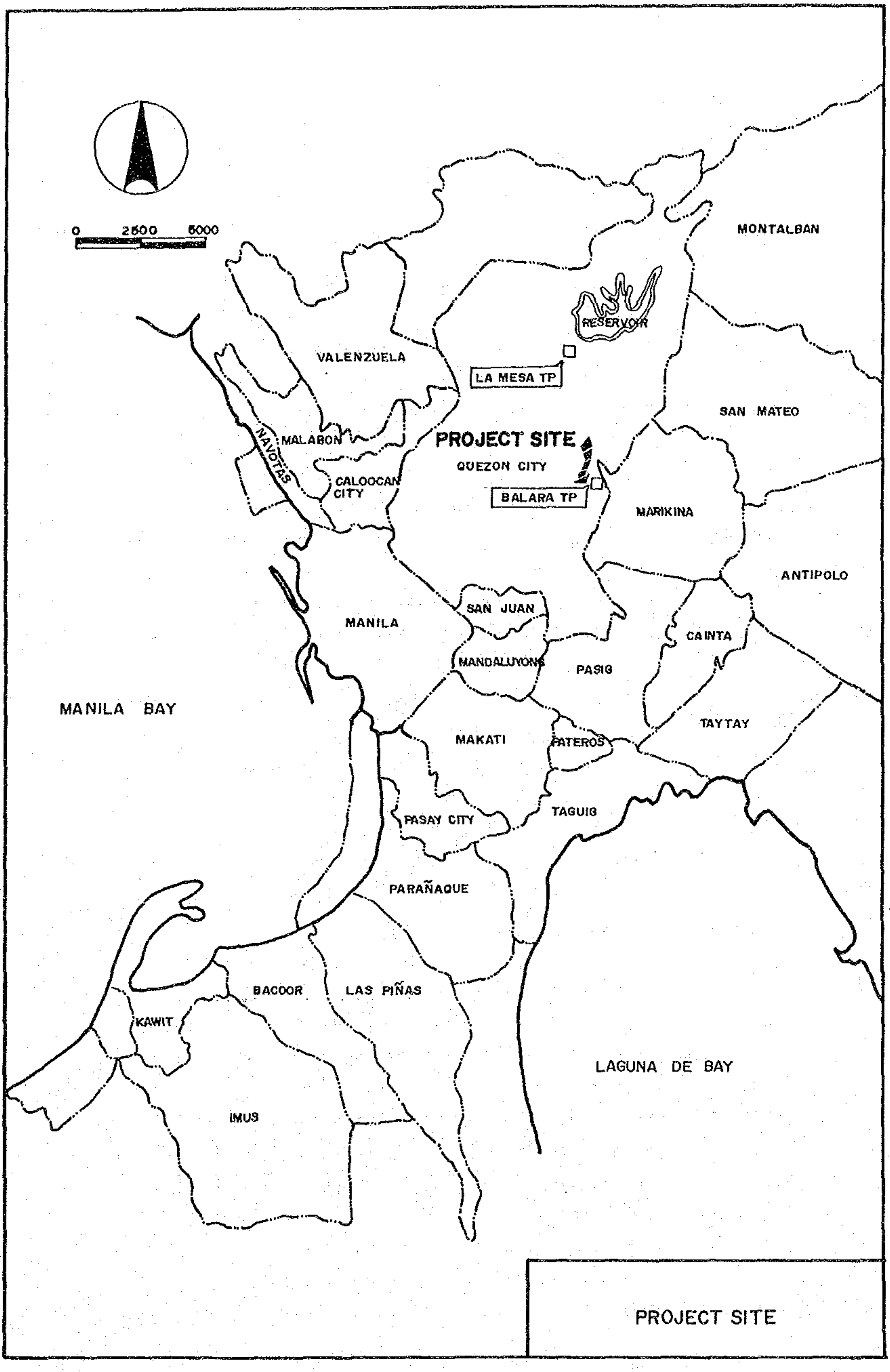
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Philippines for their close cooperation extended to the team.

March, 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency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CALOOCAN CITY
BALARA TP
MARIKINA
ANTIPOLO
SAN JUAN
MANILA
CAINTA
MANDALUYONG
PASIG
MANILA BAY
TAYTAY
MAKATI
PATEROS
TAGUIG
PASAY CITY
PARAÑAQUE
BACOOR
LAS PIÑAS
KAWIT
LAGUNA DE BAY
IMUS
PROJECT SITE

LIST OF ABBREVIATIONS

The following abbreviations have been adopted in this report.

Philippine Government Organizations:

DBP	Development Bank of the Philippines
DTI	Department of Trade and Industry
DPWH	Department of Public Works and Highways
EMB	Environmental Management Bureau
HLURB	Housing and Land Use Regulatory Board
MGB	Mines and Geoscience Bureau
MMA	Metropolitan Manila Authority
MWSS	Metropolitan Waterworks and Sewerage System
NAMRIA	National Mapping and Resource Information Authority
NEDA	National Economic and Development Authority
NEPC	National Environmental Protection Council
NHRC	National Hydraulic Research Center
NPC	National Power Corporation
NSO	National Statistics Office
NSCB	National Statistical Coordination Board
NWRB	National Water Resource Board
PIA	Philippine Information Agency
PHO	Public Health Office

Other Organizations:

ADB	Asian Development Bank
AWSOP	Angat Water Supply Optimization Project
FAWSP	Fringe Areas Water Supply Project
GWD-MWSP II	Groundwater Development-Manila Water Supply Project II
IBRD	International Bank for Reconstruction and Development
ICC	Investment Coordination Committee
JICA	Japan International Cooperation Agency
MMWDP	Metro Manila Water Distribution Project

MWSP II	Manila Water Supply Project II
MWSP III	Manila Water Supply Project III
MWSRP I	Manila Water Supply Rehabilitation Project I
MWSRP II	Manila Water Supply Rehabilitation Project II
OECF	Overseas Economic Cooperation Fund

<u>Technical Term:</u>

AC - Asphaltic Concrete
BCR - Benefit/Cost Ratio
BOD, BOD5 - Biochemical Oxygen Demand (5 days)
CDS - Central Distribution System
CI - Cast iron, grey
CIF - Cost, Insurance and Freight
Cl - Chloride Ion
COD - Chemical Oxygen Demand
DF/R - Draft Final Report
DO - Dissolved Oxygen
ECC - Environmental Compliance Certificate
EIRR - Economic Internal Rate of Return
EIS - Environmental Impact Statement
FIRR - Financial Internal Rate of Return
F/R - Final Report
F/S - Feasibility Study
FY - Fiscal Year
GNP - Gross National Product
GRDP - Gross Regional Domestic Product
GPP - Gross Provincial Product
IA - Implementing Arrangement
IC/R - Inception Report
IT/R - Interim Report
IRR - Internal Rate of Return
M/P - Master Plan
MPN - Most Probable Number
MSA - MWSS Service Area
MSL - Mean Sea Level
NCR - National Capital Region
NPV - Net Present Value

O & M	-	Operation and Maintenance
p.a.	-	Per Annum
pH	-	pH Value
PVC	-	Polyvinyl Chloride
SDR	-	Social Discount Rate
TOR	-	Terms of Reference
WACC	-	Weight Average Capital Cost

Units of Measurements:

°C	- degree Celsius	-	Temperature Unit
cm	- centimeter	-	Length Unit
d	- day	-	Time Unit
g	- gram	-	Weight or Mass Unit
ha	- hectare	-	Area Unit
h	- hour	-	Time Unit
HP	- horsepower	-	Power Unit
Hz	- hertz (cycle per second)	-	Frequency Unit
kg	- kilogram	-	Weight Unit
km	- kilometer	-	Length Unit
km^2	- square kilometer	-	Unit Measurement of Area
kV	- kilovolt	-	Electrical Potential Unit
kW	- kilowatt	-	Power Unit
kWh	- kilowatt-hour	-	Energy Unit
l	- liter	-	Volume Unit
m	- meter	-	Length Unit
mm	- millimeter	-	Length Unit
m/sec	- meter per second	-	Velocity Unit
m^2	- square meter	-	Area Unit
m^3	- cubic meter	-	Volume Unit
m^3/s	- cubic meter per second	-	Flow Rate
m^3/d	- cubic meter per day	-	Flow Rate
MGD	- million gallon per day	-	Flow Rate
Ml/d	- million liter per day	-	Flow Rate
m^3/min	- cubic meter per minute	-	Flow Rate

$m^3/m^2/d$	-	cubic meter per square meter per day	-	Surface Loading
$m^3/m/d$	-	cubic meter per meter per day	-	Overflow Rate
mg	-	milligram	-	Weight or Mass Unit
mg/l	-	milligram per liter	-	Density Unit
rpm	-	revolution per minute	-	Angular Velocity
s	-	second	-	Time Unit
yr	-	year	-	Time Unit

Currency Conversion:

1 Peso	=	5.14 Yen
1 U.S. Dollar	=	139 Yen
1 U.S. Dollar	=	27.00 Peso
1 Yen	=	0.195 Peso

COMPILATION OF THE REPORT

The study report for the Feasibility Study on the Balara Water Treatment Plant Rehabilitation Project is composed of the following four volumes.

Volume I	SUMMARY
Volume II	MAIN REPORT
Volume III	SUPPORTING REPORT
Volume IV	DRAWINGS

This report (Volume II) represents a main report setting forth the proceedings and results of the study.

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CHAPTER 1 EXECUTIVE SUMMARY

(1) Background

The present water supply system for Metro Manila is dependent mainly on surface water with groundwater as supplement. However, due to the rapid increase in the population of Metro Manila, the present water supply is insufficient in meeting the expected demand for water.

In order to solve the shortage of water supply, several projects have been undertaken by MWSS. While these projects are already in progress, the Balara Water Treatment Plant needs immediate rehabilitation. The Balara Plant consists of Plant No. 1 and Plant No. 2 which were constructed in 1935 and 1958, respectively. While both were modified in 1981, no thorough rehabilitation of any kind was implemented since then. The Plant presently performs a vital role in the water supply system since it accounts for about 60% of the total water production for Metro Manila. However, the facilities and equipment of the Plant are superannuated and difficulties have been encountered in trying to operate the plant efficiently.

Therefore, it is imperative that the rehabilitation of the Balara Plant be implemented immediately in order to restore the designed capacity of the Plant and continue providing the much needed adequate and safe water supply to Metro Manila residents.

(2) Study Area

The Study area is the Balara Plant premises (Fig. 2.2.1). In addition, in order to study the water quality management focusing on residual chlorine, water sampling near the distribution trunk main were taken in the Balara Plant service area.

(3) Objective

The objective of the Study is to formulate the rehabilitation plan for the existing Balara Plant taking into consideration the operation and maintenance aspects.

(4) Scope of Work

Main scope is planning for the rehabilitation work to recover current capacity or suitable capacity of the existing treatment process and equipment. The Study will not include any rehabilitation of aqueducts, distribution pipeline and distribution reservoirs, nor alterations on the building structure. However, some exceptions may include alterations related to the placement of equipment or to some changes in the treatment process.

(5) Plant Capacity

The existing Balara Plant is mainly composed of two Plants. Their respective capacity are summarized in Table 7.3.1. The combined total design capacity of the Plants is 1,6000,000 m^3/d.

TABLE 7.3.1 DESIGN CAPACITY AND RAW WATER SUPPLY

PLANT	SUB-SYSTEM FOR PRE-TREATMENT	DESIGN CAPACITY(m^3/d)	POTENTIAL RAW WATER AMOUNT (m^3/d)
No. 1	Sedimentation basin No.1	140,000	Aqueduct # 1
	Sedimentation basin No.2	140,000	Aqueduct # 1
	Accelators (2 tanks)	190,000	Aqueduct # 2
	Sub-Total	470,000	565,000
No. 2	Sedimentation basin (4 lines)	1,130,000	Aqueduct # 3 1,140,000
Combined	Total	1,600,000	1,705,000

While available raw water is conveyed from the La Mesa Dam by three aqueducts with a combined capacity of 1,705,000 m^3/d. Extra available raw water amount against the existing design capacity is calculated to be only 105,000 m^3/d. Expandability for production capacity of the Balara Plant is limited to and depends upon the capacity of raw water conveyance facilities.

On the other hand, another limitation is the hydraulic condition of the distribution main to the San Juan Reservoir and it is reported that high water level in the Reservoir is controlled between E.L. 48.5 m and E.L. 47.0 m. The upper limit is to reduce pressure thereby preventing leakage in the system and the lower limit is to ensure suction for the pumps on the San Juan Pumping Station.

(6) Design Condition

Design criteria for major treatment facilities used in the modification project in 1981 are shown in Table 7.3.3 and 7.3.4 with the actual operation conditions and their reference values.

TABLE 7.3.3 DESIGN CRITERIA OF PLANT NO. 1

ITEM NO.	DESCRIPTION	UNIT	DESIGN VALUE	ACTUAL OPERATION	REFERENCE VALUE
1	Rapid mixing				
	Velocity gradient	sec -1	1000	867	>100
2	Flocculation				
	No. of basins	basin	2	2	-
	Detention time	min	20	20.2	20-40
	Velocity gradient	sec -1	Max. 100	12.7-33.6	10-80
3	Sedimentation				
	No. of basins	basins	2	2	-
	Detention time	hr	2.28	2.68,2.81	2-5
	Surface loading	mm/min	27.8	23.96,22.95	15-30
	Mean passing velocity	m/min	1.38	* 1.18	0.4
4	Accelators				
	No. of tanks	tank	2	2	-
	Clarification time	min	48	* 64	90-120
	Upflow rate	mm/min	100	* 92	40-60

5	Filtration				
	No. of beds	bed	10	10	-
	Filtration area	m2	162	162	-
	Filtration rate **	m/d	288	288	-
	Filter media depth **				
	Anthracite	mm	500	480	-
	Sand	mm	250	280	-
	Media effective size **				
	Anthracite	mm	0.9-1.1	* 0.57	0.7-1.5
	Sand	mm	0.45-0.55	0.69	0.45-0.70
	Backwash				
	Type		Perforated pipings		
	Rate	m3/m2/min	0.6	0.6-0.65	0.6-0.9
	Surface wash				
	Type		Perforated pipings		
	Rate	m3/m2/min	0.2	0.15-0.2	0.15-0.2

(Notes) * Shows deviation from reference value.
** Filtration particulars were designed based on the result of a pilot scale plant.

TABLE 7.3.4 DESIGN CRITERIA OF PLANT NO. 2

ITEM NO.	DESCRIPTION	UNIT	DESIGN VALUE	ACTUAL OPERATION	REFERENCE VALUE
1	Rapid mixing				
	Velocity gradient	sec -1	800	866	>100
2	Flocculation				
	No. of basins	basin	12	12	-
	Detention time	min	21	20.2	20-40
	Velocity gradient	sec -1	30-47	26-31	10-80
3	Sedimentation				
	No. of basins	basins	12	12	-
	Detention time	hr	1.7	* 1.61	2-5
	Surface loading	mm/min	48.3	* 52	15-30
	Mean passing velocity	m/min	0.498	* 0.71	0.4
4	Filtration				
	No. of beds	bed	20	20	-
	Filtration area	m2	162	162	-
	Filtration rate **	m/d	348	348	-
	Filter media depth **				
	Anthracite	mm	400	370	-
	Sand	mm	250	292	-
	Media effective size **				
	Anthracite	mm	0.9-1.1	* 0.53	0.7-1.5
	Sand	mm	0.45-0.55	0.64	0.45-0.70
	Backwash				
	Type		Perforated pipings		
	Rate	m3/m2/min	0.6	0.6-0.65	0.6-0.9
	Surface wash				
	Type		Perforated pipings		
	Rate	m3/m2/min	0.6	0.15-0.2	0.15-0.2

(Note) * Shows deviation from reference value.
** Filtration particulars were designed based on the result of a pilot scale plant.

(7) **Existing Structures**

The survey was executed by ocular inspection and concrete compressive strength test using test hammer. The results of the ocular inspection showed that there are no major defects except for some minor repairs. The concrete compressive test indicated that the structures have sufficient strength.

(8) **Existing Mechanical/Electrical Facilities and Instrumentation**

The present staff of the Plant has been trying to maintain the existing facilities in good operating condition. These endeavors, however, are limited due to the existing budgetary constraints. For example, most of the equipment have a stand-by unit, but at present, all are already damaged. Although it is possible to operate the plant without a stand-by unit, the plant will be deficient when the main operating equipment breaks down.

(9) **Chemical Dosage and Chlorination**

In the Balara Plant, Alum, Cationic Polymer, Anionic Polymer and Chlorine are used. The chemical dosing points are as follows:

1) Alum

a. Rapid mixer at Sedimentation Basin No. 1 in Plant No. 1
b. Rapid mixer at Sedimentation Basin No. 2 in Plant No. 1
c. Accelators in Plant No. 1
d. Parshall Flume (North) in Plant No. 2
e. Parshall Flume (South) in Plant No. 2

2) Polymer

a. Rapid mixer at Sedimentation Basin No. 1 & No. 2 in Plant No. 1
b. Accelators in Plant No. 1
c. Parshall Flume/Flocculation Basin (North) in Plant No. 2
d. Parshall Flume/Flocculation Basin (South) in Plant No. 2

3) Chlorine

· Pre-Chlorination

a. Aqueduct No. 1 near Chemical House for Plant No. 1

b. Receiving well of Accelators in Plant No. 1

c. Receiving well in Plant No. 2

· Intermediate-Chlorination

a. Inflow Channel to Filter Building in Plant No. 1

b. Inflow Channel to Filter Building (East wing) in Plant No. 2

c. Inflow Channel to Filter Building (West wing) in Plant No. 2

· Post-Chlorination

a. Effluent aqueduct from Plant No. 1

b. Effluent aqueduct (84") from Plant No. 2

c. Effluent aqueduct (72") from Plant No. 2

(10) Water Quality

Tables below show water turbidity of Plant No. 1 and No. 2 from April to October. Finished water quality is affected that it exceeded the drinking water turbidity standard of 5 mg/l when raw water was high in turbidity. This is noticeable in cases where the raw water turbidity is beyond 40 mg/l.

These phenomena could be related to the performance of the overflow weir of which loading rate is more than 5,000 $m^3/m/d$ and extremely deviates from weir loading rate standard of 300-500 $m^3/m/d$.

Problems in the sedimentation basins of Plant No. 1 could be explained in a similar way as Plant No. 2, based on the monitoring results shown in Fig. 7.8.4 and 7.8.5 by the Study Team.

TABLE 7.8.4 WATER TURBIDITY (mg/l) IN PLANT NO. 1

PERIOD IN 1991	RAW WATER	TREATED WATER	INFLOW WATER	FILTERED WATER	FINISHED WATER
April	9.69	-	5.11	2.36	3.40
May	11.21	5.35	5.59	1.98	3.42
June	33.25	12.34	7.41	3.36	3.92
July	73.47	18.47	15.73	5.46	5.63
August	50.80	18.80	14.54	6.22	6.33
September	42.07	10.57	8.76	5.00	5.21
October	13.05	6.65	6.84	3.03	3.50

Source: Plant Laboratory of PQU

TABLE 7.8.5 WATER TURBIDITY (mg/l) IN PLANT NO. 2

PERIOD IN 1991	RAW WATER	TREATED WATER	INFLOW WATER 1	INFLOW WATER 2	FILTERED WATER	FINISHED WATER
April	10.51	-	5.74	6.78	3.31	3.26
May	10.61	9.08	6.04	7.17	2.83	3.02
June	27.91	25.75	7.28	9.23	3.54	3.50
July	54.06	50.63	6.94	14.78	4.98	5.14
August	52.15	49.63	14.81	22.90	6.75	5.56
September	37.64	37.18	8.82	9.84	5.64	4.18
October	12.13	10.65	7.70	8.75	3.72	4.27

Source: Plant Laboratory of PQU

(11) Water Quality in the Distribution System

In order to study the water quality management of the Balara Water Supply System, an analysis of the residual chlorine in the distribution trunk lines was conducted. According to the results chlorination itself is carried out perfectly through the trunk main. Consequently the farthest points from the main distribution line were also checked for residual chlorine. The results indicated that traces of residual chlorine is evident in the areas and indicates that chlorine concentration is depleted in the service pipes caused by the leakages.

