JAPAN INTERNATIONAL COOPERATION AGENCY
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF HOUSING AND CONSTRUCTION

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR REHABILITATION OF THE AMBATALE TREATMENT PLANT IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

DECEMBER 1992

NIPPON JOGESUIDO SEKKEI CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF HOUSING AND CONSTRUCTION

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR REHABILITATION OF THE AMBATALE TREATMENT PLANT IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

DECEMBER 1992

NIPPON JOGESUIDO SEKKEI CO., LTD.

PREFACE

In response to a request from the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct a basic design study on the Project for Rehabilitation of the Ambatale Treatment Plant and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Sri Lanka a study team headed by Mr. Haruo Iwahori, Development specialist, JICA, from July 15 to August 13, 1992.

The team held discussions with the officials concerned of the Government of Sri Lanka, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Sri Lanka in order to discuss a draft report 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 Democratic Socialist Republic of Sri Lanka for their close cooperation extended to the teams.

December, 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

December, 1992

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the Project for Rehabilitation of the Ambatale Treatment Plant in the Democratic Socialist Republic of Sri Lanka.

This study has been made by the Nippon Jogesuido Sekkei Co., Ltd., based on a contract with JICA, from June 8, 1992 to December 18, 1992. Throughout the study, we have taken into full consideration of the present situation in Sri Lanka, and have planned the most appropriate project in the scheme of Japan's grant aid.

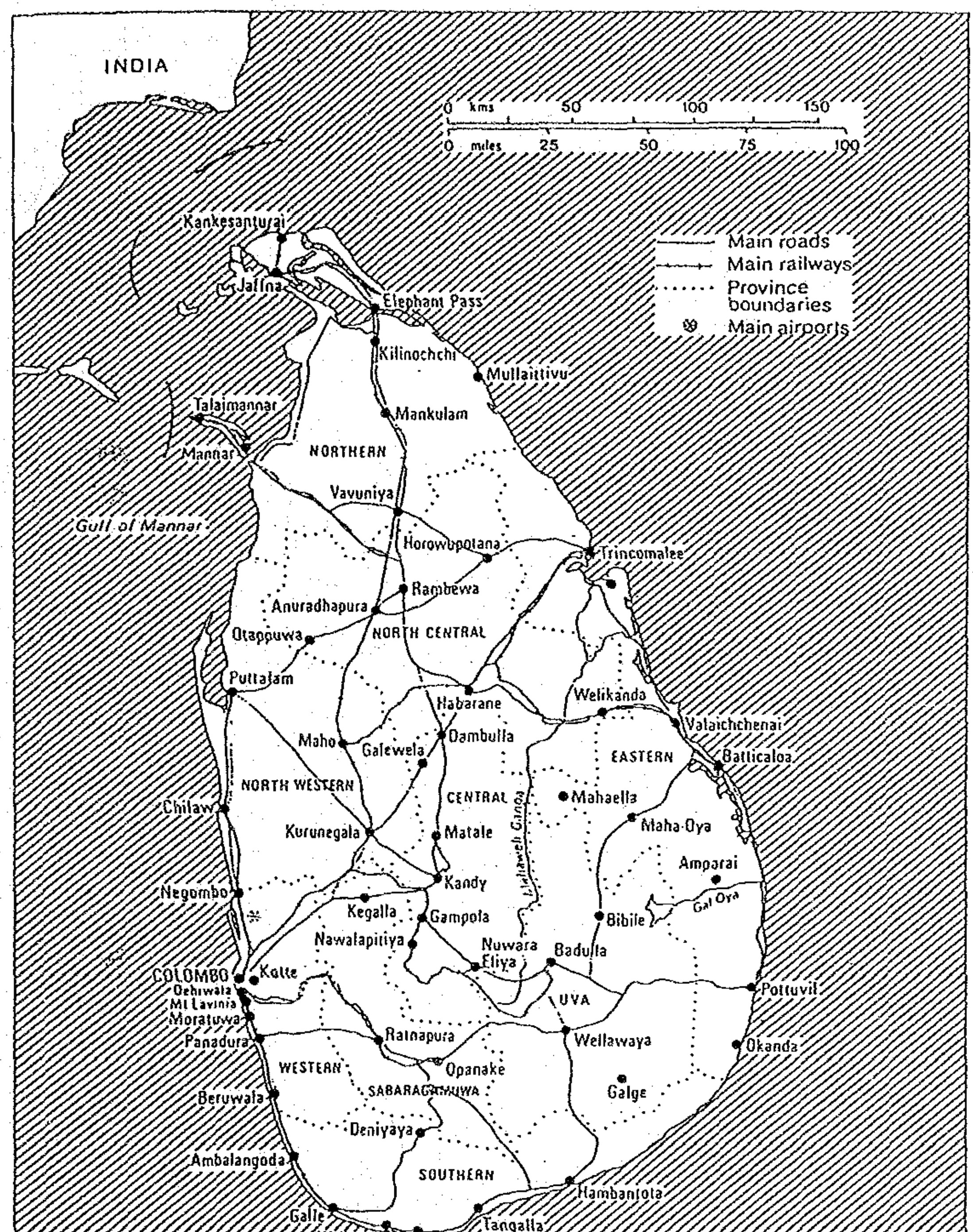
We wish to take this opportunity to express our sincerest gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, the Ministry of Health and Welfare and the Sri Lankan Embassy in Japan. We also wish to express our deep gratitude to the officials concerned of the National Water Supply and Drainage Board, the JICA office in Sri Lanka and the Japanese Embassy in Sri Lanka for their close cooperation and assistance during our study.

We hope that this report will be of use for the effective promotion of the project.

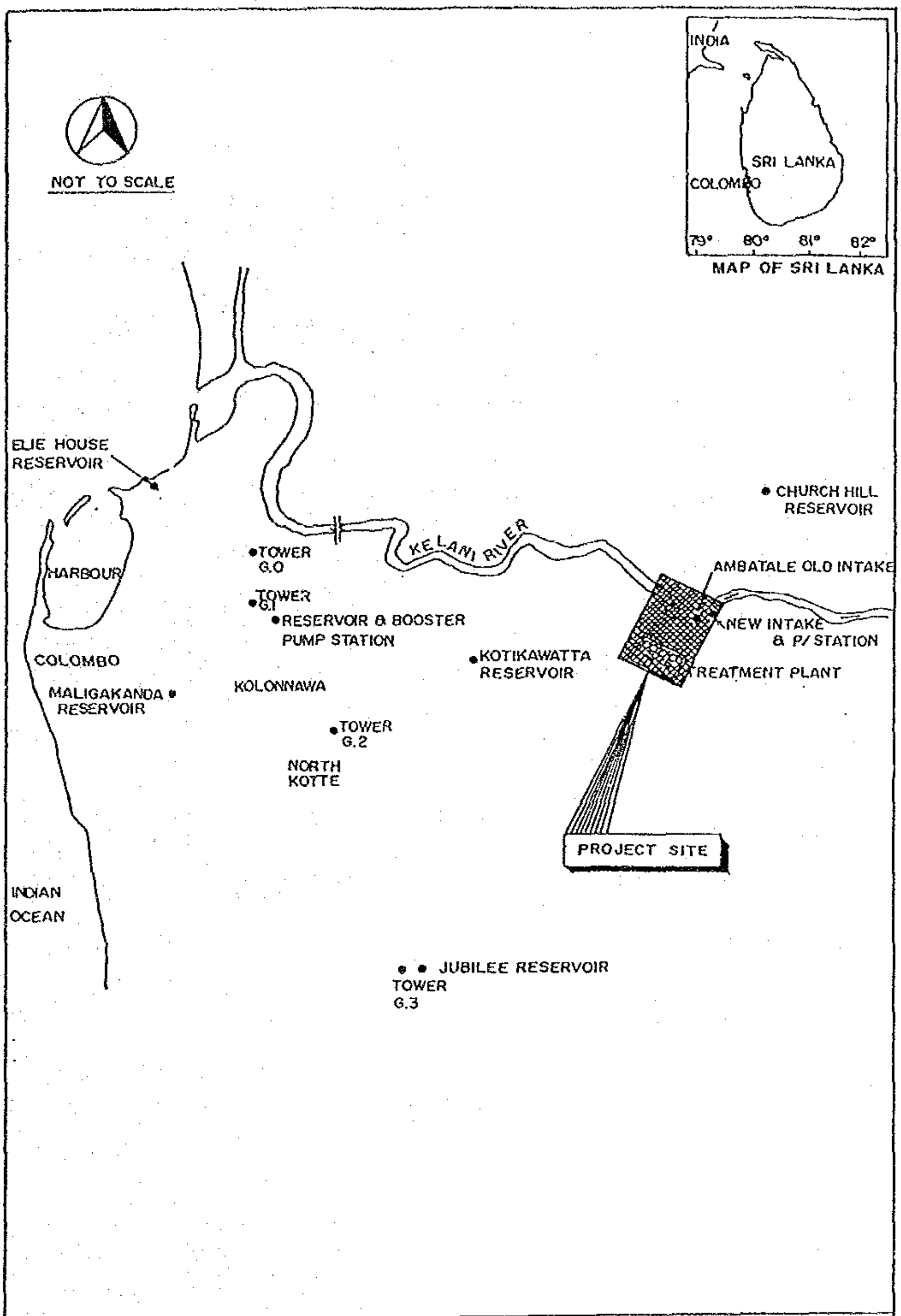
Very truly yours,

Toru Hayashi

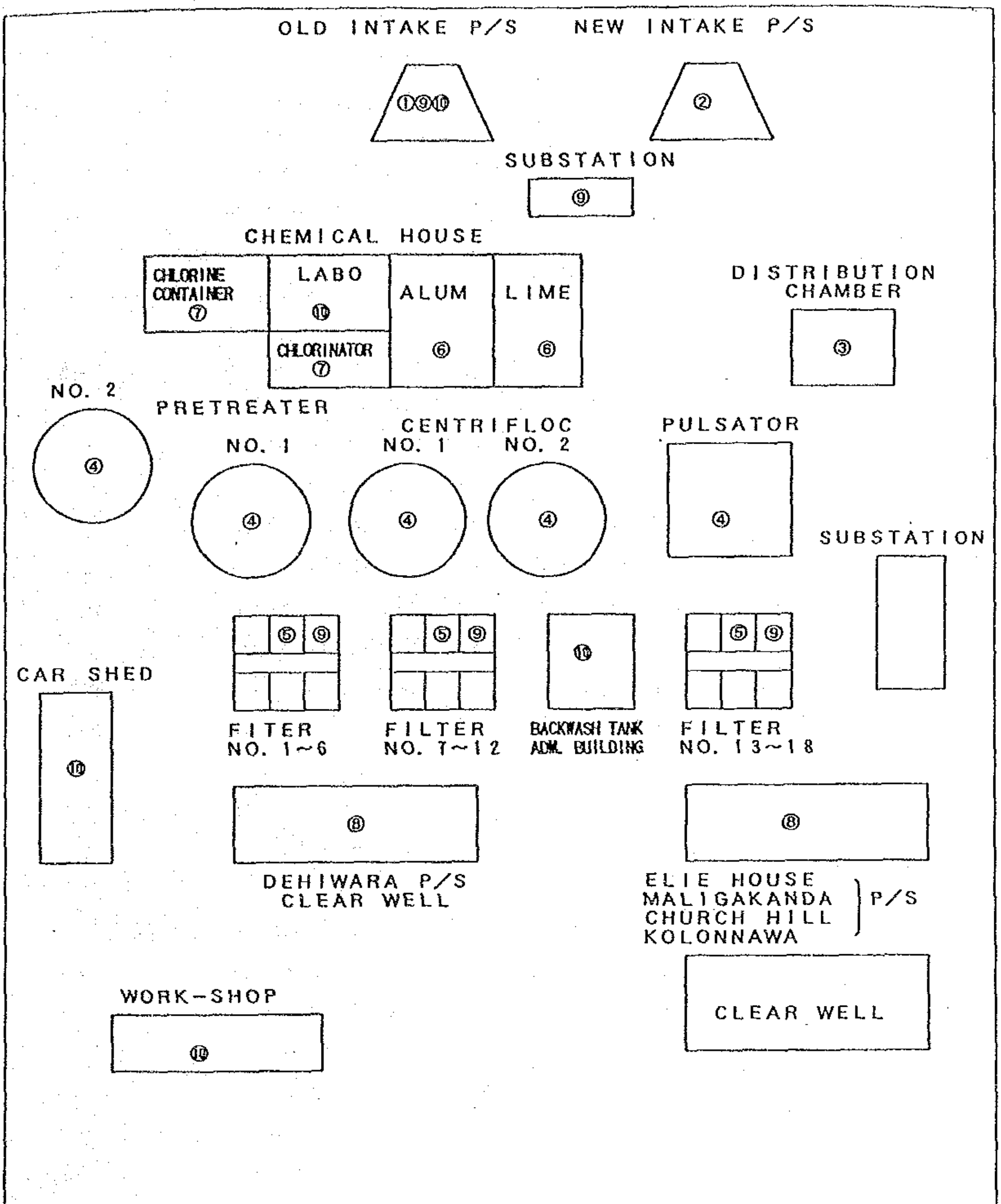
Team Leader, Toru Hayashi
Basic design study team on the Project for Rehabilitation of the Ambatale Treatment Plant.
Nippon Jogesuido Sekkei Co., Ltd.



