JAPAN INTERNATIONAL COOPERATION AGENCY

CHITTAGONG WATER SUPPLY AND SEWERAGE AUTHORITY

MINISTRY OF LOCAL GOVERNMENT, RURAL DEVELOPMENT AND CO-OPERATIVES

THE FEASIBILITY STUDY OF EXTENSION AND EXPANSION OF MOHARA WATER TREATMENT PLANT IN CHITTAGONG IN THE PEOPLE'S REPUBLIC OF BANGLADESH

FINAL REPORT

(SUMMARY)

DECEMBER 2000

NJS CONSULTANTS CO., LTD.

PREFACE

In response to request to from the Government of the People's Republic of Bangladesh, the Government of Japan decided to conduct a study on Extension and Expansion on Mohara Water Treatment Plant in Chittagong and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Bangladesh a study team composed of individuals from NJS Consultants Co., Ltd. headed by Mr. Kenji Hori. The team visited Bangladesh two times between January and October 2000.

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

I hope that the 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 Bangladesh for the close cooperation that they extended to the team.

December 2000

Kunihiko Saito, President
Japan International Cooperation Agency

December 2000

Mr. Kunihiko Saito, President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

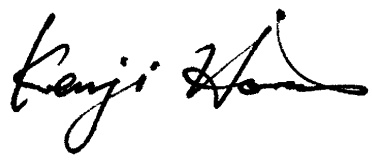
We are pleased to submit herewith the Final Report for the Study on Extension and Expansion on Mohara Water Treatment Plant in Chittagong.

The Study was completed through discussions with the officials of the Government of Bangladesh and field investigations during two visits from January and July 2000 and the homework thereafter.

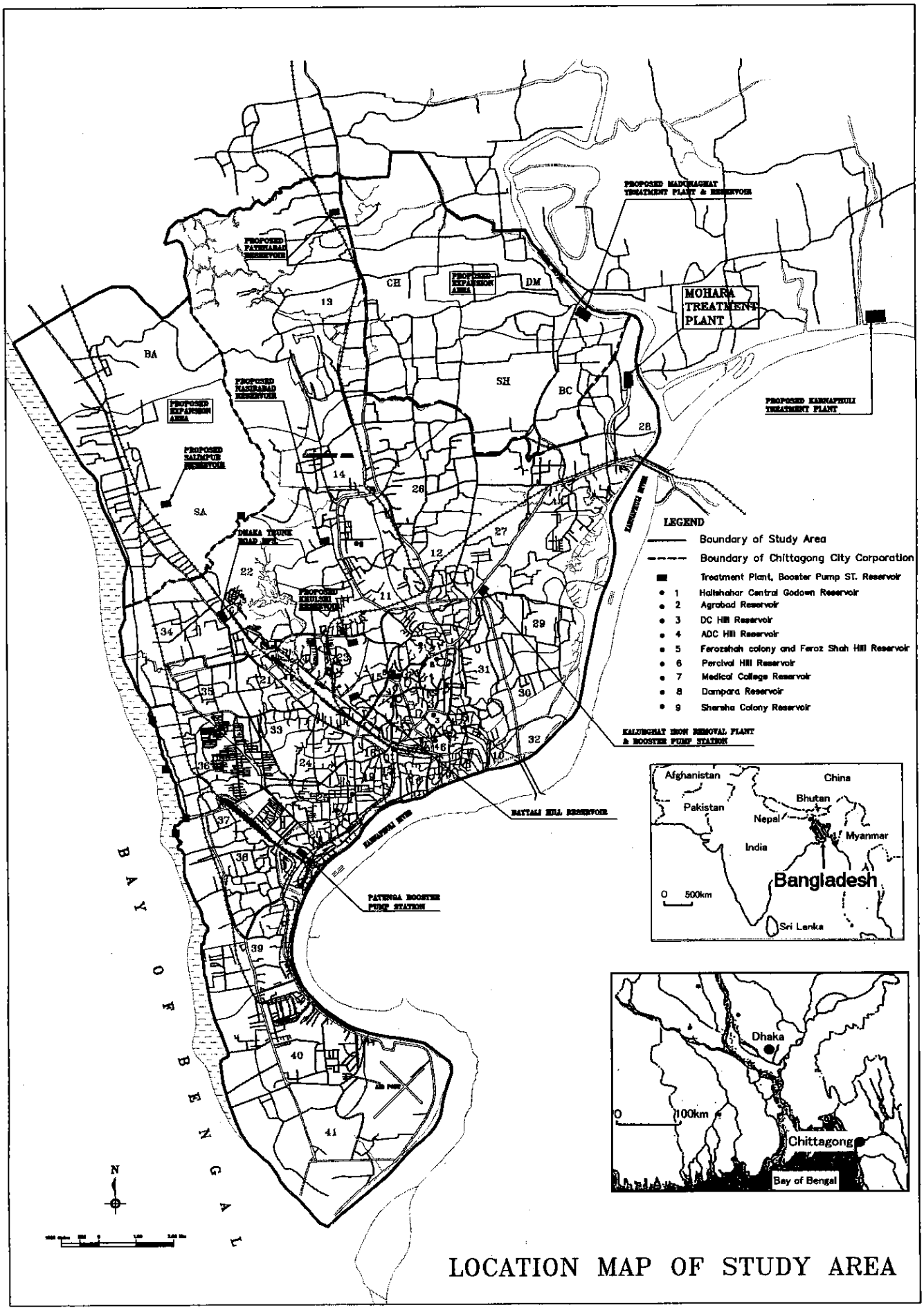
The Final Report consists of three volumes: 1) the Summary Report, which succinctly describes the study and its recommendations; 2) the Main Report, which covers the findings of the Basic Plan and the Feasibility Study on the proposed Priority Project; and 3) the Supporting Report, which contains data upon which the Basic Plan and the Feasibility Study are based.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and Ministry of Health and Welfare. We also would like to show our appreciation to the officials of the Chittagong Water Supply and Sewerage Authority, the Embassy of Japan in Bangladesh and the JICA Bangladesh Office for their kind assistance throughout this study.

Very truly yours,



Kenji Hori, Team Leader
Study on Extension and Expansion on
Mohara Water Treatment Plant in Chittagong



LOCATION MAP OF STUDY AREA

FINAL REPORT
(SUMMARY)

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 7 BASIC PLAN FOR DEVELOPMENT OF WATER SUPPLY SYSTEM

CHAPTER 8 PRIORITY PROJECT

CHAPTER 10 FINANCIAL ANALYSIS

CHAPTER 12 ORGANIZATION PLAN

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

1. Unit

A	Ampere
Cm	Centimeter
ft.	Foot
G	Gram
gpcd	gram per capita per day
ha	hectare (1 ha = 10,000m^2)
hr	Hour
kg	Kilogram
km	Kilometer
km^2 or sq.km	square kilometer
kV	Kilovolt
kVA	kilovolt ampere
kW	Kilowatt
kWh	kilowatt hour
l, or L	Liter
l/day, or l/d	liter per day
l/sec, or l/s	liter per second
lpcd, or Lpcd	liter per capita per day
m	Meter
m/s, or m/sec	meters per second
m^2, or sq.m	square meter
m^3, or cu.m	cubic meter
m^3/d, or cu.m/day	cubic meter per day
m^3/min	cubic meter per minute
m^3/s, or cu.m/sec	cubic meter per second
MCM	million cubic meter
mgd or MGD	million gallon per day (= 4,546 m^3/day)
mg/l	Milligram per liter
mm	Millimeter
kPa	Kilopascal (pressure)
MPa	Megapascal (pressure)
ppm	parts per million
Taka , TK, Tk	Bangladeshi Money Unit
V	Volt

2. Water Quality

BOD_5	Biochemical Oxygen Demand (20^oC, 5 days)
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EC	Electric Conductivity
PH	Hydrogen ion potential
SS	Suspended Solids
TS	Total Solids
TSS	Total Suspended Solids

3. Organizations

ADB	Asian Development Bank
BBS	Bangladesh Bureau of Statistics
CCC	Chittagong City Corporation
CE	Chief Engineer
CWASA	Chittagong Water Supply and Sewerage Authority
DOE	Department of Environment, Ministry of Environment and Forest
DOF	Department of Forest
DWASA	Dhaka Water Supply and Sewerage Authority
EE	Executive Engineer
ERD	Economic Relations Division, Ministry of Finance
GOB	Government of Bangladesh
IBRD	International Bank for Reconstruction and Development (World Bank)
IDA	International Development Agency (soft loan facility of IBRD)
IMF	International Monetary Fund
JBIC	Japan Bank of International Cooperation
JICA	Japan International Cooperation Agency
LGRD	Ministry of Local Government, Rural Development and Co-operatives
MOD I	Maintenance and Operation Division I of CWASA
MOD II	Maintenance and Operation Division II of CWASA
MOEF	Ministry of Environment and Forest
MOF	Ministry of Finance
NJS	Nippon Jogesuido Sekkei Co., Ltd. / NJS Consultants Co., Ltd.
OECD	Organization for Economic Cooperation and Development
SE	Superintending Engineer
WDB	Water Development Board
WHO	World Health Organization

4. Finance

B/S	Balance Sheet
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
MIS	Management Information System
MLSS	Member of Lower Subordinate Staff
MOD	Maintenance and Operation Division Circle
MODS	Maintenance Operation and Service Division
P&C	Planning and Construction Circle
PIR	Physical Inventory Report
P/L	Profit and Loss /Income and Expenditure
SL	Store Ledger
TP	Treatment Plant Circle
UFW	Unaccounted-for Water

5. Others

BDWS	Bangladesh Drinking Water Standard
BOT	Build - Operate - Transfer
BPS	Booster Pump Station
BWL	Bottom Water Level
CEPZ	Chittagong Export Processing Zone
CPI	Consumer Price Index
ECA	Environmental Conservation Act
ECC	Environmental Clearance Certificate
ECR	Environmental Conservation Rules
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
EPZ	Export Processing Zone
EQS	Environmental Quality Standards for Bangladesh
ETP	Effluent Treatment Plant
FIRR	Financial Internal Rate of Return
FY	Fiscal Year
GFF	Groundwater Flowing Flux
GL	Ground Level
GNP	Gross National Product
HWL	High Water Level

HHWL	High High Water Level
HH	Household
IEE	Initial Environmental Examination
IRP	Iron Removal Plant
KIP	Key Improvement Point
LLWL	Low Low Water Level
LWL	Low Water Level
M/M	Minute of Meeting
MSL	Mean Sea Level
NGO	Non-Governmental Organization
NOC	No Objection Certificate
NRW	Non-revenue Water
NWP	National Water Policy
O & M	Operation and Maintenance
ODA	Official Development Assistance
S/W	Scope of Work
STP	Sewage Treatment Plant
T.A	Technical Assistance
TOR	Terms of Reference
TW	Tube Well
TWL	Top Water Level
UFW	Unaccounted-For-Water
VAT	Value Added Tax
WSRP	Water Supply and Rehabilitation Project (of 2nd and 3rd Interim)
WTP	Water Treatment Plant

OUTLINE OF CHITTAGONG WATER SUPPLY PROJECT

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1. Target Year

The target year for the Basic Plan is 2010. In order to cope with rapid increase of water demand to the year 2010, the intermediate target year, which is the target year of the Priority Project, is set at the year 2005.

2. Project Area

The project area for the Study is 26,915 ha including proposed expansion area. The specific project area for the priority project is 13,986 ha[1].

3. Population of Project Area

The population of the project area is estimated at 3,186,100 in 2005, and at 3,992,300 in 2010. Out of them, the target service population[2] of the priority project area is estimated at 1,940,000. The service population, which is the restricted population of target service population due to limited water source, will be at 1,580,000.

4. Target Water Supply Service Level

The target water supply level in 2010 is set as follows:

(1) Ninety five percent (95 %) of households living in Pucca houses are supplied of water with house connections as well as 50 % of Semi-Pucca, and 20% of Kutcha.

(2) Remaining inhabitants of Pucca and Semi-Pucca houses are supplied of water with street hydrant as well as 20 % of peoples living in Kutcha houses. Remaining inhabitants in Kutcha houses are assumed to obtain water from other sources.

The intermediate target water supply level in 2005 is set as follows:

(1) Seventy percent (70 %) of households living in Pucca houses are supplied of water with house connections as well as 30 % of Semi-Pucca, and 15% of Kutcha.

(2) Regarding remaining inhabitants, 10 % of Pucca and 30 % of Semi-Pucca houses are supplied of water with street hydrant as well as 20 % of peoples living in Kutcha houses. Other remaining people are assumed to obtain water from other sources.

[1] Summation of multiplication of each word's area by demand coverage ratio

[2] Target service population was derived from target water supply service and projected population.

5. Water Supply Planning Area

The water supply service area will cover whole study area in 2010. In order to cope with limited water sources, it will cover limited area in 2005 consisting of present service area and its adjacent expansion area.

6. Planned Water Supply Flow

The water demand in the service area in the target year 2010 will be 650,000 m^3/day or 143 MGD on distribution base. While, water demand in the project area in 2005 will be 344,000 m^3/day.

Out of total demand, the planned water supply flow in 2005 is set at about 282,000 m^3/day or 62 MGD on distribution base taking account of possible service area and available water source by the year 2005:

7. Planned Water Source

Water sources of the proposed system consists of three surface water treatment plants and two groundwater treatment plants with a total capacity of 659,000 m^3/day or 145 MGD in 2010 as shown in below:

Name	Production Capacity (m^3/day)	Implementation Stage (available source capacity)		
		Existing	Phase 1 (2005)	Phase 2 (2010)
Mohara WTP (old plant, rehabilitation F/S)	20 MGD (90,900)	20 MGD	20 MGD	20 MGD
Mohara WTP (expansion plant, F/S)	20 MGD (90,900)	-	20 MGD	20 MGD
Kalurghat IRP (exist. plant, rehabilitation F/S)	20 MGD (90,900)	10 MGD	12 MGD	15 MGD
Madunaghat WTP (1st phase)	10 MGD (45,500)	-	10 MGD	10 MGD
Madunaghat WTP (2nd phase)	10 MGD (45,500)	-	-	10 MGD
Fatehabad IRP	10 MGD (45,500)	-	10 MGD	10 MGD
Karnaphuli WTP	60 MGD (272,800)	-	-	60 MGD*
Wells in MOD-I (to be abolished after Phase 1)	7 MGD (32,000)	7 MGD	-	-
Total	157 MGD(713,900)	37 MGD	62MGD	145 MGD

*: In order to compensate balances between capacity and water demand of other service blocks, capacity of the Karnaphuli WTP shall be increased.

8. Planned Water Supply System

Treated water of each WTP/IRP will be transmitted to 10 reservoirs and distributed to respective service block in 2010, while 6 reservoirs will be provided by the intermediate target year 2005.

Reservoir	Water Source	Phase 1(2005)	Phase 2(2010)
1. Exist. Mohara WTP Clearwater/Distribution Reservoir	Exist. Mohara WTP	6,700m^3	10,000m^3
2. Khulshi Ground Reservoir (F/S)	Mohara WTP Exp.	19,600m^3	19,600m^3
3. Khulshi Head Tank (F/S)	Mohara WTP Exp.	1,780m^3	1,780m^3
4. Exist. Kalurghat IRP Clearwater/Distribution Rsvr. (F/S)	Exist. Kalurghat IRP	12,700m^3	14,400m^3
5. Exist. Battali Hill Reservoir	Madunaghat WTP 1st	13,640m^3	13,640m^3
6. Madunaghat WTP 2nd Ground Clearwater/Distribution Reservoir, Head Tank	Madunaghat WTP 2nd	—	G: 10,000m^3 H: 1,530m^3
7. Fatehabad IRP Ground Clearwater/Distribution Reservoir, Head Tank	Fatehabad IRP	—	G: 10,000m^3 H: 1,530m^3
8. Nasirabad Reservoir Ground Reservoir, Head Tank	Karnaphuli WTP	—	G: 27,500m^3 H: 3,620m^3
9. Salimpur Reservoir	Karnaphuli WTP	—	11,200m^3
10. Patenga BPS Ground Reservoir (F/S)	Karnaphuli WTP*	12,000m^3	24,000m^3
(ADC Hill Reservoir)	(Exist. Mohara WTP)	(4,500m^3)	(4,500m^3)
Total		66,420m^3	139,800m^3

*: Before completion of the Phase 2 Project, the Patenga Reservoir will receive treated water from the Madunaghat WTP 1st and the existing Mohara WTP.

9. Project Cost

Total cost of the proposed Basic Plan is estimated at approximately US$ 450 million. Of which, Phase 1 project requires US$ 111 million, while US$ 339 million for Phase 2 project.

The total cost of the proposed Priority Project, which is a part of the Basic Plan Phase 1 Project is estimated at US$ 94 million without price contingency, and US$ 99 million with it.

Table S-1 Water Supply Condition and Projected Water Demand

	2000	2005	2010
1. Population in Study Area (ps)	2,550,000	3,190,000	3,990,000
2. Project Population to be served (ps)	-	1,940,000	3,370,000
3. Water Demand for above (m^3/day)	-	344,000	649,000
4. Planned Population with Water Supply Service (ps)	1,142,000	1,580,000	3,370,000
5. Adjustment ratio*1	-	82%	100 %
6. Coverage Ratio (%)	44.7	50	84
7. Water Supply Area (ha)*2	-	14,568	26,915
8. Distribution (m^3/day)	162,500	281,000	649,000
(MGD)	**35.7**	**62**	**143**
1) House Connection	68,000	134,000	329,000
2) Hydrant	16,400	23,000	42,000
3) Commercial	7,600	16,000	37,000
4) Institutional	1,100	2,000	18,000
5) Industrial	11,800	36,000	80,000
6) UFW/Leakage	57,600	70,000	143,000
(incl. UFW)	(35.4%)	(25 %)	(22 %)
9. House Connection Water Consumption (lpcd)	85	120	130
10. Water Supply Volume per capita per day (lpcd)	142	178	193
Condition	*Present*	*F/S Plan*	*Basic Plan*

Note: Population is on the Census level and not includes floating people.
*1: Ratio to adjust actual water demand against capacity of water sources.
(Planned population with service / Project population to be served)
*2: Ó (Area of each ward x Coverage Ratio of each ward (considering target water supply level))
Entire study area will be covered in 2010 because 100 % of target water level will be accomplished.

Table S-2 Assumption of Type of Housing

Type of housing	1991*	2005**	2010**
Pucca	31 %	42 %	47 %
Semi-Pucca	34 %	28 %	27 %
Kutcha	35 %	30 %	26 %

*: Chittagong Metropolitan Master Plan (Structure Plan; 1995)
**: Average ratio in whole project area projected by the Study Team.

Table S-3 Target of Water Supply Level

Type of Supply	2000	2005			2010		
	Pucca, Semi., Kutcha	Pucca	Semi.	Kutcha	Pucca	Semi.	Kutcha
House Connection	70 %	70 %	30 %	15 %	95 %	50 %	20 %
Public Hydrant	30 %	10 %	30 %	20 %	5 %	50 %	20 %

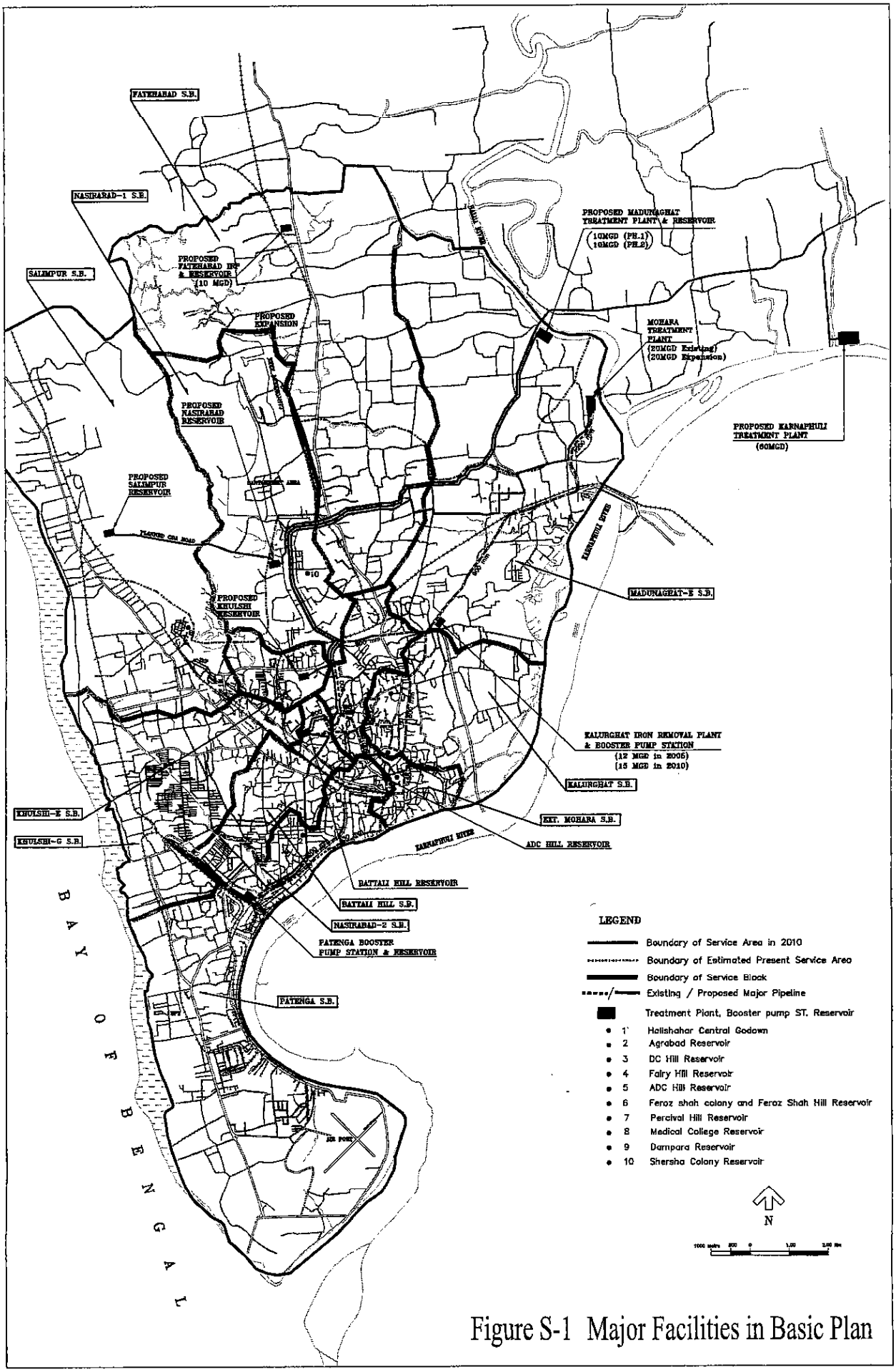

Figure S-1 Major Facilities in Basic Plan

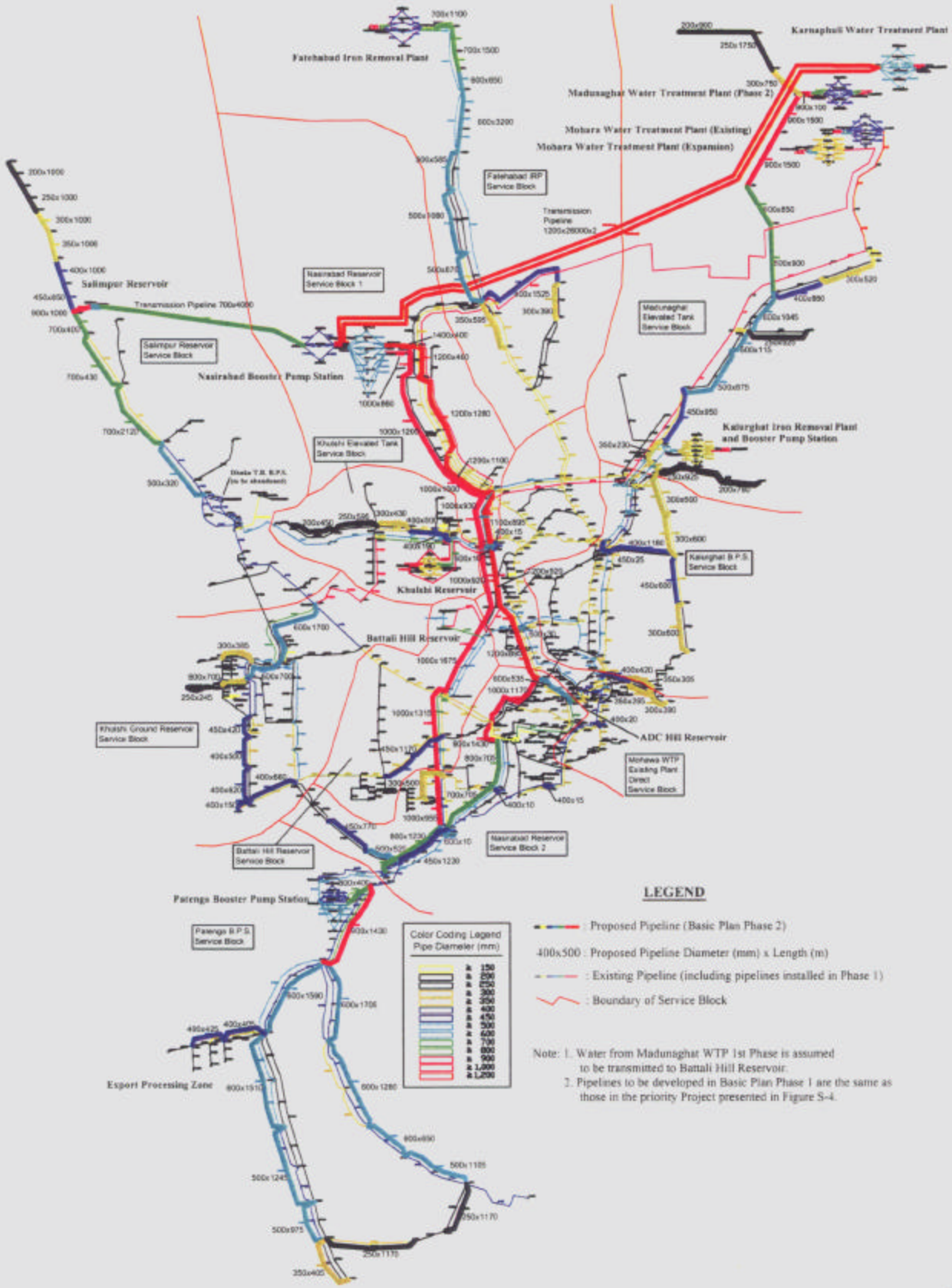

Figure S-2 Proposed Pipeline Network for Basic Plan (Phase 2, 2010)

Table S-4 Proposed Facilities of Basic Plan

Facilities	Diameter (mm)	Material	Phase 1		Phase 2	Total
			Urgent*	2005	2010	
1 Mohara WTP New Plant Service Area						
WTP Treatment Plant 20MGD			20 MGD	-	-	20 MGD
Transmission Pump 15.8m3/min x 84 m x 350 kW x 4 (+1)			5 units	-	-	5 units
Transmission Pipeline	900	DCIP	15,045 m	-	-	15,045 m
2 Khulshi Distribution Reservoir Service Area						
Khulshi Distribution Reservoir						
Ground 2,800m2 x 7mD (35m-28m) 19,600m3			19,600 m3	-	-	19,600 m3
Lift Pump 13.1m3/min x 25m x 90kW x 3 (+1)units			-	4 units	-	4 units
Elevated dia. 18m x 7mD (52m-45m) x 16mH (LWL)			-	1,780 m3	-	1,780 m3
Distribution Pipeline	1000-200	DCIP/PVC	7,725 m	13,260 m	7,880 m	28,865 m
3 Mohara WTP Old Plant Service Area						
WTP Rehabilitation Work (Filters, Intake/Transmission Pumps)			-	1 L.S.	-	1 L.S.
Distribution Pipeline	600-300	DCIP/PVC	-	20 m	1,170 m	1,190 m
4 Kalurghat BPS Service Area						
IRP Rehabilitation Work (Filters, Power Generator)			-	1 L.S.	-	1 L.S.
Clearwater Reservoir (add.)						
Ground 2,060m2 x 2.87mD (3.33m-0.46m)		exist. 2,940 m2	-	1,470 m2	590 m2	2,060 m2
(5,910m3)		(8,440 m3)		(4,220 m3)	(1,690 m3)	(5,910 m3)
Distribution Pipeline	600-200	DCIP/PVC	-	7,150 m	3,910 m	11,060 m
5 Battali Hill Reservoir Service Area						
Distribution Pipeline	800-200	DCIP/PVC	-	5,505 m	1,170 m	6,675 m
6 Madunaghat 2nd Phase Reservoir Service Area						
WTP Treatment Plant 10MGD			-	-	10 MGD	10 MGD
Madunaghat Distribution Reservoir						
Ground 2,000m2 x 5mD (7m-2m) 10,000m3			-	-	10,000 m3	10,000 m3
Lift Pump 15.6m3/min x 35m x 150kW x 3 (+1)			-	-	4 units	4 units
Elevated dia. 18m x 6mD (36m-30m) x 25mH (LWL)			-	-	1,530 m3	1,530 m3
Distribution Pipeline	900-200	DCIP/PVC	-	-	15,475 m	15,475 m
7 Fatehabad Reservoir Service Area						
Reservoir						
Ground 2,000m2 x 5mD (17m-12m) 10,000m3			-	-	10,000 m3	10,000 m3
Lift Pump 15.6m3/min x 35m x 150kW x 3 (+1)			-	-	4 units	4 units
Elevated dia. 18m x 6mD (46m-40m) x 25mH (LWL)			-	-	1,530 m3	1,530 m3
Distribution Pipeline	700-300	DCIP/PVC	-	-	10,495 m	10,495 m
8 Karnaphuli WTP						
WTP Treatment Plant 60MGD			-	-	60 MGD	60 MGD
Transmission Pump 48m3/min x 71.5m x 920kW x 4 (+1)			-	-	5 units	5 units
Transmission Line	1,200	DCIP	-	-	52,000 m	52,000 m
9 Nashirabad Reservoir Service Area						
Reservoir						
Ground 5,500m2 x 5mD (28m-23m) 27,500m3			-	-	27,500 m3	27,500 m3
Lift Pump 38.4m3/min x 28.5m x 300kW x 3 (+1)			-	-	4 units	
Elevated dia. 24m x 8mD (53m-45m) x 25mH (LWL)			-	-	3,620 m3	3,620 m3
Transmission Line to Patenga BPS			-			
Lift Pump 38.7m3/min x 22.5m x 240kW x 2 (+1)			-	-	3 units	3 units
Transmission Line	1000-600	DCIP	-	-	10,505 m	10,505 m
Transmission Line to Salimpur Reservoir			-			
Lift Pump 18m3/min x 48.5m x 240kW x 2 (+1)			-	-	3 units	3 units
Transmission Line	700	DCIP	-	-	4,000 m	4,000 m
Distribution Pipeline	1400-300	DCIP/PVC	-	-	12,725 m	12,725 m
10 Salimpur Reservoir Service Area						
Salimpur Distribution Reservoir						
Ground 1,400m2 x 8mD (55m-47m) 11,200m3			-	-	11,200 m3	11,200 m3
Distribution Pipeline	900-200	DCIP/PVC	-	-	10,120 m	10,120 m
11 Patenga BPS Service Area						
Patenga Distribution Reservoir						
Ground 4,000 m2 x 6mD (7m-1m)	24,000m3		-	2,000 m2	2,000 m2	4000 m2
				(12,000 m3)	(12,000 m3)	(24,000 m3)
Dist. Pump 19.2m3/min x 37m x 200kW x 2 (+1)			-	3 units	-	3 units
27.6m3/min x 37m x 280kW x 2 (+1)			-	-	3 units	3 units
Distribution Pipeline	900-200	DCIP/PVC	-	14,630 m	15,465 m	30,095 m
12 Secondary (Small Dia.) Distribution Pipelines						
Small Diameter Pipelines	200-100	PVC	-	1 L.S.	1 L.S.	1 L.S.
13 Staff Quarters and Zone Offices						
Staff Quarters	100m2		-	40 flats	40 flats	80 flats
Zone Offices	800m2		-	5 offices	5 offices (exp.)	5 offices
Summary of Facilities to be Developed						
Water Treatment Plants			1 plant	-	2 plants	3 plants
Capacity of WTPs			20 MGD	-	70 MGD	90 MGD
Pump Stations			1 station	2 stations	5 stations	8 stations
Number of pump units			5 units	7 units	26 units	38 units
Reservoirs**						
Ground Reservoir			1 reservoir	2 reservoirs	4+2(exp.) r.	7 reservoirs
total capacity			19,600 m3	3,470 m3	61,290 m3	84,360 m3
Elevated Tank			-	1 tank	3 tanks	4 tanks
total capacity			-	1,780 m3	6,680 m3	8,460 m3
Pipelines***			22,770 m	25,935 m	129,450 m	178,155 m
Transmission Pipeline Total Length		DCIP/PVC	15,045 m	-	66,505 m	81,550 m
Ditribution Pipeline Total Length		DCIP/PVC	7,725 m	40,565 m	62,945 m	111,235 m

Note: Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Urgent project consists of minimum required facility for production and distribution of Mohara WTP new plant. It includes Mohara WTP new plant, transmission pipeline, ground distribution reservoir and a part of main distribution pipeline.

**: Clearwater reservoirs in WTP are not included.

***:Pipeline Length does not include secondary distribution (small dia.) pipeline network.

Table S-5 Project Cost of Basic Plan

(unit: US$)

Facilities	Phase 1 (2005)			Phase 2 (2010)			Total
	Local	Foreign	Total	Local	Foreign	Total	
I. Direct Construction Cost**							
1. Mohara WTP New Plant Service Area	6,584,000	13,857,000	20,441,000	0	0	0	20,441,000
2. Khulshi Distribution Reservoir Service Area	4,074,000	4,884,000	8,958,000	367,000	801,000	1,168,000	10,126,000
3. Mohara WTP Old Plant Service Area	355,000	2,275,000	2,630,000	49,000	86,000	135,000	2,765,000
4. Kalurghat BPS Service Area*	1,915,000	4,244,000	6,159,000	408,000	412,000	820,000	6,979,000
5. Battali Hill Reservoir Service Area*	-	-	-	55,000	117,000	172,000	172,000
6. Madunaghat 2nd Phase Reservoir Service Area	-	-	-	6,654,000	7,902,000	14,556,000	14,556,000
7. Fatehabad Reservoir Service Area	-	-	-	2,544,000	3,312,000	5,856,000	5,856,000
8. Karnaphuli WTP	-	-	-	26,968,000	46,044,000	73,012,000	73,012,000
9. Nashirabad Reservoir Service Area	-	-	-	7,284,000	15,448,000	22,732,000	22,732,000
10. Salimpur Reservoir Service Area	-	-	-	1,749,000	1,566,000	3,315,000	3,315,000
11. Patenga BPS Service Area*	1,381,000	2,331,000	3,712,000	2,638,000	4,557,000	7,195,000	10,907,000
12. Small Size Distribution Pipelines	5,878,000	8,469,000	14,347,000	20,246,000	29,171,000	49,417,000	63,764,000
13. Staff Quarters and Zone Offices	1,480,000	0	1,480,000	1,480,000	0	1,480,000	2,960,000
Sub-Total I	**21,667,000**	**36,060,000**	**57,727,000**	**70,442,000**	**109,416,000**	**179,858,000**	**237,585,000**
II. Overhead and Profit							
Overhead and Profit (ICB - 25% of DC 1 to 11)	0	10,475,000	10,475,000	0	32,240,000	32,240,000	42,715,000
Overhead and Profit (LCB - 12.5% of DC 12,13)	1,978,000	0	1,978,000	6,362,000	0	6,362,000	8,340,000
Sub-Total II	**1,978,000**	**10,475,000**	**12,453,000**	**6,362,000**	**32,240,000**	**38,602,000**	**51,055,000**
III. Procurement of Equipment							
1. Water Meter (20-150mmx25,000units) x 2 phases	0	589,000	589,000	0	589,000	589,000	1,178,000
2. Vehicles (Sedan x 2, 4WD x 2) x 2 phases	0	93,000	93,000	0	93,000	93,000	186,000
3. Computers (8 sets with printers) x 2 phases	0	22,000	22,000	0	22,000	22,000	44,000
Sub-Total III	**0**	**704,000**	**704,000**	**0**	**704,000**	**704,000**	**1,408,000**
IV. Administration							
1. CWASA Administration Cost	128,000	0	128,000	128,000	0	128,000	256,000
2. Land Acquisition Cost	3,370,000	0	3,370,000	8,715,000	0	8,715,000	12,085,000
Sub-Total IV	**3,498,000**	**0**	**3,498,000**	**8,843,000**	**0**	**8,843,000**	**12,341,000**
V. Duties, Taxes, and Charges							
1. Custom Duty and Other Import Charges	12,595,000	0	12,595,000	37,724,000	0	37,724,000	50,319,000
2. VAT for Civil Work (4.5%)	1,518,000	0	1,518,000	4,607,000	0	4,607,000	6,125,000
3. VAT for M&E Equipment	6,010,000	0	6,010,000	18,437,000	0	18,437,000	24,447,000
4. Pre-Shipment Inspection Fee	302,000	0	302,000	936,000	0	936,000	1,238,000
Sub-Total V	**20,425,000**	**0**	**20,425,000**	**61,704,000**	**0**	**61,704,000**	**82,129,000**
VI. Engineering Cost							
1. D/D + C/S (8% of I+II)	849,000	4,810,000	5,659,000	2,611,000	14,798,000	17,409,000	23,068,000
2. VAT for Engineering Cost (5.25%)	297,000	0	297,000	914,000	0	914,000	1,211,000
Sub-Total VI	**1,146,000**	**4,810,000**	**5,956,000**	**3,525,000**	**14,798,000**	**18,323,000**	**24,279,000**
VII. Contingencies							
1. Physical Contingency (10% of I+II+III+IV+V+VI)	**4,871,000**	**5,205,000**	**10,076,000**	**15,088,000**	**15,716,000**	**30,804,000**	**40,880,000**
2. Price Contingency (LCP: 0.7%p.a., FCP: 2%p.a.)	**-**	**-**	**-**	**-**	**-**	**-**	**-**
VIII. Total Project Cost	**53,585,000**	**57,254,000**	**110,839,000**	**165,964,000**	**172,874,000**	**338,838,000**	**449,677,000**

Note: Costs for Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are consideredas existing facilities.

*: Costs in 2005 for distribution pipelines outside of Khulshi S.A. excluding small size pipes are summed in the column of Kalurghat BPS service area.

**: Direct Cost of each category from 1 to 12 incledes costs of all faciliteies such as transmission/main distribution pipelines, treatment plant, reservoirs, and booster pumps.