(12) **Basic Principles of Rehabilitation Plan**

The principles with which this study would follow to come up with an optimum rehabilitation plan are as follows:

1) Design capacity is restricted by the hydraulic performance of the conveyance aqueducts from the La Mesa Dam to the Balara Plant. Therefore, the capacity is proposed as 1,600,000 m^3/day.

2) Replacement is applied for such equipment and facilities that is projected to be worn-out after the completion of the project taking into consideration O & M problems.

3) Stable Plant Operation

The rehabilitation plan also intends to maintain a stable operation of the Plant after its completed rehabilitation. Also, the rehabilitation intends to furnish only the mechanical and electrical equipment which is suitable to Philippine conditions.

4) Enhancement of O & M Procedures

The actual modification items involved in this aspect is the plan to improve the efficiency of each treatment process. To specifically elaborate, by increasing the efficiency of the sedimentation process through the proposed rehabilitation items intended for this purpose will reduce the load of work that will be conveyed to the filters, thereby maximizing the capability of each facility.

Secondly, when the proper, suitable equipment is installed, a certain degree of reliability is attained. For instance, in the chemical dosing facilities where the proper dosage of chemicals is critical, accurate measuring devices should always be functioning properly.

Lastly, vital information that is utilized in the overall operation of the Plant should be obtained from accurate instrumentation and measuring devices. A specific example which illustrates this idea is the proposed installation of flow meters to accurately measure information that is important in contributing to the overall operation of the Plant.

(13) Alternatives

The classification of rehabilitation alternatives is formulated according to three levels as shown below:

<u>Level 1</u>

Consists of the minimum replacement of equipment and resumption of the operating conditions set during the modification project in 1981. Necessary review of performance of equipment which will be replaced will be considered. In addition, replacement of vital facilities such as chlorination facilities are included with Level 1 as a minimum replacement. This level is based on actual successfully managed performance of existing facilities but items are limited to only urgent matters.

<u>Level 2</u>

Consists of and in addition to Level 1, stable supply and safe quality of water to be achieved in connection with the improvement of water quality control and O & M. Rehabilitation items will be expanded which will not only involve the replacement of equipment as in Level 1, but also the improvement of process water quality control and the repair of existing structural defects, taking into consideration the actual O & M procedures and financial measures. In addition, the design of the rehabilitation of plan is based on necessary and normally prevailing technology.

Level 3

Consists of modernization and possible expansion in terms of water treatment process will be added to Level 2, providing that technical, financial, socioeconomic, and environmental aspects are all satisfied.

The contents of each level are itemized in Table 9.3.1.

The project costs for each Level are estimated as follows including engineering fee.

(Unit: 1,000 Pesos)

	Level 1	Level 2	Level 3
Grand Total	285,556	688,947	905,710
Conversion to 1,000 Yen	1,468,000	3,541,000	4,655,000

(14) **Proposed Plan**

In the view points both of engineering and financial aspects Level 2 is the most recommendable. The level can be said basic or fundamental plan because Level 2 includes the improvement for water quality control and for stable O & M after years ahead.

On the other hand, since Level 1 rehabilitation consists of urgent and survivable replacement of the worn-out equipment, it is also acceptable. From the results of economic and financial analyses, both levels are justified to be feasible. The EIRR of Level 2 was computed at 32.4% and its FIRR at 5.4%, while the EIRR of Level 1 was computed at 63.8% and its FIRR at 7.8%. The base funds of Level 1 was assumed at 286 million pesos. When the base funds increase by 10%, the adjusted Level 1 FIRR turns to 6.69%. Similarly as increase of base funds by 20%, 30%, and 40% results in the adjusted Level 1 FIRR of 6.37%, 6.06% and 5.78%, respectively. The details of Level 2 are summarized in Table 15.1.1.

(15) Environmental Assessment

The basic environmental resources of the plant premises were reviewed to substantially evaluate potential effects of the rehabilitation project and from the subsequent operation of the plant after the completion of the project. The rehabilitation work consists mainly of replacement of mechanical and electrical equipment and minor civil works; construction of troughs and perforated baffles in existing sedimentation basins. Therefore, there will be no specific changes in the environmental aspects and no lasting adverse effect was identified as a result of the proposed rehabilitation work.

(16) Project Evaluation

1) Socioeconomic Aspects

a. Needs and Beneficiary

The population that will benefit directly from the project is 6,000,000 persons, approximately 60% of MWSS service area population. Then, large scale rehabilitation of existing facilities is urgently required in order to maintain the supply of water with good quality and ensure steady operation.

b. Cost Effectiveness in Relation to Other Projects

With in a shorter period and at a much lower cost, this project will create great benefits in the service area of MWSS to maintain the potentiality of the further development of related public facilities and private services industries in the heart of the country. In addition, the rehabilitation works on the existing facilities will be required to cope with future demand of clean water even when other future expansion projects are implemented by MWSS.

c. Social Impact

To maintain public health in Metro Manila, ample and clean water supply shall be provided for. Therefore, a healthy environment in Metro Manila for international relations will in turn benefit the whole area in the Philippines.

2) <u>Technical Aspects</u>

Equipment in the Balara Plant are superannuated. If simultaneous breakdowns occur with the main equipment namely: flash mixer, alum feeder, chlorinator, the supply of sufficient amount of safe water cannot be insured. Over and above the need of replacing these equipment, existing facilities have some deficiencies in the light of normal or prevailing technological standards.

3) <u>Environmental Aspects</u>

The proposed project consists mainly of the replacement of existing equipment and very minor civil works. Therefore, there are no potential lasting adverse environmental effects that were identified during this feasibility study.

4) <u>Economic and Financial Aspects</u>

The rehabilitation project of Level 1 and Level 2 can both be justified on economic and financial grounds. Both Level 1 and Level 2 can also stand against the most adverse situations, as discussed in the sensitivity analyses of chapter 13 and 14.

(17) Recommendation

The Government of the Philippines and MWSS proceed with execution of the detailed design for the Balara Water Treatment Plant Rehabilitation Project as soon as possible.

- Should financial limitations exist, MWSS should start to implement the Level I rehabilitation or equivalent plan.

- As the completion of the work will take about four years, some equipment in the Plant will be breakdown, then MWSS has to cope with the situation without reservation as soon as possible.

- In connection with the Balara Plant, the following some items are recommended:

  a) MWSS should always establish a periodic preventive repair scheme including spare parts purchase.

  b) The interconnection pipe between La Mesa Plant No. 2 and the Balara plant should be constructed.

  c) Interconnection in a number of points between both services areas are recommendable.

  d) Distribution reservoirs should be rehabilitated to allow for emergency situations.

  e) Leakage prevention in the distribution network should be attended.

  f) Standard designs and programs to furnish unified facility plan on sludge treatment facilities for the Balara Plant should be prepared.

CHAPTER 2 INTRODUCTION

2.1 Background

The MWSS is responsible for the water supply and sewerage system for Metro Manila. The present water system for Metro Manila is dependent on surface water with groundwater as supplement. However, due to the rapid increase in the population of Metro Manila, the present water supply is insufficient in meeting the expected demand for water.

In order to solve the shortage of water supply, four projects have been undertaken by the MWSS, namely (1) the Angat Water Supply Optimization Project (AWSOP) which is co-financed by IBRD, ADB, and OECF; (2) the Study for the Groundwater Development in Metro Manila by JICA; (3) and the Manila Water Supply Rehabilitation Project I & II (MWSRP I & II) financed by ADB. The MWSRP II Project is also co-financed by the Development Bank of the Philippines (DBP).

While these projects are already in progress, there is also a need for the immediate rehabilitation of one of the two huge water treatment plants in Manila, the Balara Plant. The Plant presently performs a vital role in the water supply system since it accounts for about 60% of the total water production for Metro Manila. However, the facilities and equipment of the Plant are superannuated and difficulties have been encountered in trying to operate the plant efficiently. There are two plants in Balara, Plant No. 1 and Plant No. 2 which were constructed in 1935 and 1958, respectively. Both plants were rehabilitated in 1981, after which, no rehabilitation of any kind was implemented.

Therefore, it is imperative that the rehabilitation of the Balara Plant be implemented immediately in order to restore the designed capacity of the Plant, to continue providing Metro Manila residents with the much needed adequate supply of potable water.

2.2 Study Area

The Study area is the Balara Plant premises (Fig.2.2.1). In addition, in order to study the water quality management focusing on residual chlorine, the Balara Plant service area was selected as a related area to sample water near the distribution trunk main.

2.3 Objectives and Scope of Work

The objective of the Study is to formulate the rehabilitation plan for the existing Balara Plant taking into consideration the operation and maintenance aspects.

The scope of work consists of the following:

- Study for Rehabilitation

The main scope of rehabilitation work is a planning scheme which seeks to recover the current capacity of the existing treatment process and equipment. The Study will not include any rehabilitation of aqueducts, distribution pipeline and distribution reservoirs, nor alterations on the building structure. However, some exceptions may include alterations related to the placement of equipment or to some changes in the treatment process.

- Study for Water Quality Management in Pipeline Networks

A study is undertaken for the water quality management and operating procedure of the water treatment plant. The study focuses on the residual chlorine concentration check based on the water quality analysis and coliform tests and on the water samples obtained from sampling points near the distribution trunk line.

- Recommendation Concerning Operations/Maintenance

Proper operating methods for the treatment process are recommended as well as procedures for its rehabilitation. In addition, proper operation/maintenance methods are recommended to maintain the efficient performance of the equipment.

- Formulation of Rehabilitation and Improvement Plan

A rehabilitation and improvement plan for the Balara Plant is formulated taking into consideration the simplified operation/maintenance procedures, and the functional recovery of the design capacity of the treatment facilities and equipment.

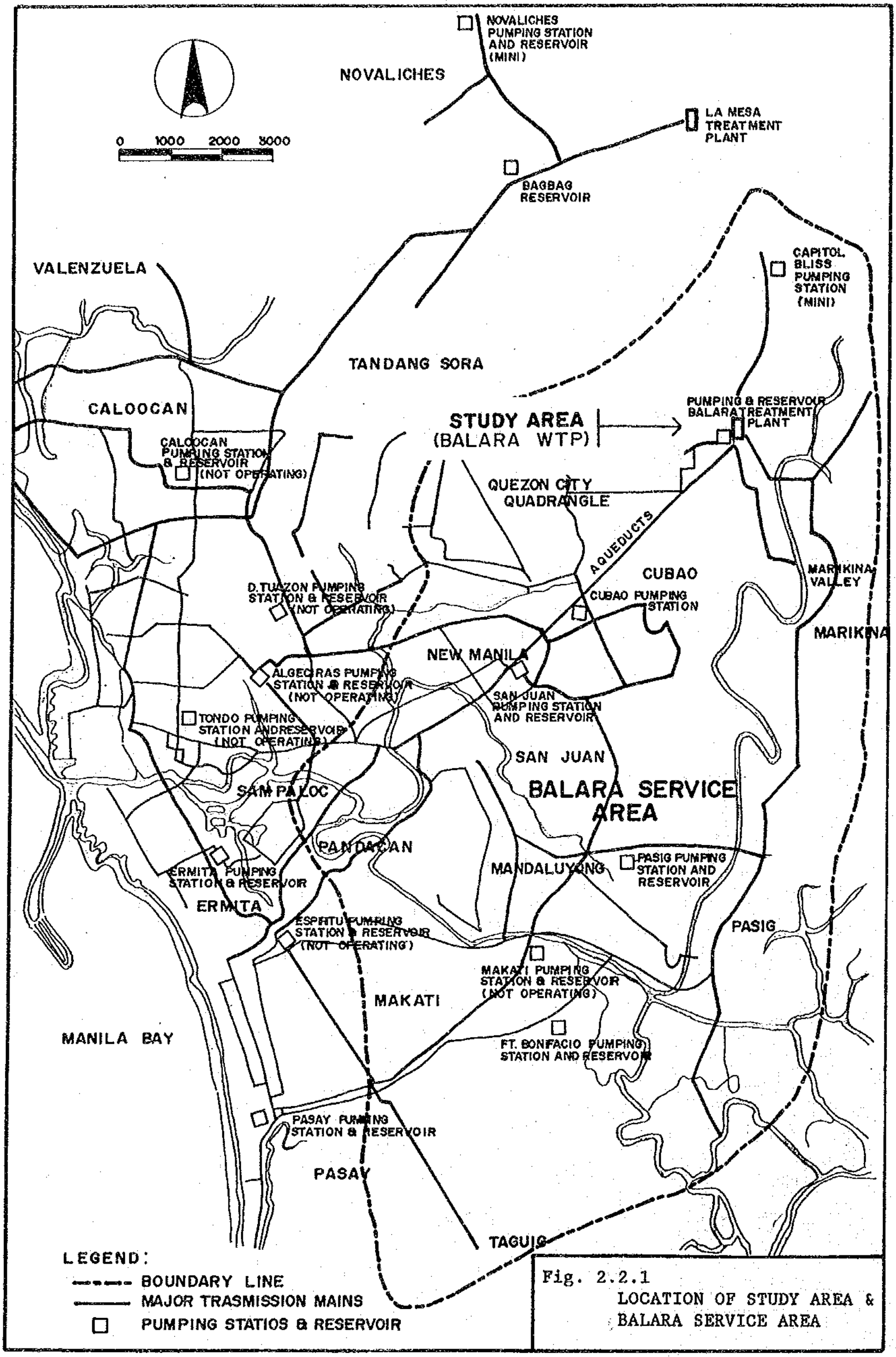


Fig. 2.2.1
LOCATION OF STUDY AREA & BALARA SERVICE AREA

CHAPTER 3 OUTLINE OF THE PROJECT AREA

3.1 Natural Conditions

3.1.1 Topography

The Balara Water Treatment Plant is located at 50m to 75m above mean sea level at an undulating topography in Quezon City, Metropolitan Manila. The service area of the Balara Plant at an elevation of 40-200 m exist in the southern part of the Luzon Central Plain East Side Hill as shown in Fig. 3.1.1. The East Side Hill ranges in the north-south direction in the eastern side of the Luzon Central Plain and extends from Pallanyan to Laguna de Bay. In west of the Balara service area, the Marikina River flows from North to South and influx into the Pasig River turning at a right angle direction pouring to the Manila Bay.

3.1.2 Geology

The Balara Plant and service area is underlain by the Guadalupe Formation and Alluvium of Quaternary age (Fig. 3.1.2).

The Marikina Valley, which is on the eastern side of the service area is about 3 to 7 km wide extending in the north-south direction. In the west of the Marikina Valley is located the Marikina Fault, which is approximately 500 meters away from the Balara Plant. the Marikina Fault has been traced to be at least 23 km from Lower Macabod, Rodriguez in the north down to the vicinity of the Ultra Sports Complex in Pasig, Metro Manila (Fig. 3.1.3).

3.1.3 Climate

The Philippines generally experiences the tropical monsoon. However, due to the complex topography, the climate varies in different parts of the country. The northern half islands of the country have the dry season and the wet season while the southern half does not have clearly defined season.

Climatic conditions in Metropolitan Manila is summarized in Fig. 3.1.4 based on the data of the Philippine Atmospheric Geographical and Astronomical Services Administration (PAGASA). Metro Manila has two pronounced season: the dry season from December to May and rainy season from June to October.

Annual average precipitation is 1885.0 mm from 1951 to 1977. Maximum rainfall occurs in the rainy season from June to October. Average monthly temperature in May is 29.4°C and which reaches up to 36 to 37°C. Humidity increases steadily in June to September from 80 to 86%.

3.1.4 Groundwater Sources

Total water production is approximately 3,310 MLD in the whole MWSS Service Area for 1990. Surface water of the Angat River System provides 2,400 MLD out of 3,310 MLD which is distributed by the Central Distribution System (CDS). The remaining 910 MLD is supplemented by deepwell water of which 90 MLD is supplied from MWSS controlled wells and 820 MLD is pumped by the private sector.

Approximately 3000 deepwells and 20,000 shallow wells exist within the Central Distribution System. Out of the 3000, 220 deepwells are owned by MWSS of which 120 wells are operational producing an average of 90 MLD. The private sector utilize approximately 780 MLD deepwell water and approximately 40 MLD of shallow well water.

These deepwells exist almost all over Metro Manila and are concentrated in the southern areas of Metro Manila such as Cavite, Las Pinas and Paranaque which are not served by the CDS. Most of the private wells are for industrial and commercial use and groundwater pumped from these wells is causing ground water table decline at the rate of 4m to 8m annually. Elevation of groundwater has lowered to 50m to 120m below sea water and salt water intrusion into groundwater has occurred specifically on the coastal areas (Fig. 3.1.5). Consequently, a number of MWSS wells as well as private wells have become non-operational.

3.2 Socioeconomic Conditions

3.2.1 Population

The present population of the Philippines is estimated at 62 million with about 9 million residing in Metro Manila, 15.37 million in other urban areas and the other 33.83 million in the rural areas.

Metro Manila has total population of 7,833,000 and the most urbanized and economically developed area of the country. The MWSS service area covers the whole of NCR and 3.2% of the Region IV. It comprises of five cities and thirty two municipalities with a combined population of 9,172,379 (6,805,630 in 1980). This figure presents 15.17% of the country's total population and reflects an increase of 34.78% over the 1980 figure, or an annual growth rate of 3.03%.

The population densities in the MSA are shown in Table 3.2.1 and historical and projected served populations are shown in Table 3.2.2.

3.2.2 Economy

Economy, as measured by the constant Gross National Product (GNP) in 1972 rose by 5.1%, 10.8%, and 5.3% in 1987, 1988, and 1989, respectively. Per capita income at 1972 prices was ₱1463 in 1989.

The manufacturing sector consistently contributed to GNP growth by 6.3%. Agriculture and fishery improved by 4.6% while the services sector gained by 5.5%.

In 1991, the growth of GNP was expected to increase at a lower rate due to natural calamities which besieged the country such as the Pinatubo Eruption, earthquake and typhoons.

Economic growth rate for the period between 1990 and 1995 is projected at 3.5% per year to accelerate at 5.7% during the period between 1995 and 2000, according to the International Monetary Fund (IMF).

Among the Asian countries, the Philippine's economic growth rate was lower than that of other Asian nations. Thailand recorded an annual rate of 6.5%; Malaysia, 5.5%; Indonesia, 5.1%; and Philippines, 2.3% during the period between 1980 and 1990.