THE DEMOCRATIC SOCLALIST OF SRI LANKA



LOCATION MAP OF THE PROJECT SITE



①	OLD INTAKE P/S	⑨	ELECTRICAL FACILITIES
②	NEW INTAKE P/S	⑩	OTHERS
③	DISTRIBUTION CHAMBER		
④	SEDIMENTATION FACILITIES		
⑤	FILTRATION FACILITIES		
⑥	CHEMICAL FEED FACILITIES		
⑦	CHLORINATION FACILITIES		
⑧	TRANSMISSION FACILITIES		

AMBATALE TREATMENT PLANT

LIST OF ABBREVIATIONS

The following abbreviations have been adopted in this report.

Sri Lankan Government Organisations:

MHC	Ministry of Housing and Construction
NWSDB	National Water Supply & Drainage Board

Other Organisations:

ADB	Asian Development Bank
BS	British Standard
DIN	Deutche Industrie-Norm
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
JEC	Japan Electrotechnical Committee
JICA	Japan International Cooperation Agency
JIS	Japan Industrial Standard
JMA	Japan Manufacturer's Association
OECF	Overseas Economic Cooperation Fund

Technical Term:

AC	- Alternative Current
BOD, BOD5	- Biochemical Oxygen Demand (5 days)
CI	- Cast iron, grey
CIF	- Cost, Insurerance, and Freight
Cl	- Chloride Ion
COD	- Chemical Oxygen Demand
DF/R	- Draft Final Report
DC	- Direct Current
DO	- Dissolved Oxygen
F/R	- Final Report
F/S	- Feasibility Study
FY	- Fiscal Year
GNP	- Gross National Product
IA	- Implementing Arrangement
IC/R	- Inception Report

IT/R	-	Interim Report
M/P	-	Master Plan
MPN	-	Most Probable Number
MSL	-	Mean Sea Level
O&M	-	Operation and Maintenance
p.a.	-	Per Annum
p	-	Pole
pH	-	pH Value
PVC	-	Polyvinyl Chloride
TOR	-	Terms of Reference

Units of Measurements:

%	-	percent	-	Rate Unit
°C	-	degree Celsius	-	Temperature Unit
cm	-	centimetre	-	Length Unit
d	-	day	-	Time Unit
g	-	gram	-	Weight or Mass Unit
ha	-	hectare	-	Area Unit
hr	-	hour	-	Time Unit
HP	-	horsepower	-	Power Unit
Hz	-	hertz (cycle per second)	-	Frequency Unit
JTU	-	Jacson turbidity unit	-	Turbidity Unit
kg	-	kilogram	-	Weight Unit
kg/hr	-	kilogram per hour	-	Dosage 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	-	litre	-	Volume Unit
l/min	-	litre per minutes	-	Flow rate Unit
m	-	metre	-	Length Unit
mm	-	millimetre	-	Length Unit
m/sec	-	metre per second	-	Velocity Unit
m/hr	-	metre per hour	-	Velocity Unit

m^2(sq.m)	- square metre	- Area Unit
m^3(cu.m)	- cubic metre	- Volume Unit
m^3/s(cu.m/s)	- cubic metre per second	- Flow Rate
m^3/d(cu.m/d)	- cubic metre per day	- Flow Rate
MGD(British)	- million gallon per day	- Flow Rate
Ml/d	- million liter per day	- Flow Rate
m^3/min	- cubic meter per minute	- Flow Rate
mm/min	- milimetre per minute	- Velocity Unit
m3/m2/d	- cubic meter per square metre 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
ton	- ton	- Weight
v	- Volt	- Electric Power UNit
yr	- year	- Time Unit

Currency Conversion:

1 Rps	=	3.03 Yen
1 U.S. Dollar	=	130.18 Japanese Yen
1 U.S. Dollar	=	42.99 Rps
1 Japanese Yen	=	0.33 Rps

SUMMARY

SUMMARY

Metropolitan Greater Colombo is composed of the City of Colombo and its adjoining towns where 1.6 million people reside. It is the centre of administration, economics and socio-cultural activities in the country.

One of the most important infrastructure components for a metropolis like Greater Colombo is a reliable waterworks system that supplies safe and adequate water. This ensures a good quality of life for the residents of Greater Colombo by providing a sanitary environment; as well as supports commerce and industry, the lifeblood of the community.

The National Water Supply and Drainage Board (NWSDB) is tasked to provide water to the growing Metropolitan Greater Colombo. NWSDB is under the supervision of the Ministry of Housing and Construction (MHC). Its main duties are to plan, operate, and construct water supply and sewerage systems throughout Sri Lanka. Its headquarters is in Greater Colombo and its five regional support centres are in Colombo, Southern, Western, Central and North Eastern regions. These regional support centres manage and operate their respective water supply systems.

NWSDB supplies 366,000 cu.m/d (80 mgd) of water to Greater Colombo. This supply of water undergoes treatment in three water treatment plants, namely; Ambatale, Kalatuwawa and Labugama.

The Ambatale treatment plant was constructed in the early 1960s or thirty years ago. It was expanded and rehabilitated twice up to its present capacity of 305,000 cu.m/d (67mgd). However, the last two phases of expansion work were executed using different designs and were constructed by different contractors. As a result, different types of treatment facilities are in operation, causing operational inconsistencies. Furthermore, the rehabilitation work was haphazardly done, with treatment facilities not adoptable to the original expansion plan.

This deterioration or aging of the Plant, plus the operational inconsistencies, has a direct link on the quality of water produced at Ambatale. Oftentimes, water produced does not meet the Sri Lankan drinking water standards.

There are limited efforts by NWSDB to rehabilitate the Ambatale water treatment plant. But these efforts are constrained financially. Thus, there is an urgent need to look for a source of funds for a thorough rehabilitation work that would take into account all the past work done, not only on Ambatale, but on the two other treatment plants, as well.

Thus, the Government of Sri Lanka requested the assistance of the Government of Japan to rehabilitate the Ambatale treatment plant to ensure good quality of water for the residents of Greater Colombo.

In response to this request, the Government of Japan decided to conduct a preliminary and a basic design study to evaluate and assess the contents of the request, and conduct field survey to determine the best rehabilitation plan for the Ambatale treatment plant. JICA sent to Sri Lanka a Preliminary Study Team from February 8, 1992 to February 28, 1992; and a Basic Design Study Team from June 15, 1992 to August 13, 1992, respectively.

The Study Teams reaffirmed the request from the Government of Sri Lanka and proposed the best alternative rehabilitation scheme. The key point of the scheme is to replace and rehabilitate all the deteriorated equipment and facilities of the Plant. The result would be the accuracy and ease of measurement and control of the water flow in the treatment plant by ensuring treatment through three types of sedimentation systems. The rehabilitation would also ensure optimum chemical dosing, good sedimentation and filtration.

Table 1 shows the list of equipment and facilities to be rehabilitated from the intake point to the point of transmission.

The total project period is estimated at 35 months, nine months to be allotted to detailed design, tendering and contracts. The rest of the 26 months will be allotted to construction activities such as manufacturing, shipping, construction at the site and test run.

The major direct effects that will be brought about by the project are:

1) Realisation of adequate distribution and measurement of raw water to the three sedimentation systems, and optimum chemical dosing to each system.

2) Improvement of coagulation and flocculation by replacement of deteriorated chemical dosing facilities.

3) Improvement of sedimentation by rehabilitation of Centriflocs and Pretreaters.

4) More stable filtration through the equal distribution of pretreated water to each of the filters.

5) Improvement of filtration by replacement of deteriorated filter sand to new sand and provision of washwater troughs.

6) Stability of water supply by replacing deteriorated intake pumps and transmission pumps.

7) Guarantee of disinfection of treated water quality by replacement of deteriorated chlorination facilities.

In addition to above direct effects to the Plant, the Project will bring the following benefits to GC.

8) The increase of water production will reduce water shortages by approximately 20% (40,000m^3/d) after the Project.

9) Realisation of potable water supply in compliance with the Sri Lankan drinking water standard.

Furthermore, combined with other on-going projects, the Ambatale treatment plant rehabilitation project brings much improvement of water supply condition for Greater Colombo area. The names of the related projects and their expected completion dates are as follows:

a. Ambatale Treatment Plant Facilities Extension Project	December, 1993
b. Ambatale-Jubilee Conveyance System Project	June, 1994
c. Maharagama Water Supply Scheme	June, 1994
d. Towns East of Colombo Water Supply Project	December, 1995
e. Pipe Replacement Project	December, 1996

Considering the expected completion dates of these projects, the Ambatale treatment plant rehabilitation project is surely a timely one and its commencement will be expected as early as possible.

It is then recommended that this project should be implemented in close cooperation between Japanese side and Sri Lankan side. Not only during the implementation period of the project, but also for pre-and-past implementation, NWSDB and the related Sri Lankan agencies are kindly requested to take necessary measurers in order to maximise the Project's effects and benefit.

These measures involve every conceivable matter such as budget, manpower training, systematic O&M, and etc., which will be useful for successful implementation and aftercare of the Project.