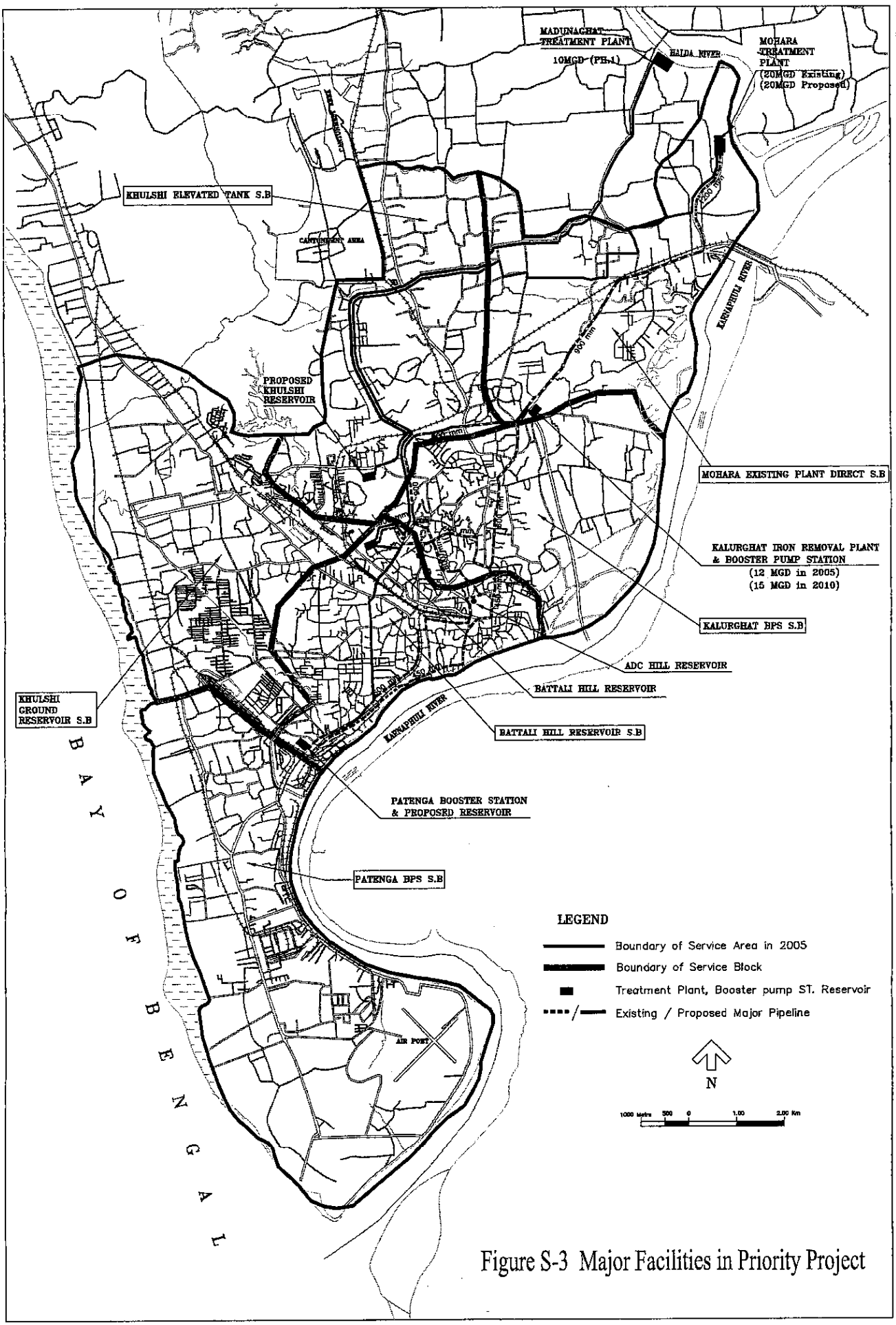

Figure S-3 Major Facilities in Priority Project

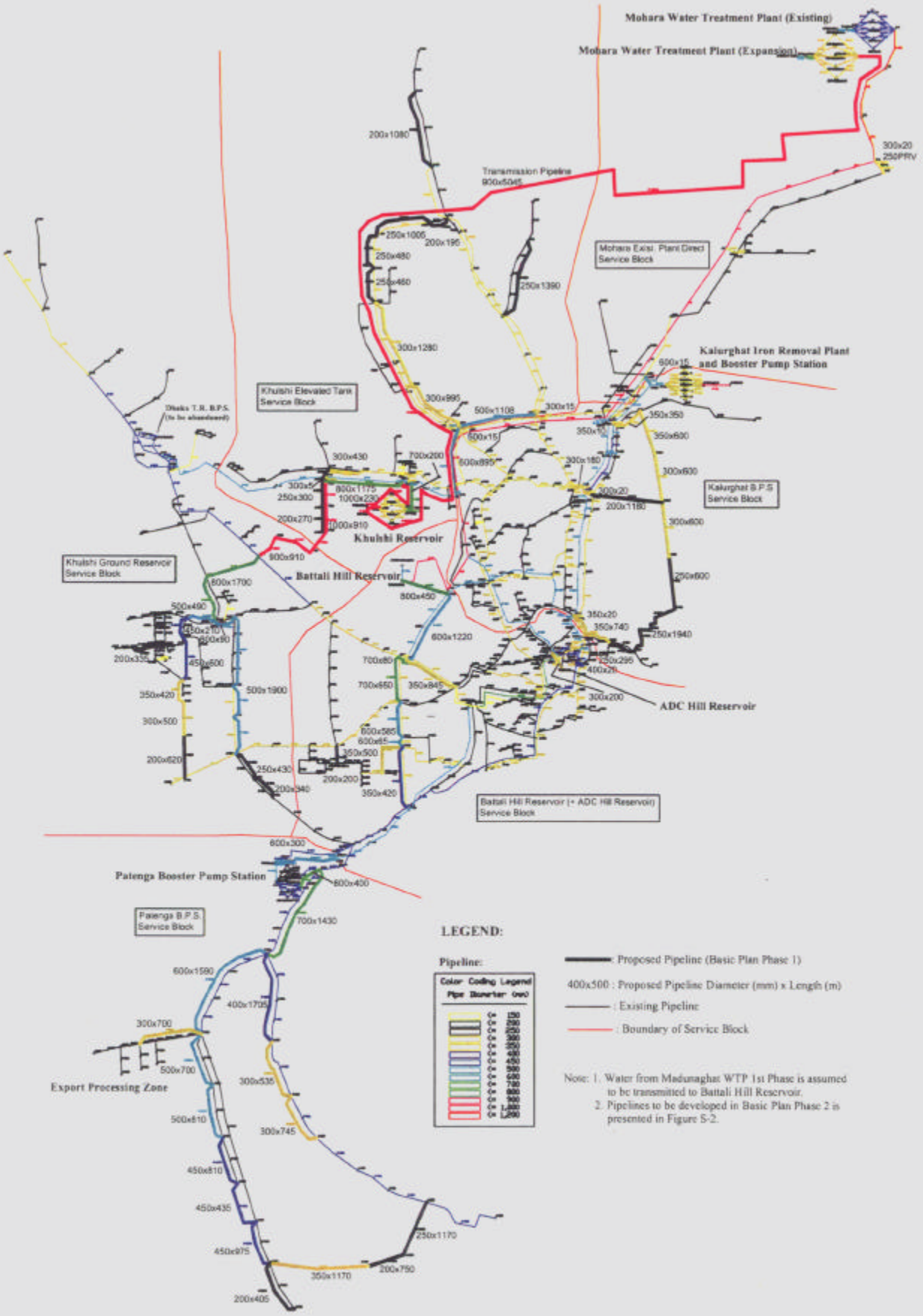

Figure S-4 Proposed Pipeline Network for Priority Project (B/P Phase 1, 2005)

Table S-6 Proposed Facilities of Priority Project

Facilities	Diameter (mm)	Material	Quantity
1 Mohara WTP New Plant Service Area			
WTP Treatment Plant 20MGD			20 MGD
Transmission Pump 15.8m3/min x 84 m x 350 kW x 4 (+1)units			5 units
Transmission Pipeline	900	DCIP	15,045 m
2 Khulshi Distribution Reservoir Service Area			
Khulshi Distribution Reservoir			
Ground 2,800m2 x 7mD (35m-28m)			19,600 m3
Lift Pump 13.1m3/min x 25m x 90kW x 3 (+1)units			4 units
Elevated dia. 18m x 7mD (52m-45m) x 16mH (LWL)			1,780 m3
Distribution Pipeline	1000-200	DCIP/PVC	20,985 m
3 Mohara WTP Old Plant Service Area			
WTP Rehabilitation Work (Filters, Intake/Transmission Pumps)			1 L.S.
Distribution Pipeline	600-300	DCIP/PVC	20 m
4 Kalurghat BPS Service Area			
IRP Rehabilitation Work (Filters, Power Generator)			1 L.S.
Clearwater Reservoir (add.)			
Ground 1,470m2 x 2.87mD (3.33m-0.46m)		exist. 2,940 m2	1,470 m2
		(8,440 m3)	(4,220 m3)
Distribution Pipeline	600-200	DCIP/PVC	7,150 m
5 Battali Hill Reservoir Service Area			
Distribution Pipeline	800-200	DCIP/PVC	5,505 m
6 Patenga BPS Service Area			
Patenga Distribution Reservoir			
Ground 2,000 m2 x 6mD (7m-1m)			12,000 m3
Dist. Pump 19.2m3/min x 37m x 200kW x 2 (+1)units			3 units
Distribution Pipeline	900-200	DCIP/PVC	14,630 m
7 Secondary (Small Dia.) Distribution Pipelines			
Small Diameter Pipelines	200-100	PVC	1 L.S.
8 Staff Quarters and Zone Offices			
Staff Quarters	100m2		40 flats
Zone Offices	800m2		5 offices
Summary of Facilities to be Developed			
Water Treatment Plants			1 plant
Capacity of WTPs			20 MGD
Pump Stations			3 stations
Number of pump units			12 units
Reservoirs*			
Ground Reservoir			3 reservoirs
total capacity			35,820 m3
Elevated Tank			1 tank
total capacity			1,780 m3
Pipelines**			63,335 m
Transmission Pipeline Total Length			15,045 m
Ditribution Pipeline Total Length			48,290 m

Note: Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Clearwater reservoirs in WTP are not included.

**: Pipeline Length does not include secondary distribution (small dia.) pipeline network.

Table S-7 Cost Estimates for Priority Project

(unit: US$)

Facilities	Priority Project		
	Local	**Foreign**	**Total**
I. Direct Construction Cost			
1. Treatment Plant			
Mohara WTP Expansion Plant, Transmission Pumps	5,535,000	9,633,000	15,168,000
Mohara WTP Rehabilitation Work	355,000	2,275,000	2,630,000
Kalurghat IRP Rehabilitation Work, Reservoir	643,000	1,393,000	2,036,000
2. Distribution Reservoir and BPS			
Khulshi Distribution Reservoir, Pumps, Tank	3,031,000	2,151,000	5,182,000
Patenga Distribution Reservoir	1,381,000	2,331,000	3,712,000
3. Transmission / Distribution Pipeline			
Transmission Pipeline DCIP 900mm x 15,045m	1,049,000	4,224,000	5,273,000
Main Distribution Pipeline	2,315,000	5,584,000	7,899,000
4. Small Size Distribution Pipelines	1,986,000	2,861,000	4,847,000
5. Staff Quarters and Zone Offices	1,480,000	0	1,480,000
Total of Direct Construction cost	**17,775,000**	**30,452,000**	**48,227,000**
II. Overhead and Profit	**791,000**	**10,475,000**	**11,266,000**
III. Procurement of Equipment	**0**	**704,000**	**704,000**
IV. Administration			
1. CWASA Administration Cost	**128,000**	**0**	**128,000**
2. Land Acquisition Cost	**3,370,000**	**0**	**3,370,000**
V. Duties, Taxes, and Charges	**16,316,000**	**0**	**16,316,000**
VI. Engineering Cost			
1. D/D + C/S	782,000	4,022,000	4,804,000
2. VAT for Engineering Cost (5.25%)	252,000	0	252,000
Total of Engineering Cost	**1,034,000**	**4,022,000**	**5,056,000**
VII. Contingencies			
1. Physical Contingency (10% of I+II+III+IV+V+VI)	**3,941,000**	**4,565,000**	**8,506,000**
2. Price Contingency (LCP:0.7%p.a.,FCP:2%p.a.)	**1,376,000**	**4,129,000**	**5,505,000**
VIII. Total Project Cost excluding Price Contingency	**43,355,000**	**50,218,000**	**93,573,000**
Total Project Cost including Price Contingency	**44,731,000**	**54,347,000**	**99,078,000**

Note: Costs for Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Costs for Distribution Pipeline in Kalurghat S.A includes all distribution pipelines outside of Khulshi S.A.

Figure S-5 Implementation Schedule of Priority Project

Activities	2000				2001				2002				2003				2004				2005				2006			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. JICA Feasibility Study																												
2. Procedures in Bangladesh Government																												
3. Procedures for Loan Proceeding																												
4. Land Acquisition																												
5. Detailed Design																												
6. Pre-Construction Procedures																												
7. Mohara WTP Extension Work																												
8. Kalurghat IRP Rehabilitation Work																												
9. Khulshi Reservoir Construction Work																												
10. Patenga BPS & Reservoir Const. Work																												
11. Mohara New Transmission Line Work																												
12. Distribution Pipelines Work																												
13. Staff Quarters and Zone Offices																												
14. Test & Comissioning of Mohara WTP																												
15. Exist. Mohara WTP Rehabilitation Work																												

Table S-8 Disbursement Schedule of Priority Project

(unit: US$)

Facilities	Priority Project Total			2001			2002			2003				2004			2005			2006		
	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign		Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
I. Direct Construction Cost																						
1. Mohara WTP New Plant Service Area																						
WTP Treatment Plant 20MGD, Trans. Pump	5,535,000	9,633,000	15,168,000	0	0	0	0	0	0	1,107,000	1,927,000	20%	3,034,000	2,214,000	3,853,000	6,067,000	2,214,000	3,853,000	6,067,000	0	0	0
Transmission Pipeline DCIP 900mm x 15,045m	1,049,000	4,224,000	5,273,000	0	0	0	0	0	0	210,000	845,000	20%	1,055,000	420,000	1,690,000	2,110,000	420,000	1,689,000	2,109,000	0	0	0
2. Khulshi Distribution Reservoir Service Area																						
Khulshi Distribution Reservoir, Pump, E..Tank	3,031,000	2,151,000	5,182,000	0	0	0	0	0	0	606,000	430,000	20%	1,036,000	1,212,000	860,000	2,072,000	1,212,000	861,000	2,073,000	0	0	0
Distribution Pipeline	1,272,000	2,851,000	4,123,000	0	0	0	0	0	0	127,000	285,000	10%	412,000	509,000	1,140,000	1,649,000	509,000	1,140,000	1,649,000	128,000	286,000	414,000
3. Mohara WTP Old Plant Service Area																						
WTP Rehabilitation Work	355,000	2,275,000	2,630,000	0	0	0	0	0	0	0	0	0%	0	0	0	0	178,000	1,138,000	1,316,000	177,000	1,138,000	1,315,000
Distribution Pipeline	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
4. Kalurghat BPS Service Area																						
IRP Rehabilitation Work, Clearwater Reservoir	643,000	1,393,000	2,036,000	0	0	0	0	0	0	129,000	279,000	20%	408,000	257,000	557,000	814,000	257,000	557,000	814,000	0	0	0
Distribution Pipeline (outside of Khulshi S.A. *)	1,272,000	2,851,000	4,123,000	0	0	0	0	0	0	127,000	285,000	10%	412,000	509,000	1,140,000	1,649,000	509,000	1,140,000	1,649,000	127,000	286,000	413,000
5. Battali Hill Reservoir Service Area																						
Distribution Pipeline	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
6. Patenga BPS Service Area																						
Patenga Distribution Reservoir, Pump	1,381,000	2,331,000	3,712,000	0	0	0	0	0	0	276,000	466,000	20%	742,000	552,000	932,000	1,484,000	553,000	933,000	1,486,000	0	0	0
Distribution Pipeline	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
7. Small Size Distribution Pipelines	1,986,000	2,861,000	4,847,000	0	0	0	0	0	0	199,000	286,000	10%	485,000	794,000	1,144,000	1,938,000	794,000	1,144,000	1,938,000	199,000	287,000	486,000
8. Staff Quarters and Zone Offices	1,480,000	0	1,480,000	0	0	0	0	0	0	592,000	0	40%	592,000	592,000	0	592,000	296,000	0	296,000	0	0	0
Total of Direct Construction Cost	**18,004,000**	**30,570,000**	**48,574,000**	**0**	**0**	**0**	**0**	**0**	**0**	**3,373,000**	**4,803,000**		**8,176,000**	**7,059,000**	**11,316,000**	**18,375,000**	**6,942,000**	**12,455,000**	**19,397,000**	**631,000**	**1,997,000**	**2,628,000**
II. Overhead and Profit																						
1. OH and Profit for ICB (25% of 1, 2, 3, 4, 5 and 6)	0	10,475,000	10,475,000	0	0	0	0	0	0	646,000	1,129,000		1,775,000	1,418,000	2,543,000	3,961,000	1,463,000	2,828,000	4,291,000	108,000	428,000	536,000
2. OH and Profit for LCB (12.5% of 7 and 8)	791,000	0	791,000	0	0	0	0	0	0	99,000	36,000		135,000	173,000	143,000	316,000	136,000	143,000	279,000	24,000	36,000	60,000
Total of Overhead and Profit	**791,000**	**10,475,000**	**11,266,000**	**0**	**0**	**0**	**0**	**0**	**0**	**745,000**	**1,165,000**		**1,910,000**	**1,591,000**	**2,686,000**	**4,277,000**	**1,599,000**	**2,971,000**	**4,570,000**	**132,000**	**464,000**	**596,000**
III. Procurement of Equipment	**0**	**704,000**	**704,000**	**0**	**0**	**0**	**0**	**106,000**	**106,000**	**0**	**598,000**	**85%**	**598,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
IV. Administration																						
1. CWASA Administration Cost	**128,000**	**0**	**128,000**	**13,000**	**0**	**13,000**	**13,000**	**0**	**13,000**	**26,000**	**0**	**20%**	**26,000**	**32,000**	**0**	**32,000**	**32,000**	**0**	**32,000**	**12,000**	**0**	**12,000**
2. Land Acquisition Cost	**3,370,000**	**0**	**3,370,000**	**2,696,000**	**0**	**2,696,000**	**674,000**	**0**	**674,000**	**0**	**0**	**0%**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
V. Duties, Taxes, and Charges																						
1. Custom Duty and Other Import Charges	9,907,000	0	9,907,000	0	0	0	52,000	0	52,000	1,061,000	0	8%	1,061,000	2,868,000	0	2,868,000	5,066,000	0	5,066,000	861,000	0	861,000
2. VAT for Civil Work (4.5%)	1,321,000	0	1,321,000	0	0	0	0	0	0	222,000	0	17%	222,000	500,000	0	500,000	528,000	0	528,000	70,000	0	70,000
3. VAT for M&E Equipment	4,842,000	0	4,842,000	0	0	0	22,000	0	22,000	502,000	0	8%	502,000	1,408,000	0	1,408,000	2,488,000	0	2,488,000	422,000	0	422,000
4. Pre-Shipment Inspection Fee	246,000	0	246,000	0	0	0	1,000	0	1,000	25,000	0	8%	25,000	72,000	0	72,000	127,000	0	127,000	22,000	0	22,000
Total of Duties, Taxes, and Charges	**16,316,000**	**0**	**16,316,000**	**0**	**0**	**0**	**75,000**	**0**	**75,000**	**1,810,000**	**0**		**1,810,000**	**4,848,000**	**0**	**4,848,000**	**8,209,000**	**0**	**8,209,000**	**1,375,000**	**0**	**1,375,000**
VI. Engineering Cost																						
1. D/D + C/S	782,000	4,022,000	4,804,000	0	0	0	321,000	1,782,000	2,103,000	115,000	529,000	10%	644,000	142,000	633,000	775,000	145,000	732,000	877,000	59,000	346,000	405,000
2. VAT for Engineering Cost (5.25%)	252,000	0	252,000	0	0	0	110,000	0	110,000	34,000	0	60%	34,000	41,000	0	41,000	46,000	0	46,000	21,000	0	21,000
Total of Engineering Cost	**1,034,000**	**4,022,000**	**5,056,000**	**0**	**0**	**0**	**431,000**	**1,782,000**	**2,213,000**	**149,000**	**529,000**	**5%**	**678,000**	**183,000**	**633,000**	**816,000**	**191,000**	**732,000**	**923,000**	**80,000**	**346,000**	**426,000**
VII. Contingencies																						
1. Physical Contingency (10% of I+II+III+IV+V+VI)	**3,941,000**	**4,565,000**	**8,506,000**	**271,000**	**0**	**271,000**	**119,000**	**189,000**	**308,000**	**610,000**	**710,000**		**1,320,000**	**1,371,000**	**1,464,000**	**2,835,000**	**1,697,000**	**1,616,000**	**3,313,000**	**223,000**	**281,000**	**504,000**
2. Price Contingency (LCP:0.7%p.a.,FCP:2%p.a.)	**1,376,000**	**4,129,000**	**5,505,000**	**21,000**	**0**	**21,000**	**18,000**	**84,000**	**102,000**	**142,000**	**478,000**		**620,000**	**427,000**	**1,327,000**	**1,754,000**	**663,000**	**1,850,000**	**2,513,000**	**105,000**	**390,000**	**495,000**
VIII. Total Project Cost excluding Price Contingency	**43,355,000**	**50,218,000**	**93,573,000**	**2,980,000**	**0**	**2,980,000**	**1,312,000**	**2,077,000**	**3,389,000**	**6,713,000**	**7,805,000**	**14,518,000**	**14,518,000**	**15,084,000**	**16,099,000**	**31,183,000**	**18,670,000**	**17,774,000**	**36,444,000**	**2,453,000**	**3,088,000**	**5,541,000**
Total Project Cost including Price Contingency	**44,731,000**	**54,347,000**	**99,078,000**	**3,001,000**	**0**	**3,001,000**	**1,330,000**	**2,161,000**	**3,491,000**	**6,855,000**	**8,283,000**		**15,138,000**	**15,511,000**	**17,426,000**	**32,937,000**	**19,333,000**	**19,624,000**	**38,957,000**	**2,558,000**	**3,478,000**	**6,036,000**

Note: Costs for Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Costs for Distribution Pipeline in Kalurghat S.A includes all distribution pipelines outside of Khulshi S.A.

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Preamble

The Feasibility study on Extension and Expansion on Mohara Water Treatment Plant in Chittagong in the People's Republic of Bangladesh (hereinafter referred to as "the study") was carried out in accordance with the Scope of Work agreed between the Ministry of Local Government, Rural Development and Co-operation (hereinafter referred to as "LGRD") and the Preparatory Study Team dispatched by the Japan International Cooperation Agency (hereinafter referred to as "JICA") on October 12, 1999.

JICA had organized the Japanese Study Team (hereinafter referred to as "the Study Team") and dispatched to commence the Study from January 2000. The Study was completed on December 2000 and all of the outcome was furnished in this Report.

1.2 Background of the Study

Chittagong City, the second largest city in Bangladesh, is situated on a peninsula located surrounded by the Bay of Bengal on the west and by the Karnaphuli River on the east.

There are various industries such as textile, fertilizer, garment and gas production. These industries have brought new life in the City. In this decade's remarkable phenomena in the economy of the country is unprecedented growth of garment industry in Chittagong. Developing the industries in Chittagong has brought rapid increase of population, and the present population in the City is more than 3.0 Million including non-registered floating people.

Chittagong Water Supply and Sewerage Authority (hereinafter referred to as "CWASA") was established in 1963 and took over the public water supply utility from the Chittagong Municipality. CWASA has taken his effort to reinforce the water supply capacity with IDA assistance and achieved the capacity of producing 40 MGD water.

According to remarkable population growth for the last decade, the present water supply coverage rate is 45% only. Moreover, due to shortage of water supply capacity, the water pressure has been lowered and the water supply interrupted area has expanded.

Under these circumstances, the Government of the People's Republic of Bangladesh (hereinafter

referred to as “the Government of Bangladesh”) requested to the Government of Japan to extend the technical cooperation on the development study aiming at extension of water supply capacity of Mohara water treatment plant in Chittagong.

In response to the request of the Government of Bangladesh, JICA, the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, conducted the Study on the Extension and Expansion of Mohara Water Treatment Plant in Chittagong including the Feasibility Study on the priority project.

1.3 Objectives of the Study

The objectives of the Study are; (1) to formulate a basic plan for the target year 2010 with reviewing existing plans, and (2) to conduct a feasibility study on the priority project selected from the basic plan, and (3) to transfer technology on planning methods and skills to counterpart personnel in the course of the Study.

1.4 Study Area

The Study Area was delineated to conform the Chittagong City with the land area of 20,004 ha and a part of the surrounding two Thanas with the land area of 6,911ha, namely a part of Sitakunda Thana, which has been covered by CWASA water supply service, and a part of Hathazari Thana, in which the Madunaghat Water Treatment Plant (WTP) is projected under financial assistance of the Government of Italy. Hence total land area of the Study is 26,915 ha.

1.5 Scope of Work

(1) The Study involves preparation of a basic plan for development of the water supply system in Chittagong for the target year of 2010. In the course of the preparation, planning of equipment and facilities, as a hard aspect, and review and analysis on the organization and financial arrangement as a soft aspect were conducted in the Study.
(2) Formulation of a Feasibility Project that was selected from the above mentioned basic plan as an urgent improvement project. The subject of feasibility study shall involve an extension of the existing Mohara W.T.P having the same capacity, and hydraulic analysis on the transmission and distribution main to be connected to the existing pipelines so as to function the whole water supply system, effectively.
(3) For the existing facilities, formulation of a rehabilitation plan was prepared, excluding the tube wells and transmission and distribution pipeline.

1.6 Formulation of the Study

1.6.1 General

The Study was carried out in accordance with the Scope of Work agreed upon between the LGRD and the JICA. CWASA was the implementation agency for the project and accomplished the Study in close cooperation with the Study Team. The overall set-up for the implementation of the Study is as discussed below.

1.6.2 Implementation Set-up of Japanese Side

The implementation set-up of the Japanese side consisted of the Study Team and Advisory Committee under the general supervision of the JICA headquarter. The composition of the JICA Advisory Committee and the Study Team are shown below:

Table 1.1 Composition of JICA Advisory Committee

Member of Advisory Committee/JICA	Organization/Authority
Mr. Ryugo Nakahara	O & M Div. Waterworks Bureau, Okayama City
Mr. Yoshio Fukuda	Social Development Study Department, JICA

Table1.2 Members of the Study Team

Name	Assignment
Mr. Kenji Hori	Team Leader / Management Planning
Mr. Takafumi Kiguchi	Water Supply Facility Planning / Design
Mr. Shigeo Sawai	Pipeline Design / Network Analysis
Mr. Satoshi Shibazaki	Mechanical Equipment Design
Mr. Masahiro Nohara	Electrical Equipment Design
Dr. Kenji Takayanagi	Hydrology / Groundwater / Water Quality-1
Dr. Abul Hasnat Golam Quddus	City Planning / Social Economics
Mr. Akio Kabasawa	Institution/Tariff System/Financial/Planning
Mr. Hiroshi Okada	Environmental Consideration / Water Quality-2
Mr. Kenji Kasamatsu	Coordination

1.6.3 Implementation Set-up of the Bangladesh Side

The implementation set-up of the Bangladesh side consists of CWASA and its counterpart personal are shown in Table 1.3:

Table 1.3 CWASA Side

Name	Assignment
CWASA	
Cap. M. Zakaria	Chairman
Mr. Abdul Hoque	Member Administration
Mr. Md. Wahidunnabi	Member Finance
Mr. Z.S.M. Bakhteyar	Member Engineering
Mr. Ataul Haque	Chief Engineer/Superintending Engr. (P&C)
Mr. Shahjahan	Commercial Manager
Mr. Mostafa Kamaluddin	Secretary
Mr. Md. Obaidullah	Chief Revenue Officer
Mr. Serajul Azim Khan	Chief Accountant
Mr. Md.Abul Kashem	Executive Engineer (Procurement)
Mr. Neazur Rahman Khan	Executive Engineer (CD-II)
Mr. Md. Safiullah	Executive Engineer (Sales)
Mr. Mostaqe Uddin Akhter	Executive Engineer (MOD-I)
Mr. Abdul Karim Chy	Executive Engineer (MOD-II)
Mr. Md. Abul Hashem	Executive Engineer (Booster Stn.)
Mr. Md. Arabinda Barua	Megistrate
Mr. Yuzo Fujishiro	JICA Expert
Counterpart	
Mr. Md. Shafiqul Islam	P.D. & E.E. (CD-I)
Mr. Ejaz Rasul	E.E. (Design)
Mr. Jane Alam Bhuiyan	E.E. (Mohara WTP)

1.7 Organization of the Study Report

The report of the Study in English language was compiled in the following three volumes:

(1) Summary Report

(2) Main Report

(3) Supporting Report

The Summary Report was edited for the convenience to grasp overview of the major study results, while the Main Report presented the overall results of the Study. Detailed discussions and field data were contained in the Supporting Report.

CHAPTER 2

DESCRIPTION OF THE STUDY AREA

CHAPTER 2 DESCRIPTION OF THE STUDY AREA

2.1 Natural Condition

Chittagong City is located at the eastern side of the Bangladesh, faced to the Bengal Bay. The city is bordered on the south and on eastern ports by the Karnaphuli River that is issued from Kaptai Lake with the distance of 50 km. The center of the City is located near the river mouth that is utilized as a port. In the northwest direction, hilly areas with the height of from 6 m to 90 m are distributed. In the eastern side of the hilly areas, a flat plain is widely distributed and is bordered by the Karnaphuli River that is the largest river in the southeastern area of the Bangladesh.

Chittagong City is located in tropical climate zone. There are three seasons. The hot season continues from March to May but has some wet days. The monsoon season begins in June and continues to September with maximum temperature. The monsoon season generally comes ends with cyclones, and cold and dry season begins in November and extends to February. Annual rainfall ranges from 2,100 mm to 3,800 mm in past nine years since 1990 with an average annual rainfall at 2,859 mm.

2.2 Socio-Economic Condition

(1) Population

The population census is conducted every 10 years. The last census, the 3rd population census, was carried out at March 1991. The census population in the City in 1999 was 1,599,000. Reflecting the rapid economic development of the Chittagong district, the present population in the city is estimated to be 2,350,000.

(2) Social Infrastructure

Status of Chittagong City is next to Dhaka in terms of industrial growth. About 30% of industrial products in the country come from Chittagong district and most of which has been produced in the City area. At present, Chittagong City houses about 2,060 industries of different sizes.

In recent years, most remarkable phenomena in the economy of the country is unprecedented growth of garment industry in Chittagong. A large number of them are in the Chittagong export processing zone (EPZ). These industries have brought new life in the city.

The EPZ at Chittagong, which houses expect oriented industries began functioning in 80. The planning commission of the City estimates that the numbers of industries in the EPZ will reach to 110 by 2001-2002. These industries are likely to generate about 50,000 jobs and earn 600 million dollars against 461 in 1995.

Resent data on employment structure of the City was not available. Results of a census on non-farm economic activities were published in 1986 in which a detail breakdown of the employment structure of Chittagong City is presented as shown in Table 2-2-1. This was adopted from CDA Master Plan prepared in 1995.

Table 2.1 Employment Structure

Sector	No. of Jobs City	No. of Jobs SMA	Sources
Manufacturing	161,000	201,000	CNFEA (1986)
Wholesale, retail and trade	121,000	133,000	CNFEA (1986)
Financial, insurance, and business services	27,000	28,000	CNFEA (1986)
Community, social, & Personal service	48,000	56,000	CNFEA (1986)
Public administration, defense & police	20,000		Team
Utilities	3,000		Team
Agriculture	8,000		Pop. Census (1991)
Transport(incl.80,000 Information)	120,000		Transport Team(Residual)
Rest of informal, floating jobs	152,000		
Total	660,000		(Derived)

*CNFEA: Census of Non Farm Economic Activities
Source: Working Paper on the Economy

The CDA Master Plan has further breakdown manufacturing jobs by sectors for showing its greatest concentration at the present time. The breakdown of jobs has helped assessing the required infrastructure for the City development.

According to the City Master Plan, the total industrial labor force is likely to increase about 68% (269,808) in 2000, and 149% (401,388) in 2010 over the 1986 non-farm economic census figure as per Finance Division's estimate. The growth of this number of industrial labor force will put great strains on the infrastructure of the City in terms of their accommodation, work place, and amenities needed for day to day living. The City is likely to get more pressure in future for industrialization because more and more export-oriented industries are being established in the City, which is again supported by liberal Government's industrial policy.

At present, the Chittagong airport has been improved under the Japanese assistance aiming improvement of airport facilities as an international airport in reality as well as in name.

CHAPTER 3

POPULATION AND WATER DEMAND PROJECTION

CHAPTER 3 POPULATION AND WATER DEMAND PROJECTION

3.1 Population

3.1.1 Population Growth Rate of Chittagong City

The Population of Chittagong City in 1991 adjusted for yearbook is 1,599,000. The population growth rates of the City are shown in Table 3.1.

Table 3.1 Population Growth Rates of Chittagong City

Period	Annual growth Rate in Percentage
1901 – 1911	2.7
1911 – 1921	2.3
1921 – 1931	4.0
1931 – 1941	5.7
1941 – 1951	4.5
1951 – 1961	2.0
1961 – 1971	6.9
1971 – 1981	9.7
1981 – 1991	2.8 *

*: The growth rates are calculated from the adjusted population of 1981 and 1991 censuses.

Source: Statistical Yearbook 1998, BBS

The City is endowed with an ideal natural port shaped by the Karnaphuli River, which is blessed with not only the major seaport but also the major industrial center with the emphases on large industries of the country. With such blessing, the population growth rate of the City has higher than that of urban average in the country.

3.1.2 Projection of Population in 2005 and 2010

The average annual population growth rate during the period 1981-1991 in Chittagong City was 2.8 % as shown in Table 3.1. This was far lower than the annual growth rate of 4.7 % in the biggest 7 cities in the country during same period (BBS. 1994). In due consideration of the stated current population, potential urban development plan and the future land use plan, the population growth rate between 1991 to 2000 was calculated at 4.5 % based on the census population in 1991 and assumed present population of 2,350,000.

In this study, as a result of discussion with CWASA, present population was assumed to be 2,350,000, and the projection of population in target years were estimated applying 4.5% as an average annual increase rate of whole Chittagong city from 1991. Population density of 41 wards in 1991 is 80 persons/ha in average and 1,466 persons/ha at maximum. In addition, high density of more than 500

persons/ha were recorded in central 5 wards. Therefore, future population was projected by wards taking account of land use situation and population density at present and in the future.

The projected populations in target year of 2005 for the F/S project and in 2010 for the basic plan are summarized in Table 3.2.

Table 3.2 Project Population of Target Year

	2000	2005	2010
City Area	2,350,000	2,930,000	3,670,000
Outside City	200,000	250,000	320,000
Total	2,550,000	3,180,000	3,990,000
Floating	400,000	500,000	700,000

Note: Floating means the peoples who do not include in the Census.

Recently, Chittagong City conducted a population survey for election purpose, from May 1999 to April 2000. Outcome of the survey is summarized as below.

Total population	3,564,580
Floating	542,965
Census population	3,021,615

Above present population exceeds the population in 2005 projected by the Study Team. As the city population survey is not for population census purpose, the population in target year projected by the Study Team was adapted in the Study.

3.2 Study on Present Water Supply Situation

Present water supply situation in the Study Area is scrutinized and future water demand was then estimated for the water supply system planning. The estimation method and major outcome on these subjects are as follows:

(1) Fundamental Data Collected

1) Collected available data for estimation of the water consumption and Unaccounted-for Water are:

a. Yearly consumption list, classified to domestic, non-domestic and public hydrant

b. Consumption and amount of billing for December 1999, and

c. Daily water production and distribution for 2000.

These data are summarized as shown in Table 3.3.

From the table, following findings are observed:

- Total water consumption is 105,000 m^3/day (23.1 MGD) in average.
- Share of average water consumption is 67 %, 21 % and 12 % for domestic, non-domestic and hydrant, respectively, and
- Unaccounted-for water (UFW); (distribution) - (consumption), is 57,400 m^3/day or 35.4 % out of the total distribution volume including leakage.

Table 3.3 Summary of Collected Data Regarding Production and Distribution

Data	Domestic (m^3/d)	Non-Domestic (m^3/d)	Hydrant (m^3/d)	UFW (m^3/d)	Total of Consumption (m^3/d)	Total of Distribution (m^3/d)
1)Yearly av. Consumption In 1999	68,900 (67.0%)	21,500 (20.9%)	12,400 (12.1%)		102,800 (100%)	
2)Consumption in December 1999	72,100 (67.1%)	22,500 (21.0%)	12,800 (11.9%)		107,400 (100%)	
3)Daily Water Distribution in January 2000						162,500 (35.7 MGD)
Average Distribution Rate in January 2000 get from the above data (prepared by the Study Team)	70,500 (43.3%)	22,000 (13.5%)	12,600 (7.8%)	57.400 (**35.4%**)		162.500 (100%)

(2) Study on Present Water Supply Condition

Assuming to physical leakage at 13 % out of the distribution, unit consumption for house connection, public hydrant and other usage rate are estimated in order to overview the present water supply conditions.

1) Water supply rate

Assuming that number of house connection and public hydrant are 32,000 units and 900 units in function respectively, and some factors underlined below, the present water supply rate is supposed as follows.

a. House connection: 32,000 units x 25 ps/unit x @ 85 lpcd = 68,000 m^3/day
b. Hydrant: 900 units x 4,000 gallon/unit/d (= 18.2 m^3/unit/d) = 16,400 m^3/day
   [Actual consumption is 12,400 ~ 12,800 m^3/day in above table]
c. Commercial; (a+b) x 9 % = 7,600 m^3/day [Assumed 18 % in CWASA III]
d. Institution: (a+b) x 1.3 % = 1,100 m^3/day
   [Actual consumption was 1,080 m^3/day in Dec. 1999]
e. Industrial: (a+b) x 14 % = 11,800 m^3/day
   [Actual consumption was 9,800 m^3/day in Dec. 1999, and assumed at 5,800 m^3/day in CWASA III]

Sub-total 104,900 m^3/day

f. UFW: 35.5 % of total distribution 57,600 m^3/day

Total 162,500 m^3/day (35.7 MGD) (Distribution as of 3 January 2000)

2) Confirmation of the above assumption

In order to confirm the propriety of the above assumption against actual water supply conditions, the following items are discussed for reference.

a. Population served water:

- House connection: 32,000 units x 25 ps/unit = 800,000 persons
- Public hydrant: 900 units x 380 ps/unit = 342,000 persons

Total population served water 1,142,000 persons

b. Coverage rate; (population served water) / (Population in the Study Area)

= 1,142,000 / 2,550,000 = 44.7 %

c. Unit consumption:

- House connection: (68,000 m^3/d + 8,700 m^3/d) / 800,000 ps = 95.9 lpcd
- Public hydrant: 16,400 m^3/d / 342,000 ps = 48.0 lpcd

Supposing one third of 500,000 persons of floating people and day-time worker, who came to the city to obtain job from the surrounding area, use the hydrants, the above unit consumption is to be 32.2 lpcd.

3.3 Water Demand Projection in Target Years

The water demand in target years was estimated by the following process:

(1) Projected population

For target year for F/S 2005: 3,190,000

For target year for Basic Plan 2010: 3,990,000

(2) Water supply target level by type of housing

1) Assumption of type of housing

Table 3.4 Assumption of Type of Housing

Type of housing	1991*	2005**	2010**
Pucca	31 %	42 %	47 %
Semi-Pucca	34 %	28 %	27 %
Kutcha	35 %	30 %	26 %

*: Chittagong Metropolitan Master Plan (Structure Plan; 1995)

**: Average ratio in whole project area projected by the Study Team.

2) Target of water supply level

Table 3.5 Target of Water Supply Level

Type of Supply	2000	2005			2010		
	Pucca, Semi., Kutcha	Pucca	Semi.	Kutcha	Pucca	Semi.	Kutcha
House Connection	70 %	70 %	30 %	15 %	95 %	50 %	20 %
Public Hydrant	30 %	10 %	30 %	20 %	5 %	50 %	20 %

(3) Water demand projection in target years

The water demand for domestic use was estimated by adopting unit water consumption of 120 lpcd and 130 lpcd for 2005 and 2010 respectively.

For hydrant, 50 lpcd was applied for 2005 and 2010. The other water demand for commercial, institutional, industrial use and UFW/leakage were estimated based on the existing data and information.

Water consumption for commercial use were estimated based on their present ratio against domestic water use taking account of future change of socio-economic condition (refer to Table 3.7).

Institutional water demand was also estimated based on their present ratio against domestic and commercial water use.

Presently, industries in Chittagong use water not only from CWASA but also private wells. There are strong request for improvement of water quality and quantity. Estimation of water demand for industrial use in 2000 is as shown in Table 3.6.

Table 3.6 Potential Water Demand for Industrial Use (2000)

User	Present Consumption	Request for Additional Supply	Potential Water Demand
1) EPZ	1.0 MGD	2.5 MGD	3.5 MGD
2) Other Industries	0.8 MGD	1.3 MGD	2.1 MGD
3) Ships	0.2～1.6 MGD depends on number of ships	1.0 MGD	1.2～2.6 MGD
Total	2.0～3.4 MGD	4.8 MGD	6.8～8.2 MGD =30,900～37,300m^3/d

As show in Table 3.6, potential water demand for industrial use in 2000 is estimated at about 36,000 m^3/day. If restriction in water supply status is solved completely in 2005, it may be assumed that the industrial use water demand will be further increased due to increase of industrial activities and shift of water sources from wells to CWASA. Assuming the annual

increase rate of said potential water demand will be at 5%, it will be about 10 MGD or 45,500 m^3/day in 2005 in entire project area.

In accordance with the result of discussion with CWASA, industrial use water demand in 2010 was assumed to be on the same level in 2005. Thus, almost same percentage against total of domestic and commercial water demand was applied for projection.

Based on the mid- and long-term plan of CWASA, ratio of UFW/leakage was assumed to be 25% and 22% in 2005 and 2010 respectively.

The water demand and supply conditions at present and in 2005 and 2010 are summarized as shown in Table 3.7.

Table 3.7 Water Supply Condition and Projected Water Demand

	2000	2005	2010
1. Population in Study Area (ps)	2,550,000	3,190,000	3,990,000
2. Project Population to be served (ps)	-	1,940,000	3,370,000
3. Water Demand for above (m^3/day)	-	344,000	649,000
4. Planned Population with Water Supply Service (ps)	1,142,000	1,580,000	3,370,000
5. Adjustment ratio*	-	82%	100 %
6. Coverage Ratio (%)	44.7	50	84
7. Distribution (m^3/day)	162,500	281,000	649,000
(MGD)	35.7	62	143
1) House Connection	68,000	134,000	329,000
2) Hydrant	16,400	23,000	42,000
3) Commercial	7,600	16,000	37,000
4) Institutional	1,100	2,000	18,000
5) Industrial	11,800	36,000	80,000
6) UFW/Leakage	57,600	70,000	143,000
(incl. UFW)	(35.4%)	(25 %)	(22 %)
8. House Connection Water Consumption (lpcd)	85	120	130
9. Water Supply Volume per capita per day (lpcd)	142	178	193
Condition	*Present*	*F/S Plan*	*Basic Plan*

Note: Population is on the Census level and not includes floating people.
*: Ratio to adjust actual water demand against capacity of water sources.
(Planned population with service / Project population to be served)

CHAPTER 4

EXISTING WATER SUPPLY SYSTEM

CHAPTER 4 EXISTING WATER SUPPLY SYSTEM

4.1 Water Source

4.1.1 Mohara Water Treatment Plant

The existing Mohara WTP has the production capacity of 20 MGD or 91,000 m^3/day, deriving surface water from the Halda River. High Rate Sludge Blanket Type Clarifier – Rapid Sand Filter treatment method is adopted in treatment process.

Plant operation has been carried out effectively against varying raw water turbidity by proper chemical dosing. However, at the time of high turbidity during rainy season, chemical dosing quantity is not sufficient because of lack of dosing capacity.

Because of deterioration of a part of facilities, backwashing effect of filters is not sufficient, so that clogging of filter media is found. In terms of treated water turbidity in last 2 years, average value of 1.1 NTU and 1.8 NTU at highest were recorded. Though these figures are less than the value in WHO guideline, it is judged that improvement of filter media and backwashing facilities are required.

4.1.2 Kalurghat Iron Removal Plant and Booster Pump Station

The Kalurghat Iron Removal Plant (IRP) and Booster Pump Station (BPS) were constructed in 1977 with a nominal capacity of 10 MGD (45,460 m^3/day) in order to reduce high iron content of its groundwater source which is derived from 24 tube wells scattered in MOD II area.

In addition to originally constructed facilities, new filters with a capacity of 5 MGD were constructed in 1987. However, new well development has not been conducted. Construction of this new filter aimed to reduce the load on the existing old filters instead of amplification of plant capacity. Present treatment capacity is estimated to be 13.5 MGD (61,000 m^3/day).

Old filter has only backwashing system. Any supporting washing system such as air washing and/or surface washing is not provided so that washing effect is poor and filter layer has been clogged. New filter has a blower and a pump so as to inject air for backwashing with water, but condition of filter layer is poor due to lack of proper maintenance. Even though the plant is functioning to some extent, iron concentration of treated water ranges from 1.1 to 2.0 mg/l which exceeds not only WHO guideline value of 0.3 mg/l but Bangladesh Drinking Water Standard of 1.0 mg/l. The water from Kalurghat is distributed after partial mixing with the water from Mohara WTP in the distribution system. Improvement of supplied water quality, however, is the second highest request of the

residents according to the results of the resident's awareness survey. It is judged that rehabilitation of both of old and new filters shall be carried out in early stage after completion of augmentation by new filters under on-going 3rd rehabilitation project.

4.1.3 Wells

CWASA owns and operates 40 deep wells in the city. Among of them, 16 wells are scattered in MOD-I area located in the central area of the city. They exploit and distribute about 32,000 m^3/day 7MGD to each water service area. While remaining 24 wells are located in MOD-II area exploiting about 58,000 m^3/day or 12.5MGD. This water is treated in the Kalurghat IRP as stated above, and is distributed through the Kalurghat BPS. Distributed water is about 46,000 m^3/day or 10MGD. Balance of production and distribution is due to production loss in KIRP.

As stated above, since most of groundwater of Chittagong contains high iron content, water from most of wells requires iron removal treatment. However, wells in MOD-I distributes water without any treatment, and therefore residents complaints about water quality.

Presently, augmentation project for wells in MOD-II has been conducted to cope with augmentation of capacity of KIRP.

In addition, new project for development of wells and a iron removal plant has also been proceeded in Fatehabad located in northern area of the city.

4.2 Water Distribution System

4.2.1 Water Supply Pipeline by Diameter and Service Areas

Major Transmission and distribution pipelines in Chittagong City were installed from 1966 to 1979 under the World Bank (IDA) financed First Chittagong Water Supply and Sanitation Project. In the 1st project, AC Pipe was adopted as pipe material and DI Pipe was employed in the 2nd Project. For smaller pipes with diameter less than 300 mm, PVC Pipe has been applied recently. Total pipe length of the existing transmission and distribution network is 543 km. Pipe length and pipe materials by diameter are shown in Table 4.1.

Table 4.1 Existing Transmission and Distribution Pipes of Chittagong WASA

Diameter (mm)	Material	Length (m)	Remarks
1,200	DI	1,570	Mohara WTP - Arakan road
900	DI	10,325	Arakan road - Battali Hill Reservoir
750	DI	1,910	ADC Hill Reservoir - Patenga B.P.S.
600	DI	11,108	Battali Hill Rsvr. - ADC Hill Rsvr. - Dhaka B.P.S. - Patenga B.P.S.
	AC	13,060	
450	DI	1,123	
	AC	23,894	
	PVC	4,000	
300	DI	5,523	
	AC	46,417	
	PVC	6,280	
200	AC	17,720	
	PVC	66,260	
150	AC	18,920	
	PVC	62,180	
100	AC	8,720	
	PVC	243,990	
Total		543,000	

Source: CWASA, as of June 2000

The Mohara System was planned and implemented aiming to send treated water to the Battali Hill Reservoir, the ADC Hill reservoir, the Dhaka Trunk Road BPS, and the Patenga BPS. However, water is not transmitted to both of reservoirs due to water shortage. Since the transmission pipeline of the Mohara System is connected with the Kalurghat System by several interconnection pipes, transmitted water pressure does not reach to designed pressure.