The IMF estimates that the comparable growth rate and per capita gross domestic products (GDP) in U.S. dollars for 1990 - 2000 is shown below:

	Growth Rate		Per Capital GDP	
	1990-95	1995-2000	1990	2000
Thailand	6.8	8.0	1,236	3,334
Malaysia	5.8	7.3	2,385	5,616
Indonesia	6.1	7.6	546	1,380
Philippines	3.5	5.7	758	1,440
ASEAN	5.8	7.4		

Economic activity by industry indicates that Agriculture, Fishery, and Forestry constituted 24.1%; the Industry sector, 29.5%; and Services sector, 46.4% in 1989.

3.2.3 Labor Force and Employment

The country's labor force participation rate (LFPR), the ratio of total persons in the labor force to the total population 15 years old and older is 62.5% in 1989. Male LFPR is 79.6% while female LFPR is 45.7%.

Employed persons amounted to 22 million or 96% of the total labor force. Approximately 64% of the total number of the employed come from the rural areas.

Unemployment rate in the Philippines in 1989 is 3.9%, while that in Metro Manila is 10%.

3.2.4 Income and Expenditure

The 1988 survey on family income and expenditures indicates an average annual family income of ₱40,408, an increase of 30% from the 1985 average of ₱31,052.

Families in urban areas earned an average of ₱60,330, more than twice that of rural families at ₱28,284. Metro Manila is the top income earner posting an average of ₱79,314.

The distribution of income by income class shows that families under ₱30,000 constituted 32.9%; those between ₱30,000 and ₱39,999, 20.1%; those between ₱40,000 and ₱59,999, 21.5%; those between ₱60,000 and ₱99,999, 16%; and those over ₱100,000, 9.5%, respectively.

The daily minimum wage rate in the Metro Manila area was ₱96 in 1989 and ₱115 in 1991. In agricultural areas, daily minimum wage ranges from ₱64 for non plantation workers, to ₱86 for plantation workers.

Most families derive their income from salaries and wages (45%), and the rest from entrepreneurial activities (39%) and other sources (16%).

Using 1989 figure of the minimum wage rate of ₱90 a day amounts to ₱27,000 (₱90 x 25 days x 12 months) a year. The poverty line was drawn at ₱36,000 a year meaning that approximately half of families falls under this category. With the minimum decent level of living at ₱60,000, 74.5% (2/3) of the population fall below this level.

Prices of consumer goods and services increased at a faster rate in 1989, compared to the price increases in 1986-1988. A double-digit increase occurred for the first time in three years as the consumer price index (CPI) rose at an annual rate of 10.6%. The inflation rate was estimated at 14% in 1990, at 12% in 1992 and 7 to 8% during the period between 1992 and 2000.

Substantial increases were recorded in the cost of food 13%), housing and repairs (12%) and services (7%).

Food items rank the top among family expenditures. The percentage distribution of family expenditures in 1988 shows that food items amounted to 51%; housing, 13%; fuel, light, and water, 5%; transportation and communication, 5%; clothing and other wear, 4%; education, 3%; personal care, 3%; and alcoholic beverages and tobacco, 3%.

3.2.5 Public Health

An overview of the health of the nation reveals a consistent decrease in the death rate and birth rate from 7.6 and 31.6 in 1986 to 4.7 and 23.8 in 1988. The above figures represents the rate per thousand population.

Of the leading causes of mortality, pneumonia is the most prevalent followed by diseases of the heart, diseases of the vascular system and tuberculosis. On the other hand, bronchitis, upper respiratory infection and diarrhea were the most common causes of morbidity. Water-borne diseases ranked among the three leading causes of morbidity and the second leading cause of infant mortality.

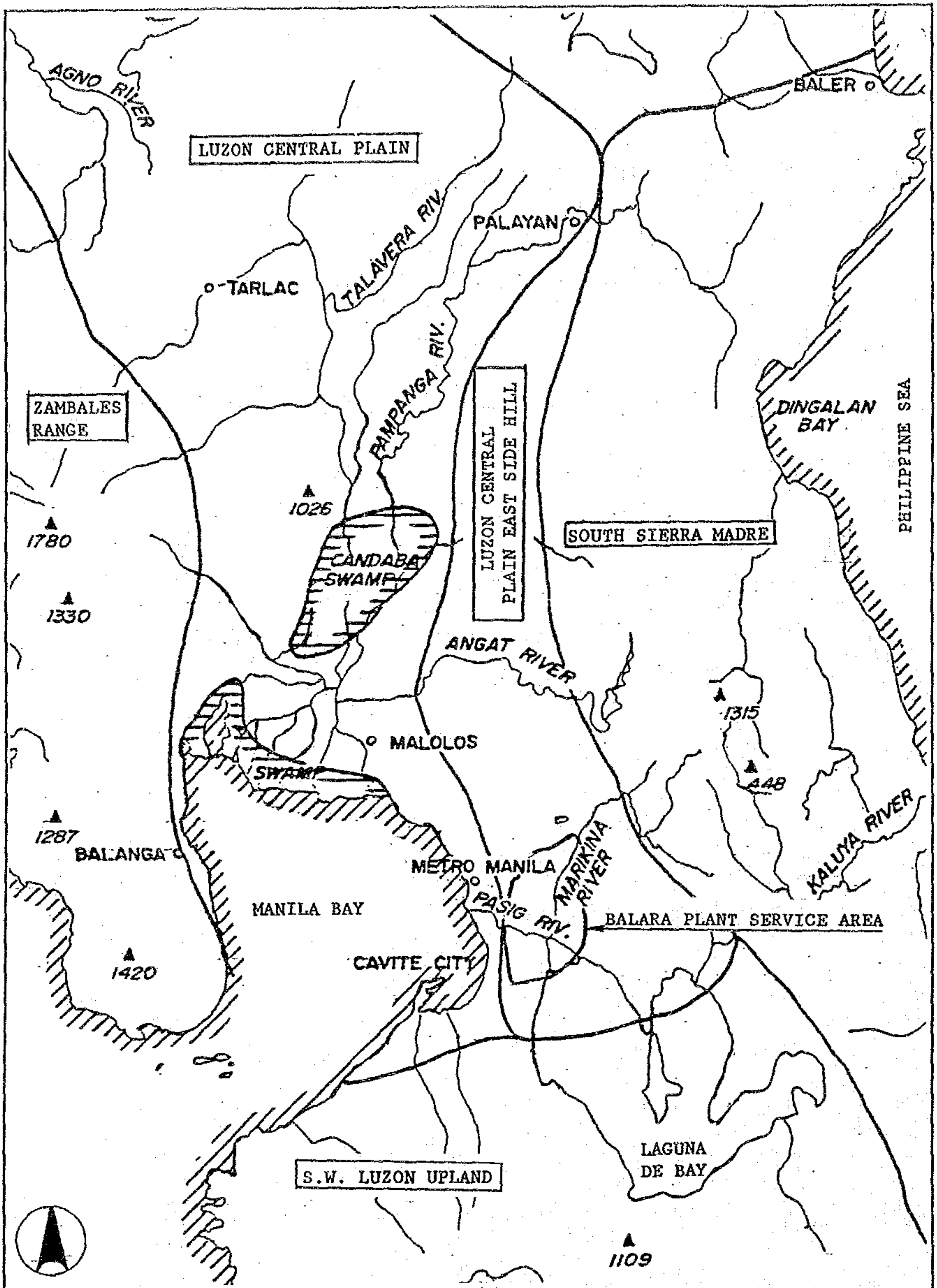
Table 3.2.3 shows the statistics concerned with water-borne diseases within NCR.

3.3 Water Supply and Sanitation Conditions

Of the country's total population, 63% have access to water supply. Water service coverage is 86% in Metro Manila, 55% in other urban areas and 62% in the rural areas. As of the end of 1986, about 69% of the total households had been provided with sanitary toilets, 15% with unsanitary toilets and 16% with no toilets at all.

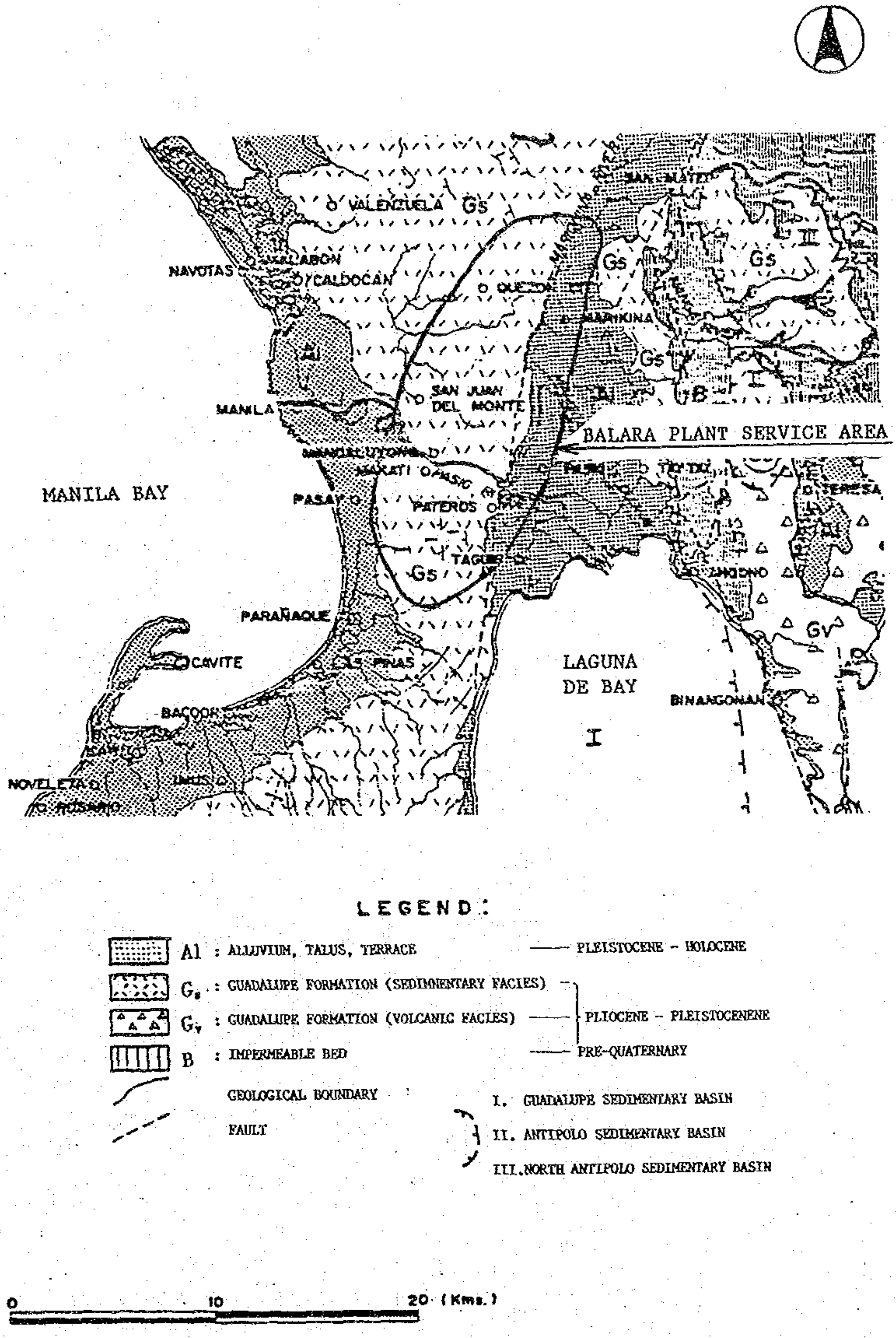
The population of Metro Manila is expected to reach 14.36 million by year 2000 and water demand is projected at 3.8 million cu.m by 1996. Based on the studies of the Angat Water Supply Optimization Project, the combined water production of 3.6 million cu.m of Balara, La Mesa and the secondary water treatment facilities of the La Mesa cannot meet the demand.

In view of this, the Metropolitan Waterworks and Sewerage system (MWSS) prepared a comprehensive expansion development plan. The Balara Rehabilitation Project is part of the plan to meet the original design level efficiency in water production and water quality. In 1991, the average daily production of water at the Balara is 1.35 million m^3, and that of the La Mesa, 1.15 million m^3.



SOURCE: STUDY FOR GROUNDWATER DEVELOPMENT IN METRO MANILA (JICA)

Fig. 3.1.1 PHYSIOGNOMY OF CENTRAL LUZON



SOURCE: STUDY FOR GROUNDWATER DEVELOPMENT IN METRO MANILA (JICA)

Fig. 3.1.2 SIMPLIFIED HYDROGEOLOGICAL MAP

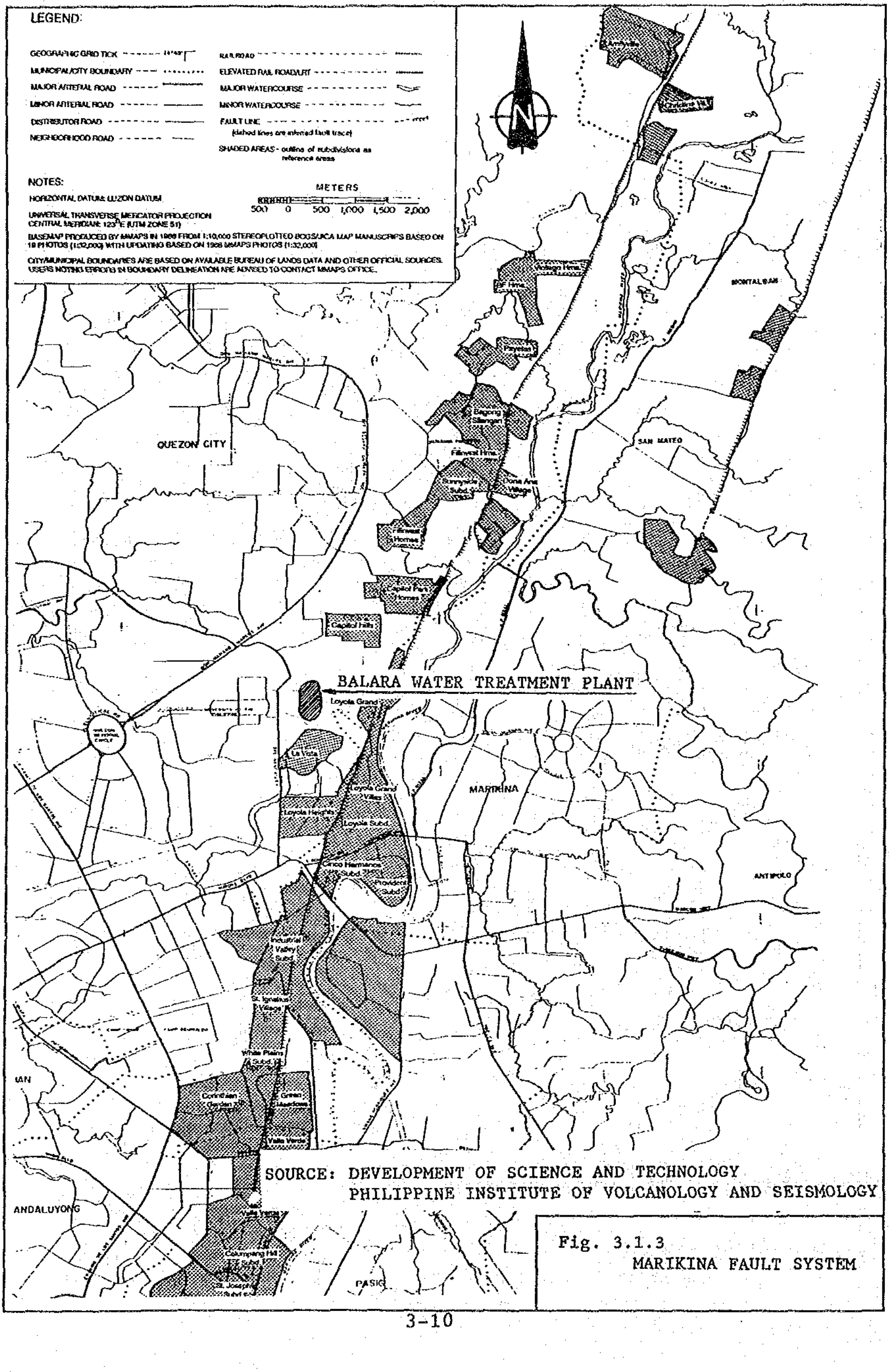
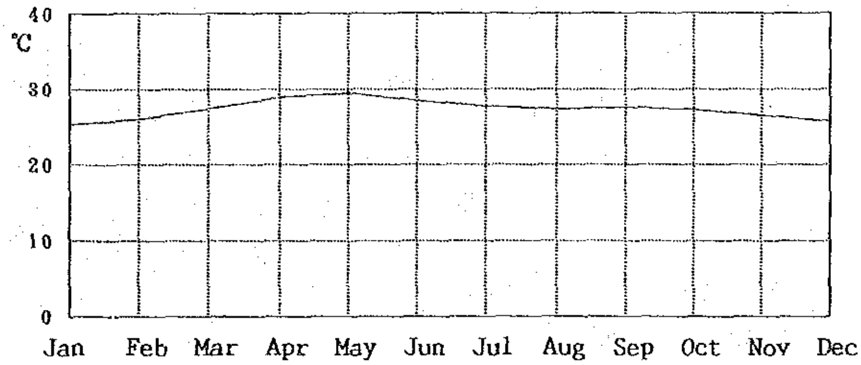
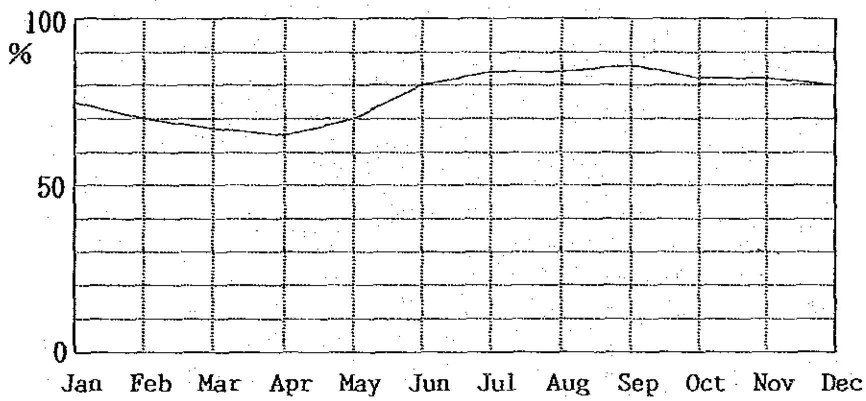


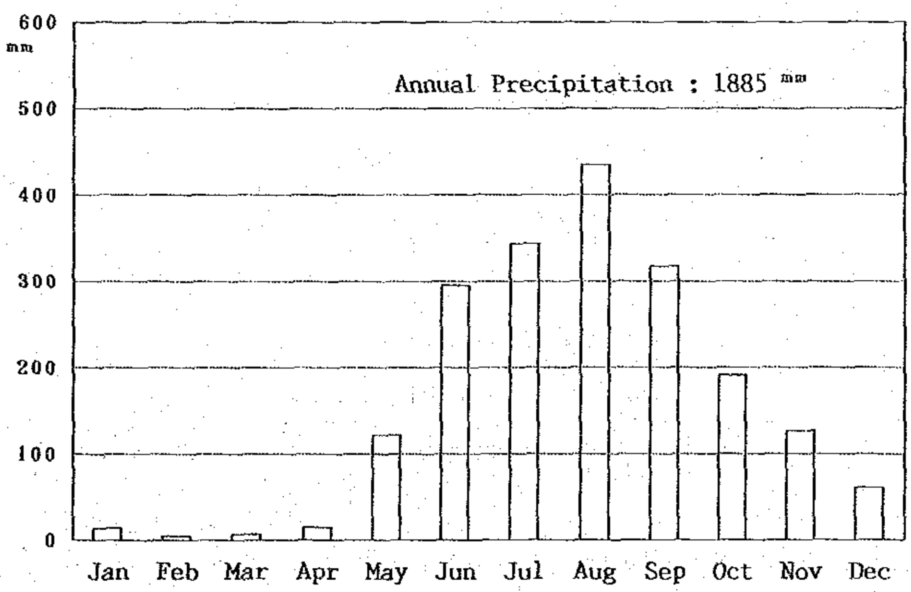
Fig. 3.1.3
MARIKINA FAULT SYSTEM



Temperature ℃ (Monthly Mean Value, 1951 - 1980)