Table 1 Rehabilitation Plan(1/2)

Item No.	Facilities/Equipment	Q'ty	Specification	Remarks
1. Old Intake Facilities (Mechanical Portion)				
a.	Main pump	2	Cap. : 3,860 m3/hr x 24 m	Addition
b.	Motor	2	Cap. : 340 kW	Addition
c.	Others	L.S	Control valves	Addition
2. New Intake Facilities (Mechanical Portion)				
a.	Control valves	L.S		Addition
3. Distribution chamber				
a.	Distribution chamber	1	Dim. : 10.8 m x 13.7 m x 11.8 m	Addition
b.	Flow measurement		D/Chamber combines flow meter	Delete
c.	Others	L.S	Intake valves, Outflow gate	
4. Sedimentation Facilities				
1)	Centrifloc			
a.	Sludge scraper	2	Type : Circular type	Addition
b.	Sludge circulation pump	2	Cap. : 120 m3/hr x 5 m x 5.5 kW	
2)	Pretreater			
a.	Sludge circulation pump	2	Cap. : 1,500 m3/hr x 2 m x 2 kW	
b.	Sludge withdrawal valve	2	Type : Motor operated excentric valve	
c.	Automatic backwash system		Misdescription	Delete
3)	Chemical feed point	L.S		
4)	Pulsator, Stilling baffles		No problems in treated water quality without baffles	Delete
5. Filtration Facilities				
1)	Filter No. 1 ~ No.12			
a.	Inflow control	12	Type : 3.6 m weirs	
b.	Washwater trough	96	Dim. : 500 mm x 400 mm	
c.	Underdrain	1,400	Material : ABS resin	
d.	Sand	1,000 m3	e.s : 0.9 mm u.c : less 1.5 depth : 900 mm	
e.	Valves	72	Type : Air operated butterfly valve	
f.	Meter for loss of head	12	Type : Manometer	
g.	Backwash flow meter	1	Type : Orifice	
2)	Filter No.13 ~ No.18			
a.	Level controller	6	Type : Float type	
b.	Valves	18	Type : Air operated butterfly valve	
c.	Level meter for backwash tank	2	Type : float type	
6.	Chemical Feeding Facilities			
1)	Alum			
a.	Mixer	4	Type : Vertical mixer	
b.	Solution tank	4	Anti-acid painting	
c.	Feed pump	2	Type : Horizontal centrifugal pump	
d.	Head tank	2	Size : 1.5 m x 1.5 m x 1.5 m depth	
e.	Constant level tank	2	Size : 0.9 m x 0.9 m x 0.6 m depth	
f.	Distribution tank	2	Size : 0.6 m x 0.9 m x 0.6 m depth	
g.	Hoist	1	Type : Electrical operated monorail type	Addition

Table 1 Rehabilitation Plan(2/2)

Item No.	Facilities/Equipment	Q'ty	Specification	Remarks
2)	Lime			
a.	Mixer	8	Type : Vertical mixer	
b.	Feed pump	4	Type : Horizontal centrifugal pump	
c.	Feeder	3	Type : Mechanical agitation type	
d.	Dust washing equipment	1	Washing tank, dust collecting duct, solution tank cover	Addition
7. Chlorination Facilities				
a.	Chlorinator	4	Cap. : 75 kg/hr x 2, 20 kg/hr x 2	
b.	Weighing scale	1	Cap. : 0 ~ 1 ton, Load cell type	Addition
c.	Hoist	1	Type : Motor operated type, 2 ton	
8. Transmission Facilities				
1)	Kolonnawa			
a.	Main pump	2	Cap. : 640 m3/hr x 45 m	
		1	Cap. : 1,280 m3/hr x 45 m	
b.	Motor	2	Cap. : 110 kW	
		1	Cap. : 220 kW	
c.	Others	L.S	Vales, floor drainage pump	Addition
2)	Dehiwala			
a.	Main pump	1	Cap. : 2,988 m3/hr x 42.67 m	
b.	Motor	1	Cap. : 440 kW	
c.	Others	L.S	Valve, vacuum pump	Addition
9. Electrical Facilities				
1)	Old intake (Electrical Portion)			
a.	Low tension panel	4	Type : Indoor use metal closed self standing type	
b.	Motor starter panel No.2	1	Type : Ditto	Addition
c.	Motor starter panel No.3	1	Type : Ditto	
2)	Treatment facilities			
a.	Sedimentation panel	L.S		
b.	Filtration panel	L.S		
c.	Chemical panel	L.S		
d.	High tension panel	4		
e.	Low tension panel	6		
f.	Lighting facilities	L.S		Addition
g.	Lightning facilities	L.S		Addition
3)	Transmission facilities			
a.	Kolonnawa			
	Low tension panel	5		
b.	Dehiwala			
	Motor starter No.3	1		
	Motor starter No.4	1		Addition
10. Others				
a.	Treatment plant lab. equipment	L.S	Jar tester, pH meter	
b.	Central lab. equipment	L.S	Miscellaneous	Addition
c.	Training	L.S		
d.	Maintenance tools	L.S		
e.	Truck with crane	1	4 ton	Addition
f.	Spare parts for Kalatuwawa/ Labugama	L.S		
g.	Communication equipment	L.S		Addition
h.	Raw water flow meter		D/chamber combines flow meter	Delete
i.	Sampling equipment		Difficulty in O & M	Delete

TABLE OF CONTENTS

LIST OF TABLES

Page

Chapter 2 BACKGROUND OF THE PROJECT

Chapter 3 OUTLINE OF THE PROJECT

Chapter 4 BASIC DESIGN

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

The Ambatale Treatment Plant (hereinafter referred to as "the Plant") is one of the three treatment plants treating an average of 366,000 cu.m/d water that is supplied to the Greater Colombo area (hereinafter referred to as "GC") where more than 1.6 million people live.

The Plant was constructed in three phases of development. While the Plant has a designed production capacity of approximately 290,000 cu.m/d, the present water supply has dropped to 245,500 m3/d due to the deterioration of the facilities/equipment. The quality of water produced in the Plant has also deteriorated and does not always meet the requirements of the Sri Lankan drinking water standard. Yet, the Plant presently performs a vital role in the water supply system since it accounts for about 70% of the total water production for GC.

The National Water Supply & Drainage Board (hereinafter referred to as "NWSDB"), an official water supply agency under supervision of the Ministry of Housing & Construction (hereinafter referred to as "MHC") of the Government of Sri Lanka, is maximising efforts for operation and maintenance of the Plant. However, due to the budgetary and technical constraints, NWSDB can not implement a full-scale rehabilitation on the Plant.

Consequently, the Government of Sri Lanka requested the Japanese Government assistance by means of Grant Aid Programme to rehabilitate the Plant, called "Rehabilitation of the Ambatale Treatment Plant (hereinafter referred to as "the Project")" which aims to:

i) Produce an acceptable quality of treated water and
ii) Receive technology transfer for the operation and maintenance for the Plant.

In response to the request from the Government of Sri Lanka, the Government of Japan conducted a Preliminary Study on the Project and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to the Sri Lanka a Preliminary Study Team headed by Mr. Haruo Iwahori, Development Specialist, JICA, from 8th February to 28th February, 1992. Through discussions with NWSDB officials concerned, field visits and observations, the project was concluded to need urgent assistance of the Government of Japan through Grant Aid in order to secure safe and stable water supply for the residents of Greater Colombo.

After the Preliminary Study, JICA sent to the Sri Lanka a Basic Design Study Team (hereinafter referred to as "the Study Team") headed again by Mr. Haruo Iwahori from June 15, 1992 to August 13, 1992.

The Study Team held detailed discussion and conducted a field survey, based on the Preliminary Study. The field survey had the following objectives:

- i) To clarify the details of the Project requested by the Sri Lanka
- ii) To examine and assess the technical and economic viability of the Project
- iii) To make a general layout and design, and
- iv) To estimate the cost of the Project and the schedule required for the implementation of construction

The study activities included:

- i) Treatment capacity measurement,
- ii) Process water quality analysis,
- iii) Pilot filtration analysis,
- iv) Grain size analysis of filter media,
- v) Concrete structure compressive strength test, and
- vi) Functional evaluation of the existing mechanical and electrical facilities/equipment.

CHAPTER 2

BACKGROUND OF THE PROJECT

CHAPTER 2 BACKGROUND OF THE PROJECT

2-1 Water Supply in Sri Lanka

At present, water supply activities are managed and operated by NWSDB and some local governments. NWSDB is under the supervision of MHC. According to the law establishing NWSDB, NWSDB is an autonomous body and is charged primarily with developing, providing, operating and controlling efficient water supply facilities, to distributing water for public, domestic or industrial purposes and fixing charges for same. But because its formation was rather recent (January 1975), some water supply activities have not been transferred to NWSDB yet. As a result, there are three kinds of operartion methods for water supply activities as shown below:

a. NWSDB
b. NWSDB and the concerned local body
c. Local body

As of 1988, there are 372 water treatment plants in Sri Lanka, 238 of which are operated and maintained by NWSDB. The operation (including collecting of charges) of 200 of these is undertaken by NWSDB. NWSDB serves approximately 80% of the entire country's population.

Total population and the percentage of served population of Sri Lanka during the period from 1981 to 1990 are given in Table 2-1-1.

As of 1990, only 67% of the entire country is served by water supply system. The service ratio for urban area is 76% while the service ratio for rural area is 64%. This ratio includes population served by unsatisfactory facilities, such as unprotected open wells, tanks, rivers and unprotected springs. Thus, actual service ratio for rural areas supplied by piped water supply system is only 8%.

Table 2-1-2 shows the estimated water supply coverage on the basis of the quality of service in 1990. Further improvement of the quality of service in rural area is required.

Table 2-1-1 Total Population and Ratio of Served Population

Year	Urban		Rural		Total	
	Served Ratio (%)	Population (x 1,000)	Served Ratio (%)	Population (x 1,000)	Served Ratio (%)	Population (x 1,000)
1981	50	3,007	56	11,622	54	14,629
1986	57	3,310	65	12,791	65	16,101
1990	75	3,663	64	10,954	67	17,617

Table 2-1-2 Estimated Water Supply Coverage on the Basis of Service Quality - 1990

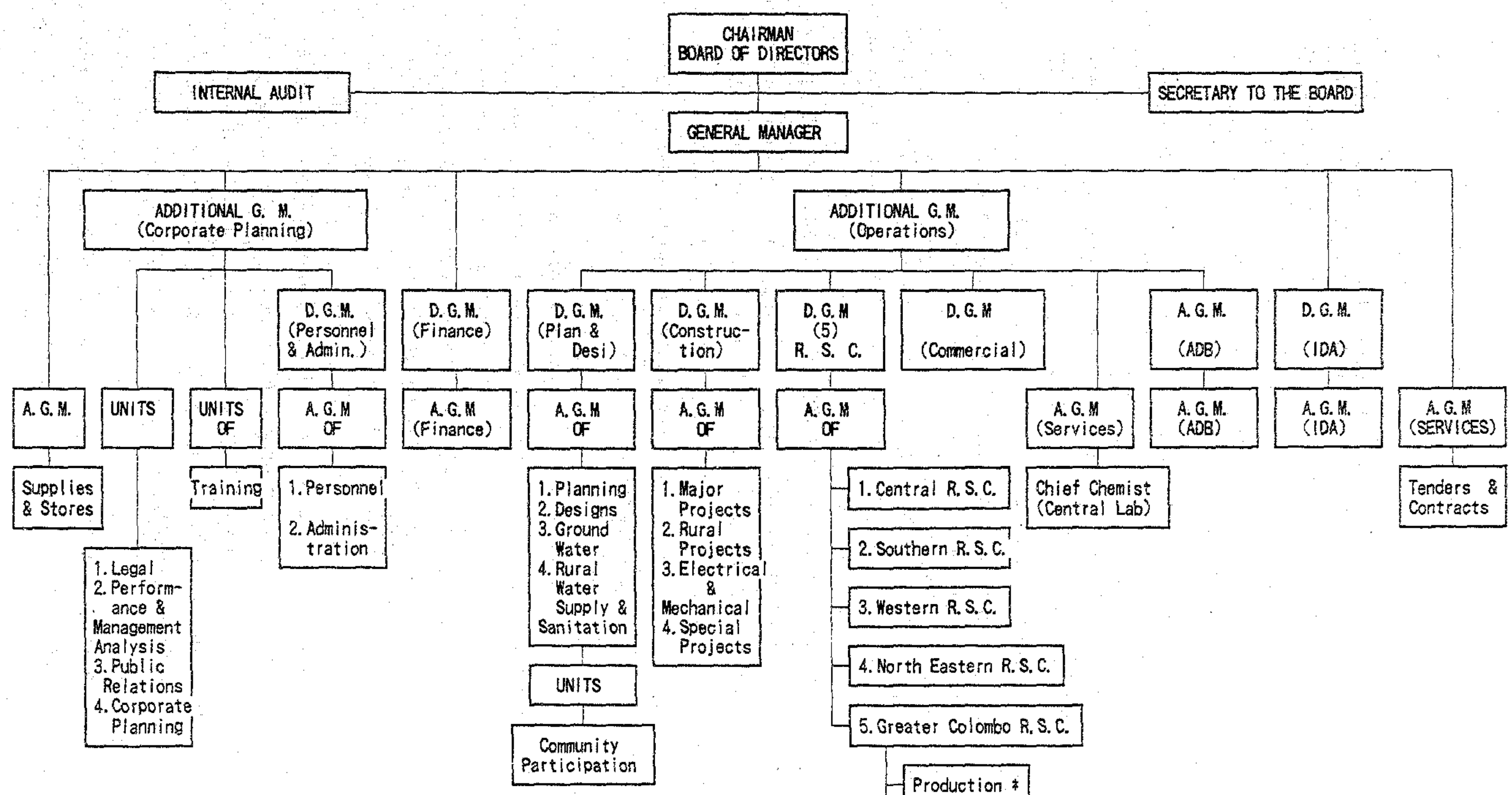
	Service Facility	Urban Nos.	%	Rural Nos.	%	Total Nos.	%
1.	Piped Water Supply						
	- Satisfactory	815	30	364	33	1179	30
	- Non Satisfactory	1967	70	739	67	2706	70
2.	Hand Pump Water Supply						
	- Satisfactory	-	-	434	36	434	36
	- Non Satisfactory	-	-	772	64	772	64
3.	Protected Open Wells						
	- Satisfactory	881	100	3286	50	4167	56
	- Non Satisfactory	-	-	3287	50	3287	44
4.	Other Unsatisfactory Facilities	-	-	5072	-	5072	-
5.	Total population	3663	-	13954	-	17617	-