By this irregular plant operation, water pressure in areas, where originally to be served by reservoir by gravity is reduced and areas suffered by water supply interruption has been expanding. In addition, distribution without reservoir cannot cope with peak demand and areas suffered by water supply interruption has also been expanding.

4.2.2 Reservoir and Booster Pump Station

Among the existing reservoirs, the Battali Hill Reservoir has the largest storage volume of 3 MG (13,600 m^3), followed by the ADC Hill Reservoir having 1 MG (4,500 m^3). Others are small, namely; Agrabad elevated tank with 0.125 MG (568 m^3) and other elevated tanks and ground reservoirs have volumes of less than 0.1 MG (454 m^3). Those small reservoirs and attached small pumping system are serving water to relatively high-elevated areas or isolated remote areas scattered in the city deriving water mainly from wells located nearby. Storage capacity and water level of major two reservoirs are as shown in Table 4.2.

Table 4.2 Storage Volume of Major Reservoir

Reservoir Name		Capacity		Water Level		Remarks
		Gallon	m^3	HWL(m)	LWL(m)	
1	ADC Hill, RC Ground Reservoir	1,000,000	4,500	38.1	33.5	Water Source: 3 tube wells, no surface water
2	Battali Hill, RC Ground Reservoir	3,000,000	13,600	51.5	42.7	Not used

CHAPTER 5

STUDY ON WATER SOURCES

CHAPTER 5 STUDY ON WATER SOURCES

5.1 Water Sampling Program for Water Quality Analysis

5.1.1 Water Quality Analysis Program at Mohara Water Treatment Plant (MWTP)

The water quality analysis at MWTP was programmed to confirm the appropriateness of the Halda River as a water source for the water supply. The MWTP intakes the river water from the intake facility along the Halda River. Water quality analysis was conducted in both raw water and treated water.

In addition, the past records of water quality analysis indicated that even if had been rare case, high chloride concentration in the intake water occurred. This phenomenon may be being caused by the intrusion of saline water toward the river from the sea at the high tidal time. Thus, the possibility of the intrusion was also checked by this survey. To reveal the saltwater intrusion, the water sampling was conducted at both spring and neap tidal time.

Analyzed items of water quality were general and chemical items, and Heavy Metals (Hg, Cu, Zn, Pb, Cr, Cd, As, F, and CN).

5.1.2 Water Quality Analysis Program of Groundwater

To confirm safety of groundwater as water sources, quality of water in existing shallow and deep wells was analyzed. Selected deep wells for analysis are TW5 and Lave Lane TW managed and owned by CWASA, together with three shallow hand pumps wells.

In addition, raw and treated water at Kalurghat Iron Removal Plant (KIRP), sample water at a distribution pipeline, and water sample mixed both treated water from the MWTP and the KIRP with ratio of 2:1 were analyzed. Analysis items were T-Fe, Color, Turbidity, and Arsenic.

5.2 Analysis of Surface Water and Groundwater Condition

5.2.1 Water Quality of Surface Water

Manganese concentration in treated water of the MWTP was higher than the BDWS. This chemical item shall be cross-checked by another laboratory. In case that the analysis values are still higher, manganese removal process shall be considered.

Table 5.1 Water Quality at Mohara Water Treatment Plant (Dry Season)

No.	Parameter	Unit	MWTP				BDWS	WHO DWS
			Raw Water*	Treated Water*	Raw Water**	Treated Water**		
1	pH	-	7.5	7.1	7.8	7.2	6.5-8.5	-
2	Turbidity	NTU	24	0.68	30	0.8	10	5
3	T-Alkalinity	(mg/liter)	55	47	59	45	-	
4	NH_3-N (NH_3)	(mg/liter)	0.28	0.21	0.31	0.26	0.5	1.5
5	NO_3-N (NO_3)	(mg/liter)	0.41	0.18	0.53	0.22	44	
6	Chloride	(mg/liter)	7	6	7	6	600	250
7	Residual Chlorine	(mg/liter)	-	0.71	-	0.68	0.2	
8	T-Fe	(mg/liter)	0.58	0.21	0.52	0.19	1	0.3
9	Mn.	(mg/liter)	0.35	0.16	0.38	0.1	0.1	0.1
10	S.S.	(mg/liter)	58	-	57	-	10	
11	B.O.D.	(mg/liter)	1.0	-	0.9	-	0.2	
12	C.O.D.	(mg/liter)	16	-	22	-	4	
13	Fecal Bacteria	(MPN/100ml)	1800	0	2100	0		0
14	As	(mg/liter)	0.001	<0.001	<0.001	<0.001	0.05	0.01

Note, (Sampling Date) *: Feb.21, 2000, **: Mar. 2, 2000, BDWS: Bangladesh Drinking Water Standard (July 1991),
N.D. = not detectable, WHODWS: Guidelines for Drinking Water Quality of WHO (1993)

5.2.2 Water Quality of Groundwater

Raw and treated water of the KIRP, shallow and deep groundwater from existing wells, distribution pipeline water, water sample mixed the treated water from the MWTP and the KIRP with ratio of 2:1 did not exceed in arsenic concentration standard of the Bangladesh. However, most water samples had excess in analysis parameters of turbidity, color, and T-Fe.

As a result, it will be concluded that groundwater in this area has no arsenic contamination. On the other hand, most well water analyzed had high iron concentration resulting in higher color and turbidity than the BDWS.

Table 5.2 Result of Water Quality Analysis for Groundwater

No.	Source	Parameters				Remark
		Turbidity (NTU)	Color (HAZEN)	T-Fe (mg/liter)	Arsenic (mg/liter)	
1	KIRP Raw Water	28	110	5.3	0.004	
2	KIRP Treated Water	5.2	35	1.4	0.002	
3	TW 5	11	70	3.4	0.001	
4	Love Lane TW	0.6	5-10	0.2	0.005	
5	Shallow Well (TW 5)	12	90	3.8	0.002	
6	Shallow Well (TW 11)	16	110	1.1	0.004	
7	Shallow Well (Agrabad 1)	36	180	6.1	0.005	
8	Distribution Pipeline (WASA point)	1.2	> 5	1.1	0.002	
9	Mixed Water (2:1) MTWP & KIRP	1.4	>15	0.7	0.002	
Bangladesh Drinking Water Standard		10	15	1.0	0.05	
WHO Drinking Water Standard		5	15	0.3	0.01	

Note; KIRP: Kalurghat Iron Removal Plant
BDWS: Bangladesh Drinking Water Standard (1991), WHODWS: Guidelines for Drinking Water Quality of WHO (1993)
CWASA has adapted 1.0 mg/liter from the range (0.3 mg/liter - 1.0 mg/liter) of T-Fe concentration in BDWS which was confirmed in the meeting of March 15, 2000

5.3 Saltwater Intrusion in Halda River

5.3.1 General

The chloride concentration of intake water from the Halda River has been observed at the MWTP, together with tidal height of the river at the intake point since the year 1995. In the past time, it has been observed that intake water at the MWTP sometimes included high salinity. This indicates that saltwater intrusion in the Halda River has happened. The observed date and high chloride concentration of intake water are as follows:

Table 5.3 Observed Records of High Chloride Concentration of Intake Water at MWTP

Year	Month/Day	Chloride Concentration (mg/liter)
1995	March 14 – March 18	50 – 875
1995	April 12 – April 17	56 – 450
1995	May 12 – May 20	22 – 6,800
1997	April 24 – April 30	55 – 210
1997	May 18 – May 22	30 – 1,000

Source: CWASA, MWTP

The normal concentration of chloride is in range from 7 mg/liter to 10 mg/liter. Thus, these concentrations are extremely very high compared with the normal one. To investigate this cause, the saltwater intrusion survey in the Halda River was carried out on February 22, 2000. In addition, an analysis of the existing data including tidal height and chloride concentration of intake water was also conducted. The results of the survey and analysis are indicated in the following sections.

5.3.2 Halda River Survey

The saltwater intrusion surveys in the Halda River carried out on February 22 and March 21, 2000. The survey days correspond to the spring tidal days for the period from February to March 2000.

The survey was carried out for three hours before and after the highest tidal time using a hired boat and an EC measuring meter with a 20 m long cable.

EC measurement was carried out every one meter from water surface (depth 0.5 m) and in 7 times after and before the high tidal time at the same locations during the survey. This measurement aimed to investigate the influence of ebbing and flooding to saltwater intrusion during the highest tidal time in the Halda River.

The tidal information and survey hours are as follows:

Table 5.4 Tidal Information and Survey Hours

Spring Tidal Date	The Highest tidal Time	Tidal height	EC Measuring Hours
February 22, 2000	15:27	3.31 m	12:27 – 18:27
March 21, 2000	14:28	3.57 m	11:28 – 15:28

(1) EC measuring Results at Inlet Point of MWTP

On both survey days, the measurement results at the intake point of the MWTP indicate that EC values does not largely fluctuate in ebbing and flooding in range from 180 μS/cm (conversion value of EC values to chloride concentration: about 7 mg/liter).

These results imply that saltwater intrusion was not happened at the highest tidal time in the intake point of the MWTP along the Halda River.

(2) EC Measuring Results in Halda River

At the same time with EC measurement at intake point of the MWTP in the Halda River, the same measurement was carried out in about 100 m downstream of Halda River from the intake facility on February 22 and March 2000.

These EC values correspond to chloride concentration of about 10 mg/liter. However, EC values at 18:31 indicated to be very low. This will imply that ebbing after high causes the discharge of fairly fresh water from the upstream of the Halda River. The measurement results on March 21, 2000 also indicated the same ones.

5.3.3 Relationship between Tide and Saltwater Intrusion

Chloride concentration of intake raw water of the MWTP has been measured since 1995 and tidal height since 1998. According to these data, there seems to be no relationship between tidal height and chloride concentration.

5.3.4 Causes of Saltwater Intrusion

Causes of saltwater intrusion observed at the Intake Point of the MWTP in the past time were examined.

The Halda River near the intake point of the MWTP is known as the sea tide influenced stream.

Ebbing and flooding with sea tidal cycle are repeated day.

According to the Report on development Plan and Feasibility Study (1979), the tidal flow is influenced up to Sattarghat of about 26 km upstream the Halda River and the Enayathat gauge (near the MWTP, and now does not exist) is in hydraulic continuity with the Karnaphuli River. Actually, a flooding flow with fairly high flow velocity is usually observed from low tide to high tide, with an ebbing flow from high tide to low tide.

The EC measuring results in the Halda River indicated that the river water was fresh water with almost no fluctuation of EC values during the saltwater intrusion survey. Therefore, the barrier of water block formed during high tide at the mouth of the Karnaphuli River will reversibly press toward upstream fresh water that is stored in river channel during ebbing time. Otherwise, discharge water of the Karnaphuli River may directly flow in to the Halda River through a main stream or a diversion channel near the MWTP due to the barrier effectiveness.

If the discharge from Kaptai Dam (namely, of the Karnaphuli River) decrease, it shall allow the saltwater intrusion to cause an unbalance in a stress relationship between the river flow and tidal flow.

To confirm the above inference, the relationship between the discharge from the Kaptai Dam and high salinity concentration observed at the MWTP in the past time was examined.

The chloride concentration from March 13 to April 17 was fairy low and the discharge was sometimes high. In the period from May 13 to 17, the concentration became fairly higher with the small discharge. After May 17, the concentration rapidly lowered with the increasing discharge.

Especially, the most high intensity saltwater intrusion happened in the dry season of the drought year 1995 when the discharge from the Kaptai Dam was very little. According to the 30-years existing effluent records from the Kaptai Dam, the discharge corresponds to the probability that happened with the ratio of one time during 30 years.

The weather conditions such as temperature, rainfall and flood have been remarkably changed from little year back in the world-wise. Further detailed examination, therefore, should be conducted on the issue in question when the project is implemented.

5.4 Study on Surface Water Resources Development

5.4.1 Halda River

The intake point of the MWTP is located along the Halda River, upstream about 500 m from the confluence between the Karnaphuli and the Halda Rivers. In addition, the Italian project has a plan to establish a new Madunaghat Water Treatment Plant along the upstream of the Halda River, away about 4 km from the intake point of the MWTP. Development water volume for the water supply at the present and in the future amounts to 297,000 m^3/day in total as shown in Table 5.5. This section examines the possibility of the utilization of surface water in the Halda River.

Table 5.5 Development Water Volume for Water Supply from Halda River

No	Present and Future Water Source Development	Capacity (m^3/day)
1	Present supply capacity of the MWTP	91,000
2	Future plan, the Madunaghat WTP (Italian Project) (Phase I)	45,500
3	Future plan, Extension and Expansion Project for the MWTP	91,000
4	Future plan, the Madunaghat WTP (Italian Project) (Phase II)	45,500
	Total	273,000
	Actual planned development water volume (add 10%)	300,000

Note: The MWTP actually intakes surface water corresponded to 110 % of treated capacity.
Therefore, actual planned development water volume is calculated as addition of 10%.

In the river, the Water Development Board (WDB) under the Ministry of Water Sources has a gauging station at Panch Pukuria. In this station, current velocities of the river and stages were measured two or three times per a month. These data are indicated in Table 5.6.

Table 5.6 Minimum and Maximum Discharges of Halda River at Panch Pukuria

Year	Minimum Discharge		Maximum Discharge	
	Discharge (m^3/sec.)	Month	Discharge (m^3/sec.)	Month
1995	0.40	March	195.79	August
1996	1.39	March	195.79	August
1997	2.38	March	244.23	September
1998	2.10	March	386.95	July
1999	8.08	March	548.67	July

Source: Water Development Board (March 2000)

According to these data, the river discharge at the gauging station was very small because of drought years during the years of 1994 to 1995. Therefore, the data of these drought years were excluded to calculate a base flow in normal years. Considering the above condition, minimum flow (1.39 m^3/sec) on March 1996 was selected as a representative of normal years for calculation of a base flow of the Halda River.

The catchment areas of the Halda River at Panch Pukuria and Madunaghat are 833 km^2 and 1,515 km^2, respectively. In this calculation, the catchment area at Madunaghat is roughly estimated to be the same size as that of the MWTP. The daily minimum discharge converts to that at the Madunaghat point.

This calculated minimum discharge, about 218,000 m^3/day at the Madunaghat point, shall correspond to a base flow of the Halda River as a representative. Therefore, the possibility of surface water utilization is examined based on this calculated base flow.

At the time of spring and neap tide, the flooding flow with high velocities in the upstream direction of the Halda River is usually observed by the drift of aquatic plants. The flooding flow is soon started after the turn of tide. The observation at the river survey indicated that the flooding flow was started with the stirring up of the mud and clay on the river bottom over the all area of the river.

Furthermore, the Report on Development Plan and Feasibility Study (1979) described that the river stage in the downstream became higher than that of the upper stream at the points between near the confluence and the river mouth.

Considering the above-mentioned, it is concluded that flooding flow water in the Halda river is supplied by surface water of the Karnaphuli River, and the flooding flow is occurred at the all places in the vertical and cross sectional directions of the Halda River.

(1) The total discharge of the Halda River and the flooding discharge form the Karnaphuli River is summed up to be 2,038,000 m^3.
(2) Planned water volume for intake in the Halda River is 300,000 m^3/day. (Total production capacity 273,000 m^3/day [60 MGD] x 1.1 [addition of production loss of and consumption in Planned Future Water Treatment Plant]= 300,000 m^3 [planned water volume for intake]).
(3) Ratio between the planned water volume (300,000 m^3) and the total discharge (2,038,000 m^3) of the Halda River and the flooding discharge form the Karnaphuli River comes to be 14.7 %.

This planned water volume is considered fairy small, compared with the estimated total of the Halda River discharge and the flooding discharge from the Karnaphuli River and it shall not be influenced even in a viewpoint of maintenance flow.

5.4.2 Karnaphuli River

As described in sub-section 5.3.4, the discharge of the Karnaphuli River is considered to have a close

relationship to the saltwater intrusion at the intake point of the MWTP in the past time. Therefore, the minimum flow of the river is a very important factor. This is also a key factor to consider the development possibility of surface water in the future. According to the monthly discharge from the Kaptai Dam in the period of from 1991 to 1999 is from 0.09 x 10^6 m^3/day to 766.23 x 10^6 m^3/day.

The Basic Plan frames to directly intake the quantity of 300,000 m^3/day (60 MGD) from the Karnaphuli River after the year 2010. In addition, the Halda River is somewhat influenced by the flooding flow accompanying with inflow from the Karnaphuli River at high tidal time. However, the mixing ratio of both surface water of the Karnaphuli and the Halda Rivers at the intake point of the MWTP is unknown due to the influence of sea tidal cycle.

According to the estimation of the flooding discharge form the Karnaphuli River to the Halda River (refer to 5.4.1 Water Resources Development in Halda River), the flooding discharge is considered to be consumed for the planned intake volume at MWTP due to the small base flow of the Halda River. The total necessary intake volume from the Karnaphuli River is actually estimated to be 600,000 m^3/day [300,000 m^3/day for Mohara and Madunaghat WTPs plus 300,000 m^3/day for planned Karnaphuli WTP].

Normal minimum effluent from the Kaptai Dam was supposed to be 5,000,000 m^3/day. Necessary intake amount 600,000 m^3/day corresponds to 12 % of the effluent from the Kaptai Dam.

Regarding water rights of the river, this country has no any rules and regulations. However, the provisional national water development policy worked out by the Ministry of Water Resources regulates that water supply has the first priority for the water utilization. From the viewpoint of river maintenance flow, intake of this amount is considered to be possible.

In addition, the effluent data indicated that the number of days of effluent less than 5,000,000 m^3/day was very few, except for drought years from 1994 to 1995 as shown in Table 5.7. Therefore, the intake of the water amount, 600,000 m^3/day was evaluated to be possible.

Based on the above consideration, (1) indirect intake volume (300,000 m^3/day) for the MWTP and the Madunaghat WTP at present and in the future and (2) direct intake volume (300,000 m^3/day) from the Karnaphuli River after the year 2010 will be possible to be developed.

However, the intake of large quantity from the Halda and the Karnaphuli Rivers in the future for the Madunaghat WTP, industrial water, and the Karnaphuli WTP is anticipated to change the present tidal

river flow condition influenced by the sea tide at both the intake points of the MWTP and of the Karnaphuli WTP. This may cause saltwater intrusion at the intake point at that time.

Table 5.7 Number of Days with Discharge of Less than 5 Million m^3/day

Years	Number of Days
1991	1 day
1992	1 day
1993	3 days
1994	18 days
1995	32 days
1996	2 days
1997	10 days
1998	4 days
1999	3 days

Note、Source: Kaptai Dam Management Office (March, 2000)

Further, data are almost unavailable on saltwater intrusion of the Karnaphuli River. Therefore, the further detailed survey on the saltwater intrusion will be necessary after the completion of the Madunaghat WTP, and at the planning stages for the intake of the industrial water and the Karnaphuli WTP.

5.5 Study on Groundwater Resources Development

5.5.1 Existing Deep Wells Owned by CWASA

CWASA owns 40 existing deep wells for water supply in the Chittagong City area. These wells are mainly distributed in both the northeast and the south sides of the city, where they are divided into two wellfields: MOD I and MOD II areas. Of 40 wells in total, 16 wells are located in the MOD I area and remaining 24 wells in the MOD II area. The MOD I wells directly distribute water to the city area through the distribution network, while groundwater from the MOD II wells is collected to Kalurghat Iron Removal System, and treated water is distributed to the city area together with water from transmission pipelines of the MWTP.

Wells had high concentration of Manganese from 0.17 mg/liter to 0.28 mg/liter and groundwater of most wells exceeded BDWS in nitrate concentration.

In addition, T-Fe and Mn concentration of the CWASA deep wells were re-analyzed to reconfirm. Sampling was carried out in the period from March 24 to April 3, 2000. Analysis was conducted in the laboratory of the MWTP. As a result, most of the MOD II wells and many MOD I well also had higher iron and manganese concentration in groundwater than those of BDWS.

5.5.2 Issues of Existing Wells

Deep groundwater in the Study Area almost includes high iron concentration more than 1.0 mg/liter. In most wells, the basements of the vertical turbine pumps are stained by iron rust and/or jelly of iron bacteria. The production rate often becomes very small in a few years after construction. This phenomenon is considered to be caused by the clogging of the well screens and/or gravel pack layers

According to the MOD section of CWASA, the regeneration method is effective for 7 months to a year. Therefore, CWASA sometimes repeats the regeneration using their budget. These methods are evaluated to be effective according to the recovery ratio of production rate of 70 to 80%.

5.5.3 Hydrological Conditions of Groundwater

The columnar sections of each well indicate that most formations belong to the alluvial formations, consisting of alternating and unconsolidated layers of clay, sand, and gravel. Deep groundwater of these wells is in confined condition.

The CWASA existing well tap to two or three sand and gravel layers in order to withdrawal. These layers connect each other and form an aquifer with total thickness of average 60 m in the MOD II area. However, a part of the wells located in the MOD I area penetrate into the tertiary formation, consisting of hard clay, and hard sand formations. This may imply that hillocks area extended from NNW to SSE are hidden under the alluvial plain in the south area of the city. Therefore, some wells were drilled in the hilly area and another wells were sunk in the alluvial area.

Based on all of pumping test data, the transitivity and the permeability were analyzed by Theis's recovery method [$T=(2.30Q/4\pi Sr) \times \log (t/t')$, Sr: remaining drawdown, t': time after stoppage of pumping]. Pumping test is usually conducted by step drawdown test, continuous pumping test and recovery test. However, the pumping test method for the CWASA wells was not carried out by formal manners. Thus, the results were used to roughly estimate the groundwater flowing flux. The analyzed results are shown below.

Analyzed average transmissivity (T) = 2,270 m^2/day

Average permeability (K) = 6.84 x 10^{-2} cm/sec.

The values of T and K indicated that the aquifer had a fairly good permeability because of alluvial formation.

5.5.4 Possibility of Groundwater Resources Development

(1) Possibility of Groundwater Development

Using the calculated T and K values, the possibility of groundwater development was examined in the study area.

In calculation of the groundwater flowing flux (GFF), the groundwater table is necessary to determine groundwater flow direction. However, suitable measured data of static water level at present time were not obtained due to operating condition of all the wells. Therefore, the water table in past time reported by F/S report - Parsons Overseas Company (1979) was referred to, supposing that natural condition in groundwater was almost not changed.

Total withdrawal at present and in the future sums up as follows:

1) Present withdrawal by existing deep wells in MOD II area: 58,000 m^3/day (1999)
   (As a part of the deep wells in the MOD I area tap from the tertiary formation, this calculation excludes them.)
2) Ongoing project of the 2nd Interim WSRP: 25,875 m^3/day
   (Actual extraction of groundwater is estimated 1.15 times as large as planned pumping rate due to wastewater in the plant.)
3) Planned withdrawal in the 3rd Interim WSRP: 51,750 m^3/day
   (Actual extraction of groundwater is estimated 1.15 times as large as planned pumping rate due to wastewater in the plant.)

Total withdrawal: 135,625 m^3/day

On the other hand, the groundwater flowing flux is calculated as follows.

$$GFF\ (Q) = Perimeter \times Aquifer\ Thickness \times K \times (\Delta H / \Delta L)$$

Where, K = permeability,

$\Delta H / \Delta L$ = gradient of groundwater table

Considering the groundwater flow direction, the parameters necessary for the calculation were roughly determined as follows:

Perimeter = 17,000 m,
Aquifer thickness = 60 m,
Ave. K = 6.84 x 10^{-2} cm/sec.,
Gradient = 0.00625

As a result, GFF (Q) = 376,700 m^3/day. This flux is not so much, compared with the necessary projected total withdrawal (135,625 m^3/day). The total withdrawal corresponds to about 36 % of the calculated GFF. This rough estimation does not consider groundwater recharge from ground surface and hillocks and the rivers, and the present situation of groundwater table, together with aquifer continuity. In addition, the withdrawal and tapped depth of private wells are not unknown.

Therefore, further investigation shall be necessary to evaluate groundwater development. However, the estimation may give a rough warning that groundwater development in the CWASA wells aquifer is in near-limitation.

5.6 Conclusions and Recommendations

(1) Necessity of Injection of Chorine for Well Water Supply System

In the MOD I area, well water is directly supplied without injection of chlorine through distribution pipelines. However, this system shall be improved from the viewpoint of safety as water supply system. After treatment, all iron content of groundwater shall be oxidized and colored. Therefore, iron removal systems shall be necessary to be set up.

(2) Training on Groundwater Analysis Techniques and Groundwater Hydrology

The pumping test is not carried out by a normal manner. The pumping test data that was carried out by normal manner is very useful for analysis and evaluation of effectiveness of regeneration. This seems to be derived from the shortage of groundwater analysis technology and information of groundwater hydrology. Therefore, the training and study on this field shall be necessary.

(3) High Mn Concentration of Supplied Water

According to an analysis result of water quality, Mn concentration in both surface water and groundwater often exceeds BDWS. Therefore, firstly, the reconfirmation of the concentration shall be necessary for the crosscheck. If high concentration reconfirms, Mn removal process shall be considered.

(4) Possibility of Surface Water Development

As a result of the study, surface water of the Halda and the Karnaphuli was revealed to have fairly development possibility. In addition, saltwater intrusion in the Halda River is presumed to be mainly caused by the decrease of discharge in the Karnaphuli River due to a little effluent from the Kaptai Dam. Also, this phenomenon relates to the stress relationship among the discharges of the Halda and the Karnaphuli Rivers, and tidal flow toward upstream of both streams. The relationship may be

changed if a new Madunaghat Treatment Plant (Italian Project) is constructed and/or intake of industrial water is planned. In addition, data are almost unavailable on saltwater intrusion of the Karnaphuli River. Therefore, further study on saltwater intrusion will be necessary after completion of the Madunaghat plant in the future and at the planning stages of the intake of industrial water and the Karnaphuli WTP.

(5) Possibility of Groundwater Development

After completion of the 3rd Interim Water Supply and Rehabilitation Project in the future, the possibility of groundwater development seems to become over development according to the rough estimation. However, it results from the rough estimation based on limited information. Furthermore, it does not include the evaluation of groundwater development in the left bank in the Karnaphuli River and of that of deeper aquifers in the study area. Therefore, further groundwater study shall be necessary if groundwater development in new proposed area and of deeper aquifers in the study area is planned.

CHAPTER 6

SYUDY ON MANAGERIAL ASPECTS OF WATER WORKS

CHAPTER 6 STUDY ON MANAGERIAL ASPECTS OF WATER WORKS

6.1 Central Government Level Institution

6.1.1 Sector Organization (Water Supply and Sanitation Sector)

The statutory responsibility for the water supply and sanitation sector is under the Ministry of Local Government, Rural Development and Cooperative (LGRD). The Ministry, together with the planning Commission shares the task of sectional resource allocation, funding and policy decisions as well as project appraisal, approve, evaluation and monitoring.

All projects in the sector are processed through the Ministry. The Ministry's Department of Public Health Engineering (DPHE) is responsible for planning, construction and operating water supply and sanitation facilities in smaller towns and rural areas. In Dhaka and Chittagong, the Government established Water Supply and Sewerage Authorities (DWASA and CWASA) as autonomous agencies responsible for provision of water supply and sewerage services. These authorities also come under LGRD as public utilities.

In the two cities, the Dhaka and Chittagong City Corporation (DCC and CCC) are responsible for all other sanitation activities other than water borne sewerage. Additionally, the Local Government Engineering Department (LGED), also under the Ministry, is responsible for providing technical assistance to sanitation and other municipal services to district towns that do not have municipal corporation status. DPHE and LGED assist local governments to construct water supply and sanitation facilities, either through donor or Government financing.

6.1.2 Sector Financing

Sector development in Bangladesh has mainly been financed by donor assistance, which has been mainly responsible for the tenfold increase in availability of water supply. Although the Government has declared its intention to develop safety water supply and sanitation, the level of investment in the sector has remained very low due to funding constrains. Between 1973 and 1990, public outlays for water and sanitation steadily dropped from 2.48, 2.14 % of development expenditures in the first, second and third Five-Year Plans respectively. This is significantly below allocation in other comparable countries in Asia e.g., Sri-Lanka (6.0 %), Nepal (4.0 %) and Myanmar (2.9 %). In the Fourth five-year Plan (1990-1995), allocations to the sector were budgeted to be 1.4 % of the development expenditure, which is too low even to meet the physical targets of the plan. The most recent three-year Rolling Investment Program for FY95-97, however, shows a reversal to this trend.

Allocations for this period were 4.0 % of the total expenditure.

Although DWASA and CWASA are supposed to be commercial and autonomous, their capacity to generate financial resource to finance their own investments has been limited. Donor responses for financing investments in the sector have normally been supplemented by Government equity contribution and grants. For operation and maintenance, tariff level revenue have generally been inadequate to fully meet all operating costs and cover debt servicing costs as mentioned in the relevant sections. The resulting deficits are usually financed by the Government indirectly by not servicing debt and interest.

6.1.3 Sector Issues and Conditions

(1) Funding of Investments and Resource Mobilization

The availability of local funds to support investments in the sector is generally inadequate. Government counterpart fund, even when budget for, are not always made available when required, due to competing demands, this delaying project execution. Inadequate tariffs, poor revenue collection and a high level of systems losses in DWASA hamper the mobilization of adequate internal resources to finance capital expenditures for water and sanitation. CWASA has also the same issues except that arrears are distinctly low and the water physical loss is also remarkably low than DWASA. However, the latter seems due to the reason that water is supplied under comparatively low pressure and regulated likely to two-shift supply, half-day in daytime or evening/night time, depending upon the location conditions of service area such as high land and far distance from the distribution plants.

(2) Sector Management

Overall sector management is characterized by Government control and interference in the planning and operation of the water sector entities. While CWASA and DWASA are supposed to be autonomous, most management decisions, including tariff review and adjustments, staffing and investment decisions have been controlled by the Government through LGRD.

There are no clearly defined guidelines for sector development or mandates for WASA's operation. As a result, the WASA have never had real commercial or management autonomy, which has significantly hampered their performance. In additions, management and staff of these sector and training to effectively management, operate and maintain the system because of no chance to do so.

(3) Lack of Commercial Orientation

In Bangladesh, IDA has assisted the Government in the water supply and sanitation sector since 1963, having financial and technical assistance. IDA is executing the Forth Water Supply and Sanitation

Program for DWASA in which Operation and management Supporting Program (Twinning Program) has being conducted with target data of the end of September 2000. IDA emphasizes in its interim report that DWASA suffers from a lack of commercial orientation and accountability, poor management system, and shortage of trained and motivated staff.

6.2 Study on Chittagong Water Supply and Sewerage Authority

6.2.1 Organization/Institution of CWASA

CWASA bears responsibility for piped water supply and sewerage services for the city. The sewerage service, though it is stipulated by the regulation, at present does not commence in CWASA. Sanitary and draining works in the city are managed by the Chittagong City Corporation.

(1) Organization Structure

CWASA is expected to function as autonomous agency responsible for provision of water supply services. The CWASA organization structure together with roles is shown in Figure 6.1.

CHAIRMAN

- MEMBER ADMINISTRATION - SECRETARY (158 persons)
  - Land estate, Transport pool, Public relation, Board meeting implementation & co-ordination, Common service, Magistrate and Procurement Division.
- MEMBER ENGINEERING - CIEF ENGINEER (367 persons)
  - Planning and Construction Circle (P&C), Treatment Plant Circle (TP), and Maintenance Operation Division (MOD).
- MEMBER FINANCE - COMMERCIAL MANAGER (192 persons)
  - Accountant, Revenue, Sales and Computer Divisions.
- AUDIT SECTION (6 person)
- DEVELOPMENT SECTION (8 person)

Figure 6.1 Organization of CWASA

(2) Manpower Structure

Manpower structure of CWASA at present is shown in Table 6.1.

Table 6.1 Manpower Structure of CWASA

Class	Sanctioned (Revised After Dec. 1983)	Actual number As of Apr. 2000	Kind of works
Class- I	53 person	48 person	Main staffs
Class- II	21 person	21 person	Sub assistant staffs
Class-III	538 person	521 person	Operator, driver etc.
Class-IV	125 person	160 person	*MLSS
Total	737 person	750 person	

Note*: Member of Lower Subordinate Staff such as sweeper, cleaner and helper

6.2.2 Legislation and Regulations Concerned with Water Works

The Dhaka/Chittagong WASA were authorized on the basis of the ordinance of the following:

(1)"The East Pakistan Water Supply and Sewerage Authority Ordinance in 1963" and "The Dhaka/Chittagong Water Supply and Sewerage Authority (Water Connection and Levy of Water Rate) Rules in 1966"

They would be summarized as follows:

1) To provide for improvement, expansion, operation and maintenance of water works.
2) May levy and collect water rates for its services provided that no water rate shall be levied or collected in any area until the Authority makes provision for the supply of water.
3) May exempt a place of worship from the levy and collection of water rates.
4) Rates or charges shall be reviewed once in every year, or at any time for special reasons and may be revised once in every five years or earlier. However, the revise of tariff cannot enforce if it is not approved by the Government.
5) May cut-off: any unauthorized connection at any time; and water connection of a consumer for non-payment of water or sewer rate with one month's notice.
6) No person shall make an unauthorized connection and such connection shall be construed as an offence under this Ordinance.
7) Shall keep a revenue account and shall be credited proceeds of water rate and shall be applied to paying the cost of management and all operating costs.

(2) "The Low of Bangladesh Government for Dhaka Set at August 17, 1996"

In the "Low of Bangladesh Government for Dhaka Set at August 17, 1996", a commitment of waterworks to private sectors is announced for DWASA. Responded to this law, the collection works are partially committed to the Co-operative Union (under Labor Union) and the Private Party at two MOD.

6.2.3 Water Tariff and Revenue

(1) Present Water Tariff System

The past changes of the average water tariff of CWASA are summarized in Table 6.2.

Table 6.2 History of Water Rate (unit: Tk /m^3)

Term	Domestic	Non-domestic
From 15/10/1980	1.32	4.40
From 1/7/1982	2.20 (66%)	6.16 (40%)
From 10/6/1986	2.75 (25%)	7.70 (25%)
*From 1/11/1987	3.03 (10%)	8.47 (10%)
*From 15/10/1990	3.33 (10%)	9.31 (10%)
*From 30/11/1992	3.83 (15%)	10.71 (15%)
*From 1/7/1997	4.06 (6%)	11.35 (6%)

Note*: Increase of Water rate owes to the adjustment of power cost.
Note1: Excise Duty is from 14th October 1990.
Note2: Value Added Tax is from 1st July 1992.
Note3: The figures in parentheses present the increasing percentage compared with before rate.

Domestic is categorized into Private (inhabitants), Government (hospital/school/courage/city-office), Street Hydrant (public tap) and Religious Institution (mosque). Non-domestic is categorized into Private (commercial/industry/hotel/shop) and Government (industry/city-market). Almost all connections are adopted metered rate system. However, Street Hydrant is charged at fixed rate based on 4,000 gallon per day per connection. Water charge for Street Hydrant is billed to the Municipality.

(2) Trends of Other Price

Trends of fuel and electricity prices for past five years are shown in Table 6.3.

Table 6.3 Trend of Other Price

Item	Specification	Unit	1994	1995	1996	1997	1998
Gas	Domestic,for Double burner	Per Month (Tk)	250	250	250	250	250
Electricity	Domestic	Per,KWH (Tk)	1.9	1.9	1.9	1.9	1.95
Consumer Price Index	Urban	1986=100	163	175	186	191	204
Rate of Inflation		%	1.8	5.2	4.1	3.9	6.3

6.2.4 Financial Performance

(1) Analysis of present financial situation

1) Financial Status

Balance Sheet for recent five years indicates that the long term debts, which have been accumulated principal and interest year by year, are too large as equivalent amount of about 74 % of the property and assets or about 6.5 times of the operating revenue in 1977, that is of the latest

audited.

Profit and loss statement for recent five years shows that although the operating balance is surplus every year, the net operating balance is deficit every year due to the high level of interest payment. The accumulated interest is calculated about Tk 39 million in 1997, which is equivalent to about 19 % of operating revenue in the year. Deficit brought forward, which is calculated the amount of Tk 409 million in 1996, is summed up big amount every year resulted negative situation in the net balance.

The cash outflow is about 1.6 times of the cash inflow in 1997 fiscal year. This shows the decreasing of cash bank balance year by year as equivalent to the reduction of 33 % in 1997 compared with previous year.

2) Results of financial analysis

The current ratio is calculated at 1,678 % in 1998, following to 1,858 % in 1997, 1,824 % in 1996, 1,400 % in 1995 and 793 % in 1994. This implies amounts of current assets such as accounts receivable/stores is too large comparing with the amounts of current liabilities such as account payable.

The ratio of fixed assets to equity capital is calculated at 250 % in 1998, following to 245 % in 1997, 278 % in 1996, 263 % in 1995, 995 % in 1994 and 231 % in 1993. The figure of CWASA generally shows worse results comparing with that of DWASA in 1999 at 78 %. This means that owned capital and surplus are too little comparing with fixed assets in one aspect, resulted in low ability of long-term trust of CWASA.

The profit ratio of gross capital is recorded at 12 % in 1998 and 11 % in 1997, 1996 and 1995. The results achieved by CWASA showed much bigger figures comparing with the figure of DWASA in 1998/99 at 9 %. This means that CWASA has better level of management achievement compared with DWASA in simple comparison.

(2) Investment planning of CWASA

CWASA has been conducted big investment project assisted by the World Bank. Long-term loans payment in audited report are summarized in Table 6.4.

Table 6.4 Repayment for Long-term Loans (Unit: 1000 Tk /year)

Item		1997	1996	1995	1994
IDA Loan	1st Phase	31,728 (*2,115)	33,844 (*2,115)	35,959 (*2,115)	38,074
IDA Loan	2nd Phase	544,223 (*0)	544,223 (*5,000)	544,223 (*0)	544,223
IWSRP Loan (GOB)	1st Phase	248,725 (*0)	248,725 (*0)	241,975 (*0)	174,000
IWSRP Loan (GOB)	2nd Phase	30,750 (*0)	30,750 (*0)	-	-
Reimbursable loan For sewerage (GOB)	-	2,700 (*0)	2,700 (*0)	2,700 (*0)	2,700
UFW Management Program (IDA)	-	4,900 (*0)	3,250 (*0)	3,000 (*0)	-
Sub-total		863,027 (*2,115)	863,492 (*7,115)	827,857 (*2,115)	758,998
(Accrued interest on):					
IDA Loan	1st Phase	7,565 (*2,519)	8,069 (*1,583)	8,574 (*1,646)	9,078
IDA Loan	2nd Phase	432,875 (**71,906)	466,686 (*5,000)	421,606 (*0)	371,526
IWSRP	1st Phase	60,614 (*0)	41,959 (*0)	23,663 (*0)	8,992
Sub-total		501,054 (*2,519) (**71,906)	516,715 (*6,583)	453,843 (*1,646)	389,597
Total		1,364,082 (*4,634) (**71,906)	1,380,208 (*13,698)	1,281,701 (*3,761)	1,148,595

Note (*): Payment made during the year (less amount)
Note (**): Adjustment for the provision of excess interest (less amount)

As indicated in the above table, the repayment of principal and interest amounts to huge, which is about 6.8 times of the annual sales income. CWASA has already applied to the Ministry of Finance for dismissal of repayment of the loan.

6.2.5 Water Supply Management

(1) Collection ratio

Present situation of the management in the view of financial points is shown in the following. The yearly collection ratio for past five years are presented in Table 6.5.

Table 6.5 Collection Ratio (Unit: million Tk)

	1995	1996	1997	1998	1999
Billing	167.54	179.71	191.99	196.36	204.70
Collection	156.79	153.21	173.73	178.69	198.66
Collection Ratio (%)	93.6	85.3	90.5	91.0	97.0

Source; Computer Division of CWASA dated 05/04/2000. Computer system of customer ledger started in Dec. 1988 of two areas and covered 33 areas in Jun. 1989.

In the above table, the collection ratio for recent three years shows increasing trend.

(2) Management situation

In the grasp of management condition, structure of water supply cost in 1997 is presented in Table 6.6.

Table 6.6 Structure of Water Supply Cost

Order	Item	Rate (%)	Payment amount (Tk million)
1	Power cost	26	63.11
2	Wage and salaries	21	51.28
3	Depreciation	18	40.94
4	Interest	17	39.11
5	Other expenses	7	16.29
6	Repair and maintenance cost	5	11.37
7	Chemicals cost	5	10.90
8	Division to government	1	1.50

Basic indexes on water supply management are shown in Table 6.7. These indexes are compared with Dhaka management in the following sub-section, and implied how to improve the CWASA's management efficiency from the viewpoints of finance.

Table 6.7 Management Index

Item	1995	1996	1997	1998
(Operating Indication):				
Accounted for water after distribution (%) (Water Sold/Water Distribution) x 100	64	65	70	65
Daily Average Supply per capita (l/person/day) (Water Distribution/Population Served)	122	127	126	137
(Management Indication):				
Selling Cost (Tk /m^3) (Operating Revenue/Water Sold)	5.52	5.52	5.68	5.66
Water Supply Cost (Tk /m^3) (Net Operating Expenditure/Water Sold)	6.71	6.58	6.36	6.67
Number of Population Served per one Employee (person) (Population Served/Stuff Number)	-	-	-	1,523
Water Sold per one Employee (1000m^3/employee/year) (Water Sold/Stuff Number)	43	46	49	50
Operating Revenue per one Employee (1000m^3/employee/year) (Operating Income/Stuff Number)	239	254	279	280
(Financial Indication):				
Collection Ratio per year (%) (Collected Amount/Billing Amount) x 100	93.6	85.3	90.5	91.0
Working Ratio per year (%) (Operating Revenue/Working Expenditure) x 100	139.0	140.2	136.8	120.6
Operating Ratio per year (%) (Operating Revenue/Operating Expenditure) x 100	108.1	109.1	107.9	102.2
Salaries Ratio of Employee to Expenditure (%) (Salaries Cost/Working Expenditure) x 100	33.8	35.3	33.5	32.6

Current Ratio (%) (Current Assets/Current Liabilities)	1,400	1,824	1,858	1,678
Fixed Assets to Equity Capital Ratio (%) (Fixed Assets/Owned Capital & Surplus) x 100	263	278	245	250
Profit Ratio of Gross Capital (%) (Net Operating Profit/Liabilities & Capital) x 100	11	11	12	12

Note1: The number of employee is used 750. Note2: Cost includes depreciation and interest.
Note3: Population served is used 1,142,000 people.

6.2.6 Evaluation on Management System

1) It was observed that, as a whole, the CWASA's operations seem to suffer from a lack of commercial/business orientation and accountability, insufficient management system and shortage of trained and motivated staff. The operational performance is required to improve though a series of training such as operation and maintenance, management and finance, management information system, personal management and computerization.
2) Recognition for improvement of Accounted for Water is rather low so as to be scheduled an actual UFW reduction plan.
3) Despite revenue improvement by computerizing for ledger book recording, billing and collection, CWASA could not fully service its interest obligations in recent years, and was in default on some covenants for the credits.
4) Many of issues have been continuous and pervasive in CWASA, because WASA's tariffs are currently regulated by the Central Government and do not reflect the cost structure and hence the tariffs could not designed to respond to changes in the financial requirement.