Humidity % (Monthly Mean Value, 1961 - 1967)



Precipitation (mm) (Monthly 1951 - 1977)

SOURCE: PAGASA

Fig. 3.1.4
METEOROLOGY IN MANILA

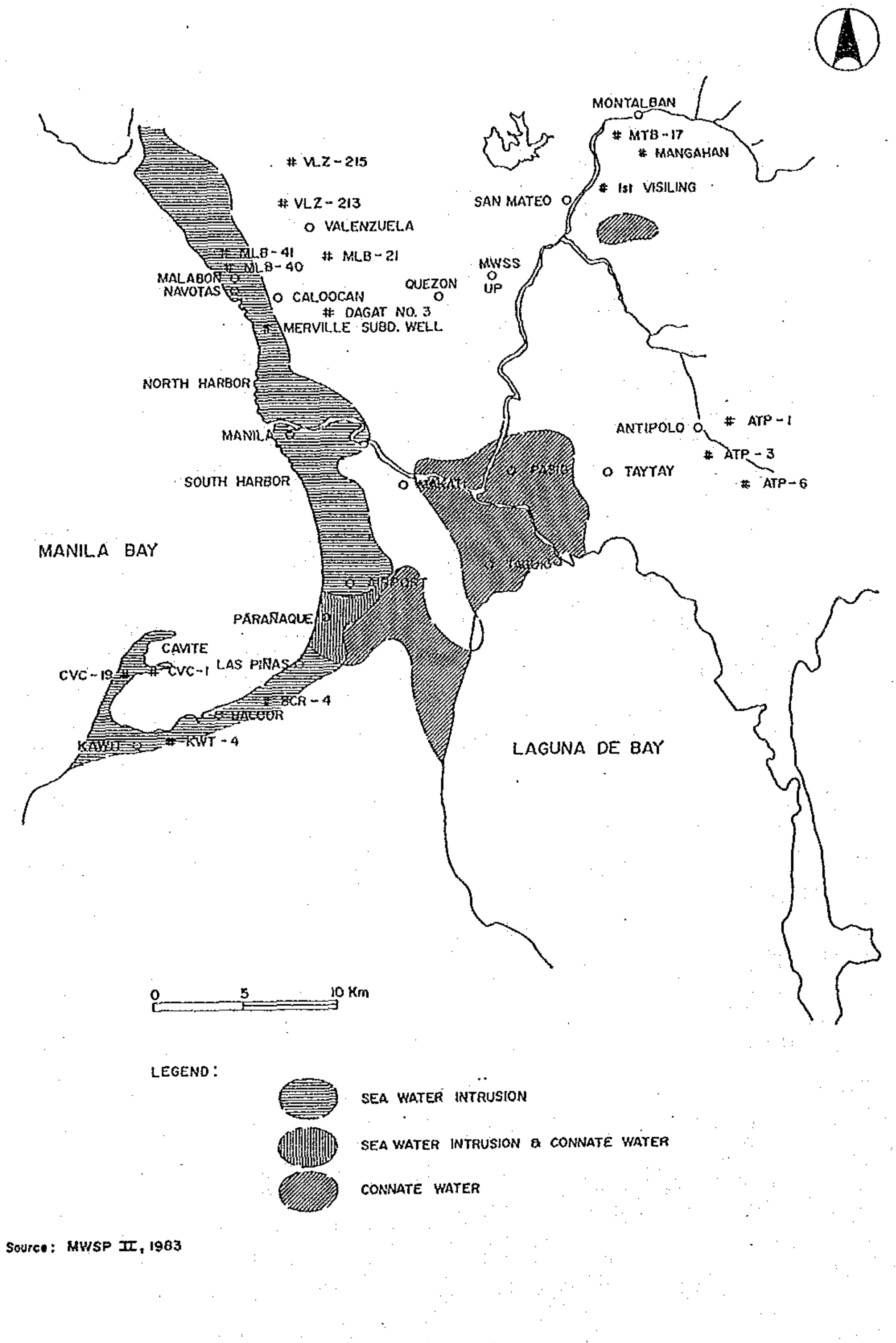


Fig. 3.1.5
AREA OF SALINE WATER CONTAMINATION

Table 3.2.1 POPULATION DENSITIES IN MSA

City/Municipality	POPULATION DENSITY (Persons/Ha.)				
	1970	1975	1980	1985	1990
NCR	62.4	78.1	93.2	109.2	123.2
1. Manila	347.5	386.2	425.7	461.1	414.4
2. Pasay	148.4	183.5	207.0	238.7	254.7
3. Quezon	45.4	57.6	70.1	82.9	98.2
4. Caloocan	49.2	71.2	83.8	97.4	133.7
5. Las Pinas	11.0	19.7	32.9	50.1	68.9
6. Makati	88.6	111.9	124.6	140.9	151.2
7. Malabon	60.5	74.7	81.6	94.1	118.4
8. Mandaluyong	57.5	70.1	79.0	89.9	95.0
9. Marikina	29.2	43.3	54.4	66.8	79.2
10. Muntinlupa	13.9	20.2	29.3	39.3	59.5
11. Navotas	320.2	373.5	485.2	566.8	715.4
12. Paranaque	25.4	41.5	54.5	69.6	78.3
13. Pasig	120.4	161.5	206.6	257.5	303.8
14. Pateros	24.5	31.6	38.7	46.5	49.0
15. San Juan	100.5	117.8	125.1	137.0	122.1
16. Taguig	16.4	21.9	39.8	49.3	79.2
17. Valenzuela	20.9	32.0	45.2	61.8	72.3
CAVITE	12.4	14.4	17.5	21.0	24.7
18. Bacoor	9.2	11.9	17.2	22.3	30.6
19. Cavite City	64.0	69.7	74.1	81.7	77.5
20. Imus	4.5	5.0	6.1	7.4	9.5
21. Kawit	21.1	25.2	29.4	35.3	35.6
22. Noveleta	19.5	22.4	26.7	31.6	40.0
23. Rosario	42.0	50.7	58.8	71.5	80.0
RIZAL	2.4	3.2	4.3	5.2	6.8
24. Angono	4.7	6.8	10.2	13.0	17.5
25. Antipolo	0.9	1.3	2.3	3.0	5.7
26. Baras	3.1	4.2	4.8	5.7	7.1
27. Binangonan	7.2	8.7	11.1	12.9	12.8
28. Cainta	20.3	36.3	57.9	81.2	107.5
29. Cardona	5.4	6.8	7.9	8.8	10.5
30. Jala-Jala	1.6	1.9	2.4	2.8	3.3
31. Morong	5.0	5.6	6.6	7.0	8.6
32. Pililla	2.0	2.6	3.1	3.6	4.4
33. Montalban	0.7	1.0	1.3	1.6	2.0
34. San Mateo	4.5	6.0	8.0	9.5	12.6
35. Tanay	1.0	1.4	1.7	2.0	2.0
36. Taytay	13.8	17.3	22.3	25.6	33.3
37. Teresa	5.0	7.2	7.9	8.6	11.1

Table 3.2.2 HISTORICAL AND PROJECTED WATER SUPPLY

Year	Population *	Water Supply (MLD)	Number of Customers (Yearend)	Population Served: Directly -Persons-	Directly -%-	Indirectly ** -Persons-	Indirectly ** -%-	Total -Persons-	Total -%-
1946	1,450,000	360	73,233	645,747	44.53%	209,643	14.46%	855,390	58.99%
1948	1,600,000	380	77,301	681,622	42.60%	221,290	13.83%	902,912	56.43%
1960	2,500,000	760	154,603	1,363,243	54.53%	442,580	17.70%	1,805,823	72.23%
1976	5,657,588	1284	261,197	2,303,164	40.71%	747,728	13.22%	3,050,891	53.93%
1982	7,015,586	1530	303,244	2,650,032	37.77%	957,908	13.65%	3,607,940	51.43%
1983	7,193,410	1685	327,521	2,800,421	38.93%	1,084,050	15.07%	3,884,471	54.00%
1984	7,412,135	1830	371,641	2,908,220	39.24%	1,357,770	18.32%	4,265,989	57.55%
1985	7,641,960	2156	438,288	3,353,068	43.88%	1,948,695	25.50%	5,301,763	69.38%
1986	7,883,543	2583	501,225	3,881,856	49.24%	2,733,012	34.67%	6,614,868	83.91%
1987	8,137,590	2576	534,337	4,295,207	52.78%	2,481,227	30.49%	6,776,434	83.27%
1988	8,404,858	2581	566,506	4,520,302	53.78%	2,403,201	28.59%	6,923,504	82.38%
1989	8,686,156	2579	627,312	4,856,302	55.91%	2,427,044	27.94%	7,283,346	83.85%
1990	8,982,355	2592	667,817	5,282,443	58.81%	2,644,298	29.44%	7,926,742	88.25%
1992	9,805,001	3311	914,422	6,624,721	67.56%	2,667,121	27.20%	9,291,842	94.77%
1993	10,587,703	4059	999,994	7,666,246	72.41%	2,870,895	27.12%	10,537,141	99.52%
1995	11,641,983	4447	1,176,539	9,019,708	77.48%	2,459,001	21.12%	11,478,709	98.60%
1997	13,378,109	4797	1,283,513	10,039,905	75.05%	2,184,019	16.33%	12,223,924	91.37%
2000	15,030,486	5247	1,486,391	11,514,248	76.61%	2,506,442	16.68%	14,020,690	[illegible].28%

Service Area Pop'n Figures fr. 1984-1991 NCR,Cav-5,Riz-5u/r; On 1992 NCR,Cav-5,Riz-5,Bul-2u/r; On 1993-94 NCR,Cav-5,Bul-2,Riz-14u/r;On 1995-96 NCR,Cav-5,

Table 3.2.3 NOTICEABLE (WATER-BORN) DISEASES WITHIN NCR

Unit: Number/100,000 pop.

YEAR	AREA	CHOLERA EL TOR		TYPHOID & PARATYPHOID FEVER & OTHER SALMONELLA INFECTIONS		DIARRHEAS	
		CASES	DEATH	CASES	DEATH	CASES	DEATH
1985	TOTAL	0	0	697	131	18543	1133
	1ST DIST. MUN. MANILA CITY	0	0	80	53	3766	241
	2ND DIST. MUN.	0	0	20	14	786	197
	QUEZON CITY	0	0	160	24	3014	227
	3RD DIST. MUN.	0	0	60	3	3136	136
	CALOOCAN CITY	0	0	12	4	1270	75
	4TH DIST. MUN.	0	0	51	18	2704	221
	PASAY CITY	0	0	314	15	3867	36
1986	TOTAL	0	0	884	79	20490	800
	1ST DIST. MUN. MANILA CITY	0	0	453	25	5083	154
	2ND DIST. MUN.	0	0	44	18	639	109
	QUEZON CITY	0	0	166	16	3917	190
	3RD DIST. MUN.	0	0	13	3	2844	100
	CALOOCAN CITY	0	0	15	1	2271	58
	4TH DIST. MUN.	0	0	161	9	2539	166
	PASAY CITY	0	0	32	7	3197	23
1987	TOTAL	0	0	820	105	24872	780
	1ST DIST. MUN. MANILA CITY	0	0	437	31	4747	192
	2ND DIST. MUN.	0	0	47	25	2115	109
	QUEZON CITY	0	0	217	23	5503	177
	3RD DIST. MUN.	0	0	7	0	4341	79
	CALOOCAN CITY	0	0	12	3	2212	54
	4TH DIST. MUN.	0	0	87	19	2414	143
	PASAY CITY	0	0	13	4	3341	26

SOURCE: Philippine Health Statistics
Health Intelligence Service Dept. of Health

CHAPTER 4 EXISTING WATER SUPPLY FACILITIES OF MWSS

4.1 Raw Water Sources

The present raw water sources of MWSS are surface water and groundwater which contribute 96.3% and 3.7% of the supply, respectively.

Surface water, the major water source comes from the Angat Dam and the Ipo Dam, which comprise the Angat-Novaliches Water Supply System. The system was originated in the characteristics of a whole water flow by the force of gravity from sources to the treatment plant through the Angat dam, the Ipo dam, the Bicti headworks, and the La Mesa dam. Thereafter, it is channeled to the Balara Water Treatment Plant and the La Mesa Water Treatment Plant No. 1. After treatment, it is then distributed to Metro Manila through 15 distribution reservoirs. A schematic diagram of the Angat-Novaliches Water Supply System is shown in Fig. 4.1.1.

Groundwater source comprise of 3,000 wells most of which are privately owned. Out of which, MWSS manages 220 wells and 120 wells are presently operational. Well water is directly delivered to the consumer after chlorination.

4.1.1 Angat Reservoir

The Angat reservoir formed by the Angat dam is a huge semi-elliptical loop 35 km long and 3 km at its widest section with a storage capacity of 850 million m^3, receiving runoff from its 568 km^2 watershed. The water level changes between Max. Pool El. 217 and Extreme Min. Pool El. 160. The dam, managed by the National Power Corporation, stores water to be used by MWSS and also to be used in power generation and irrigation. Water from the Angat reservoir is discharged through the power plant to the Angat river which flows into the Ipo dam. MWSS allocation from the Angat reservoir is 1,900,000 m^3/day.

4.1.2 Ipo Dam

Another major source of water for MWSS is the Angat-Ipo river watershed with an area of 66 km^2 from which the Ipo dam collects a storage capacity of 5.9 million m^3. Max. Pool El. is 100, while the poundage is controlled by the discharge from the Angat dam. The Ipo dam is utilized and managed solely by MWSS.

4.1.3 Ipo Dam to Bicti Headworks

From the Ipo dam, water is drawn by 2 tunnels 6.4 km long and flows by gravity to the Bicti Headworks. Tunnel No. 1 was constructed in 1939 with a capacity of 0.76 million m^3/day and Tunnel No. 2 was constructed in 1969 with a capacity of 1.89 million m^3/day with the Ipo dam at maximum pool level.

4.1.4 Bicti to La Mesa Dam and La Mesa Plant

From the Bicti Headworks, 4 aqueducts deliver a total of 2.46 million m^3/day to the La Mesa Dam.

Bicti-Novaliches Aqueduct No. 1 and Aqueduct No. 2, 15.1 km long and connected to each other, were constructed in 1939 and 1948, respectively with a capacity of 380,000 m3/day. Bicti-Novaliches Aqueduct No. 3, 15 km long, was constructed in 1969 with a capacity of 830,000 m3/day. Aqueduct No. 4, 16.5 km long, was constructed in 1983 to deliver a capacity of 1.25 million m^3/day directly to the La Mesa Plant No. 1 bypassing the La Mesa reservoir.

At the outlet to the reservoir Aqueduct No.4, an overflow and a diversion weir is provided, where the flow is diverted into an open channel and then conveyed to the La Mesa Plant No. 1. This capacity is variable and may be increased up to 1.79 million m^3/day by manipulating flow capacity of the Bicti-Novaliches Aqueduct No. 1, No. 2, and No. 3.

4.1.5 La Mesa Reservoir (Novaliches Reservoir)

The artificial lake forming the La Mesa reservoir was created by constructing the 300 m long, 30 meters high La Mesa dam across the La Mesa reservoir in 1929. The reservoir which received runoff from its

25.7 km^2 watershed has a total storage capacity of 45.42 million m3 attained by raising the spillway crest as well as the dam and dikes in 1959. The surcharge level is El. 79.7 and the lowest withdrawable level is El. 64. To maintain raw water quality at the reservoir, copper sulfate is occasionally applied for algae control.

4.1.6 La Mesa (Novaliches) Reservoir to the Balara Plant

A total combined capacity of 1.705 million m^3/d is conveyed from the La Mesa reservoir to the Balara Plant through three aqueducts.

The first intake tower connected with Aqueduct No.1 was constructed in 1929 to deliver raw water with a capacity of 470,000 m^3/d to Sedimentation Basin No.1 & No.2 of Plant No.1. Aqueduct No. 1 is also connected to a bypass around the La Mesa reservoir which can be utilized to divert the flow from Bicti-Novaliches Aqueduct No. 1 and No. 2 directly to the Balara Plant.

The second intake tower connected with Aqueduct No. 2 was constructed in 1956 to deliver raw water to Accelerators with a design capacity of 190,000 m^3/d. A total capacity of the Aqueduct No. 1 and No. 2 is 565,000 m^3/d.

The third intake tower connected with Aqueduct No. 3 was constructed in 1968 with a capacity of 1.14 million m^3/d. Plant No. 2 with a design capacity of 1.13 million m^3/d receives water from Aqueduct No. 3.

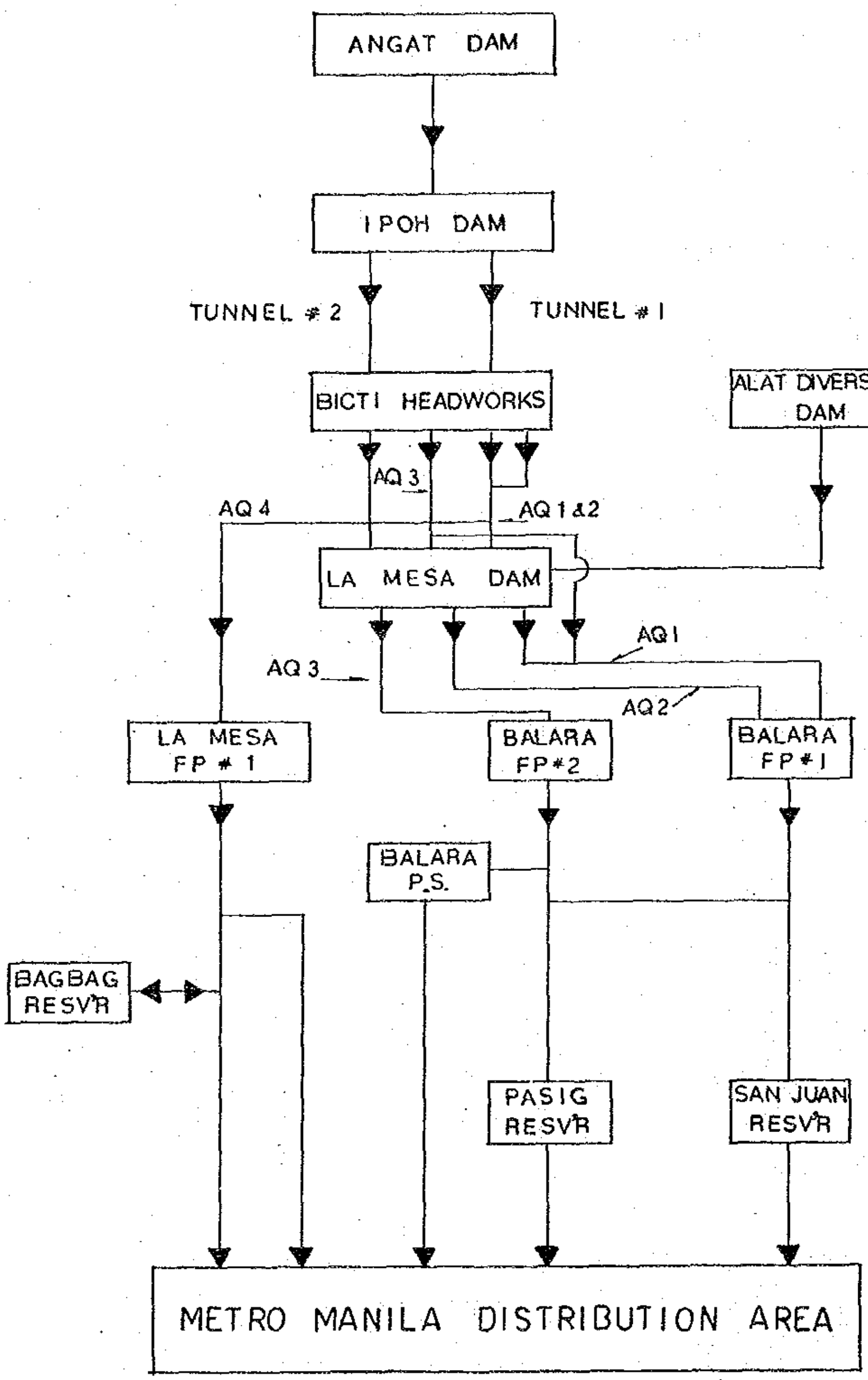


Fig. 4.1.1
ANGAT-NOVALICHES WATER SUPPLY SYSTEM

4.2 Water Treatment Facilities

MWSS supplies potable water to Metro Manila through two large water treatment plants, the Balara Plant and the La Mesa Plant, with the Angat-Novaliches Water Supply System as source of supply. The Balara Plant and the La Mesa Plant have a current design capacity of 1.6 and 1.5 million m^3/d, respectively and a total capacity of 3.1 million m^3/d. Besides this situation, the La Mesa No.2 Plant are under construction from the beginning of year 1991.