Source: Corporate Plan 1991, NWSDB
Notes : Other non satisfactory facilities include unprotected open wells, tanks, rivers and unprotected springs.

Figure 2-1-1 shows the organisational structure of NWSDB. The headquarters is composed of the sectors of Personnel & Administration, Finance, Planning & Designing, Construction, Commercial and etc. It also takes charge of the preparation of water supply schemes throughout the country, large scale construction projects and overall financial management. On the other hand, the five regional support centres take charge of day-to-day operation and maintenance of the water supply systems within their respective regions.

To achieve 100 percent coverage by the year 2000, the main implementation agency, NWSDB, has identified an investment programme, expecting community participation to be an integral component. The financial and physical targets set in this programme are given in Table 2-1-3.

NATIONAL WATER SUPPLY & DRAINAGE BOARD
ORGANISATION STRUCTURE



Notes:
D. G. M - Deputy General Manager.
A. G. M - Assistant General Manager.
R. S. C - Regional Support Centre.
* - Takes charge of the Ambatale plant.

Fig. 2-1-1 ORGANISATION OF NWSDB

Table 2-1-3 Investment and Physical Targets to be Achieved in Water Supply During the Period 1991 - 2000

Description	Urban	Rural	Total	NWSDB Responsibility	Other Agencies
1. Physical Targets					
(Population in '000 by year 2000)					
i. Piped Water Supply	1850	1285	3135	2350	785
ii. Wells with Hand Pumps	-	1820	1820	1550	270
iii. Protected Open Wells	-	8530	8530	4265	4265
Total	1850	11635	13485	8165	5320
2. Investment Targets					
(Rs. million)					
i. Piped Water Supply	12025	5795	17820	14600	3220
ii. Wells with Hand Pumps	-	910	910	820	90
iii. Protected Open Wells	-	6400	6400	4480	1920
Total	12025	13105	25130	19900	5230

As indicated in Table 2-1-3, NWSDB does not implement all the proposed development of water supply systems. Water supply system for about 40% of population or about 20% of the investment amount are planned to be developed by local authorities. It is expected, for the time being, that NWSDB may emphasise the development of piped water supply systems for prioritised urban areas.

The differences in financial capability among the communities, due to size, source of supply and other local considerations, make it difficult for each of the local communities to achieve the same quality of services (e.g., water quality, water charge, and etc.). In this connection, it is advisable that NWSDB manages and operates water supply systems nationwide by regional management.

GC at present, suffers from unsatisfactory quality and service of water supply due to old and deteriorated distribution mains and low production capacity that cannot meet the growing demand. Because of the deterioration of most of the facilities in the Plant, the quality of water does not meet the set standards for drinking water.

The thorough rehabilitation of the Plant, together with the rehabilitation of the Kalatuwawa and Labugama treatment plants, will bring about needed improvement in the quality of water. In addition to this, and with the completion of the other ongoing projects, such as Ambatale treatment plant extension, rehabilitation/replacement of old distribution mains and construction of new transmission/distribution facilities, the quality of service will also be greatly improved.

2-2 Water Supply Sector Programme in Sri Lanka

At present, NWSDB is in the midst of activities geared at achieving 100 percent coverage by the year 2000. As illustrated in Table 2-1-2 and Table 2-1-3 in the previous section, however, not all of the projected water supply systems are piped water supply, and not all of the proposed schemes will be implemented by NWSDB. In the year of 2000, the expected served population by piped water supply systems will only be 23%, and the rest will receive water by wells with hand pumps or protected open wells.

At present in Sri Lanka, there are about 400 piped water supply schemes, but the vast majority of these are quite small. NWSDB is responsible for approximately 250 of these schemes. About 50 of these are bulk supply schemes where NWSDB sells in bulk to the local authorities which in turn are responsible for distribution and billing.

For the time being, the development of water supply systems in Sri Lanka will be executed in the following categories;

1. Development for GC and its fringe areas
2. Improvement and augmentation of existing piped water supply systems
3. Development of water supply systems by means of well with hand pumps or protected open wells for rural areas

Category 1 is for GC, and will urgently be implemented.

Category 2 is a countermeasure to eliminate unsatisfactory services in water quality, quantity, tariff and etc., for which more than 2/3 of people strongly complain. The sooner this is addressed, the better.

Category 3 is for about 5 million people who can only have access to unprotected water resources. Hence, some measures to replace such undesirable water source to more sanitary ones, or to take whatever measures to protect existing unprotected sources should be done by the year 2000.

The Department of National Planning, Ministry of Policy Planning and Implementation has prepared " The Public Investment Programme 1991-1995" in October 1991. In this document, the financial and physical targets to be achieved in the year 2000 in the water supply sector were indicated (Table 2-1-3). Also, for selected 24 districts and their peri-urban areas, priority matrix on water supply and sanitation needs by 1995, based on total population needing service, was shown.

2-3 The Circumstances and Contents of the Request

GC comprises the city of Colombo and its adjoining towns where 1.6 million people reside. NWSDB supplies 366,000 cu.m/d (80 mgd) of water to Metropolitan Colombo. This supply of water undergoes treatment in three water treatment plants, Ambatale, Kalatuwawa and Labugama.

In 1971, the World Health Organisation prepared the "Southwestern Region Water Supply and Sewerage Master Plan". The aim of this plan was to develop by the year 2000, the water supply and sewerage systems in Greater Colombo and the municipalities in the region. It was from this master plan that a feasibility study was conducted, after which the "Greater Colombo Water Supply System Master Plan" was prepared. Augmentation work on the Plant was carried out from 1978 to 1985 to increase water supply capacity to what it has at present. In 1985, rehabilitation work on the Kalatuwawa and Labugama treatment plants was undertaken under the Japanese Grant Aid Programme.

In July 1991, the "Greater Colombo Water Supply System Master Plan Update" was prepared with the assistance of the United States Agency for International Development (USAID). It reviewed the 1971 Master Plan and recommended necessary changes to meet the present requirements for water. To date, there are three major projects being implemented by NWSDB to improve water supply to the existing service area towards an expanded area by 1995.

These projects are:

1. Construction of a new treatment plant with a capacity of 182,000 cu.m/d (40 mgd) at Ambatale by the French aid.

2. Construction of a new pumping station, transmission main and service reservoir for the Jubilee system to augment supply capacity.

3. The "Towns East" scheme to expand the existing supply area partly financed by an OECF loan.

Despite all these efforts of NWSDB, the repair and rehabilitation of the equipment and facilities of the Plant are not satisfactory. This is partly due to financial constraints of NWSDB. Oftentimes, the quality of water produced at Ambatale does not meet the set standards. Thus, a more thorough rehabilitation work is urgently required.

Under these circumstances, the Government of Sri Lanka requested the assistance of the Japanese Government to rehabilitate the Plant to ensure good quality water to the residents of GC.

In response to a request from the Government of Sri Lanka, the Government of Japan decided to conduct a preliminary study and a basic design study on the rehabilitation of the Plant. JICA sent to Sri Lanka a Preliminary Study Team from February 8, 1992 to February 28, 1992; and a Basic Design Study Team from June 15, 1992 to August 13, 1992, respectively. Both teams held discussions with the officials concerned from the Government of Sri Lanka. They also conducted field surveys in the study area.

As the result of the Preliminary Study, it was agreed by both parties that the objective of this project is to improve the quality of treated water produced by the Plant as well as to ensure its stable production of water. Also, the following matters were decided in the begining of the basic design study.

1. The Study Team of JICA, with the NWSDB Project Team, shall conduct a survey on the functional ability of facilities/equipment at Ambatale and set a basic strategy for the general rehabilitation plan;

2. Possibility of assistance shall be considered for those matters which were not initially included in the request, in the light of the objective of this project and taking into account of their necessity and priority;

3. A training programme shall be prepared by the time of completion and of turning over the rehabilitated facilities/equipment.

The major subjects of requested rehabilitation are as follows:

1. Adequate and accurate distribution of raw water to each of three sedimentation basins -- Construction of a new Receiving/Distribution Chamber;

2. Improvement of efficiency of each sedimentation basin;

3. Improvement of filtration
   - to ensure uniform water inflow to all filters
   - replacement of filter media of the filters from No. 1 to No. 12
   - modification of filter backwashing system of the filters from No.1 to No. 12

4. Replacement/improvement of defective chemical dosing system and chlorinators;

5. Replacement of defective intake and transmission pumps;

6. Replacement of deteriorated electric facilities;

Notes: Appurtenant pipes, valves, wiring and other fittings to be included.

Table 3-2-5 shows the final requested items at the time of completion of field survey, on July 29, 1992.

CHAPTER 3

OUTLINE OF THE PROJECT

CHAPTER 3 OUTLINE OF THE PROJECT

3-1 Objectives

In July 1991, the "GREATER COLOMBO WATER SUPPLY MASTER PLAN UPDATE" was promulgated by NWSDB. This is a review/update of the 1971 Master Plan, aiming to serve 85% of the population by the year 2020. Through the review, changes were recommended taking into account the developments which have occurred since 1971, including the recent expansion of the service area of the Greater Colombo Water Supply System.

There are three major water treatment plants for the Greater Colombo Water Supply System. These are the Labugama treatment plant, constructed in 1917; the Kalatuwawa treatment plant, constructed in 1958; and the Ambatale treatment plant, constructed in 1962. The Labugama and the Kalatuwawa treatment plants were rehabilitated under a grant aid programme by the Government of Japan.

With the deterioration of the facilities and equipment of the Plant, a serious problem is being encountered on the quality of water supplied to GC. The objective of this Project is to rehabilitate the facilities and equipment of the Ambatale water treatment plant in order to restore it to its designed capacity. By doing so, the residents of Greater Colombo can look forward to an adequate supply of treated and potable water.

3-2 Study and Examination on the Request

3-2-1 Necessity and Appropriateness of the Project

(1) Conformity with National Plan

This Project is consistent with the following plans:

CORPORATE PLAN INCLUDING RECOMMENDED NEW NATIONAL STRATEGY FOR THE SRI LANKA WATER SUPPLY AND SANITATION SECTOR (1991-1995)

GREATER COLOMBO WATER SUPPLY SYSTEM MASTER PLAN UPDATE (1991)

The Mission Statement of the Corporate Plan gives a high priority to the provision of adequate water supply: to serve as "the principal agency responsible for providing a safe and adequate water supply to the population of Sri Lanka. The New National Strategy aims to achieve a stable water supply by "rehabilitating existing urban and rural piped water supply schemes to achieve a minimum 12 hr/d supply".