6.3 Comparison with Business of DWASA

Comparison of business between CWASA and DWASA will suggest an useful measures for improvement of CWASA's management. Comparing the following data, however, must take note that there are some differences of condition between CWASA and DWASA, namely DWASA has sewerage sector as well as water supply sector while CWASA had water supply sector only.

(1) Basic Date of CWASA's/DWASA's Condition for Comparison

Basic indexes on water supply management are shown in Table 6.8.

Table 6.8 Basic Condition of DWASA/CWASA

Item	Unit	DWASA		CWASA
		1998	1999	1997
(Basic Index):				
Population Served	person	-	3,530,000	1,142,000
Population Served Ratio	%	64	66	44
Water Distribution	m^3/day	870,000	930,000	143,803
Water Sold	m^3/day	609,000	651,000	101,008
UFW after Distribution	%	30	30	30
Number of Connections (water)	number	-	180,129	30,006
Number of Connections (sewerage)	number	-	45,325	-
Number of Hydrant	number	-	1,643	900
Number of Staff	person	-	3,215	750
Un-collected Ratio (Arrear)	%	-	26	9.5
(Income/Expenditure Index):				
Operating Revenue	million Tk	1,127	1,251	209
Working Expenditure	million Tk	833	812	153
Operating Expenditure	million Tk	982	1,034	194
Net Operating Expenditure	million Tk	1,098	1,197	233
(Balance Sheet Index):				
Property and Assets	million Tk	11,467	13,457	1,853
Capital Fund and Liabilities	million Tk	11,467	13,457	1,853
Current Liabilities	million Tk	48	154	(25)

Note: Current Liabilities of CWASA shown at (25) is including in Capital Fund and Liabilities of CWASA

In the above table, the following characteristics are observed:

1) Population served ratio is 44 and 66 % for CWASA and DWASA, respectively. This means water supply situation in CWASA is mostly critical and expansion of the supply system is urgently needed.
2) Un-collected ratio is 9.5 and 26 % for CWASA and DWASA, respectively. This means service section in CWASA managed better than DWASA.
3) Operating expenditures are lower than operating revenue both in CWASA and DWASA.
4) Comparing net operating expenditure and operating revenue, net operating expenditure is higher than operating revenue in CWASA. Net operating expenditure, however, is lower than operating revenue in DWASA. This means operating revenue in DWASA covers its interest payment, but not in CWASA.

(2) Comparison used Management Indexes between CWASA and DWASA

The comparative indexes on water supply management from the viewpoint of operation, management and finance are shown in Table 6.9.

Table 6.9 Management Index

Item	CWASA				DWASA
	1995	1996	1997	1998	1999
(Operating Indication):					
Accounted for water after distribution (%) (Water Sold/Water Distribution) x 100	64	65	70	65	70
Daily Average Supply per capita (l/person/day) (Water Distribution/Population Served)	122	127	126	137	263
(Management Indication):					
Selling Cost (Tk /m^3) (Operating Revenue/Water Sold)	5.52	5.52	5.68	5.66	5.27
Water Supply Cost (Tk /m^3) (Net Operating Expenditure/Water Sold)	6.71	6.58	6.36	6.67	5.04
Water Sold per one Employee (1000m^3/employee/year) (Water Sold/Stuff Number)	43	46	49	50	92
Operating Revenue per one Employee (1000m^3/employee/year) (Operating Income/Stuff Number)	239	254	279	280	389
(Financial Indication):					
Collection Ratio per year (%) (Collected Amount/Billing Amount) x 100	93.6	85.3	90.5	91.0	73.9
Working Ratio per year (%) (Operating Revenue/Working Expenditure) x 100	139.0	140.2	136.8	120.6	154.1
Operating Ratio per year (%) (Operating Revenue/Operating Expenditure) x 100	108.1	109.1	107.9	102.2	120.9
Salaries Ratio of Employee to Expenditure (%) (Salaries Cost/Working Expenditure) x 100	33.8	35.3	33.5	32.6	23.6
Current Ratio (%) (Current Assets/Current Liabilities)	1,400	1,824	1,858	1,678	1,221
Fixed Assets to Equity Capital Ratio (%) (Fixed Assets/Owned Capital & Surplus) x 100	263	278	245	250	78
Profit Ratio of Gross Capital (%) (Net Operating Profit/Liabilities & Capital) x 100	11	11	12	12	9

Note1: The number of employee is used 750.

The results of analysis are shown below.

1) Operating indication

(a) CWASA's accounted for water during the previous four years except for 1997, presents rather low % compared with DWASA. However, it is still high level.

(b) Daily average supply/distribution per capita of CWASA is about 52 % of DWASA. It is assumed that share of water supply to commercial and urban infrastructure usage are larger in DWASA than CWASA.

2) Management indications

(a) Selling cost is lower than water supply cost in CWASA, but it is opposite in DWASA.

(b) The trend of operating revenue per one employee for past several years in CWASA is gradually increasing year by year, however, that of CWASA in 1998 is only 72 % of DWASA.

3) Financial indication

(a) Collection ratio of CWASA is better than that of DWASA.

(b) Operating ratio of operating revenues to operating expenditure of CWASA is worse than of

DWASA.

(c) Salaries ratio of employee to working expenditure in CWASA are higher than that of DWASA.

6.4 Inhabitant's Awareness Survey on Water Supply and Environmental Sanitation

6.4.1 Objective of the Questionnaire Survey

The questionnaire survey on the " Inhabitant's Awareness on Water Supply and Environmental Sanitation" was intended to scrutinize the following aspects covering a total of about 60 households in the Study Area.

(1) Existing water supply conditions,
(2) Proposition of the water charge to income/expenditure of the families,
(3) Willingness and affordability to pay for water supply,
(4) What is the consumers' wanted issues to CWASA for improvement of the water supply system and services, and
(5) Knowledge on public hygiene causality between water borne/related/vector diseases and hygienic condition.

6.4.2 Questionnaire Survey

(1) Questionnaire Form

A set of questionnaire form covering the aforementioned survey contents was prepared in the Study Team. The questionnaire form was designed primarily to be answered as "Yes" or "No" and chosen from plural answers, which were prepared in advance by the Study Team as forecasted/expected answers for convenience in statistical evaluation, while some questions required narrative answers. This survey was carried out by local engineers under the supervision of the Study Team.

(2) Questionnaire Target

The target number of households to be interviewed was initially separated into two categories:

1) Approximately 50 households are to be consumers who are served piped water through house connections or public hydrants and the other 10 households are to be one un-served piped water.
2) 50 %, 30 % and 20 % of the families to be interviewed are living in Pucca, Semi-pucca or Kutcha types of housing so as to represent the present proportion of the number of households in the Study Area.

The number of interviewed households was resulted as shown in Table 6.10.

Table 6.10 Number of Interviewed Households

Name of Thana		Pucca	Semi-pucca	Kutach	Total
1	Kotwali	5	1	1	7
2	Double Mooring	11	2	1	14
3	Panchlaish	4	3	1	8
4	Pahartali	2	4	1	7
5	Chandgaon	2	2	2	6
6	Chittagong Port	2	3	2	7
7	Hathazari	2	1	1	4
8	Hathazari (P)	1	0	2	3
9	Sitakunda (P)	2	1	1	4
Total		31	17	12	60

6.4.3 Survey Results

(1) Income and Expenditure

1) Monthly income

Distribution of the number of families interviewed by income per month is shown in Figure 6-1. The average monthly income of the interviewed families was approximately Tk 8,000, and majority of the families fell on Tk 20,000 /month.

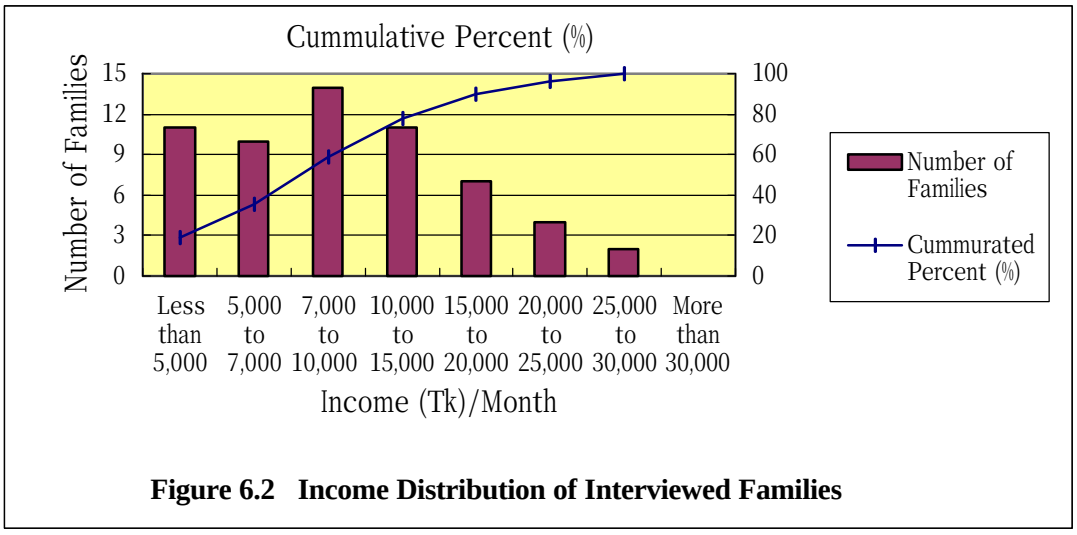

Figure 6.2 Income Distribution of Interviewed Families

2) Proportion of water charge to income

Proportion in ratio of water charge to the income/expenditure is shown inn Table 6.11.

Table 6.11 Proportion in Ratio of Water Charge to the Income/Expenditure

Income per Month (Tk)	Proportion in Ratio of the Water Charge to the Income					
	Less 1.0 %	1.0 to 2.0%	2.0 to 3.0%	3.0 to 4.0%	4.0 to 5.0%	More 5.0%
Less than 5,000	–	3	3	1	–	2
5,000 to 7,000	–	3	–	–	2	–
7,000 to 10,000	–	1	4	3	1	4
10,000 to 15,000	4	3	1	–	–	–
15,000 to 20,000	2	1	1	–	1	
20,000 to 25,000	1	–	–	1	–	–
25,000 to 30,000	1	–	–	–	–	–
Total	8	11	9	5	4	6

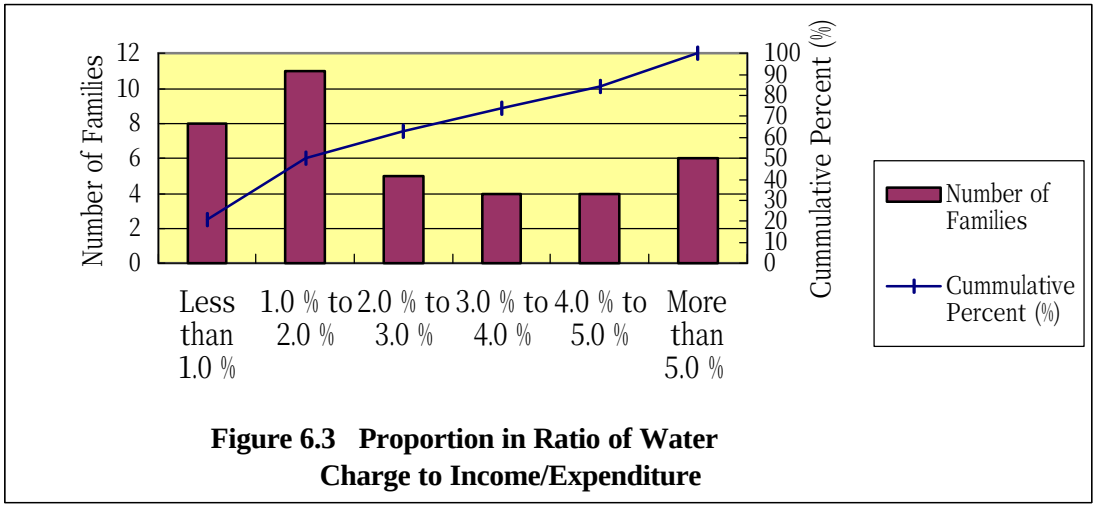

Figure 6.3 Proportion in Ratio of Water Charge to Income/Expenditure

From the survey result mentioned above, it is found that half of the families interviewed pay less than 2 % of their income amount for water charge that is approximately Tk 180 per month.

(2) Willingness to Pay and Affordability for Water Charge

Table 6.12 shows the number of families grouped by income range and by the affordability to pay for water charge, provided that CWASA's services are improved.

Table 6.12 Proportion of Willingness to Pay for Water Charge

Income (Tk/Month)	Willingness to Pay for Water Charge						Total
	No change	Up to 1.5 times	Up to 2.0 times	Up to 2.5 times	Up to 3.0 times	More 3.0 times	
Less than 5,000	7	2	2	0	0	0	11
5,000 to 7,000	4	1	1	0	0	0	6
7,000 to 10,000	5	4	4	0	0	0	13
10,000 to 15,000	5	0	4	0	0	0	9
15,000 to 20,000	0	2	1	1	1	1	6
20,000 to 25,000	1	0	0	0	0	0	1
25,000 to 30,000	1	0	1	0	0	0	2
More than 30,000	0	0	0	0	0	0	0
Total	23	9	13	1	1	1	48

Result of the willingness survey is different by largely depending on income level, especially low-income class wanted to be maintained the present charge. However, more than 50 % of interviewed families show a willingness to pay as charged by meter reading, when the current water supply conditions are improved. This response is verified by the other questions on the priority for water supply improvement, namely first ranked request is " continuous supply ", the second is " enough water pressure" and "safety for drinking" and following to "low water rate/charge.

In detailed examination on the outcome, it is observed that the families get monthly income ranging less than TK 7,000 has no willingness to pay more even though CWASA's service would increased. The families who get monthly income ranging more than TK 7,000 to TK 15,000 are likely having a willingness to pay charge up to 1.5 to 2.0 times of the present charge. As the name, the families having monthly income ranging more than TK 15,000 to TK 20,000 are having a willingness to do up to 2.0 to 3.0 times.

Therefore, it is considerable that slab structure tariffs method would be able to introduce as an alternative idea for water tariffs examination from new point of closs-subsidy among the consumers.

(3) Request to CWASA for Improvement of Water Supply Services

Table 6.13 shows the priorities to be improved the water supply services that is requested to CWASA. The survey was carried out by means of selection and allowable plural answers from the given answers in advance as forecasted request/claim to CWASA.

Table 6.13 Request for Improvement of Water Supply Services

Item for Improvement	Number of Families Requested
1. Continuous supply	51
2. Enough water pressure	29
3. Cheap water charge	29
4. Safe for drinking	27
5. Good quality water supply	25
6. Others	0

CHAPTER 7

BASIC PLAN FOR DEVELOPMENT OF WATER SUPPLY SYSTEM

CHAPTER 7 BASIC PLAN FOR DEVELOPMENT OF WATER SUPPLY SYSTEM

7.1 Fundamentals for Planning of Basic Plan

7.1.1 Target Year

The target year for the Basic Plan is 2010. In order to cope with rapid increase of water demand to the year 2010, the intermediate target year is set at the year 2005.

7.1.2 Project Area

The project area for the Study is 26,915 ha including proposed expansion area.

7.1.3 Population of Project Area

The population of the project area in 2005 is estimated as follows:

Chittagong City	2,930,600
Out of Chittagong City	255,500
Project Area	3,186,100

The population of the project area in 2010 is estimated as follows:

Chittagong City	3,670,800
Out of Chittagong City	321,500
Project Area	3,992,300

7.1.4 Target Water Supply Service Level

The target water supply level in 2010 is set as follows:

(1) Ninety five percent (95 %) of households living in Pucca houses are supplied of water with house connections as well as 50 % of Semi-Pucca, and 20% of Kutcha.

(2) Remaining inhabitants of Pucca and Semi-Pucca houses are supplied of water with street hydrant as well as 20 % of peoples living in Kutcha houses. Remaining inhabitants in Kutcha houses are assumed to obtain water from other sources.

The intermediate target water supply level in 2005 is set as follows:

(1) Seventy percent (70 %) of households living in Pucca houses are supplied of water with house connections as well as 30 % of Semi-Pucca, and 15% of Kutcha.

(2) Regarding remaining inhabitants, 10 % of Pucca and 30 % of Semi-Pucca houses are supplied of

water with street hydrant as well as 20 % of peoples living in Kutcha houses. Other remaining people are assumed to obtain water from other sources.

7.1.5 Water Supply Planning Area

The water supply service area will cover whole study area in 2010. In order to cope with limited water sources, it will cover limited area in 2005 consisting of present service area and its adjacent expansion area.

7.1.6 Planned Water Supply Flow

The water demand in the service area in the target year 2010 will be 650,000 m^3/day or 143 MGD on distribution base. While, water demand in the project area in 2005 will be 344,000 m^3/day, water supply will be less due to limitation of water sources' capacity. Following water sources will fulfill the requirement in 2010:

(1) Existing/Under-processing and Planned Water Sources

i) Existing/Under-processing Water Sources

Following plants are operated or being implemented with definite schedule:

a.	Existing Mohara WTP:	91,000 m^3/day	(20 MGD)
b.	Kalurghat IRP including planned plant after the 2nd project (GOB)[1]:	68,000 m^3/day	(15 MGD)
c.	Madunaghat WTP Italian project (1st Phase):	46,000 m^3/day	(10 MGD)
	Sub-total	205,000 m^3/day	(45 MGD)

ii) Planned Water Sources

Following plants are expected to be implemented in the future:

a.	Mohara WTP expansion project planned under this Study:	91,000 m^3/day	(20 MGD)
b.	Fatehabad IRP planned by GOB[2]:	46,000 m^3/day	(10 MGD)
c.	Madunaghat WTP 2nd Phase expansion[3]:	46,000 m^3/day	(10 MGD)

[1] Present treatment capacity of the Kalurghat IRP is 15 MGD. In addition, construction project for 5 MGD new filters is under processing (out of scope of this project). Therefore total treatment capacity will be 20 MGD in 2010. However, due to shortage of production capacity of wells, water supply capacity of the Kalurghat BPS is estimated at 12 MGD in 2005 and 15 MGD in 2010.

[2] Implementation of this project is requested to GOB by CWASA. It is expected to be completed by 2005. However, in the F/S (2005), it is assumed to be an isolated water supply system to serve for the Chittagong University and the Cantonment. In 2010 plan, it is integrated with other systems.

Sub-total	183,000 m^3/day	(40 MGD)
Total of i) and ii)	388,000 m^3/day	(85 MGD)

(2) New water source to be developed:

Additional water source shall be secured to fulfill the water demand in 2010 as follows:

Planned Water Demand in 2010	650,000 m^3/day	(143 MGD)
Capacity of Existing Water Sources	388,000 m^3/day	(85 MGD)
Balance (Required New Water Source)	262,000 m^3/day	(58 MGD)

This additional water source shall be secured from surface water source, i.e. Karnaphuli river, because groundwater exploitation in the Study Area will be in near-limitation by the above mentioned development plans (i.e. b and c) and existing wells. Since it is equivalent to 36 % of allowable groundwater exploitation in the study area, further groundwater development without adverse effect on the groundwater condition is judged to be difficult.

With regard to water sources in 2005, it will consists of existing water sources, on-going planned sources, and the Mohara WTP expansion plan. Total water source capacity in 2005 will be 282,000 m^3/day or 62 MGD[4], and distribution system will be developed in compliance with that source capacity.

7.2 Basic Policy for Water Supply System Development

7.2.1 Design Policy of Existing System

The Kalurghat System was constructed in 1977 under IDA financed First Chittagong Water Supply Project. It covers the central area of Chittagong City by direct pump supply from the Kalurghat IRP & BPS with a balancing tank, i.e. the Battali Hill Reservoir. However, water has not been supplied to the Battali Hill Reservoir due to water shortage. During the Second Water Supply Project, the Kalurghat system temporarily supplied water to the Patenga BPS for two years. After completion of the Mohara WTP, water source of the Patenga BPS was replaced with it.

In 1988, afore-mentioned Second Chittagong Water Supply Project was completed under the finance of IDA. In the project, the Mohara WTP, the ADC Hill Reservoir, the Patenga BPS, and the Dhaka Trunk Road BPS had been constructed, and the pipelines connecting those facilities and the Battali

[4] Capacity of Kalurghat IRP in 2005 is presumed at 12 MGD.

Hill Reservoir[5] were also installed.

The transmission line from the Mohara WTP does not distribute water in principle. Initially, it was designed to supply water to two reservoirs, i.e., the Battali Hill Reservoir and the ADC Hill Reservoir and two booster pump stations, i.e., the Dhaka Trunk Road BPS and the Patenga BPS. However, water has not been supplied to both reservoirs due to water shortage. Only the ADC Hill Reservoir has been used for water supply to its adjacent area with groundwater form wells located nearby.

Presently, several interconnection pipes connect the Kalurghat system with the Mohara system. They are partially opened usually in order to relieve water shortage of the Kalurghat system. Consequently, the Kalurghat system and the Mohara system cover one integrated water service area including areas served by two booster pump stations, i.e. Dhaka Trunk Road and Patenga. However, the service area has been suffered by chronic water supply interruption due to absolute water supply capacity shortage.

7.2.2 System Development Policy for the Project

In order to cope with afore-mentioned circumstances and to improve/expand the existing facilities for the stable supply of safe drinking water, a system development plan was prepared based on the following policies:

- Water intake and treatment facilities shall be operated with constant load in order to maximize their capacity effectively.
- Currently, water is supplied by the system consisting of WTP, distribution pump stations, booster pump stations and reservoirs. Whole system shall be re-organized under the principle, "one reservoir serves one distribution area" for stable water supply. Inter-connection, however, shall be provided between distribution areas providing for accidents.
- Transmission facilities, namely transmission pumps and transmission pipes, shall be designed appropriately corresponding to the average daily flow.
- Distribution facilities, namely distribution pumps, reservoirs and distribution pipes, shall be designed appropriately corresponding to the peak distribution flow.
- In principle, water shall be supplied from reservoirs by gravity. If site with suitable high elevation is not available, ground reservoir at lower elevation and a pressure control head tank at high elevation will be provided.

[5] The pipeline connecting the transmission line with the Battali Hill reservoir was also arranged for use as "Balancing Tank".

- New distribution mains and branch pipes shall be developed systematically with effective utilization of the existing distribution network in order to suppress investment cost.
- Existing tube wells scattered in MOD I area will be abolished after commissioning of new system due to unsuitable water quality.
- To cope with rapid increase of water demand through the year 2010, phased implementation plan will be introduced with intermediate target year 2005.
- Since a period to intermediate target year 2005 is very short, only the source facilities with high possibility of realization shall be presumed as a base of water supply plan. Planned service area shall be limited in accordance with source capacity.

7.3 Design Criteria

7.3.1 Water Treatment System

(1) Water Treatment Process

A treatment process with High Rate Sludge Blanket Type Clarifier and Rapid Sand Filter is adopted for the existing Mohara WTP. Desilting Basins are also provided at upstream of these facilities to deal with high turbidity. Facilities were designed economically by abstaining from use of mechanical and electrical equipment, which requires capital and operation & maintenance costs.

Judging from present operational status and above-mentioned characteristics, there is no reason not to select the method adopted in the existing system. Consequently, the treatment method adopted in the existing plant; i.e. High Rate Sludge Blanket Type Clarifier and Rapid Sand Filter will also be adopted for the Mohara WTP expansion plant. Proposed Karnaphuli WTP will also employ the same treatment process. Desilting basin shall be provided at upstream of treatment facilities to lessen the turbidity during rainy season.

Filtration rate of present filters of the Mohara WTP is 267 m/day in normal operation, and 306 m/day in case one filter is suspended. Since this filtration rate is too high, proposed plant will be designed to have decreased rate, which will be equal to the one of present filter in normal operation even in case one filter is suspended.

Though design turbidity for chemical dosage is set by 350 NTU in the existing plant, larger turbidity is frequently recorded including the maximum value of 830 NTU. Therefore, design maximum turbidity will be set by 850 NTU.

7.3.2 Water Transmission/Distribution System

Average daily flow was applied for design of transmission pipeline, while hourly peak flow was adopted for distribution pipeline. Since reliable data is not available, the hourly peak flow is assumed to be 1.5 times[6] of average daily flow based on the investigation results in various cities in Japan.

Required size of pipelines and capacity of pumps were decided based on computer based 72-hour long dynamic hydraulic analysis. Capacities of reservoirs were also decided based on the results of simulation. Some extent of surplus capacity was added to adopted capacity.

Capacity of pumps were also planned with average daily flow for transmission pumps and with hourly peak flow for distribution pumps. Planned capacities were verified through 72-hour long dynamic hydraulic analysis.

7.3.3 Electrical Equipment and Instrumentation

All electrical design shall be in conformity to technical standards for electrical design adopted in Bangladesh, Japanese and other industrialized countries. Electrical equipment shall be selected so as to endure humidity and high temperature condition. The equipment will be simple and reliable to ensure stable and long services allowing easy and low cost operation and maintenance.

7.4 Recommended Chittagong Water Supply System

7.4.1 Outline of the System

Water sources of the proposed system consists of three surface water treatment plants and two groundwater treatment plants with a total capacity of 659,000 m^3/day or 145 MGD in 2010 as shown in Table 7.1.

Usage of tube wells scattered in the MOD I area will be ceased as soon as possible after development of recommended system because of their high iron concentration and lack of on-site disinfection facilities.

[6] Though measurement trials were carried out on several pipeline disposed portions in the distribution system using a portable ultrasonic flow meter, but they are failed maybe due to unsuitable internal condition of pipe. This ratio was decided based on actual investigation results in many cities in Japan.

Table 7.1 Treatment Plants in Recommended System

Name	Production Capacity (m^3/day)	Implementation Stage (available source capacity)		
		Existing	Phase 1 (2005)	Phase 2 (2010)
Mohara WTP (Exist., Rehab.)	20 MGD (90,900)	20 MGD	20 MGD	20 MGD
Mohara WTP (Expansion)	20 MGD (90,900)	-	20 MGD	20 MGD
Kalurghat IRP (Rehab.)	20 MGD (90,900)	10 MGD	12 MGD	15 MGD
Madunaghat WTP (1st phase)	10 MGD (45,500)	-	10 MGD	10 MGD
Madunaghat WTP (2nd phase)	10 MGD (45,500)	-	-	10 MGD
Fatehabad IRP	10 MGD (45,500)	-	10 MGD**	10 MGD
Karnaphuli WTP	60 MGD (272,800)	-	-	60 MGD***
Wells in MOD-I	7 MGD (32,000)	7 MGD*	-	-
Total*	157 MGD (713,900)	37 MGD	62 MGD**	145 MGD

Note: *: Existing tube wells in MOD-I area will be abolished after completion of Phase 1 project.
**: The Fatehabad IRP will be developed outside of the service area in 2005. It will be integrated with the recommended system by 2010.
***: In order to compensate balances between capacity and water demand of other service blocks, capacity of the WTP shall be increased.

Treated water of each WTP/IRP will be transmitted to 10 reservoirs and distributed to respective service block in 2010, while 6 reservoirs will be provided by the intermediate target year 2005. Besides of reservoirs to be constructed/augmented at the WTPs and IRPs, i.e. Karnaphuli, Kalurghat, Mohara new plant, and Patenga BPS, four new reservoirs, namely, Madunaghat, Fatehabad, Salimpur, and Khulshi, shall be constructed. Existing Battali Hill reservoir and the ADC Hill reservoir will be used effectively in the recommended system. Capacities of those reservoirs are listed in Table 7.2.

Table 7.2 Proposed Reservoirs

Reservoir	Water Source	Phase 1(2005)	Phase 2(2010)
1. Exist. Mohara WTP Clearwater/Distribution Reservoir	Exist. Mohara WTP	6,700m^3	10,000m^{3*}
2. Khulshi Ground Reservoir	Mohara WTP Exp.	19,600m^3	19,600m^3
3. Khulshi Head Tank	Mohara WTP Exp.	1,780m^3	1,780m^3
4. Exist. Kalurghat IRP Clearwater/Distribution Reservoir	Exist. Kalurghat IRP	12,700m^{3**}	14,400m^{3**}
5. Exist. Battali Hill Reservoir	Madunaghat WTP 1st	13,640m^3	13,640m^3
6. Madunaghat WTP 2nd Ground Clearwater/Distribution Reservoir, Head Tank	Madunaghat WTP 2nd	—	G: 10,000m^3 H: 1,530m^3
7. Fatehabad IRP Ground Clearwater/Distribution Reservoir, Head Tank	Fatehabad IRP	—	G: 10,000m^3 H: 1,530m^3
8. Nasirabad Reservoir Ground Reservoir, Head Tank	Karnaphuli WTP	—	G: 27,500m^3 H: 3,620m^3
9. Salimpur Reservoir	Karnaphuli WTP	—	11,200m^3
10. Patenga BPS Ground Reservoir	Karnaphuli WTP#	12,000$m^{3##}$	24,000$m^{3##}$
(ADC Hill Reservoir)###	(Exist. Mohara WTP)	(4,500m^3)	(4,500m^3)
Total		66,420m^3	139,800m^3

*: Existing clearwater reservoir and new plant clearwater reservoir will be interconnected to be used as an integrated distribution reservoir.
**: Addition to existing clearwater/distribution reservoir of 8,500m^3 by 4,200m^3 in 2005, and by 1,700m^3 in 2010.
#: Till completion of Phase 2 project of Basic Plan (2010), water source for Patenga BPS Reservoir will be supplied from Madunaghat WTP 1st phase through Battali Hill reservoir and Exist. Mohara WTP.
##: A half of total capacity will be completed by 2005.
###: To be utilized as a supporting reservoir in day time for the Battali Hill Reservoir in 2005, and for direct pump supply from existing Mohara Plant in 2010.

Existing small-scale reservoirs scattered in the service area will be utilized as far as possible for water supply to high-elevated isolated area by taking water from the recommended distribution network.

Locations of WTPs and reservoirs and transmission pipeline routes are also presented in Figure 7.1.

7.4.2 Proposed Treatment Facilities

Besides of existing plants and on-going projects, following treatment plants shall be constructed for the recommended system.

(1) Mohara WTP New Plant

This plant is the subject of the F/S (Stage 1 of Basic Plan). In addition to existing plant with a capacity of 91,000 m^3/d or 20MGD, new plant with a same capacity will be augmented beside of existing plant by the year 2005, so that total capacity of the WTP will be 182,000 m^3/d or 40 MGD. Layout plan of the WTP is as shown in Figure 7.2.

(2) Madunaghat WTP 2nd phase

This project will be a succeeding stage of the 1st phase project being processed under the financial assistance of the Italian government. Total capacity of the Madunaghat WTP will be 91,000 m^3/day or 20 MGD and a half of it will be completed in the 1st phase project. This 2nd project is assumed to be completed by the year 2010.

(3) Karnaphuli WTP

This Karnaphuli WTP shall also be completed by the year 2010. Water source of the plant is the Karnaphuli River. The WTP will be located at the right bank of the Karnaphuli river as shown in Figure 7.1. This plant will have a capacity of 27,3000 m3/d or 60MGD, which will be the largest amo0ng the CWASA's facilities. Layout plan of the WTP is as shown in Figure 7.3.

7.4.3 Comparison Study for Location of Distribution Reservoir

This comparison study was conducted to identify the appropriate plan among various alternatives on location of reservoir site for distribution of water from the Mohara WTP expansion plant.

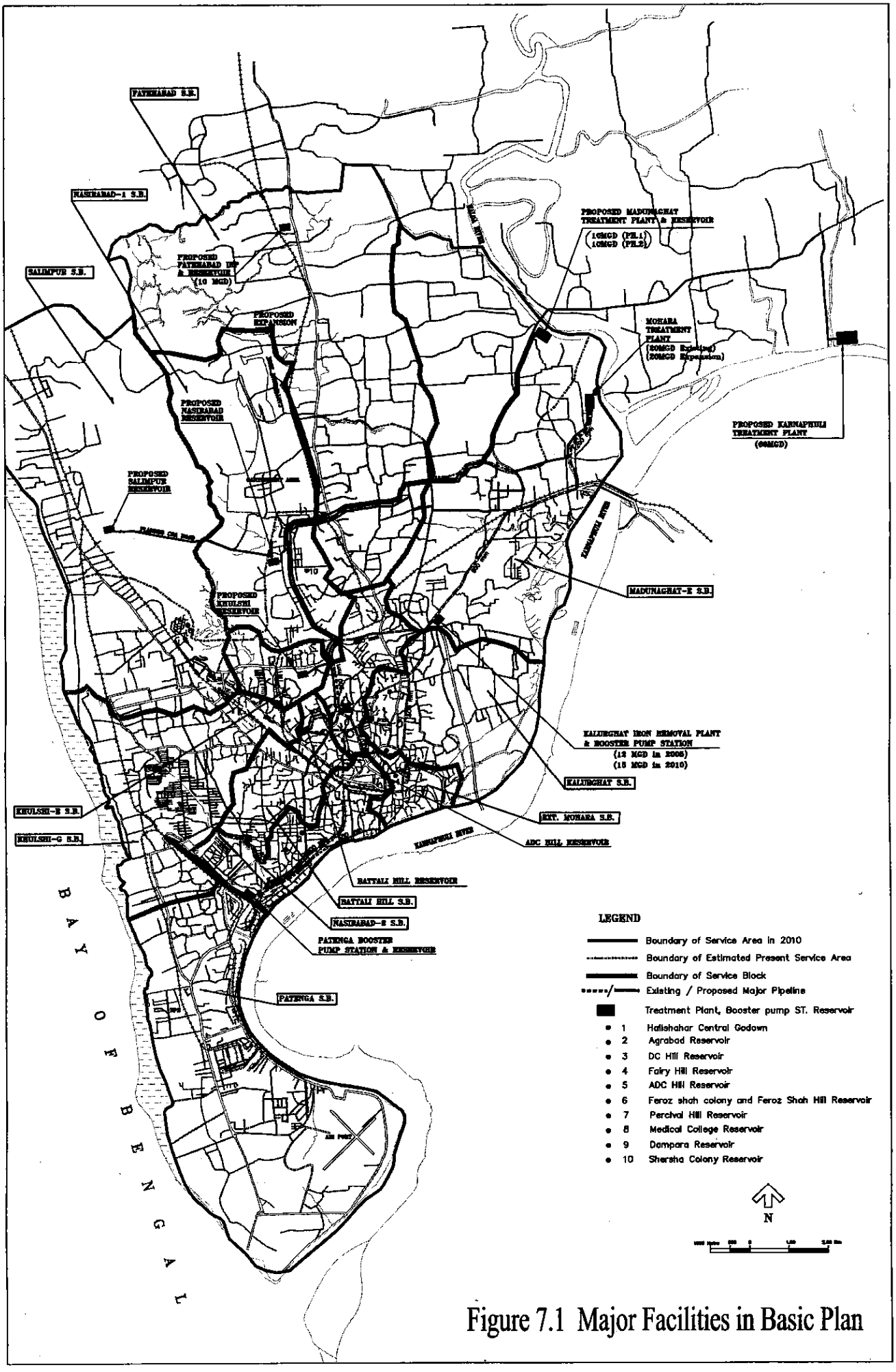

Figure 7.1 Major Facilities in Basic Plan

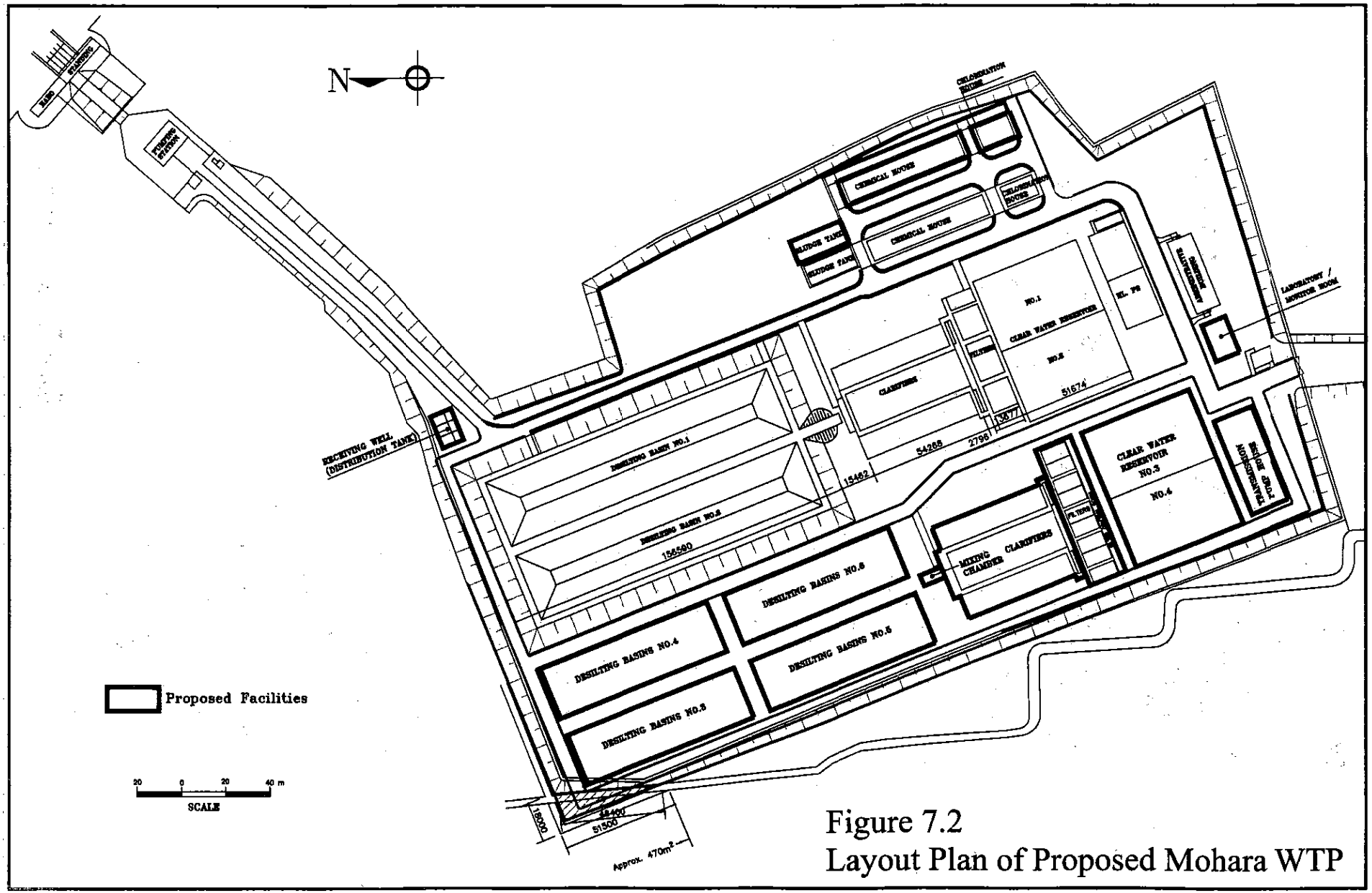

Figure 7.2
Layout Plan of Proposed Mohara WTP

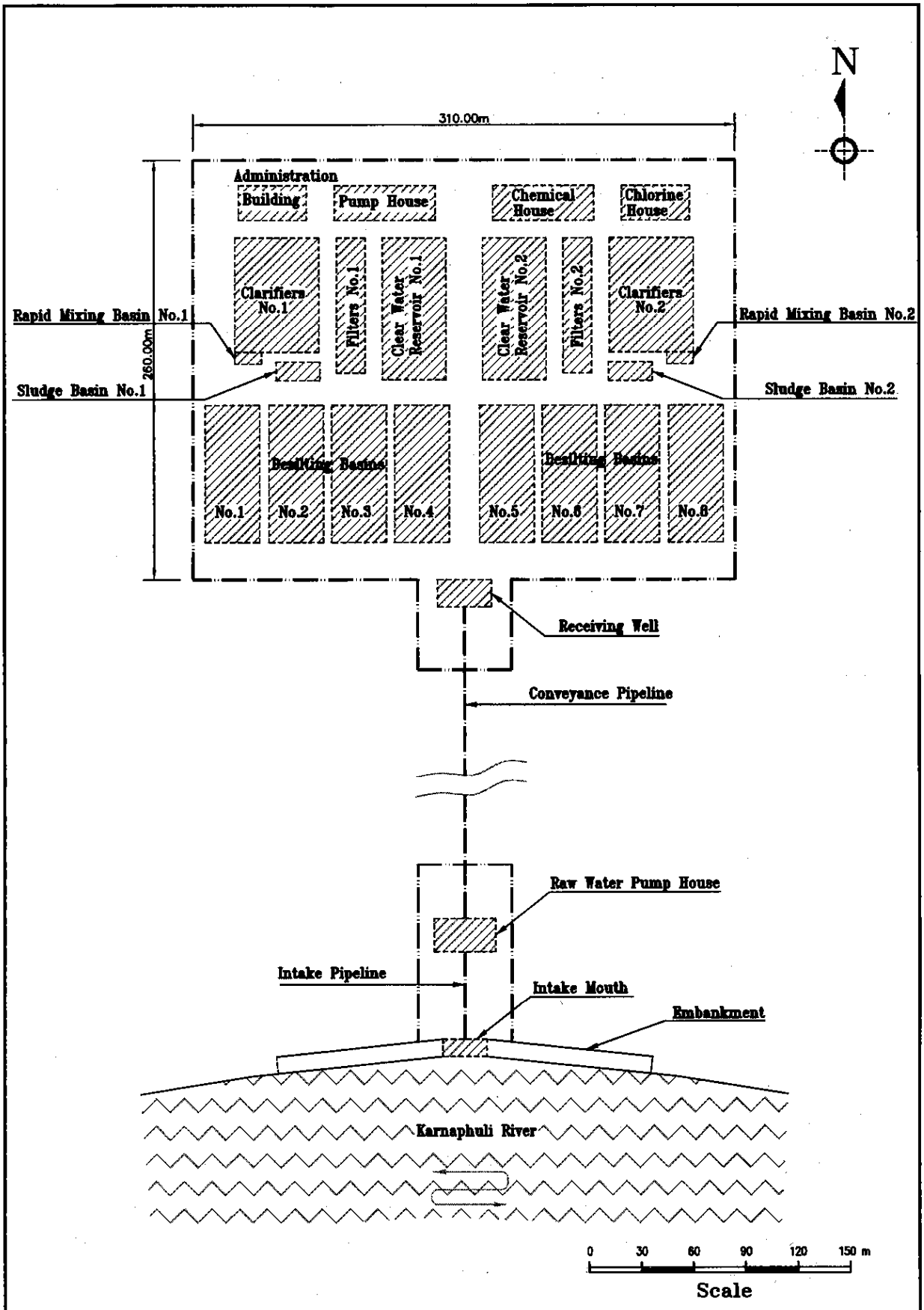

Figure 7.3 Layout Plan of Proposed Karnaphuli WTP

(1) Alternatives

The study was carried out on the following 7 alternatives taking account of location of land to construct the reservoir and distribution method[7].

Case I-a: Construction of a new reservoir at Khulshi Hill.

Case I-b: Construction of a new reservoir at Nasirabad Hill (back of the Tea Board Factory). Case I-b was further divided into 3 alternatives.

Case I-c: Construction of a new reservoir at the CWASA Nasirabad storage yard. Case I-c was further divided into 2 alternatives.

Case II-a: Construction of a new reservoir beside of existing Battali Hill reservoir.

Case II-b: Demolition of existing Battali Hill reservoir and reconstruction of a new reservoir with appropriate big capacity.

Case III-a: Construction of new reservoir at new Mohara plant. Case III-a was further divided into 3 alternatives.

Case III-b: Construction of new reservoir at new Mohara plant with a new reservoir and a booster pump station at CWASA Nasirabad storage site.