4.2.1 The Balara Plant

At present, the Balara Plant consists of two separate treatment system including common use of chemical and chlorine feeding facilities, an old plant (Plant No. 1) and a new plant (Plant No. 2). Both of plants have particulars of expansion and/or upgrading as shown hereunder.

The original treatment plant was constructed in 1935 with a design capacity of 190,000 m^3/d (50 MGD) to ultimate increasing capacity of 300,000 m^3/d (80 MGD). It was a part of Plant No. 1, which utilized horizontal flow sedimentation and rapid sand filtration systems.

Aluminum sulfate as coagulant was applied by dry feeder proportionate to the volume of water treated as measured by a venturi meter installed on the aqueducts from the La Mesa reservoir. Coagulated water was introduced to two plain sedimentation basins where the passing velocity is reduced to 0.8 m/min and the detention time was approximately 4 hours. Settled water at the tail end of the basins was drawn on to the rapid sand filter beds of sand with 75 cm depth. The filter consisted of 10 units with an area of 162 m^2 each. In normal operation, the filtration rate was 117 m/d. Filter washing was normally conducted every 24 to 40 hours depending on the character of the raw water.

The plant was originally equipped with an aeration system beside the filter beds where the water after being filtered was aerated. However it is now used as a storage tank for the filter washwater recovery. Aeration is reported to remove corrosive carbon dioxide gas and foul and odoriferous oils from the filtered water.

With the increase in demand, two Accelerator units with a capacity of 95,000 m^3/d (25 MGD) each were expanded as a part of Plant No. 1. to enhance pretreatment processes in 1958. Correspondingly, filtration velocity was doubled to be 234 m/d by replacing the filter rate-of-flow controller. Thereafter, total capacity of Plant No. 1 was 380,000 m^3/d.

Likewise, a part of Plant No. 2 was constructed in 1958 and was used occasionally as a direct filtration system consisting of only conveyance facility and 12 filter beds with an area of 162 m^2 each. Applied filtration rate was 234 m/d, giving a total plant capacity of 454,000 m^3/d (120 MGD). Applied depth of sand layer was 60 cm which was different from Plant No. 1, while the other functional figures such as effective size and uniformity coefficient of sand were almost the same as Plant No. 1.

In 1965, 7 years after completion of the 12 filters, pretreatment facilities were completed, equipped with a parshall flume for chemical mixing and flow measurement, mechanical flocculators and 6 sedimentation basins, while new chemical feeding facilities were placed in operation in 1967. These facilities provided 30-minute flocculation period and 2.4-hour sedimentation time at a design flow of 380,000 m^3/d (100 MGD).

Another pretreatment facility with a design capacity of 380,000 m^3/d (100 MGD), was then expanded in 1968. Additional 8 filters was constructed in 1970 to complete a total design capacity of 760,000 m^3/d (200 MGD).

A series of expansion work was undertaken until 1981 when the major modification and addition was conducted as shown in item 7.2.

4.2.2 The La Mesa Plant

The La Mesa Plant was constructed in 1985 under the Manila Water Supply Project II (MWSP II) with a capacity of 1.5 million m^3/d (extreme hydraulic capacity of 170 million m^3), designed to provide sufficient water supply to the growing water population of Metro Manila up to 1987. Raw water is supplied to the plant by Aqueduct No.4 from the Bicti Headworks.

Horizontal flow sedimentation and rapid sand filtration systems utilized in the same manner as the Balara Plant, comprise 2 units of rapid mixing basins, 12 units of flocculators, 24 beds of filters and chemical feeding facilities. A sludge treatment system with 4 basins of sludge lagoon was employed, and pH adjustment facilities were added for pH control of raw water. Two pre-treatment systems operate separately namely North Treatment Plant and South Treatment Plant.

Although the plant has sufficient hydraulic capacity, actual production capacity in 1990 was limited to about 1.04 million m3/d on the average due to constraints in the capacities of raw water conveyance facilities and the Bagbag distribution tank.

Outline of the treatment system is as follows:

1) Rapid Mixing:
   Vertical mechanical mixers
2) Flocculation:
   Vertical mechanical flocculators with 20-minute detention time
3) Sedimentation:
   Plain sedimentation with 80-minute detention time and 5.6 mm/min of surface loading
4) Filtration:
   Dual media of filters with 348 m/d filtration velocity, providing with surface and backwash facilities
5) Lagoon: Total area of 50,000 m^2
6) Chemicals and chlorination:
   Liquid alum of 50% solution as coagulant
   Polymer (anion, cation) as coagulant aids

Lime for pH adjustment

Liquid chlorine as disinfectant

(Notes): Although fluoride facilities were provided with the original plant, however, these are not in operation. The same situation exists in the Balara Plant.

4.3 Distribution Facilities

The water distribution facilities of the MWSS has been undergoing a series of expansion and rehabilitation under the MWSP I and II, MWSRP I and II, MMWDP, and AWSOP to meet the increasing demand in Metro Manila.

The existing MWSS distribution facilities are shown in Tables 4.3.1, 4.3.2 and 4.3.3 based on the PRELIMINARY ENGINEERING REPORT - WATER DISTRIBUTION SYSTEM, Vol. I - TEXT, November 1989, ANGAT WATER SUPPLY OPTIMIZATION PROJECT. For the location of these facilities, refer to Fig. 2.2.1.

Table 4.3.1 MWSS EXISTING PDS MAINS (1989)

PIPE SIZE	PIPE LENGTH (km)		
(mm)	PRE-MWSP II	MWSPII/MMWDP	TOTAL
300	86	20	106
400 - 1500	195	119	314
1525 - 1650	11	-	11
2000 - 2600	7	16	23
2800 - 3000	-	15	15
2100 - 1800(Tunnel)	3	-	3
T O T A L	302	170	472

Notes : PDS shows primary distribution system.
MMWDP shows Metro Manila Water Distribution Project.

The distribution facilities include 472 km of main pipelines, 15 reservoirs with a total storage capacity of 650,000 m3 and 13 major pumping stations. However, 6 reservoirs were not utilized in 1991 due to the breakdown of the pumping facilities and leakage problems on the reservoir structures. Likewise, only 9 pumping stations are presently operating.

Table 4.3.2 MWSS EXISTING RESERVOIRS (1991)

Item No.	Location	DIMENSIONS (m) Length	Width	Diameter	Depth	CAPACITY (ML)	ELEVATION (m) Floor	Overflow	PUMPED OR GRAVITY	STATUS
1	Caloocan	-	-	52.0	9.3	19	25.40	34.40	Pumped	Not utilized
2	D. Tuazon	-	-	52.0	9.3	19	20.20	29.20	Pumped	- do -
3	Tondo	-	-	52.0	9.3	19	12.83	21.83	Pumped	- do -
4	Algeciras	108	27	-	15.15	38	12.80	26.80	Pumped	- do -
5	Balara *	-	-	52.0	9.5	19	43.85	51.65	Pumped	- do -
6	Pasig *	120	96	-	9.5	80	40.29	48.00	Pumped	Utilized
7	Ermita *	-	-	52.0	9.3	19	12.65	21.65	Pumped	- do -
8	Bapiritu	-	-	52.0	9.3	19	12.78	21.78	Pumped	Not utilized
9	Pasay	-	-	52.0	9.3	19	13.30	22.30	Pumped	Utilized
10	Makati *	-	-	52.0	9.3	19	23.70	32.70	Pumped	Not utilized
11	Port Bonifacio	-	-	69.0	9.0	30	39.75	47.55	Pumped	Utilized
12	San Juan I *	92	86	-	8.0	56	43.50	51.40	Pumped	- do -
13	San Juan II*	132	107	-	6.7	94	44.70	51.40	Gravity	- do -
14	Bagbag I	168	114	-	9.0	100	65.00	71.00	Gravity	- do -
15	Bagbag II	168	114	-	9.0	100	65.00	71.00	Gravity	- do -

TOTAL : 650 ML

Note : Those reservoirs with (*) belong to the Balara Water Supply system.

Table 4.3.3. MWSS EXISTING PUMP STATIONS (1991)

Item No.	Pump station	Type of pumps	Number and capacity of pumps	Status (As of Feb. 1989)
1	Algeciras	Booster Storage	3-200 HP 2-225 HP	Decommissioned
2	Caloocan	Booster Storage	2-200 HP 3-225 HP	- do -
3	D. Tuazon	Booster Storage	3-200 HP 3-225 HP	- do -
4	Tondo	Booster Storage	2-200 HP 3-225 HP	- do -
5	Espiritu	Booster Storage	3-200 HP 3-225 HP	Not Operating
6	Makati *	Booster Storage	2-300 HP 2-225 HP	- do -
7	Balara *	Booster Storage	7-500 HP 1-250 HP	Operating
8	Cubao *	Booster Storage	4-200 HP ----	- do -
9	Ermita *	Booster Storage	2-225 HP 3-200 HP	- do -
10	Fort Bonifacio	Booster Storage	4-350 HP ----	- do -
11	Pasig *	Booster Storage	---- 5-375 HP	- do -
12	Pasay	Booster Storage	2-200 HP 2-225 HP	- do -
13	San Juan *	Booster Storage	6-500 HP 1-250 HP	- do -
14	Novaliches (Mini)	Booster Storage	---- 3-20 HP	- do -
15	Capitol Bliss (Mini)	Booster Storage	2-40 HP ----	- do -

Notes:

(1) Source : Pumping Station Monthly Operation report for the Month of Feb. 1989, MWSS

(2) Those pump stations with (*) belong to the Balara Water Supply System

CHAPTER 5 PRESENT FINANCIAL SITUATION

This chapter briefly discusses selected indicators of financial efficiency over the period between 1991 & 2000, shows projected cash flow of MWSS, and indicates a cash flow problem in the coming decade.

At present, daily water production amounts to 2,580,000 m^3/d, out of which the Balara contributes 60% of total production. This level of production is expected to increase up to 5,240,000 m^3/d by year 2000.

Approximately 55% of the water distribution is unbilled due to leakages, theft, and water meter malfunctioning. MWSS projects that billing efficiency defined as the volume of water billed divided by the volume of water distributed, is expected to increase from the current level of 45% to 65% by year 2000.

On the other hand, collection efficiency defined as the ratio of total collection to total billing, is 73%, and is expected to decrease to 63% by year 2000.

When billing efficiency multiplied by collection efficiency gives revenue efficiency. This efficiency is at present 33% and is expected to increase to 41% by year 2000.

As indicated in Table 5.1.1, water revenue will continue to increase from the current level of 1,698 million pesos to 4,287 million pesos by year 2000. This indicates substantial increase of water revenue.

Still another important indicator of employee efficiency, measured as the number of employees per 1000 water connections shows a remarkable improvement. The number of employees was ten in 1991, and is expected to decrease to 5.7 persons by year 2000.

Table 5.1.1 SELECTED EFFICIENCY INDICATORS

Year	1991	1996	2000
Daily water production (M m^3)			
(1) Balara	1.35	1.35	1.35
(2) La Mesa	1.15	1.15	1.15
(3) Other	0.08	1.79	2.74
Total	2.58	4.29	5.24
Annual water production (M m^3)	941.7	1565.9	1912.6
Billing Efficiency (%)	45	62	65
Collection Efficiency (%)	73	66	63
Revenue Efficiency (%)	32.9	40.9	40.9
Water Revenue (M pesos)	1697.8	3509.6	4286.7
Employees per 1000 Connections	10.0	6.8	5.1

Source : Financial Projection, Corplan of MWSS, Oct. 24, 1991.
Revenue efficiency = Billing efficiency x Collection efficiency
Water Revenue = Annual water production x Revenue efficiency x 5.48 pesos/m^3

Table 5.1.2 PROJECTED FINANCIAL DATA (million pesos)

Year	1991	1995	2000	2010	2013
(1) Total Revenue	3397	6813	11114	16635	18712
(2) Total Expenditure	5959	7695	13728	29639	37337
(3) Financing Requirement	2562	882	2614	13004	18624
(4) External Finance	711	1106	-98	1508	1899
(5) Domestic Finance	1099	-220	-8	754	949
(6) Net Cash	-752	4	-2720	-10741	-15776

Source : Data from 1991 to 2000 were taken from Financial Projection by Corplan of MWSS, Feb.6, 1992.

Water revenue is part of the total revenue. Table 5.1.2 shows six major categories of financial data: (1) total revenue, (2) total expenditure, (3) financing requirement (equal to (2)-(1)), (4) external finance, (5) domestic finance, and (6) net cash (equal to (3)-(4)-(5)).

Operating revenue and other revenue are assumed to increase at 4% from year 2001. Current expenditure will increase at 8% while capital expenditure at 3.6% from year 2001 and beyond. External finance will be 10% of capital expenditure while domestic finance, 5% of capital expenditure from year 2001 and beyond.

The net cash flow of MWSS is negative in 1991, and will continue to be negative for the entire project period between 1993 and 2013. Only three positive figures in column (12) of Table 13.7.4 are minor and temporally and will not contribute to the financial well-being.

CHAPTER 6 OUTLINE OF RELATED PROJECTS

Purposes of this chapter are to establish the status of the present water supply system and to put in perspective the role of the Balara plant.

For the above purposes related projects are listed as follows:

1) Angat Water Supply Optimization Project
2) Study for the groundwater Development in Metro Manila
3) Manila Water Supply Rehabilitation Project I
4) Manila Water Supply Rehabilitation Project II

(1) Angat Water Supply Optimization Project

Aimed to increase the supply capacity of the System, AWSOP came into picture as an interim project prior to the implementation of MWSP III. It is expected that after the completion of the project, MWSS would avail of an additional water right from Angat Reservoir by as much as 15 m^3/s. Under this project, it is also programmed that the available flow of at least 9 m^3/s. from the adjacent Umiray River would be diverted to Angat Reservoir. The project will benefit 3.6 million customers at a cost of 6.7 billion Pesos.

The project implementation program is based into three major stages as follows:

1) Stage I : The pre-feasibility study to confirm the availability of additional water from Angat Reservoir for MWSS.
2) Stage II : The detailed project feasibility study to establish the technical, economic and financial viability of withdrawing additional water from Angat Reservoir.
3) Stage III: The preliminary and detail engineering design of all conveyance structures, and hydroelectric powerhouse.

The components of the project include the following:

1) Construction of 6.4 km tunnel with 4.3 meter diameter

2) Construction of 16 km aqueduct with a 3.6 meter diameter
3) Expansion of La Mesa Water Treatment Plant (900,000 m^3/d capacity)
4) New Distribution Networks (240 kms of primary lines, 1,200 kms of secondary lines, 330 service connections and a La Mesa by-pass)
5) Renovation/Impronement of Angat Reservoir

The project entails an estimated investment cost of around 6.7 billion Pesos and expected to be completed by 1996.

The Angat Water Supply Optimization Project I (AWSOP I) is a major component of the comprehensive water supply development project of the Angat dam reservoir projected to harness an additional 15 m^3/S from the Angat dam after a first use by the National Power Corporation to generate power. AWSOP I is composed of two major components, a transmission tunnel and an auxiliary power plant. According to "1990 ANNUAL REPORT OF MWSS", under Contract T-3 for the Ipo-Bicti Transmission Tunnel No. 3 the completion of the tunnel was pegged at 33.81%, while overall accomplishment for the whole project to include the tunnel and the power plant was pegged at 13.77%

(2) Study on the Metro Manila Groundwater Development Project

This study was commenced from August of 1990 under JICA assistance in response to the request of the Philippines Government. The study area covers the MWSS Service Area and the area comprised of five cities and thirty two municipalities.

The study aims at achieving the following four objectives:

1) To formulate a plan for the rehabilitation, operation, maintenance and development of MWSS supervised wells in the MWSS Service Area.
2) To evaluate the groundwater resources potential and formulate a groundwater development plan in Antipolo.
3) To study a solution or remedial measure and preventive scheme for the area with intense saline water intrusion.
4) To formulate a plan for establishment of groundwater monitoring system in Metro Manila.

Final Report will be submitted at the end of May of 1992.

(3) Manila Water Supply Rehabilitation Project I (MWSRP 1)

This on-going project covers 56 zones (8,872 hectares) of the MWSS service area with an estimated cost of 1832.91 million Pesos and scheduled to be completed by the year 1991. It aims to reduce non-revue water, replace 150 kms tertiary lines, install 280 public faucets, construct 50kms new tertiary lines, replace 108,000 house service connection and relocate 12,000 water meters. The project also targets to recover 500 million liters of unaccounted water. When completed about 1.56 million population will benefit from this project at cost of 1.4 billion Pesos.

According to 1990 ANNUAL REPORT OF MWSS, overall project accomplishment for the year was 86.35%. Estimated volume of non-revenue water (NRW) recovered during the year reached 39,746 m^3/d, thus bringing up total recovered NRW to 261,348 m^3/d.

(4) Manila Water Supply Rehabilitation Project II

With same objectives as that of MWSRP I, MWSRP II was introduced and scheduled to be completed within 5 year period (1988 - 1992) at an estimated cost of 1,376 million Pesos. This project covers another 9,000 hectares within 52 zones which MWSRP I does not cover. It aims to further recover 247 million liters per day of uncounted water benefiting anew 2.6 million population of the South-Eastern part of Metro Manila. The project will replace 100 kms of tertiary lines, install 285 public faucets and replace 87,000 water meters.

According to "1990 ANNUAL REPORT OF MWSS", as of the end of the year 1900, total volume of recovered water from the three completed zones (ZR-22, 44, and 66) was 6,347 m^3/d, while the total volume of measured from 38 zones was 390,170 m^3 with an average of 58.16%. Under this project, the total number of house service connections completed was 8,133, serving an equivalent 65,064 persons. Total length of pipeline laid out during the year was 70,369.62 linear meters. Over all project completion was pegged at 35.37%.

CHAPTER 7 PRESENT CONDITIONS OF THE BALARA PLANT

7.1 The Role of the Balara Plant in the Whole System

The service area of MWSS has been expanded to more than 1500 square kilometers, covering five cities and twenty two towns, stretching from Metro Manila to Rizal and Cavite provinces. By the end of the decade, the MWSS intends to expand to the Lungsod Silangan and other outlying areas.

Under these conditions it was reported at the end of September 1991 that the population directly served by MWSS was 6,110,000 residents and those indirectly served was estimated to be 3,020,000, totaling to about 9,130,000 residents served. The increasing ratio of served population in 1990 was indicated to be 9.40%. Corporate Planning Group (CORPLAN) estimates that by the year 2000, the population served will be 14,020,690 persons. Table 7.1.1 below shows the expeditious increase of MWSS water services:

Table 7.1.1 WATER SERVICES OF MWSS IN RECENT YEARS

Year	Population under MWSS (Million)	Connection 1000 (End of Period)	Population served (Directly) Million	Population served (Indirectly) Million (40% NRW)	Total
1984	7.425	371,641	3.10	1.36	4.46
1985	7.656	438,282	3.58	1.96	5.55
1986	7.898	501,225	4.15	2.74	6.89
1987	8.153	534,377	4.57	2.49	7.05
1988	8.421	566,506	4.75	2.38	7.13
1989	8.703	627,312	5.09	2.40	7.49
1990	9.133	667,818	5.58	2.65	8.23
Sep'91	10,008	701,019	6.11	3.02	9.13

In order to meet the rapidly increasing demand, MWSS has been intensifying water production as seen in the following table.

Table 7.1.2 WATER PRODUCTION OF MWSS IN RECENT YEARS

Year	Water Production (Million M^3) Surface	Ground	Total
1984	642.2	25.6	667.8
1985	757.4	29.5	786.8
1986	874.1	30.4	904.5
1987	834.8	27.4	862.6
1988	849.3	29.5	878.8
1989	859.1	29.0	888.1
1990	857.8	33.3	909.1

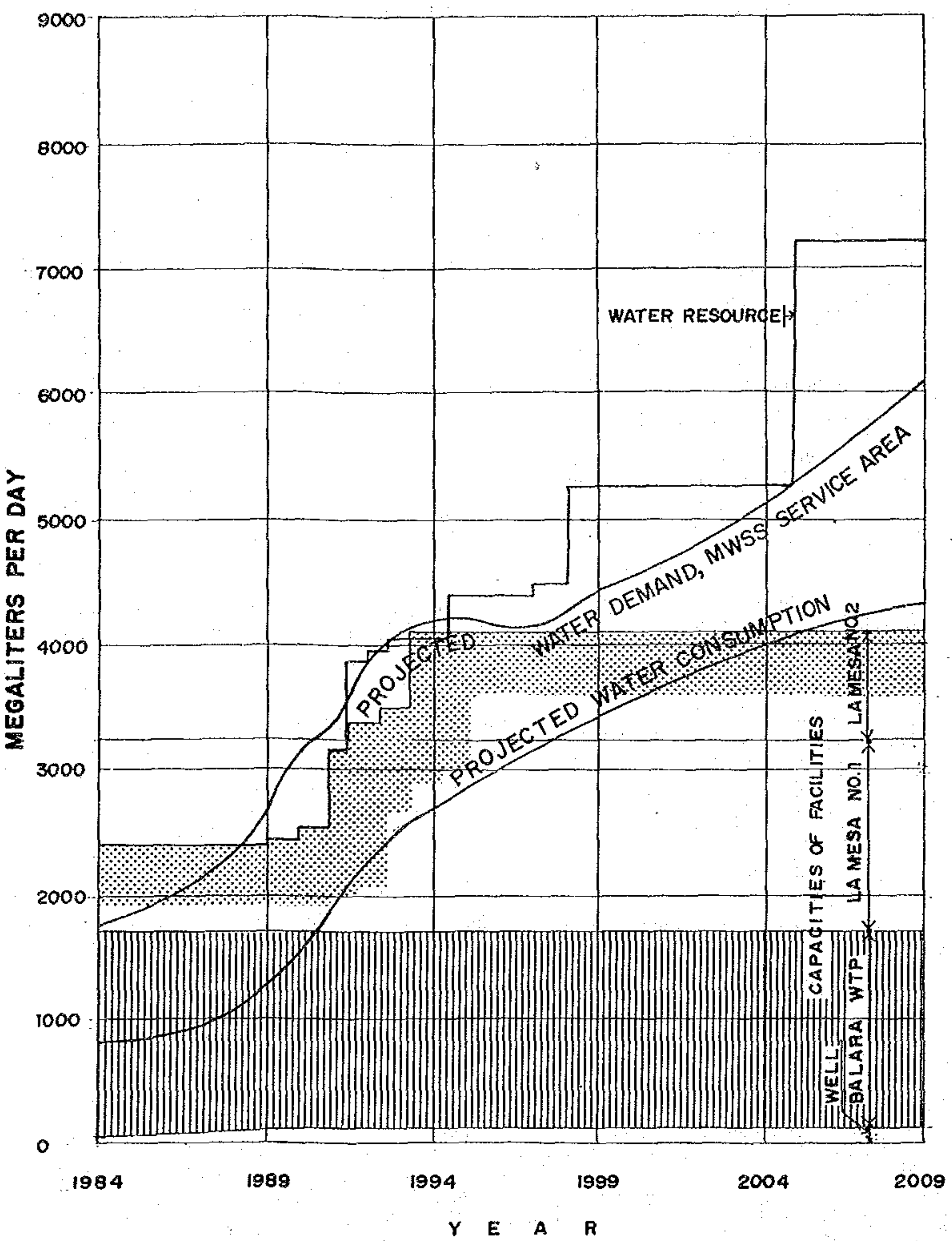
Under the present situation,the MWSS is exerting all efforts to maintain water production at its treatment capacity. The capacity of the Balara Plant is 1.60 million m^3/day while the La Mesa capacity is 1.50 million m^3/day. As the preceding figures show, the output of the Balara Plant is 51.60% of the total production of the two treatment plants, showing the important role of the Balara Plant in the MWSS system. (Actual production in September 1990 of the La Mesa Plant was recorded at 105 million m^3/day for the Balara Plant indicating a 60% share in the total production output)

After the completion of La Mesa No. 2, its capacity will increase by 0.90 million m^3/day. Even at this stage, the Balara Plant still performs a major function since it will be supplying 40% of the total water production.

After the year 1997, as shown in Fig. 7.1.1 construction of an additional plant will be necessary to cope with the ever increasing water demand. Also to be taken into consideration are the number of years required for land acquisition, design, fund allotment and

actual construction. In view of this, the performance of the Balara Plant will have to be maintained on a long-term basis.
Therefore the rehabilitation of the Plant is of paramount importance and its implementation is urgent. In addition, the on-going project of AWSOP-OECF expects a lasting role of the Balara Plant as shown in Fig. 7.1.2.

The distribution pipelines of the Balara and the La Mesa service areas are interconnected only at the Manila South portion. It is evident that a wide area of Quezon City, Cubao & Makati area is solely serviced by the Balara Plant (Refer to Fig. 2.2.1 Balara Service Area). It would certainly be unthinkable of what would happen if and when the Balara Plant suddenly ceases to operate due to simultaneous breakdown of superannuated facilities. The proposed rehabilitation plan promptly offers vital solutions to the Plants' urgent problems.



SOURCE ; PPD

Fig. 7.1.1
WATER SUPPLY AND DEMAND PROJECTION (AS OF MAY 1991)

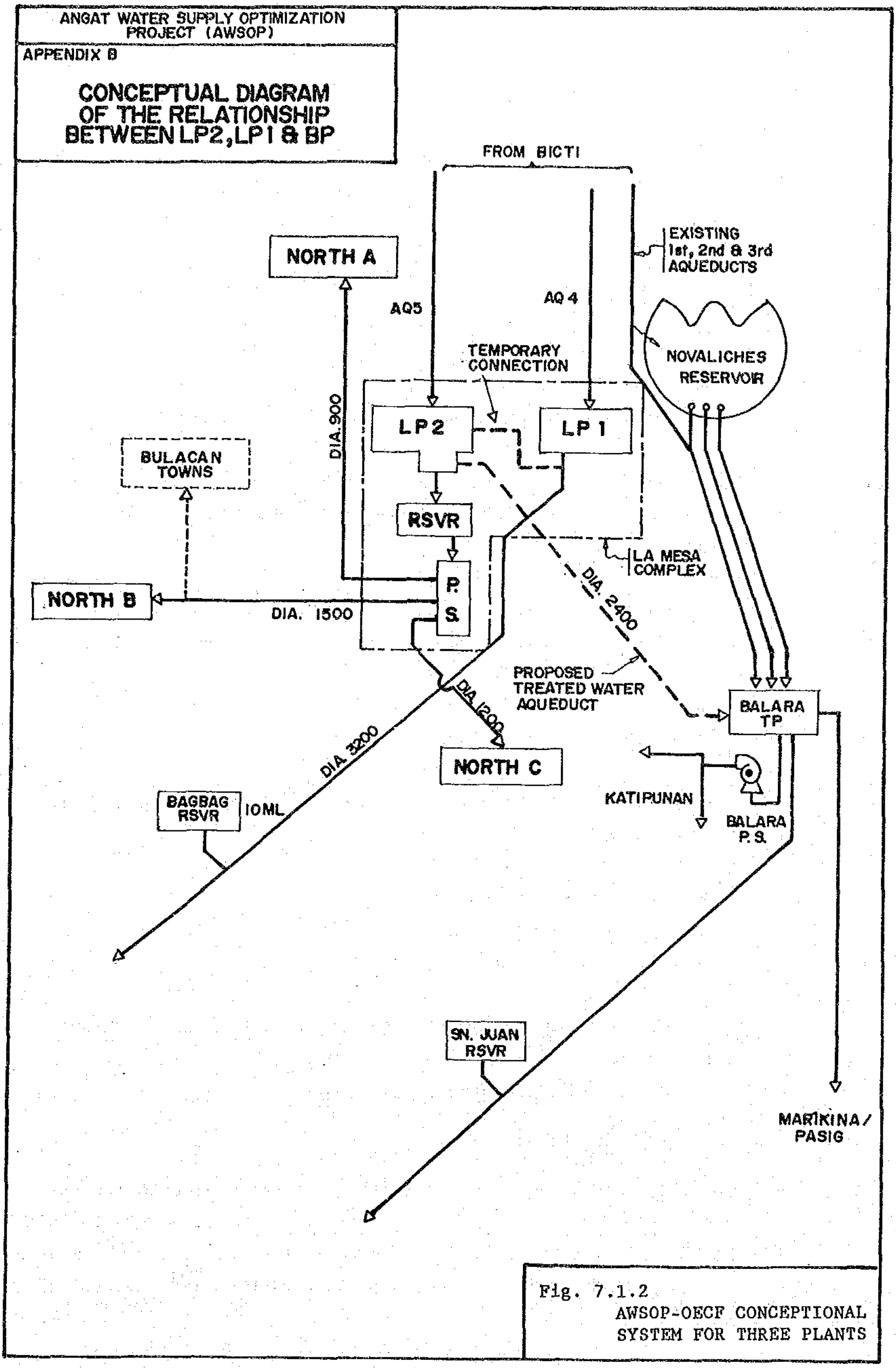


Fig. 7.1.2
AWSOP-OECF CONCEPTIONAL SYSTEM FOR THREE PLANTS

7.2 Outline of the Balara Plant

In 1981, Plant No. 1 was upgraded to a capacity of 470,000 m^3/d. The major modifications in the upgrading are as follows:

a.	rapid mixer	1 unit X 2 basins
b.	flocculation	12 units X 2 basins
c.	high rate dual media for filter	10 units
d.	fixed grid surface wash system	10 units
e.	flow control unit for filter	10 units
f.	washwater recovery pump	3 units

In the same period in 1981 as Plant No. 1, Plant No. 2 was upgraded to a capacity of 1,130,000 m^3/d. The major modifications in 1981 are as follows:

g.	high rate dual media for filter	20 units
h.	fixed grid surface wash system for filter	20 units
i.	flow control unit for filter	20 units
j.	washwater recovery pump	3 units

As common facilities of Plant Nos. 1 & 2, the following facilities were installed:

k. alum dosing facilities
l. polymer dosing facilities
m. chlorination facilities

General plot plan of the existing Balara Plant is shown in Fig.7.2.1, the flow diagram of Plant No. 1 and Plant No. 2 are shown in Fig. 7.2.2 and Fig. 7.2.3, respectively. Outline of facilities is shown in Table 7.2.1.

At present, Plant No. 1 consists of 2 units of sedimentation basins and 2 units of Accelators as pre-treatment facilities, and 10 units of high rate dual media filters, while Plant No. 2 consists of 2 units of parshall flume, 12 units of flocculation and sedimentation basins and 20 units of high rate dual media filters.

7.2.1 PLANT NO. 1

The following is a description of the present condition of Plant No.1:

(1) Horizontal Flow Sedimentation Basin

In both Sedimentation Basins No. 1 and No. 2, separation walls were constructed at the upstream of the sedimentation basins to install one rapid mixer and twelve vertical type of flocculators, respectively during the previous modification works. The applied design criteria was for a velocity gradient of 867 sec^{-1} for the rapid mixer, detention time of 20.2 minutes for the flocculation basin, the velocity gradient of 13-34 sec^{-1} for the flocculator, and surface loading of approximately 24 mm/min for the sedimentation basin. Detention time in basin No.1 and basin No.2 are 2.68 hr and 2.81 hr, respectively. However, due to the size of the basin, the mean passing velocity seems to be at a high level of 1.18 m/min. Liquid alum and polymers are applied as coagulant and coagulant aid, respectively.

(2) Accelator Units

The Accelator is a rectangular tank with a central mixing and flocculation chamber and built-in sludge circulation system. In the lower part of the central chamber, mechanical mixing is done for raw water with alum and settled sludge from a peripheral slit, then the water is introduced to the upper chamber for upflow flocculation. The water with flocs is discharged radially and flocs is settled at the bottom of the tank and the supernatant is collected by launders.

The facilities were designed with a clarification time of 64 minutes and with an upflow rate of 92 mm/min.

(3) Filters

The filtration facilities in the Balara Plant No. 1 are of the constant rate filtration type with effluent rate control system. There are ten beds with a filtration area of 162 m^2 per bed. The filter is a dual media type which consists of a thickness of approximately 500 mm anthracite and 250 mm sand. The design filtration rate is 288 m/day. The flow rate is controlled by the combined operation of venturi tubes and automated hydraulic actuated butterfly valves at the effluent. Filter washing is by a combination of surface wash and backwash. Total control of the filter is done manually at the control panel. Flow rates and losses of head of filters are indicated on the control panels.

7.2.2 PLANT NO. 2

The following is a description of the present condition of Plant No. 2:

(1) Rapid Mixing

Plant No. 2 employs a rapid mixing type of hydraulic jump below the parshall flume. Applied chemicals are the same as Plant No. 1. The velocity gradient of the parshall flume is designed to be 866 sec -1.

(2) Flocculation

The flocculation basins are located in the upstream of sedimentation basins and contain horizontal shaft with paddles type flocculators which are installed in right-angled direction to flow. Detention time of the basins is 20.2 min and the flocculator has velocity gradients ranging from 26 to 31 sec^{-1}. By observing actual operation, it can be seen that one third of the water at the surface directly pass through without certain mixing due to the water depth of 6 meters and the deep installation of the equipment. In addition, the flocculation equipment is worn out through more than 30 years of operation and has many water leakages at the sidewalls where the driving shafts penetrate.

(3) Sedimentation

The sedimentation basins are of the horizontal flow sedimentation type with a detention time of 1.61 hours and surface loading of 52 mm/min. According to some observations, floc passes through the sedimentation basins to filters without sufficient settling due to the probable insufficient floc formation.

(4) Filters

The filtration facilities are of the constant rate filtration type with an effluent flow control. There are twenty beds with a filtration area of 162 m^2 per bed. The filter is a dual media type which consists of approximately 400 mm thick anthracite and 250 mm sand. The average filtration rate is 348 m/day.

Basic operating procedures such as the control of flow rate is almost similar to that of Plant No. 1.

While all the beds of Plant No. 1 have all the facilities under a roof, in Plant No. 2 twelve out of twenty beds are indoors and the remaining eight are located in open space.

7.2.3 Chemical Dosing and Chlorination

In the Balara Plant, liquid alum as coagulant and polyelectrolyte as coagulant aid are used. Fluoridation facilities are also provided but never operated. Coagulant and coagulant aid is ordinarily used throughout the year.

Liquid alum of 50% solution with 8% alumina content is purchased and then delivered by tank lorry and stored in a concrete tank. Thereafter, the alum is measured by dosing equipment (volumetric liquid feeder) and injected by gravity flow. Flow diagram of alum dosing is shown in Fig. 7.2.4.

On the other hand, polymers are purchased in drums and dissolved as the occasion demands. A plunger pump is used for the injection.

Flow diagram of polymer is shown in Fig. 7.2.5.

Due to the relatively high raw water alkalinity (about 50 mg/l) and the low water turbidity, there is low dosage of coagulant and pH value will be stable in good conditions therefore the alkalinity still remains sufficient and the pH value slightly declines.

Chlorination equipment, as shown in the flow diagram of chlorination in Fig. 7.2.6, are installed in the chlorine house. One chlorination room, one container room and one operation room are inside this house. There are two evaporators and four chlorinators in the chlorinator room. There are four platform weighing scales in the container room and some containers are stored in the remaining space of this room. As the storage space is not enough ten-odd containers are left outdoors under direct sunlight. Such a condition should be improved so that the containers can be protected from direct sunlight by providing roofing. Facilities such as neutralizing apparatus are not provided. The structure of the chlorinator room has a good ventilation while the container room has only an exhaust fan installed.

7.2.4 Washwater Recovery and Sludge Disposal

The washwater during filter washing in Plant No. 1 is discharged to the washwater recovery tank and returned to Sedimentation Basin No. 2 in the Plant by washwater recovery pump after a few hours of sludge settlement.

The washwater of filter washing in Plant No. 2 and sludge which drains from Sedimentation basins in Plant No. 1 and No. 2, are discharged to the creek in the plant. At the downstream of the creek, flashboards are located and some of the washwater and sludge are introduced to washwater recovery pump and returned to accelators in Plant No. 1.