The rehabilitation of the Plant is one of the strategies in the Master Plan Update to secure a stable water supply that complies with the water quality set by the Sri Lankan national drinking water standard. It is evident, therefore, that this project is part of the national Major Plan.

(2) **Socio-economic Aspect**

The Plant produced an average of 245,500 cu.m/d of treated water in 1991 serving 640,000 persons within a service area of 165 sq.km, which is approximately 40% of GC population. After the Plant's rehabilitation, water productivity will be improved to the nominal treatment capacity of 288,400 cu.m/d, a good 17% higher than the present production capacity. The quality of water is also bound to improve thereby complying with the Sri Lankan drinking water standard. This marked improvement in water quality will redound to the substantial upliftment of health and sanitation conditions in GC.

(3) **Technical Aspect**

The Study Team conducted a field survey with the cooperation of the Project Team organised by NWSDB. The following are the technical objectives of the field survey:

i) To clarify the Scope of Work for the Project requested by the Government of Sri Lanka; and

ii) To examine and assess the technical and economic viability of the Project.

The field survey included treatment capacity measurement, concrete compressive strength tests, pilot scale filtration experiment, chemical feed measurement and process water quality analysis. The results indicate that the Project is technically viable as validated by the following points.

1) Necessity of Construction of Distribution Chamber

The present problems related to treated water quality are caused undoubtedly by disregard of designed capacity of each treatment facility. Table 3-2-1 shows that the actual inflow rate of the sedimentation tanks varies from 62% to 172% of the designed capacity. In accordance with this, filtration capacity is imbalanced from Filter No. 1 to No. 12 where the settled water from the Centriflocs and Pretreaters is treated. The same is true with Filter No. 13 to No. 18, where settled water from the Pulsator is treated.

Unless the actual flow rate is exactly measured, all the treatment processes, i.e., coagulation, flocculation, sedimentation, and filtration do not function well. Every step for the process water quality control should be based on the measurement of actual flow rate, and at the same time, the flow rates which are imposed on each unit of facilities should meet their individual designed capacity.

Therefore, it is recommended that a new distribution chamber should be constructed to measure and distribute incoming raw water to sedimentation basins with their designed capacity each. Then, optimum coagulation, flocculation, sedimentation, and filtration will be expected, together with optimum chemical dosing.

2) Appropriateness of Chemicals

The chemicals used in the Plant, whose quality is shown in Table 3-2-2, are effective enough to produce clean and safe water if the proper dosage is applied.

Table 3-2-1 Loading Ratio of Sedimentation Tanks

(%)	Pulsator	C'floc No.1	C'floc No.2	P'treater No.1	P'treater No.2
Max.	127	172	127	132	118
Avg.	88	115	85	118	104
Min.	62	80	67	110	97

Table 3-2-2 Chemicals Used in the Plant

Usage	Chemicals	Quality
Coagulant	Alum	$16\%Al_2O_3<$
pH adjustment	Lime	$80\%Ca(OH)_2<$
Disinfectant	Chlorine	$99.8\%Cl_2<$

3) Durability and Strength of the Existing Concrete Structure

The existing concrete structures are found to have sufficient compressive strength of more than 300 kgf/cm^2.

4) Availability of the Existing Filters and Filter Media

From the pilot scale filtration experiment, a filtration rate of 200 m/d is feasible enough to realise a stable and even filter operations; provided that the filter media be arranged as follows:

Effective size	:	0.9 mm
Uniformity coefficient	:	less than 1.5
Depth of layer	:	900 mm

The existing filter media of Filters No. 1 to 12 need to be replaced with the above indicated media. The existing filter media of Filter No. 13 to 18 can continue to operate at the filtration rate of 200 m/d.

3-2-2 Implementation and Management Plan

(1) Organisational Continuity

The Project would be implemented by NWSDB under the supervision of MHC. At NWSDB, there are three possible departments/sections that can implement the Project. These are the Plan and Design Department and Construction Department that take charge of general design and construction aspects of the National Plan; and the Greater Colombo RSC that takes charge of practical operation and maintenance of the Plant.

NWSDB is presently securing necessary funds for the Project as well as conduction of institutional strengthening activities. For example, the assistant general manager who was assigned to manage the Kalatuwawa, Labugama and Ambatale plants since July 1991, implemented a proper preventive maintenance program for these plants. The operation and maintenance of the plants is seen to improve with the assistance of the trained personnel especially after the rehabilitation works and the replacement of deteriorated facilities and equipment.

Judging from the above, NWSDB has the technical, organisational and institutional capability to undertake and continue the implementation of the proposed Project.

(2) **Financial Continuity**

The provision of safe and reliable supply of water is needed by the people and the industries of GC. The Plant is, therefore, a critical facilities here because of its importance that potable water supply brings the health and well-being of the population. The Plant must then be well operated and maintained in order for it to achieve its mission.

Securing necessary funds to achieve preventive O&M, NWSDB plans to set up an O&M budget covering such expenses as personnel, electricity, chemical, repair, and maintenance as shown in Table 3-2-3. Since 1990, it was reported that adequate surplus funds have been generated from the water revenue of NWSDB. Further, NWSDB can revise water charges depending on the need for increased funds.

From the financial viewpoint, it can be concluded that NWSDB has the capability of continuing the implementation of the proposed Project.

Table 3-2-3 O&M Budget for the Plant

Year	Budget
1992	115,970.6
1993	124,668.4
1994	134,018.5
1995	144,069.9
1996	154,875.7

Source:NWSDB Unit:1,000Rps

3-2-3 Similar Projects and Projects Financed by the Other Foreign Donors

In Greater Colombo, there are several ongoing projects in the water supply sector related to transmission, distribution, and/or water service, as follows:

1) Ambatale Treatment Plant Facilities Extension Project

This project, funded by the Government of French, is the construction of a new Ambatale treatment plant with a capacity of 182,000 cu.m/d (40 mgd) on the premises of the Plant, expanding intake facilities and a transmission pump station. Increase of water production by the new Ambatale treatment plant brings such merits to the existing Plant as the decrease of the overloading , improvement of treated water quality, and stable operation.

This project, therefore, is in conformity with the proposed Project in supplying safe water in the projected water supply area. Likewise, supplemental water supply necessary to cover the water interruption which might be occured by the Project implementation could be secured after the commissioning of this project in the end of 1993.

2) Ambatale-Jubilee Conveyance System Project

This project, funded by the International Development Association (hereinafter referred to as "IDA"), is the construction of a reservoir at Jubilee, and the laying of a transmission main with a diameter of 1,100 mm between the Ambatale Plant and the Jubilee reservoir until June, 1994. It takes into consideration the future expansion of the service area with the water to be produced at the new Ambatale Plant.

This particular project, therefore, supports the aim of the proposed Project, that is, supplying safe water supply to an expanded service area.

3) Maharagama Water Supply Scheme

This project, funded by IDA, is the construction of transmission mains, a pumping station, a storage reservoir and a distribution network for the Maharagama area, supplying water to be produced from the existing and new Ambatale plants. Expected completion date is June, 1994.

This project, therefore, is in conformity with the proposed Project in supplying safe water to the projected water supply area.

4) Towns East of Colombo Water Supply Project

This is a project funded by the OECF for the construction of transmission facilities, tapping the existing transmission main to the towns east of Colombo area, supplying water to be produced at the existing and new Ambatale Plants. Expected completion date is December, 1995.

5) Pipe Replacement Project

This project is funded by the World Bank and aims to rehabilitate either the destroyed or the deteriorated water distribution network in Colombo Municipality until December, 1996. This will decrease the present 40% water loss due to leakages in the system.

This project, therefore, is in consonance with the proposed Project that it will realise safe and adequate water supply for Greater Colombo.

3-2-4 Project Component

The proposed rehabilitation plan consists of the improvement of treatment process and the replacement of deteriorated facilities/equipment as shown in Table 3-2-4.

There is an uneven distribution of the sedimentation and filtration processes in the five sedimentation tanks and the 18 filters. In connection with this, fluctuations in treatment capacity cannot be avoided because chemical dosages cannot be properly controlled in the present system. This results in the deterioration of treated water quality. What should be used is hydraulic distribution without complex mechanical and electrical work.

Table 3-2-4 Component of the Project Requested

	Rehabilitation		Description
A.	Improvement of the existing water treatment process	i)	Even distribution of raw water to sedimentation tanks through distribution chamber to be constructed.
		ii)	Even distribution of settled water to 18 filter tanks by weirs to be installed.
		iii)	Proper chemical dosage in accordance with the capacity to be treated and measured.
B.	Replacement of deteriorated facilities/ equipment	i)	Restore the function of facilities/equipment by replacement

3-2-5 Requested Rehabilitation Plan

The rehabilitation plan shows the technical urgency and the economic viability of the Project. Table 3-2-5 presents the summary of the rehabilitation plan requested by the Government of Sri Lanka. In Table 3-2-5, Identification "A" means the improvement of the existing water treatment process while Identification "B" means the replacement of deteriorated facilities/equipment. Likewise the words "AD", "MS", "DE", and "AR" mean alterations as follows:

AD	:	Request added to the original
MS	:	Request of misdescription on the original
DE	:	Request deleted from the original
AR	:	As requested

Table 3-2-5 Requested Rehabilitation Plan (1/3)

Item	Facilities/Equipment	Identification	Alteration	Remarks
1	Old Intake (Mechanical)			
	a. No.2 & No.3 pumps	B	AD	Deterioration
2	New Intake (Mechanical)			
	a. Valves	B	AD	Deterioration
3	Distribution Chamber			
	a. Distribution chamber	A	AD	Indispensable for the improvement of water quality
	b. Intake flow measurement		DE	Distribution chamber works as flow measurement equipment
4	Sedimentation Facilities			
	a. Chemical feeding points	A	AR	Indispensable for the improvement of water quality
	b. Pulsator stilling baffles		DE	No problem from past experiences
	c. Pretreater			
	Automatic backwash control system		MS	
	Sludge circulation system	A	AR	Out of order
	Automatic sludge withdrawal system	A	AR	Out of order
	d. Centrifloc			
	Sludge circulation system	A	AR	Indispensable for the improvement of sedimentation effects
	Sludge scrapper	A	AD	Deterioration
5	Filtration Facilities			
	a. Inflow controller	A	AR	By hydraulically by inflow weir
	b. Filtration controller and head loss metre	A	AR	Deterioration
	c. Backwashing system	A	AR	Deterioration
	d. Underdrain system	A	AR	Partly damaged
	e. Trough	A	AR	Improvement of backwash Filter No. 1- No. 12
	f. Filter media	A	AR	Filter No. 1- No. 12

Table 3-2-5 Requested Rehabilitation Plan (2/3)

Item	Facilities/Equipment	Identification	Alteration	Remarks
6	Chemical Feed Facilities			
	a. Alum			
	Mixers	A	AR	Out of order, deterioration
	Pumps	A	AR	Out of order, deterioration
	Piping	A	AR	At new D/chamber
	Feed measurement system	A	AR	At new D/chamber
	Hoist	A	AR	Deterioration
	b. Lime			
	Mixers	A	AR	Out of order, deterioration
	Pumps	A	AR	Out of order, deterioration
	Piping	A	AR	At new D/chamber
	Feed measurement system	A	AR	At new D/chamber
	Dust collector	A	AD	Protection against lime dust
7	Chlorination Facilities			
	a. Chlorinators	A	AR	Out of order, deterioration
	b. Piping	A	AR	At new D/chamber
	c. Hoist	A	AR	Out of order, deterioration
	d. Cylinder weighing scale	A	AD	Insurance of O&M
8	Transmission Facilities			
	a. Kolonnawa			
	Pumps/Motors	A	AR	Deterioration
	Valves	B	AR	Deterioration
	b. Dehiwala			
	No. 3 Pump/Motor	A	MS/AD	No. 3 is read as No. 4
	No. 4 Motor		DE	
9	Electrical Facilities			
	a. Old intake (electrical) high tension panel		DE	To be rehabilitated by CEB
	Low tension panel	A	AR	Out of order, malfunction
	Pump starter No. 2	A	AD	Mech. portion replacement
	Pump starter No. 3	A	AD	Mech. portion replacement
	b. Treatment Plant			
	Sedimentation control panel	A	AR	Mech. portion replacement