(2) Evaluation Criteria

Following 9 items were set up for evaluation of each alternative.

1) Water supply stability:
   It is better to store sufficient water in the reservoir from which water can be supplied by gravity.
2) Ease of system control:
   Gravity flow supply is given higher evaluation.
3) Ease of maintenance:
   Some alternatives require new pump station in addition to pump station at the Mohara WTP.
4) Construction cost:
   The cost includes distribution pumps, transmission pipe, reservoir, distribution pipe and land cost for the comparison. Costs for works common to each alternative are excluded from the evaluation.
5) Operation and maintenance cost:
   Pump operation cost is estimated for period of 30 years for comparison. In addition, 1% of mechanical and electrical equipment cost is added annually as maintenance costs. The material life for M&E is estimated as 15 years and adapted power charge is Tk 2.95/kWh.
6) Net Present Value of capital cost and O&M cost:

[7] Capacity of facilities, i.e. pumps, pipes and reservoirs were decided as minimum requirements for examined system. Actual facilities shall be designed including surplus capacity for ease of operation.

Net present value (NPV) of capital cost and O&M cost during operation period of 30 years was calculated based on 7.5% discount rate.

7) Availability of land:

Higher evaluation is given in order of CWASA own land, governmental land, and private land. The land price was given by CWASA as a reference price only for comparison purpose.

8) Workability and Compensation:

9) Necessity of Demolition of Existing Battali Reservoir:

(3) Cost Estimates

The comparative cost is estimated for a period of 30 years. Net present value of capital and O&M costs was computed with a discount rate of 7.5 %. Construction cost, operation and maintenance cost, and net present value of both costs of major alternatives[8] are summarized as shown in Table 7.3:

Table 7.3 Cost Estimates of Major Alternatives

Unit: Tk million

Items	I-a	I-b-3	I-c-1	III-a-3	III-b
1.Construction Cost	1,424	1,501	1,770	1,545	1,733
Ratio to Case I-a (=1.00)	1.00	1.05	1.24	1.08	1.22
2.Annual O & M Cost	46.1	47.1	43.3	42.8	42.4
Ratio to Case I-a (=1.00)	1.00	1.02	0.94	0.93	0.92
3.Net Present Value of Total Costs	1,692	1,771	1,965	1,754	1,920
Ratio to Case I-a (=1.00)	**1.00**	**1.05**	**1.16**	**1.04**	**1.13**

Note: 1) Construction cost includes overhead and profit of contractor (25% of direct. cost) and land cost.
2) Net Present Values are calculated for 30 years operation after 3-year construction period based on 7% discount rate.

(4) Evaluation Results

The evaluation results of each item are summarized as shown in Table 7.4.

[8] CWASA intends to utilize existing Battali Hill Reservoir after repair. Because of this reason, alternatives which needs demolition of the Battali Hill reservoir are not presented in the table together with alternatives of direct pump distribution which is not favorable from technical viewpoint.

Table 7.4 Evaluation Results of Alternatives

Items	I-a	I-b-3	I-c-1	III-a-3	III-b
1. Stability	B	B	C	C	D
2. Ease of System Control	A	A	A	B	C
3. Ease of Maintenance	C	C	C	A	C
4. Construction cost	B	B	D	C	D
5. O & M Cost	D	D	C	C	C
6. Total Cost NPV	B	C	D	C	D
7. Availability of land	C	C	A	A	A
8. Workability and Compensation	A	A	C	C	C
9. Existing Battali Hill reservoir demolition	A	A	B	B	B
Evaluation Result*	3A 3B 2C 1D (1)	3A 2B 3C 1D (5)	2A 1B 4C 2D (9)	2A 2B 5C 0D (7)	1A 1B 4C 3D (11)

*: Numbers in parentheses indicate the order based on weighted pointing evaluation

(5) Recommendable Alternative Plan

Among 11 alternatives, highest ranked alternative is Case I-a; construction of a new reservoir at Khulshi Hill. Though this plan requires rather high O&M cost, net present value of total cost is attractive because of low capital cost, and therefore it may be judged economical. Candidate site at Khulshi is a private land and there is a possibility of expropriation. In that case, it will take long period for solution and necessity of adoption of next ranked alternatives arise to avoid delay of the project. The second highest ranked alternative is Case I-c-2, which is not shown above table; construction of a new elevated reservoir at CWASA Nasirabad storage yard, and transmission to new Battali Hill reservoir through a branched pipeline. However, this involves demolition of existing Battali Hill reservoir and it differs from present policy of CWASA. Consequently, it is not recommended for the basic plan.

Next ranked alternative is Case I-b-3; construction of new ground reservoir with a head tank at Nasirabad Hill, which also requires a private land. Since both of Cases I-a and I-b-3 requires use of private land, if land acquisition in both cases does not succeed, adoption of Case III-a-3; direct distribution from a new reservoir at the Mohara plant through new Battali Hill head tank, shall be considered. However, this alternative requires construction work on Battali Hill and along the access road to the hill. This alternative also requires rather high capital cost. In view of those characteristics of Case III-a-3, if Case III-a-3 is being adopted, it is recommendable to re-consider the possibility of adoption of other alternatives, which require demolition of existing Battali Hill reservoir.

As a result of comparison study, Case I-a is selected as a most recommendable plan. Basic plan was established based on Case I-a.

7.4.4 Transmission / Distribution Facilities

(1) Water Supply Service Block

The distribution system shall be improved and enhanced because the capacity of water sources will be augmented to about 1.7 times of present capacity in 2005 and about 3.9 times in 2010. As stated in previous sections, whole water supply system will be fractionalized into 6 service blocks by the year 2005 and 10 blocks in 2010 as shown in Table 7.5.

Table 7.5 Service Blocks in Basic Plan

Service Block	Reservoir	Type of Dist.	Construction of Reservoir	
			Ph.1 - 2005	Ph.2 - 2010
1. Exist. Mohara WTP	Exist. Mohara CW/Dist. Reservoir	Pumped Flow	cont. use	connection w/new plant
2. Mohara WTP Exp.-1	Khulshi Ground R.	Gravity Flow	new	cont. use
3. Mohara WTP Exp.-2	Khulshi Head Tank	Gravity Flow	new	cont. use
4. Kalurghat IRP	Kalurghat CW/Dist. R.	Pumped Flow	expansion	expansion
5. Madunaghat WTP 1st	Exist. Battali Hill R.	Gravity Flow	repair	cont. use
6. Madunaghat WTP 2nd	Madunaghat CW/D R. (ground + head tank)	Gravity Flow	—	new
7. Fatehabad IRP	Fatehabad CW/D R. (ground + head tank)	Gravity Flow	—	new
8. Karnaphuli WTP-1	Nasirabad R. (ground + head tank)	Gravity Flow	—	new
9. Karnaphuli WTP-2	Salimpur R.	Gravity Flow	—	new
10. Karnaphuli WTP-3	Patenga R.*	Pumped Flow	new	expansion

Legend: cont. use - continuous use as it is
connection w/new plant – connect existing reservoir with a reservoir of new plant to utilize a half of its capacity

*: Patenga reservoir will receive the water from existing Mohara WTP and Madunaghat WTP 1st phase during Phase 1 till 2010

Each area to be served from those reservoirs will form an individual service block. Valves will separate boundaries of each service block. Location of boundaries was decided based on the results of hydraulic analysis of pipeline network.

(2) Distribution Network

The network model for the hydraulic analysis was established based on the various data, record, and information in design section and MOD sections. Based on the network model presented in Figures 7.4 and 7.5, hydraulic analysis for B/P was conducted for the demand in the year 2005 as Phase 1 and the demand for the year 2010 as Phase 2.

In the network analysis, following considerations were given:

- Existing pipelines shall be utilized in the proposed network system as far as possible.

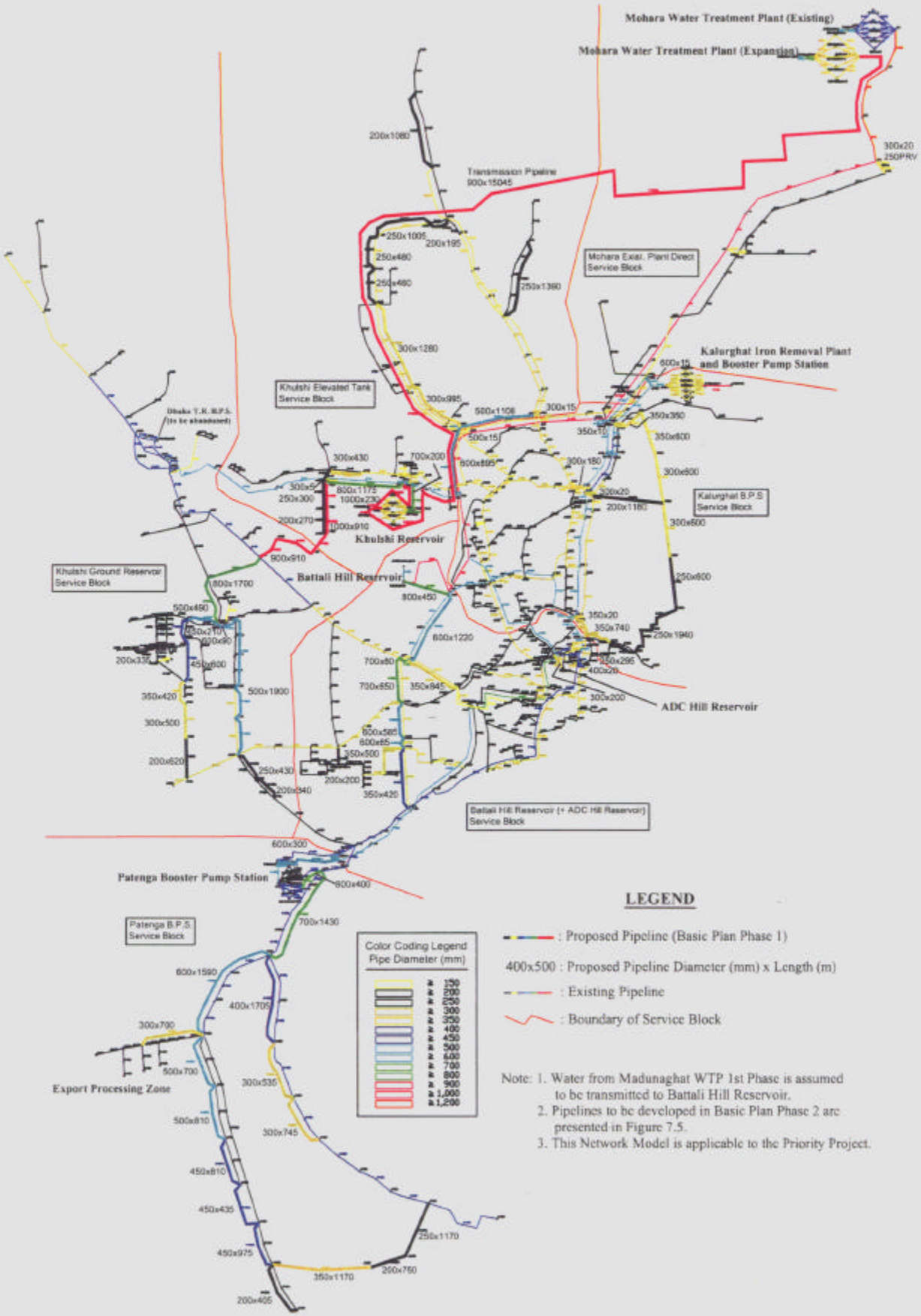

Figure 7.4 Proposed Pipeline Network for Basic Plan (Phase 1, 2005)

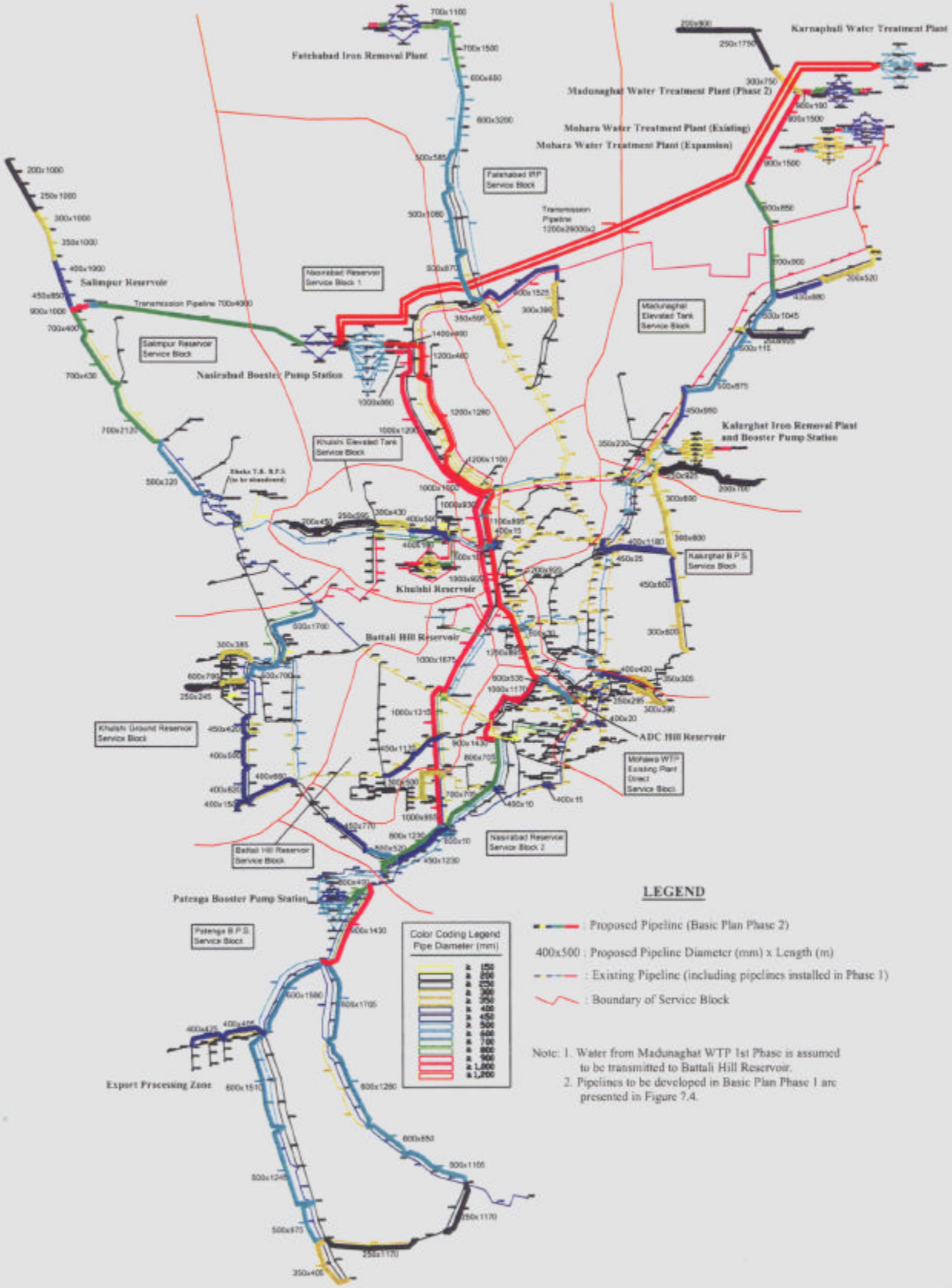

Figure 7.5 Proposed Pipeline Network for Basic Plan (Phase 2, 2010)

- Pipelines development program is scheduled in two stages, namely Stage 1 for 2005 and Stage 2 for 2010 because of large difference of the water demand between both years.
- Hydraulic analysis was conducted on primary distribution system consisting of pipelines with a diameter of 200mm or larger. Cost for development of secondary distribution system was estimated separately based on the assumed area to be developed.
- Minimum hydraulic pressure at any node in the distribution network was designed to be maintained at 98 kPa or 10m of hydraulic column.

7.4.5 Summary of Proposed Facilities

Proposed facilities for B/P are summarized in Table 7.6. Out of the Stage 1 Project, components to be implemented as a minimum requirement to receive and distribute the water from the Mohara WTP new plant are extracted as an urgent project.

7.5 Project Cost

7.5.1 Composition of Project Cost

The composition of project cost is shown in Figure 7.6

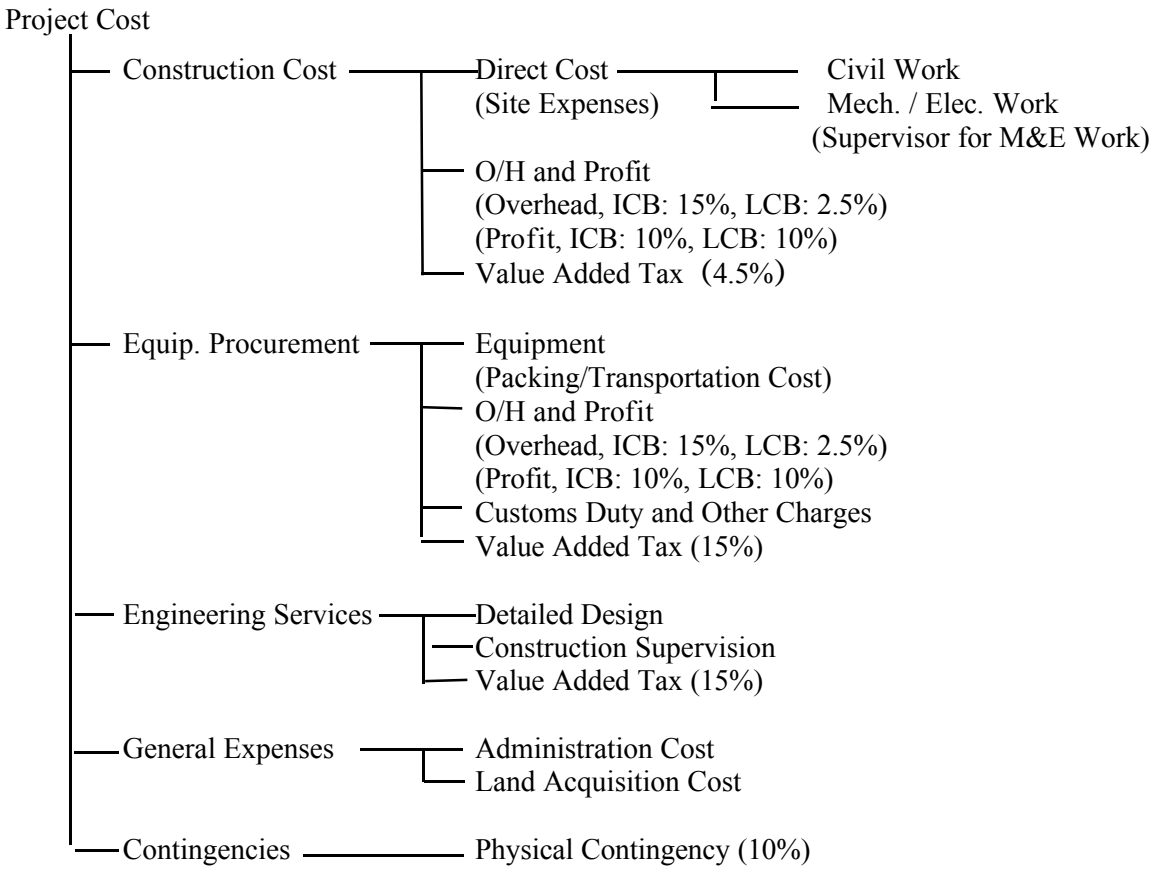

Figure 7.6 Composition of Project Cost

Table 7.6 Proposed Facilities of Basic Plan

Facilities	Diameter (mm)	Material	Phase 1		Phase 2	Total
			Urgent*	2005	2010	
1 Mohara WTP New Plant Service Area						
WTP Treatment Plant 20MGD			20 MGD	-	-	20 MGD
Transmission Pump 15.8m3/min x 84 m x 350 kW x 4 (+1)			5 units	-	-	5 units
Transmission Pipeline	900	DCIP	15,045 m	-	-	15,045 m
2 Khulshi Distribution Reservoir Service Area						
Khulshi Distribution Reservoir						
Ground 2,800m2 x 7mD (35m-28m) 19,600m3			19,600 m3	-	-	19,600 m3
Lift Pump 13.1m3/min x 25m x 90kW x 3 (+1)units			-	4 units	-	4 units
Elevated dia. 18m x 7mD (52m-45m) x 16mH (LWL)			-	1,780 m3	-	1,780 m3
Distribution Pipeline	1000-200	DCIP/PVC	7,725 m	13,260 m	7,880 m	28,865 m
3 Mohara WTP Old Plant Service Area						
WTP Rehabilitation Work (Filters, Intake/Transmission Pumps)			-	1 L.S.	-	1 L.S.
Distribution Pipeline	600-300	DCIP/PVC	-	20 m	1,170 m	1,190 m
4 Kalurghat BPS Service Area						
IRP Rehabilitation Work (Filters, Power Generator)			-	1 L.S.	-	1 L.S.
Clearwater Reservoir (add.)						
Ground 2,060m2 x 2.87mD (3.33m-0.46m)		exist. 2,940 m2	-	1,470 m2	590 m2	2,060 m2
(5,910m3)		(8,440 m3)		(4,220 m3)	(1,690 m3)	(5,910 m3)
Distribution Pipeline	600-200	DCIP/PVC	-	7,150 m	3,910 m	11,060 m
5 Battali Hill Reservoir Service Area						
Distribution Pipeline	800-200	DCIP/PVC	-	5,505 m	1,170 m	6,675 m
6 Madunaghat 2nd Phase Reservoir Service Area						
WTP Treatment Plant 10MGD			-	-	10 MGD	10 MGD
Madunaghat Distribution Reservoir						
Ground 2,000m2 x 5mD (7m-2m) 10,000m3			-	-	10,000 m3	10,000 m3
Lift Pump 15.6m3/min x 35m x 150kW x 3 (+1)			-	-	4 units	4 units
Elevated dia. 18m x 6mD (36m-30m) x 25mH (LWL)			-	-	1,530 m3	1,530 m3
Distribution Pipeline	900-200	DCIP/PVC	-	-	15,475 m	15,475 m
7 Fatehabad Reservoir Service Area						
Reservoir						
Ground 2,000m2 x 5mD (17m-12m) 10,000m3			-	-	10,000 m3	10,000 m3
Lift Pump 15.6m3/min x 35m x 150kW x 3 (+1)			-	-	4 units	4 units
Elevated dia. 18m x 6mD (46m-40m) x 25mH (LWL)			-	-	1,530 m3	1,530 m3
Distribution Pipeline	700-300	DCIP/PVC	-	-	10,495 m	10,495 m
8 Karnaphuli WTP						
WTP Treatment Plant 60MGD			-	-	60 MGD	60 MGD
Transmission Pump 48m3/min x 71.5m x 920kW x 4 (+1)			-	-	5 units	5 units
Transmission Line	1,200	DCIP	-	-	52,000 m	52,000 m
9 Nashirabad Reservoir Service Area						
Reservoir						
Ground 5,500m2 x 5mD (28m-23m) 27,500m3			-	-	27,500 m3	27,500 m3
Lift Pump 38.4m3/min x 28.5m x 300kW x 3 (+1)			-	-	4 units	
Elevated dia. 24m x 8mD (53m-45m) x 25mH (LWL)			-	-	3,620 m3	3,620 m3
Transmission Line to Patenga BPS			-			
Lift Pump 38.7m3/min x 22.5m x 240kW x 2 (+1)			-	-	3 units	3 units
Transmission Line	1000-600	DCIP	-	-	10,505 m	10,505 m
Transmission Line to Salimpur Reservoir			-			
Lift Pump 18m3/min x 48.5m x 240kW x 2 (+1)			-	-	3 units	3 units
Transmission Line	700	DCIP	-	-	4,000 m	4,000 m
Distribution Pipeline	1400-300	DCIP/PVC	-	-	12,725 m	12,725 m
10 Salimpur Reservoir Service Area						
Salimpur Distribution Reservoir						
Ground 1,400m2 x 8mD (55m-47m) 11,200m3			-	-	11,200 m3	11,200 m3
Distribution Pipeline	900-200	DCIP/PVC	-	-	10,120 m	10,120 m
11 Patenga BPS Service Area						
Patenga Distribution Reservoir						
Ground 4,000 m2 x 6mD (7m-1m)	24,000m3		-	2,000 m2	2,000 m2	4000 m2
				(12,000 m3)	(12,000 m3)	(24,000 m3)
Dist. Pump 19.2m3/min x 37m x 200kW x 2 (+1)			-	3 units	-	3 units
27.6m3/min x 37m x 280kW x 2 (+1)			-	-	3 units	3 units
Distribution Pipeline	900-200	DCIP/PVC	-	14,630 m	15,465 m	30,095 m
12 Secondary (Small Dia.) Distribution Pipelines						
Small Diameter Pipelines	200-100	PVC	-	1 L.S.	1 L.S.	1 L.S.
13 Staff Quarters and Zone Offices						
Staff Quarters	100m2		-	40 flats	40 flats	80 flats
Zone Offices	800m2		-	5 offices	5 offices (exp.)	5 offices
Summary of Facilities to be Developed						
Water Treatment Plants			1 plant	-	2 plants	3 plants
Capacity of WTPs			20 MGD	-	70 MGD	90 MGD
Pump Stations			1 station	2 stations	5 stations	8 stations
Number of pump units			5 units	7 units	26 units	38 units
Reservoirs**						
Ground Reservoir			1 reservoir	2 reservoirs	4+2(exp.) r.	7 reservoirs
total capacity			19,600 m3	3,470 m3	61,290 m3	84,360 m3
Elevated Tank			-	1 tank	3 tanks	4 tanks
total capacity			-	1,780 m3	6,680 m3	8,460 m3
Pipelines***			22,770 m	25,935 m	129,450 m	178,155 m
Transmission Pipeline Total Length		DCIP/PVC	15,045 m	-	66,505 m	81,550 m
Ditribution Pipeline Total Length		DCIP/PVC	7,725 m	40,565 m	62,945 m	111,235 m

Note: Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Urgent project consists of minimum required facility for production and distribution of Mohara WTP new plant. It includes Mohara WTP new plant, transmission pipeline, ground distribution reservoir and a part of main distribution pipeline.

**: Clearwater reservoirs in WTP are not included.

***:Pipeline Length does not include secondary distribution (small dia.) pipeline network.

7.5.2 Conditions for Cost Estimates

The project cost is estimated on the basis of the preliminary design. Unit prices obtained from the CWASA and PWD, a local consultant, and a contractor are compared and adopted unit costs are established as of September 2000.

Assumptions and conditions applied for the cost estimate are as follows:

Price level: as of September 2000

Foreign exchange rate: Tk. 54.00 = US$1.00 = Japanese Yen 106

7.5.3 Project Cost

Total cost of the proposed Basic Plan is estimated at approximately US$ 450 million as presented in Table 7.7. Of which, Phase 1 project requires US$ 111 million, while US$ 339 million for Phase 2.

7.5.4 Construction Equipment and Materials

Most of the construction materials are imported from adjacent countries, except sand, gravel, concrete pipe etc. Imported materials are available in the local market in Bangladesh. Major mechanical and electrical equipment, however, must be imported from foreign countries by contractors.

7.5.5 Implementation Schedule

In connection with the target years for this Study (2005 and 2010), Phase 1 is an urgent and priority project and is expected to be completed by the end of 2005, while the overall project in Phase 2 are considered to be completed by the end of 2010.

Phase 1

2000-01	Preparation of project
2002-03	Detailed design, Bidding
2003	Commencement of construction & procurement of equipment
2003-05	Construction
2005	Commissioning

Phase 2

2005-06	Preparation of project
2006-07	Detailed design, Bidding
2008	Commencement of construction & procurement of equipment
2008-10	Construction
2010	Commissioning

Table 7.7 Project Cost of Basic Plan

(unit: US$)

Facilities	Phase 1 (2005)			Phase 2 (2010)			Total
	Local	Foreign	Total	Local	Foreign	Total	
I. Direct Construction Cost**							
1. Mohara WTP New Plant Service Area	6,584,000	13,857,000	20,441,000	0	0	0	20,441,000
2. Khulshi Distribution Reservoir Service Area	4,074,000	4,884,000	8,958,000	367,000	801,000	1,168,000	10,126,000
3. Mohara WTP Old Plant Service Area	355,000	2,275,000	2,630,000	49,000	86,000	135,000	2,765,000
4. Kalurghat BPS Service Area*	1,915,000	4,244,000	6,159,000	408,000	412,000	820,000	6,979,000
5. Battali Hill Reservoir Service Area*	-	-	-	55,000	117,000	172,000	172,000
6. Madunaghat 2nd Phase Reservoir Service Area	-	-	-	6,654,000	7,902,000	14,556,000	14,556,000
7. Fatehabad Reservoir Service Area	-	-	-	2,544,000	3,312,000	5,856,000	5,856,000
8. Karnaphuli WTP	-	-	-	26,968,000	46,044,000	73,012,000	73,012,000
9. Nashirabad Reservoir Service Area	-	-	-	7,284,000	15,448,000	22,732,000	22,732,000
10. Salimpur Reservoir Service Area	-	-	-	1,749,000	1,566,000	3,315,000	3,315,000
11. Patenga BPS Service Area*	1,381,000	2,331,000	3,712,000	2,638,000	4,557,000	7,195,000	10,907,000
12. Small Size Distribution Pipelines	5,878,000	8,469,000	14,347,000	20,246,000	29,171,000	49,417,000	63,764,000
13. Staff Quarters and Zone Offices	1,480,000	0	1,480,000	1,480,000	0	1,480,000	2,960,000
Sub-Total I	**21,667,000**	**36,060,000**	**57,727,000**	**70,442,000**	**109,416,000**	**179,858,000**	**237,585,000**
II. Overhead and Profit							
Overhead and Profit (ICB - 25% of DC 1 to 11)	0	10,475,000	10,475,000	0	32,240,000	32,240,000	42,715,000
Overhead and Profit (LCB - 12.5% of DC 12,13)	1,978,000	0	1,978,000	6,362,000	0	6,362,000	8,340,000
Sub-Total II	**1,978,000**	**10,475,000**	**12,453,000**	**6,362,000**	**32,240,000**	**38,602,000**	**51,055,000**
III. Procurement of Equipment							
1. Water Meter (20-150mmx25,000units) x 2 phases	0	589,000	589,000	0	589,000	589,000	1,178,000
2. Vehicles (Sedan x 2, 4WD x 2) x 2 phases	0	93,000	93,000	0	93,000	93,000	186,000
3. Computers (8 sets with printers) x 2 phases	0	22,000	22,000	0	22,000	22,000	44,000
Sub-Total III	**0**	**704,000**	**704,000**	**0**	**704,000**	**704,000**	**1,408,000**
IV. Administration							
1. CWASA Administration Cost	128,000	0	128,000	128,000	0	128,000	256,000
2. Land Acquisition Cost	3,370,000	0	3,370,000	8,715,000	0	8,715,000	12,085,000
Sub-Total IV	**3,498,000**	**0**	**3,498,000**	**8,843,000**	**0**	**8,843,000**	**12,341,000**
V. Duties, Taxes, and Charges							
1. Custom Duty and Other Import Charges	12,595,000	0	12,595,000	37,724,000	0	37,724,000	50,319,000
2. VAT for Civil Work (4.5%)	1,518,000	0	1,518,000	4,607,000	0	4,607,000	6,125,000
3. VAT for M&E Equipment	6,010,000	0	6,010,000	18,437,000	0	18,437,000	24,447,000
4. Pre-Shipment Inspection Fee	302,000	0	302,000	936,000	0	936,000	1,238,000
Sub-Total V	**20,425,000**	**0**	**20,425,000**	**61,704,000**	**0**	**61,704,000**	**82,129,000**
VI. Engineering Cost							
1. D/D + C/S (8% of I+II)	849,000	4,810,000	5,659,000	2,611,000	14,798,000	17,409,000	23,068,000
2. VAT for Engineering Cost (5.25%)	297,000	0	297,000	914,000	0	914,000	1,211,000
Sub-Total VI	**1,146,000**	**4,810,000**	**5,956,000**	**3,525,000**	**14,798,000**	**18,323,000**	**24,279,000**
VII. Contingencies							
1. Physical Contingency (10% of I+II+III+IV+V+VI)	**4,871,000**	**5,205,000**	**10,076,000**	**15,088,000**	**15,716,000**	**30,804,000**	**40,880,000**
2. Price Contingency (LCP: 0.7%p.a., FCP: 2%p.a.)	-	-	-	-	-	-	-
VIII. Total Project Cost	**53,585,000**	**57,254,000**	**110,839,000**	**165,964,000**	**172,874,000**	**338,838,000**	**449,677,000**

Note: Costs for Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are consideredas existing facilities.

*: Costs in 2005 for distribution pipelines outside of Khulshi S.A. excluding small size pipes are summed in the column of Kalurghat BPS service area.

**: Direct Cost of each category from 1 to 12 incledes costs of all faciliteies such as transmission/main distribution pipelines, treatment plant, reservoirs, and booster pumps.

7.6 Selection of Priority Project

As mentioned in sub-section 7.1.6, three new WTPs are required to meet the projected water supply capacity for the target year of 2010 in addition to the planned/on-going projects, namely the Kalurghat expansion plant under the 3rd interim rehabilitation project, and the Madunaghat 1st phase project.

Present water supply population is 1,140,000 or 44.7% service coverage ratio with intermittent water supply due to shortage of water, and unit water distribution is 140 lpcd including commercial /industrial usage.

After completion of the planned/on-going projects under GOB finance, the water supply situation is required to be 60 lpcd in unit water distribution for the projected water supply population in 2010. Otherwise it is required to restrict the population with water supply service within 1,460,000 which is equivalent to 36% in service coverage ratio in the year 2010 and 45% in 2005 in order to maintain the present water supply conditions. These projection mean no improvement of coverage ratio and more severe service supply conditions than present one taking account of rising of life style of the inhabitants and increasing demand for industrial usage in the future.

To cope with such conditions, a water treatment plant with middle size capacity must be constructed. With such circumstance, the Mohara WTP extension project is recommendable as an urgent project, which is one of the projected WTPs in the basic plan.

The reasons why the expansion of Mohara WTP is selected among the three projected WTPs in the basic plan are as follows:

(1) The land for the project is already secured and it is good for extension of existing WTP by same capacity.
(2) Construction work of the Madunaghat WTP 1st phase plant is not yet started, and the size of 2nd phase plant is too small for relief present water supply situation. While the Karnaphuli WTP requires huge amount of investment cost and it is too large for stringent financial situation of CWASA. The Mohara WTP extension project has an appropriate project size and financial requirement.
(3) It meets the contents of S/W and M/M agreed between CWASA and JICA.

After completion of the project in the Feasibility Study, it is expected that the water supply condition be improved as follows:
(1) Population with water supply service is to be 1,580,000 or 50% in coverage ratio in 2005
(2) Unit water distribution volume can be increased to 174 lpcd, which is sufficient amount for

improved life style of inhabitants.

(3) Supply volume for industrial usage is to be three times of present supply level.

(4) Quality of supplied water in Mode I area with existing groundwater sources, such as high iron content and no disinfection, will be improved with treated water supplied by new system.

CHAPTER 8

PRIORITY PROJECT

CHAPTER 8 FEASIBILITY STUDY ON PRIORITY PROJECT

8.1 Fundamentals for Planning

A part of components in the Basic Plan (Phase 1) was selected as a priority project. The priority project is a subject for the feasibility study. Fundamentals for the planning of the priority project is as follows:

8.1.1 Target Year

The target year for the feasibility study was set at 2005, which is the intermediate year to the year 2010, taking account of drastic change of water demand between two years[1].

8.1.2 Project Area

The total project area is 26,915 ha as same as the Basic Plan. The specific project area for the priority project is 13,986 ha[2].

8.1.3 Population of Project Area

The population in the project area in 2005 including outside of service area is estimated as follows:

Chittagong City	2,930,600
Out of Chittagong City	255,500
Project Area	3,186,100

Out of them, the target service population[3] of the priority project area is estimated as follows:

Chittagong City	1,801,300	
Out of Chittagong City	137,700	
Project Area	1,939,000	say 1,940,000

The service population, which is the restricted population of target service population due to limited water source, will be as follows:

Chittagong City	1,570,280

[1] The demand in 2010 is equivalent to 1.9 times of 2005 demand.
[2] Summation of multiplication of each word's area by demand coverage ratio
[3] Target service population was derived from target water supply service and projected population.

Out of Chittagong City	10,080	
Project Area	1,580,360	say 1,580,000

8.1.4 Target of Water Supply Service Level

The target of water supply level is set as follows:

(1) Seventy percent (70 %) of households living in Pucca houses are supplied of water with house connections as well as 30 % of Semi-Pucca, and 15% of Kutcha.
(2) Out of the remaining inhabitants, 10 % of Pucca and 30 % of Semi-Pucca houses, are supplied of water with street hydrant as well as 20 % of peoples living in Kutcha houses.

8.1.5 Water Supply Service Area

Taking account the present water distribution network status and the expected available water source in 2005, the service area after the priority project was limited within the present Chittagong WASA service area. Expansion of the service area was also be limited only for the area adjacent to existing network so that demand in the service area will be less than the capacity of available water sources.

8.1.6 Planned Water Supply Flow

The total potential water demand in the project area is estimated at 344,000 m^3/day or 76MGD. However, it is difficult to fulfill the demand due to limited time and fund. Consequently, out of total demand, the planned water supply flow in 2005 is set at about 282,000 m^3/day or 62 MGD on distribution base taking account of possible service area and available water source by the year 2005:

a)	Existing Mohara WTP:	91,000 m^3/day (20 MGD)
b)	Kalurghat IRP including a plant planned in the 2nd project (GOB):	55,000 m^3/day (12 MGD)[4]
c)	Madunaghat WTP including Italian project (1st Phase):	46,000 m^3/day (10 MGD)
d)	Expansion of Mohara WTP project planned under this Study:	91,000 m^3/day (20 MGD)
	Total	283,000 m^3/day (62 MGD)

The water supply system of the Fatehabad IRP is treated as an isolated separate system[5] for supply to

[4] Total treatment capacity of the IRP will be 20 MGD by the year 2005. However, due to shortage of water production capacity of groundwater wells, distribution capacity of the Kalurghat BPS in 2005 is set at 12 MGD.

the Cantonment and adjacent area to be developed temporarily.

Existing CWASA tube wells scattered in the MOD-I area will be abolished after the commissioning of the new distribution system, because of their poor water quality.

8.2 Design Policy (Refer to Figure 2.1)

8.2.1 Mohara WTP Expansion Plant

As stated in section 8.1.6, the Mohara WTP Expansion Project will be completed by 2005. Its production capacity is 91,000 m^3/day or 20MGD, and a total production capacity of CWASA after the project will be 282,000 m^3/d or 62 MGD.

Design policy for the Mohara WTP Expansion Project is as follows:

(1) Intake Facility

In the designing of the new plant, intake amount was set at 110% of production capacity because of no wastewater recovery system and high turbidity of wastewater, which increase sludge discharge volume from desilting basins. Consequently capacity of new intake facility is designed so as to take 110% of production capacity or 44MGD and to convey water to a receiving well (distribution chamber) to be constructed in the project. Since intake structure was constructed with room for expansion facilities, only intake pumps will be installed.

(2) Treatment Facility

Treatment method of the existing facility is high rate sludge blanket type clarifier – sand filtration system. The same treatment method will be employed in new treatment facility taking account of performance of existing plant, required cost, required land area, and ease of operation and maintenance. Design capacity of new treatment facility is 91,000 m^3/d or 20 MGD, while design flow for from intake to clarifiers is 22 MGD, 21 MGD to filters and 20MGD after that.

(3) Transmission Pump Facility

New transmission pumps will be installed so as to transmit water to the Khulshi reservoir with 900 mm dia. ductile cast iron pipe. Pumps will be operated separately from the existing ones and are controlled by water levels of the Khulshi reservoir and clearwater reservoir of the new plant. Those water levels are monitored in the central monitoring room of the new plant.

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[5] The Fatehabad system will be integrated with the distribution network system planned in the Basic Plan.

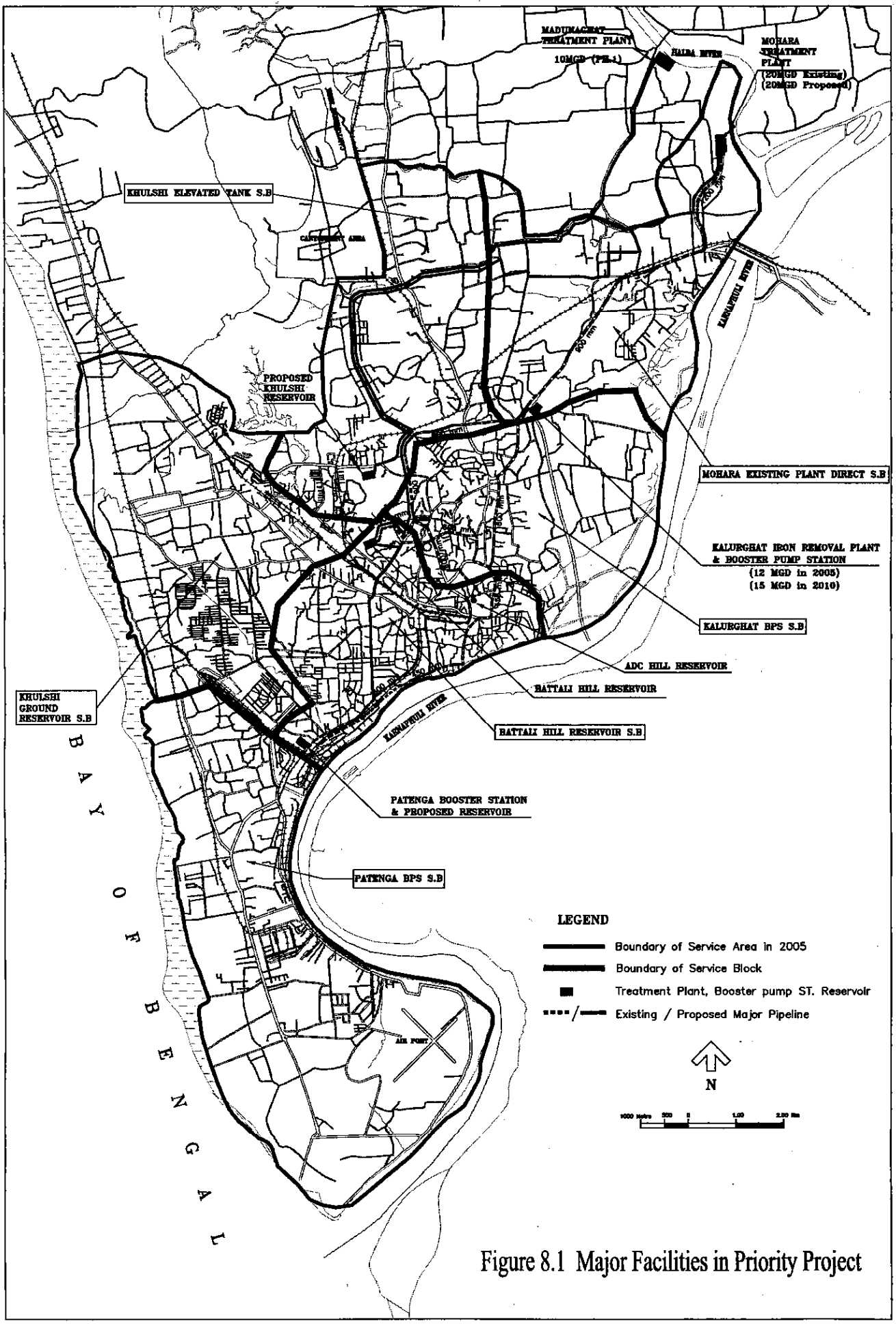

Figure 8.1 Major Facilities in Priority Project

Rehabilitation of existing facilities is concentrated on improvement of deteriorated or insufficient functioning facilities of the Mohara WTP and the Kalurghat IRP. Distribution facilities and tube wells are not included in the scope.