TABLE 7.2.1 OUTLINE OF PLANT (1/3)

NAME OF PLANT: PLANT NO.1

NAME OF FACILITIES AND SPECIFICATION	Q'TY	NAME OF EQUIPMENT AND SPECIFICATION	Q'TY
Rapid Mixing	2	Rapid Mixer	2
- Concrete structure - channel		- Vertical fixed speed mixer	
- Dimension 2.0m Wx2.8m D		- Dia. of turbine 831 mm	
		- Revolution 104 rpm	
Flocculation Basin	2	Flocculator	24
- Concrete structure with partition		- Vertical variable speed mixer	
- Dimension 32.44m Lx21.25m Wx5.0m D		- Dia. of turbine 838 mm	
		- Revolution 13.7-34.2 rpm	
Sedimentation Basin	2		
- Concrete structure			
- Dimension			
No.1 190.2m Lx21.25m Wx5.0m D			
No.2 199.4m Lx21.25m Wx5.0m D			
Accelator	2	Accelator	2
- Concrete structure		- Dia. of impeller 8.5m	
- Dimension 29.56m x 29.56m		- Drive unit	
x7.1m D		motor 1 pc	
		variable speed gear 1 pc.	
		reduction gear 1 pc.	
		worm reduction gear 1 pc.	
Filter	10	Filter	
- Concrete structure		- Sluice gate and valve	
- Dimension 15.3m Lx(5.3+5.3)m W		Influent sluice gate 600mm dia.	10
- Filter bed 162 m2/bed		Wash drain sluice gate 1,200mm Wx600mm H	10
- Thickness of filter media		Effluent valve 450mm dia.	10
Anthracite 500mm		Washwater valve 800mm dia	10
Sand 250mm		Surface wash valve 450mm dia.	10
Gravel 450mm		Filter drain valve 150/250mm dia.	20
		- Surface wash pipe	
		PVC fixed grid piping	10
Washwater Pumping House	1	Washwater pump	3
- Concrete structure		- Double suction centrifugal pump	
- Dimension 24.4m x 47.42m x 2.0mD		No.1 / No.2 / No.3	
		- Capacity (l/sec) 110 / 117 / 110	
		- Head (m) 33.5 / 21 / 33.5	
		- Motor (kw) 45 / 49 / 45	
Aerator (Recovery Water Basin)	1		
- Concrete structure			
- Dimension			
Recovery Pump Station	1	Recovery Pump	2
- Steel framed structure		- Double suction centrifugal pump	
- Dimension 14m Lx4.7m L		End suction centrifugal pump	
		-Capacity	
		- Head N/A	
		- Motor 45kW/37.3kW	

TABLE 7.2.1 OUTLINE OF PLANT (2/3)

NAME OF PLANT: PLANT NO. 2

NAME OF FACILITIES AND SPECIFICATION	Q'TY	NAME OF EQUIPMENT AND SPECIFICATION	Q'TY
Receiving well - Concrete structure	1		
Parshall flume - Concrete structure - Size of throat 3.658m	2		
Flocculation Basin - Concrete structure - Dimension 16.02m Wx19.25m L x3.5-6.02m D	12	Flocculator - Horizontal fixed speed paddle - Motor 3.7kW (1st / 2nd / 3rd) - Dia. of paddle (m): 2.72 / 3.54 / 3.6 - Length of paddle (m): 3.01 / 3.07 / 3.15 - No. of paddle: 3x4x4 / 2x4x4 / 1x4x4 - Revolution(rpm): 2.83 / 2.12 / 2.12	2
Seddimentation Basin - Concrete structure - Dimension 18.3m Wx73.2m Lx6.77-7.68m D	12	Flushing Pump - End suction centrifugal pump - Capacity N/A - Head N/A - Motor 18.5 kW	12
Filter - Concrete structure - Dimension 15.3m Lx(5.3+5.3)mW - Filter bed area 162 m2 - Thickness of filter media Anthracite 400mm Sand 250mm Gravel 410mm	20	Filter - Sluice gate and valve	
		Influent sluice gate 920mm W x 760mm H	20
		Wash drain sluice gate 1120mm W x 610mm H	20
		Effluent valve 500mm dia.	20
		Effluent control valve 500mm dia.	20
		Washwater valve 1000mmdia.	20
		Surface wash valve 300mm dia.	20
		Filter drain valve 300mm dia.	20
		- Surface wash pipe PVC fixed grit piping	20
Washwater Pumping house - Concrete structure - Dimension		Washwater pump - Double suction centrifugal pump (No.1 / No.2 / No.3) - Capacity: N/A / N/A / N/A - Head: N/A / N/A / N/A - Motor(kW): 94 / 45 / 49	3
Recovery Sump - Concrete structure - Dimension 3.0m Wx19.8m Lx4.9mD			
Recovery Pump Station - Steel framed structure - Dimension 10.5m Wx19.8m L		Recovery Pump - Double suction centrifugal pump - Capacity N/A - Head N/A - Motor 45kw	3

TABLE 7.2.1 OUTLINE OF PLANT (3/3)

NAME OF PLANT: CHEMICAL/CHLORINE HOUSE

NAME OF FACILITIES AND SPECIFICATION	Q'TY	NAME OF EQUIPMENT AND SPECIFICATION	Q'TY
Chemical House	1	Alum Feeder (Rotodip)	6
- Steel framed structure		- Volumetric liquid feeder	
- Dimension 12m Wx(36+18)m L		- Capacity 113-6.813 l/H	
- Area 1st floor 648 m2		- Motor 0.25 KW	
Basement 144 m2			
		Polymer Mixing Tank	4
		- FRP cylindrical tank	
		- Dimension 0 1.7m x 2.0m H	
		- Capacity 4.5 m3	
		Polymer Mixer	4
		- Vertical type	
		- Motor 1.12 kW	
		Polymer Feeder	5
		- Plunger pump	
		- Capacity N/A	
		- Head N/A	
		- Motor 0.37 kW	
Chlorine House	1	Chlorinator	
- Concrete sturcture		- Wet vacuum type	4
- Dimension 12.2m Wx25.4m L		- Capacity 160 kg/h	
		Evaporator	
		- Electric immersion heater type	2
		- Capacity 160 kg/h	
		- Heater 15 kW	
		Booster Pump	3
		- End suction centrifugal	
		- Capacity N/A	
		- Head N/A	
		- Motor N/A	

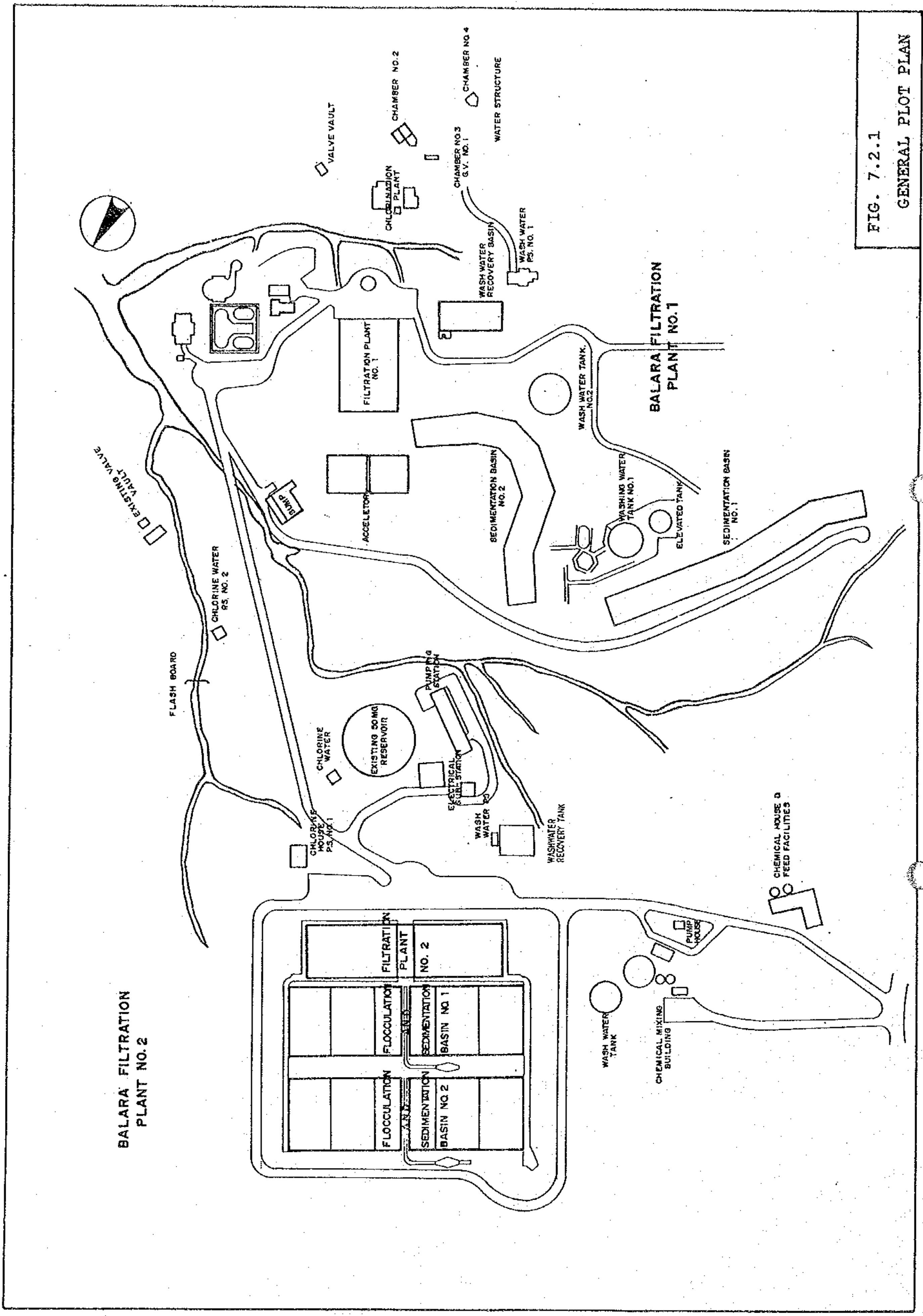


FIG. 7.2.1 GENERAL PLOT PLAN

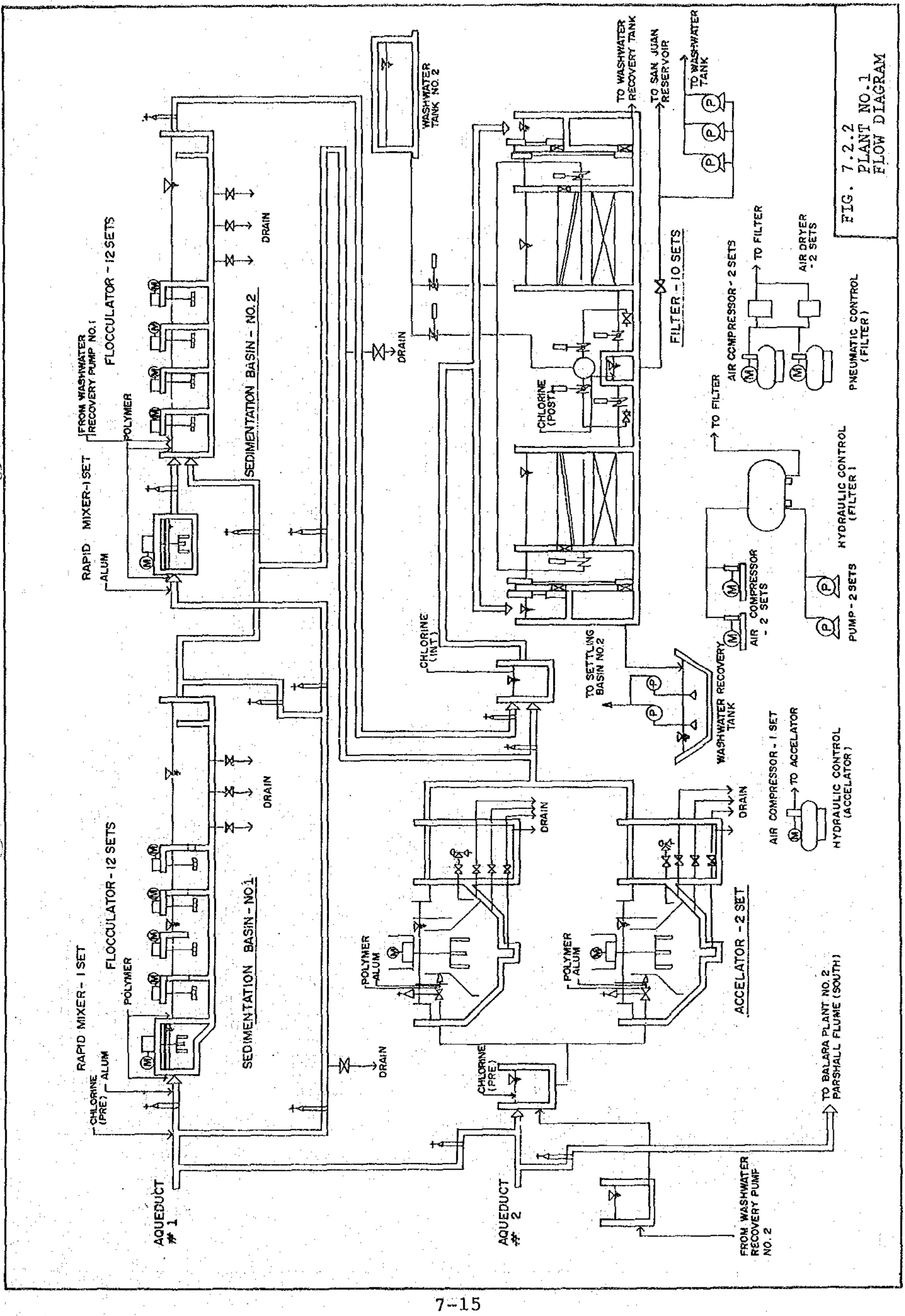


FIG. 7.2.2 PLANT NO.1 FLOW DIAGRAM

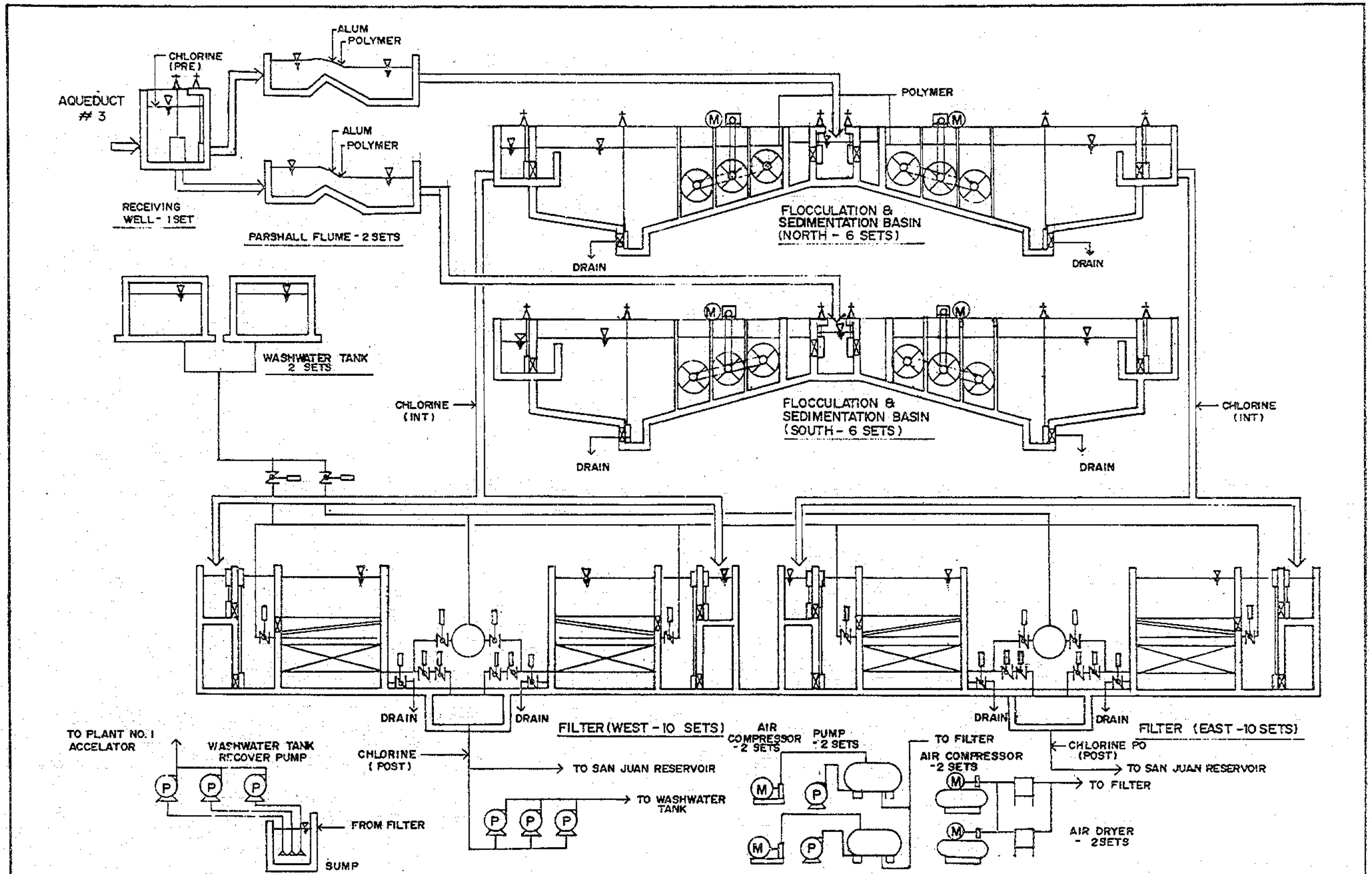


FIG. 7.2.3
PLANT NO.2
FLOW DIAGRAM

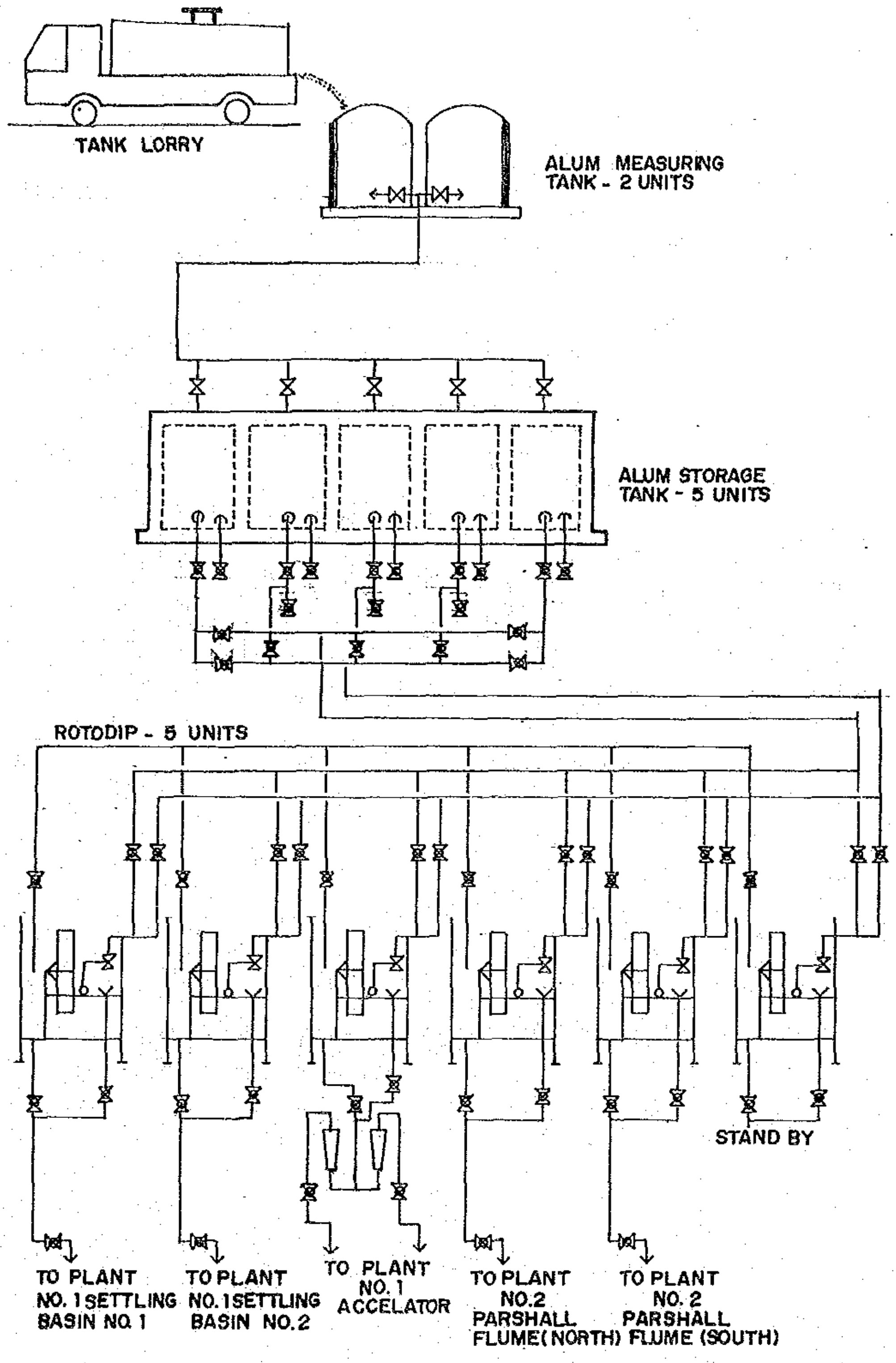


Fig. 7.2.4
FLOW DIAGRAM OF
ALUM DOSING

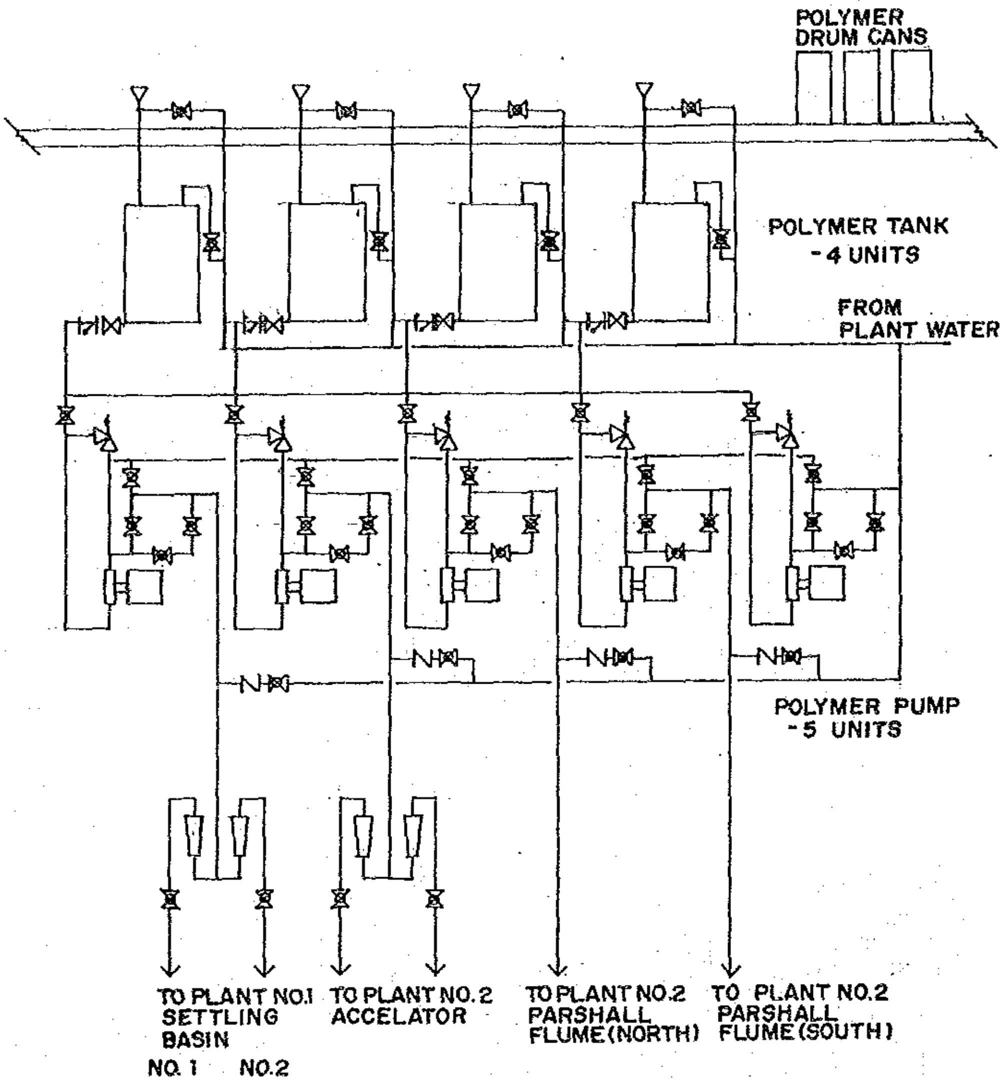


Fig. 7.2.5
FLOW DIAGRAM OF
POLYMER DOSING

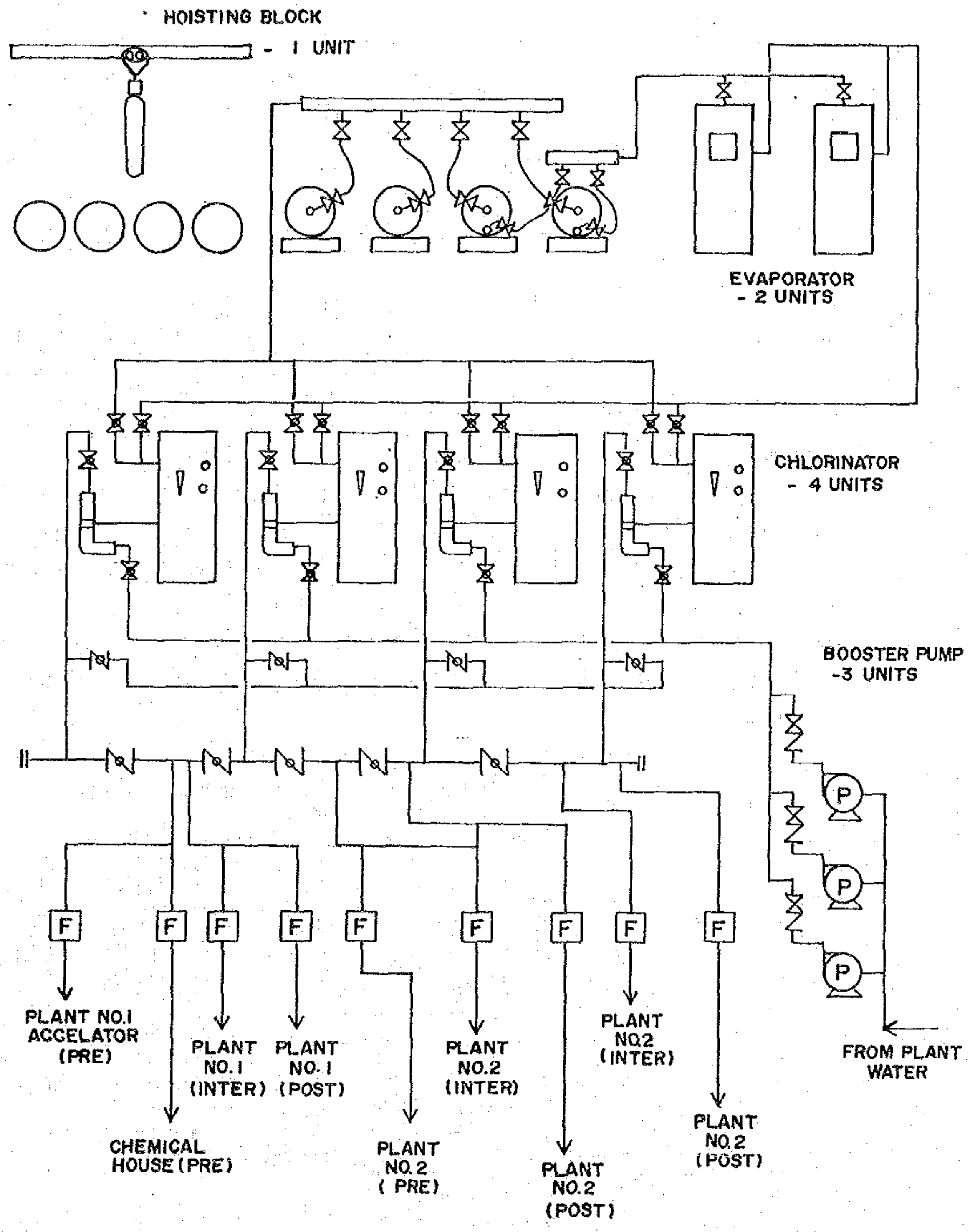


Fig. 7.2.6
FLOW DIAGRAM OF
CHLORINE DOSING

7.3 Design Conditions and Plant Capacity

In the preparation of the design conditions and criteria, verification of "Report on Optimizing the Operation of the Balara and La Mesa Water Filtration Plants", which was prepared by a World Bank consultant in 1988, was made together with actual inspection of the existing facilities of the Balara Plant.

7.3.1 Design Conditions

The existing Balara Plant is mainly composed of two Plants, Plant No. 1 with a design capacity of 470,000 m^3/d and Plant No. 2 with a design capacity of 1,130,000 m^3/d as listed in Table 7.3.1 at present. The combined total design capacity is 1,600,000 m^3/d.

Plant No. 1 consists of three lines of pre-treatment processes such as coagulation/flocculation/ sedimentation process, which is composed of sedimentation basin No. 1 & No. 2 with a designed capacity of 140,000 m^3/d each and Accelators with a designed capacity of 190,000 m^3/d. Then a combined total of 470,000 m^3/d treated water is introduced to 10 beds of filter through the gate chamber where each treated water joins.

TABLE 7.3.1 DESIGN CAPACITY AND RAW WATER SUPPLY

PLANT	SUB-SYSTEM FOR PRE-TREATMENT	DESIGN CAPACITY(m^3/d)	POTENTIAL RAW WATER AMOUNT (m^3/d)
No. 1	Sedimentation basin No.1	140,000	Aqueduct # 1
	Sedimentation basin No.2	140,000	Aqueduct # 1
	Accelators (2 tanks)	190,000	Aqueduct # 2
	Sub-Total	470,000	565,000
No. 2	Sedimentation basin (4 lines)	1,130,000	Aqueduct # 3 1,140,000
Combined Total		1,600,000	1,705,000

Plant No. 2 consists of mainly four lines of sedimentation process. Each sedimentation tank is composed of three separate tanks combined with three-step tapered flocculation process. Treated water is then combined and flow into 20 filter beds through effluent channels located at both sides of sedimentation basins.

Available raw water supply is conveyed from the La Mesa Dam by three aqueducts with a combined capacity of 1,705,000 m^3/d. Extra raw water available as against the existing design capacity is calculated to be only 105,000 m^3/d. Transmitted amount of the existing aqueducts are almost at full capacity after the modification project in 1981. Expandability for production capacity of the Balara Plant is limited to and depends upon the potential capacity of raw water conveyance facilities.

7.3.2 Plant Capacity

The actual water production listed in Table 7.3.2 shows the results of water production in the Balara Plant in 1989 and 1990. Filtered water capacity ranges from 1,364,000 m^3/d to 1,554,000 m^3/d. Average amount of filtered water is kept stable around 1,450,000 m^3/d in these two years.

TABLE 7.3.2 COMPARATIVE QUANTITY OF RAW, FILTERED, AND DISTRIBUTED WATER FOR THE YEAR 1989-1990

UNIT	MIN.		AVE.		MAX.	
X 1000 m^3/d	1989	1990	1989	1990	1989	1990
Raw Water	1,376	1,354	1,454	1,432	1,515	1,545
Filtered Water	1,379	1,364	1,452	1,435	1,514	1,554
Distribution Water	1,335	1,319	1,400	1,380	1,456	1,488

Source: 1) Water Sources Division Annual Report for the Calendar year 1990
2) Figures in filtered water includes some of raw water and recovered washwater amount

Range of production will be dependent upon not only the potential amount of raw water but also other factors like hydraulic conditions between the Balara Plant and the distribution system. For example, World Bank reports mentioned that high water level in San Juan Reservoir is controlled between E.L. 48.5 and E.L. 47.0. The upper limit is to reduce pressure preventing leakage in the system and the lower is to ensure suction for the booster pumps on the San Juan Pumping Station.

Therefore, it is proper that this Rehabilitation aim at recovery of capacity and maintenance of mechanical and electrical performances of the facilities; and improvement of the efficiencies of the facilities to meet the available raw water. When the rehabilitation works are completed, leakage control and low pressure problems in the distribution network should be investigated.

7.3.3 Design Criteria

Design criteria for major treatment facilities used during the modification project in 1981 are shown in Table 7.3.3 and 7.3.4 for Plant No. 1 and Plant No. 2, respectively, compared with the actual operating conditions and their reference values which are ordinary applied in design conditions for conventional water treatment systems.

The tables indicate several items that deviate from reference values, which could be attributed to the low efficiencies of the facilities and should be improved as a rehabilitation scheme.

In connection with the verification of actual operation, capacity calculation, G-value calculation, and grain size analysis, data are referred to Appendix A, B, and C, Supporting Report, respectively.

TABLE 7.3.3 DESIGN CRITERIA OF PLANT NO. 1

ITEM NO.	DESCRIPTION	UNIT	DESIGN VALUE	ACTUAL OPERATION	REFERENCE VALUE
1	Rapid mixing				
	Velocity gradient	sec -1	1000	867	>100
2	Flocculation				
	No. of basins	basin	2	2	-
	Detention time	min	20	20.2	20-40
	Velocity gradient	sec -1	Max. 100	12.7-33.6	10-80
3	Sedimentation				
	No. of basins	basins	2	2	-
	Detention time	hr	2.28	2.68,2.81	2-5
	Surface loading	mm/min	27.8	23.96,22.95	15-30
	Mean passing velocity	m/min	1.38	* 1.18	0.4
4	Accelators				
	No. of tanks	tank	2	2	-
	Clarification time	min	48	* 64	90-120
	Upflow rate	mm/min	100	* 92	40-60
5	Filtration				
	No. of beds	bed	10	10	-
	Filtration area	m2	162	162	-
	Filtration rate **	m/d	288	288	-
	Filter media depth **				
	Anthracite	mm	500	480	-
	Sand	mm	250	280	-
	Media effective size **				
	Anthracite	mm	0.9-1.1	* 0.57	0.7-1.5
	Sand	mm	0.45-0.55	0.69	0.45-0.70
	Backwash				
	Type		Perforated	pipings	
	Rate	m3/m2/min	0.6	0.6-0.65	0.6-0.9
	Surface wash				
	Type		Perforated	pipings	
	Rate	m3/m2/min	0.2	0.15-0.2	0.15-0.2

(Notes) * Shows deviation from reference value.

** Filtration particulars were designed based on the result of a pilot scale plant.

TABLE 7.3.4 DESIGN CRITERIA OF PLANT NO. 2

ITEM NO.	DESCRIPTION	UNIT	DESIGN VALUE	ACTUAL OPERATION	REFERENCE VALUE
1	Rapid mixing				
	Velocity gradient	sec -1	800	866	7400
2	Flocculation				
	No. of basins	basin	12	12	-
	Detention time	min	21	20.2	20-40
	Velocity gradient	sec -1	30-47	26-31	10-80
3	Sedimentation				
	No. of basins	basins	12	12	-
	Detention time	hr	1.7	* 1.61	2-5
	Surface loading	mm/min	48.3	* 52	15-30
	Mean passing velocity	m/min	0.498	* 0.71	0.4
4	Filtration				
	No. of beds	bed	20	20	-
	Filtration area	m2	162	162	-
	Filtration rate **	m/d	348	348	-
	Filter media depth **				
	Anthracite	mm	400	370	-
	Sand	mm	250	292	-
	Media effective size **				
	Anthracite	mm	0.9-1.1	* 0.53	0.7-1.5
	Sand	mm	0.45-0.55	0.64	0.45-0.70
	Backwash				
	Type			Perforated pipings	
	Rate	m3/m2/min	0.6	0.6-0.65	0.6-0.9
	Surface wash				
	Type			Perforated pipings	
	Rate	m3/m2/min	0.6	0.15-0.2	0.15-0.2

(Note) * Shows deviation from reference value.

** Filtration particulars were designed based on the result of a pilot scale plant.

7.4 Existing Structures

The survey results on the existing structures which show whether the facility has any structural defect or is still durable to withstand future long-term utilization is discussed in this section.

The method of investigation of the concrete facility involves ocular inspection and a check on the compressive strength using a concrete test hammer which was provided by JICA.

The results of the ocular inspection showed that there are no major defects except for some needed minor repairs as mentioned below. The concrete compressive test indicated that the structures have sufficient strength.

(1) The results of the ocular inspection are as follows.

<u>Plant No. 1</u>

-Sedimentation Basin No. 1

The top surface of the beam at the outlet of the flocculator compartment has a minor longitudinal crack. As compared to the overall condition of the structure, this does not pose any structural deficiency problems.

-Accelator

The steel supports around the outer perimeter of the steel structure are already corroded. These should be reinforced with structural shaped-steel.

<u>Plant No. 2</u>

-Sedimentation basin

a) Three portions of the concrete slab of the pedestrian carriageway were observed to have uneven settlement ranging from 1.0

to 4.0 cm.

b) The entire length of the outermost slab at the northern basin has an uneven protrusion of 1.0 to 2.0 cm. which was caused by an earthquake in 1968. At present, one sedimentation basin in the southern portion has been empty for two months. The structure of the sedimentation basin at the north side is identical with the southern basin. Therefore, the northern basin can be safely emptied for the rehabilitation work. In addition to the information reported by the MWSS, there are drainage pipes under all the basins which will protect it from the buoyant force.

c) Cracks were observed at the roots of cantilever concrete members where the inlet sluice gate pedestals are fastened.

-Filter Bed

Water leakages were found in the pipe gallery located in the basement, however, these are negligible and will not pose any risk.

-Others

There are some minor architectural defects which can be corrected by management thru proper maintenance works. (e.g. roof leaks, corroded steel windows, damaged glass windows, etc.)

(2) Results of the compressive strength test

The test was conducted in twenty eight existing concrete structure points. The results are as follows:

<u>Plant No. 1</u>

		Strength (kg/cm^2)
Sedimentation basin #1	Channel	378-485
	Sloping wall	420
Sedimentation basin #2		416-368

Open channel	368-449
Accelator	454-528
Filter bed	446-568
Washwater recovery basin	346-398
Washwater tank No. 2	350-391

Plant No. 2

Parshall flume #1	337-401
Sedimentation basin	345-501
Parshall flume #2	351-387
Inlet channel to filter bed	379-415
Filtration	539-581
Washwater tank	408-456
Pumping station	449-501
50 MG reservoir	418-506

As mentioned above the strength varies from 345 to 581 kg/cm^2. In conclusion, the concrete structures tested were found to be structurally safe. Detailed data are shown in Appendix D, Supporting Report.