Table 3-2-5 Requested Rehabilitation Plan (3/3)

Item	Facilities/Equipment	Identification	Alteration	Remarks
	Filter control panel	A	AR	Deterioration
	Chemical feed panel	A	AR	Mech. portion replacement
	High tension panel	A	AR	OCB out of order, malfunction
	Low tension panel	A	AR	OCB out of order, malfunction
	Wiring	A	AR	Together with panel replacement
	Lighting	A	AD	Improvement of water quality control in the night
	Lightning	A	AD	Protection from lightning
	c. Transmission			
	Low tension panel (Kolonnawa)	A	AR	Mech. portion, replacement
	Starter No. 3 (Dehiwala)	A	AR	Mech. portion, replacement
	All starters (Dehiwala)		MS	Only starter No. 3
	Starter No. 4 (Dehiwala)	A	AD	Mech. portion, replacement
10	Others			
	a. Raw water flow measurement		DE	By new D/chamber
	b. Lab. equipment for the Plant	B	AR	Improvement of water quality control
	c. Process water sampling	B	DE	Deficiency in O&M, unreliable
	d. Maintenance tools	B	AR	Reinforcement of O&M
	e. Training	B	AR	Reinforcement of O&M
	f. Lab. equipment for the Central Lab.	B	AR	Improvement of raw water quality control
	g. Communication system	B	AD	Deterioration
	h. Truck with crane	B	AD	Reinforcement of O&M
	i. Spare parts for Kalatuwawa/ Labugama	B	AD	Reinforcement of O&M

3-2-6 Basic Principle for Project Implementation

The Project is urgently needed by the Government of Sri Lanka particularly in meeting the goals of its National Plan. It has been found to be feasible with respect to socio-economic, financial and technical aspects. The Government of Sri Lanka has the organisational, institutional and financial capability for implementing the Project. This Project, therefore, meets the requirements for funding under the government of Japan's Grant Aid Programme considering the benefits that the Project will generate for the population of Greater Colombo.

Therefore, the implementation of the Project under Japan's Grant Aid Programme is appropriate and recommended. The Basic Design for the Project has been prepared for inclusion under this Programme.

The Project will provide for the necessary facilities and equipment in accordance with the plan as shown in Table 3-2-5. However, the success of the Project is in the proper operation and maintenance of these facilities and equipment. NWSDB is required, therefore, to come up with an appropriate O&M system for the continuous operation of the Project.

3.3 Project Description

3-3-1 Executing Agency and Operational Structure

The Plan and Design Department of NWSDB shall be the overall agency in charge of the execution of the Project in cooperation with the Project Team to be organised for the purpose as shown in Figure 4-4-1. The execution of the Project should comply with the "Greater Colombo Master Plan Update". Through the Project, the residents of Greater Colombo will be provided with safe and sufficient water with the rehabilitation of the existing Plant by restoring it to its designed capacity.

After the completion of the Project, the facilities will be transferred to the GC RSC for operation and maintenance. The Assistant General Manager (AGM) of the Ambatale Treatment Plant will directly manage the Plant.

3-3-2 Project Plan

In conclusion, the Project involves the following:

a) the improvement of the existing process; and
b) the replacement of the deteriorated facilities and equipment.

In the preparation of the Project Plan, the existing facilities such as concrete structures and piping which are still functionable are planned to continue to be utilised effectively. The construction method and the construction schedule should be determined so as to ascertain the period for the implementation of the project.

The main portion of facilities/equipment to be rehabilitated are itemised as follows:

i) Replacement of main pumps for the old intake pumping station
ii) Replacement of operation valves for the new intake pumping station
iii) Construction of a new distribution chamber
iv) Replacement of sedimentation facilities
v) Replacement and improvement of filtration facilities
vi) Replacement and improvement of chemical feed facilities
vii) Replacement of chlorination facilities
viii) Replacement and expansion of transmission pumps
ix) Replacement of electrical facilities in connection with the replacement of mechanical facilities
x) Others

3-3-3 Location and Condition of Project Site

The Plant is located 12 km east of downtown colombo City, the heart of GC, where fully developed infrastructure facilities and organised utilities exist as shown below:

Air Transportation	:	The Katunayake International Airport
Marine Transportation	:	The Colombo Port
Inland Transportation	:	A trunk road
Electricity	:	The Ceylon Electric Board

There is no problem related to construction on the location and condition of the Project site.

3-3-4 Outline of Facilities and Equipment

After a thorough examination of the rehabilitation plan requested by NWSDB, the following facilities and equipment will be rehabilitated and included in the Project:

i) Old intake pumping facilities
   - replacement of the main pumps No. 2 and No. 3

ii) New intake pumping facilities
   - replacement of the operation valves

iii) Distribution chamber
   - construction of a new distribution chamber which has both functions for the distribution of inflow to the following five sedimentation tanks and the measurement of inflow rate

iv) Sedimentation facilities
   - Sludge circulation system for Pretreaters
   - Automatic sludge withdrawal system for Pretreaters
   - Sludge scraper for Centriflocs

v) Filtration facilities
   - replacement of filtration controller
   - construction of inflow distribution weirs for filter No.1 to No.12
   - installation of loss of head meters for filter No.1 to No. 12
   - replacement backwashing equipment for filter No. 1 to No. 12
   - repair of underdrain system for filter No. 1 to No. 12
   - replacement of filter media to sand for filter No. 1 to No. 12

vi) Chemical feed facilities
   - replacement of alum feed facilities including mixers, pumps, piping, measurement system and hoist
   - replacement of lime feed facilities including mixers, pumps, piping, measurement system and installation of lime dust collector.

vii) Chlorination facilities
   - replacement of chlorinators, piping and hoist
   - installation of chlorine cylinder weighing scale

viii) Transmission facilities

- replacement of Kolonnawa pumps and valves
- installation of Dehiwala No. 4 pump

ix) Electrical facilities

- replacement of low tension panel for the old intake pumping station
- replacement of motor starter panels for pump No. 2 and No. 3 for the old intake pumping station
- replacement of control panels for sedimentation facilities
- replacement of control panels for filtration facilities
- replacement of control panels for chemical feed facilities
- replacement of high tension panels at Dehiwala pump station
- replacement of low tension panels at Dehiwala pump station
- replacement of low tension panels at Kolonnawa pump station
- replacement of motor starter panels for Dehiwala No. 3 and No. 4
- replacement of lighting facilities
- replacement of lightning facilities

x) Others

- replacement of laboratory equipment for the Plant
- provision of O&M tools
- training for engineers and operators
- provision of laboratory equipment for the Central Laboratory
- provision of communication system
- provision of spare parts for Kalatuwawa/Labugama Plants

3-3-5 Operation and Maintenance Plan

The Preliminary Study Team requested Sri Lankan side to submit an official report regarding the future operation and maintenance of the plant. In response to this request, the Government of Sri Lanka submitted an official report regarding "Strategy for Future Maintenance, Rehabilitation and Replacement of Equipment & Facilities at Labugama, Kalatuwawa and Ambatale Treatment Plants". This report describes the basic strategy, institutional strengthening measures and budgetary allocation strategy for future maintenance, replacement and rehabilitation at the said three plants.

Sri Lankan side agreed to the opinion and recommendation of the Preliminary Study Team, recognising the importance of institutional strengthening and securing necessary funds.

Described hereunder are the major problems on the operation and maintenance at Ambatale and the corresponding findings/recommendations.

(1) Problems on organisation at present

i. No senior staff to assist Assistant General Manager (AGM) - Production who takes charge of the Plant are provided (see Figure 2-1-1).

ii. Education of middle management staff who are in charge of operation & maintenance, and cooperation between Operation & Maintenance and Laboratory staff are insufficient.

(2) Proposed improvement

i. To make clear and precise the rule on positions and duties regarding AGM-Production and the staff of Ambatale treatment plant and to assign additional staff who assist AGM-Production exclusively according to necessity.

ii. Proper operation & maintenance methods for replaced/newly installed facilities/equipment should be taught to the staff, especially about renewed filtration and chemical feed system. Also, much closer cooperation between O & M staff and Laboratory staff, on day-to-day water treatment procedures, is recommended.

(3) Problems on maintenance and repair at present

i. Little preventive maintenance and repairs are done .

ii. There is no carefully planned rules of transaction necessary when an imported equipment breaks down.

(4) Proposed countermeasures

i. To prepare a manual on O & M, and to provide sufficient on-the-job training for the staff in every section and every position to understand the importance of preventive maintenance. To prepare a mid-term to long- term plan to ensure necessary budget for repair/rehabilitation, come up with regular preventive maintenance program.

ii. To prepare a detailed and precise ledger of facilities/equipment in which dates, such as year of construction/installation, specifications, dimensions, record of repair and etc. are logged.

iii. In addition to above, it is recommended that the original drawings of the equipment and facilities should be kept on file at Ambatale. It is also recommended to prepare reduced size drawings compiled in book style, say A-2 size in spread, for staff's convenience at any time needed.

(5) Maintenance and repair cost after the completion of this project

Taking into consideration the last five years tendency of the escalation of O&M costs including personnel expenditure, repair cost, chemical cost, and power cost, the O&M cost in 1996, when the Project would be commissioned, is expected to be lower than that of NWSDB's budget plan as shown in Table 3-2-3. However, qualitatively it can be said that;

i. As the result of rehabilitation of intake pumps and transmission pumps, increase in revenue from water charges will be expected by maximising/stabilising intake and transmission water volume.

ii. By reducing water used in the Plant (backwash water for the filters and drain water from sedimentation basins), and by reducing leakage water from valves and pipes, the Project will contribute to reduce unaccounted-for water.

iii. By the replacement of filter media of the filters from No.1 to No.12, longer filter run can be expected thus, reducing backwash water per unit of hours, and eventuary reducing unaccounted-for water.

iv. By the rehabilitation and improvement of chemical feed systems, wastage of chemicals can be eliminated.

v. Replacement of pumps will bring energy cost saving.

vi. Improvement of electric facilities (development of protection systems, etc.) may greatly reduce the possibility of accidents resulting in reduction of expenditure for repair.

3-4 Technical Cooperation

(1) Past Records for Technical Cooperation

Dispatch of experts in the water supply sector has been extended twice between Sri Lanka and Japan as a technical cooperation scheme of the Japanese Government as shown in Table 3-4-1. Both of those technical cooperation were implemented successfully in the subject of water supply and management.

Tale 3-4-1 Past Records for Dispatch of Experts

Period	Subject
Nov. 1985 - Mar., 1987	Water supply and management
Apr. 1986 - Apr., 1991	ditto

(2) Necessity of Technical Cooperation

After the implementation of the project, circumstance of water supply in GC will be remarkably improved especially in view point of facility arrangement. In corroboration with that, human resources should be developed to utilise the plant effectively through technical training on the system of water supply and water quality control. The effects derived from the progress of water supply technology in GC will be expanded firstly to the surrounding areas and possibly to the local water supply authorities. Therefore, technical cooperation in provision of training course and dispatch of Japanese experts especially in the field of water supply planning and O & M for water treatment plant could produce synergic effects in combination with grant aid scheme.