Rehabilitation work is divided into two scopes as follows.

Scope-1: Rehabilitation of filters to improve water quality.

Scope-2: Repair and replacement of deteriorated equipment and their accessory equipment.

8.2.2 Transmission and Distribution System

(1) Transmission Pipeline

Existing transmission pipeline from the Mohara WTP with a diameter of 1,200 mm cannot be utilized because the pressure of proposed transmission pumps will be different from that of existing one. Therefore, new transmission pipeline from the Mohara WTP shall be provided with 900 mm dia. ductile cast iron pipe. Other transmission pipeline will not be provided in the priority project.

(2) Distribution Reservoir

A new reservoir will be provided at South Khulshi Hill as stated in Chapter 7. This reservoir will cover service areas located at northern part and western part of the city. Because of difference in elevations of service areas, the western part will be supplied from a ground reservoir by gravity flow, while northern part and the Khulshi area will receive the water from elevated tank via a lift pump station, which will be constructed in the premises at Khulshi.

Through the dynamic hydraulic analysis of distribution system, it was found that the distribution reservoir of existing Kalurghat BPS (the clearwater reservoir of the IRP) does not have a sufficient capacity. Consequently, it shall be augmented. Pumping facility, however, has been augmented by the second rehabilitation project by GOB. It will have an enough capacity for planned distribution amount of 12 MGD by 2005 with replacement and augmentation of new 2 pumps.

The Battali Hill Reservoir, which is expected to receive water from Madunaghat WTP 1st phase plant and existing Mohara WTP, is presumed to be utilized as it is after proper repair work in accordance with the policy of CWASA.

Presently, the Patenga BPS does not have any water storage facility. Since it also be expected to receive water from Madunaghat WTP 1st phase plant and existing Mohara WTP, new reservoir with proper capacity shall be provided. Because of lack of present pump capacity against projected demand, pump capacity shall be augmented with new pumps.

Existing small-scale reservoirs including the ADC Hill reservoir will also be used to augment the lacking reserve capacity for existing Mohara and Kalurghat systems. Especially, isolated local small-scale reservoirs and attached lift pump stations shall be used for high-elevated isolated service area in the distribution network system.

(3) Distribution Pipeline

Existing distribution pipes shall be utilized as far as possible. Augmentation of pipeline capacity will be accomplished by providing new pipes paralleling with existing pipelines. As stated previously, extension of distribution main will not be conducted in principle because of limited water source capacity. However, installation of new distribution main at Chandgaon Thana at eastern part and Chittagong Port Thana at southern part will be conducted in order to reinforce the capacity of pipeline network.

8.3 Water Treatment Plant

8.3.1 Mohara Water Treatment Plant (Expansion Plant)

(1) General

The existing Mohara WTP was designed and constructed taking account the future expansion. The expansion plant will be constructed in the reserved land beside existing plant.

Intake facility comprised of intake mouth, intake pipe and intake pump house was constructed considering the future expansion. Therefore, additional equipment will be intake pumps only.

Treatment facilities to be provided are; a receiving well which can be used as distribution chamber, desilting basins, rapid mixing chambers, clarifiers, rapid sand filters, a clearwater reservoir, chemical dosing facilities for alum and lime, chlorination facilities, transmission pumps, and a monitoring/laboratory house. Layout of these facilities was presented in Figure 7.2.

(2) Outlines of Facilities

1) Intake Facilities

Two discharge control type pumps will be provided. Capacity of pump shall be increased comparing with existing one to secure required intake amount of 44MGD because of increased water head to new distribution chamber. Vertical shaft type pump will be adopted. New pumps shall be provided with following specifications:

42.1 m^3/min x 15.3 m x 185 kW x 2 units (incl. 1 standby unit) with inverter control

A conveyance pipeline will be installed in parallel with existing pipeline starting from existing

tee branch. Dimensions of conveyance pipe are as follows:

Diameter 900 mm x length 220 m, ductile cast iron pipe

2) Receiving Well (Distribution Chamber)

A receiving well will be provided to receive intake water for existing and new plants. This well will also act as a distribution chamber supplying raw water to desilting basins of both plants. Outline of the well is as follows;

(for Old Plant) Width 5 m x Length 5.5 m x Depth 4 m x 1 unit

(for New Plant) Width 7 m x Length 5.5 m x Depth 4 m x 1 unit

3) Desilting Basin

New desilting basins will have RC structure due to restriction of the proposed site. A traveling bridge over the basin with a sand pump will be provided for each basin to enable continuous removal of sediments. Dimensions of basins are as follows;

Width 23.0 m x Length 76.0 m x Depth 3 m (effective depth 2.5 m) x 4 units

4) Rapid Mixing Chamber

Taking account of satisfactory mixing condition and flocculation status of existing facility, same facility will be newly constructed. Dimensions are as follows:

Chamber for Lime

Width 2.29 m x Length 2.29 m x Depth 1.91 m x 1 unit

Chamber for Alum

Width 2.29 m x Length 2.29 m x Depth 1.45 m x 1 unit

5) Clarifier

Because of satisfactory treatment status in existing clarifiers, the same type of clarifiers will be provided. Dimensions of clarifiers are as follows:

7.62 m x 7.62 m (25' x 25') x 24 units

6) Filter

Taking account of present issues of the existing filters, following considerations will be reflected in the designing of new filters:

- To lessen filtration velocity, during backwashing operation, number of filters will be increased to nine.
- Surface washing pipes shall be equipped with steel or ductile cast iron pipes.[6]

[6] Existing filters employed deep filtration layer and surface washing device. However, air washing is

- To relieve the current improper washing status of filter, automated washing devices as well as improvement of the existing facility will be introduced.
- For efficient washing and supply of filter media, sand-washing equipment, sieve for grading control and reserve filter media will be provided. Dimensions of filters are as follows:

  9.14 m x 2.44 m (30' x 8') x 2 filters/unit x 9 units

7) Clearwater Reservoir

Capacity of new clearwater reservoir will be equal to the existing one, providing for accidents, such as power interruption. Following considerations will be given on design of new one;

- Two compartments of clearwater reservoir including a part of chlorination basin is needed for maintenance.
- An interconnection pipe shall be provided to connect with existing clearwater reservoir.
- Lime injection point of the existing one shall be shifted to the effluent weir of chlorination basin.
- Lime injection point of the new one shall be inlet of chlorination basin.

Dimensions of the clearwater reservoir are as follows:

Width 29.97 m x Length 39.11 m x Depth 2.88 m x 2 units

8) Chemical Dosing Facility

Design turbidity for chemical dosage is set at 350 NTU, while design maximum turbidity is set at 850 NTU. Chemical dosing facilities for the new plant will be as follows;

- Alum injection pump – 3 units
- Alum solution mixing tank – 3 units
- Lime injection pump – 3 units
- Lime solution mixing tank – 3 units

Necessity of lime injection, however, shall be further examined during project preparation stage because of high alkalinity of raw water. Though alum is also planned for the project in this study taking account of availability of chemicals and capital and O&M costs, possibility of adoption of PAC shall be examined in detailed design stage.

9) Chlorination Facility

In the planned plant, chlorination facilities shall be provided. Chlorine injection points are;

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commonly employed for thick filtration layer, and surface washing is common for thinner filtration layer. It shall be further examined in detailed design stage with regard to filtration method.

inlet of desilting basin, inlet of mixing chamber, inlet of filters, and inlet of chlorination basin. Points and rate of chlorine injection can be controlled by valve operation. Though liquid chlorine disinfection method is employed in the plan taking account of availability of chemicals and capital and O&M costs, possibility of introduction of safer disinfection method, such as sodium hypochlorite, shall be examined in D/D stage for safe of neighboring residents.

10) Transmission Pump

Total design capacity of new transmission pumps shall be 91,000 m^3/day or 20 MGD, equivalent to the existing ones. Pumps shall be operated automatically by water levels of the Khulshi reservoir and the clearwater reservoir of the new plant. Four pumps and one standby pump will be installed in a pump house together with power generators as same as existing facility. Water for in-plant use, cleaning of facilities, chemical solution, chlorine solution, and so on will be obtained by branching the transmission pipe after pressure reduction.

Based on the calculation results presuming 900 mm dia. 15.1 km long transmission pipeline to the proposed Khulshi reservoir, specifications of pumps shall be as follows;

15.8 m^3/min x 84 m x 350 kW x 5 units (incl. 1 standby unit)

11) Wastewater Discharge Facilities

Since existing sludge discharge pumps have an enough capacity to discharge wastewater from both of existing and new plants, only a wastewater basin will be provided with an interconnection pipe between both basins. Dimensions of the new basin will be as follows;

Width 9.14 m x Length 22.86 m x Avg. Depth 4.3 m

12) Central Monitoring / Laboratory Building

Since the existing central monitoring room and laboratory room are too small to handle required work for both plants, a new 2-storey building will be constructed beside of the existing administration building to house both rooms and storage.

13) Electrical / Instrumentation Equipment

A transformer with an enough capacity to cover operation of existing facilities will be installed in the new plant. Existing facilities will be operated with existing transformer in normal operation, though it will be connected with the new transformer.

A tap-changer will be attached to the new transformer to stabilize power voltage. Uninterrupted power supply devices will be provided for inter-com system, sequence controller, monitoring equipment and instrumentation devices. In addition, power generator

with diesel engine will be provided to operate whole equipment in emergency. System flow diagram for major equipment and facilities is presented in Figure 8.2.

8.3.2 Rehabilitation of Mohara Water Treatment Plant (Existing Plant)

In addition to the expansion plant work, some improvement works shall be conducted for the existing plant. Those are; introduction of automated filter washing system; replacement of filter media, purchase of reserve filter media and filter media washing machine; and replacement of an intake pump and a transmission pump.

(1) Rehabilitation of sand filter

Proposed rehabilitation plan consists of rehabilitation of filters and introduction of automated backwash process. Though required work shall be identified through precise investigation during detailed design stage, following work is prospected:

1) Replacement of filter media
2) Rehabilitation of under drain system
3) Rehabilitation of surface wash system
4) Rehabilitation for adjustment of weir level for backwash water
5) Introduction of automatic backwashing system
6) Purchase of reserve filter media and sand washing machine

Construction for rehabilitation work will be executed after commissioning of new plant so as not to stop water supply services.

(2) Repair and replacement of deteriorated equipment and their accessory equipment

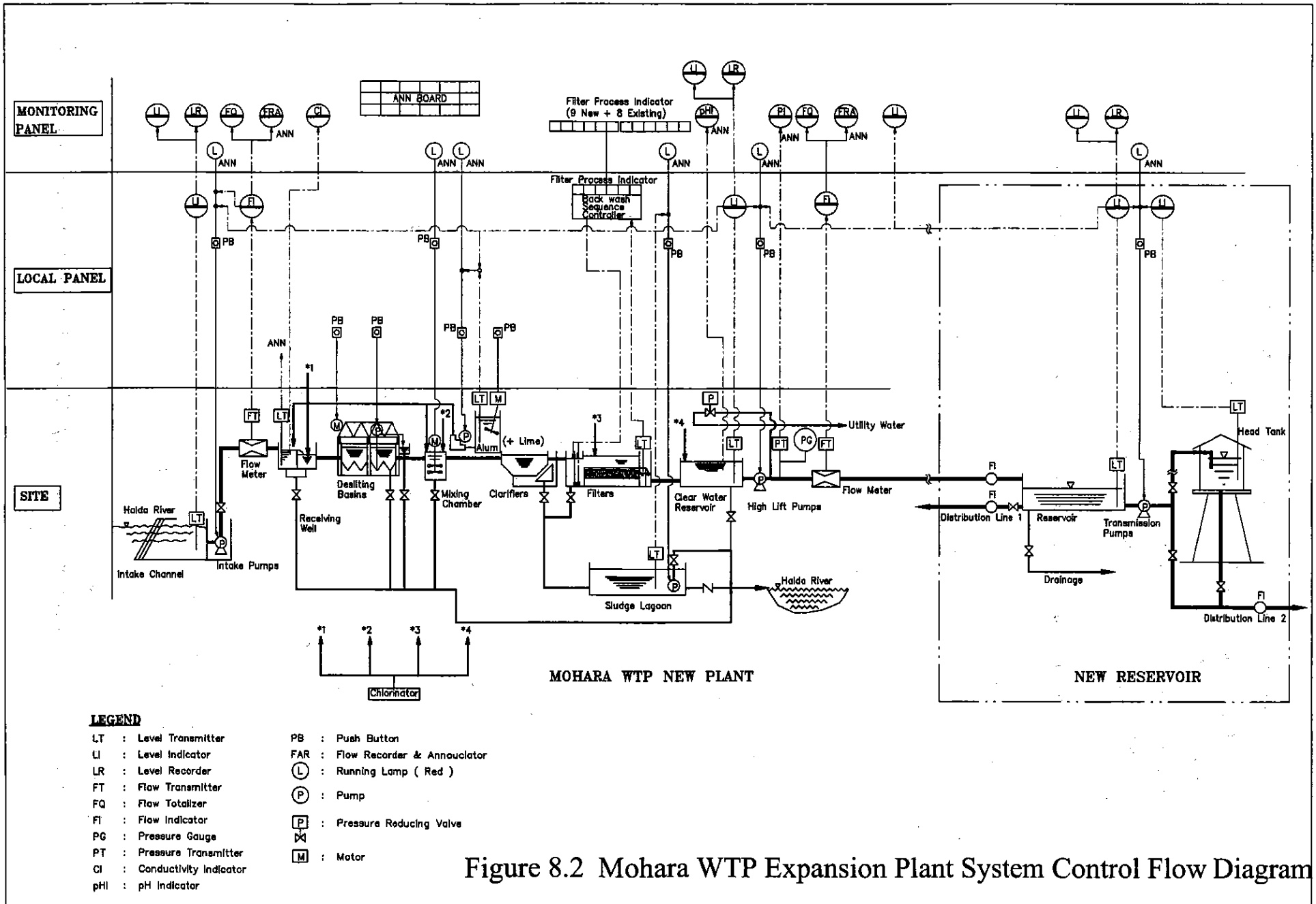
1) Alum feeding devices

In the proposed plan, new alum dosing system will be designed for 10% concentration alum solution to improve performance of the system. Items to be executed are as follows:

- Augmentation of alum solution equipment
- Augmentation of titrating pumps
- Rehabilitation of dosing pipeline

2) Intake facility

Provisional sludge removal equipment at inlet of the intake facility will be provided to dredge sediments regularly. Items to be executed are as follows:



LEGEND

LT	:	Level Transmitter	PB	:	Push Button
LI	:	Level Indicator	FAR	:	Flow Recorder & Annauciator
LR	:	Level Recorder	(L)	:	Running Lamp (Red)
FT	:	Flow Transmitter	(P)	:	Pump
FQ	:	Flow Totalizer	[P]	:	Pressure Reducing Valve
FI	:	Flow Indicator			
PG	:	Pressure Gauge	[M]	:	Motor
PT	:	Pressure Transmitter			
CI	:	Conductivity Indicator			
pHI	:	pH Indicator			

Figure 8.2 Mohara WTP Expansion Plant System Control Flow Diagram

- Provision of portable sand pumps and power outlet at the site.
- Replacement of flashing valves installed on intake pump pipeline

3) Replacement of Pumps

Frequent troubling intake pump will be replaced. In addition, cost for replacement of a transmission pump is considered in cost estimates for the project.

8.3.3 Rehabilitation of Kalurghat Iron Removal Plant and Booster Pump Station

Efficiency of iron removal facility of Kalurghat is poor and volume of the clearwater reservoir is insufficient for distribution purpose. In order to cope with such issues, following improvement work is recommended for the Kalurghat IRP:

1) Provision of Oxidation-Sedimentation Basin

To remove the oxidized iron, oxidation-sedimentation basins shall be provided. For efficient oxidization, chlorine injection is recommendable rather than aeration. Dimensions of the basin will be as follows;

Width 8.5 m x Length 18.0 m x Avg. Depth 2.5 m x 3 basins

2) Provision of Additional Reservoir

Existing clearwater reservoir shall be augmented by an additional reservoir. Required capacity was confirmed through the dynamic hydraulic analysis for 72 hours. Dimensions of the basin will be as follows;

Width 16.8 m x Length 47.6 m x Avg. Depth 2.87 m x 2 basins

3) Rehabilitation of Filters

Degree of deterioration of filters in the plant is worse than Mohara WTP, so that immediate rehabilitation work is needed. Items to be executed are as follows.

- Replacement and repair of filter media, gravel layer and under drain system
- Improvement of quantity and pressure of backwash water
- Provision of filter media washing machine
- Provision of Drainage Trough in filters
- Introduction of air-washing facility to old filters, which was once planned in the Second Water Supply Project under IDA.

4) Introduction of Power Generator

After the on-going augmentation project by GOB fund, distribution pumps will have an

enough capacity for future use. However, power generator will be provided in the project to compensate abolishment of two diesel engine driven pumps under said GOB augmentation project. Capacity of generator will be enough to operate a half of motor driven pumps.

8.4 Transmission Pipeline and Distribution Facility

8.4.1 Design Policy

In order to cope with hourly peak demand, several distribution blocks will be provided with respective distribution reservoir and distribution network.

8.4.2 Design Criteria for Pipeline

For the transmission system, average daily flow was adopted as design flow presuming provision of reservoirs. While, distribution system was designed with hourly peak flow. Peak flow rate was assumed to be 150% based on past survey results in Japan because of non-availability of reliable data in CWASA.

Required volume of distribution reservoirs, and pump capacities were obtained and verified through 72-hour dynamic hydraulic analysis of distribution network system. Minimum pressure in the network was set at 98 kPa, in general.

8.4.3 Selection of Transmission Route

Along with the expansion of the Mohara WTP, a new transmission pipeline shall be installed starting from the Mohara WTP to the proposed reservoir. Three alternatives exist for examination of appropriate transmission route. Those are; Existing Mohara transmission line (Arakan Road), Planned CDA Road, and Abdul Karim Road.

Based on the field survey and examinations on practicality and required cost, the route on Abdul Kalim Road was selected for the transmission pipeline. However, since implementation of afore-mentioned CDA planned road is on-going, its availability shall be verified at the time of implementation of the project. If it is available for the project at that time, required cost and difficulty of construction work can be lessened.

8.4.4 Proposed Water Distribution System

(1) Water Supply Service Block

Taking account availability of reservoirs and effective use of existing large diameter transmission/distribution pipelines, water produced in those plants will be distributed through distribution reservoirs as follows:

a) Mohara WTP Old Plant[7]: i) Pumped supply from clearwater reservoir
ii) Gravity-flow supply from Battali Hill reservoir and ADC Hill reservoir
iii) Pumped supply from Patenga BPS

b) Mohara WTP New Plant: Gravity-flow supply from a proposed reservoir

c) Kalurghat IRP: Pumped supply from the clearwater reservoir

d) Madunaghat WTP: Gravity-flow supply from Battali Hill reservoir (the same block with above a) ii))

Each of the areas to be served from those reservoirs forms an individual service block.

(2) Distribution Network

The network model for the distribution pipeline network hydraulic analysis was established based on the various data, record, and information in design section and MOD sections. Based on this network model, hydraulic analysis for F/S was conducted for the demand in the year 2005 for the network model.

In the network analysis, following considerations were given:

- Existing pipelines shall be utilized in the proposed network system as far as possible.
- Because of shortage of water source capacity, service area shall be limited within the present service area.
- Extension of new pipeline shall be limited except for the Chandgaon Thana and Chittagong Port Thana.
- Due to shortage of water source against water demand in 2005, coverage of secondary distribution system is assumed to be limited as discussed in Chapter 3.
- Hydraulic analysis shall be conducted on primary distribution system consisting of pipelines with a diameter of 200mm or larger. Cost for development of secondary distribution system shall be estimated separately based on the assumed area to be developed.

[7] Dhaka Trunk Road BPS may be abolished based on the results of hydraulic analysis.

As a result of above considerations, most of pipelines to be developed in the priority project is reinforcement pipelines paralleling with existing pipelines.

(3) Distribution Reservoir

By the year 2005, several reservoirs shall be developed or rehabilitated as follows:

a) Clearwater reservoir of Mohara WTP Old Plant

Capacity of the existing clearwater reservoir of the old plant is enough for planned distribution system. Existing transmission pumps has enough capacity for planned supply system.

b) Battali Hill Reservoir

Physical soundness of the Battali Hill reservoir is under examination. In accordance with the policy of CWASA, however, it is assumed that the Battali Hill reservoir is used as a distribution reservoir receiving water transmitted from the Madunaghat WTP 1st phase and excess of transmitted water from the existing Mohara WTP.

c) ADC Hill Reservoir

Since capacity of the reservoir is not enough to serve the adjacent area fully, it will work as a supplemental water supply source during water demand peak hours.

d) Kalurghat BPS

The Kalurghat BPS is attached to the IRP. Since the capacity of the existing clearwater reservoir is not enough for the planned distribution system, augmentation of the reservoir with a capacity of about 4,200 m^3 is needed. Capacity of existing pumps is enough for planned distribution in 2005.

e) Patenga BPS

New distribution pumps shall be provided at the Patenga BPS to augment present pumping capacity. In addition, a ground distribution reservoir receiving transmitted water from the existing Mohara WTP and Madunaghat WTP 1st phase with a capacity of 12,000[8] m^3 shall be provided. Capacity of new distribution pumps to be added to existing pumps will be as follows:

14.7 m^3/min x 37 m x 132 kW x 3 units (incl. 1 stand-by)

[8] This capacity shall be increased in Phase 2 to cope with increased demand.

f) Khulshi Reservoir

Water transmitted from the Mohara WTP new plant will be received by a ground reservoir. A part of water will be distributed from the ground reservoir directly. Remaining water will be lifted up to an elevated tank by lift pumps, and then distributed to the service area.

Transmission pipeline to the Dhaka Trunk Road BPS will be connected with the proposed ground reservoir. Since water can reach to the end of northward pipeline in Sitakunda Thana, operation of the Dhaka Trunk Road BPS may be ceased.

Following facilities will be provided at the Khulshi reservoir site.

Ground Reservoir: 13,300 m^3

Lift Pump: 30m x 10 m^3/min x 90 kW x 4 units (incl. 1 stand-by unit)

Elevated Tank: dia. 25m x 8mD x 25mH (bottom)

(3) Small Diameter Distribution Pipelines

In addition to the primary distribution system, the distribution pipeline network identified in the hydraulic analysis, secondary distribution system, i.e. small diameter distribution pipelines consisting of pipelines with a diameter of 200 mm or less, shall be developed to transfer water from primary distribution system to consumers. Those pipelines have been installed by CWASA through its history. In the central area of the city, such pipelines were already installed except for minor roads. In the future, it will be installed at the time of developing of residential area, commercial area, and industrial area. In the priority project, costs for them were estimated only for the area identified by CWASA to be developed immediately to solve water shortage.

8.5 Operation of Mohara WTP Expansion Plant

Equipment and facilities as shown in Figure 8.1 will be provided in the Mohara WTP expansion plant. Operation of those equipment and facilities will be conducted as follows:

(1) Intake Pumps

Intake pumps will be controlled by inverter control device to stabilize the intake quantity against fluctuation of water level in Halda River.

(2) Desilting Basins

Sand pumps installed on traveling bridges over desilting basins will remove settled sludge in the basins continuously.

(3) Clarifiers

Sludge control will be carried out by manual valve operation as same as the existing facility.

(4) Filters

A sequence controller will control filter-washing process. Operation will be monitored at a central monitoring room. Washing will be started at the condition of; i) filtration time, ii) water level in filter, and iii) judgment of operator.

(5) Transmission Pumps

Transmission pumps will be controlled based on water levels of clearwater reservoirs and the Khulshi reservoir. Operational status of pumps, water levels of reservoirs will be monitored at the central monitoring room.

(6) Central Monitoring Board

A graphic panel will be installed on the Central Monitoring Board. It indicates operational status of pumps, warning of failure, and recorders of water level, pressure, and current and cumulated flow of intake and transmission, will be equipped on a instrumentation panel.

(7) Local Control Panels

Local control panels of respective equipment will be located at site.

(8) Khulshi Reservoir

Lift pumps will be operated based on water levels of the ground reservoir and the elevated tank. Water levels and operational status of pumps will be monitored at the Khulshi reservoir and the central monitoring room at the Mohara WTP. For that purpose, signal transmission cable will be installed together with transmission pipeline.

(9) Patenga BPS and Reservoir

Distribution pumps will be controlled in accordance with fluctuation pattern of water consumption. It will stop at LWL of the reservoir. A float valve or an altitude valve will control water inflow at HWL of reservoir, automatically.

8.6 Summary of Proposed Facilities

Proposed facilities in the Priority Project are summarized in Table 8.1. Locations of proposed facilities and transmission pipelines are illustrated in Figure 8.1. Main transmission and distribution pipelines to be installed in the project are shown in Figure 8.3.

8.7 Project Cost

The total cost of the proposed priority project is estimated at US$ 94 million without price contingency, and US$ 99 million with it as presented in Table 8.2.

Table 8.1 Proposed Facilities of Priority Project

Facilities	Diameter (mm)	Material	Quantity
1 Mohara WTP New Plant Service Area			
WTP Treatment Plant 20MGD			20 MGD
Transmission Pump 15.8m3/min x 84 m x 350 kW x 4 (+1)units			5 units
Transmission Pipeline	900	DCIP	15,045 m
2 Khulshi Distribution Reservoir Service Area			
Khulshi Distribution Reservoir			
Ground 2,800m2 x 7mD (35m-28m)			19,600 m3
Lift Pump 13.1m3/min x 25m x 90kW x 3 (+1)units			4 units
Elevated dia. 18m x 7mD (52m-45m) x 16mH (LWL)			1,780 m3
Distribution Pipeline	1000-200	DCIP/PVC	20,985 m
3 Mohara WTP Old Plant Service Area			
WTP Rehabilitation Work (Filters, Intake/Transmission Pumps)			1 L.S.
Distribution Pipeline	600-300	DCIP/PVC	20 m
4 Kalurghat BPS Service Area			
IRP Rehabilitation Work (Filters, Power Generator)			1 L.S.
Clearwater Reservoir (add.)			
Ground 1,470m2 x 2.87mD (3.33m-0.46m)		exist. 2,940 m2	1,470 m2
		(8,440 m3)	(4,220 m3)
Distribution Pipeline	600-200	DCIP/PVC	7,150 m
5 Battali Hill Reservoir Service Area			
Distribution Pipeline	800-200	DCIP/PVC	5,505 m
6 Patenga BPS Service Area			
Patenga Distribution Reservoir			
Ground 2,000 m2 x 6mD (7m-1m)			12,000 m3
Dist. Pump 19.2m3/min x 37m x 200kW x 2 (+1)units			3 units
Distribution Pipeline	900-200	DCIP/PVC	14,630 m
7 Secondary (Small Dia.) Distribution Pipelines			
Small Diameter Pipelines	200-100	PVC	1 L.S.
8 Staff Quarters and Zone Offices			
Staff Quarters	100m2		40 flats
Zone Offices	800m2		5 offices
Summary of Facilities to be Developed			
Water Treatment Plants			1 plant
Capacity of WTPs			20 MGD
Pump Stations			3 stations
Number of pump units			12 units
Reservoirs*			
Ground Reservoir			3 reservoirs
total capacity			35,820 m3
Elevated Tank			1 tank
total capacity			1,780 m3
Pipelines**			63,335 m
Transmission Pipeline Total Length			15,045 m
Ditribution Pipeline Total Length			48,290 m

Note: Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Clearwater reservoirs in WTP are not included.

**: Pipeline Length does not include secondary distribution (small dia.) pipeline network.

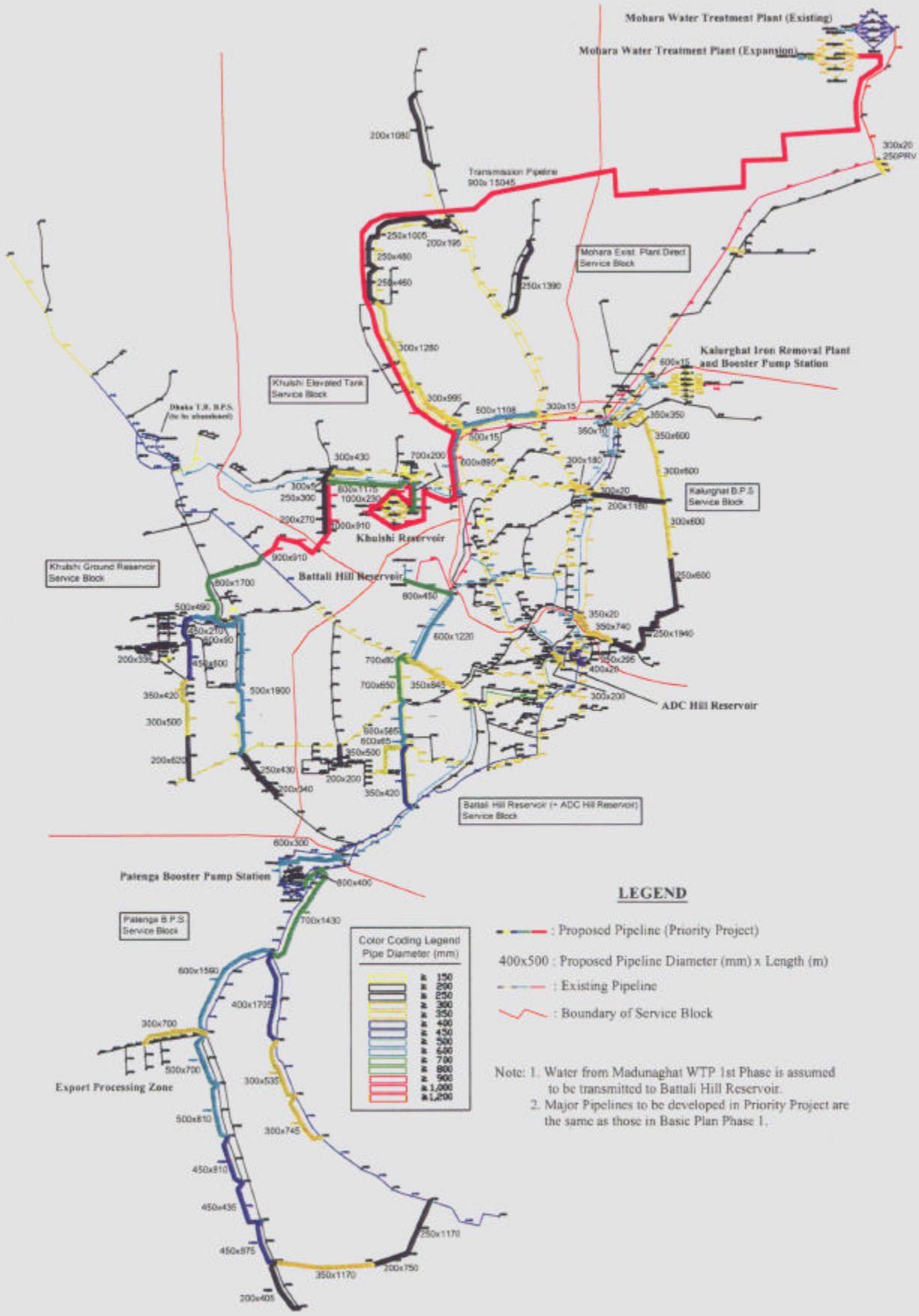


Figure 8.3 Proposed Pipeline Network for Priority Project

Table 8.2 Cost Estimates for Priority Project

(unit: US$)

Facilities	Priority Project		
	Local	**Foreign**	**Total**
I. Direct Construction Cost			
1. Treatment Plant			
Mohara WTP Expansion Plant, Transmission Pumps	5,535,000	9,633,000	15,168,000
Mohara WTP Rehabilitation Work	355,000	2,275,000	2,630,000
Kalurghat IRP Rehabilitation Work, Reservoir	643,000	1,393,000	2,036,000
2. Distribution Reservoir and BPS			
Khulshi Distribution Reservoir, Pumps, Tank	3,031,000	2,151,000	5,182,000
Patenga Distribution Reservoir	1,381,000	2,331,000	3,712,000
3. Transmission / Distribution Pipeline			
Transmission Pipeline DCIP 900mm x 15,045m	1,049,000	4,224,000	5,273,000
Main Distribution Pipeline	2,315,000	5,584,000	7,899,000
4. Small Size Distribution Pipelines	1,986,000	2,861,000	4,847,000
5. Staff Quarters and Zone Offices	1,480,000	0	1,480,000
Total of Direct Construction cost	**17,775,000**	**30,452,000**	**48,227,000**
II. Overhead and Profit	**791,000**	**10,475,000**	**11,266,000**
III. Procurement of Equipment	**0**	**704,000**	**704,000**
IV. Administration			
1. CWASA Administration Cost	**128,000**	**0**	**128,000**
2. Land Acquisition Cost	**3,370,000**	**0**	**3,370,000**
V. Duties, Taxes, and Charges	**16,316,000**	**0**	**16,316,000**
VI. Engineering Cost			
1. D/D + C/S	782,000	4,022,000	4,804,000
2. VAT for Engineering Cost (5.25%)	252,000	0	252,000
Total of Engineering Cost	**1,034,000**	**4,022,000**	**5,056,000**
VII. Contingencies			
1. Physical Contingency (10% of I+II+III+IV+V+VI)	**3,941,000**	**4,565,000**	**8,506,000**
2. Price Contingency (LCP:0.7%p.a.,FCP:2%p.a.)	**1,376,000**	**4,129,000**	**5,505,000**
VIII. Total Project Cost excluding Price Contingency	**43,355,000**	**50,218,000**	**93,573,000**
Total Project Cost including Price Contingency	**44,731,000**	**54,347,000**	**99,078,000**

Note: Costs for Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Costs for Distribution Pipeline in Kalurghat S.A includes all distribution pipelines outside of Khulshi S.A.

8.8 Implementation Schedule

The implementation schedule of the priority project was planned so as to complete the Mohara WTP expansion plant by the end of 2005, which is the target year of the feasibility study. However, full operation of the Mohara WTP with a capacity of 40MGD will be materialized in latter half of 2006 because the rehabilitation work of existing Mohara WTP shall be carried out after operation of new plant to secure continuous water supply of 20MGD. A bar chart showing the schedule is presented on Figure 8.4. Table 8.3 presents a disbursement schedule with breakdown by foreign and local currency portions

8.9 Considerations for Implementation

Following considerations shall be given for implementation of the project:

(1) Route of Transmission Pipeline

The route of the transmission pipeline from the Mohara WTP expansion plant is desirable to be the CDA Planned Road. It was judged that adoption of the CDA road route is difficult from viewpoint of timing. However, at the time of implementation of pipeline work, if use of the CDA road is possible, it shall be shifted on this route because of less cost and less difficulty in construction work.

(2) Equipment

Mechanical and electrical equipment shall be specified to enable repair work on them in local. They shall be specified to endure local condition of high humid and high temperature. It is desirable to avoid use of complicated mechanical and electrical equipment.

(3) Rehabilitation Work

Rehabilitation works of existing Mohara plant shall be conducted after completion of expansion plant. Rehabilitation works of Kalurghat IRP should also be conducted upon completion of new 5MGD capacity filters.

(4) New Reservoir

New reservoir for receiving water from the Mohara WTP expansion plant was planned at Khulshi. Land acquisition procedure for the site shall be conducted as soon as possible, as well as for the site of Patenga reservoir. If land acquisition is difficult, it is desirable to re-consider applicability of plans with Battali Hill Reservoir Re-construction to lessen the cost.

Figure 8.4 Implementation Schedule of Priority Project

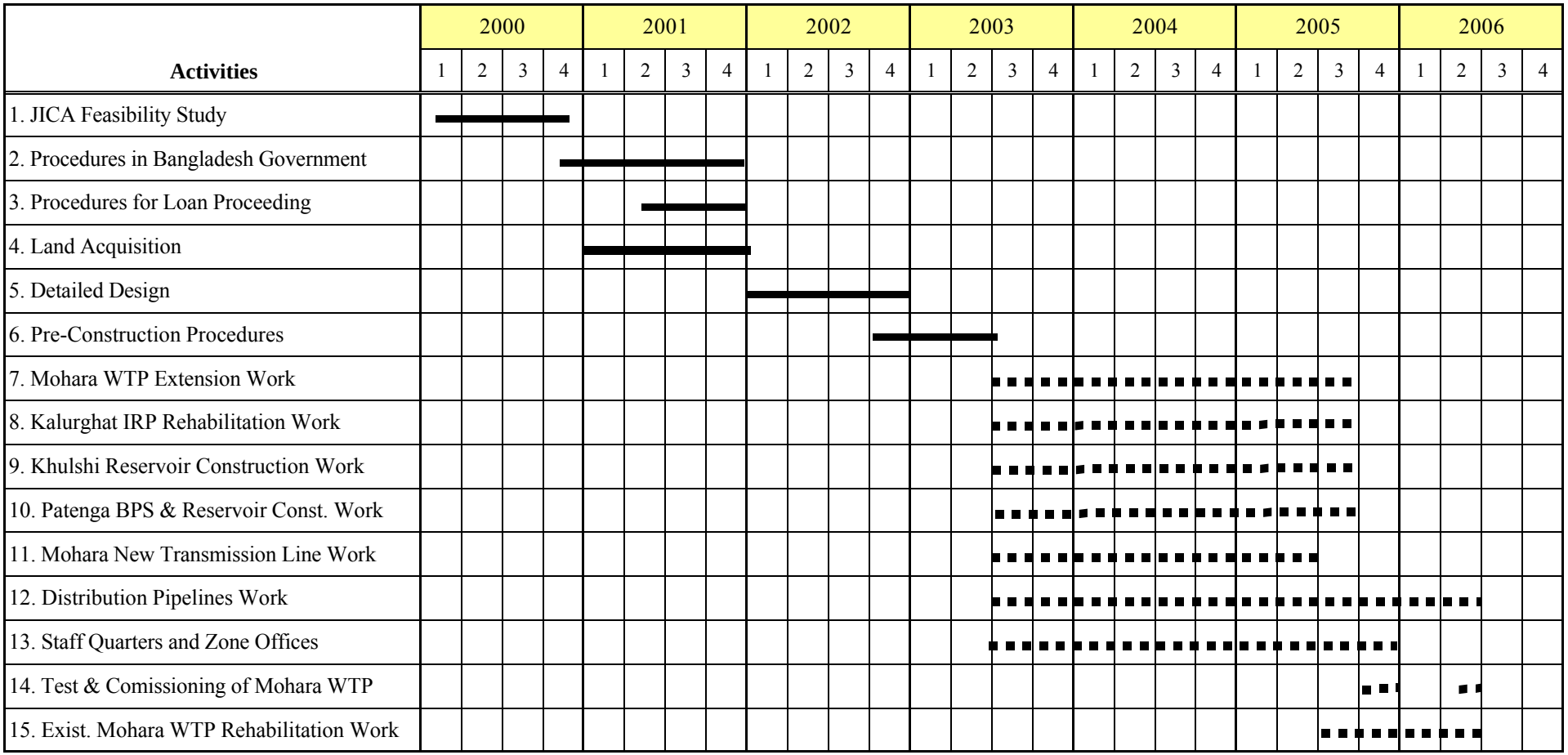


Table 8.3 Disbursement Schedule of Priority Project

(unit: US$)

Facilities	Priority Project Total			2001			2002			2003			2004			2005			2006		
	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
I. Direct Construction Cost																					
1. Mohara WTP New Plant Service Area																					
WTP Treatment Plant 20MGD, Trans. Pump	5,535,000	9,633,000	15,168,000	0	0	0	0	0	0	1,107,000	1,927,000	3,034,000	2,214,000	3,853,000	6,067,000	2,214,000	3,853,000	6,067,000	0	0	0
Transmission Pipeline DCIP 900mm x 15,045m	1,049,000	4,224,000	5,273,000	0	0	0	0	0	0	210,000	845,000	1,055,000	420,000	1,690,000	2,110,000	420,000	1,689,000	2,109,000	0	0	0
2. Khulshi Distribution Reservoir Service Area																					
Khulshi Distribution Reservoir, Pump, E..Tank	3,031,000	2,151,000	5,182,000	0	0	0	0	0	0	606,000	430,000	1,036,000	1,212,000	860,000	2,072,000	1,212,000	861,000	2,073,000	0	0	0
Distribution Pipeline	1,272,000	2,851,000	4,123,000	0	0	0	0	0	0	127,000	285,000	412,000	509,000	1,140,000	1,649,000	509,000	1,140,000	1,649,000	128,000	286,000	414,000
3. Mohara WTP Old Plant Service Area																					
WTP Rehabilitation Work	355,000	2,275,000	2,630,000	0	0	0	0	0	0	0	0	0	0	0	0	178,000	1,138,000	1,316,000	177,000	1,138,000	1,315,000
Distribution Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Kalurghat BPS Service Area																					
IRP Rehabilitation Work, Clearwater Reservoir	643,000	1,393,000	2,036,000	0	0	0	0	0	0	129,000	279,000	408,000	257,000	557,000	814,000	257,000	557,000	814,000	0	0	0
Distribution Pipeline (outside of Khulshi S.A. *)	1,272,000	2,851,000	4,123,000	0	0	0	0	0	0	127,000	285,000	412,000	509,000	1,140,000	1,649,000	509,000	1,140,000	1,649,000	127,000	286,000	413,000
5. Battali Hill Reservoir Service Area																					
Distribution Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Patenga BPS Service Area																					
Patenga Distribution Reservoir, Pump	1,381,000	2,331,000	3,712,000	0	0	0	0	0	0	276,000	466,000	742,000	552,000	932,000	1,484,000	553,000	933,000	1,486,000	0	0	0
Distribution Pipeline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Small Size Distribution Pipelines	1,986,000	2,861,000	4,847,000	0	0	0	0	0	0	199,000	286,000	485,000	794,000	1,144,000	1,938,000	794,000	1,144,000	1,938,000	199,000	287,000	486,000
8. Staff Quarters and Zone Offices	1,480,000	0	1,480,000	0	0	0	0	0	0	592,000	0	592,000	592,000	0	592,000	296,000	0	296,000	0	0	0
Total of Direct Construction Cost	**18,004,000**	**30,570,000**	**48,574,000**	**0**	**0**	**0**	**0**	**0**	**0**	**3,373,000**	**4,803,000**	**8,176,000**	**7,059,000**	**11,316,000**	**18,375,000**	**6,942,000**	**12,455,000**	**19,397,000**	**631,000**	**1,997,000**	**2,628,000**
II. Overhead and Profit																					
1. OH and Profit for ICB (25% of 1, 2, 3, 4, 5 and 6)	0	10,475,000	10,475,000	0	0	0	0	0	0	646,000	1,129,000	1,775,000	1,418,000	2,543,000	3,961,000	1,463,000	2,828,000	4,291,000	108,000	428,000	536,000
2. OH and Profit for LCB (12.5% of 7 and 8)	791,000	0	791,000	0	0	0	0	0	0	99,000	36,000	135,000	173,000	143,000	316,000	136,000	143,000	279,000	24,000	36,000	60,000
Total of Overhead and Profit	**791,000**	**10,475,000**	**11,266,000**	**0**	**0**	**0**	**0**	**0**	**0**	**745,000**	**1,165,000**	**1,910,000**	**1,591,000**	**2,686,000**	**4,277,000**	**1,599,000**	**2,971,000**	**4,570,000**	**132,000**	**464,000**	**596,000**
III. Procurement of Equipment	**0**	**704,000**	**704,000**	**0**	**0**	**0**	**0**	**106,000**	**106,000**	**0**	**598,000**	**598,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
IV. Administration																					
1. CWASA Administration Cost	**128,000**	**0**	**128,000**	**13,000**	**0**	**13,000**	**13,000**	**0**	**13,000**	**26,000**	**0**	**26,000**	**32,000**	**0**	**32,000**	**32,000**	**0**	**32,000**	**12,000**	**0**	**12,000**
2. Land Acquisition Cost	**3,370,000**	**0**	**3,370,000**	**2,696,000**	**0**	**2,696,000**	**674,000**	**0**	**674,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
V. Duties, Taxes, and Charges																					
1. Custom Duty and Other Import Charges	9,907,000	0	9,907,000	0	0	0	52,000	0	52,000	1,061,000	0	1,061,000	2,868,000	0	2,868,000	5,066,000	0	5,066,000	861,000	0	861,000
2. VAT for Civil Work (4.5%)	1,321,000	0	1,321,000	0	0	0	0	0	0	222,000	0	222,000	500,000	0	500,000	528,000	0	528,000	70,000	0	70,000
3. VAT for M&E Equipment	4,842,000	0	4,842,000	0	0	0	22,000	0	22,000	502,000	0	502,000	1,408,000	0	1,408,000	2,488,000	0	2,488,000	422,000	0	422,000
4. Pre-Shipment Inspection Fee	246,000	0	246,000	0	0	0	1,000	0	1,000	25,000	0	25,000	72,000	0	72,000	127,000	0	127,000	22,000	0	22,000
Total of Duties, Taxes, and Charges	**16,316,000**	**0**	**16,316,000**	**0**	**0**	**0**	**75,000**	**0**	**75,000**	**1,810,000**	**0**	**1,810,000**	**4,848,000**	**0**	**4,848,000**	**8,209,000**	**0**	**8,209,000**	**1,375,000**	**0**	**1,375,000**
VI. Engineering Cost																					
1. D/D + C/S	782,000	4,022,000	4,804,000	0	0	0	321,000	1,782,000	2,103,000	115,000	529,000	644,000	142,000	633,000	775,000	145,000	732,000	877,000	59,000	346,000	405,000
2. VAT for Engineering Cost (5.25%)	252,000	0	252,000	0	0	0	110,000	0	110,000	34,000	0	34,000	41,000	0	41,000	46,000	0	46,000	21,000	0	21,000
Total of Engineering Cost	**1,034,000**	**4,022,000**	**5,056,000**	**0**	**0**	**0**	**431,000**	**1,782,000**	**2,213,000**	**149,000**	**529,000**	**678,000**	**183,000**	**633,000**	**816,000**	**191,000**	**732,000**	**923,000**	**80,000**	**346,000**	**426,000**
VII. Contingencies																					
1. Physical Contingency (10% of I+II+III+IV+V+VI)	**3,941,000**	**4,565,000**	**8,506,000**	**271,000**	**0**	**271,000**	**119,000**	**189,000**	**308,000**	**610,000**	**710,000**	**1,320,000**	**1,371,000**	**1,464,000**	**2,835,000**	**1,697,000**	**1,616,000**	**3,313,000**	**223,000**	**281,000**	**504,000**
2. Price Contingency (LCP:0.7%p.a.,FCP:2%p.a.)	**1,376,000**	**4,129,000**	**5,505,000**	**21,000**	**0**	**21,000**	**18,000**	**84,000**	**102,000**	**142,000**	**478,000**	**620,000**	**427,000**	**1,327,000**	**1,754,000**	**663,000**	**1,850,000**	**2,513,000**	**105,000**	**390,000**	**495,000**
VIII. Total Project Cost excluding Price Contingency	**43,355,000**	**50,218,000**	**93,573,000**	**2,980,000**	**0**	**2,980,000**	**1,312,000**	**2,077,000**	**3,389,000**	**6,713,000**	**7,805,000**	**14,518,000**	**15,084,000**	**16,099,000**	**31,183,000**	**18,670,000**	**17,774,000**	**36,444,000**	**2,453,000**	**3,088,000**	**5,541,000**
Total Project Cost including Price Contingency	**44,731,000**	**54,347,000**	**99,078,000**	**3,001,000**	**0**	**3,001,000**	**1,330,000**	**2,161,000**	**3,491,000**	**6,855,000**	**8,283,000**	**15,138,000**	**15,511,000**	**17,426,000**	**32,937,000**	**19,333,000**	**19,624,000**	**38,957,000**	**2,558,000**	**3,478,000**	**6,036,000**

Note: Costs for Madunaghat WTP 1st phase, its transmission pipeline to Battali Hill Reservoir, Fatehabad IRP and wells are considered as existing facilities.

*: Costs for Distribution Pipeline in Kalurghat S.A includes all distribution pipelines outside of Khulshi S.A.

(5) Battali Hill Reservoir

The priority project was planned presuming the existing Battali Hill will be used after proper repair work in accordance with the policy of CWASA. If this presumption became in vain after final decision of CWASA, proposed distribution system shall be re-considered to cope with the final decision. Even in that case, the distribution system in the service block of Khulshi reservoir will be effective, because it is separated from service blocks of existing facilities. However, it is desirable to conduct analysis on whole distribution system to establish an effective and economical distribution system in Chittagong water supply system.

CHAPTER 9

OPERATION AND MAINTENANCE PLAN

CHAPTER 9 OPERATION AND MAINTENANCE PLAN

9.1 Proposed Organization of Mohara Treatment Plant

The Mohara water treatment plant has been operated 24-hours mainly by members of CWASA staff. The organization is made up of Executive Engineer, Assistant Engineers, office workers, operators, laborers and securities.

The proposed organization structure is shown in Figure 9.1, which is divided to tow divisions, the engineers to operate existing plant and to operate new plant will be supervised by the Executive Engineer. The arrangement of staff requires total of 145 staffs to operate the whole treatment plant including security.

9.2 Work Plan for Operation of Treatment Plant

New water treatment plant will be constructed beside the existing water treatment plant. All information regarding performance of the system will be gathered to monitoring panel in the monitoring room from each measurement devices, such as water level, water flow, operational status of motors, as well as indication of filter backwash status.

Existing water quality analytical room will be moved and integrated to new laboratory room located next to new monitoring room.

9.2.1 Backwashing of Filter

Hydraulically gravity flow with free water board is adopted as structure of the sand filler. Filtration rate is about 250m per day, with which filter layer remove fine floc and suspended substance mixed with the supernatant from the clarifies.

Floc and suspended substance are removed mostly near the surface of the filter layer, if the size of them is small or fine, they intrude into deeper layer.

If filter back wash system is insufficient, filter problems such as quick rising of water level by clogging of filter bed, and growing of mud-ball will occur, and crack of the filter bed will provide breakthrough of water, then water quality of filtered water will be deteriorated.

Once such problem occurs, back wash process is not functioned well, and filter cleaning is needed to return to normal filter layer condition to maintain porosity of filter bed.

To execute the filter back wash process effectively, the proposed system employs back wash system with pressurized filtered water from other filters and fixed surface wash system with pressurized treated water. The back wash process is started by pressing start button manually, or automatically started by timer or when the water level on filter bed reaches to high level. Backwashing and surface washing periods will be set for about 8 and 15 minutes by timer to secure sufficient wash out effect.

After a long period of operation, filter system may have some problems. For examples, filter layer will be dirty gradually, a part of filter sand will be washed away and layer depth will be decreased, interface between filter sand layer and gravel layer will be irregular, under drain system will be broken, surface wash facility will be broken so on.

To maintain proper effect of back wash it is required that the following operational data and conditions always be monitored. Refer the Main Report for each item in detail.

(1) State of Operation
(2) Filter media
(3) Rehabilitation of filter media
(4) Determination for backwash
(5) Determination for rehabilitation / cleaning

9.2.2 Production Plan Aiming at Daily Consumption

After completion of new plant, total water supply capacity including being implemented Madunaghat WTP will be increased to about double of present capacity. However, capacity of water distribution system is not sufficient to distribute such volume of water.

Therefore, reinforcement and expansion of small diameter distribution network is requisite, though most of it is out of scope of the project because it requires high cost and long construction period. It is desirable to be implemented in accordance with the progress of the project as far as possible.

For the time being, control of water production is important to meet actual water demand. It is desirable that operation of the plant be in stable condition to keep proper water quality. For this reason, water production schedule must be established. Methodology of water production control will be presented and trained by Consultants during commissioning period of the new plant.

9.3 Work Items of Maintenance

(1) Inspection and examination of facilities

During long operation period, equipment and facilities have problems, such as deterioration of efficiency, failure of equipment, breakage of facilities, even though they have been functioning at that time. Schedule of repair and rehabilitation shall be planned based on data and observation results obtained through following regular maintenance and inspection work. Refer the Main Report for details.

1) Daily inspection (about 3 times a day):
2) Periodical inspection (once a week / a month / 3 months / 6months):
3) Middle-term inspection (once a year):
4) Long-term inspection (once every 3 years or longer interval):
5) Emergency inspection (as needed):

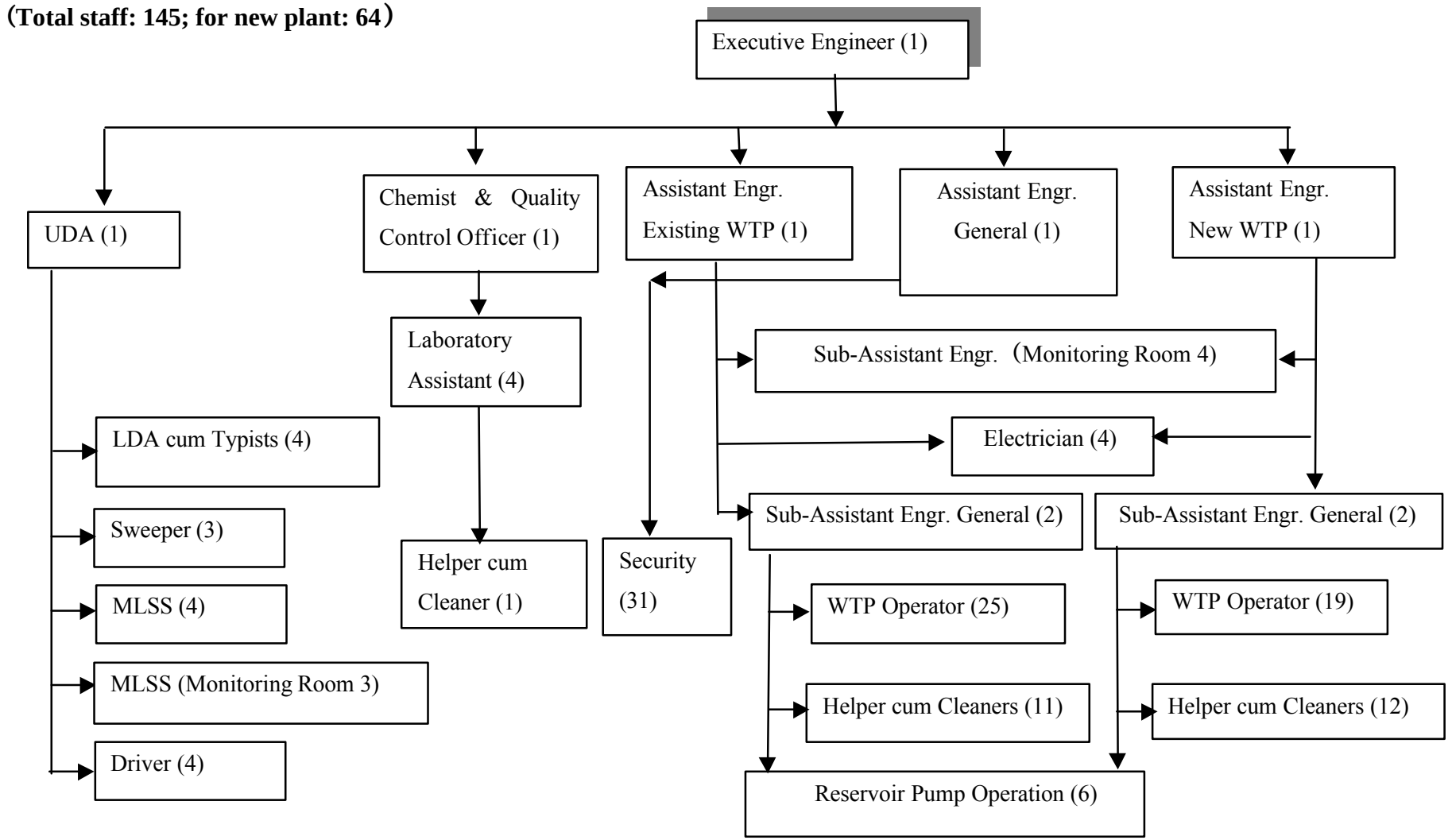
(2) Repair and maintenance

1) Daily (about 3 times a day):
2) Periodical (once a week / a month / 3 months / 6months):
3) Middle-term (once a year):
4) Long-term (once every 3 years or longer interval):
5) Emergency (as needed)

(3) Data recording

1) Daily (about 3 times a day):
2) Periodical (once a week / a month):
3) Middle-term (once a year):

Figure 9.1 MOHARA W.T.P. OPERATION & MAINTENANCE ORGANIZATION



CHAPTER 10

FINANCIAL ANALYSIS

CHAPTER 10 FINANCIAL ANALYSIS

Financial issues to be discussed for the implementation of the project are summarized into three items; 1) Securing of financial source, 2) Establishment of appropriate rate structure, and 3) Influence on the financial situation of water supply authority.

10.1 Assumed Financial Source

Because of distressed financial status of the central government and CWASA, it is difficult to invest required investment cost from local fund. Consequently, financial assistance from international financing authorities and foreign governments is requisite for the implementation of the project.

Financial assistance to CWASA is conducted through the central government, and CWASA has obligation to amortize principal and interest to the government. Financial assistance from foreign governments and international lending agencies are also provided to CWASA through the central government as sublease with same loan condition. However, obligations for amortization of principal and interest is exempted for grant aid.

Soft loan by the Japan Bank for International Cooperation (JBIC) was assumed as the financial source in this financial study. The funding conditions were assumed as shown in Table 10.1.

Table 10.1 Type of Fund and Condition

Source	Source rate	Assumed Conditions
Local Loan (GOB)	25 %	Period: 30 years Interest rate: 7.5 % Grace period: 10 years
Foreign Loan (JBIC)	75 %	Period: 30 years Interest rate: 1 % (sublease rate: 7.5 %) Grace period: 10 year
Grant	Given a grant for construction of main facility for WTP, transmission pipeline and a reservoir.	

10.2 Financial Analysis

Financial analysis was conducted by discounted cash flow method. Financial Internal Rate of Return (FIRR) is presented as a discount rate that makes Net Present Value (NPV) zero. NPV is calculated for the balance of revenue and cost in the cash flow. Benefit and Cost ratio (B/C ratio) is the ratio of the benefit to cost.

Financial analysis is conducted under following procedure:

(1) Assumption for revenue (income):

water production, water rate, ratio of accounted-for water, water rate collection efficiency, increase of consumers

(2) Assumption for cost (expenditures):

construction cost, operation cost, remuneration, maintenance cost, depreciation, amortization

(3) Analysis:

calculation of FIRR, NPV, and B/C ratio, sensitivity analysis, profit & loss statement, net cash flow

10.2.1 Assumption for Financial Analysis

Principal assumptions for the financial analysis are as follows:

(1) Cash Receipt

Revenue is derived by following formula:

Annual Revenue = Water production volume x Accounted-for Water x Water tariff rate x Collection ratio x Increase of consumers

1) Water production volume

Water production volume is assumed to be 91,000 m^3/day.

2) Accounted-for Water

Current Unaccounted-for Water (UFW) ratio is estimated to be 30 % to 35 %. UFW was assumed to be reduced toward future. Based on the assumption of the Basic Plan, UFW was assumed to be improved to 25 % in 2005, 22 % in 2010 and 20 % in 2025 gradually.

3) Water tariff rate

(Weighted average unit Tariff)

= (Tk 4.06/m^3 x 0.74 for domestic) + (Tk 11.35/m^3 x 0.26 for non-domestic)

= Tk 5.96/m^3, say Tk 6.0/m^3

4) Collection ratio

The future collection ratio was set at 91 % as same as present average collection ratio during past five years.

5) Distribution progress/Increase of consumers

Water sales ratio against production after completion of the project, which is expected in 2005, was expected to be 70 % in 2005 and increased to 100 % in 2010 provided that extension and expansion of secondary distribution network are carried out on schedule.

(2) Cash Disbursement

1) Construction cost

The sum of construction cost is US$ 96 million*, which is quoted from Chapter 8.

(*: A part of contingencies was reducted.)

2) O&M cost

(a) Power Cost:

It was assumed that power cost for existing wells might be reduced due to shift of water source after completion of the project.

i) Based on the past record of the MWTP in 1999, power cost of the Mohara WTP expansion plant was estimated to be Tk 32,216,090 /year.

ii) Annual power cost for existing wells in MOD-I area was Tk 13,165,928 /year.

Thus, increase of power cost will be:

Tk 32,216,090 /year - Tk 13,165,928 /year = Tk 19,050,162 /year

Consequently, US$ 353,000 /year was applied for the analysis.

(b) Chemical cost

Based on the past record of the MWTP in 1999, chemical cost of the Mohara WTP expansion plant was estimated to be Tk 10,100,000 /year. Consequently, US$ 187,000 /year was applied for the analysis.

(c) Remuneration

Based on the past record of the MWTP in 1997, Remuneration of CWASA was Tk 51.28 million /year for its 750 employees. Number of staff members of existing MWTP and MOD-I district office is 262. As shown in Figure 9.1, increase of staff members for the MWTP Expansion plant will be 64, and other operation and maintenance staff is required for distribution facilities. In addition administrative staff should also be enhanced to cope increase of service connection. On the other hand, shift of staff members due to change of water source in the future is also expected. Taking account of those situations, a half number of staff, which is equivalent to 18% of total CWASA's employee, is assumed as the required number of staff members for the operation of facilities constructed in the project. Thus, required remuneration for the project was assumed to be US$ 171,000 /year.

(d) Maintenance cost

Annual cost for maintenance of equipment is estimated to be 0.3% of capital cost for equipment.

Consequently, operation and maintenance cost for the project is assumed to be US$ 765,000 per year as summarized in Table 10.2.

Table 10.2 Operation and Maintenance Cost

Item	Cost (US$ per annum)
Power cost	353,000
Chemicals cost	187,000
Personal cost	171,000
Repair cost	54,000
Total	765,000

3) Depreciation (Financial aspect)

Depreciation was calculated under fixed rate method with following conditions:

(a) Equipment: 15 years (annual depreciation rate: 6.7 %)

(b) Civil constructions and pipes: 50 years (annual depreciation rate: 2 %)

4) Amortization

Amortization for principal and interest is also included in the cash flow statement.

10.2.2 Result of Financial Analysis

Financial analysis was conducted in accordance with following three stages:

Stage 1: Basic Analysis

The basic analysis has been studied on the basis of the assumption stated in preceding sub-section.

(1) Free Cash Flow Analysis

Based on the assumptions stated above, free cash flow was calculated. The results of analysis shows not feasible with following major financial indices:

- Financial Internal Rate of Return (FIRR) = -2.50 %
- Net Present Value (NPV) = US$ -62,690 (at discount rate of 7.5 %)
- Benefit/Cost Ratio (B/C) = 0.26 (at discount rate of 7.5 %)

Calculated FIRR, -2.50 %, is far lower than the expected loan interest of 7.5 %. NPV and B/C Ratio are not sufficient as well. This means that the project is needed to be improved financially.

(2) Sensitivity Analysis

Table 10.3 Sensitivity Analysis

Cost		Revenue	FIRR	NPV (at 7.5%)	B/C
Capital	O&M		(%)	(US$)	(at 7.5%)
100%	100%	100%	-2.50%	-62,690	0.26
100%	100%	165%	1.02%	-48,129	0.43
100%	100%	190%	2.01%	-42,529	0.50
100%	100%	200%	2.37%	-40,289	0.53
100%	100%	300%	5.46%	-17,888	0.79
100%	**100%**	**380%**	**7.50%**	**32**	**1.00**
100%	90%	380%	7.58%	715	1.01
100%	110%	380%	7.43%	-651	0.99
90%	100%	380%	8.42%	7,858	1.10
110%	100%	380%	6.72%	-7,794	0.92

Note: The 100% presents the basic conditions described in sub-chapter 10.2.1.

As shown in Table 10.3, if FIRR of the project shall be kept at 7.5 %, which is equivalent to the interest

rate of sublease loan from the government, the revenue shall be secured at 380 % of the one in basic condition. If FIRR is required to be 2.0 or 1.0 %, the revenue shall be raised to 190 or 165 %, respectively.

(3) Profit & Loss Statement

Based on the previous calculation, a profit & loss statement was calculated. As a result, the profit & loss statement shows the break-even point in the year 2034.

(4) Net Cash Flow/Source of Funds and Expenditure

Net cash flow/Source of funds and expenditure in the course of project implementation are calculated up to the year 2050. The fund flows are in negative net cash position throughout the project life.

Stage 2: Study on Relation between FIRR and Tariff / UFW

Relations between FIRR and water tariff, and between FIRR and Unaccounted-for-water (UFW) were analyzed in this stage.

(1) Sensitivity analysis between FIRR and water tariff

In accordance with the Resident's Awareness Survey, water tariff increase may be allowed to be around 1.5 times of present tariff. Consequently, sensitivity analysis was conducted for the cases with tariff increase rate up to 100 % and annual increase rate in the rage between 0 % and 9 %.

Table 10.4 and Figure 10.1 show relation between FIRR and Basic Tariff / Annual Raise Rate of Tariff. For instance, when the initial tariff is set at present rate of Tk 6/m^3, tariff should be raised 3 % annually if FIRR is required to be over 2.0 %. When the initial tariff is set at Tk 9/m^3, which is 1.5 times of present rate, tariff should be raised at 2 % annually if FIRR is required to be over 3.0 %.

Table 10.4 Relation between FIRR and Water Tariff

Base Tariff (Tk/m^3)		6.0 (100%)	6.6 (110%)	7.2 (120%)	7.8 (130%)	8.4 (140%)	9.0 (150%)	9.6 (160%)	**10.2 (170%)**	10.8 (180%)	11.4 (190%)	12.0 (200%)
Annual Raise Rate (%)	0	-2.50	-1.81	-1.19	-0.63	-0.12	0.36	0.80	**1.23**	1.63	2.01	2.37
	1	-0.76	-0.17	0.37	**0.87**	1.34	1.77	2.19	2.58	2.95	3.31	3.66
	2	**0.70**	1.24	1.74	2.20	2.64	**3.05**	3.44	3.81	4.17	4.51	4.85
	3	**2.00**	2.51	2.98	3.42	3.84	4.24	4.61	4.97	5.32	5.65	5.97
	4	3.20	3.69	4.14	4.57	4.98	5.36	5.73	6.08	6.42	6.74	7.06
	5	4.33	4.81	5.25	5.67	6.07	6.44	6.80	7.15	7.48	7.80	8.11
	6	5.42	5.88	6.32	6.73	7.12	7.49	7.85	8.19	8.52	-	-
	7	6.47	6.93	7.36	7.77	8.15	8.52	-	-	-	-	-
	8	7.49	7.95	8.38	-	-	-	-	-	-	-	-
	9	8.50	-	-	-	-	-	-	-	-	-	-

Legend: Base Tariff - Upper; Price, Lower; Ratio of Base Tariff against Present Tariff

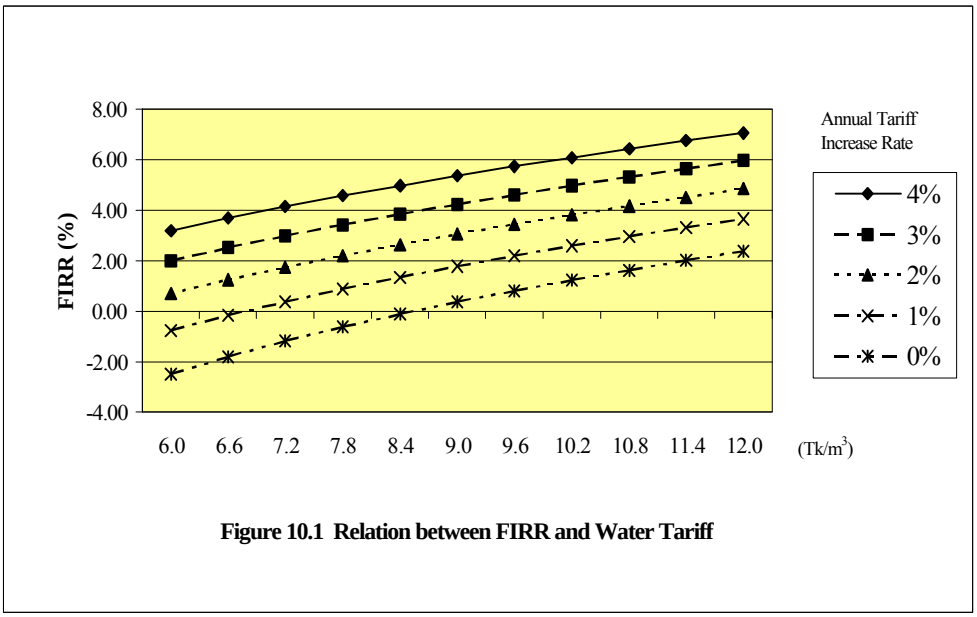


Figure 10.1 Relation between FIRR and Water Tariff

(2) Sensitivity analysis between FIRR and UFW

Table 10.5 and Figure 10.2 show relation between FIRR and UFW ranging from 35 to 15 %.

Table 10.5 Relation between FIRR and UFW

Base Tariff (Tk /m^3)		10.2 (170%)	10.8 (180%)	11.4 (190%)	12.0 (200%)
UFW (%)	Base	**1.23**	1.63	2.01	2.37
	35	-0.15	0.24	0.62	**0.98**
	30	0.36	0.76	**1.14**	1.51
	25	0.85	**1.25**	1.63	2.00
	20	1.30	1.71	2.09	2.46
	15	1.73	2.14	2.53	2.91

Note: Base is the case of UFW 25% in 2006, 24% in 2007, 23% in 2008/9, 22% in 2010/13, 21% in 2014/24 and 20% in 2025/50, respectively.

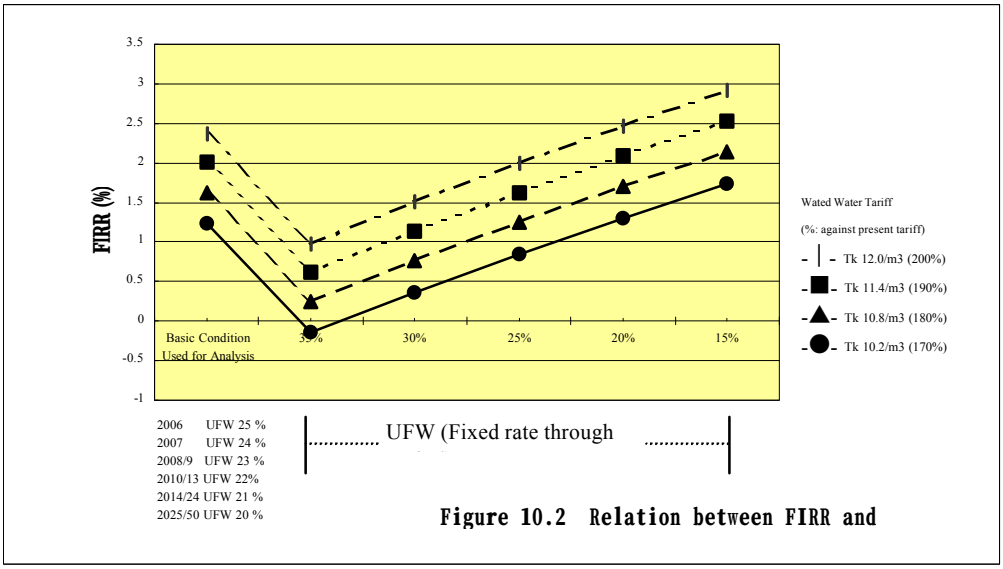


Figure 10.2 Relation between FIRR and

Following findings were obtained through Stage 1 and Stage 2:

Case 1 - UFW improvement is on schedule (to secure FIRR at 1.0 % at least)

1-a: If tariff is raised within residents' willingness-to-pay,

(i) Tariff should be raised to 170 % (Tk 10.2/m^3) and no annual raise is needed, or as an instance;

(ii) Tariff should be raised to 130 % (Tk 7.8/m^3) and annual raise of around 1.0 % is needed.

1-b: No change on the present tariff level (Tk 6 /m^3), annual raise of around 2.2 % is needed.

Case 2- UFW improvement is not on schedule (to secure FIRR at 1.0 % at least)

2-a: If no improvement of UFW (35 %) is expected,

(i) Tariff should be raised to Tk 12.0 /m^3 and no annual raise is needed, or as an instance;

(ii) Tariff can be kept at present level but annual raise of 3.5 % is needed.

2-b: If UFW is expected to be improved to 30 %,

(i) Tariff should be raised to Tk 11.4 /m^3 and no annual raise is needed, or as an instance;

(ii) Tariff can be kept at present level but annual raise of 3.2 % is needed.

2-c: The UFW is expected to improve by 25 %,

(i) Tariff should be raised to Tk 10.8 /m^3 and no annual raise is needed, or as an instance;

(ii) Tariff can be kept at present level but annual raise of 2.9 % is needed.

Stage 3: Sensitivity Analysis assuming reduction of Investment Cost

Table 10.6 Sensitivity Analysis (30% Cost Reduction)

Cost		Revenue	FIRR	NPV(US$)	B/C Ratio
Capital	O&M	(Present tariff=100%)	(%)	(Discount Rate)	(Discount Rate)
70%	100%	**152%**	**2.53**	414 (2.5%)	1.00 (2.5%)
70%	100%	**162%**	**3.02**	6,550 (2.5%)	1.07 (2.5%)
70%	100%	200%	4.70	29,869 (2.5%)	1.32 (2.5%)
70%	100%	276%	7.53	76,508 (2.5%)	1.82 (2.5%)

Note: Discount rate used for NPV and B/C ratio are weighted average interest rate of foreign and local loan (75%/25%).

In order to secure FIRR at 2.53 %, which is the weighted average interest rate (2.5 %) of foreign and local portion of the construction cost estimate (75%: 25%), 152 % of the revenue level (equal to 1.52 times of the present tariff level) is required. In this case, the Profit & Loss Statement shows the break-even point in 2016.

If the interest rate is at 3.0%, which is the same interest rate of IDA 1ST Phase, 162 % of the revenue level shall be secured. In this case, the Profit & Loss Statement shows the break-even point in 2017.

In case capital investment cost is reduced to 70 % (assuming 30% of project cost is subsidized by GOB),

the Net Cash Flow with an interest rate at 2.5 % and a tariff level at 152 % is positive throughout the project life. However, in early period, cash is needed as operation fund, which will be provided by commercial loan. Also, middle period of the project life, expenditure for the principal repayment will increase, and the tariff revision to 152 % of the present tariff in 2006 and 125 % in 2020 will be needed so as to keep positive cash flow.

In case the interest rate is 3.0 %, raise of tariff level to 162 % is needed to maintain the Net Cash Flow positive as same as the above case. In addition, rate increase by 30 % is requisite to prevent negative cash flow through the project life.

10.2.3 Projection of CWASA Financial Plan up to 2015

Projection of financial plan of CWASA up to 2015 was conducted with following considerations as presented in Table 10.7:

- positive support by external financial agencies and the Government (subsidy for the project);
- collection improvement strategies; and
- tariff revision (9.2 Tk./m^3 in 2005).

Income/loss from operation in the statement shows negative side in the first five years, from 2001 to 2005, and in the middle three years, from 2011 to 2013. However, it shows positive side in the middle five years, from 2006 to 2010, and in the last two years, from 2014 to 2015. These are mainly due to tariff revision in 2006 and reduction of interest payment in 2014. On the other hand, the projected cash flow will be negative in the first two years, from 2001 to 2002, and in 2004, while another year shows positive side. This means that the internal reserves such as cash deposit need to be allotted.

As presented in Table 10.8, an alternative plan, in which tariff rate is Tk 6.6 /m^3 (10 % up against present level) from 2001 to 2005, the income/loss from operation turns to positive side only in 2003 in comparison with the case of Tk 6.0 /m^3. On the other hand, the balance of projected cash flow in those three years with negative side in previous case turns to positive side.

The debt service schedule for the Mohara WTP Expansion Project is shown in Figure 10.3. As shown in the figure, the peak of payment including the interest/principal comes in 2016, and the annual amount reaches to Tk 268 million. The interest amount increases from 2004 to 2006, and decreases from 2007 to 2035. The principal payment, required from 2005 to 2035, will be compensated mainly by depreciation.

Table 10.7 Financial Plan of CWASA up to 2015

1. Projected Income/Loss Statement

1.1 Estimate of Accounted-for Water (AFW)

Item	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MOD-1	m^3/day	32,000	32,000	32,000	32,000	32,000	0	0	0	0	0	0	0	0	0	0
(Rate of AFW)	(%)	95%	95%	95%	95%	95%										
Sub-total (AFW)	m^3/day	30,400	30,400	30,400	30,400	30,400	0	0	0	0	0	0	0	0	0	0
Kalurghat (inc.3rd Interim)	m^3/day	46,000	46,000	46,000	46,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000
Mohara	m^3/day	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
Madunaghat	m^3/day	0	0	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000
New Mohara	m^3/day	0	0	0	0	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
(Rate of AFW)	(%)	68%	70%	73%	74%	75%	75%	76%	77%	77%	78%	78%	78%	78%	79%	79%
Sub-total (AFW)	m^3/day	93,160	95,900	133,590	135,420	222,750	222,750	225,720	228,690	228,690	231,660	231,660	231,660	231,660	234,630	234,630
Total (AFW)	m^3/day	123,560	126,300	163,990	165,820	253,150	222,750	225,720	228,690	228,690	231,660	231,660	231,660	231,660	234,630	234,630
1.2 Estimate of Income																
Weighted Average Tariff	(Tk /m^3)	6.0	6.0	6.0	6.0	6.0	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Tariff income	(Tk)	270,596,400	276,597,000	359,138,100	363,145,800	554,398,500	747,994,500	757,967,760	767,941,020	767,941,020	777,914,280	777,914,280	777,914,280	777,914,280	787,887,540	787,887,540
Other income (5%)	(Tk)	13,529,820	13,829,850	17,956,905	18,157,290	27,719,925	37,399,725	37,898,388	38,397,051	38,397,051	38,895,714	38,895,714	38,895,714	38,895,714	39,394,377	39,394,377
Total	(Tk)	284,126,220	290,426,850	377,095,005	381,303,090	582,118,425	785,394,225	795,866,148	806,338,071	806,338,071	816,809,994	816,809,994	816,809,994	816,809,994	827,281,917	827,281,917
1.3 Estimate of Expenditure																
O&M cost & Other expenditure	(Tk)	215,070,000	219,010,000	243,020,000	247,590,000	280,230,000	285,670,000	291,260,000	297,010,000	302,940,000	309,040,000	315,320,000	321,800,000	328,480,000	335,370,000	342,480,000
Depreciation	(Tk)	51,620,000	70,940,000	91,250,000	166,480,000	202,190,000	213,460,000	227,920,000	241,460,000	254,840,000	264,930,000	264,930,000	264,930,000	264,930,000	264,930,000	264,930,000
Interest	(Tk)	54,360,000	52,400,000	60,210,000	149,110,000	216,080,000	246,870,000	245,810,000	244,750,000	243,680,000	242,620,000	242,880,000	242,880,000	242,880,000	215,910,000	196,260,000
Total	(Tk)	321,050,000	342,350,000	394,480,000	563,180,000	698,500,000	746,000,000	764,990,000	783,220,000	801,460,000	816,590,000	823,130,000	829,610,000	836,290,000	816,210,000	803,670,000
1.4 Net Earning																
Income/loss from operation	(Tk)	-36,923,780	-51,923,150	-17,384,995	-181,876,910	-116,381,575	39,394,225	30,876,148	23,118,071	4,878,071	219,994	-6,320,006	-12,800,006	-19,480,006	11,071,917	23,611,917

2. Projected Cash Flow

2.1 Sources of Fund

Item	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Income/loss from operation	(Tk million)	-36.92	-51.92	-17.38	-181.88	-116.38	39.39	30.88	23.12	4.88	0.22	-6.32	-12.80	-19.48	11.07	23.61
Depreciation	(Tk million)	51.62	70.94	91.25	166.48	202.19	213.46	227.92	241.46	254.84	264.93	264.93	264.93	264.93	264.93	264.93
Loan 1	(Tk million)	264.69	264.69	220.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loan 2	(Tk million)	166.68	166.68	138.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loan 3	(Tk million)	0.00	0.00	1,209.60	1,239.84	1,276.13	6.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grant	(Tk million)	0.00	0.00	518.40	518.40	518.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total source	(Tk million)	446.07	450.39	2,161.35	1,742.84	1,880.34	258.95	258.80	264.58	259.72	265.15	258.61	252.13	245.45	276.00	288.54
2.2 Application of Fund																
Capital expenditure 1	(Tk million)	264.69	264.69	220.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital expenditure 2	(Tk million)	166.68	166.68	138.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital expenditure 3	(Tk million)	0.00	0.00	1,728.00	1,728.00	1,728.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt repayment	(Tk million)	41.77	41.77	41.77	41.77	44.79	51.17	50.79	49.76	48.74	47.71	46.68	32.44	41.44	110.93	193.62
Total disposal	(Tk million)	473.14	473.14	2,129.25	1,769.77	1,772.79	51.17	50.79	49.76	48.74	47.71	46.68	32.44	41.44	110.93	193.62
2.3 Increase/Decrease in Resources																
Balance (2.1)-(2.2)	(Tk million)	-27.07	-22.75	32.10	-26.93	107.55	207.78	208.01	214.82	210.98	217.44	211.93	219.69	204.01	165.07	94.92

Note: Conditions for Calculations

1. Estimate of increasing ratio

	Average Increasing Ratio for Previous 4/5 years	Adopted Increasing Ratio per year
Electricity	0.65%	1%
Consumer Price	5.80%	6%
Real Wage	1.95%	2%

2. Estimate of CWASA's staff number

	Estimate of CWASA's staff number (person)
As of 2001	750
As of 2003	815
As of 2005	946

Source: Statistical Pocketbook of Bangladesh 1998.

3. Unpaid accrued interest/principal are included in this table.
4. Interest/principal payment of the New Mohara Project is calculated with the condition of interest rate 2.5 percent and 70 percent of the project cost assuming 30% of the cost will be granted..
5. Loan 1/Capital expenditure 1 mean the Madunaghat Project. Loan 2/Capital expenditure 2 mean the 3rd Interim Project. Loan 3/Capital expenditure 3 and Grant mean the New Mohara Project.
6. Madunaghat WTP 2nd Phase and Karnaphuli WTP Projects are not included in this financial plan.
7. Water volume produced by the 3rd Interim/Fatehabad IRP Project is counted as 3 MGD from 2005 in Kalurghat (incl. 3rd Interim).
8. Decrease in sources from 2001 to 2002 will be alloted by internal reserve.

Table 10.8 Financial Plan of CWASA up to 2015 (Alternative Plan)

1. Projected Income/Loss Statement

1.1 Estimate of Accounted-for Water (AFW)

Item	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MOD-1	m^3/day	32,000	32,000	32,000	32,000	32,000	0	0	0	0	0	0	0	0	0	0
(Rate of AFW)	(%)	95%	95%	95%	95%	95%										
Sub-total (AFW)	m^3/day	30,400	30,400	30,400	30,400	30,400	0	0	0	0	0	0	0	0	0	0
Kalurghat (inc.3rd Interim)	m^3/day	46,000	46,000	46,000	46,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000	69,000
Mohara	m^3/day	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
Madunaghat	m^3/day	0	0	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000	46,000
New Mohara	m^3/day	0	0	0	0	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000	91,000
(Rate of AFW)	(%)	68%	70%	73%	74%	75%	75%	76%	77%	77%	78%	78%	78%	78%	79%	79%
Sub-total (AFW)	m^3/day	93,160	95,900	133,590	135,420	222,750	222,750	225,720	228,690	228,690	231,660	231,660	231,660	231,660	234,630	234,630
Total (AFW)	m^3/day	123,560	126,300	163,990	165,820	253,150	222,750	225,720	228,690	228,690	231,660	231,660	231,660	231,660	234,630	234,630
1.2 Estimate of Income																
Weighted Average Tariff	(Tk /m^3)	6.6	6.6	6.6	6.6	6.6	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Tariff income	(Tk)	297,656,040	304,256,700	395,051,910	399,460,380	609,838,350	747,994,500	757,967,760	767,941,020	767,941,020	777,914,280	777,914,280	777,914,280	777,914,280	787,887,540	787,887,540
Other income (5%)	(Tk)	14,882,802	15,212,835	19,752,596	19,973,019	30,491,918	37,399,725	37,898,388	38,397,051	38,397,051	38,895,714	38,895,714	38,895,714	38,895,714	39,394,377	39,394,377
Total	(Tk)	312,538,842	319,469,535	414,804,506	419,433,399	640,330,268	785,394,225	795,866,148	806,338,071	806,338,071	816,809,994	816,809,994	816,809,994	816,809,994	827,281,917	827,281,917
1.3 Estimate of Expenditure																
O&M cost & Other expenditure	(Tk)	215,070,000	219,010,000	243,020,000	247,590,000	280,230,000	285,670,000	291,260,000	297,010,000	302,940,000	309,040,000	315,320,000	321,800,000	328,480,000	335,370,000	342,480,000
Depreciation	(Tk)	51,620,000	70,940,000	91,250,000	166,480,000	202,190,000	213,460,000	227,920,000	241,460,000	254,840,000	264,930,000	264,930,000	264,930,000	264,930,000	264,930,000	264,930,000
Interest	(Tk)	54,360,000	52,400,000	60,210,000	149,110,000	216,080,000	246,870,000	245,810,000	244,750,000	243,680,000	242,620,000	242,880,000	242,880,000	242,880,000	215,910,000	196,260,000
Total	(Tk)	321,050,000	342,350,000	394,480,000	563,180,000	698,500,000	746,000,000	764,990,000	783,220,000	801,460,000	816,590,000	823,130,000	829,610,000	836,290,000	816,210,000	803,670,000
1.4 Net Earning																
Income/loss from operation	(Tk)	-8,511,158	-22,880,465	20,324,506	-143,746,601	-58,169,733	39,394,225	30,876,148	23,118,071	4,878,071	219,994	-6,320,006	-12,800,006	-19,480,006	11,071,917	23,611,917

2. Projected Cash Flow

2.1 Sources of Fund

Item	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Income/loss from operation	(Tk million)	-8.51	-22.88	-20.32	-143.75	-58.17	39.39	30.88	23.12	4.88	0.22	-6.32	-12.80	-19.48	11.07	23.61
Depreciation	(Tk million)	51.62	70.94	91.25	166.48	202.19	213.46	227.92	241.46	254.84	264.93	264.93	264.93	264.93	264.93	264.93
Loan 1	(Tk million)	264.69	264.69	220.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loan 2	(Tk million)	166.68	166.68	138.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loan 3	(Tk million)	0.00	0.00	1,209.60	1,239.84	1,276.13	6.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grant	(Tk million)	0.00	0.00	518.40	518.40	518.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total source	(Tk million)	474.48	479.43	2,158.41	1,780.97	1,938.55	258.95	258.80	264.58	259.72	265.15	258.61	252.13	245.45	276.00	288.54
2.2 Application of Fund																
Capital expenditure 1	(Tk million)	264.69	264.69	220.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital expenditure 2	(Tk million)	166.68	166.68	138.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital expenditure 3	(Tk million)	0.00	0.00	1,728.00	1,728.00	1,728.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Debt repayment	(Tk million)	41.77	41.77	41.77	41.77	44.79	51.17	50.79	49.76	48.74	47.71	46.68	32.44	41.44	110.93	193.62
Total disposal	(Tk million)	473.14	473.14	2,129.25	1,769.77	1,772.79	51.17	50.79	49.76	48.74	47.71	46.68	32.44	41.44	110.93	193.62
2.3 Increase/Decrease in Resources																
Balance (2.1)-(2.2)	(Tk million)	1.34	6.29	29.16	11.20	165.76	207.78	208.01	214.82	210.98	217.44	211.93	219.69	204.01	165.07	94.92

Note: Conditions for Calculations

1. This is an alternative plan, of which tariff rate is Tk 6.6 /m^3 from 2001 to 2005, Tk 9.2 /m^3 from 2006 to 2015.

2. Estimate of increasing ratio

	Average Increasing Ratio for Previous 4/5 years	Adopted Increasing Ratio
Electricity	0.65%	1%
Consumer Price	5.80%	6%
Real Wage	1.95%	2%

Source: Statistical Pocketbook of Bangladesh 1998.

3. Estimate of CWASA's staff number

	Estimate of CWASA's staff
As of 2001	750
As of 2003	815
As of 2005	946

4. Unpaid accrued interest/principal are included in this table.

5. Interest/principal payment of the New Mohara Project is calculated with the condition of interest rate 2.5 percent and 70 percent of the project cost assuming 30% of the cost will be granted..

6. Loan 1/Capital expenditure 1 mean the Madunaghat Project. Loan 2/Capital expenditure 2 mean the 3rd Interim Project. Loan 3/Capital expenditure 3 and Grant mean the New Mohara Project.

7. Madunaghat WTP 2nd Phase and Karnaphuli WTP Projects are not included in this financial plan.

8. Water volume produced by the 3rd Interim/Fatehabad IRP Project is counted as 3 MGD from 2005 in Kalurghat (incl. 3rd Interim).

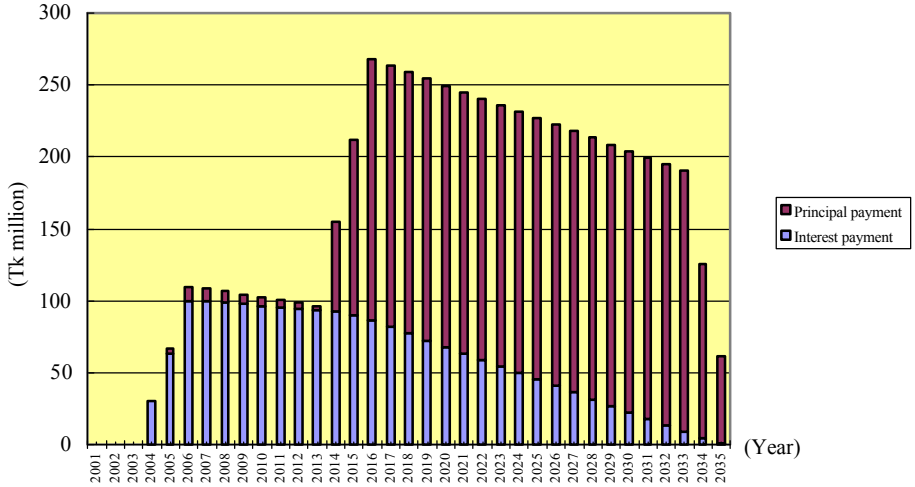


Figure 10.3 Debt Service Schedule (Mohara WTP Expansion Project)

The integrated debt service schedule of CWASA is shown in Figure 10.4. As shown in the figure, the peak of payment including the interest/principal comes in 2016, and the annual amount reaches to Tk 426 million. The interest/principal payments of loan for the on-going projects are shown in this figure, which also shows the accrued debt service. As for the Madunaghat and 3rd Interim projects, the interest/principal payments are included from 2003 to 2034 together with the New Mohara project mentioned above.

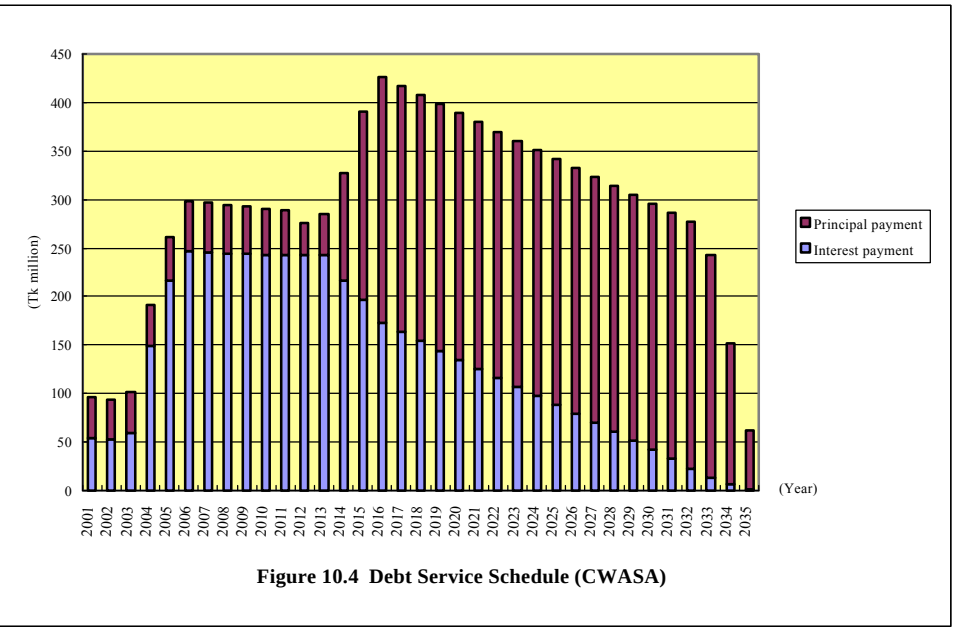


Figure 10.4 Debt Service Schedule (CWASA)

10.3 Results of Analysis

10.3.1 Conclusion

(1) To keep this project financially feasible with the FIRR of 7.5 %, which is same to the interest rate of sublease loan through the government, it is necessary to raise the water tariff to around 380 % of the present level, or as an instance, 200 % up and also annual raise of 4.5 % provided UFW is improved on schedule.
(2) If UFW is improved from the present level (34.5 %) up to 30 % only, the water tariff should be raised to 400 % of the present.
(3) As a result, the intention to collect all investment cost only by the water tariff is unrealistic.
(4) Therefore, it is recommended that subsidy from the government to some extent is requisite for the viability of the project.
(5) If FIRR is allowed to be 1.0 %, which is the same to the condition of foreign government assisted soft loan (JBIC) to the government, it is possible by affordable tariff raise such as raise to around 170 % of the present level or raise to 130 % and annual raise at 1.0 % as an instance. In this case, CWASA will have a sound business operation provided best effort is made to improve UFW.

10.3.2 Necessity of Subsidy

As a result of examination about necessity and effect of subsidy by the government, following findings were obtained:

(1) If the government subsidizes 30% of project cost, required increase of tariff is depressed to 180 % instead of 280 % in case of no subsidy.
(2) If the government subsidizes 30% of project cost, and the interest rate of sublease by the government is set at weighted interest rate at 2.5%, required rate increase to secure FIRR of 2.5 % is about 50 % that is within the willingness to pay of the residents.

10.4 Consideration on Water Tariff

Taking account of above characteristics of present unified price system, it is recommendable that following policies for water rates system be employed:

(1) As a public utility charge, the rate shall be set at affordable level for most of residents.
(2) The rate shall be fare for all people, and beneficiary shall shoulder required cost in principle.
(3) Consideration shall be given to distressed people as a public utility charge for basic human needs.

In order to accomplish said antithetic policies, a stepwise progressive water rates system is recommendable as illustrated in Figure 10.5 and 10.6. It is the tariff structure to ensure poor people can

In the rate system for domestic use, the unit price of first step is set at the low level lower than the water cost to supply water as a public utility for basic human needs. The second step is set higher than the water cost to recover the required cost for water supply. Unit price at third step is set at higher level to restrict the redundant water use.

In the rate system for non-domestic use, the unit price is set higher than the water cost from first step to recover the required cost for water supply. Unit price at second and third steps are set at higher level to restrict the redundant water use.

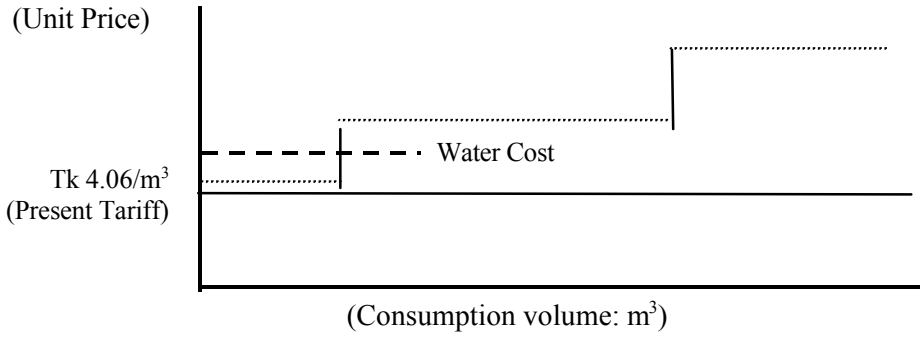


Figure 10.5 Tariff Table for Domestic Use

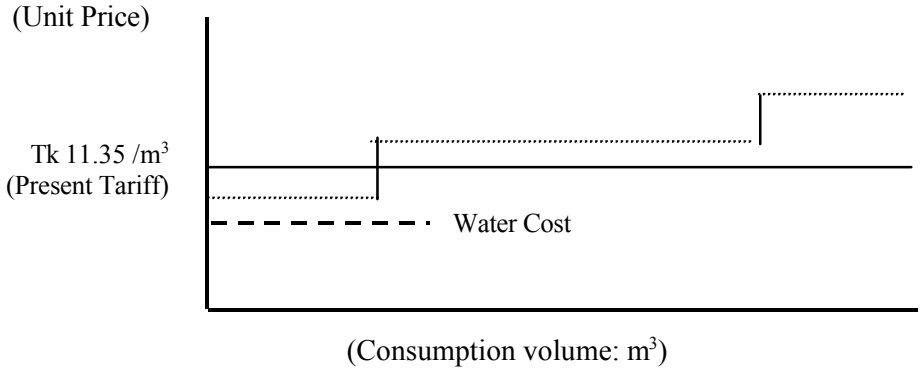


Figure 10.6 Tariff Table for Non-domestic Use

CHAPTER 11

INSTITUTIONAL ARRANGEMENT FOR IMPLEMENTATION AND MANPOWER DEVELOPMENT PLAN

CHAPTER 11 INSTITUTIONAL ARRANGEMENT FOR IMPLEMENTATION AND MANPOWER DEVELOPMENT PLAN

11.1 General

This project will be implemented by CWASA, which will be accountable and responsible for the Scope of Work (S/W) agreed in the meeting with other authorities and operating objectives. With the completion of the Second CWASA Project under IDA assistance in 1987, he has demonstrated his ability to satisfactorily implement medium sized waterworks project.

11.2 Proposed Legislative and Policy Reforms

To the extent possible, this Study presents no additional need for new legislation arrangement. However, several policy reforms will have to be enacted by the CWASA Board to ensure the sustainability of the new water supply facilities.

Regarding water service connection promotion policy, current experience with water supply project, local and elsewhere, indicates that the high connection costs have tended to discourage potential customer from apply for the service. In the fact, CWASA has not been able to supply water through house connection so easily even being requested from the customers due to absolutely lack of water supply capacity.

When this project is completed following to the Madunaghat WTP, the water supply capacity will be remarkably increased. To help ensure the financial viability and raise the utilization rate of the new water supply system, CWASA should change the stance from "demand-driven approach" to "service-driven approach" to sell water.

At current prices, house connection is estimated to cost about Tk 10,000 per connection including labor, materials, surface restoration and a meter. A policy allowing CWASA to advance a portion (say 20 % to 30 %) of the service connection costs, to be repaid by the customer over six months - one year, is recommended. Still another variation is to offer service connection discounts out-right for a fixed some period after installation of lateral pipe for the expansion areas. Such policies would, however, have an implication on CWASA's cash flow, which should be assessed, carefully.

11.3 Proposed Human Resource Development Plan

The proposed program is aiming not only at investigating the present working situation so as to make an improvement plan, but also at supporting CWASA personal to develop their waking method/manner, time to time through the program. The program will be conducted by the Consultants deeply taking account of current organized practice work/manner, and meanwhile from institutional reform point of view. Therefore, close liaison to ensure consistency with manpower development sector will be maintained. The program shall be contained in the detailed design stage and the construction stage for a period of 15 months. The implementing schedule will be reviewed depending upon the financing source and contract condition.

The supporting program will be consisted of four Key Improvement Program (KIPs), which will bear personnel with clear and challenging work plan. The program will be executed in parallel with each expert in the field of the program.

KIP 1: Operation and Maintenance

The scope of work will include, but not necessarily limited to the following:

(i) Provision of specialist operational support: advice and direction in water treatment and distribution, particular attention being given to operational processes and technology for improvement water quality and distribution control practices for formulation of preventive daily production capacity plan in order to continuously operation of the WTP as much as possible depend on seasonal demand.

(ii) Improvement of yield test method for groundwater resources: advice and direction in introduction of systematic water yield test methods; Step Draw Down Test, Continuous Draw Down Test and Recovery Test methods, to decide the suitable production capacity of the wells.

(iii) Analysis for distribution network: support, advice and direction in hydraulic analysis for development of the secondary expansion pipe network to be done by CWASA. The program will be trained intensively to nominated 2 specialists using the CAD equipment transferred through JICA in this Study;

(iv) Provision of preventive maintenance: Advice and direction in preventive maintenance, particular attention being given to the existing facilities including necessity of rehabilitation. Guidelines for preventive maintenance of the water treatment plant including Iron Removal Plant will be provided.

(v) Monitoring indicators: Determination suitable monitoring indicators for use by CWASA to

assist in its duties and in general quality control, and in establishing a management information system utilizing these indicators. The proposed monitoring indicators to be developed for the purpose are presented in the succeeding sub-section in this report.

KIP 2: Management and Finance

CWASA's tariffs have been regulated by the Government, and then do not reflect the cost structures to respond in CWASA's financial requirements. This is not only CWASA but also DWASA in the same situation.

Regarding the reason why DWASA's tariffs do not properly reflect the cost of service provided to consumers, the IDA pointed out the following in their report, Fourth Dhaka Water Supply Project, 1996. Those are as follows:

(a) They convey the wrong economic signals, since inefficiencies and distortions (e.g., system losses) are passed on to consumer;
(b) they do not give adequate guidance whether there should be cross-subsidies to the poor;
(c) they do not provide enough justification on the charges being supplied to small, large, domestic or commercial consumers;
(d) they do not reflect externalities (e.g., the cost of treating pollution to the water supply and how this would be reflected in the charge), and
(e) being non-progressive, they encourage wasteful water consumption practices, particularly among upper income and unmetered consumers.

The above-mentioned issues are not properly applied to CWASA. However, it is meaningful to consider the necessity of the institutional reform, loss reduction, efficiency improvement and introduction of commercial business in order to arise institutional performance.

With above mentioned background, the scope of work under this area will included, but not necessarily limited to:

(i) Review of financial accounting systems: from viewpoint of commercial financing/ accounting and advice for improvement;

(ii) Systematic financial management: review and advice the systematic financial management;

(iii) Provide advice on improvement of presentation systems in financial and cost accounting to be used for budgeting management and improved productivity;

(iv) Review tariff policy and billing system; and

(v) Rearrangement of consumer ledger book: review and complication of the existing ledger book and introduce a Task Force for the purpose.

KIP 3: Management Information System (MIS)

The objective of this area is to establish a management information system to assist CWASA in financial and operational decision-making. Activities in this area will include:

(i) Assist in data collection, information generation, survey and analysis so as to provide statistics and reports that determine existing operation and financial conditions. This should include screening useful data/information and requirement data/information in addition;

(ii) Advise on preparation of fundamental data/records, maps, plans for water supply and sewerage and drainage system planning for feature work;

(iii) Provide assistance in the preparation of information and data needed for the decision of annual operation, maintenance and investment programs, and determine the frequency of reporting with management;

(iv) Concentrate the data/information, and statistic and systematic analyze; and

(v) Provide assistance on how best to record and analyze for presentation.

KIP 4: Personnel Management and Training

The objection in this area would be to establish a training system in CWASA. There is no training organization and system so for. First of all, therefore, a core of training center should be set up at following steps:

1) Assign a leader who is educated personnel having an enterprising sprit for set up a training center.
2) Preparation of set up program with the consultancy assistance to formulate that; but not necessarily limited;
    - to select a target the type of occupation for improvement and reform with respect to working method/manner, systematic management, institutional rationalization in management and financial sections;
    - to select a target the type of engineering for introduction of new technology;

- to select a target the type of engineering work for improvement of their experience and present routine work; and
- to select a target the type of job for reform .

3) Selection of urgent items for training in order.
4) Assign educated personnel having rich experience in the field work for training items as to be trainer.
5) Preparation and collection of training text and materials, and discuss and study with the trainers and the consultant exports.
6) Preparation of training program and schedule, and notification to CWASA's employer.

11.4 Public Information and Education Program

CWASA has a responsibility for service connection with meter branching from a nearest lateral pipe, depending on the consumers' offering. A part of consumers have a storage tank in their houses so as to storage water to deal with interrupt or failing water supply. Sometime the consumers are to claim waterworks regarding water quality received. Therefore, CWASA should always educate the consumers to clean the house storage tank and or overhead tank of their house frequently due to the tank are in condition being dirty within the water supply processes.

CHAPTER 12

ORGANIZATION PLAN

CHAPTER 12 ORGANIZATION PLAN

This particular chapter presents review and suggestion pertaining to new organization and institutional improvement for the autonomous enterprise assuming that the proposed basic plan is carried out in the future.

12.1 Size of Organization

To discuss future organization structure, appropriate number of staff for operation of water works was examined, firstly.

12.1.1 Number of Staff Member

Magnitude of organization is different depending upon the following conditions such as size of business, type of business, composition of facilities, system of water billing, and scope of internal repairing works. he above mentioned suggests even in the fact that if there are the same management and size of business, that staff number is almost equal proportionally to size of business.

12.1.2 Comparison of Staff Number with Similar Countries

The relationship of number of staff as per population served, production and number of connection is compared in relation to the different in relation to the different size of waterworks in the similar countries in Asia.

As a result, it is able to presume that the following index would indicate staff number per size of waterworks.

a) Staff number per population served of 1,000 persons	0.70 to 0.85 (person)
b) Stuff number per amount of water production of 1,000m^3	3.0 to 4.0 (person)
c) Staff number per water connection of 1,000 pieces	7.0 to 13.0 (person)

12.1.3 Establishment of Future Organization Structure and Staff

Designed specification for fusibility study is as follows:

a) Planed population served:	3,370,000 (person)
b) Planed amount of water supply:	650,000 (m^3/d)
c) Planed number of service connections:	120,000 pieces for house connections
	2,300 pieces for public hydrant

Based on our analysis, staff number is estimated by utilizing above index.

i) by planed population served:

3.370 (x 10^3ps) x @ 0.70 - 0.85 = 2,360 - 2,860 (staff number)

ii) by planed amount of water production:

650 (x 10^3.m^3/d) x @ 3.0 - 4.0 = 1,950 - 2,600 (staff number)

iii) by number of service connection:

122 (x 10^3 pieces) x @ 7 - 13 = 850 - 1,590 (staff number)

From above result, it is estimated that the maximum level of staff number is estimated 2,860 parsons calculated from population served base. As well, 1,950 persons calculated from water production base as minimum level. It is expecting that office automation equipment become more popular and then business reorganization may be accelerated in the future. Therefore, a total number of 1,900 persons, who is given by minimum level from previous calculation, are recommended. Following is the examination of its appropriateness by comparing with DWASA.

Table 12.1 Comparison of Number of Staff with DWASA

	DWASA*1 (present) (a)	CWASA*2		CWASA/DWASA, % (d)=(c)/(a)
		1999 (b)	2010*2 (c) (%=c/b)	
1. Served Population	4,100,000	1,142,000	3,370,000 (300%)	82
2. Served Water (m^3/day)	930,000	162,500	650,000 (400%)	70
3. Service Connection (units)	180,100	32,000	120,000 (380%)	61
4. Number of Staff	3,215	750	1,900 (250%)	59
5. Staff Number per 1,000 Served Population	0.78	0.66	0.56	72
6. Staff Number per 1,000 Served Water	3.5	4.6	2.9	83
7. Staff Number per 1,000 Service Connection	17.9	23.4	15.8	88

*1: World Bank's Data for 4th project (1996), *2: recommended by the Study Team

Following considerations were given to decide number of staff members:

(1) Comparison of present and future size of CWASA;

i) Served water will be 400 % while Served Population will be 300 % against present level, because of improvement of service level.

ii) Against increase rate of Served Population (300 %) and Served Water (400 %), increase rate of number of staff members (250 %) is low, because of following reasons;

a) Present number of staff is too large against size of business. Streamlining of the organization is necessary.

b) Operation of existing wells scattered in MOD-I area will be ceased in the future so that

the number of staff can be decreased.

c) Water supply by lorry will be not necessary except emergency case in the future so that required number of staff may be reduced.

d) Introduction of office automation equipment in the future will streamline the number of staffs.

e) Training of staff members will encourage business philosophy.

(2) Comparison with DWASA

i) Served water will be equivalent to 70 % of DWASA, while number of staff will be equivalent to 59 % of DWASA, because DWASA is operating sewerage system, which CWASA does not operate.

ii) DWASA relies on wells for 95 % of water source. Thus, scale of facilities are small and efficiency of administration is low.

iii) Water supply facilities of DWASA is old, and leakage ratio is high. Thus, many maintenance staff is required.

Consequently, proposed number of staff for CWASA in the future has appropriateness based on the comparison with DWASA.

12.2 Proposed Organization

New organization structure is needed to be established for adopting the new concept and strategy to improve or reform the current institutional organization. Taking account of the development of the water supply system and size of the services, the organization structure shown in Figure 12.1 is recommended.

Key points of the recommended plan are ;

(1) To organize a division for each WTP

(2) To change the MOD to MODS (Maintenance-Operation-Distribution-Service), zonal operating unit of CWASA.

MODS 1 manages the Mohara WTP supply area, MODS 2 manages the Karnaphuli IRP supply area, MODS 3 manages the Madunaghat WTP & Fatehabad IRP supply area, and MODS 4 manages the Kalunaphuli WTP supply area, for instance.

(3) In connection to the above, Sales section is struck and the shifted its duty to each MODS.

(4) To reorganize the Procurement from under Secretary to under management of P&C circle.

(5) To change the division name from Development to Planning and Monitoring.

(6) To establish two new divisions, namely Training Center under Secretary, and Task Force for extension and expansion of pipe network (EEP) and house connection as temporally section.

(7) To provide a computer system to section with “circled marks” for management of information.

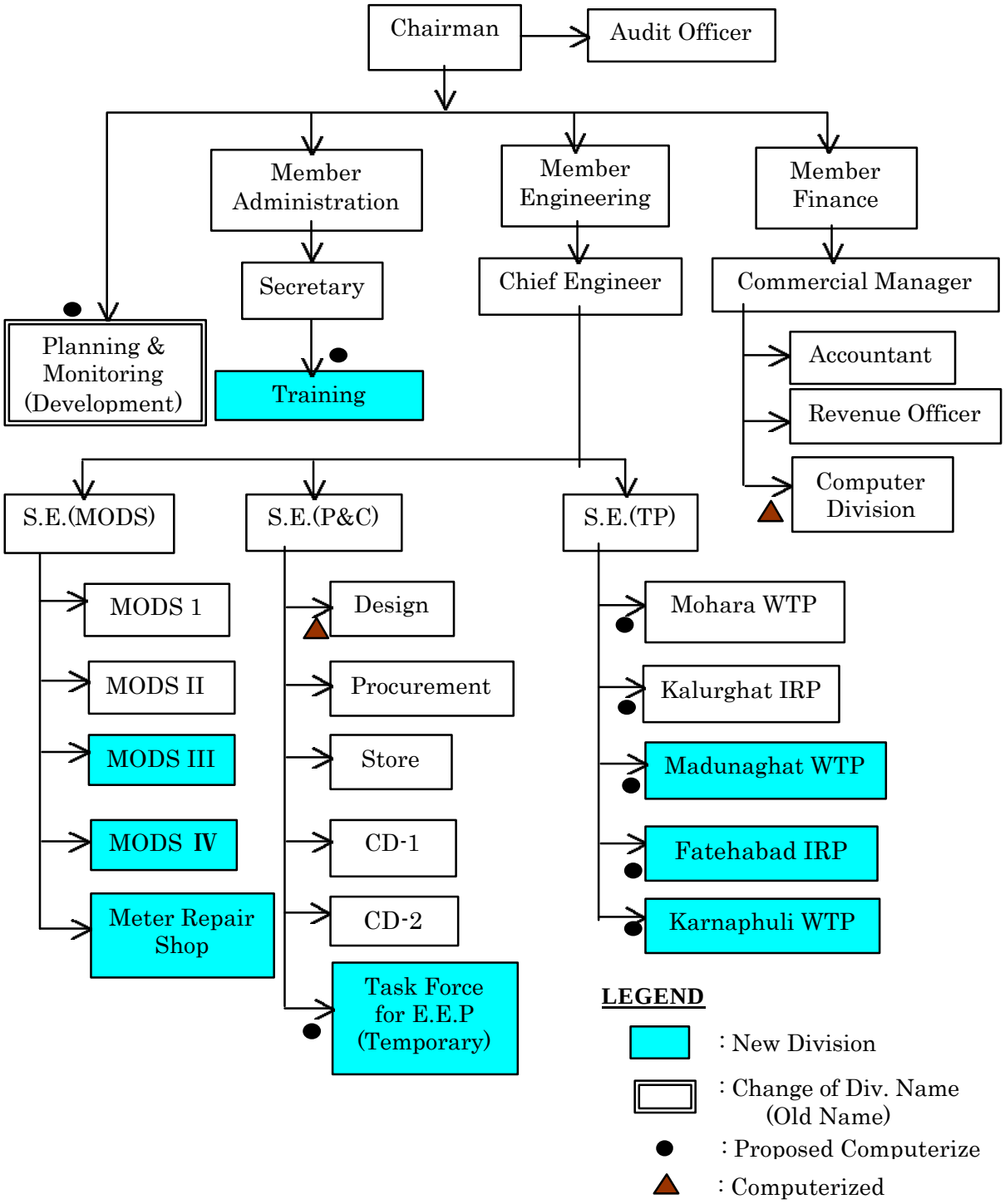


Figure 12.1 Recommended CWASA Organization Chart

CHAPTER 13

ENVIRONMENTAL IMPACT ASSESMENT

CHAPTER 13 ENVIRONMENTAL IMPACT ASSESSMENT

As a conclusion of the EIA, the significant or major adverse impacts caused by the proposed project are unlikely. Some minor or short-term impacts could happen, but they could be sufficiently reduced to an environmentally acceptable level by implementation of the Environmental Management Plan (EMP) , which includes proper mitigation measures. The essential parts of the EIA were summarized as follows:

In the early stage of the EIA survey, the IEE results were reviewed. And it was decided to carry out the EIA for the following ten items, which are composed of eight items identified by the IEE and additional two items suggested by the Chittagong office of the Department of Environment.

- Item 1: Resettlement and Land acquisition/compensation due to the project implementation
- Item 2: Traffic congestion during the construction works
- Item 3: Infringement to water use/right for the other sectors/users.
- Item 4: Waste disposal during the construction.
- Item 5: Change of river regime and river environment
- Item 6: Water pollution due to sludge discharge during low flow in the river.
- Item 7: Water pollution due to industrial effluent through Krishuna khal
- Item 8: Noise and vibration caused by construction works
- Item 9: Noise from the pumping house of the Mohara WTP
- Item 10: Air pollution by construction works

The EIA survey was carried out for the respective items to find the specific environmental conditions. The measurement of water quality, air quality, noise level at the present conditions was carried out and the other relevant data/information were collected. The public hearing was also carried out to obtain the reference information for the practicable and effective EIA. It was realized that all the respondents to questionnaires are in favor of the project and their concerns to the environmental impacts are generally high.

The mitigation measures for reducing and protecting the anticipated impacts were studied.

Refer to the Main Report for the proposed measurers for the individual item below in detail.

Item 1: Resettlement and Land acquisition/compensation

Item 2: Traffic congestion

Item 3: Infringement to water use/right (of the Halda River)

It may not be possible to present the measures without confirming the adverse impact, as the kind/type and scale of adverse impacts can not be predictable, at least at specific level, for this item. The definite mitigation measures, if necessary, will be proposed from the

monitoring results.

Item 4: Waste disposal

Item 5: Change of River regime/environment

It may not be possible to present the measures without confirming the adverse impact, as the kind/type and scale of adverse impacts can not be predictable, at least at specific level, for this item. The definite mitigation measures, if necessary, will be proposed from the monitoring results.

Item 6: Water pollution (Sludge effluent)

Item 7: Water pollution (Industrial effluent)

Item 8: Noise/Vibration (by construction works)

Item 9: Noise (Pump house)

Item 10: Air pollution (including dust, by construction works)

The Environmental Management Plan (EMP) was prepared for the implementation of the effective necessary environmental mitigation measures, when required.

(a) Establishment of practical organization (including the Environment department/section in CWASA, Cooperative relation with some related government offices/agencies, and Staffing of experienced and active experts/engineers)

(b) Improvement of existing Rules and Standards for more practical and detailed application and Establishment of more strict and effective Regulations for the actual operation of the rules and standards.

(c) People's Participation to the EMP for cost saving, avoiding disputes, enhancement of interest for local people, taking quick measures, etc.

(d) Preparation of Implementation Plan for the EMP, which contains the implementation schedule, the organization and staffing, the section/division of objective sites, the alternative mitigation measures, the survey and monitoring program, the budget allocation, the facilities & equipment list, etc. The monitoring and survey for the respective environmental item is significant to find/confirm the necessity and extent of application of mitigation measures.

The monitoring items to be considered necessary are listed as follows:

1) Resettlement and Land acquisition/compensation
   (a) Inspection and hearing of the changes of living conditions (after the resettlement).
2) Traffic Congestion
   (a) Inspection and identification of actual conditions of traffic during construction.
   (b) Hearing from the inhabitants about the differences on traffic/pass before and during the construction works.

3) Infringement to water use/right (of the Halda River)
   (a) Periodical survey of the water use/demand conditions.
   (b) Periodical (and additional, if required) measurement of tidal/saline water intrusion.
   (c) Continuous/periodical measurement of stream flow (water level and discharge) in the Halda River and the Karnaphuli River.
4) Waste disposal
   (a) Inspection and identification of actual conditions of waste disposal during the construction works.
5) Change of River regime/environment
   (a) Periodical survey of the water use/demand conditions.
   (b) Periodical (and additional, if required) measurement of tidal/saline water intrusion.
   (c) Observation of changes of natural conditions in the basin/watershed.
   (d) Continuous/periodical measurement of stream flow (water level and discharge) in the Halda River and the Karnaphuli River.
   (e) Monitoring of water quality of the river.
   (f) Periodical inspection/observation of the river conditions (riverbank erosion, aquatic fauna including fishes & flora, river profile & sections, etc.).
6) Water pollution (sludge effluent)
   (a) Survey of water quality in the river at the outlet of the sludge-pipe and the inspection of sludge dilution without piling during the dry season.
   (b) Hearing from the inhabitants about the changes of water conditions (if any) before and during the construction works.
7) Water pollution (industrial effluent)
   (a) Periodical water quality survey in the Krishuna Khal and at the Mohara intake in the Halda River in the dry season. (Survey of the other khals as well, if considered to be necessary)
   (b) Periodical water quality survey of effluent from the industries into the Krishuna Khal.
8) Noise/Vibration (construction works)
   (a) Inspection and measurement of actual sound and vibration level/conditions during the construction works. Evaluation of noise and vibration by the standards.
   (b) Hearing from the inhabitants about the differences on noise and vibration before and during the construction works.
9) Noise (pump house)
   (a) Measurement of the conditions of sound level after completion of the project.
   (b) Hearing from the inhabitants about the nuisance of sound.
10) Air pollution (construction works)
   (a) Inspection and measurement of air pollution level/conditions during the construction

works. Evaluation of air pollution by the standards.

It is necessary to include the EMP and monitoring during the construction stage in the specifications of construction contract. The contractor should be in charge of mitigation of adverse environmental impacts, although the inspection and guidance by the government side is also required.

The recommendation as a conclusion of the EIA is presented as follows:

(1) Earlier implementation

The project will contribute a lot for the people in Chittagong City. The project produces not only the social and economic enhancement but also remarkable improvement of sanitary conditions. It is required to realize these positive environmental impacts without delay. The present water supply system has various issues and the level of negative conditions will become more serious in the future, if the project implementation is postponed.

(2) Establishment of the EMP to the Project Implementation

The negative environmental impact is predicted to be not significant and only some minor impacts may happen. However, it is probable that a slight impact may change to a significant/major one, if the proper environmental management plan (proposed in this EIA study) is not carried out. In addition, the EMP with execution of appropriate mitigation measures may reduce a moderate/slight impact to a negligible or acceptable level. The first step may be the establishment of an environment section in CWASA, which should have responsibility for the EMP and the monitoring as well as for the project implementation.

CHAPTER 14

PROJECT EVALUATION

CHAPTER 14 PROJECT EVALUATION

14.1 General

The proposed project for the Extension and Expansion of Mohara Water Treatment Plant was evaluated from viewpoints of expected benefits and appropriateness/feasibility. Composition of the adopted evaluation items was technical aspects, financial aspects, environmental aspects, and social and economic aspects.

14.2 Benefit and Justification of the Project

The principle purposes of water supply system development and its operation are; (1) to always supply water with safety and reasonable price, and (2) to help human health and hygiene for improvement of living level.

The present population of Chittagong City is estimated at 3.0 million and projected at 3.7 million in 2010. The present supply capacity of the CWASA is 161,500 m^3/day. The coverage rate is only 45 percent, which is very low level as a big and representative city of a country. The current water supply situation of the City is of service for 15 hours a day or several hours for two or three days, depending on the location of area.

Showing the present water supply situation by means of the unit water supply rate, (supply volume per capita per day), the present rate is 142 lpcd. Even if two planned projects, excluding Mohara expansion project, are completed by CWASA, the unit supply rate in 2005 will be at 120 lpcd, which is lower than the present service level. That means no improvement of the water supply services will be accomplished after projects. Taking account of level-up of the peoples' living standard and increase of water demand for industrial usage, the service level is rather decline from the present level, and hence the city economy activities will be constrained.

If CWASA would have an intention to maintain the planned water supply target level in 2005, no more house connection is allowed. In that case, water supply coverage ratio would be lower than the present levels, which will results serious socio-economic problems.

This particular project is to extend the existing Mohara Water Treatment Plant and to supply the water to the areas with increased population density in the city and new supply areas to be expanded and

also to industrial zones. When the project is implemented, the water coverage rate is to be 50%, and the unit supply rate is expected to be improved to 178 lpcd.

14.3 Project Evaluation

14.3.1 Technical Evaluation

Project evaluation from technical viewpoint is carried out as described below:

1) According to the extension of existing Mohara Water Treatment Plant under the proposed project, the water service conditions will be considerable improved in water quality and quantity.
2) Since the proposed water treatment plant adopts the same type of treatment method/type with the present system, no special technical operator will be required.
3) The distribution system is changed from directly pumped transmission and distribution method/system to natural flow-down through a reservoir. According to the change of distribution system; (1) the users will be served safety water "any time when they needed at stable water pressure"; (2) no valves and pumps control are required for arrangement of water supply areas. As "one water reservoir covers one supply area", the operation and maintenance work are to be simple and easy.

14.3.2 Financial Evaluation

As a result of the financial analysis, the following findings are obtained:

1) When FIRR should be secured at 7.5 %, which is the loan condition of the governmental sublease financial aid, the present weighted average tariff (6 Tk/m^3) should be raised by 3.8 times, or as an instance, raise to twice with annual raise of 4.5 percent is needed. This is unrealistic.
2) If FIRR should be secured at 1.0 %, which is the loan condition of the foreign financial aid, the present tariff should be raised by 1.7 times, or as an instance, raise by 1.3 times with annual raise of 1 % is needed. This will meet the residents' willingness to pay.

As a result, the implementation of the project is needed to be complemented by an appropriate government financial subsidy.

14.3.3 Economic and Social Evaluation

In economic term, indirect benefits are brought about for even those who are not receiving water services directly. The following are examples of such benefit:

1) Improvement of public health regardless of whether or not they have house connections.

2) Cost saving in health care cost and in auxiliary health and sanitation cost.
3) Infrastructure as a basis for economic development.
4) Long-term job creation for operation and management of the water supply system.
5) Ripple effect on the economy by O&M activities.
6) Short-term job creation by plant construction work.
7) Long-term effects on the local economy by pipeline network construction work.

As explained above, economic benefits of expanding the water supply system are not limited to individual users, but rather spread over society as a whole, as well as industries. Some of industries in EPZ and other factories are awaiting stable water supply with sufficient water quality and quantity. They have direct effects on the enterprise and broaden the economic development to the entire country.

Therefore, investment cost for water supply service shall be shouldered not only by direct beneficiaries like users but indirect beneficiaries. However, it is difficult to allocate the cost to indirect beneficiaries, and it's feasibility shall not be judged only from financial feasibility indices.

Following items are typical economic effects by the project:

1) Improvement of living environment of poor people
2) Vitalization of urban activities
3) Improvement of public sanitation condition
4) Dissolution of water drawing work of women and children
5) Increase of value of asset.

14.3.4 Environmental Evaluation

As the results of EIA survey, the overall evaluation concluded as follows:

The significant or major adverse impacts caused by the proposed project are unlikely. Some minor impacts could happen, but could be sufficiently reduced to an environmentally acceptable level by implementation of an Environmental Management Plan (EMP).

The mitigation measures for reducing and protecting the anticipated impacts were studied for the individual environment item. Then, the Environmental Management Plan (EMP) was prepared for confirming the necessity of the proposed mitigation measures and also for implementing the measures effectively. The EMP includes various monitoring plans, which may be necessary to confirm the

level of impacts or the effectiveness of the mitigation measures. It is necessary to include the EMP and monitoring in the specification of the construction contract.

14.3.5 Emergency Project and Hidden Costs

The project proposed as the emergency countermeasures is designed to solve the present critical water service in the City. Development of the project will be a further extension toward materialization of the basic plan. The hydraulic analysis for distribution network was also executed aiming at the water demand in the basic plan with a target year of 2010.

With regard to development of the water supply system, this particular project is not completed itself. The project is planned to meet water demand in F/S target year on premise of the implementation of the CWASA's on-going projects, namely Madunaghat WTP and the 3rd Kalurghat IRP. However, these projects are designed to increase the production capacity only, and not include the implementation or extension and expansion of the distribution main and network.

Accordingly, this particular project covers a part of the improvement work of distribution pipeline network as an emergency measure against deficiency of existing distribution system.

In additions to the project cost, therefore, there are extra hidden costs so as to complete the overall projects including this project and the CWASA's on-going projects, which might sum up as follows:

(1) Extension and expansion of distribution network in a part of the proposed water supply project covering area and CWASA's on-going project supply area, as well
(2) Construction of household connections, which will be mainly borne by the user.
(3) As for cost of industrial wastewater treatment, it should be treated for discharge at their own cost in accordance with regulations

CHAPTER 15

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 15 CONCLUSIONS AND RECOMMENDATIONS

15.1 Conclusions

Owing to remarkable development of the industrial sector in Chittagong City and its suburban area, the population of the City has been remarkably increased for this decade.

The present water supply situation of the City is summarized that water served population is 1.14 million, water coverage ratio is 45 percent, and water supply volume per capita per day (unit rate) is 142 lpcd. These figures in the basic plan with the target year of 2010 are estimated at 3.37 million, 84 percent, and 193 lpcd, respectively. The new water source for the proposed water treatment plant for the improvement/expansion of the water supply system in the Chittagong City is to be the Halda River and Karnaphuli River. Availability of the raw water was confirmed in water quality and quantity.

To solve the current critical water supply situation, the expansion project of Mohara WTP, which is included in the basic plan, was formulated as a priority project. The planned target year for the priority project is 2005 as an emergency project, which is the subject of the feasibility study. After completion of the project, the present water supply conditions will be improved so that served population will be 1.58 million and unit rate will be 173 lpcd.

It shall be noted that the proposed expansion project of Mohara WTP meets with the national policy for infrastructure development stipulated in the Annual Development Program 2000-2001 being adopted by the Government of Bangladesh.

Likewise, the necessary and appropriateness as well as urgency of the proposed project has been substantially acknowledged and justified for betterment of critical water shortage, public hygiene and environmental conservation in Chittagong City and urban infrastructure as well.

According to the financial analysis, in order to recover all cost of this project entirely by water tariff, it will be necessary to raise the tariff to 3.8 times of the present weighted average tariff. This amount equivalents to 2.5 times upper than limit of the general resident' willingness-to-pay. As a result, the intention to collect all costs by the water tariffs only is unrealistic. The implementation of the project should be complemented by an appropriate government financial subsidy.

Financial analysis was further conducted to establish the practical idea; (1) assuming that FIRR of 1%, which is equivalent to the rate of JBIC, allowed, raise up by 1.7 times of the present tariff is sufficient,

and (2) assuming that 30% out of total project cost of US $ 96 million is assisted by the government as a subsidy, it is needed to raise up the tariff to 2.7 times of the present tariff. (3) Assuming that 30% out of total project costs of US $ 96 million is subsidized by the government subsidy, and also if FIRR of 2.5%, which is a weighted average rate based on the foreign and local potions (75%: 25%) of the project cost estimate, should be secured, it is needed to raise up by 1.5 times of the present tariff. As a result, only the cases of (1) and (3) mentioned above are practical for the project implementation.

Overall Conclusion

(1) Based on this study, it may be concluded that the scale and scope of investment of the project appear appropriate, and the effects of the investment, which seem to be satisfactory. Management Systems necessary for the project operation are considered to be sufficient.
(2) However, it is difficult to recover costs of the investment fully without substantial financial complements by the government subsidies. As a result, special considerations should be given for a financial scheme, which can fully fund the project.

15.2 Recommendations

The following recommendations are presented in accordance with their importance and priority.

(1) Establishment of measures to secure project fund,
(2) Negotiation with landowners for land acquisition,
(3) Preparation and submission an application of change the tariffs to the government for their approval,
(4) Consideration on introduction of the stepwise progressive water tariff structure for cross-subsidy between consumers so as to help the low income group, and
(5) The proposed project is designed to construct Mohara WTP extension plant, transmission pipe, reservoirs, and distribution main, and also it includes installation of a part of main connection pipe in the existing supply areas so as to form a certain network to distribute water from the existing system. Therefore, secondary distribution pipeline and house-connection, which are out of scope of the implementation cost estimate, should be executed in parallel with the progress of the proposed project.