CHAPTER 4

BASIC DESIGN

CHAPTER 4 BASIC DESIGN

4-1 Design Policies

The basic design is carried out based on the following design policies.

1) The scope of the rehabilitation works is to be limited within the facilities/equipment in the Plant that presently have problems relating to the quality of the treated water.

2) The existing structures and equipment are to be utilised as much as possible.

3) The treatment capacity to be applied is to the original design capacity.

4) Water quality for the treated water is to conform to the Sri Lankan drinking water standard.

5) The operational methods is to employ on-site, manual type, except for the case where automatic operation is required for the safety reasons.

6) The facilities/equipment are to be a type that is able to run continuously except the period of power shut-down.

7) The metric system is to be adopted in all the design works, while the yard-pound system is attached, if necessary.

8) The standards for designing are to adopt Japan Industrial Standard (JIS), Standards of the Japan Manufacturer's Association (JMA) and Standard of Japan Electrotechnical Committee(JEC). British Standard (BS) and Deutsche Industrie Norm (DIN) that are used in the existing facilities/equipment are to be adopted if necessary.

9) The types of facilities and construction methods are to be selected so as to minimise the length of water cut period due to the execution of the project.

4-2 Study and Examination on Design Conditions

4-2-1 Aims and Methods of the Rehabilitation

The scope of the design is to rehabilitate the facilities and equipment in which problems have been identified through this study as mentioned in the previous chapters. Targets of the improvement of each facilities/equipment are given as follows:

1) Intake

To ensure the intake capacity for the designed treatment amount, the existing facilities/equipment which are deteriorated and/or malfunctioning are to be replaced.

2) Distribution Chamber

To measure the water amount taken and to distribute this amount in accordance with the designed capacity to the sedimentation tanks, a new distribution chamber is to be constructed nearby the existing distribution chamber which would be abandoned.

3) Coagulation and Sedimentation

To improve the floc formation, sedimentation , and the sludge withdrawal so as to reduce the turbidity loading to the filtration process, the existing facilities/equipment that are deteriorated and/or malfunctioning are to be replaced.

4) Filtration

To improve the quality of treated water in compliance with the Sri Lankan drinking water standard, the existing facilities/equipment which are deteriorated and/or malfunctioning are to be replaced.

5) Chemical Dosing

To control the chemical dosing to the required rate, the existing facilities/equipment which are deteriorated and/or malfunctioning are to be replaced.

6) Chlorination

To ensure effective disinfection of the filtered water, the existing facilities/equipment which are deteriorated and/or malfunctioning are to be replaced.

7) Transmission

To ensure the designed transmission capacity, the existing facilities/equipment which are deteriorated and/or malfunctioning are to be replaced.

8) Power Supply

To ensure the stable operation of mechanical facilities/equipment which leads to reliable water service, the existing facilities/equipment which are deteriorated and/or malfunctioning are to be replaced.

9) Instrumentation

To measure the amount of water in order to monitor the operation rate and to control chemical and chlorine dosing rate, the existing facilities/equipment which are out of order are to be replaced.

4-2-2 Design Conditions

The following design conditions are adopted in the rehabilitation plan:

1) General Condition

The following environmental condition is applied to the design of the rehabilitation project.

Ambient temperature	Max.	35°C
	Avg.	28
	Min.	20
Humidity	Max.	100%
	Avg.	80
	Min.	40

2) Treatment Capacity

Based on a series of discussions between NWSDB and the Study Team, the following treatment capacity is applied as nominal design capacity in the design of facilities/equipment (see Figure 4-3-1).

Intake capacity	305,000 cu.m/day
Production capacity	288,420 cu.m/day

3) Treated Water Quality

The applied treated water quality standard is to conform to the Sri Lankan drinking water standard as shown in Table 4-2-1.

4) Water Level of the Kelani River

The recorded water level at the intake point of the Kelani river is shown as follows:

Max.	14.67 m
Avg.	2.53
Min.	0.17

Accordingly, 0 (zero) meter is applied as the minimum river water level in the design of intake pump lifting head.

5) Applied Chemicals

Based on the field survey, chemicals shown in Table 4-2-2 are applied.

Table 4-2-1 Design Treated Water Quality Standard

Characteristics	Maximum Desirable Level	Maximum Permissible Level	Japan
pH	7.0 - 8.5	6.5 - 9.0	5.8 - 8.6
Turbidity	2JTU	8JTU	2°
Color	5>	30>	5
Odor	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Unobjectionable	Unobjectionable	Unobjectionable
Total Residue	500 mg/l	2,000 mg/l	500 mg/l
Nitrate	N/A	10 mg/l	10 mg/l
Total Coliforms	Not detected	Note	Not detected
Total Iron	0.3 mg/l	1.0 mg/l	0.3 mg/l
Manganese	0.05 mg/l	0.5 mg/l	0.5 mg/l
Chloride	200 mg/l	1,200 mg/l	200 mg/l
Total Hardness	250 mg/l	600 mg/l	300 mg/l

Notes:

a. Throughout any year, 95% of the samples shall not contain any coliform organisms in 100 ml.

b. None of samples examined shall contain more than 10 coliform organisms per 100 ml.

c. Coliform organisms shall not be detectable in 100 ml of any two consecutive samples.

d. None of the samples examined shall contain E. coli in 100 ml.

Table 4-2-2 Characteristics and Dosage of Chemicals

Description		Alum	Lime	Chlorine
Characteristics	Purity (%)	16	80	99.9
	Solution Concentration	10	10	100
Dose (mg/l)	Max.	60	Pre 30 Post 20	Pre 5 Post 2
	Avg.	15	Pre 10 Post 5	Pre 2 Post 1

6) Power Receiving Capacity

The following power source is to be adopted:

a. Receiving Voltage

AC three-phase three-wire system, 11,000 V, 50 Hz

b. Distribution Voltage

High Voltage:

AC three-phase three-wire system, 11,000 V, 50Hz

AC three-phase three-wire system, 3,300 V, 50Hz

Low Voltage:

AC three-phase four-wire system 415/240v, 50Hz

c. Motors

High Voltage:

AC three-phase three-wire system, 3,000V, 50Hz

Low Voltage:

AC three-phase three-wire system, 400V, 50Hz

d. Control circuit voltage

AC 220V, DC 110V

e. Instrumentation circuit voltage

AC 220V, DC 24V

Signal transmission system

DC 4-20mV, 1-5V

f. Lighting and Receptacle

AC 220V

4-3 Basic Plan

4-3-1 System Design

(1) Design Capacity

Design capacity for each treatment process is shown in Table 4-3-1.

Table 4-3-1 Design Capacity (cu.m/day)

Description	Tank	Capacity Per Tank	Total Capacity
Pulsator	1	61,000	61,000
Centrifloc	2	61,000	122,000
Pretreater	2	61,000	122,000
Total			305,000
Filter	18	16,867	303,600

Schematic diagram of the Plant is shown in Figure 4-3-1. Sludge discharge from the sedimentation tanks and washwater discharge from the filtration tanks are assumed to be 0.5% and 5% of inflow rate, respectively.

(2) Design Calculation

A. Pulsator

1. Number of tanks and dimensions

a.	Number of tanks	:	1 tank
b.	Dimensions	:	36.2 m x 34.6 m x 4.8 m depth
c.	Capacity	:	6,012 cu.m
d.	surface area	:	1,252 sq.m

2. Treatment Capacity

a. Detention Time

6,012 cu.m/61,000 cu.m/d x 24 hr = 2.36 hr

b. Surface Loading

61,000 cu.m/d / (1252 x 0.85) = 57.3 m/d (40mm/min)

Effective surface area is discounted to be 85% (0.85) of the total area.

c. Velocity at Inflow Pipe

Inflow rate per tank
61,000 cu.m/d = 0.71 cu.m/sec.
Area of inflow pipe
$\pi \times 0.7^2/4 = 0.385$ sq.m
Velocity
0.71 / 0.385 = 1.85 m/sec

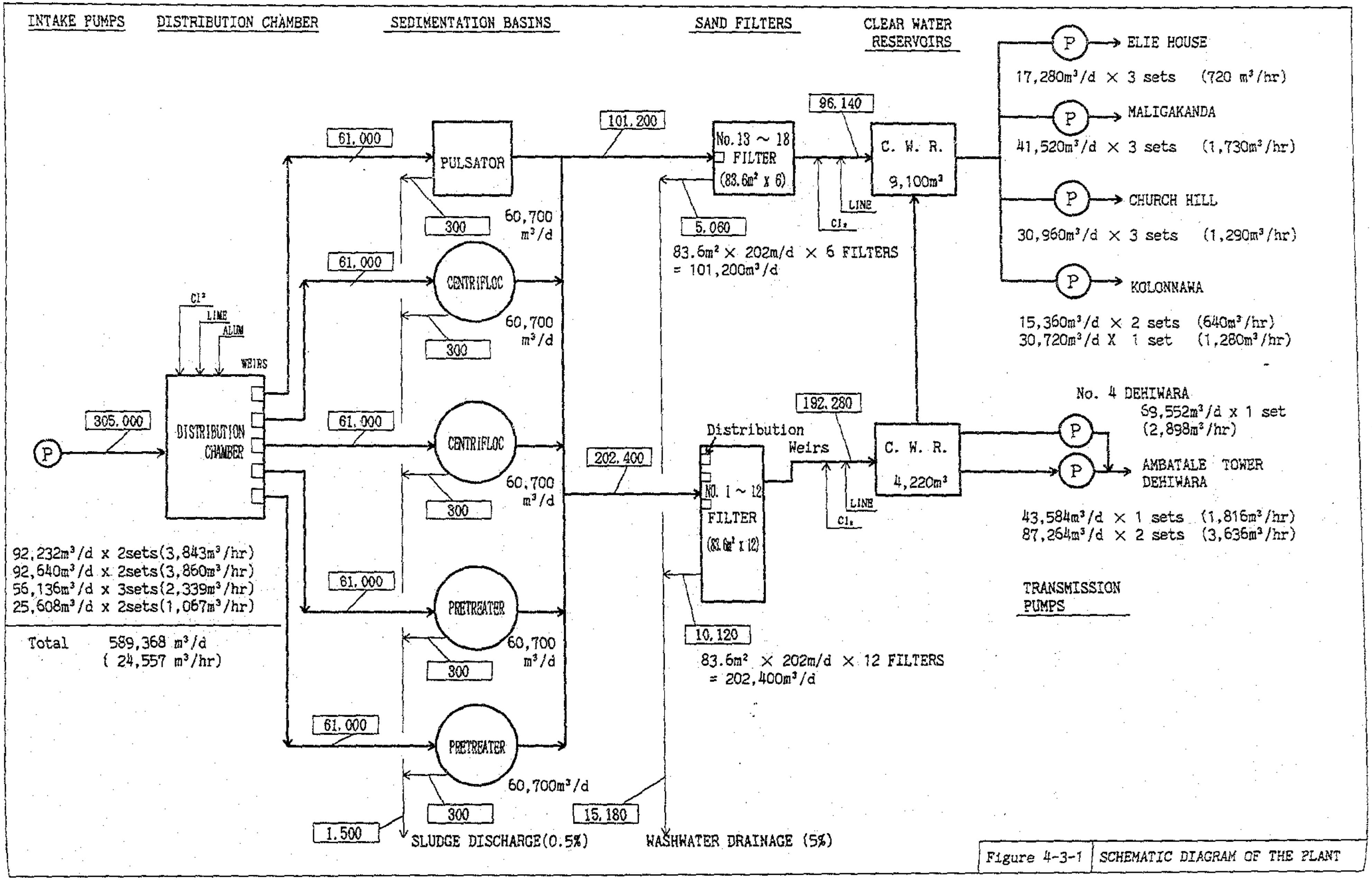


Figure 4-3-1 SCHEMATIC DIAGRAM OF THE PLANT

d. Discharged Sludge

$$So = Q[K(T-t)+d \cdot m] \times 10^{-6}$$

Where:

- Q: capacity treated (61,000 cu.m/d)
- K: SS/Turbidity conversion ratio (1.0)
- T: raw water turbidity (20)
- t: turbidity after sedimentation (0)
- d: alum dose (30 mg/l)
- m: $2Al(OH)_3/Al_2(SO_4)_3 \cdot 18H_2O = 0.234$

$$So = 61{,}000 \text{ cu.m/d} \times [1 \times (20-0)+30 \times 0.234] \times 10^{-6}$$
$$= 1.65 \text{ ton/d (dry weight)}$$

Assuming that sludge concentration will be 1% (10 kg/cu.m), wet solids amount will be obtained to be 165 cu.m/d. Therefore, discharged amount could be counted to be 0.5% (330 cu.m/d)

B. Centrifloc

1. Number of tanks and dimensions

a. Number of tanks	:	2 tanks
b. Dimensions	:	ϕ39.6 m x 6.2 m depth
c. Capacity	:	7,179 cu.m.
d. Surface area	:	1,124 sq.m

2. Treated Capacity

a. Detention Time

7,179 cu.m/61,000 cu.m/ x 24 hr = 2.8 hr

b. Surface Loading

61,000 cu.m/d / (1,124 x 0.85) = 63.8 cu.m/d (44 mm/min)

Effective surface area is discount to be 85% (0.85) of total area.

c. Discharge Sludge

Same as Pulsator

C. Pretreater

1. Number of Tanks and Dimensions

a. Number of tanks	:	2 tanks
b. Dimensions	:	ϕ40 m x 7 m depth
c. Capacity	:	9,462 cu.m
d. Surface area	:	1,256 sq.m

2. Treatment Capacity

a. Detention Time

9,462 cu.m / 61,000 cu.m/d x 24 hr = 3.7 hr

b. Surface Loading

61,000 cu.m/d / (1,256 x 0.85) = 57.1 m/d (40 mm/min)

Effective surface area is discounted to be 85% (0.85) of total area.

c. Sludge Circulation

According to the capacity of the existing sludge circulation pump, the maximum sludge circulation is calculated as follows:

5,636 gpm = 25.6 cu.m/min

3. Discharge Sludge

Same as Pulsator

D. Filters

1. Number of Filters and Dimensions

a. Number of filters : 18 filters

b. Dimensions per filter: 9.144 m x 4.572 m x 2 (83.6 sq.m)

2. Treatment Capacity

Capacity to be treated in filters is obtained after 0.5% reduction of sludge discharge from inflow rate.

305,000 cu.m/d x 0.995 = 303,600 cu.m/d

3. Filtration Rate

a. Normal Condition

303,600 cu.m/d / (83.6 sq.m x 18 filters) = 202 m/d (8.4 m/hr)

b. In case of one filter backwashing

303,600 cu.m/d / (83.6 sq.m x 17 filters) = 214 m/d (8.9 m/hr)

4. Backwash

Available backwash water (Q1) is obtained hydraulically as follows:

$$Q1 = a\ (2gH\ /\ (1 + fe + fl\ /\ d))^{1/2}$$
$$= 0.28 \times (2 \times 9.8 \times 4.5/(1 + 0.5 + 0.003 \times 40/0.6)^{1/2}$$
$$= 121.2 \text{ cu.m/min}$$

Where:

Q1 : available backwash water (cu.m/sec)
g : acceleration of gravity (9.8 m/sq.sec)
a : area of backwash pipe ($\pi/4 \times 0.6^2 = 0.28$ sq.m)
H : available head between backwash water tank and trough level (21 - 16.5 = 4.5 m)
fe : friction coefficient at entrance (0.5)
f : friction coefficient of pipe (0.003)
l : length of pipeline (40 m)
d : Pipe diameter (0.6 m)

Therefore, possible backwash amount is obtained as follows:

$121.2 / 83.6 = 1.45$ m/min > 0.8 m/min

Assuming that each filter will be backwashed in 0.8 m/min for 10 min a day, a total washwater amount per day is obtained as follows:

$q = 0.8 \times 83.6 \times 10 \times 18 = 12,038$ cu.m/d

12,038 cu.m/d is equal to 3.9 % of the treatment capacity of 305,000 cu.m/d. Washwater amount is then counted to be 0.5 % including unexpected backwash.

E. Alum

1. Feeding rate

$$q = 305,000 \text{ cu.m/d} \times A \times (100/B) \times (1/c) \times 10^{-6}$$

Where:

q : feeding rate (cu.m/d)

A : dosage (60 mg/l)

B : solution concentration (10%)

C : specific gravity of alum (1.06)

$$q = 305,000 \times 60 \times (100/10) \times (1/1.06) \times 10^{-6}$$

= 172.6 cu.m/d (120 l/min, maximum daily consumption)

2. Solution Tank

Total volume : 45 cu.m x 4 tanks = 180 cu.m

Available period : 180 cu.m/172.6 cu.m/d = 1.04 d

3. Head Tank

Head tank volume is provided with approximately 30 minutes detention time.

172.6 cu.m/d / 24 / 2 = 3.6 cu.m --> 3 cu.m

4. Alum Feed Pump

Assuming that pump can feed alum solution to the head tank in five (5) minutes.

3 cu.m / 5 min = 600 l/min

F. Lime

1. Feed Rate

Pre-lime

= 305,000 cu.m/d x A x (100/B) x (1/C) x 10^{-6}

Where :

A : dosage (30 mg/l)

B : solution concentration (10%)

C : specific gravity (1.08)

= 305,000 x 30 x (100/10) x (1/1.08) x 10^{-6}

= 84.7 cu.m/d = 3.6 cu.m/hr = 59 l/min

Post-lime (I)

= 202,400 x 20 x (100/10) x (1/1.08) x 10^{-6}

= 37.5 cu.m/d = 1.6 cu.m/hr = 26 l/min

Post-lime (II)

= 101,200 x 20 x (100 x 10) x (1 x 1.08) x 10^{-6}

= 18.8 cu.m/d = 0.78 cu.m/hr = 13 l/min

Maximum daily consumption

84.7 + 37.5 + 18.8 = 141 cu.m/d

2. Solution Tank

Effective volume : 40 cu.m

Number of tanks : 4 tanks

Available period : 40 cu.m x 4 tanks / 141 cu.m/d = 1.1 d

G. Chlorine

1. Feeding Rate

Chlorine feeding rate

$$= 305{,}000 \text{ cu.m/d} \times A \times 10^{-3} \times 1/24$$

Where, A : Dosage
Pre-chlorine 2 ~ 5 mg/l
Post-chlorine 1 ~ 2 mg/l

Pre-chlorine

$$= 305{,}000 \times (2 \sim 5) \times 10^{-3} \times (1/24)$$
$$= 25.4 \sim 63.5 \text{ kg/hr}$$

Post-chlorine (I)

$$= 202{,}400 \times (1 \sim 2) \times 10^{-3} \times (1/24)$$
$$= 8.5 \sim 16.9 \text{ kg/hr}$$

Post chlorine (II)

$$= 101{,}200 \times (1 \sim 2) \times 10^{-3} \times (1/24)$$
$$= 4.3 \sim 8.5 \text{ kg/hr}$$

Maximum daily consumption

(63.5 + 16.9 + 8.5) x 24 = 2,034 kg/d (89 kg/hr)

However, it is very rare that pre and post chlorine hits the maximum dosage at the same time. Then, actual maximum daily consumption is discounted to be 60 kg/hr. (5 mg/l dosage in total)

2. Ton Container

A ton container can feed about 10 kg/hr with no additional heat input (evaporator) in premises at 20°C. Six ton containers are available within the existing storage. Accordingly, available chlorine without evaporators is obtained as follows:

Available chlorine

= 6 cylinders x 10 kg/cylinder/hr = 60 kg/hr

Available period with 6 cylinders at the maximum daily consumption

= 6 cylinders x 1000 kg / 2,034 kg/d = approx. 3 days

(3) Hydraulic Profile

Distribution chamber is to be constructed to measure inflow rate and to distribute this evenly to the following sedimentation process. Inflow weirs for the filter No. 1 to No. 12 is to be installed to distribute the settled water to each filter in order to ensure stable operation of the filter tanks.

After the rehabilitation plan the hydraulic profile will be improved as shown in the Basic drawings.

(4) Distribution Chamber

Necessary volume for the distribution chamber is provided with more than 1.5 minutes detention time and is obtained as follows:

305,000 cu.m/d / 1,440 x 1.5 min = 318 cu.m

The distribution chamber play the most important role in the treatment process as it distributes raw water equally to five sedimentation tanks.

In addition to that, the chamber becomes a flow measurement chamber where water level fluctuation is not allowed to measure the rate properly. Therefore, 50% allowance should be added to the theoretical volume of 318 cu.m. Dimensions is obtain as follows:

5.4 m x 8.4 m x (WL 21.83 - 11.0) = 491 cu.m

Detention time

491 cu.m/(305,000/1,440) = 2.3 min.

(5) Hydraulic Analysis Between Distribution Chamber and Aerator

According to the hydraulic analysis between the distribution chamber and the aerator, loss of head is calculated to be 0.49 m. Then, necessary weir level at this distribution chamber is:

$$+20.409 + 0.49 + 0.300 = +21.300$$

(where, 0.3 m is added as allowance for free overflow)

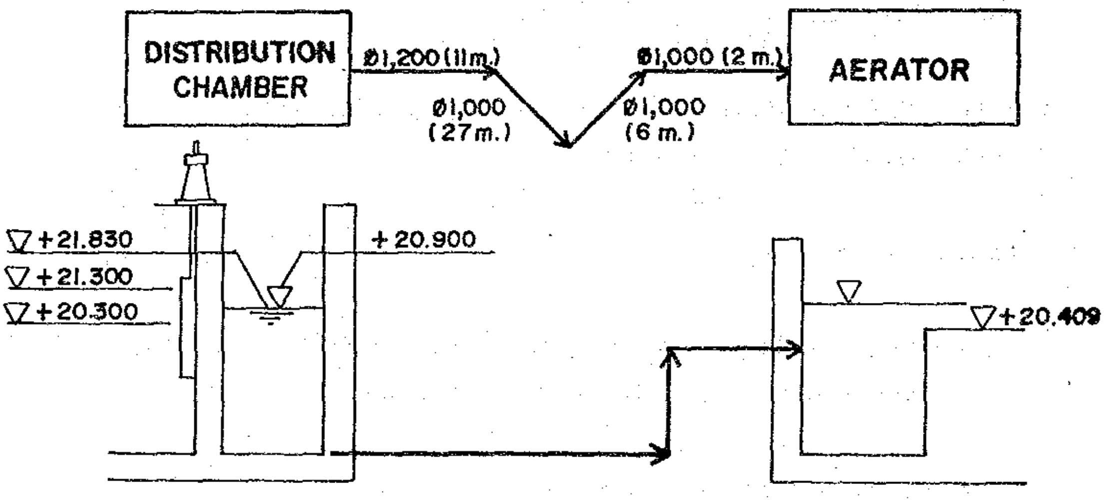


Fig. 4-3-2 Hydraulics of Distribution Chamber

Moreover, the water level at the Kelani river drops down to the critical level, the available pumping head of the existing intake pumps might be insufficient to lift the raw water up to the level of +21,300 m. Accordingly, five penstocks which control overflow water level is to be installed.

(6) Hydraulic Analysis of Filter Inlet Weir

Filter inlet weir is to be installed to distribute evenly the settled water to the filters. To maximise the use of the existing structure, the weir length is adjusted to 3.6 m, half of the existing weirs for filters No. 13 to No. 18. Overflow depth at the filter inlet weir is obtained as follows: