MINISTRY OF FINANCE
MINISTRY OF LOCAL GOVERNMENT, RURAL DEVELOPMENT AND CO-OPERATIVES
KHULNA WATER SUPPLY AND SEWERAGE AUTHORITY (KWASA)
THE PEOPLE'S REPUBLIC OF BANGLADESH

FEASIBILITY STUDY FOR KHULNA WATER SUPPLY IMPROVEMENT PROJECT IN THE PEOPLE'S REPUBLIC OF BANGLADESH

FINAL REPORT

VOLUME Ⅱ

MAIN REPORT

MARCH 2011

JAPAN INTERNATIONAL COOPERATION AGENCY
NJS CONSULTANTS CO., LTD.

GED
CR(3)
11-038

The cost estimate is based on the price level and exchange rate of November 2010.

The exchange rate is:

Bangladesh Taka 1.00 = Japanese Yen 1.23 (= US$ 0.0144)

Location Map

FEASIBILITY STUDY
FOR
KHULNA WATER SUPPLY IMPROVEMENT PROJECT
IN
THE PEOPLE'S REPUBLIC OF BANGLADESH

FINAL REPORT
VOLUME II
MAIN REPORT

TABLE OF CONTENTS

List of Tables and Figures

<List of Tables>

CHAPTER 1 BACKGROUND

CHAPTER 2 GENERAL DESCRIPTION OF THE KHULNA CITY AREA

CHAPTER 6 PROPOSED LONG TERM DEVELOPMENT PLAN

CHAPTER 7 PROJECT SCOPE AND FACILITIES

CHAPTER 8 INSTITUTIONAL AND MANAGEMENT CONSIDERATIONS

CHAPTER 9 FINANCIAL AND ECONOMIC CONSIDERATION

CHAPTER 10 ENVIRONMENTAL AND SOCIAL CONSIDERATION

<List of Figures>

CHAPTER 1 BACKGROUND AND OUTLINE OF THE STUDY

CHAPTER 2 GENERAL DESCRIPTION OF THE KHULNA CITY AREA

CHAPTER 3 EXISTING WATER SUPPLY

CHAPTER 4 POPULATION AND WATER DEMAND PROJECTION

CHAPTER 5 KHULNA WATER SUPPLY WATER SOURECE

CHAPTER 6 PROPOSED LONG TERM DEVELOPMENT PLAN

CHAPTER 7 PROJECT SCOPE AND FACILITIES

ACRONYMS

ADB	Asian Development Bank
ARIPO	Acquisition & Requisition Property Ordinance
BOD	Biological Oxygen Demand
BDT	Bangladeshi Taka
BWDB	Bangladesh Water Development Board
CCL	Cash Compensation under the Law
CDIA	City Development Initiative for Asia
COD	Chemical Oxygen Demand
DF/R	Draft Final Report
DMD	Deputy Managing Director
DOE	Department of Environment
DPHE	Department of Public Health Engineering, MLGRD&C
DWASA	Dhaka Water and Sewerage Authority
EA	Environmental Assessment
ECC	Environmental Clearance Certificate
ECCo	Environmental Clearance Committee
EIA	Environmental Impact Analysis
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
ENPV	Economic Net Present Value
EOCC	Economic Opportunity Cost of Capital
EQS	Environmental Quality Standard
ERD	Economic Relations Division, Ministry of Finance
FCD/I	Flood Control Drainage and Irrigation
FGD	Focus Group Discussion
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
FOCC	Financial Opportunity Cost of Capital
F/R	Final Report
F/S	Feasibility Study
GI	Galvanized Iron
GDP	Gross Domestic Product
GOB	Government of Bangladesh
GOJ	Government of Japan
GRC	Grievance Redress Committee
HR	Human Resource
HRD	Human Resource Development
IC/R	Inception Report
IEE	Initial Environmental Examination
IIP	Interim Improvement Project
IT/R	Interim Report
IUCN	International Union for Conservation of Nature & Natural Resources
JBIC	Japan Bank of International Cooperation
JICA	Japan International Cooperation Agency
JTU	Jackson Turbidity Unit
JVIT	Joint Inventory Verification Team
KCC	Khulna City Corporation
KDA	Khulna Development Authority
KWASA	Khulna Water Supply and Sewerage Authority
LAP	Land acquisition Plan
LGD	Local Government Division, MLGRD&C
MARV	Maximum Allowable Replacement Value
MBBR	Moving Bed Bio-Reactor
MBR	Madaripur Beel Route
MD	Managing Director
MDG	Millennium Development Goal
MLGRD&C	Ministry of Local Government, Rural Development and Co-operatives
MoEF	Ministry of Environment and Forest
NCS	National Conservation Strategy
NEMP	National Environmental Management Plan
NOC	No Objection Certificate
NRW	Non-Revenue Water
NWMP	National Water Management Plan

NWP	National Water Policy
NWRC	National Water Resources Council
O&M	Operation and Maintenance
PAP	Project Affected People
PCU	Project Coordination Unit
PMO	Project Management Officer
PMU	Project Management Unit
PPTA	Project Preparatory Technical Assistance
PTW	Production Tube Well
P/R	Progress Report
RAP	Resettlement Action Plan
RO	Reverse Osmosis
RU	Resettlement Unit
SAPROF	Special Assistance for Project Formation
SCC	Site Clearance Certificate
S/C	Steering Committee
SIA	Social Impact Assessment
SPS	Safeguard Policy Statement
SPT	Standard Penetration Test
SRDI	Soil Resources Development Institute
S/W	Scope of Work
SWTP	Surface Water Treatment Plant
TA	Technical Assistance
TOR	Terms of Reference
UFW	Unaccounted for Water
USD	United States Dollar
WASA	Water and Sewerage Authority
WARPO	Water Resource Planning Organization
WTP	Water Treatment Plant
WUG	Water User Group

EXECUTIVE SUMMARY

1. The water supply system of Khulna city (third largest city in Bangladesh), is totally being depended on groundwater source. Due to the increasing water demand in the city the water supply system is vulnerable to supply required water to the people. To deal with this difficulty GOB and JICA decided to conduct a Feasibility Study for Khulna Water Supply Improvement Project.

2. The objectives of the Study are; (1) to review and analyse National and Local Policies of water supply and existing conditions in the study area, (2) to formulate of a Long Term Water Supply Development Program for the study area, and (3) to identify priority project(s) and conduct a Feasibility Study (F/S) on the identified priority projects.

3. The design year for the Feasibility Study shall be set the year 2025 in consideration of the construction period of the new water supply system including the time needed for detailed design and project implementation.

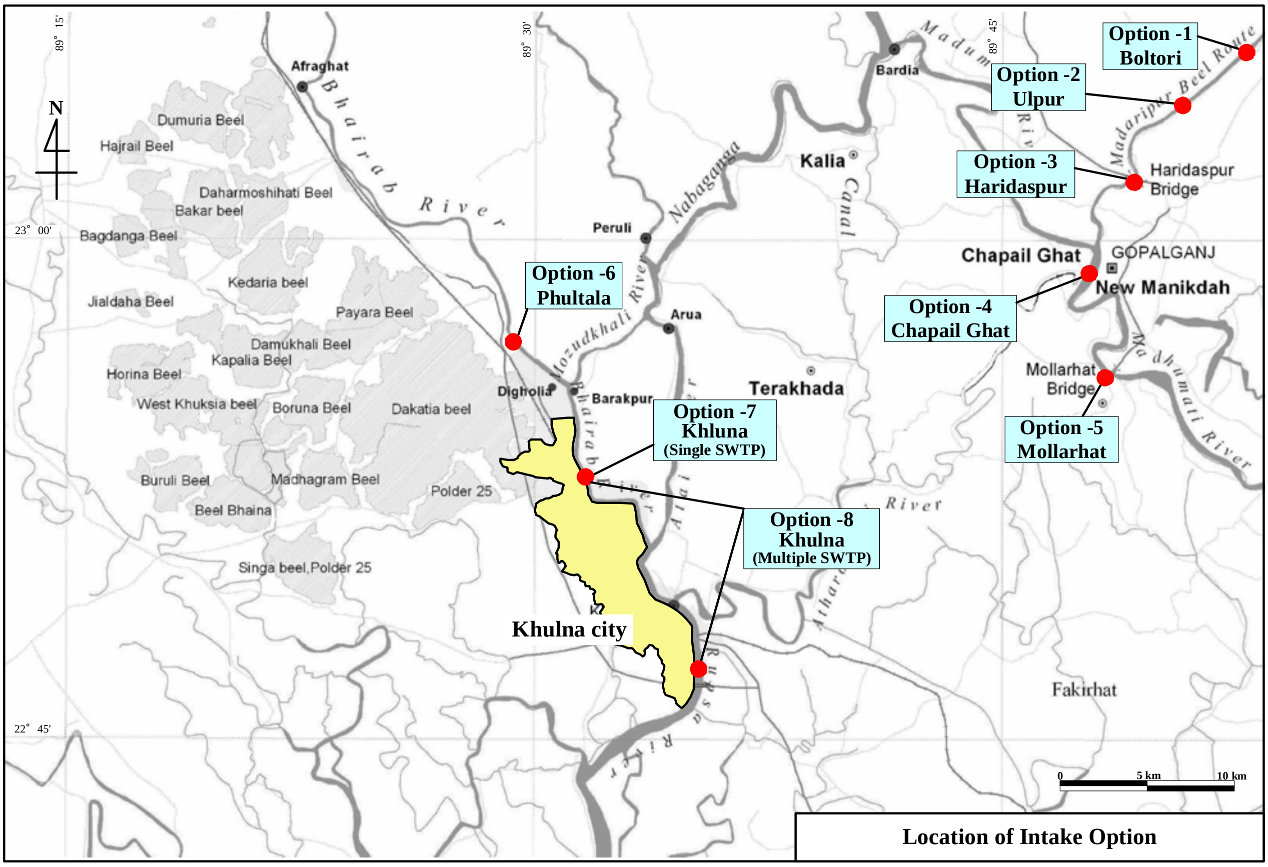
4. The study area comprises the area under the Khulna City Corporation (KCC), which is about 45 km^2. The populations in 2025 to be 1,314,000 persons and in 2030 to be 1,450,000 are projected respectively.

5. The study started with the collection and review of available data and information. Additional survey works also had been conducted to justify the current water supply system in Khulna city.

6. Based on the result of the justification of existing water supply situation including the current water use and the future water demand in Khulna were justified as follows;

    - Target year: 2025
    - Population: 1,314,000 persons
    - Consumption/ capita/day: 113 lpcd
    - Water for non-domestic use: 10%
    - Leakage after WTP: 18%
    - Domestic water demand: 132,000 m^3/day
    - Total water demand: 230,700 m^3/day
    - Capacity of new system: 110,000 m^3/day

7. Regarding the water source for the new water supply, the increasing salinity intrusion into the river water surrounding the Khulna City is the most significant issue. And in the study, 8 options were compared.



Location of Intake Option

8. The comparison of the options was conducted comprehensively in the aspects of technical subjects such as, intake river flow amount, certainty in water treatment, raw water transmission pipe diameter and length, necessity of impounding reservoir and its size, difficulty of construction works, easiness of O&M and cost for construction and O&M.

9. In addition to the technical issues social and environmental aspects were taken into consideration.

Social Environment	Natural environment	Pollution aspect
• Land Acquisition/Resettlement • Economic Activities • Traffic and Public Facilities • Split of Communities • Cultural Property • Water Rights and Rights of Common • Public Health Condition • Waste • Hazards (Risk)	• Topography and Geology • Soil Erosion • Groundwater • Hydrological Situation • Coastal Zone • Fauna, Flora and Protected Area • Meteorology • Landscape	• Air Pollution • Water Pollution (Surface &Groundwater) • Soil Contamination • Noise and Vibration • Land subsidence • Offensive Odour

10. Option 5, to take water from Madhumati River at Mollarhat was selected as optimum option.

11. The issue on salinity intrusion into river water at Mollarhat in the FS the period of high Chloride concentration which exceed the limit of EOQ standard, 1,000 mg/l, was estimated at 45 days based on the mentoring result of DOE in previous years.

12. Meanwhile in 2010 JICA Study Team conducted the monitoring survey in dray season and the result of the survey was only 15 days in April the chloride concentration of the water exceeded the limit of EOQ standard.

13. Based on this result the size and area of the impounding reservoir were determined.

14. Availability of the river water at Mollarhat was justified by the flow rate between intake flow and river flow will be 0.41 % in 2025 and 0.81% in 2030 respectively, and justified as the Madhumati River will possess sufficient water flow enable to demarcate its water to water supply system for Khulna city in future.

15. Regarding water distribution system in Khulna a comprehensive zonal approach was carried out and 5 distribution zones option was selected.

16. Summary of Proposed Water Supply System is as follows,

	Facility Name	Capacity	Quantity
1	Water Intake	110,000m^3/day	1 nos
2	Raw Water Transmission Pipe	-	ϕ 1350mm, L=33km
3	Impounding Reservoir	775,200m^3	1 nos
4	SWTP	110,000m^3/day	1 nos
5	Clear Water Transmission Pipe	-	ϕ 300mm-1100mm, L=25km
6	Distribution Reservoir	10,000m^3 - 20,000m^3	5 nos
7	Overhead Tank	300m^3 - 500m^3	11 nos
8	Distribution Pipe Network	-	ϕ 50mm-400mm, L=700km
9	Service Pipe Connection	-	90,000

17. Proposed sites of new water supply system are as follows,

Name	**Dimension (m)**	**Area**	**Proposed Location**
Water Intake	75 x 125 + Access road	1.0ha	Mollarhat (Madhumati River)
Impounding Reservoir	400 x 400	16 ha	Samanto Sena
Samanto Sena SWTP	250 x 400	10ha	Samanto Sena
Deana West Para Reservoir	100 x 70	0.7ha	Paddy land
Ward No.16 office Reservoir	100 x 70	0.7ha	KCC land
Sonadanga Moha Sarak Reservoir	100 x 90	0.9ha	Personal land
Beside of No.7 Ward office Reservoir	100 x 70	0.7ha	Personal land
Khalishpur Charerhat River Ghat Reservoir	100 x 90	0.9ha	Government land
Rab Sarani Over Head Tank	45 x 30	0.14ha	Personal land
Mujgunni Over Head Tank	45 x 30	0.14ha	KCC land
Ferry Ghat Power House Over Head Tank	45 x 30	0.14ha	KCC land
Andir Pukur Over Head Tank	50 x 35	0.18ha	Personal land
South Side of Ward No. 31 Office Over Head Tank	50 x 35	0.18ha	Paddy land
DPHE Rupsha Over Head Tank	50 x 35	0.18ha	DPHE

18. KWASA were established in February 2008 and the initial organization structure of KWASA is on the way to be approved by the Government. However, this has not yet been secured, thus KWASA has been operating under the LGD-approved organogram (2008), and recently under a revised organogram (2010).

19. In terms of staff, KWASA has a total of 284 personnel. Of this number is the 157 non-permanent posts created by LGD, where 127 have been filled up by former KCC employees; two posts – the Managing Director and Deputy Managing Director for Technical – have been filled through contract; and one post, that of the Secretary, was filled through deputation.

20. The Human Resources Plan for 2017 takes into consideration the proposed organization structure, the full utilization of KWASA's current personnel, the need for additional staff to operate the new system, and the projected number of staffs was to be 502 persons.

21. For the implementation of the project a PMU will be established directly under the Office of the Chief Engineer, and shall be headed by a Project Director.

22. Under the base case scenario (O&M cost recovery tariff), the project will not be financially viable.

- Tk 5/m^3 for domestic and Tk 10/m^3 for non-domestic
- FIRR (Financial Internal Rate of Return) = - 6.09%
- FOCC (Financial Opportunity Cost of Capital) = 0.23%
- FIRR < FOCC, thus not financially viable.

23. The full cost recovery tariffs boost the FIRR.

- Tk 27/m^3 for domestic and Tk 54/m^3 for non-domestic
- FIRR = 0.37%
- FIRR > FOCC, thus financially viable

24. O&M cost recovery tariff is the minimum requirement. KWASA should at least keep the O&M cost recovery tariff. Even if KWASA increases the nominal tariff by 5% a year, the constant tariff (in real terms) may decrease if inflation rate is higher.

25. Depending on conditions of subsidiary loans and grant/loan mix from GOB, KWASA should impose higher tariff than O&M cost recovery level in order to service the debts as much as possible. Full cost recovery tariff is unrealistic but not completely illogical. The rationale is that the full cost recovery tariffs are below affordability to pay price.

26. Domestic user's affordable tariff to pay is estimated at Tk 48/m^3 and Non-domestic user's affordable tariff to pay is estimated at Tk 54/m^3.

27. Net economic benefits of the project will bring economic internal rate of return (EIRR) of 14.41%, exceeding economic opportunity cost of capital (EOCC) of 12%. Thus the Project is economically

viable. Quantifiable economic benefits are: Incremental water, Nonincremental water, Value Added to Tube Well Water, Administrative water loss, O&M cost resource saving, and Residual values.

28. An IEE report for the project was prepared and was approved by MD KWASA on August 2010. DOE issued SCC for the project dated on 18th October 2010 to KWASA of which No. is DoE/Clearance/5021/2010/343 with terms and conditions.

29. An EIA report (Draft Final) for the project was prepared was approved by MD KWASA on November 2010. The official Application form for ECC attaching necessary documents and was submitted to DOE Khulna on 4th November 2010. In accordance with Environmental Conservation Rules, DOE shall issue the ECC for the project within 30 working days, in which terms and conditions will generally be included for the issuance.

30. With regard to necessary land acquisitions for the project, based on relevant rules in Bangladesh Land Acquisition Plan (LAP) / Resettlement Action Plan (RAP) shall be elaborated. In November 2010, a LAP/RAP report (Draft Final) for the project was prepared.

31. Project Implementation Schedule is as flows,

Pledge of JICA Loan	February 2011
Exchange of Note between GOB and GOJ	March 2011
Signing of Loan Agreement	March 2011
Selection of consultant for Designing and Project Management	9 months
Detailed Engineering Design, Preparation of specifications	9 months
Contractor Prequalification (P/Q), evaluation and JICA concurrence	3 months
Tender documents for individual project components, JICA concurrence on tender documents	3 months
Project Tender period	2 months
Evaluation of contractor proposals	2 months
JICA concurrence on tender evaluation (Contractor proposals)	1 month
Contract negotiation	1.5 months
JICA concurrence on contract award	0.5 months
L/C Issuance for project	1 month
Total period of Construction Work	36 months
Completion of the Project and Plant trails	June 2016
O&M Training	12 months (July 2016 to June 2017)

32. Conditions of the cost estimation are,

- Base Year: October, 2010
- Exchange Rate: 1 Taka = 1.23 JPY, 1 USD = 69.4 Taka, 1 USD = 85.5 JPY
- Price Escalation Rate per annum: Foreign Currency = 1.8%, Local Currency = 4.8%
- Physical Contingency: 5%
- Administration Cost: Appropriated for ADB loan
- VAT for local currency: 15% (of the expenditure in local currency of the eligible portion)
- VAT for foreign currency: 15% (of the expenditure in foreign currency of the eligible portion for Consulting Service)

- Import tax: 30% (of the expenditure in foreign currency of the eligible portion for Procurement/Construction)

33. The project cost is estimated as follows.

(US$)

Item	JICA	ADB	GOB	Total
A. Investment Cost				
1. Physical Works and Equipments	145,871,345	57,893,287	34,824,982	238,589,613
2. Consultants	10,865,308	7,345,294		18,210,602
3. Resettlement Cost				
4. Administration Cost		694,196	920,214	1,614,410
Sub-total A	**156,736,653**	**66,308,134**	**41,296,576**	**264,341,363**
B. Contingencies				
1. Physical	8,760,215	2,894,539	1,933,678	13,588,433
2. Price	18,467,650	3,422,192	2,372,333	24,262,176
Sub-total B	**27,227,865**	**6,316,732**	**4,306,012**	**37,850,609**
C. Financing Charges During Implementation				
1. Interest During Implementation		2,571,373	69,817	2,641,191
Sub-total C		**2,571,373**	**69,817**	**2,641,191**
D Tax and Duties			**58,333,278**	**58,333,278**
Grand Total	**183,964,518**	**75,196,239**	**104,005,683**	**363,166,440**

34. The performance indicators for the project are as follows.

Indicator	2010	2016	2018	2025	Remarks
Water coverage (%)	24.1	57.0	62.3	73.5	
Population served	273,555	633,778	766,667	977,089	
NRW ratio (%)	36	25	20	20	
Water produced (m^3/day)	30,100	68,320	121,070	167,950	
Water sold (m^3/day)	29,640	68,110	105,440	167,500	
Meter coverage (%)	0	0	100	100	
Billing ratio (%)	84	100	100	100	
Rate of facility utilization (daily average, %)	0	51	59	100	Surface water

CHAPTER 1 BACKGROUND AND OUTLINE OF THE STUDY

1.1 Background

Khulna, the third-largest city in Bangladesh, is located on the banks of the Bhairab and Rupsha rivers in the southwest of the country. The present water supply to Khulna is mainly from groundwater sources drawn from both deep and shallow tube wells. In the long term as demand increases, conjunctive use of groundwater and surface water will be required, even though surface water may suffer from salinity intrusion in dry season. To cope with current insufficient supply and increasing demand, the Khulna Water Supply and Sewerage Authority (KWASA) had been established in February 2008. And KWASA plans to construct a new water supply system which utilizes surface water with assistance from the Japan International Cooperation Agency and ADB.

The Feasibility Study for Khulna Water Supply Improvement Project in The People's Republic of Bangladesh (hereinafter referred to as "the Study") has been carried out in accordance with the Scope of Work for Feasibility Study for Khulna Water Supply Improvement Project in The People's Republic of Bangladesh agreed upon between Ministry of Finance, Ministry of Local Government, Rural Development and Co-operatives (hereinafter referred to as "MLGRD&C"), Khulna Water Supply and Sewerage Authority (hereinafter referred to as "KWASA") and Japan International Cooperation Agency (hereinafter referred to as "JICA"), Dhaka on 31 March 2009; and Minutes of the Meeting on 2nd Preparatory Study on the Feasibility Study for Khulna Water Supply Improvement Project in The People's Republic of Bangladesh agreed upon between Ministry of Finance, MLGRD&C, KWASA and JICA, Dhaka, signed on 12 August 2009.

JICA had selected the Japanese Study Team (hereinafter referred to as "the Study Team") and dispatched the Study Team to commence the Study on 4 October 2009 and the 1st Field Study started. Based on the findings and discussions with Bangladeshi authorities concerned during the 1st Field Study period the Study Team compiled the Progress Report (1) in January 2010.

On 31 January 2010, LGD held a Steering Committee (hereinafter referred to as "S/C") Meeting with the JICA Study Team and in the meeting the JICA Study Team explained the progress of the Study and the Progress Report (1).

In the 2nd Field study period the JICA Study Team compiled the Interim Report in March based on their analysis and approaches mainly for selection of water intake point.

On May 26 2010, LGD held the 2nd S/C Meeting with the JICA Study Team and in the meeting the JICA Study Team explained the what they had proceeded up to the date and discussed with S/C members what should be clarified to decide the final option of the water intake point.

On July 8 2010, LGD held the 3rd S/C Meeting with the JICA Study Team and in the meeting the JICA

Study Team and all participants agreed to take water at Mollarhat from Madhumati River and to construct a surface water treatment plant and its impounding reservoir at Samanto Sena.

On July 28 2010, LGD held the 4th S/C Meeting with the JICA Study Team and in the meeting the JICA Study Team and all participants agreed with the size of the impounding reservoir at Samanto Sena.

After the 4th S/C, JICA Study Team compiled the result of approached up to that time and draft feasibility study result.

The 3rd Filed Study started on October 4 2010 and the JICA Study Team updated the feasibility study result based on the discussion with Bangladeshi counterparts.

On October 31 2010, LGD held the 5th S/C Meeting with the JICA Study Team and in the meeting the JICA Study Team and all participants agreed with the component of the new project.

And JICA and ADB dispatched a joint appraisal mission to Bangladesh from November 21 to December 2 2010.

This report has been compiled and assembled by the Study Team based on the feedbacks what discussed in the above-motioned joint appraisal mission.

1.2 Objectives of the Study

Through examination of the background, objectives and contents of the project a Long Term Development Plan shall be proposed. And through justification of the possibility of the Japan's ODA loan and its effectiveness, technical and economical feasibility a Feasibility Study shall be conducted.

1.3 Study Area

The Study Area covers the whole area of Khulna Coty Cooperation (KCC) , a part of Phultana Thana and areas of proposed water supply system; intake area , water treatment plant, raw transmission pipeline and clear water transmission pipeline.

The location of Khulna City is shown in the **Figure 1.3.1**.

1.4 Design Years

"Long Term Development Plan of the Water Supply System in Khulna" is set in 2030 to meet the projected the water demand in the study area by 2030.

As for the design year for the Feasibility Study is set in year 2025 in consideration of the new water supply system capacity duration of 10 years i.e. taking into consideration that the assumed time needed for detailed design and project implementation will be up to 2016.

Figure 1.3.1 Location Map of Study Area

1.5 Terms of Reference of the Study

The Terms of Reference identified and agreed between JICA and the Study Team are as follows;

Phase 1: Reconnaissance Survey and Formulation of a Long-term Water Supply Development Program

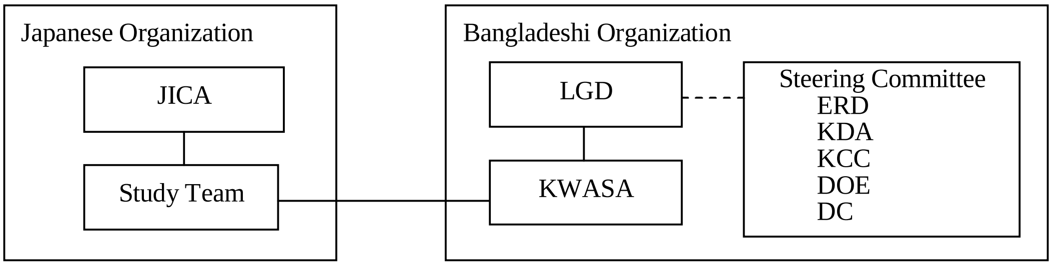
- Existing data analysis and preparation of questionnaires
- Preparation and submission of Inception Report (IC/R)
- Explanation of IC/R and discussion
- Confirmation of long-term plan and policy in water supply sector
- Collection and analysis of relevant data
- River water quality survey (Stage-1)
- Current status of existing water supply system
- Long-term water supply system development plan (Stage-1)
- Preparation and submission of Progress Report 1 (P/R1)
- Long-term water supply system development plan (Stage-2)
- Long-term water supply system development plan (Stage-3)
- Preparation of Interim Report (IT/R)

Phase 2: Feasibility Study for the Priority Projects

- Explanation and discussion on IT/R
- Interim Seminar
- Supplemental Investigations
- Natural condition survey
- Preliminary design
- Preparation and submission of Progress Report 2 (P/R2)
- Preliminary project cost estimation
- Establishment of project implementation plan
- Assistance in preparation of EIA and RAP
- Project evaluation
- Operation and effect index
- Study on future technical assistance and cooperation
- Finalization of long term water supply system development plan
- Recommendation
- Preparation of Draft Final Report (DF/R)
- Submission and presentation of DF/R
- Final Seminar
- Preparation and submission of Final Report (F/R)

1.6 Study Organization

The general organization for the Study is as shown below.



The Japanese organization consists of the Study Team under JICA headquarters. The members of the Study Team are as follows.

Mr. Tadao Funamoto	Team Leader/Water Supply Specialist
Mr. Sumitada Okamoto	Hydrological/Hydraulic Specialist
Mr. Kazuhisa Ogawa	Water Quality Analysis Specialist
Mr. Toru Yagi	Water Intake/Conveyance Specialist
Mr. Toshio Iijima	Water Purification Facility Specialist
Mr. Yasuaki Konda	Mechanical Specialist
Mr. Yoshihiro Akiyama	Electrical Specialist
Mr. Kenji Asano	Water Transmission/ Distribution Specialist
Mr. Satoru Oniki	Implementation Planning/Cost Estimation Specialist
Mr. Satoshi Katchi	-ditto-
Mr. Mitsuhiro Doya	Economics & Finance Specialist
Dr. Consuelo B. Estepa	Administration & Institution/Management Specialist
Mr. Kenji Igarasi	Social/Environmental Specialist

The Bangladeshi organizations consist of the KWASA Counterpart Team, and Steering Committee composed of the representatives of the organizations concerned with the Khulna Water Supply Project in coordination with the KWASA.

The principle members of the KWASA Counterpart Team and the KWASA are as follows:

Mr. Md. Abdullah	Managing Director
Mr. Md. Alim Uddin	Deputy Managing Director (Administration & Finance)
Mr. S. M. Jaglul Haider	Deputy Managing Director (Engineering)
Mr. Md. Moniruzzaman	Secretary
Mr. Sushanta Kumar Kundu	-ditto-
Mr. Mafizuddin Ahamed	Executive Engineer
Mr. Md. Monirul Islam	Assistant Engineer (Electrical)
Mr.Debotos Kumar Das	Assistant Engineer (Civil)
Mr. G. M. Abdul Gaffar	Sub-Assistant Engineer (Electrical/Mechanical)
Mr. Rafiqul Alam	Sub-Assistant Engineer (Civil)

The members of the Steering Committee are as follow:

Mr. Monzur Hossain	Secretary, LGD
Ms. Zuena Aziz	Joint Secretary, LGD
Mr. Tapan Kumar Ghosh	CEO, Khulna City Cooperation
Mr. S. M. Jaglul Haider	Deputy Managing Director (Engineering)
Mr. Kazi Md. Sabirul Alam	Superintend Engineer, Khulna Development Authority
Mr. Ashoke Kumar Biswas	Director, DOE Khulna Division
Dr. Tarun Kanti Sikder	-ditto-

CHAPTER 2 GENERAL DESCRIPTION OF THE KHULNA CITY AREA

2.1 Natural Condition

2.1.1 Topography

(1) Nationwide Area

Bangladesh is a tropical country, situated mainly on the deltas of large rivers flowing from the Himalayas. The Brahmaputra River, known locally as the Jamuna, unites with part of the Ganges to form the Padma, which, after its juncture with a third large river, the Meghna, flows into the Bay of Bengal. Offshoots of the Ganges-Padma, including the Burishwar, Garai, Kopotakkho, and Madhumati, also flow south to the Bay of Bengal. No part of the delta area is more than 150 m above sea level, and most of it is but a meter or two above sea level. Its soil consists mostly of fertile alluvium, which is intensively farmed and mineral deposits are negligible. During the rainy season floodwater covers most of the land surface, damaging crops and injuring the economy.

(2) Khulna Division

Khulna Division is situated in the southeast of Bangladesh and lies in the delta of the River Ganges. The topography is flat, slopes gently towards the Bay of Bengal and is criss-crossed by a network of revivers and canals which are affected by tides and intrusion of seawater.

(3) Khulna City

The city of Khulna is in the northern part of the district, and is mainly an expansion of trade centers close to the Rupsha and Bhairob rivers. The city lies along the River Bhairab over a length of about 15 km, covering area of approximately 45 km^2. Low lying swamps and marshes located in northwest of the city are other major topographic features.

2.1.2 Meteorology

Metrological observation in Bangladesh is conducted under jurisdiction of the Bangladesh Meteorological Department. In Khulna, Jessore and Satkhira, there are meteorological observation stations. Jessore locates in northwest of Khulna and approximately 60 km from Khulna City respectively.

(1) Rainfall

Annual rainfall in Khulna is shown in **Table 2.1.1**. The average annual rainfall during 2004 to 2009 is 1,946 mm.

Table 2.1.1 Rainfall in Khulna

Unit: mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
2004	0	0	7	85	180	383	253	266	621	183	0	0	1978
2005	15	0	148	43	215	102	435	194	410	420	0	0	1982
2006	0	0	5	19	230	262	522	364	579	79	1	0	2061
2007	0	54	14	92	119	374	591	160	397	197	113	0	2111
2008	66	36	48	36	151	190	301	202	379	187	0	0	1596
2009	1	6	10	23	137	233	347	570	357	111	20	0	1815
2010	0	2	14	21	146	287	-	-	-	-	-	-	-
Average (2004-2009/2010)	12	14	35	45	168	262	408	293	457	196	22	0	1924

Source: Metrological Department Climate Division

(2) Evaporation

Annual evaporation in Khulna is shown in **Table 2.1.2**. The average annual evaporation during 2003 to 2007 is 953 mm.

Table 2.1.2 Evaporation in Khulna

Unit: mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	60	85	143	156	169	110	110	116	93	69	78	73
2004	69	110	166	151	179	108	109	91	94	105	91	72
2005	56	71	117	129	134	112	82	71	78	75	77	64
2006	78	83	118	142	121	95	81	96	89	101	87	88
2007	83	72	106	135	139	111	80	106	96	102	77	67
2008	68	79	116	135	137	102	69	95	86	90	89	63
2009	78	83	110	145	146	132	-	-	-	-	-	-
Average (2003-2008/2009)	70	83	125	142	147	110	89	96	89	90	83	71

Source: Metrological Department Climate Division

(3) Temperature, Relative Humidity, Wind and Sunshine

Temperature, relative humidity, wind, sunshine duration in Khulna, and sunshine duration in Jessore are as shown in **Table 2.1.3**.

Table 2.1.3 Temperature, Relative Humidity, and Wind in Khulna/Sunshine Duration in Jessore

Temperature °C of Khulna												
Item	J	F	M	A	M	J	J	A	S	O	N	D
Highest	32.2	36.1	39.4	40.6	41.7	39.4	37.2	36.1	37.2	36.1	34.4	31.7
Av. Max	26.3	29.2	33.4	34.6	34.3	32.6	31.2	31.3	31.7	31.3	29.1	26.7
Av. Min	13.6	16.1	21.0	24.2	25.6	26.1	26.2	26.2	26.0	24.3	19.1	14.7
Lowest	7.2	7.2	10.0	17.8	18.3	21.7	21.7	22.2	22.8	17.8	11.7	7.2
Relative Humidity in % of Khulna												
9 A.M.	73	71	73	76	78	83	86	85	83	78	62	72
6 P.M.	62	55	55	65	74	82	84	84	83	78	69	67
Average wind velocity of Khulna												
Km/hr	3.0	3.9	5.8	7.8	8.9	7.4	7.8	6.9	5.6	3.9	3.2	3.0
ml/hr	1.9	2.4	3.6	4.8	5.6	4.6	4.8	4.3	3.5	2.4	2.0	1.9

Sunshine Duration of Jessore												
Hours of bright sunshine.	9.1	9.5	8.7	8.9	9.7	4.8	5.1	5.7	5.9	8.2	9.3	9.4
Day (Length) (hours)	10.9	11.4	12.0	12.7	13.3	13.6	13.4	13.0	12.3	11.7	11.1	10.7
Sunshine as % of Day Length	83	83	72	70	73	35	38	44	48	70	84	88

2.1.3 Tidal Water Level

Bangladesh Water Development Board (BWDB) is in charge of collects primary data for generating information on the hydrological regime and undertaking necessary technical analyses. BWDB has monitored the tidal water levels their mentoring points in the rive network in Bangladesh. BWDB monitors discharge and water level at each monitoring points; however, regarding tidal water influenced monitoring points BWDB monitor only tidal water level.

The tidal water level monitoring points in Bangladeshi are as shown in **Figure 2.1.1**. All of the rivers which flow surrounding Khulna City are tidal influenced.

Based on the collected tidal data, discussion on the tide for the estimate of saline water intrusion in the rivers surrounding Khulna City is presented in the sub-section 5.4 "Approach of River Water Source Development".

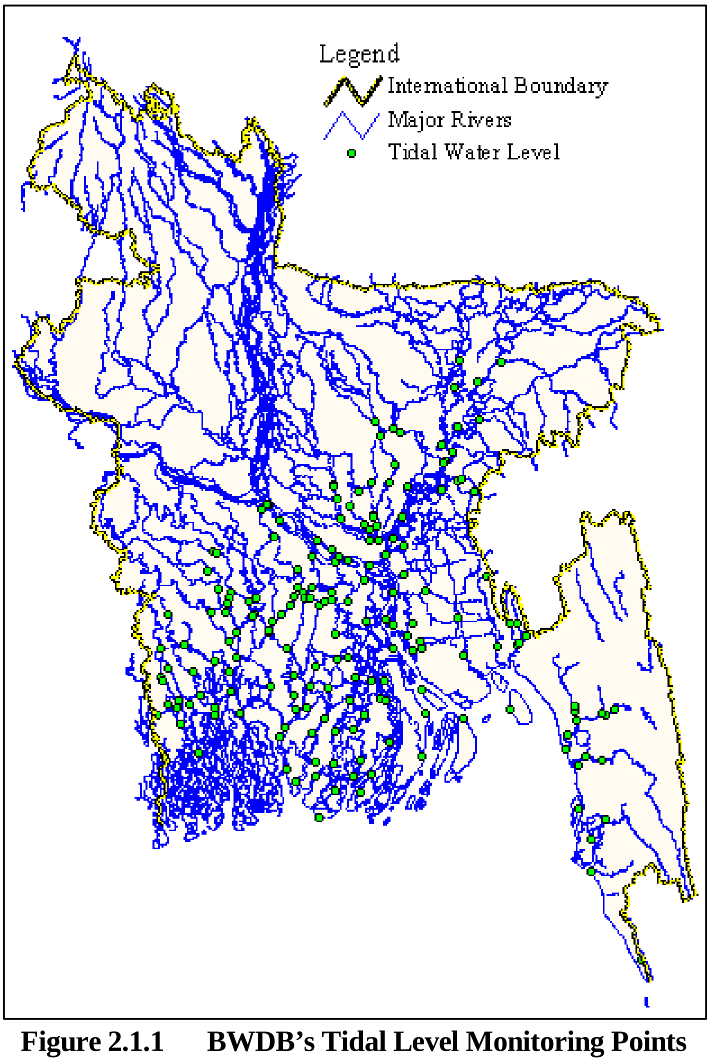


Figure 2.1.1 BWDB's Tidal Level Monitoring Points

2.1.4 Geology

The Khulna City area consists of late Holocene to Recent Alluvium of the Ganges deltaic plain in north and tidal plain in south. The area is composed of sand, silt and clay in various proportions with small amount of coarse sand, which is classified into seven litho-stratigraphic units from base to top. Complexes of channels of fluvial/tidal origin, natural levees, bars, swamps and plains like floodplain, deltaic plains, estuarine plains or coastal plain constitute the Khulna City area. Channels (tidal as well as fluvial), natural levee, flood plain, flood basin, ox-bow lake, abandoned channels, bars, swamps/ flood basins and estuarine plain have been recognized as geomorphologic units within the Khulna City area.

2.2 Legislative Conditions

2.2.1 General

(1) National Water Policy

The government has adopted following of policies to putting matters right in the sector,

- National Water Policy (1999),
- National Water Management Plan (2004),
- National Policy for Arsenic Mitigation (2004)

National Water Policy (1999)

NWP was adopted in 1999 and it explicitly states 6 main objectives

a) To address the use and development of groundwater and surface water in an efficient and equitable way
b) To ensure the availability of water to all parts of the society
c) To accelerate the development of public and private water systems through legal and financial measures and incentives, including appropriate water rights and water pricing rules
d) To formulate institutional changes, encouraging decentralization and enhancing the role of women in water management
e) To provide a legal and regulatory framework this encourages decentralization, consideration of environmental impacts, and private sector investment
f) To develop knowledge and capability in order to facilitate improved future water resources management plans to encourage among other things, broad user participation.

National Water Management Plan (2004)

NWMP was approved by the National Water Resources Council (NWRC) in 2004 and aims at implementing the NWMP within 25 years. It is expected to be reviewed and updated every five years. In 2005, the government included the improvement of water supply and sanitation as part of its agenda for reducing poverty.

National Policy for Arsenic Mitigation (2004)

Complementing the NWP, the government adopted a National Policy for Arsenic Mitigation in 2004. The policy emphasizes public awareness, alternative safe water supply, proper diagnosis and management of patients, and capacity building. In terms of alternative supplies it gives "preference to surface water over groundwater".

The Department of Public Health and Engineering (DPHE) under the Ministry of Local Government, Rural Development and Co-operatives (MLGRD&C) are in charge of assisting municipalities and communities in building water supply infrastructure, exclusive Dhaka, Chittagong and Khulna. For the above three metropolitan areas Water and Sewerage Authority (WASA) is responsible to provide water supply and sewerage facilities to the subscribers.

(2) Legislative Requirement

Access to safe drinking-water is essential to health, a basic human right and a component of effective policy for health protection.

The national Environmental legislation known as Environmental Conservation Act, 1995, is currently the main legislative document relating to Environmental protection in Bangladesh, which repealed the earlier Environmental Pollution Control Ordinance of 1997 and has been promulgated in 1995. In the Environment Conservation Rules, 1997, Standards for water are stipulated.

Table 2.2.1 Standard for Inland Surface Water

Best Practice based classification	pH	BOD mg/L	DO mg/L	Total Coliform number/100
a. Source of drinking water for supply only after disinfecting	6.5-8.5	2 or less	6 or above	50 or less
b. Water usable for recreational activity	6.5–8.5	3 or less	5 of more	200 or less
c. Source of drinking water for supply after conventional treatment	6.5–8.5	6 of less	6 or more	5000 or less
d. Water usable by fisheries	6.5–8.5	6 of less	5 or more	---
e. Water usable by various process and cooling industries	6.5–8.5	10 or less	5 or more	5000 or less
f. Water usable for irrigation	6.5–8.5	10 or less	5 or more	1000 or less
Notes: 1. In water used for pisiculture, maximum limit of presence of ammonia as Nitrogen is 1.2 mg/l. 2. Electrical conductivity for irrigation water – 2250 μmhoms/cm (at a temperature of 25°C); Sodium less than 26%; boron less than 0.2%.				

Table 2.2.2 Standard for Drinking Water

Parameter	Unit	Standards	Parameter	Unit	Standards
1. Aluminum	mg/L	0.2	26. Hardness (as CaCO3)	mg/L	200 – 500
2. Ammonia (NH3)	mg/L	0.5	27. Iron	mg/L	0.3 – 1.0
3. Arsenic	mg/L	0.05	28. Kjeldhl Nitrogen (total)	mg/L	1
4. Balium	mg/L	0.01	29. Lead	mg/L	0.05
5. Benzene	mg/L	0.01	30. Magnesium	mg/L	30 – 35
6. BOD5 20°C	mg/L	0.2	31. Manganese	mg/L	0.1
7. Boron	mg/L	1.0	32. Mercury	mg/L	0.001
8. Cadmium	mg/L	0.005	31. Manganese	mg/L	0.1
9. Calcium	mg/L	75	32. Mercury	mg/L	0.001
10. Chloride	mg/L	150 – 600*	33. Nickel	mg/L	0.1
11. Chlorinated alkanes			34. Nitrate	mg/L	10
carbontetrachloride	mg/L	0.01	35. Nitrite	mg/L	<1
1.1 dichloroethylene	mg/L	0.001	36. Odor	mg/L	Odorless
1.2 dichloroethylene	mg/L	0.03	37. Oil and grease	mg/L	0.01
tetrachloroethylene		0.03	38. pH	--	6.5 – 8.5
trichloroethylene		0.09	39. Phenolic compounds	mg/L	0.002
12. Chlorinated phenols			40. Phosphate		6
pentachlorophenol	mg/L	0.03	41. Phosphorus	mg/L	0
2.4.6 trichlorophenol	mg/L	0.03	42. Potassium	mg/L	12
13. Chlorine (residual)	mg/L	0.2	43. Radioactive materials (gross alpha activity)	Bq/L	0.01
14. Chloroform	mg/L	0.09	44. Radioactive materials (gross beta activity)	Bq/L	0.1
15.Chromium (hexavalent)	mg/L	0.05	45. Selenium	mg/L	0.01
16. Chromium (total)	mg/L	0.05	46. Silver	mg/L	0.02
17. COD	mg/L	4.0	47. Sodium	mg/L	200
18. Coliform (fecal)	n/100mL	0	48. Suspended particulate matters	mg/L	10
19. Coliform (total)	n/100 mL	0	49. Sufide	mg/L	0
20. Color	Hazen unit	15	50. Sulfate	mg/L	400

Parameter	Unit	Standards	Parameter	Unit	Standards
21. Copper	mg/L	1	51. Total dissolved solids	mg/L	1000
22. Cyanide	mg/L	0.1	52. Temperature	°C	20-30
23. Detergents	mg/L	0.2	53. Tin	mg/L	2
24. DO	mg/L	6	54. Turbidity	JTU	10
25. Fluoride	mg/L		55. Zinc	mg/L	5

* Khulna locates in coastal area and in coastal area 1000 mg/L is applied. (Bangladesh Gazette, Addendum, August 28, 1997)

(3) Environmental Requirement

In Bangladesh, the following Policy, Acts and Rules cover and facilitate all the activities regarding environment conservation mainly.

a) Environmental Policy, 1992
b) The Bangladesh Environment Conservation Act, 1995)
c) Environment Conservation Rules, 1997

2.2.2 Water Resource for Water Supply System

The management of water resources has become a critical need in Bangladesh because of growing demand for water and increasing conflict over its alternative uses. In Bangladesh water had been considered as a free gift of nature and access to water is recognised as a basic right. But procedural and fiscal measures are enforced to regulate its mobilisation and use. The Government of Bangladesh has formulated a National Water Policy, which is in operation since1999.

According to the Government policy, the ownership of water does not vest in an individual but in the State.

The Government reserves the right to allocate water to ensure equitable distribution, efficient development and use, and to address poverty. The Government can redirect its use during periods of droughts, floods, cyclones, and other natural and man-made disasters, such as contamination of groundwater aquifers that threaten public health and the ecological integrity. Allocation rules will be the formal mechanism for deciding who gets water, for what purpose(s), how much, at what time, for how long, and under what circumstances water use may be curtailed. Rules for water allocation will be developed for in-stream needs (ecological, water quality, salinity control, fisheries and navigation) during low flow periods; for off-stream withdrawal (irrigation, municipal and industrial, power), and for groundwater recharge and abstraction. Allocation for non-consumptive use (e.g. navigation) would imply ensuring minimum levels in water bodies used for that purpose.

2.2.3 Environmental and Social Consideration

(1) Statute Framework on Environment and Social Aspects

1) Relevant Policy, Strategy and Action Plan

Table 2.2.3 summarizes relevant statute including policy, Strategy and Action Plan on environment and social aspects in Bangladesh.

Table 2.2.3 Relevant Policy, Strategy and Action Plan

Title	Year	Outline
National Environmental Policy (NEP)	1992	NEP was drawn up in1992 based on the IUCN concept of sustainable development, which was an outcome of the National Conservation Strategy. The objectives of NEP are to: ・ Maintain ecological balance and overall development through protection and improvement of the environment ・ Protect the country against natural disasters ・ Identify and regulate activities which pollute and degrade the environment ・ Ensure development that is environmentally sound for all sectors ・ Ensure sustainable, long-term, and environmentally sound use of all national resources ・ Actively remain associated with all international environmental initiatives to the maximum possible extent. For the water resources, the most relevant Policy clauses for FCD/I EAs are: ・ ensure environmentally sound utilization of all water resources. ・ ensure that water development activities and irrigation networks do not create adverse environmental impact. ・ ensure that all steps taken for flood control be environmentally sound at the local, zonal and national levels. ・ ensure mitigation measures of adverse environmental impact of completed FCD/I projects ・ keep the rivers, canals, ponds, lakes, *haors*, *baors* and all other water bodies and water resources free from pollution. ・ ensure sustainable management of underground and surface water resources. ・ conduct EA before undertaking projects for water resources development and management. The Policy was supported by the 1992 NCS and following widespread and lengthy public consultations, by a recommended implementation strategy as part of the 1995 NEMAP.
National Forest Policy (NFP)	1994	NFP of 1994 is the amended and revised version of the NFP of 1977 in the light of the National Forestry Master Plan. The major target of the policy is to conserve the existing forest areas and bring about 20% of the country's land area under the forestation Program and increase the reserve forest land by 10% by the year 2015 through coordinated efforts of GO-NGOs and active participation of the people. Amendments of the existing laws (acts, rules and regulations) relating to the forestry sector and creation of new laws for sectoral activities have been recognized as important conditions for achieving the policy goals and objectives. The Forestry Policy also recognizes the importance of fulfilling the responsibilities and commitments under International Conventions, Treaties and Protocols.
National Water Policy (NWPo)	1999	NWPo of 1999 forms a comprehensive framework for ensuring activities in the water resources sector are fully environment friendly. Its many environmental concerns and specific demands recognize that most of the country's environmental resources are linked to water. Compliance with the Policy will ensure that the development and management of the nation's water resources include protection, restoration, preservation of natural habitats and their dependent bio-diversity, and water quality -with specific provisions for wetlands, mangrove and other forests, and endangered species. NWPo, also prescribes water resource management practices that avoid, or at least minimize environmental degradation. Specific provisions include; ・ Protection, restoration and enhancement of the water resources ・ Protection of water quality, including strengthening of the regulations concerning agrochemicals ・ and industrial effluent monitoring ・ Facilitation of potable water and sanitation provision ・ Provisions for fish and fisheries ・ Participation of local communities is a requirement for all water sector development as a subject to an environmental assessment procedure and for the planning and management process. NWPo, however, fails to address issues like consequences of trans-boundary water disputes and watershed management.

Note: IUCN; International Union for Conservation of Nature and Natural Resources, FCD/I; Flood Control Drainage and Irrigation, EA; Environmental Assessment, NEMAP; National Environmental Management Action Plan, NCS; National Conservation Strategy

JICA Study Team

Table 2.2.4 Relevant Policy, Strategy and Action Plan (Continued)

Title	Year	Outline
National Fisheries Policy	1999	National Fisheries Policy 1999, highlights the need to conserve fish breeding grounds and habitats, especially in the development of water management infrastructure such as FCD/I projects. It clearly points to a determination to prevent further drainage of standing water bodies for agricultural development, and to promote fisheries development in all water bodies. Beyond conservation, the policy emphasizes the need to expand fisheries areas and integrate rice, fish and shrimp cultivation. The policy proposes banning discharges of industrial waste, agro-chemicals and fish-farm chemicals into water bodies. Measures should be introduced to support shrimp culture, with co-ordination through national, divisional, district and than a level committees. Shrimp and fish culture should not be expanded into areas which damage coastal mangrove forests. Implicit in the Policy is the need to conserve fish migration routes which, in turn, implies the need to assess off-site impacts of interventions in the water resources sector.
National Policy for Safe Water Supply & Sanitation	1998	The objectives of the "National Policy for Safe Water Supply and Sanitation" are to improve the standard of public health and to ensure improved environment. For achieving these objectives, steps will be taken for: ・ Facilitating access of all citizens to basic level of services in water supply and sanitation ・ Bringing about behavioral changes regarding use of water and sanitation ・ Reducing incidence of water borne diseases ・ building capacity in local Governments and communities to deal more effectively with problems relating to water supply and sanitation ・ promoting sustainable water and sanitation services ・ ensuring proper storage, management and use of surface water and preventing its contamination ・ taking necessary measures for storage and use of rain water ・ ensuring storm-water drainage in urban areas

National Conservation Strategy (NCS)	1993	Bangladesh's endorsement of the World Conservation Strategy in 1980 was followed by its initiatives for developing a National Conservation Strategy. IUCN Bangladesh Country Office had been an active party to the process all through, which culminated in the preparation and subsequent submission of a draft NCS document with the Cabinet of in 1993. After about one decade of the submission, the IUCN office successfully updated the Draft NCS document and forwarded to the Government for review and approval of the draft. The draft was approved in1993 and it is now to be presented in the National Level Workshop. The Final NCS Document will be modified in the light of feedback and comments to be received from the participants in the workshop.
National Environmental Management Action Plan (NEMAP)	1995	NEMAP, 1995, based on a nationwide consultation programme, was intended to develop the Environmental Policy and the National Conservation Strategy into an implementable strategy. NEMAP has the broad objectives of: ・ Identification of key environmental issues affecting Bangladesh; ・ Identification of actions necessary to halt or reduce the rate of environmental degradation; ・ Improvement of the natural and built environment; ・ Conservation of habitats and biodiversity; ・ Promotion of sustainable development; and ・ Improvement in the quality of life of the people. In addition, it identified the main national environmental issues, including those related to the water sector which EA (Environmental Assessment) practitioners should note. The main national concerns included flood damage, riverbank erosion, environmental degradation of water bodies, increased water pollution, shortage of irrigation water and drainage congestion; various specific regional concerns were also identified. A surprising omission, however, was specific mention of fisheries issues, but these may have been perceived as 'fish' rather than a 'water resources' concern. Arsenic contamination of groundwater used for potable water supply did not appear as an issue, as the threat had not then been identified.
Flood Action Plan (FAP)	1990	FAP an initiative to study the causes and nature of flood in Bangladesh and to prepare guidelines for controlling it. FAP included 29 different components of which 11 were regional, with some pilot projects, and the rest were supporting studies on issues like Environment, Fisheries, Geographic Information System, Socio-economic studies, Topographic Mapping, River Survey, Flood Modeling, Flood Proofing, Flood Response, etc. The aim of FAP is to set the foundation of a long-term programme for achieving a permanent and comprehensive solution to the flood problem.

Note: IUCN; International Union for Conservation of Nature and Natural Resources, FCD/I; Flood Control Drainage and Irrigation, EA; Environmental Assessment, NEMAP; National Environmental Management Action Plan, NCS; National Conservation Strategy

2) Relevant Act, Ordinance Rules

Table 2.2.5 summarizes relevant Acts, Ordinances and Rules on environment and social aspects in Bangladesh.

Table 2.2.5 Relevant Act, Ordinance Rules

Title	Year	Outline
Bangladesh Forest Act	1927	The Act of 1927 provides for reserving forests over which the government has an acquired property right. This act has made many types of unauthorized uses or destruction of forest produce punishable. The Government may assign any village community its right to or over any land, which has constituted a reserved forest.
The Private Forest Ordinance	1959	The Private Forest Ordinance of 1959 provides for the conservation of private forests and for the forestation, in certain cases, of wastelands in Bangladesh.
East Bengal Protection and Fish Conservation Act	1950	The East-Bengal Protection and Fish Conservation Act of 1950, as amended by the Protection and Conservation of Fish (Amendment) Ordinance of 1982 and the Protection and Conservation of Fish (Amendment) Act of 1995, provides provisions for the protection and conservation of fish in inland waters of Bangladesh. This is relatively unspecific and simply provides a means by which the Government may introduce rules to protect those inland waters not in private ownership. This is framework legislation with rule making powers. Among others, some of these rules may: Prohibit the destruction of, or any attempt to destroy, fish by the poisoning of water or the depletion of fisheries by pollution, by trade effluent or otherwise.
The Embankment and Drainage Act	1952	An Act to consolidate the laws relating to embankment and drainage and to make better provision for the construction, maintenance, management, removal and control of embankments and water courses for the better drainage of lands and for their protection from floods, erosion or other damage by water
Antiquities Act	1968	Antiquity act (ACT No. XIV of 1968) was set by the Government in 1968 to the preservation and protection of antiquities in the country
Bangladesh Wildlife Act	1973	The Bangladesh Wildlife (Preservation) Act of 1973 provides for the preservation, conservation and management of wildlife in Bangladesh. The earlier laws on wildlife preservation, namely, the Elephant Preservation Act 1879, the Wild Bird and Animals Protection Act 1912, and the Rhinoceros Preservation Act 1932 have been repealed and their provisions have been suitably incorporated in this law. This Act encompasses a range of different activities including hunting and fishing although the provisions of greatest significance relate to the establishment of National Parks, Wildlife Sanctuaries and Game Reserves by MoEF. Such designations have enormous significance for the types of developments that may take place. An executive order issued in June 1998, in relation to the Bangladesh Wildlife Preservation Order of 1973 has imposed a ban for the next five years on hunting of any form of wildlife.
Protection and Conservation of Fish Rules	1985	These are a set of rules in line with the overall objectives of the Fish Act. Section 5 of the Rules requires that "No person shall destroy or make any attempt to destroy any fish by explosives, gun, bow and arrow in inland waters or within coastal waters". Section 6 of the Rules states -"No person shall destroy or make any attempt to destroy any fish by poisoning of water or the depletion of fisheries by pollution, by trade effluents or otherwise in inland waters".
Environmental Conservation Act (ECA 1995) Amended in 2000 & 2002	1995	ECA 1995, the principal legislation for environment protection in Bangladesh, is promulgated for environment conservation, environmental standards development and environment pollution control and abatement. A key provision in the Act is that No industrial unit or project shall be established or undertaken without obtaining an ECC from the DG of DoE in the manner prescribed by the Environmental Rules The main strategies of the Act can be summarized as:

		• Declaration of ecologically critical areas and restriction on the operations and processes, which can or cannot be carried/initiated in the ecologically critical areas • Regulations in respect of vehicles emitting smoke harmful for the environment • Environmental clearance • Regulation of the industries and other development activities' discharge permits • Promulgation of standards for quality of air, water, noise and soil for different areas for different purposes • Promulgation of a standard limit for discharging and emitting waste; and • Formulation and declaration of environmental guidelines. The following shows amendments of the Act • The amendment in 2000 of ECA focuses on: (1) ascertaining responsibility for Compensation in cases of damage to ecosystems, (2) increased provision of punitive measures both for fines and imprisonment and (3) fixing authority on cognizance of offences. • The amendment in 2002 of ECA elaborates on: (1) restriction on polluting automobiles, (2) restriction on the sale and production of environmentally harmful items like polythene bags, (3) assistance from law enforcement agencies for environmental actions, (4) break up of punitive measures and (5) authority to try environmental cases.
Environmental Conservation Rules	1997	Promulgated under ECA of 1995, the Environment Conservation Rules of 1997 provides categorization of industries and projects and identified types of environmental assessments needed against respective categories of industries or projects. The rules set ; 1) National Environmental Quality Standards for ambient air, various types of water, industrial effluent, emission, noise, vehicular exhaust etc. 2) Requirements for and procedures to obtain environmental clearance 3) Requirements for IEE /EIA's according to categories of industrial and other development interventions
Urban open-fields, Garden and Natural Water-bodies Protection Act	2000	Those sites throughout urban areas should preserve their individual characters and should not be leased out or transferred to any other authority. Any encroachment to these areas will be strictly controlled.
Environmental Court Act	2000	By this act the Government shall establish one or more environment court in each Division and each environment court shall be constituted with one judge and, in consultation with the Supreme Court; the Government shall appoint an officer of the judicial service of the rank of Joint District Judge. An Environment Court shall be competent to impose penalty for offences under section 5A of this Act and under any other environmental law, to confiscate an equipment or part thereof, a transport used in the commission of such offence or an article or other thing involved with the offence, and to pass order or decree for compensation in appropriate cases.

Note: MoEF; Ministry of Environment and Forest

3) Multilateral Environmental Agreements in force in Bangladesh

Relevant international treaties, conventions and so on to which Bangladesh is a party are summarized in **Table 2.2.6**.

Table 2.2.6 International Conventions, Protocols and Treaties on Environment

No.	Title	Signed	Ratified/Accessed/ Accepted/Adaptation	Being Ratified
1.	International Plant Protection Convention (Rome, 1951)		1978	
2.	International Convention for the Prevention of Pollution of the Sea by Oil (London, 1954 (amended in 1962 and 1969.)		1981 (entry into force)	
3.	Plant Protection Agreement for the South East Asia and Pacific Region (as amended) (Rome, 1956)		1974 (AC) (entry into force)	
4.	Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water (Moscow, 1963)	1985		
5.	Treaty on Principles governing the Activities of States in the Exploration and use of outer Space Including the Moon and Other Celestial Bodies (London, Moscow, Washington, 1967)		1986 (AC)	
6.	International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (Brussels, 1969)		1982 (entry into force)	
7.	Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, 1971) ("Ramsar Convention")		1992 (ratified)	
8.	Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxic Weapons, and on Their Destruction (London, Moscow, Washington, 1972.)		1985	
9.	Convention Concerning the Protection of the World Cultural and natural Heritage (Paris, 1972)		1983 (Accepted), (ratified)	
10.	Convention on International Trade in Endangered Species of Wild Fauna and flora (Washington, 1973) ("CITES Convention")	1981	1982	
11.	United Nations Convention on the Law of the Sea (Montego Bay, 1982)		1982	
12.	Vienna Convention for the Protection of the Ozone Layer (Vienna, 1985)		1990 (AC), (entry into force)	
13.	Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal 1987)		1990 (AC), (entry into force)	

13a.	London Amendment to the Montreal Protocol on substances that Deplete the Ozone Layer (London, 1990)		1994 (AC), (entry into force)	
13b.	Copenhagen Amendment to the Montreal protocol on Substances that Deplete the Ozone Layer, Copenhagen, 1992		2000 (AT), 2001 (Entry into force)	
13c.	Montreal Amendment of the Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal, 1997		2001 (Accepted), (Entry into force)	
14.	Convention on Early Notification of a Nuclear Accident (Vienna, 1986)		1988(ratified &entry into force)	
15.	Convention on Assistance in the Case of a Nuclear Accident of Radiological Emergency (Vienna, 1986)		1988(ratified &entry into force)	
16.	Agreement on the Network of Aquaculture Centres in Asia and the Pacific (Bangkok, 1988)		1990(ratified)	
17.	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel, 1989)		1993 (AC)	
18.	International Convention on Oil Pollution Preparedness, Response and Cooperation (London, 1990)	1990		*
19.	United Nations Framework Convention on Climate Change, (New York, 1992)	1992	1994	
20.	Convention on Biological Diversity, (Rio De Janeiro,1992)	1992	19.94	
21.	International Convention to Combat Desertification, (Paris 1994)	1994	1996(ratified &entry into force)	
22.	Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, (Geneva, 1976)		1979 (AC) (entry into force)	
23.	Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982 (New York, 1994)	1996		
24.	Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (New York, 1995)	1995		

Note: AC: Accession/Accessed, AD: Adaptation/Adapted, AT: Accepted, *; In the process of ratification
Source; DoE

Table 2.2.7 International Conventions, Protocols and Treaties on Environment (continued)

No.	Title	Signed	Ratified/Accessed/ Accepted/Adaptation	Being Ratified
25.	Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (Paris, 1993)	1993		
26.	United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (Paris, 1994)	1994	1996	
27.	Convention on Nuclear Safety (Vienna, 1994)	1995	1995 (AT)	
28.	Cartagena protocol on Biosafety to the Convention on Biological Diversity	2000		*
29.	Convention on persistent Organic Pollutants, Stockholm	2001		*
30.	Kyoto protocol to the United Nations Framework Convention on Climate Change		2001 (AC), 1997 (AD)	

Note: AC: Accession/Accessed, AD: Adaptation/Adapted, AT: Accepted, *; In the process of ratification
Source; DoE

(4) Environmental Conservation Rules 1997 and Environmental Clearance System

As specified in Clause 7 of the Environmental Conservation Rules 1997, all new industries and projects must apply for a Site Clearance Certificate (SCC) and/or an Environmental Clearance Certificate (ECC). For the purpose of the issuance of ECC, the industries and projects are classified according to their sites and potential impact on the environment into the four (4) categories as shown in **Table 2.2.8**. Details can be found in the Rules, especially, Schedule 1 attached in the Rules provides the Category classification of most common industries, in which “Water Distribution Line (Laying /Relaying/Extension) and “Water Treatment Plant” projects are classified as “Red” Category.

Table 2.2.8 Four Categories of Industries and Issuance of SCC and/or ECC

Category	Issuing of SCC and/or ECC	Time Period from receipt of application

		SCC	ECC
1. Green	An ECC shall be issued to all existing and proposed industrial units and projects	-	~ 3 w. days
2. Amber-A	For industrial units and projects firstly a SCC and thereafter an ECC shall be issued	~ 15 w. days	~ 7 w. days
3. Amber -B	For industrial units and projects firstly a SCC and thereafter an ECC shall be issued	~ 30 w. days	~ 15 w. days
4. Red	For industrial units and projects firstly a SCC and thereafter an ECC shall be issued	~ 30 w. days	~ 30 w. days

Note: SCC; Site Clearance Certificate, ECC; Environmental Clearance Certificate, ~ ; within, w. days; wording days

Source; Environmental Conservation Rules 1997, MoEF, SRO No, 118-Law/2008, Environmental Conservation Law, 1995, 2008, MoEF,

Provided that the Director General (DG) of DoE may, without issuing a SCC at the first instance, directly issue ECC if DG, on the application of an industrial unit or project, considers it appropriate to issue such certificate to the industrial unit or project.

1) Application for SCC and/or ECC

The entrepreneur of the concerned industrial unit or project shall apply to the concerned Divisional Officer of DoE in Form-3 along with appropriate fees as specified in Schedule- 13 attached in the Rule. The necessary documents to be attached with an application for SCC and/or ECC by the each category are summarized in **Table 2.2.9**.

Table 2.2.9 Necessary Documents Applied for ECC by Category

Category	Necessary Documents
1. Green	i. General information about the industrial unit or project ii. Exact description of the raw materials and the manufactured product an iii. NOC from the local authority
2. Amber -A	i. General information about the industrial unit or project ii. Exact description of the raw materials and the manufactured product iii. NOC from the local authority iv. Process flow diagram v. Layout Plan (showing location of ETP) vi. Effluent discharge arrangement vii. Outlines of the plan for relocation, rehabilitation (if applicable); viii. Other necessary information (if applicable)
3. Amber- B	i. F/S report of the industrial unit or project (applicable only for proposed industrial unit or project) ii. (ii) IEE Report of the industrial unit or project, and also the process flow diagram, Layout Plan (showing location of Effluent Treatment Plant), design of ETP of the unit or project (these are applicable only for a proposed industrial unit or project) iii. EMP report for the industrial unit or project, and also the Process Flow Diagram, Layout Plan (showing location of Effluent Treatment Plant), design of ETP and information about the effectiveness of the ETP of the unit or project, (these are applicable only for an existing industrial unit or project) iv. NOC from the local authority; v. Emergency plan relating adverse environmental impact and plan for mitigation of the effect of pollution vi. Outline of the relocation, rehabilitation plan (where applicable) vii. Other necessary information (where applicable)
4. Red	i. F/S report of the industrial unit or project (applicable only for proposed industrial unit or project) ii. IEE report relating to the industrial unit or project, and also the TOR for the EIA of the unit or the project and its Process Flow Diagram or EIA report prepared on the basis of TOR previously approved by the Department of Environment, along with the Layout Plan (showing location of ETP), Process Flow Diagram, design and time schedule of the Effluent Treatment Plant of the unit or project, (these are applicable only for a proposed industrial unit or project) iii. EMP Report for the industrial unit or project, and also the Process Flow Diagram, Layout Plan (showing location of ETP), design and information about the effectiveness of ETP of the unit or project (these are applicable only for an existing industrial unit or project) iv. NOC from the local authority v. Emergency plan relating adverse environmental impact and plan for mitigation of the effect of pollution; vi. Outline of relocation, rehabilitation plan (where applicable) vii. Other necessary information (where applicable)

Note: NOC; No Objection Certificate, ETP; Effluent Treatment Plant, F/S; Feasibility Study, IEE; Initial Environmental Examination, TOR; Terms of Reference, EIA; Environmental Impact Assessment, EMP; Environmental Management Plan

Source: Environmental Conservation Rules 1997, MoEF

2) Actions may/shall be taken by Applicant after Issuing of SCC

Upon receiving a Site Clearance Certificate (SCC) from DoE, the entrepreneur (applicant);

① may undertake activities for land and infrastructure developments

② may install machinery including an Effluent Treatment Plant (ETP) (applicable for industrial units or projects of Amber-A and Amber-B Category only)

③ shall apply for an ECC upon completion of the activities specified in a. and b. above, and without the ECC shall not have gas line connection, and shall not start trial production in the industrial unit, and in other cases shall not operate the project (applicable for Amber-A and Amber-B Category industrial units or projects only)

④ shall submit, for approval of the Department, the EIA report prepared on the basis of program outlined in the IEE Report along with time schedule and the ETP design (applicable only for Red Category industrial units or projects);

3) Flow Chart of Environmental Clearance Procedure

Figure 2.2.1 shows the flow chart of the environmental clearance procedures for industrial projects.

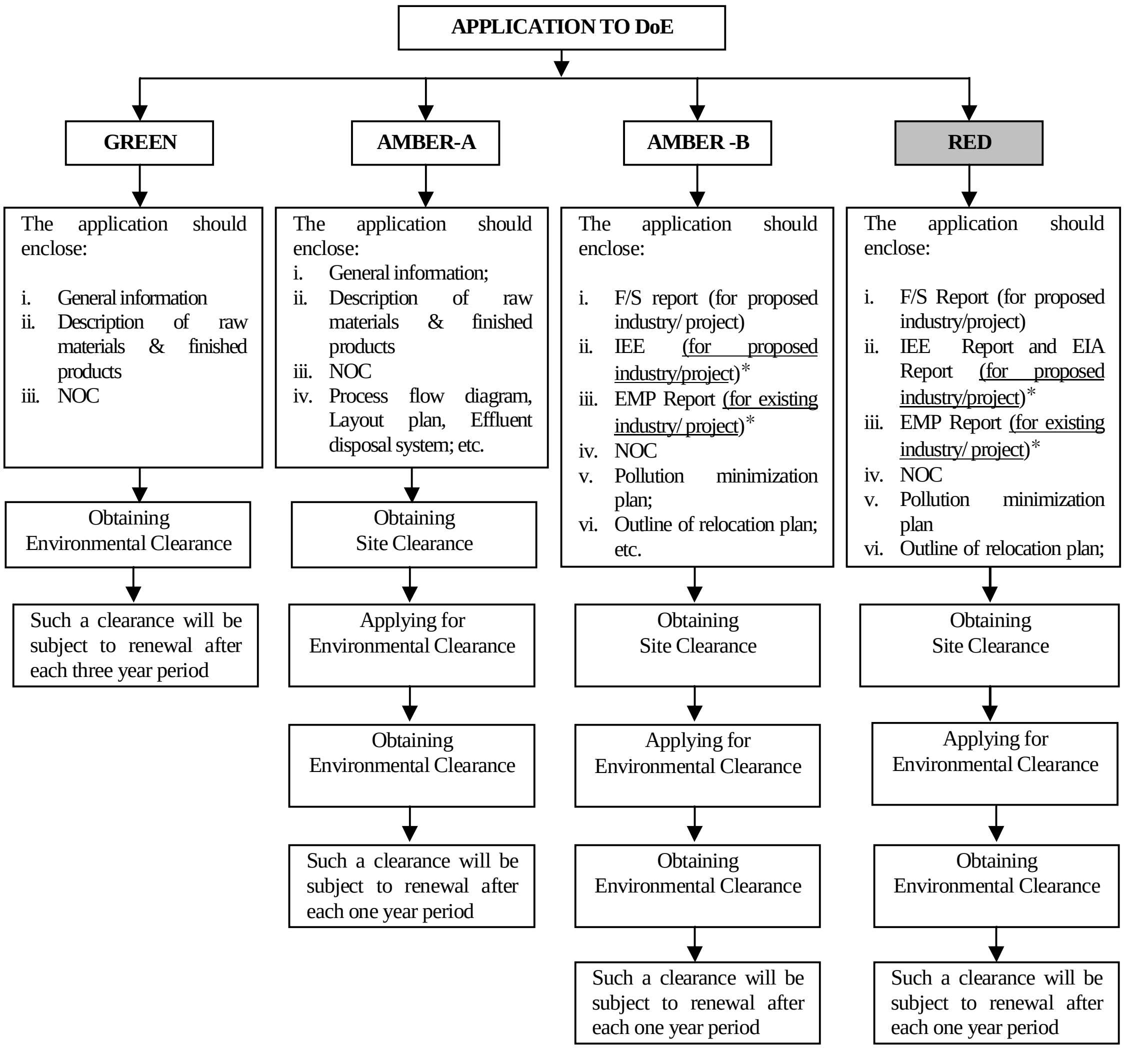
4) Validity period of ECC

Table 2.2.10 shows the period of validity of an ECC and it renewal period.

Table 2.2.10 Validity Period of ECC

Category	Validity period from ECC issuance Date	Renewal Period (days before expiry of its validity period)
1. Green	Three (3) years	at least thirty (30) days
2. Amber-A	One (1) year	at least thirty (30) days
3. Amber -B	One (1) year	at least thirty (30) days
4. Red	One (1) year	at least thirty (30) days

Source; Environmental Conservation Rules 1997, MoEF



NOC ; No Objection Certificate, usually obtained from local government, F/S; Feasibility Study, IEE; Initial Environmental Examination, TOR; Terms of Reference, EIA; Environmental Impact Assessment, EMP; Environmental Management Plan,
__* ; See 3) Environmental Assessment Process in WARPO Guidelines

Source: EIA Guidelines for Industry 1997. DoE. MoEF.

Figure 2.2.1 Flow Chart of Environmental Clearance Procedure

(5) Environmental Assessment Procedures in Bangladesh

Environmental Assessment (EA) system and its procedures are dealt with in the framework of the Environmental Clearance system mentioned in (2) above.

1) Guidelines

Relevant official entities including DoE and Local bodies has published a set of environmental guidelines and manuals for conducting environmental assessment and management of different types of projects including water supply and management as shown in **Table 2.2.11**.

Table 2.2.11 Environmental Guidelines on Environmental Assessment & Management

Title	Year	Outline
Guidelines for Environmental Assessment of	1994	The purpose of this guideline is to enable the local level engineers (Thana Engineers) and other technical staff to better appreciate the environmental issues related to small-scale (less than 1000 ha benefited area) selected infrastructure development and equip them to carry out environmental

Small-scale Projects		impact assessment and incorporate the environmental protection parameters in the project preparation process. The guidelines are planned to enable the Thana Engineers to analyze the adverse environmental consequences of projects and adopt appropriate measures to eliminate, reduce to acceptable levels or offset such adverse consequences through proper planning and design and thus to optimize overall socio-economic benefits. The ultimate purpose of the guidelines is to strengthen and guide the initiatives of LGED to ensure planned development of physical infrastructure facilities taking environmental and social dimensions into consideration at the local level. The guidelines constitute simple procedures and formats to guide Initial IEE and EIA of proposed projects and draw up plans for environmental management. The guidelines may also be used to conduct IEE and EIA of ongoing and implemented projects to identify potential negative impacts and to design environmental protection measures and appropriate monitoring programmes.
Guidelines for Project Assessment (GPA)	1994	Developed by FPCO in 1994, GPA aims to ensure that all project components are assessed in a similar manner and to permit MCA techniques to be used when comparing proposed project or component alternatives.
Manual on EIA for large-scale projects	1995	Under FAP, a manual on EIA was prepared in 1995 (ISPAN, 1995) so that all FAP regional plans and projects are subject to a comprehensive and uniform EIA. The goal of all environmental assessments is to protect the environment by ensuring that only environmentally sound projects are designed and implemented. In EIA, positive and negative impacts are identified and either project designs are altered or mitigation measures are developed to lessen or alleviate negative ones. Public participation is central to the process and should take place at all stages of an EIA. The EIA involves an integrated assessment of the impacts of a project or plan on both natural and human environments. It focuses on linkages among the physical-chemical, biological, social and economic components of the environment.
EIA Guidelines for Industries	1997	The Guidelines sets out the procedures for environmental clearance of projects by DoE, as required by the Environmental Conservation Rules (DoE, 1997). Although intended primarily for the industrial sector, the procedures also apply to FCD/I projects. Namely, the guidelines covers significant water sector interventions, including flood control embankments, polders, dykes, water supply and sewage treatment, as well as roads and bridges. All these water sector interventions fall under the 'Red' category, with the exception of bridges less than 100 m long, and feeder and local roads. This requires the most stringent EIA process to be followed for proposed project construction, re-construction and extension. The responsibility for following the environmental assessment procedure lies with the project proponent or developer. The procedures are different, depending upon the categorization of the proposed intervention. The two most stringent classes, Orange/Amber B and Red, are required to have an IEE, with an EMP. The red classification requires an additional full EIA to be undertaken. Once DoE approves these documents, then a SCC is issued - provided the developer has obtained an NOC from the local authority.

Note: LGED; Local Government Engineering Department, FCD/I; Flood Control Drainage and Irrigation, FAP; Flood Action Plan, FPCO; Flood Plan Co-ordination Organization, MCA; Multi-criteria Assessment, ISPAN; Irrigation Support Project for Asia and the Near East,

Source; State of Environment Bangladesh 2001, MoEF, DoE,
Guidelines for Environmental Assessment of Water Management (Flood control, Drainage and Irrigation) Projects 2005 WARPO,
Integrating Environmental Considerations into the Economic Decision-Making Process, ESCAP

Table 2.2.12 Environmental Guidelines on Environmental Assessment & Management (continued)

Title	Year	Outline
EIA Guidelines for the Water Resources Sector	1992	The environmental component of the FAP-16, drew up a set of EIA Guidelines, which were approved by the MoEF and DoE for use in the water resources sector; and they were adopted by FPCO and WARPO in 1992. In addition to the water resources EIA Guidelines, FAP 16 drafted a manual in 1995 for carrying out EIA. The manual was intended to assist people not familiar with EIA work, and to give more detail on the use of the Guidelines for a wide range of water sector projects. Under SEMP, the DoE has recently started drafting 18 sets of sectoral EIA Guidelines. In 2003, WARPO in collaboration with DoE modified the guidelines as "Guidelines for Environmental Assessment of Water Management (Flood control, Drainage and Irrigation) Projects (as shown in the following column)
Guidelines for People's Participation in Water Management (GPP)	2000	GPP was finalized jointly by the Ministry of Water Resources (MOWR) and the Ministry of Local Government Division (LGD) also provide insight into people's participation in small scale water resources development projects (GPP, 2000) .
Guidelines on Participatory Water Management	2001	The guidelines were prepared by Bangladesh Water Development Board (BWDB) of LGED in 2001 which sets out the procedures for people's participation.

Guidelines for Environmental Assessment of Water Management (Flood control, Drainage and Irrigation) Projects	2003	These Guidelines for Environmental Assessment are an update of the "EIA Guidelines for the Water Resources Sector" for assessment of FAP projects by FPCO in 1992 under the FAP 16 activities. The "Guidelines for Environmental Assessment of Water Management Projects (FCD/I)" was prepared on December, 2001 and approved by MoEF in 2003. The Guidelines cover EA - a process that covers two key activities of IEE and EIA at the planning level. All agencies involved in the planning, implementation, operation and maintenance and monitoring of FCD/I projects should use these Guidelines to assist in drawing up a TOR for environmental studies, in monitoring the studies and in evaluating the resulting EA reports.
Sectoral Guidelines for Environmental Management		These guidelines covering 18 sectors which have potentially great impacts on the environment (DoE, under the Sustainable Environmental Management Programme (SEMP), in preparation

Note: LGED; Local Government Engineering Department, EA; Environmental Assessment, EIA; Environmental Impact Assessment, IEE; Initial Environmental Examination, EMP; Environmental Management Plan, FCD/I; Flood Control Drainage and Irrigation, FAP; Flood Action Plan, FPCO; Flood Plan Co-ordination Organization, MCA; Multi-criteria Assessment, ISPAN; Irrigation Support Project for Asia and the Near East, WARPO; Water Resources Planning Organization, TOR; Terms of Reference

Source; State of Environment Bangladesh 2001, MoEF, DoE,
Guidelines for Environmental Assessment of Water Management (Flood control, Drainage and Irrigation) Projects 2005 WARPO
Integrating Environmental Considerations into the Economic Decision-Making Process, ESCAP

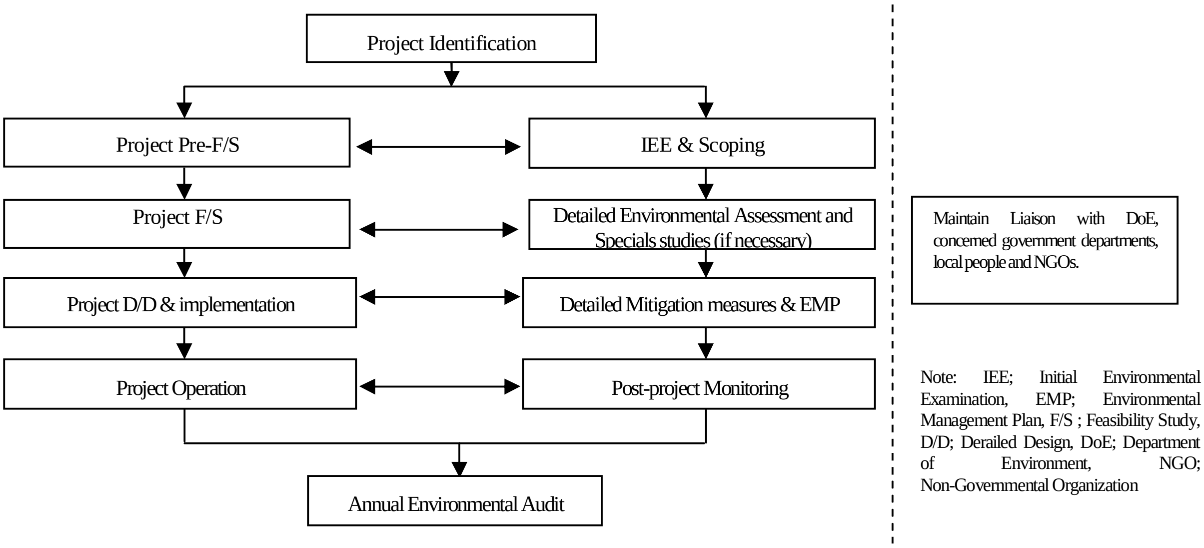
Among those "EIA Guidelines for Industries" and "Guidelines for Environmental Assessment of Water Management (Flood control, Drainage and Irrigation) Projects" initially be made reference to this JICA project in Khulna.

2) Environmental Impact Assessment (EIA) Process

In Bangladesh, according to the EIA Guidelines for Industry 1997 DoE, The EIA Process can be summarized as follows;

- The primary responsibility for carrying out an EIA study of any project lies with the project proponent. The proponent may get the study done through the in-house expertise or through a project consulting agency or an independent environmental consulting agency having requisite qualification to perform the task.
- EIA should be carried out in tiers and as indicated in **Figure 2.2.2**. It will be seen from this figure that the EIA procedure should be initiated simultaneously with the project planning and the level of efforts required for various tiers of EIA should be commensurate with the project development, throughout the stages of its identification to implementation. Thus the environmental planning should be project centered and integrated with the project.
- The TOR for EIA study has been indicated in the form of structures of an IEE report and EIA report, respectively. These will normally be found meeting the study requirement in most of the EIA studies.
- The important stages in the development of an EIA study are:
  - Screening / scoping
  - Identification of significant environmental issues and how these will be resolved
  - Adequacy of imitative measures and an Environmental Management Plan (EMP)
- At this stage, interaction among the DoE, concerned other Governmental Departments/Authorities, NGOs and the people likely to be affected may be establish, in order to formulate views and suggesting and consider them while preparing further proposals for development of the project and environment planning.
- Review of an EIA report in the responsibility of DoE wherein the review exercise will be carried

out either through the staff of DoE and /or an Environmental Clearance Committee (ECCo) to be appointed by the Government. Namely the EIA will be reviewed by the respective Divisional office of DoE whereby the review report will be submitted for consideration by DG (Director General) at DoE for the entire industrial project, which require IEE/EIA (Refer to **Figure 2.2.2** below). Then the Environmental Clearance Committee (ECCo) will call the proponent to give presentation about the project objective, strategy, remedial action, findings and etc. The office of the DG will make final decision which will be communicated to respective Divisional office, who in turn, will communicate to the entrepreneur.



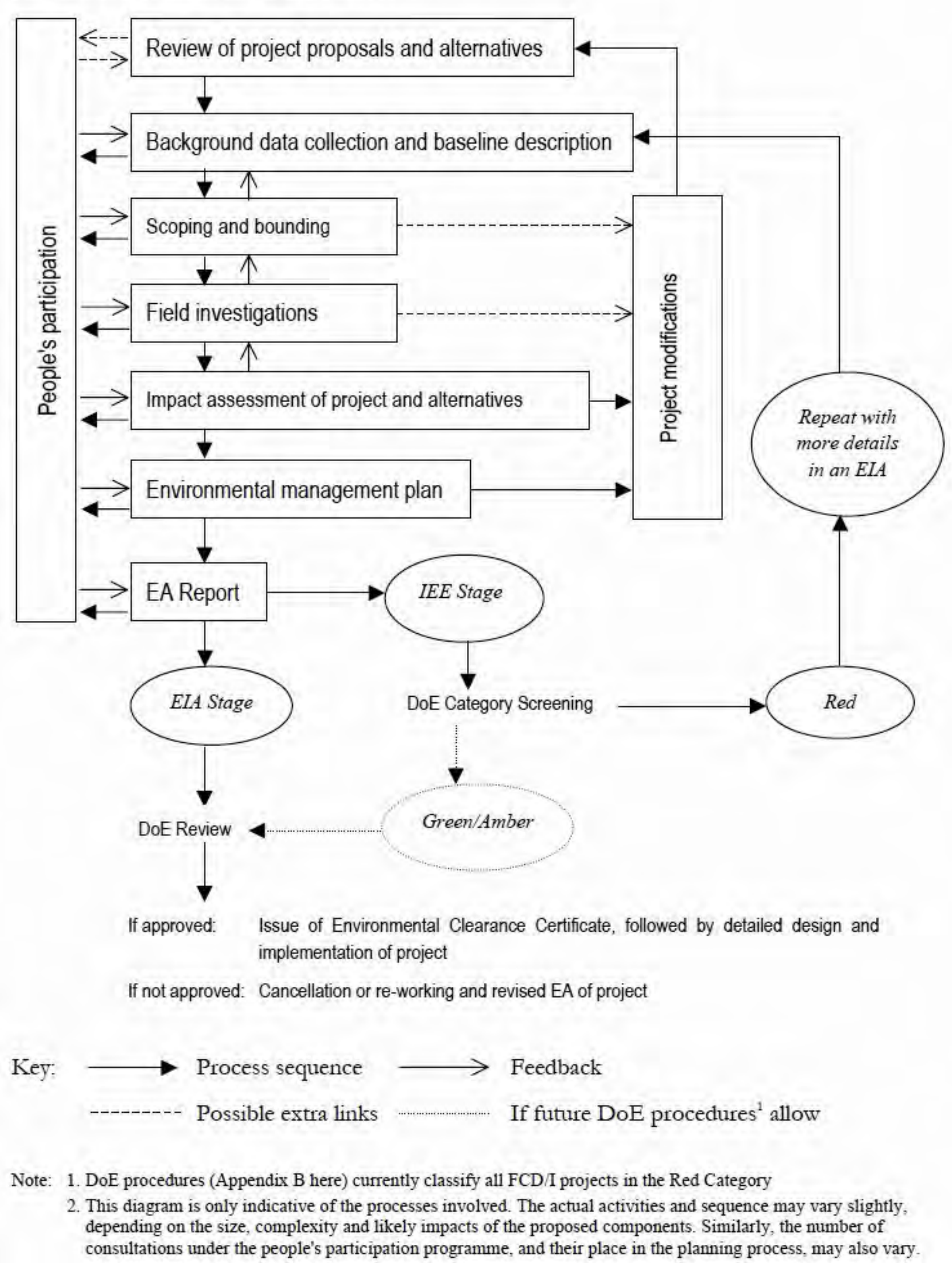
Source; EIA Guidelines for Industries 1997 DoE

Figure 2.2.2 Project Planning, It's Implementation and EIA Process

- Finally, DoE will issue environmental clearance to a project, or reject it, or call for some more information/studies before clearance in accorded. The environmental clearance may be subject to such conditions as may be considered necessary from the point of view of environmentally should implementation and operations of the project.

- Environmental Assessment (IEE & EIA) Process in WARPO Guidelines

In addition, the Guidelines for Environmental Assessment of Water Management (FCD/I) Projects 2005 WARPO, which basically follows the EIA Guidelines for Industries 1997 DoE, depicts a process for Environmental Assessment (EA) including IEE and EIA that employs a people's participation oriented approach as shown in **Figure 2.2.3**.

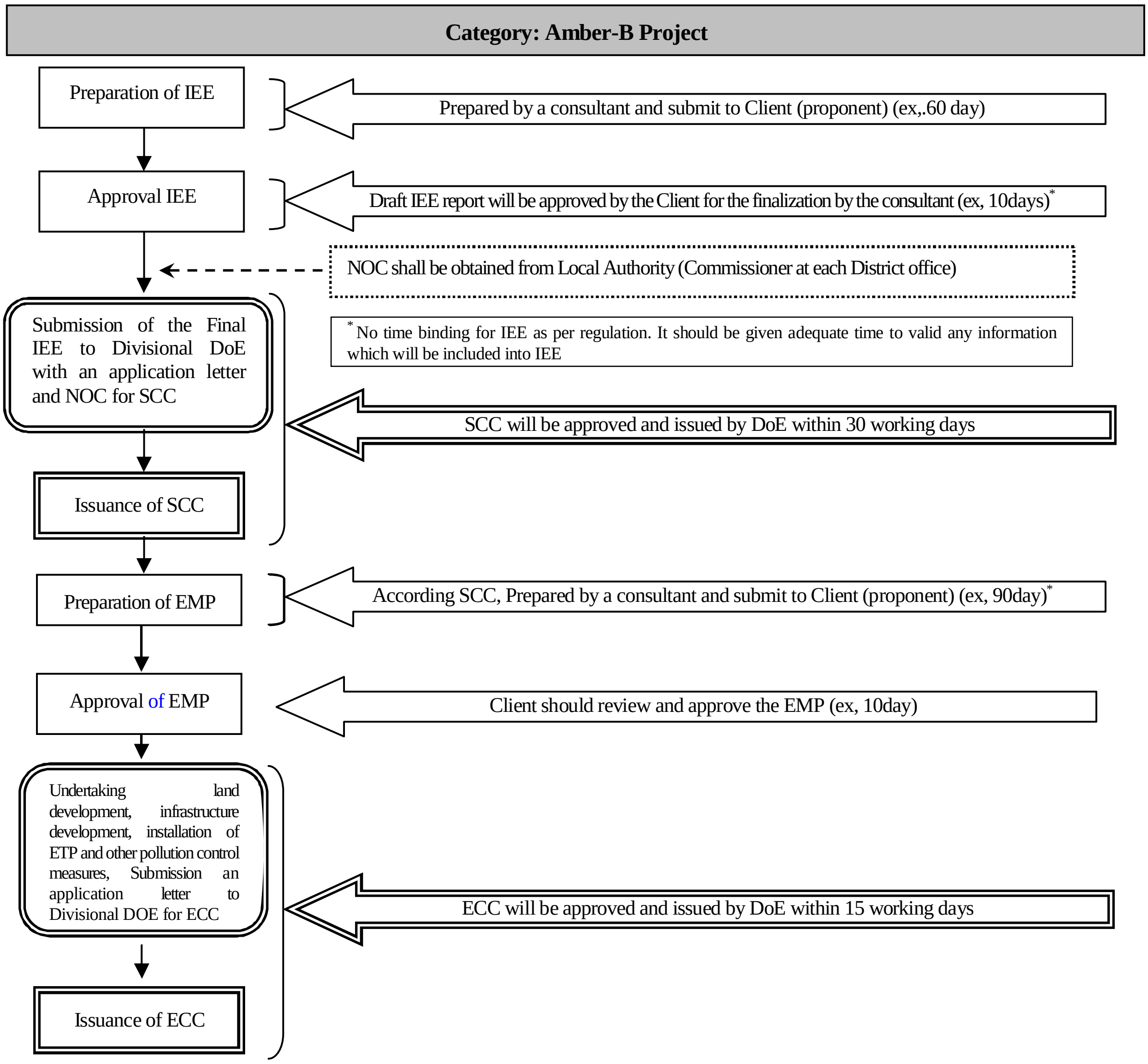


Source; Guidelines for Environmental Assessment of Water Management (FCD/I) Projects 2005 WARPO

Figure 2.2.3 Key Steps in the Environmental Assessment for FCD/I Projects

The Guidelines of WARPO mentions that the DoE procedures currently classify all FCD/I projects in the "Red" Category. In addition, the Guidelines of WARPO basically employs the "Flow Chart of Environmental Clearance Procedure" shown in **Figure 2.2.1**. However, the requirements of WARPO vary from those of the DoE 1997, in requiring an IEE, EIA and EMP for proposed, as well as existing industry/ projects (asterisk and underlined explanation in **Figure 2.2.1**) which are omitted in the WARPO Guidelines. As well, the "Guidelines" notes that automatic application of the Red Category procedures and regular renewal of the Certificates is not appropriate for all FCD/I projects, especially small interventions with minimal impacts. Unless/until the procedures are formally revised, the DoE should be consulted for guidance on individual projects.

3) Sequence between Environmental Clearance system and Environmental Assessment Procedures

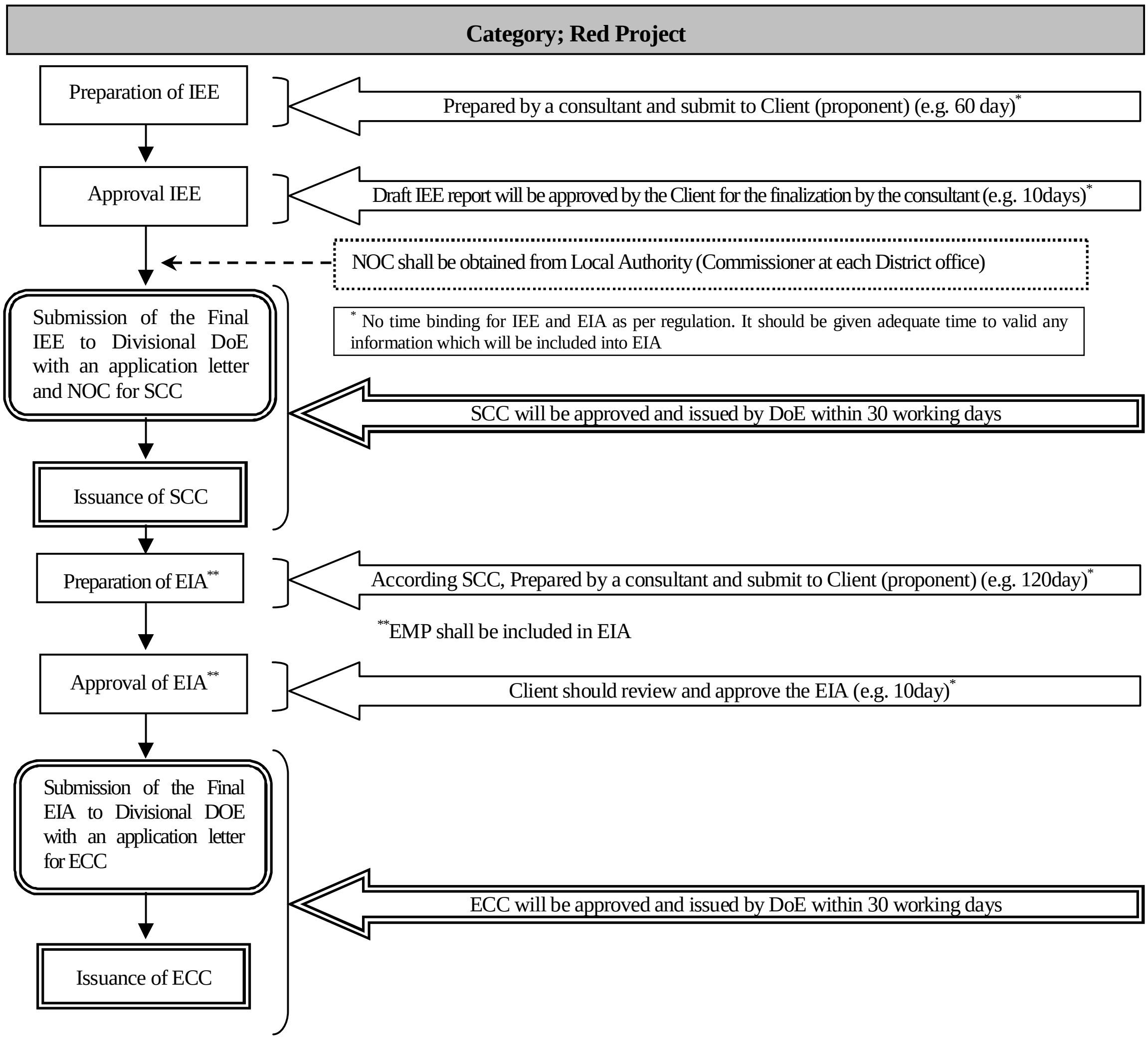


IEE; Initial Environmental Examination, No Objection Certificate EMP; Environmental Management Plan, SCC; Site Clearance Certificate, ECC; Environmental Clearance Certificate, ETP: Effluent Treatment Plant

JICA Study Team

Figure 2.2.4 Environmental Clearance & Environmental Assessment in Amber-B Category

As mentioned above, the Environmental Assessment (EA) system and its procedures are dealt with in the framework of the Environmental Clearance system. **Figure 2.2.4** and **2.2.5** show sequence between the “Environmental Clearance system” and “Environmental Assessment Procedures” in case of Amber-B and Red Projects.



IEE; Initial Environmental Examination, EIA; Environmental Impact Assessment, No Objection Certificate, EMP; Environmental Management Plan, SCC (Site Clearance Certificate), ECC; Environmental Clearance Certificate
JICA Study Team

Figure 2.2.5 Environmental Clearance & Environmental Assessment in Red Category

4) Public Participation

The "EIA Guidelines for Industries" mentions the public participation as follows;

- ***Public Participation;*** Since the general public is the ultimate recipient of the economic benefits and environmental damages, an EIA study should involved the public as part of the decision making process development. To achieve effective public participation, it is necessary to communicate with as many people as possible, as early as possible, and through as many different ways possible. This requires pre-planning, resources, identification of target groups and a variety of techniques for effective communication. Some of the techniques which could be adopted are;

- Radio and Television
- News releases
- News Letters
- Advertisements
- Sample polls
- Lobbying
- Workshops
- Public Meetings
- Public Hearings (consultations)
- Information van
- Citizens advisory committee

In addition, "Guidelines for Environmental Assessment of Water Management (Flood control, Drainage and Irrigation) Projects" notes as follows:

- ***People's Participation during IEEs;*** People's participation at the IEE stage involves four steps:

- Wide and effective dissemination of information on potential interventions
- Local-level meetings and discussions, identifying problems and developing a problem-solving process
- Inventory of problems/ constraints and potentials
- Assessment and reconnaissance of social, agricultural, fishery, livestock and environmental issues

- ***People's Participation during EIAs;*** During EIAs, the participation should be more detailed, involving:

- Identification of all stakeholders - individuals, communities and government and nongovernmental agencies at all levels from the project site to regional and central agencies
- Application of field methods to ensure full participation, including social assessment by surveys and participatory rapid rural appraisal
- Assessment of the capacity of local stakeholder to participate effectively and implementation of measures to ensure the latter (e.g. by involvement of NGOs to help voice local concerns)
- Identification of support of, and opposition to, the proposed project and enhancement/mitigation measures.

However, "Public Hearing" (to disclose a draft or summary EIA report to public for asking comments upon it, which usually seen in other countries) is not identified in the EIA procedures in Bangladesh.

5) JBIC Environmental & Social Consideration Guidelines[*]

Based on the JICA's policy on the environmental and social consideration for Japanese loan projects, KWASA shall refer to the JBIC Environmental & Social Consideration Guidelines[1], which is exclusively used for JICA's roan projects at present. In the Guidelines, "Screening Form" and "Sectoral Environmental Check List" of No.18 Water supply are attached, which shall be prepared by KWASA in consultation with the JICA Study Team in the timing of the feasibility study of the project.

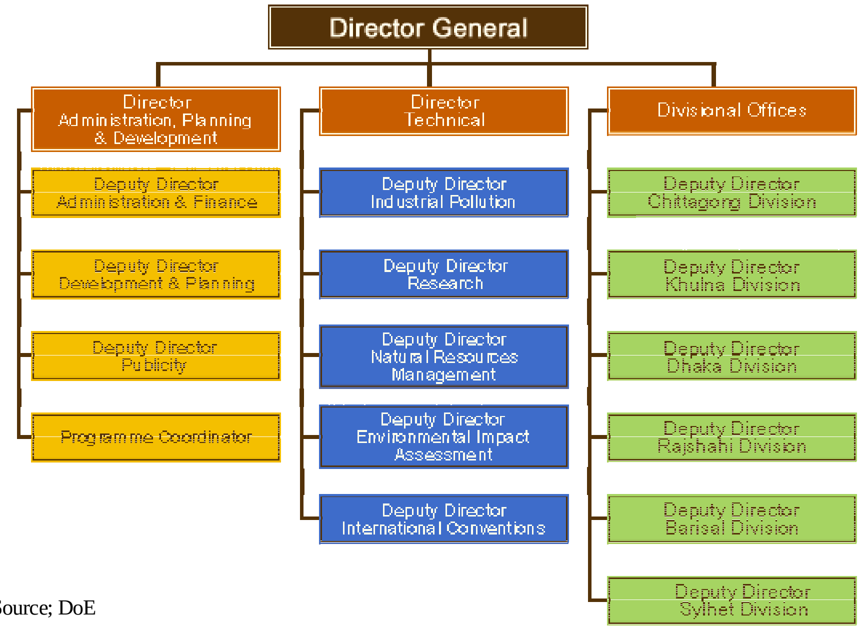
(6) Environmental Management System in Bangladesh, Khulna and KWASA

1) Department of Environment

Under the Ministry of Environment and Forest (MoEF), the DoE is the practical official entity for managing environment and evaluating IEE and EIA reports to be submitted. Headquarters of DoE is located in Dhaka and organized into two main functions of "Administration, Planning and

[1] JICA was merged with the Overseas Economic Cooperation Operation of JBIC (Japan Bank for International Cooperation) for ODA loan projects in October 2008. Therefore, the JBIC Environmental & Social Consideration Guidelines is being used for Japanese ODA loan projects by JICA as of March in 2010.

Development" and "Technical", each of which is headed by a Director. There are 4 Units under Administration, Planning and Development and 5 under Technical, each headed by a Deputy Director or equivalent, among which the Technical Unit is in charge of Environmental Assessment (evaluation IEE/EIA and issuing SCC and ECC). (See **Figure 2.2.6**)



Source; DoE

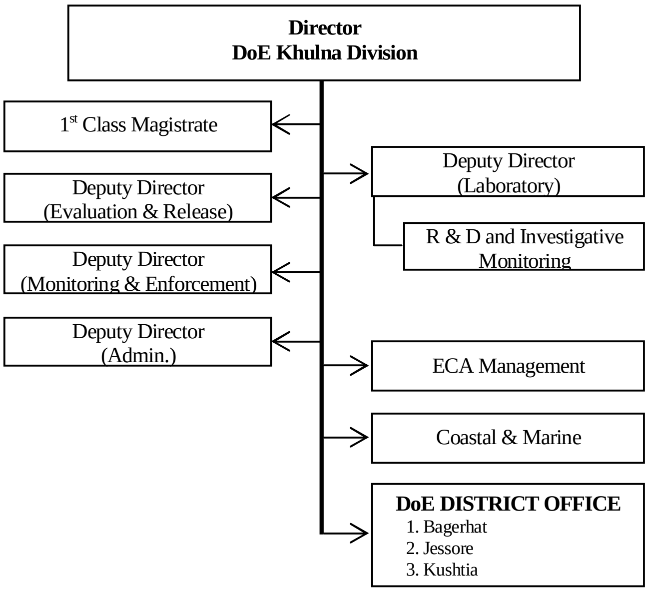
Figure 2.2.6 DoE Organization Chart and EIA Unit

2) Divisional Level

As shown in **Figure 2.2.6**, there are six Divisional Offices that carry out enforcement activities including overall management of the environment supported by the laboratory analysis.

In case of approval of EIA, after the submission, it is initially checked and verified at divisional level. Later on, it is sent to a committee, called "Environmental Clearance Committee (ECCo)" formed by the Director General (DG) of DoE, where the EIA report is reviewed in detail, recommended to Deputy Director of DoE for rejection or approval. The decision is sent to divisional officials to issue approval or rejection letter, usually with condition. Once the mitigation measures are place as recommended in the EIA report, proponent applies for ECC to relevant Divisional DoE office. After the field inspection by the DoE Officials and then the DoE will send an ECC application with their recommendations to ECCo at Dhaka office. ECCo make recommendation on the application to DG for his decision. After DG'S approval, the divisional officer issues ECC. (See **Figure 2.2.8**)

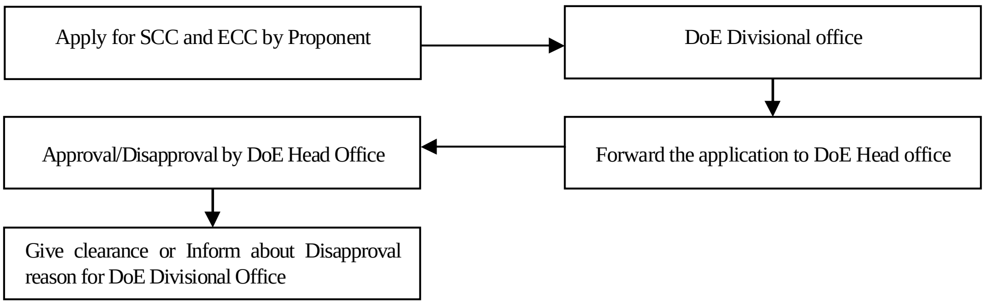
In addition, Environmental monitoring in EIA and /or IEE, each Divisional Office including Khulna will follow as per the direction of the DoE, Head Office.



Note; ECA; Environmentally Critical Areas

Source; DoE

Figure 2.2.7 Organization Chart of DoE Khulna Division



Source; DoE Khulna Divisional Office

Figure 2.2.8 Environmental Clearance Flow between DoE Head Office & Divisional Office

3) KWASA

In KWASA, a new official entity in Khulna that was set up in 2009, but it has no section in charge of environmental assessment and theses experiences at all.

2.2.4 Land Acquisition and Resettlement

(1) Statute Framework on Land Acquisition and Resettlement

Table 2.2.13 shows relevant ordinance and acts on land acquisition and resettlement in Bangladesh.

Table 2.2.13 Relevant ordinance and Act on land acquisition and resettlement

Title	Year	Outline
Acquisition and Requisition of Immovable Property Ordinance	1982	The Ordinance (Ordinance 11 of 1982) has replaced the Land Acquisition Act of 1894 and the East Bengal (Emergency) Requisition of Property Act of 1948. The Ordinance governs acquisition and requisition by the government of immovable property for any public purpose or in the public interest. It may be noted that contrary to the previous Acts (i.e. Act XIII of 1948), this Ordinance deals only with immovable property. Detailed procedures have been prescribed to ensure that a deputy commissioner proceeds systematically and on sound principles in such cases, leaving room for owners to raise objections which must be disposed of after due hearing. In addition, the Ordinance has well-defined procedures regarding payment of compensation for an acquired piece of land. If, for example, the land is used for rice growing, then an amount equivalent to approximately 1.5 times the market value of a given variety of rice (e.g., paddy) that is currently being (or could be) produced annually is fixed as a yearly lease value. In case of outright purchase (carried out on a 99-year lease), the compensation-value of acquired land varies widely according to the locality, soil fertility, and access to transportation and related infrastructure factors. The current compensation and resettlement provisions are however inadequate both in terms of timing of payments and quantum. The procedures involved are cumbersome and time consuming and often causes hindrance to the smooth execution of the project. Legal provisions covering adequate compensation to the project affected persons, particularly disadvantaged groups such as women & squatters and such other vulnerable groups are yet to be framed.
The Acquisition of Immovable Property Rules 1982	1982	The Acquisition of Immovable Property Rules of 1982 , are made for the exercise of the powers conferred upon by Section 46 of the Acquisition and Requisition of Immovable Property Ordinance 1982.
Land Reform Ordinance	1984	Under the Ordinance 1984, families owning lands up to 60 Bighas (about 6.7 ha) at a given time were to be barred from acquiring further land by purchase, inheritance, or otherwise. A family or person inheriting lands in excess of 60 Bighas would have to surrender the 'surplus' land, for which due compensation was to be paid. In addition, the Ordinance is a bar on the eviction from rural homestead, even in the process of law, for non-payment of rent or tax.
The Movable Property Requisition (Compensation) Rules, 1990	1990	The Rules makes provision for constituting a Compensation Assessment Committee in each district for determining compensation for any requisitioned vehicle, vessel or bus, truck, minibus etc. In case of requisition of a vehicle or vessel, the order of requisition should clearly state the period of requisition, purpose of requisition, and the amount of compensation to be awarded.
Acquisition and Requisition Act, 1994 **(under determining compensation)**	1994	In December 1994 the government passed a rule in order to amend the provisions of the Acquisition of Property on Emergency Basis Act 1989 for determining compensation under the Acquisition and Requisition Act. According to this Rule, in case of an arbitration suit lodged against the compensation determined by the Deputy Commissioner an increase of only an additional 10 %t of the compensation can be awarded by the Arbitrators. Similarly, the Arbitration Appellate Tribunal should limit its award to within this additional 10 %.

Source; Acquisition and Requisition of Immovable Property Ordinance 1982,
Land Reform Ordinance, 1984
Banglapedia "National Encyclopedia of Bangladesh", February 2006, Asiatic Society of Bangladesh

(2) Land Acquisition and Compensation Systems

Land Acquisition and its compensation systems in Bangladesh can be summarized as follows:

- Special attention has to be made for vulnerable, indigenous people and female headed households, as applicable, from resettlement point of view in case of donor supported projects. Though not legally obligated, the government takes care about providing these facilities through administrative instance.
- As mentioned above, Acquisition and Requisition are held under the Acquisition and Requisition Immoveable Property Ordinance (ARIPO) of 1982 and its subsequent amendments in 1993 and 1994. It covers all cases of acquisition and requisition by the government for public purpose and interest.
- The legal process is initiated by the Deputy Commissioner (DC) of the concerned district with a detailed map of the area and a land acquisition plan. The DC is empowered to exercise permanent acquisition or temporarily requisition of property and pay compensation to legal owners.
- The DC assesses the level of compensation, taking into consideration of the factors such as, land

transaction in the locality over the past twelve months by averaging recorded land price categorically in the land registry office. Consideration for extra payment is based on land market survey. The value ascertained thereof is treated as present market value of the acquired land.

- The amendments, which has been made to the ARIPO in 1993 has increased the amount of the premium (to reflect market or replacement values) for compulsory acquisition from 25% to 50% on the assessed value of the property. The 1994 amendment provides provision for payment of crop compensation to tenants. ARIPO does not cover compensation for loss of wage income for floating people; it also doesn't cover losses of non-titled persons (squatters, encroachers, etc) aside from crop losses to tenants.

- The policy framework and entitlements for the Projects are all based on this national law called Acquisition and Requisition of Immovable Property Ordinance of 1982.

- For the purpose of acquisition and requisition of immovable properties in Bangladesh, the government, taking into consideration all previous Acts, Rules, Ordinances etc., have prepared 'Acquisition of Immovable Properties Manual-1997'. This manual guides all acquisition and requisition of immovable properties, for all related purposes whatsoever as well as payment of compensation for all sorts of losses.

1) Step-wise Land Acquisition Process

The Acquisition of Immovable Property Rules of 1982 (No. S.R.O. 172-U82) are made for the exercise of the powers conferred upon by Section 46 of ARIPO. The rules spell out the procedural details required for the acquisition of immovable properties as follows:

i. Proceedings for acquisition
ii. Issuing Notices under sections 3, 6, and 7
iii. Declaration of acquisition and possession
iv. Declaration of abatement and revocation of proceedings
v. Transfer of acquired land
vi. Assessment of compensation, and
vii. Unutilized acquired property

In other words, when the pre-requisites are fulfilled, the step-wise activity of land acquisition process that has to be followed is given below:

a. Receive NOC (No Objection Certificate) of land from Khulna Development Authority
b. Submission of land acquisition proposal by the requiring body to the Deputy Commissioner (DC)
c. Holding District Land Acquisition meeting and providing land allocation
d. Declare Notice under Section 3 to the affected persons

e. Joint verification of the acquired property
f. Final approval of land to be acquired by the Divisional Commissioner (for area of land 50 Bighas (Approximately 6.7 ha) or less) or the Land Ministry (for area of land over 50 Bighas) on the basis of land area requirement
g. Declare Notice under Section 6 to settle any dispute
h. Estimation of jointly verified property for the cost of compensation and informing requiring body.
i. Acceptance of estimated cost for compensation and placement of fund to the Deputy Commissioner by the requiring body
j. Declare Notice under Section 7 by the Deputy Commissioner to the affected land owners for disbursement of compensation
k. Disbursement of compensation as per estimate to the affected persons
l. Giving possession of land to the requiring body
m. Cash Compensation under the Law (CCL) payment by the DC.

2) Time frame of Final Decision of Land Acquisition

As mentioned above, depending on total property areas to be acquired the following will be preceded for the final decision of Land Acquisition according principally to ARIPO.

- Property exceeds fifty (50) Bighas (Approximately 6.7 ha): the DC submits the record of the proceedings including a report prepared by the DC for the decision of <u>the Bangladesh Government</u>.

- Property does not exceed fifty (50) Bighas (Approximately 6.7 ha): the DC submits the record of the proceedings including a report prepared by the DC for the decision of <u>the Divisional Commissioner.</u>

After considering the report submitted by the DC, the Government (in case of exceeds fifty Bighas) or the Divisional Commissioner (in case of not exceed fifty Bighas) makes a final decision about acquisition of the property within the time limitation as summarized in **Table 2.2.14**.

Table 2.2.14 Time Frame of Final Decision of Land Acquisition

Property	Submissions by DC	Final Decision	Days from the submissions' date
> 50 Bighas	Record of the proceedings including a report by DC	By the Bangladesh Government (Local Land Authority)	Within 15 days, or within such further time but not exceeding one (1) month
≤ 50 Bighas	Record of the proceedings including a report by DC	By the Divisional Commissioner.	Within 90 days

Note: DC; District Deputy Commissioner, 50 Bighas; Approximately 6.7 ha
Source: Acquisition and Requisition of Immovable Property Ordinance 1982

3) Compensation System

Since the provision of land for cash compensation under the law 1982 (CCL) for land will be determined and paid by the concerned Deputy Commissioner (DC) using funds provided by the project executing agency.

Further, as per the existing law under 1982, the DC of the respective District shall consider CCL includes 50% premium. Additional grants will be provided up to the Maximum Allowable Replacement Value (MARV). Separate market survey of land will be needed during the period of implementation for determination of MARV. In addition, the DC is legally bound to pay compensation money for the acquired land, structures and trees. Apart from payment of CCL (Cash Compensation under the Law which includes 50% premium) money, the DC is doing all recognized efforts in regaining previous socio economic position of affected persons.

A joint inventory verification team (JIVT) will be proposed for determining the amount of Project Affected People (PAPs)' assets loss and it is treated as Property valuation advisory team (PAVT) regarding determination of exact additional compensation other than DC's payment, as well as for redressing the grievances which is named "Grievance Redress Committee (GRC)" that may arise during implementation.

Video filming will be needed as a precaution to check against fake structures on the proposed alignment before serving notices for land acquisition. Adequate information campaign will be carried out for ensuring participation of PAPs/ beneficiaries in the implementation of RAP.

4) Public Consultations on land Acquisition

In accordance relevant laws and guidelines noted above, the process of public consultation is to be initiated and conducted in two stages as follows.

a. The 1st stage (Focus Group Discussion):

- During earlier IEE & EIA/ Resettlement Action Plan (RAP) studies through Focus Group Discussion (FGD) at and around different spots of the project at around different areas of the proposed study.
- Representative(s) of concerned local government will also present in these meetings to understand the people's views and suggestions. Leaflets on the proposed project in Bengali were distributed among the participants. An open discussion was made on the proposed project and its positive and negative impacts, and then people's perceptions were written by the project proponent representatives for record and reference.
- The salient features of the opinions expressed by the participants of different profession have divulged in general that they are concerned with due compensation and rehabilitation wherever any damage will be done and with request for providing water in their localities on priority basis.
- Though they have, in general, appreciated laying of as a development work of the country and in their opinion, it will help setting up industries, generate employment and its nature of impact is usually temporary, but note of caution was there from them that the work should be done carefully to avoid any accident in future and reinstatement along the alignment has to be done properly and promptly after completing the total works.

b. The 2nd stage (Project Affected Person)

- Since the relevant work could not be covered during the monsoon season, direct one to one consultation with each individual Project Affected People (PAP) at all affected household (HH) during the stage-2 of consultation will be conducted in the dry season.

- Project Affected Person and members of the local government, local elites and people of different profession, representatives, its survey concerned organization and donor agency will be present to understand the views and suggestions of the PAP and the local people when the background, nature and components of project, summary findings of the Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) studies will be considered in respect of its positive and negative impacts etc including market value of their assets being affected, payment of compensation and grievance redress mechanism need to be discussed in details.

5) Land Acquisition Flow and Organizational Setting

Based on the above reviews on land acquisition and compensation system, the process can be summarized as shown in **Figure 2.2.9** and the organizational setting can be depicted as shown in **Figure 2.2.10**.

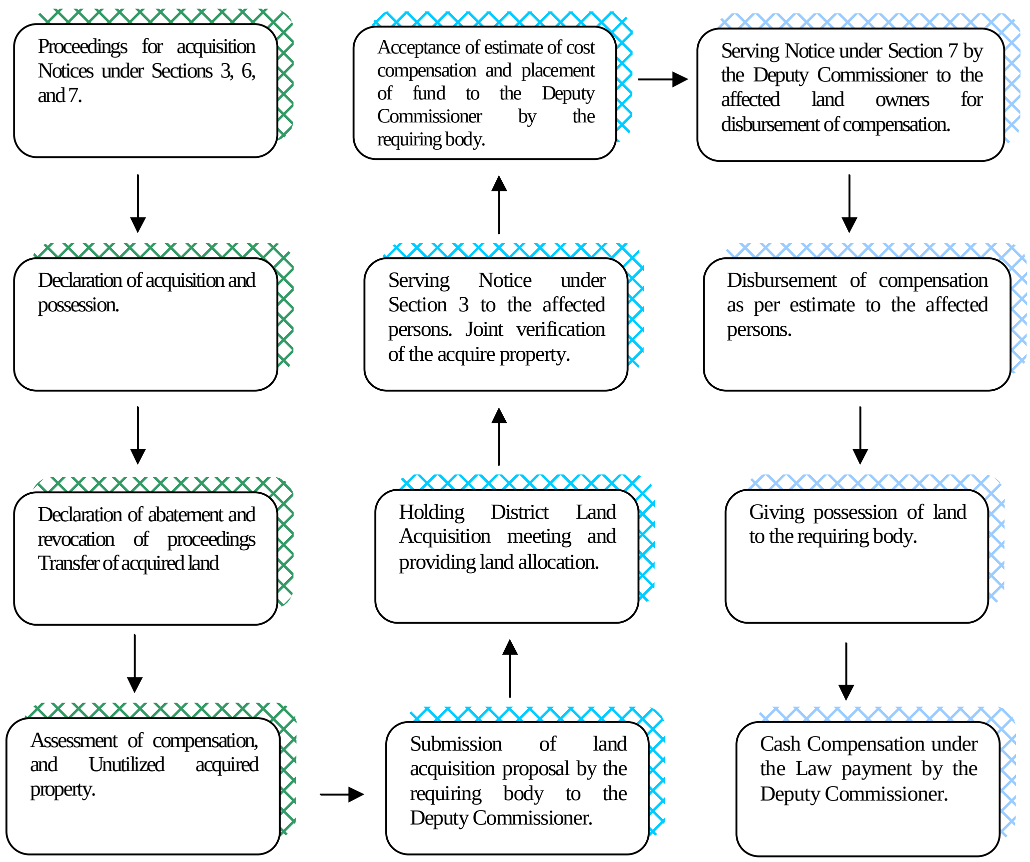


Figure 2.2.9 Land Acquisition Flow Chart

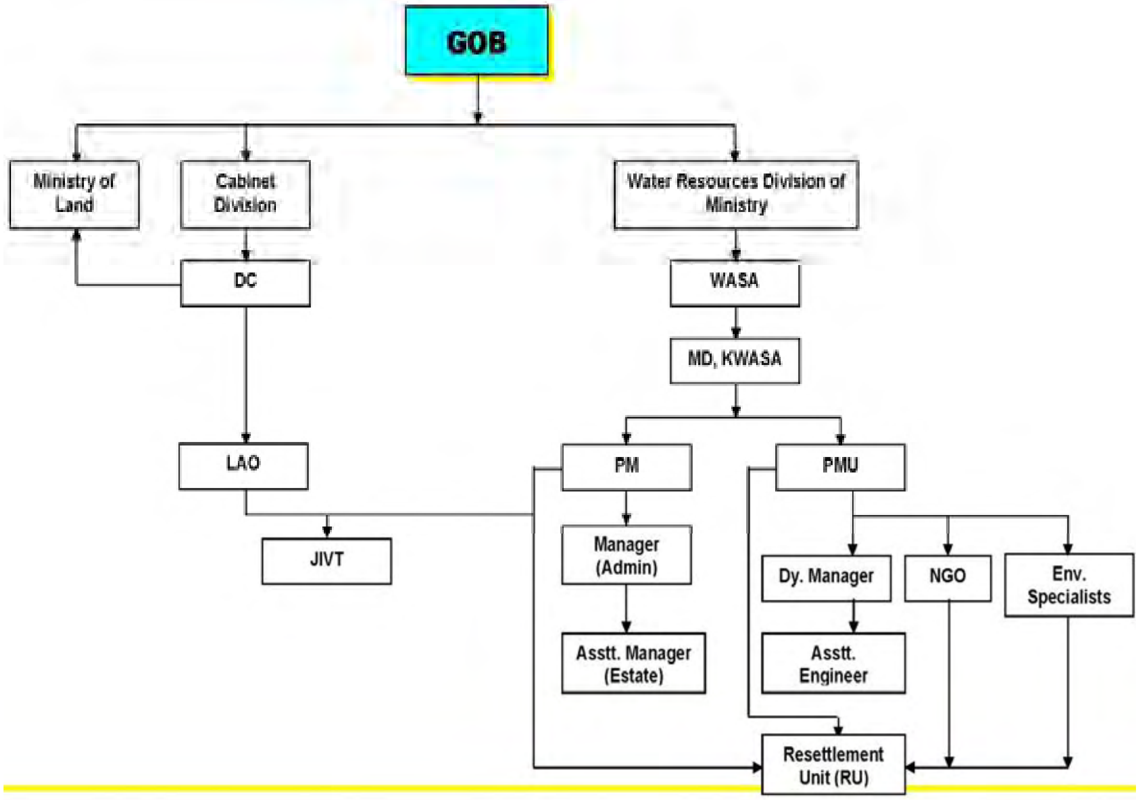


Figure 2.2.10 An Organizational Setting of Land Acquisition and Compensation

(3) Resettlement Systems

Since there had been no specified policy on resettlement for particular areas, the Government of Bangladesh in 2004 requested the Asian Development Bank (ADB) to provide an advisory Technical Assistance (TA) for the preparation of a national policy on involuntary resettlement. The purpose of the TA was to strengthen the Government's legal framework for mitigation of development-induced displacement and resettlement of affected persons caused by acquisition and requisition of land for development projects like WASA.

After the preparation of the policy by the ADB TA which was concluded on 31st December 2008, the Bangladesh government basically accepted it to;

i. Safeguard the rights of project-affected and displaced persons
ii. Ensure that appropriate mitigation measures are to be undertaken, including resettlement of the displaced households
iii. Restore livelihoods and re-establish community socio-cultural systems.

The concern body of Bangladesh Government then under the Acquisition and Requisition of Immovable Property Ordinance of 1982 harmonizes the policy on resettlement. The following outputs of these are

- Development of a comprehensive national policy on resettlement based on local contexts and needs of the primary stakeholders and applicable to public and private sector development projects like WASA is relevant in this context.

- Recommendations for modifications of the Acquisition and Requisition of Immovable Property Ordinance of 1982 to harmonize with the national policy which prepared by the Technical advisory Committee (TA).
- Action plan for implementation of the national resettlement policy for Bangladesh. These were consistent with the proposing entitlements, based on potential losses for accomplishing the legal procedures of land and for resettlement of financing on the basis of local values of land and properties.

However, the policy has not been used at a concrete national resettlement policy so far. Therefore, it can be considered that there is not relevant policy and regal frame on resettlement in Bangladesh. On the other hand, a Resettlement Action Plan (RAP) shall be required for a development project which may cause resettlements of people in the project sites following the relevant act and ordinance reviewed above and EIA system and its guidelines. Based on the past cases of RAPs prepared by some development projects in Bangladesh, the following shows a recommendable action for the resettlement.

1) Recommendable Organizational Framework for Resettlement

The Project Management is responsible for the resettlement of the people affected by the project. For efficient implementation and management of the resettlement activities, a Resettlement Unit (RU) headed by Manager (Resettlement) is to be established. The RU will be responsible for the implementation, management and monitoring of the RAP. A Project Coordination Unit (PCU) has also to be set up for monitoring implementation of the RAP. This will provide overall coordination on land acquisition and resettlement activities for all subcomponents.

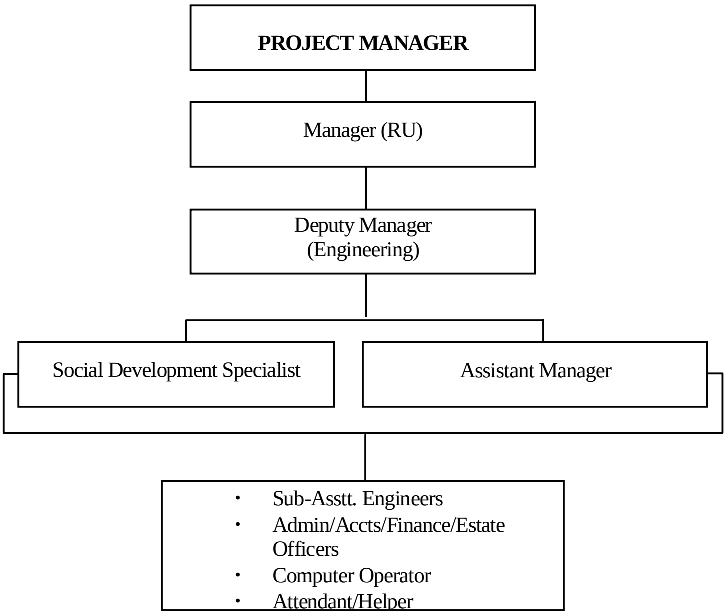
The Project Management fully recognizes the very complex nature of the resettlement operation and the limited availability of personnel with relevant expertise. It will be neither practical nor feasible for the Project Management to develop all necessary in house expertise and capacity within reasonable period. It is therefore, necessary to delegate specific areas of work to specialized agencies such as experienced NGOs and similar other organization. The implementing agency's experience with carrying out various socio-economic development programs and their ability to work closely with beneficiary population will be of great advantage in the implementation of the RAP. In addition, Project Management will seek cooperation and participation of other government agencies such as District Administration, Forest Department, Agriculture Department as well as Lending Institutions in the implementation of the resettlement program.

Project management will make arrangement for its entire staff of resettlement unit (RU) so that proper orientation is provided to them regarding resettlement activities. This would help the project implementation smooth.

The main tasks of the Resettlement Unit (RU) are:

- Overall planning, implementation and monitoring of the resettlement program.
- Design and set up necessary computer facilities.

- Ensure that all affected peoples (APs) are identified and provided with their respective entitlement according to the resettlement policy.
- Ensure timely acquisition of lands by the district administration, and payment of compensation prior to construction.
- Form Joint Investigation Verification Team (JIVT)s and make those operational.
- Monitor the effectiveness of entitlement packages and propose modification, to Project Management, when necessary.
- Prepare Term of Reference for implementing agencies that are to execute specified components of resettlement program.
- Select and appoint implementing agencies and monitor their progress.
- Prepare and submit monthly and quarterly progress report to Project Management.
- Study and monitor unforeseen adverse impacts during and after construction works.
- Liaise with other governmental and non-governmental agencies in the country on matters of mutual interest related to resettlement.
- An example organization of RU is shown in **Figure 2.2.11**.



JICA Study Team

Figure 2.2.11 Example Organization for Resettlement Unit

2) Monitoring and Evaluation

Monitoring & Evaluation is an important task for measuring the periodic progress of activities under a resettlement program. Socio economic information of the concerned affected persons will be recorded for ready reference. The authority will arrange necessary step in this connection for proper and successful resettlement work.

The major input in to the system will be:

- Affected household data
- Land acquisition data
- Data on losses
- Resettlement entitlement and delivery data
- Resettlement monitoring and evaluation data
- Other management related data
- Monitoring and evaluation (M&E) are critical for ensuring effective implementation of the RAP and achievement of the set targets. Resettlement monitoring is a continuous process of data collection, dialogue with the various stakeholders, analysis and reporting and feedback to management to enable timely adjustment of implementation procedures and entitlements, if required.
- The monitoring will commence with the commencement of the Project implementation and shall continue throughout the implementation of the Project.
- At the implementation period field officials will design a format for resettlement monthly monitoring and data collection. The project proponent will prepare a post-resettlement evaluation report at the end of the Project activity. The report should provide evidence whether adverse effects of the project have been mitigated adequately or at least pre-project standard of living and income have been restored as a result of the RAP.

For the smooth implementation of the resettlement work, the implementing agency will prepare monthly report which includes affected person's grievances, progress and shortcomings of the resettlement work both quantitatively and qualitatively. The report will be submitted to the project proponent RU regularly.

The implementing agency or NGOs will monitor PAPs participation in the vocational training and other economic rehabilitation program. The implementing agency will develop Computerized Management Monitoring System and will supply to the client and implementing agency and client will preserve data.

Monitoring can ensure transparency. The Project Management Officer (PMO) will establish a quarterly monitoring system involving staff of the implementing agency. The PMO will prepare progress reports on all aspects of land acquisition and resettlement activities. The report contains progress made in the RAP implementation with particular attention to compliance with the principles and matrix set out in the plan for efficient implementation and management of the RAP, some review work is needed. This will be internal and external. The authority will produce monthly and quarterly reports for monitoring the progress. The client will engage efficient official/ consultant review of the project after the implementation period. At the same time Donor Agency and other stakeholders may arrange separate study to monitor the implementation of the RAP.

2.3 Socio-Economy Conditions

2.3.1 General

(1) Bangladesh

Socio-Economic indicators of Bangladesh are summarized in **Table 2.3.1**. Bangladesh's economy has grown at the rate of about 6 percent per year over the past few years, resulting in provisional GDP of 2009 is estimated at US$89.4 billion. Its per-capita GDP is estimated as US$621. More than half of the GDP belongs to the service sector. Agriculture contributes about 20 percent of the GDP. Industry (including manufacturing) contributes about 30 percent.

Bangladesh produces large quantities of agricultural goods including rice and jute. Although wheat production has increased in recent years; the country is largely self-sufficient in rice production. Bangladesh's growth of its agro industries is due to its rich deltaic fertile land, enabling multiple harvests.

The service sector has expanded rapidly during last two decades. Bangladesh's industrial base remains positive, including its vast human resource base, rich agricultural land, relatively abundant water, and substantial reserves of natural gas, with two natural sea ports in Chittagong and Mongla. In addition Bangladesh is one of eight member countries in an emerging economic hub group, South Asia Association for Regional Cooperation (SAARC) and functions as a geographical linking with the Association of South-East Asian Nations (ASEAN).

Table 2.3.1 Socio-Economic Indicators of Bangladesh

Poverty and Social Ratios			
Population, mid-year (millions, 2008)		160.0	
GDP per capita (US$ current, 2009)		621.1	
Population average annual growth (2002-2008, %)		1.5	
Labor force average annual growth (2002-2008, %)		2.4	
Most recent estimate (latest year available, 2002-2008)			
Poverty (% of population below national poverty line)		40	
Urban population (% of total population)		26	
Life expectancy at birth (years)		66	
Infant mortality (per 1,000 live births)		43	
Child malnutrition (% of children under 5)		41	
Access to an improved water source (% of population)		80	
Literacy (% of population age 15+)		53	
Gross primary enrollment (% of school-age population)		92	
Male		89	
Female		94	
Key Economic Ratios	**Y 2007**	**Y 2008**	**Y 2009**
GDP (US$ billion current)	68.4	79.6	89.4
GDP (Billion Tk. current)	4,725	5,458	6,149
Gross capital formation/GDP (%)	24.5	24.2	
Exports of goods and services/GDP (%)	19.8	20.3	
Gross domestic savings/GDP (%)	17.5	15.8	
Gross national savings/GDP (%)	34.6	35.7	
Current account balance/GDP (%)	1.4	0.9	
Interest payments/GDP (%)	0.4	0.3	
Total debt/GDP (%)	31.9	25.7	
Total debt service/exports (%)	5.1	4.4	
Present value of debt/GDP (%)	22.1	18.4	
Present value of debt/exports (%)	76.6	61.0	
GDP annual growth (%, constant)	6.4	6.2	5.9
GDP per capita annual growth (%)	4.7		
Exports of goods and services annual growth (%)	13.0	7.0	
Structure of Economy (% of GDP)			
Agriculture	19.2	19.0	
Industry	28.4	28.5	
Manufacturing	17.8	17.8	
Services	52.4	52.5	
Household final consumption expenditure	76.9	78.9	
General gov't final consumption expenditure	5.5	5.3	
Imports of goods and services	26.7	28.8	
Structure of Economy (average annual growth, %)			
Agriculture	4.6	3.2	
Industry	8.4	6.8	
Manufacturing	9.7	7.2	
Services	6.9	6.5	
Household final consumption expenditure	6.7	5.2	
General gov't final consumption expenditure	6.4	3.6	
Gross capital formation	8.5	1.8	
Imports of goods and services	16.0	-2.1	

Prices and Government Finance	Y 2007	Y 2008	Y 2009
Domestic prices (% change)			
Consumer prices	7.2	9.6	6.7
Implicit GDP deflator	6.8	8.8	
Government finance (% of GDP, includes current grants)			
Current revenue	10.5	11.5	11.2
Current expenditure	13.6	15.1	15.3
Overall surplus/deficit	-3.1	-3.6	-4.1
Trade			
Total exports (fob, US$ millions)	12,053	14,151	
Raw jute	147	165	
Leather and leather produts	266	284	
Manufactures	11,118	13,153	
Total imports (cif, US$ millions)	15,511	19,481	
Food	1,918	3,492	
Fuel and energy	2,233	2,753	
Capital goods	1,929	1,664	
Export price index (Year 2000 = 100)	132		
Import price index (Year 2000 = 100)	153		
Terms of trade (Year 2000 = 100)	86		
Balance of Payments (US$ millions)			
Exports of goods and services	13,537	16,042	
Imports of goods and services	18,250	22,897	
Resource balance	-4,713	-6,855	
Net income	-905	-994	
Net current transfers	6,554	8,529	
Current account balance	936	680	
Financing items (net)	557	-349	
Changes in net reserves	-1,493	-331	
Memo:			
Reserves including gold (US$ millions)	3,614	4,171	
Exchange rate (Average, local/US$)	69.1	68.6	68.8
External Debt and Resource Flows (US$ millions)			
Total debt outstanding and disbursed	21,859	23,644	
IBRD	0	0	
IDA	10,077	10,613	
Total debt service	1,008	1,046	
IBRD	0	0	
IDA	265	290	
Composition of net resource flows			
Official grants	1,027	1,746	
Official creditor	406	1,083	
Private creditors	-23	112	
Foreign direct investment (net inflows)	653	973	
Portfolio equity (net inflows)	153	10	
External Debt to GDP (%)	28.3	23.2	
Domestic Debt to GDP (%)	16.6	..	

Sources: Compiled by Study Team based on data of WB, ADB and Bangladesh Bureau of Statistics

(2) Khulna

Khulna City originated as a market town and has a history of more than one hundred years. During the early days, tobacco and sugarcane were traded and Khulna had a shopping link with Calcutta. Khulna was declared as a municipality in 1884, became a railway link in 1985, district headquarters in 1961, and a city corporation in 1984.

Nowadays Khulna City is the third largest city in Bangladesh, after Dhaka and Chittagong. Khulna City is a part of Khulna District, which in turn, lies within Khulna Division at the Southwest of Bangladesh. Khulna City is located on natural banks of the Rupsha and Bhairab rivers and characterized by Ganges tidal floodplains with low relief, crisscrossed by rivers and water channels and surrounded by tidal marshes and swamps.

Khulna is a port city but also connected to other parts of the country by road and railway. This location and linkages with regional towns and growth centers have made it a hub of the region. Notably a link to the second sea port of the country, Mongla, located about 50 km south of Khulna City, is considered strategically important. Also Sundarban, the world largest mangrove forest is located to the south of Khulna, which attracts tourists from inside and outside the country.

A number of large scale industrial units were set up in Khulna during the period of 1950-70. These industrials units were located mainly in present Khulna City and its adjacent areas. Khulna Newsprint Mills Ltd, Khulna Hardboard Mills Ltd, Khulna Textile Mills Ltd, Khulna Power Station and seventeen jute mills were established by the bank of Bhairab river. Another important industrial unit, Khulna shipyard Ltd was established in 1957.

After its independence from Pakistan in 1971, due to socialist economy adopted by the then government, many of the industrial units in Khulna were nationalized. The static economic model resulted in inefficiency and economic stagnation. Also external markets for jute were lost because of the instability of supply and the increasing popularity of synthetic substitutes. As a result, many of industrial units in Khulna were closed as per government decision, including Khulna Newsprint Mills, Textile Mills and a number of jute mills. Khulna shipyard Ltd was handed over to Bangladesh Navy for running its operation.

However, since the 1980s, the government has been giving greater scope to private sector participation with the aim of improving efficiency in the public sector. Many state-owned enterprises such as banking, telecommunication, aviation, media, jute and a range of other vital sectors have been privatised. Khulna's economy has been recovering as well. The development of shrimp processing and the establishment of two major universities in the 1990s also contributed the economic boost. Major commerce and industrial establishments registered at the Khulna Chamber of Commerce and Industry are shown in **Table 2.3.2**.

Table 2.3.2 Major Industries in Khulna

Type of Industry	Company Name
Fish processing and export	Ashia Sea Foods Ltd.
Fish processing and export, Ice Factory	Aqua Resources Ltd.
Fish processing and export	Achia Sea Foods Ltd.
Fish processing and export	Bangladesh Sea Food Industries Ltd.
Fish processing and export	Bionic Fish Processing Ltd.
Fish processing and export, Ice Factory	Fresh Foods Ltd.
Fish processing and export	Genini Sea Food Ltd.
Fish processing and export	Shahnewaz Sea Foods (Pvt.) Ltd.
Fish processing and export	Rupali Sea Foods Ltd.
Fish processing and export	International Shrimp Export (Pvt.) Ltd.
Fish processing and export	Jahanabad Sea Food Ltd.
Fish processing and export	Khulna Frozen Foods Export Ltd.
Fish processing and export, Ice Factory	Locpur Fish Processing Co. Ltd.
Fish processing and export, Ice Factory	Modern Sea Foods Ind. Ltd.
Fish processing and export	National Sea Food Ind. Ltd.
Fish processing and export, Ice Factory	Oriental Fish Processing & Culture Ltd.
Fish processing and export, Ice Factory	Penguin Ice & Fish Processing (Pvt.) Ltd.
Fish processing and export, Ice Factory	Sobi Fish Processing Ind. Ltd.
Jute Processing and Export	F. R. Jute Trading Co. Ltd.
Raw Jute Supplier, Export, Transport	Agrani Jute Shangsta
Raw Jute Supplier, Export, Transport	F. M. Trade Works
Road and River Transportation	M. Trading Consent
Raw Jute Supplier, Export, Transport	Zaman Brothers
Road and River Transportation	Eastern Trades
Jute Processing and Export	Wahab Jute Mills Ltd.
Road and River Transportation	H. S. Jute Traders
Raw Jute Supplier	M/s. Progoti Jute Supply
Road and River Transportation	Pintha Trade International
Raw Jute Supplier, Export, Transportation	Rishad Enterprise
Raw Jute Supplier, Export, Transportation	Pubali Traders
Jute Processing and Export	The Crescent Jute Mills Co. Ltd.
Jute Processing and Export	Alim Jute Mills Ltd.
Jute Processing and Export	Sonali Jute Mills Ltd.
Jute Processing and Export	Super Jute Mills Ltd.
Raw Jute Supplier, Export, Transportation	Mollah Jute Trading
Jute Export & Supplier	Reza Jute Trading
Raw Jute Supplier, Export, Transportation	Arian Trade International
Raw Jute Supplier, Export, Transportation	Showrab Traders
Jute Export & Supplier	Mita Traders
Jute Processing and Export	Platinum Jubli Jute Mills Ltd.
Jute Processing and Export	Nowapara Jute Mills Ltd.
Jute Processing and Export	Star Jute Mills Ltd.
Jute Export & Supplier	S. M. Jute Trading
Jute Export & Supplier	M/s. Sharif Jute Trading
Jute Export & Supplier	M/s. Uttara Jute Traders
Jute Export & Supplier	Wahab Jute Trading Co. Ltd.
Export, Import, Bus Transport	M/s. Mita Traders
Shipping, Raw Jute Supplier, Food industry	Abdur Razzaque Ltd.
Food, Fertilizers, Export, Import	M/s. Sarco Enterprise
Shipping, Raw Jute Supplier, Food industry, Fertilizer, Storage, Ince Mills	M/s. Munir Ahmed & Brothers
Fertilizer & Food	M/s. S. Ahmed & Brothers
Fertilizer & Food	M/s. Shapla Traders
Flour, Rice Mills, Fish Cultivation & processing, Export and Import, Storage	M/s. Hazi A. Aziz Khalashi & Sons
Salt Industries, Export, Import	United Jute Press Ltd.
Transportation Business	M/s. Dhaka Transport Agency
Printing press, Polymer, Export, Import	M/s. Alim Enterprise
Shipping	M/s. Sonar Bangla Shipping Lines
Textile, Shipping	M/s. S. S. Impex International
River Transportation	Khulna Bivagiya Abyantarin
Cement factory, Salt factory, Export, Import	Khulna Cement Amdanikarak Malik Group
Electrical Fittings and ware	M/s. Mars Communication

Source: Khulna Chamber of Commerce

It is noted that recent development of national infrastructure projects will benefit Khulna. Particularly important is the Padma Bridge project, which is a road-and-rail bridge over the river Padma at Mawa-Janjira point. This bridge will give Khulna Division a direct communication to the capital Dhaka by completing the missing link in the Dhaka-Khulna/Mongla National Highway and also link to the Asian Highway. The bridge construction is also expected to induce pipeline project to increase gas supply to Khulna, development of multi-modal transport system, revival of Mongla port and establishment of free export zones, rail link with other regions, improvement of power supply, exploiting farm and non-farm growth potentials, and tourism promotion.

2.3.2 Public Hygiene

(1) General

Bangladesh has made significant progress in health outcomes since its independence. Reduction of infant and child mortality rates has been significant. For example the under-five mortality rate declined from 151 deaths per thousand live births in 1991 to 65 in 2007. During the same period infant mortality rate reduced from 94 deaths per thousand live births to 52. An overview of the current health profiles of Bangladesh is presented in the Health Bulletin 2009, which is an attempt of Management Information System (MIS) of Directorate General of Health Services (DGHS), Ministry of Health & Family Welfare (MOHFW).

Water-borne diseases or diseases associated with unsafe water, poor sanitation, and poor food handling practices include among others, diarrhoea, dysentery, malaria, and dengue. Disease data of Bangladesh in 2008 are available in Health Bulletin 2009. Morbidity data of those diseases shown in the bulletin are twofold. The one is the top 10 diseases among in-patients at public health facilities (**Table 2.3.3**) and the other is data of children who attended out-patient and emergency departments of Integrated Management of Childhood Illness (IMCI)[2] facilities (**Table 2.3.4**).

Table 2.3.3 Percent Distribution of Diseases among Inpatients in Bangladesh (2008)

Position	0-28 d	29d-11m	1-4y	5-14y	15-24y	25-49 y	50+	All age
1	Pneumonia 34.1%	Pneumonia 38.3%	Diarrhea 30.4%	Diarrhea 21.3%	Assault 14.7%	Assault 15.1%	Diarrhea 11.9%	Diarrhea 15.1%
2	Diarrhea 8.6%	Diarrhea 26.5%	Pneumonia 20.9%	Assault 5.9%	Diarrhea 11.0%	Diarrhea 9.3%	Peptic Ulcer 8.6%	Assault 9.8%
3	Septicemia 6.2%	Bronchiolitis 2.9%	Dysentery 5%	Pneumonia 5.8%	Peptic Ulcer 6.0%	Peptic Ulcer 8.6%	Assault 8.5%	Pneumonia 7.4%
4	Anemia 2.7%	Viral fever 1.4%	Viral fever 2.4%	Peptic Ulcer 3.9%	Poisoning 3.3%	Obstructed Labor 3.6%	Hypertension 5.5%	Peptic Ulcer 5.9%
5	Bronchiolitis 0.9%	Enteric Fever 1.1%	Enteric Fever 1.7%	Viral fever 3.0%	Road Traffic Accident 2.8%	Poisoning 3.0%	Bronchial Asthma 3.5%	Viral fever 2.3%
6	Allergic Reaction 0.9%	Anemia 1.1%	Worm Infestation (Intestinal) 1.4%	Enteric Fever 2.9%	Enteric Fever 2.3%	Road Traffic Accident 2.8%	COPD 3.4%	Poisoning 2.0%
7	Bacillary Dysentery 0.6%	Protein Energy Malnutrition 1.0%	Assault 1.3%	Dysentery 2.6%	Viral fever 2.0%	Viral fever 2.6%	Road Traffic Accident 2.4%	Road Traffic Accident 2.0%
8	Congenital Heart Disease 0.5%	Suppurative Otitis Media 0.9%	Anemia 1.3%	Anemia 2.3%	Anemia 1.9%	Enteric Fever 1.8%	Anemia 2.2%	Enteric Fever 2.0%
9	Viral fever 0.4%	Dysentery 0.9%	Bronchial Asthma 1.2%	Worm Infestation (Intestinal) 2.3%	Obstructed Labor 1.8%	Hypertension 1.8%	Dysentery 2.1%	Bronchial Asthma 1.8%
10	Meningitis 0.4%	Bacillary Dysentery 0.8%	Suppurative Otitis Media 1.2%	Bronchial Asthma 2.0%	Head Injury 1.8%	Bronchial Asthma 1.7%	Enteric Fever 1.9%	Anemia 1.8%
No. of patients	42,808	1, 52, 491	2,18,293	2,38,638	3,88,734	6,12,762	158,240	19,96,541

Source: Health Bulletin 2009

[2] Integrated Management of Childhood Illness (IMCI) is a strategy as well as a program developed in mid-1990s by WHO, UNICEF and other partners to unify existing vertical child health programs (e.g., Control of Diarrheal Diseases and Acute Respiratory Infections). IMCI addresses morbidities which are responsible for almost 75% of under-5 deaths. MOHFW of Bangladesh introduced IMCI in 2002.

Table 2.3.4 Children who Attended Out-patient and Emergency Departments of IMCI Facilities in Bangladesh

Disease	No. of Patients
Very severe disease	4,528
Pneumonia	33,472
Cough & cold	113,235
Diarrhea	42,996
Dysentery	23,680
Malaria fever	515
Non-malaria fever	43,152
Measles	293
Ear problem	13,703
Malnutrition	17,002
Drowning	468
Injury	8,189
Others	84,842
Total	386,075

Source: Health Bulletin 2009

It should be noted that these data cannot represent the overall population morbidities of Bangladesh. This is because data in the bulletin cover public hospitals only. Public hospitals of Bangladesh are attended by only a part of the patients who seek health care. The rest seek health care from any of different types of non-public providers such as informal healers, drug retailers, private practitioners, private clinics and hospitals. The bulletin suggests that the ratio of patient attendance at public hospitals is about 20 percent of all patients.

The population base used in the bulletin was 143.86 million for the estimated national population in 2008 and 16.83 million for under-five population of 2007 estimate. Public hospitals under DGHS amounted to 597 nationwide and the number of beds in totaled 38,171 in December 2008.

National data in the table above indicates that diarrhea topped the disease burden at 15.1 percent in overall age range. Diarrhoea also topped in 1-4 years, 5-14 years, and over 50 years age ranges. Dysentery appears in the top 10 at lower age ranges, but it does not in overall age range. **Table 2.3.4** shows that IMCI program classifies childhood diseases into 13 categories, of which highly associated with water or unsanitary conditions are diarrhea and dysentery. Both diseases are ranked relatively high in terms of morbidity.

2) Khulna Division

In Khulna Division, there are 69 public hospitals which are under DGHS. The total number of beds at these hospitals is 3,995 as of December 2008. The population of Khulna Division in 2008 is estimated at 16,964,974. Diarrhoeal incidence data in Khulna Division is summarized in **Table 2.3.5**.

Table 2.3.5 Diarrhoeal Incidence in Khulna Division

Year	Number of incidence reported	Number of death
2005	428,502	81
2006	413,268	32
2007	445,631	37
2008	476,231	26

Source: Health Bulletin 2009

The number of diarrhoea incidence reported at public hospitals has been relatively stable, hovering around 0.4 million cases per year. The number of death has been significantly reduced since 2006, being about 30 per year.

(3) Khulna District

The number of public hospitals in Khulna District is 15 and the total number of beds at these hospitals is 1,097 in December 2008. The population of Khulna District in 2008 is estimated at 2,738,970. Diarrhoeal incidence data in Khulna District is summarized in **Table 2.3.6.** Dysentery incidence is also included in the diarrhoeal cases.

Table 2.3.6 Diarrhoeal Incidence in Khulna District

Year	Number of incidence reported	Number of death
2004	17,590	34
2005	29,197	20
2006	105,927	0
2007	82,449	4
2008	97,933	1
2009	148,388	8

Source: Civil Surgeon Office in Khulna Division

(4) Khulna City

As an administrative and industrial centre of region, Khulna City has a high concentration of hospitals. Medical institutions which provide health care services such as hospital, dispensary, and urban primary health centre (UPHC) in Khulna total about 60. Major hospitals in Khulna City are shown in **Table 2.3.7**. At the Khulna General Hospital alone, the numbers of inpatients and outpatients in 2009 amounted to 8,271 and 178,210 respectively.

Table 2.3.7 Hospitals in Khulna City

Type	Name	Number of Beds
Public	Medical College Hospital	250
Public	Sheikh Abu Naser Specialized Hospital	250
Public	General Hospital	150
Public	Chest Hospital	100
Public	Infections Diseases Hospital	20
Private	Children Hospital	220
Private	Divisional Police Hospital	100
Private	Girebe-E-Newaj Clinic	24
Private	Nargis Memirial Clinic	20

Type	Name	Number of Beds
Private	City Nursing Home	21
Private	Khalishpur Clinic	30
Private	Sandhani Clinic	20
Private	Khulna Pongu Hospital (Orthopedic)	10
Private	Islami Bank Hospital	69
Private	Rashida Memorial Hospital	40
Private	Green Maternity	10
Private	Mishu Clinic	10
Private	Metropolitan Clinic	18

The consumer survey of 3,006 households which was conducted in 2009 under an ADB technical assistance indicated an average of 0.85 incidence per household of diarrhoea per year. The average number of family members per household was 5.46 at this survey, suggesting that about 15 percent of population may suffer from bad diarrhoea in a year.

2.3.3 Sanitation and Sewerage

(1) Drainage System

Urban drainage is a major issue in most cities of Bangladesh due to their low-lying topography, their location next to rivers and the short, but very intensive, monsoon season. Khulna is no exception. The city drains both to the east and the west with the watershed being provided by the railway embankment and Khanjahan Ali Road. On its eastern side, a long, narrow strip of land (around 9 sq km) drains directly into the Rupsha River and Bhairab River. The majority of the city however drains westward into the Mayur River.

(2) Sewerage

Khulna has virtually no sewerage system. Lack of sewerage treatment for domestic and industrial purpose is a major concern. Only a small sewerage system is under construction. It is situated at Khalishpur and KCC will transfer to KWASA its land with sewerage system.

(3) Solid Waste Management (SWM)

SWM in Khulna, and in many other Bangladeshi cities, is hampered by the absence of adequate national or local legislation relating to municipal SWM and the treatment and disposal of hazardous waste. In particular, there are no mandatory regulations or performance standards for city corporations (e.g. KCC) to establish and manage an effective SWM system; nor are there any sanctions to prevent littering and indiscriminate dumping. As a result SWM in Khulna has developed in a piecemeal and unintegrated manner with NGOs, CBOs, informal recyclers and private enterprises being involved along with KCC. Apart from one ward where KCC operates Door to Door (DtD) collection, its main responsibilities are the transport of waste from Secondary Disposal Sites (SDS) and roadside Dustbin Points (DBP) to the landfill site it operates about 8km to the west of the city. NGOs and CBOs, along with a KCC contracted private company, collect household waste door to door on a daily basis, using rickshaw vans, in parts of several wards and then transport it to the SDS; these are considered to be effective operations, although only a minority of city dwellers receives this service. For the most part, householders take the waste to the SDS themselves or dispose of it indiscriminately.

2.3.4 Commerce and Industry

In Khulna, most of the industrial establishments are located at Khalishpur. During the latest two decades the Khulna region has become the producer of 80% of the shrimp exported from Bangladesh. The remaining 20% is produced in the Cox's Bazaar region and in small pockets in the other coastal districts. Jessore-Khulna highway has been developing as an industrial hub because of its proximity to national highway, railway and the Mongla Port. Commercial activities are mostly related to port, shipping industry and agriculture. Major urban centers have delineated commercial hubs. These hubs are catered by a host of forward and backward linkage activities and establishments like banks and insurance companies, clearing and forwarding agents, warehouses and hotels.

2.3.5 Willingness to Pay for Improved Water Service

Based on findings of the consumer survey conducted under ADB TA in 2009, the study team estimated domestic user's willingness to pay (WTP) for new water (water that will be provided by the project). The WTP is calculated at Tk. 232 per household per month when the initial connection fee is Tk. 5,000. The WTP becomes Tk. 240 at the connection fee of Tk. 3,000 and Tk. 270 at the connection fee of Tk. 1,000. For those already connected to the KWASA system from tube wells, the WTP is estimated at Tk. 322 per household per month. The non-domestic user's WTP is estimated at Tk. 18,446 per connection per month. As the average water use of a non-domestic user is 341 m^3/month, the WTP is computed at Tk. 54/m^3. We elaborate how these numbers are computed and evaluated in subsequent sections.

(1) Domestic User's WTP

A consumer survey for about 3,000 selected residents in Khulna to know their behaviour for water supply service was conducted in April and May 2009 under a technical assistance (TA) supported by ADB. One of the survey items was willingness to pay for water supply. This customer survey was informative as the questionnaire contained questions to ask the WTP for improved water supply service. The questions actually used in the consumer survey were classified into the following four types according to their connection situation:

(1) Question asking to those households already connected, for their willingness to stay connected if the water supply service is improved and the monthly water bill is Tk. 100, 200, 300, 400 or 500.

(2) Question asking to those households still unconnected, for their willingness to get connected if the initial connection fee is Tk. 1,000, and the monthly water bill is Tk. 100, 200, 300, 400 or 500.

(3) Question asking to those households still unconnected, for their willingness to get connected if the initial connection fee is Tk. 3,000, and the monthly water bill is Tk. 100, 200, 300, 400 or 500.

(4) Question asking to those households still unconnected, for their willingness to get connected if the initial connection fee is Tk. 5,000, and the monthly water bill is Tk. 100, 200, 300, 400 or 500.

The questions are designed as a dichotomous choice where households are supposed to answer either "yes" or "no". This dichotomous choice is single-bound, not double-bound, meaning that the bid price (monthly water bill) is presented only once. In the double-bound choice there is a second bidding, which is a higher price if the answer for the first bidding has been "yes", or a lower price if it has been "no".

The number of households who were asked these questions and the percentages of households who replied "yes" to the questions are summarized in **Table 2.3.8**.

Table 2.3.8 Results of Willingness to Pay Questions

Connection Fee (Tk.)	Monthly Bill (Tk.)	Number of households who were asked	Percentage of households willing to stay (or get) connected
Zero (Already connected)	100	187	96%
	200	179	73%
	300	185	51%
	400	183	34%
	500	179	31%
1,000	100	135	69%
	200	150	61%
	300	150	43%
	400	136	36%
	500	134	28%
3,000	100	141	61%
	200	142	46%
	300	130	41%
	400	137	34%
	500	136	29%
5,000	100	140	64%
	200	138	51%
	300	136	31%
	400	136	31%
	500	143	19%
Total		2,997	

One obvious conclusion from the results is that the higher the initial connection fee and the monthly water bill are, the fewer the number of households willing to connect to the service will be. Others conclusions are making of sentence from the numbers such as "A 96 % of connected respondents are willing to pay Tk. 100 monthly and 73 % for Tk. 200 for a good piped water supply." and "For low connection fee (Tk. 1,000) the willingness remains 69 % for Tk. 100 monthly bill and 61 % even though the monthly bill is Tk. 200."

Those conclusions however, do not give us a straight answer to a question like "how much is the willingness to pay price?" In order to estimate the mean WTP at each connection fee, a logic regression analysis[3] was performed. The logit model was run in a statistical software CVM31[4]. As the customer

[3] The logit and probit models are introduced as methods to estimate WTP in the ADB ERD Technical Note No. 23, *Good Practices for Estimating Reliable Willingness-to-Pay Values in the Water Supply and Sanitation Sector*, 2007.

[4] CVM31 runs on Excel and has a function to estimate WTP from results of CVM. CVM31 is available at

survey question for WTP was designed as single-bound, the single-bound logic model was used.

Replies from the consumers already connected to the piped water system are analyzed using CVM31 and the computation results of WTP estimation are summarized in **Table 2.3.9**. The logit regression line is graphed in **Figures 2.3.1**.

Table 2.3.9 Willingness to Pay of Those Already Connected

Variable	Coefficient	t-value	p-value
constant	13.3452	13.062	0.000
ln (Bid)	-2.3164	-13.019	0.000
n	913		
Log likelihood	-497.06		
Mean WTP (cut-off at the maximum WTP)			Tk.322
Mean WTP (without cut-off)			Tk.441
Median WTP			Tk.318

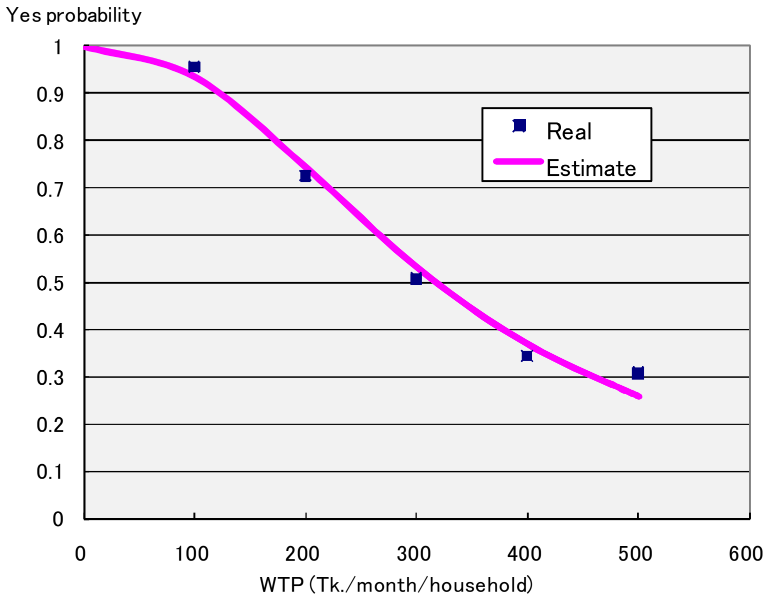


Figure 2.3.1 Regression Line of WTP of Those Already Connected

Three types of WTP are estimated, which are (i) the mean WTP computed by cutting off the area outside the maximum monthly water charge payable, (ii) the mean WTP computed without cutting off the area outside the maximum monthly water charge payable, and (iii) the median WTP. The WTP which will be used in the economic analysis of the project should be the mean WTP with the cutting-of as this WTP is considered the most suitable in aggregating economic benefits of consumers. Therefore we use Tk. 322 as the average WTP of those who already connected, for better water supply services.

The same type of analysis was performed in estimating the WTP of those who are not currently connected but willing to pay for new connection to piped water system. They are classified into three groups

(http://homepage1.nifty.com/kkuri/workingpaper.html).

according to the initial connection fee, which are Tk. 1,000, 3,000, and 5,000. The willingness to pay computation results are summarized in **Tables 2.3.10** to **2.3.12**. Their logit regression lines are respectively shown in **Figures 2.3.2** to **2.3.4**.

Table 2.3.10 Willingness to Pay of Those Willing to be Connected at Tk.1,000

Variable	Coefficient	t-value	p-value
constant	6.0966	7.372	0.000
ln (Bid)	-1.1130	-7.535	0.000
n	705		
Log likelihood	-456.80		
Mean WTP (cut-off at the maximum WTP)			Tk.270
Mean WTP (without cut-off)			Tk.2,153
Median WTP			Tk.239

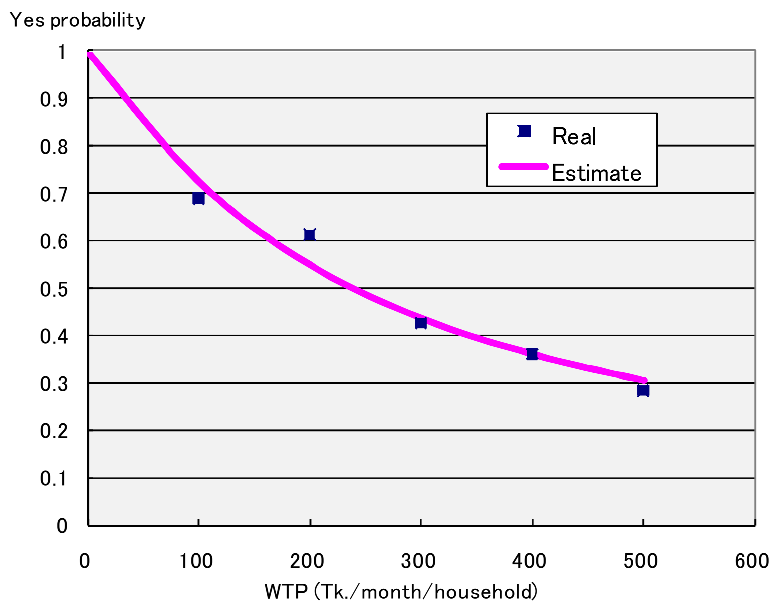


Figure 2.3.2 Regression Line of WTP of Those Willing to be Connected at Tk.1,000 Initial Cost

Table 2.3.11 Willingness to Pay of Those Willing to be Connected at Tk.3,000

Variable	Coefficient	t-value	p-value
constant	4.1653	5.374	0.000
ln (Bid)	-0.8073	-5.789	0.000
n	686		
Log likelihood	-450.17		
Mean WTP (cut-off at the maximum WTP)			Tk.240
Mean WTP (without cut-off)			Tk.∞
Median WTP			Tk.174

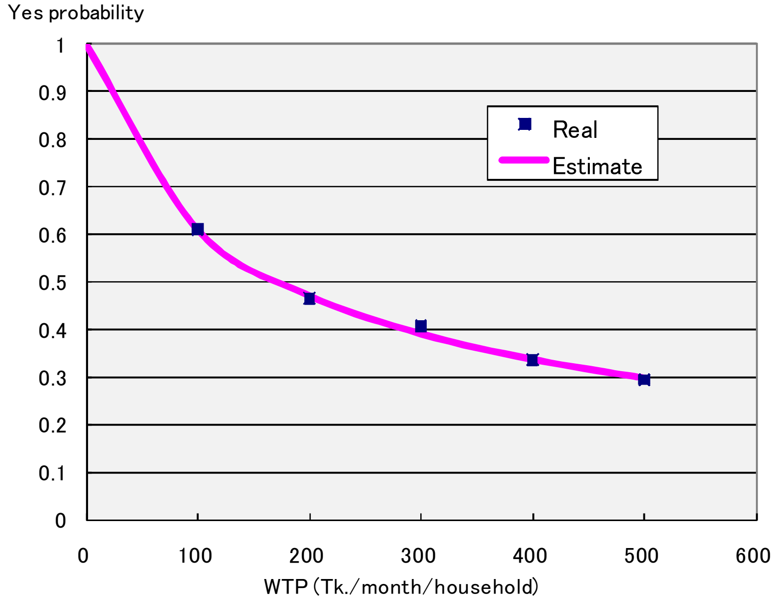


Figure 2.3.3 Regression Line of WTP of Those Willing to be Connected at Tk.3,000 Initial Cost

Table 2.3.12 Willingness to Pay of Those Willing to be Connected at Tk.5,000

Variable	Coefficient	t-value	p-value
constant	6.1882	7.638	0.000
ln (Bid)	-1.1986	-8.200	0.000
n	693		
Log likelihood	-427.18		
Mean WTP (cut-off at the maximum WTP)			Tk.232
Mean WTP (without cut-off)			Tk.920
Median WTP			Tk.175

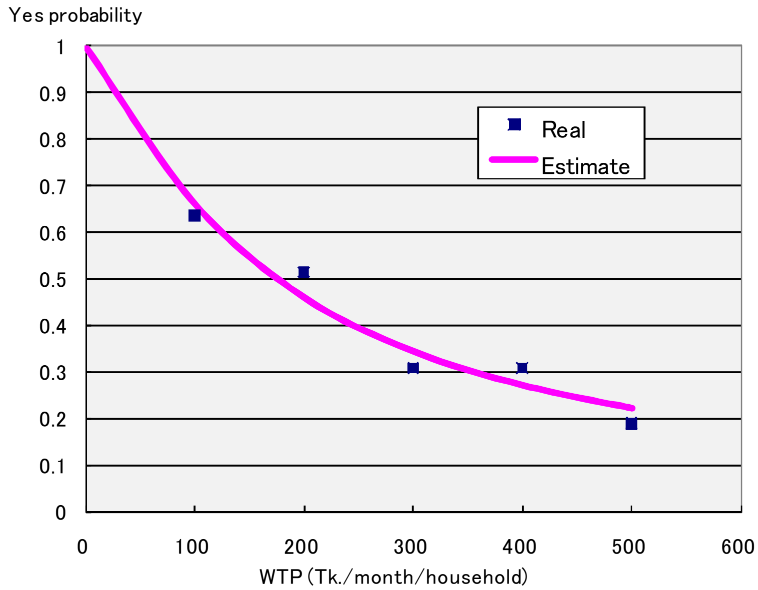


Figure 2.3.4 Regression Line of WTP of Those Willing to be Connected at Tk.5,000 Initial Cost

In summary, we estimate that the average WTP for better water supply is Tk. 322 for those already connected to piped KWASA water system. For those unconnected to the water system, the average WTP is Tk. 270 when the connection fee is Tk. 1,000. If the connection fee is Tk. 3,000, the average WTP decreases to Tk. 240. If the connection fee is Tk. 5,000, the average WTP becomes Tk. 232.

According to the data of current water use situation in Khulna City, which is compiled by the Study Team, the average water consumption is 82 liter/day/person and the average number of household member is 4.4 persons. These data indicate that the WTP of those already connected is Tk. 29.7 per cubic meter [=322/(4.4*82*30)]. For those unconnected, the WTPs per cubic meter are Tk. 24.9 at the connection fee of Tk. 1,000, Tk. 22.2 at the connection fee of Tk. 3,000, and Tk. 21.4 at the connection fee of Tk. 5,000.

These WTPs of domestic users which range between Tk. 21 and 30 per cubic meter are higher than the current water tariff of KWASA, which is Tk. 4 per cubic meter. However they are still lower than the estimated ability to pay. Assuming that 4% household income can be allocated to water, the ability to pay for water is estimated at Tk. 48.1 per cubic meter (**Section 9.1.1 (7)**). Tk. 21 to 30 per cubic meter are lower than the Tk. 48.1, therefore considered plausible.

(2) Non-Domestic User's WTP

Under the same technical assistance (TA) of ADB by which the consumer survey was carried out in 2009, also conducted in 2010 was a non-domestic water user survey. This non-domestic water user survey covered a total of 505 establishments in Khulna. The findings contain many suggestive data to estimate non-domestic users' willingness to pay for water supply services.

The survey prepared several questions to investigate the non-domestic water users' water sources. The results are summarized in **Table 2.3.13**. As several questions were presented to the non-domestic users and the questions had several answers to opt, the total number of users turned out to be 677, instead of 505. This means that some of the users use plural water sources and the total water use may include some double counting. From those 677 water sources, a total of 230,890 m^3 water is used monthly. Considering possible double counting, this is interpreted as 341 m^3 per month per water user.

It should be also noted that the majority of the non-domestic water which volume amounts to 211,916m^3/month is taken from private tube wells with motor pump by 267 users.

Unlike domestic users, water usage pattern of non-domestic users should be dissimilar with each other. For example, in some industries where water is used as major raw materials or as coolant/ washer in manufacturing process, water cost may be significant. However, in other industries where water use is limited for its size, the water cost will be negligible.

The survey did not prepare direct questions to clarify non-domestic user's willingness to pay for better water supply. Instead a question was asked to know whether the water charge for institutional customers should be (i) the same as, (ii) less than double of, (iii) two to three times of, or (iv) more than three times of the domestic customers. We considered it difficult to estimate the non-domestic user's WTP from answer to this question, because there was no indication of concrete number of customer charge. Therefore we estimated the ability to pay (ATP) of non-domestic users and regarded the ATP as the WTP.

Table 2.3.13 Non-Domestic User's Water Consumption

User type	Water source	KWASA piped system	KWASA hand pump	Private tube well with hand pump	Private tube well with motor pump	Private water vendor	Total
Retail Shop	No. of users	1	23	6	4	1	35
	Average (m3/month)	30	2	1	19	0	4
Restaurants	No. of users	9	85	45	26	15	180
	Average (m3/month)	212	15	23	64	11	34
Residential Hotels	No. of users	5	7	4	29	4	49
	Average (m3/month)	44	5	1	211	2	130
School	No. of users	2	6	9	9	0	26
	Average (m3/month)	15	30	27	97	0	51
College	No. of users	0	4	4	10	0	18
	Average (m3/month)	0	39	381	1,747	0	1,064
University	No. of users	1	2	0	6	0	9
	Average (m3/month)	106	7	0	1,229	0	833
Madrassa	No. of users	0	7	3	6	0	16
	Average (m3/month)	0	278	12	233	0	211
Hospital	No. of users	1	4	1	7	0	13
	Average (m3/month)	150	1,442	6	1,140	0	1,069
Clinic	No. of users	3	9	8	24	0	44
	Average (m3/month)	61	12	2	178	0	104
Pathology	No. of users	4	6	1	5	0	16
	Average (m3/month)	62	2	3	42	0	30
Religious Institution	No. of users	4	16	6	17	0	43
	Average (m3/month)	38	55	22	206	0	109
Flaten Rice Mill	No. of users	0	0	1	3	0	4
	Average (m3/month)	0	0	250	216	0	225
Shrimp Factory	No. of users	0	0	0	7	0	7
	Average (m3/month)	0	0	0	7,721	0	7,721
Ice Mill	No. of users	0	0	0	7	0	7
	Average (m3/month)	0	0	0	713	0	713
Jute Mill	No. of users	0	0	2	5	0	7
	Average (m3/month)	0	0	120	7,339	0	5,277
Rice Mill	No. of users	1	1	5	24	0	31
	Average (m3/month)	413	1	3	856	0	677
Cable Factry	No. of users	0	0	0	1	0	1
	Average (m3/month)	0	0	0	4,500	0	4,500
Hard Board Mill	No. of users	0	0	0	1	0	1
	Average (m3/month)	0	0	0	13,592	0	13,592
Super Market/ Commercial Building	No. of users	2	1	0	13	5	21
	Average (m3/month)	23	24	0	365	1	229
Cinema Hall	No. of users	2	1	0	1	0	4
	Average (m3/month)	30	2	0	60	0	30
Govt. Office	No. of users	5	11	13	24	3	56
	Average (m3/month)	11	11	38	721	1	321
Non-Govt. and Private Office	No. of users	7	9	8	22	5	51
	Average (m3/month)	24	6	5	131	1	62
Bank	No. of users	4	10	6	16	2	38
	Average (m3/month)	86	2	3	58	0	34
Total	No. of users	51	202	122	267	35	677
	Average (m3/month)	81	53	33	794	5	341
	Total (m3/month)	4,114	10,636	4,044	211,916	180	230,890

Source: Prepared by Study Team based on the findings of "Non-Domestic Water Consumer Survey in Khulna City"

The survey asked some questions that could be useful to deduce the appropriate water cost for an average non-domestic user in Khulna. One question was to ask the monthly electricity bill. The results of this question are summarized in **Table 2.3.14**. The average monthly electricity bill of 496 non-domestic water users was computed at Tk. 36,892. There is no rule of thumb to estimate the proper ratio of electricity bill and water bill for non-domestic users. We provisionally assume that a non-domestic customer can pay half of the electricity bill to the water bill. This level is computed at Tk. 18,446 per month per user.

Table 2.3.14 Non-Domestic User's Electricity Consumption

User Type	No. of Users	Average Electricity Bill (Tk/month)	Total Electricity Bill (Tk/month)
Retail Shop	31	723	22,420
Restaurant	150	1,010	151,475
Residential Hotel	35	19,274	674,600
School	18	2,942	52,950
College	13	20,835	270,850
University	7	99,014	693,100
Madrassa	12	2,933	35,200
Hospital	10	49,550	495,500
Clinic	29	5,850	169,650
Pathology	10	3,020	30,200
Religious Institution	34	1,488	50,600
Flaten Rice Mill	3	8,000	24,000
Shrimp Factory	7	271,429	1,900,000
Ice Mill	7	153,571	1,075,000
Jute Mill	5	1,826,000	9,130,000
Rice Mill	24	28,000	672,000
Cable Factory	1	370,000	370,000
Hard Board Mill	1	1,200,000	1,200,000
Super Market / Commercial Building	13	21,208	275,707
Cinema Hall	3	4,733	14,200
Government Office	31	25,496	790,390
Non-Government Office and Private Office	31	3,161	98,000
Bank	21	4,876	102,400
Total	496	36,892	18,298,242
50% of Average Electricity Bill (Tk/month)		18,446	

Source: Prepared by Study Team based on the findings of
"Non-Domestic Water Consumer Survey in Khulna City"

In the survey, there was another relevant question to deduce the appropriate water cost which was to ask the monthly income/revenue of non-domestic users. The results of this question are summarized in **Table 2.3.15**. A total number of 316 non-domestic water users replied to this question, meaning that more than 60 percent of the non-domestic users in Khulna are subject to some income/revenue generation. The average monthly income of the non-domestic users was Tk. 2,189,543. Tk. 18,446, which is 50 percent of the average electricity bill of the non-domestic users is 0.8 percent of the average income. We can consider this 0.8 percent of income as a plausible level of non-domestic user's ATP for water, which is a proxy of the WTP.

This WTP, when divided by the average monthly water consumption of 341 cubic meters, becomes Tk. 54 per cubic meter. This Tk. 54 per cubic meter is 1.8 to 2.6 times of Tk. 21 to 30 which is the estimated WTP of domestic users. This ratio is similar to that of existing KWASA water tariff where the non-domestic tariff is 2.5 times the domestic tariff. Therefore we can consider Tk 54 as a plausible WTP of non-domestic users.

Table 2.3.15 Non-Domestic User's Income

User Type	No. of Users	Average Income (Tk/month)	Total Income (Tk/month)
Retail Shop	32	142,266	4,552,500
Restaurant	153	100,362	15,355,400
Residential Hotel	35	830,147	29,055,150
School	19	n.a.	n.a.
College	13	n.a.	n.a.
University	7	n.a.	n.a.
Madrassa	12	n.a.	n.a.
Hospital	10	934,400	9,344,000
Clinic	29	298,172	8,647,000
Pathology	10	420,000	4,200,000
Religious Institution	34	n.a.	n.a.
Flaten Rice Mill	3	434,020	1,302,060
Shrimp Factory	7	60,685,714	424,800,000
Ice Mill	7	334,286	2,340,000
Jute Mill	4	44,900,000	179,600,000
Rice Mill	24	134,482	3,227,560
Cable Factory	1	n.a.	n.a.
Hard Board Mill	1	10,000,000	10,000,000
Super Market / Commercial Building	5	146,360	731,800
Cinema Hall	3	360,000	1,080,000
Government Office	34	n.a.	n.a.
Non-Government Office and Private Office	32	n.a.	n.a.
Bank	21	n.a.	n.a.
Total of respondents	316	2,189,543	691,895,470

Source: Prepared by Study Team based on the findings of
"Non-Domestic Water Consumer Survey in Khulna City"

2.3.6 The Electricity Power Supply Situation of Bangladesh

(1) Situation

Lack of power supply compared to demand is severe in Bangladesh. In contrast to peak time power demand of 5,100 MW, installed power supply capacity is 5,202 MW and actual maximum power supply capacity is 3,717 MW, and planned power outages are frequently required throughout the year on 2007 from the report of "The Rolling Plan for Bangladesh" in July 2009 by Ministry of Foreign Affairs[5]. It is also informed from the general manager of PBS, Bagerhat Office that the peak time power demand is reached about 6,000 MW on this survey.

Continuous investment for new power infrastructure is needed. Generation plants are run continuously and not even stopped for regular maintenance. As a result, it takes a long time to repair the plants when those plants are broken down. The regular maintenance of the power plants is highly required.

[5] Remarks) http://www.mofa.go.jp/Mofaj/gaiko/oda/seisaku/jigyou/pdfs/bangladesh.pdf

Though 80 % of the power plants are gas based, the shortage of gas supply has become so intense that it has become urgent to examine the alternative energy sources. Considering the 8 % growth of the demand of power annually, Government of Bangladesh plans to generate more power by installing 4,350 MW of new power plant by 2012(mainly gas thermal), and 10,000 MW of new power plant by 2025(mainly coal thermal). For the expedition of coal thermal power plant development, the government is formulating the coal policy.

The network of transmission line extends to 8,015 km and the capacity of substations is 13,402 MVA (as of 2008). Since power supply itself is increasing, continuous development of transmission line is required. The network of distribution line extends to 209,932 km and 42 % of nationals can access to electricity (as of 2008). GOB plans to extend the distribution line to 477,558 km and to cover latter 100 % by 2020.

The coverage must be corresponded to the development progress of overall power supply system. On the other hand, system loss is at serious level (19.3 %) and countermeasure such as rehabilitation for efficient operation must be implemented immediately. It is important to examine and take measures for non technical loss (7-8 %).

(2) Electricity Operation Condition in Bangladesh

The electric power generation and distribution was developed and operated by BPDB (Bangladesh Power Development Board) as the electric sector of the government. From 1996, the un-handling of the power generation, transmission and distribution sector of the government have been made progress and IPP (Independent Power Producer) has gone into them, the administrative improvement is aimed by the delegation of authority and streamlining administrative structure.

The electric power generation is operated by ASPCL (Ashuganj Power Station Company Ltd.), EGCB (Bangladesh Generation Company of Bangladesh), NWPGCL (North West Power Generation Company Ltd.) and IPP further to the BPDB. The power plant that is the one of the sector of ASPCL and BPDB, they conclude a sales contract of electricity with the single buyer.

The power transmission is operated by PGCB (Power Grid Company of Bangladesh) exclusively and their income resource is the charge of 0.23 TK per kWh of electric energy from the distribution companies. The power distribution is operated as follows:

Dhaka Metropolitan North area	Dhaka Power Distribution Company (DPDC)
Dhaka Metropolitan South area	Dhaka Electric Supply Company Ltd. (DPDC)
Other main area	West Zone Power Distribution Company (WZPDC)
	North West Zone Power Distribution Company (NWZPDC)
	South Zone Power Distribution Company (SZPDC)
	Bangladesh Power Development Board (BPDB)

The power distribution for other rural area is operated by 70 parties of PBS and covered 40 % of that assisted with REB. Bangladesh Energy Regulatory Commission (BERC) as independent regulatory committee has been examining tariff structure for efficient operation. BERC was established recently, and capacity development is in progress.

(3) Electricity Operation Condition in Khluna City Area

A comparison alternative for this study's geographical area covers Gopalganj beyond the Khulna city area. In these areas, WZPDC covers the Khulna City area, PBS Bagerhat covers the east side area of Rupsa River and PBS Khluna coves the west side area of Khluna City.

The regulation and tariff is different from WZPDC and PBS, but that is same between PBS Bagerhat and PBS Khluna. Then, the survey team collects the information of the stability for power source, regulation and tariff from WZPDC and PBS Bagerhat.

The power outage, the duration time is within 30 minutes, is sometimes occurred while the survey. Also, at the 12 feeders of WZPDC sub-station, average times of power outages are 31 times in one month and total time is 1,500 minutes. The scheduled outage is about 15 % in time and 20 % in frequency. It seemed that the power outage is occurred not only maintenance but also load shedding for electricity power lack.

Scheduled power outage time is around two hours and un-scheduled power outage time is about 30 minutes informed from BPS Bagerhat. Power outage in Khulna city informed from WZPDC is tabulated below.

Table 2.3.16 Power Outage in Khulna City

Month	Power outage period (minutes)		Power outage time (number)		Affected customers
	Not planned	Total	Not planned	Total	
11/08	1,990	4,779	49	143	30,282
12/08	793	3,388	31	72	30,354
01/09	3,833	5,854	82	143	30,424
02/09	2,220	9,169	50	228	30,700
03/09	3,072	24,751	71	513	30,808
04/09	2,921	55,078	46	947	30,893
05/09	3,298	16,684	85	364	31,001
06/09	2,880	30,423	112	667	31,138
07/09	4,879	17,575	123	374	30,901
08/09	2,924	19,724	88	421	31,545
09/09	1,622	16,188	58	367	31,603
10/09	1,712	12,114	83	273	31,475
Total	32,144	215,727	878	4,512	371,124
Month.Avrage	2,679	17,977	73	376	30,927
Month. Average for one feeder	223	1,498	6	31	2,577

Remarks: total outage of 12 feeders from Division-1 Sub-station

Voltage fluctuation is within plus minus 6 to 10 % in WZPDC and within plus minus 10 % in PBS distribution area. Frequency fluctuation is within 49 Hz to 51 Hz, and the record of harmonics was not available in this survey.

Power distribution system is three face four wire methods. Then, three face unbalance will be occurred in case of using single face loads. While above reasons, it will be necessary to make a detail investigation for harmonics and three face unbalancing condition and/or to stipulate the detail investigation to the contractor on the contract document.

In Bangladesh, roadside tree growth velocity is rapid. So, it is necessary to cut the brunch of tree to guard a contact accident. This is one of the factors of high number of scheduled power outage.

(4) Receiving Voltage

Receiving voltage is tabulated below. These voltages are applied for WZPDC and PBS.

Table 2.3.17 Power Demand and Receiving Voltage

Demand	Up to 50kW	50kW to 5,000kW	5,000kW to 15,000kW	Over 15,000kW
Voltage	400V	11kV	33kV	132kV

From the above, the receiving voltage of water treatment plant for Option-7 and 8 applying the RO membrane is 33kV and others is 11kV.

(5) Boundary Point of Electrical Works

According to the regulation, power receiving facilities and incoming overhead line in case of that there is not exist the power line near the site, material and installation fee will be pay by customer. The power receiving facility will be installed by the customer and power incoming line will be installed by power distribution companies. As well, in case of that the power line is existed within 100 ft from the site, the power incoming line material and installation fee will be pay by power companies.

According to the public construction works price list issued by Bangladesh government (7edition), the installation cost of 11 kV power incoming overhead line per 30 m will be tabulated below.

Installation cost for overhead power line among pole to pole with 30m distance		
12m Concrete Pole	28,518TK	
Installation works for 12m concrete pole	1,544TK	
Material and installation cost for rack	735TK	
Material and installation cost for insulator	819TK	
Material and installation cost for stay	1,381TK	
Material and installation cost for wire	3,210TK	
Total	36,207TK	For 30m

In case of 33 kV power line receiving, the installation cost of overhead power line is 0.81 MTK/km informed by PBS. This cost is about 6.75 times of the case of 11 kV incoming line installation.

The contribution for construction will be not necessary for Option-7, because 33kV distribution power line exists near the site. But for Option-8, the power line is not existing near the site, so the contribution will be necessary to construct the power line from the power company sub-station that is about 4.5 km distance from the site.

(6) Electricity Charges

Electricity charge is applied by two forms, one is basic charge and the other is demand charge at both WZPDC and PBS like Japan. The basic charge is same value at WZPDC and PBS but demand charge is not equal. WZPDC prepare a category of time zone charge system but PBS does not have that. The charge is tabulated in **Table 2.3.18**. The power charge is same both 11kV and 33kV.

Table 2.3.18 Basic Charge and Demand Charge

Electricity Company	Category	Basic Charge	Demand Charge	Notes
WZPDC	F	40TK/kW	3.8TK/kWh	Flat rate
			6.73TK/kWh	Hour time 17:00～23:00
			3.14TK/kWh	Other than above
PBS	6	40TK/kW	4.3TK/kWh	Flat rate

Remarks: Basic charge will be calculated from multiplying 40TK and peak demand.

(7) Another Fees

Security charge and installation fee will be necessary for the installation of Watt-hour meter. Security charge is 600 TK for WZPDC and 802 TK for PBS per peak power demand. And installation fee will be 25,000 TK both WZPDC and PBS.

2.4 Project Area and Land Use

2.4.1 Definition of Project Area

There are several definitions relating to the Khulna's urban area as shown in **Figure 2.4.1**.

- The KCC area: based around the thana of Daulatpur, Khalishpur, Sonadanga and Khulna Sadar, covering around 45 sq. kms.
- Khulna pourashava (municipality): KCC area with a portion of Khan Jahan Ali thana but excludes part of Daulatpur thana.
- Khulna Master Plan (KMP)[6] area: as above together with areas on the eastern side of the Rupsha river (Dighalia and Rupsha), Phultala and Noapara[7] municipalities to the North and various mouza in Batiaghata and Dumuria to the south and east. In total, the master plan area covers 178 sq. kms of which around 61 sq. kms are located west of the Rupsha River.
- Khulna Statistical Metropolitan Area (SMA): as defined by Bangladesh Bureau of Statistics (BBS) which includes Rupsha, Dighalia and Khan Jahan Ali thana in addition to the KCC area.
- Furthermore KCC have submitted a formal proposal to the central government to extend KCCs boundaries by essentially including the entire KMP area located to the west of the Rupsha River.

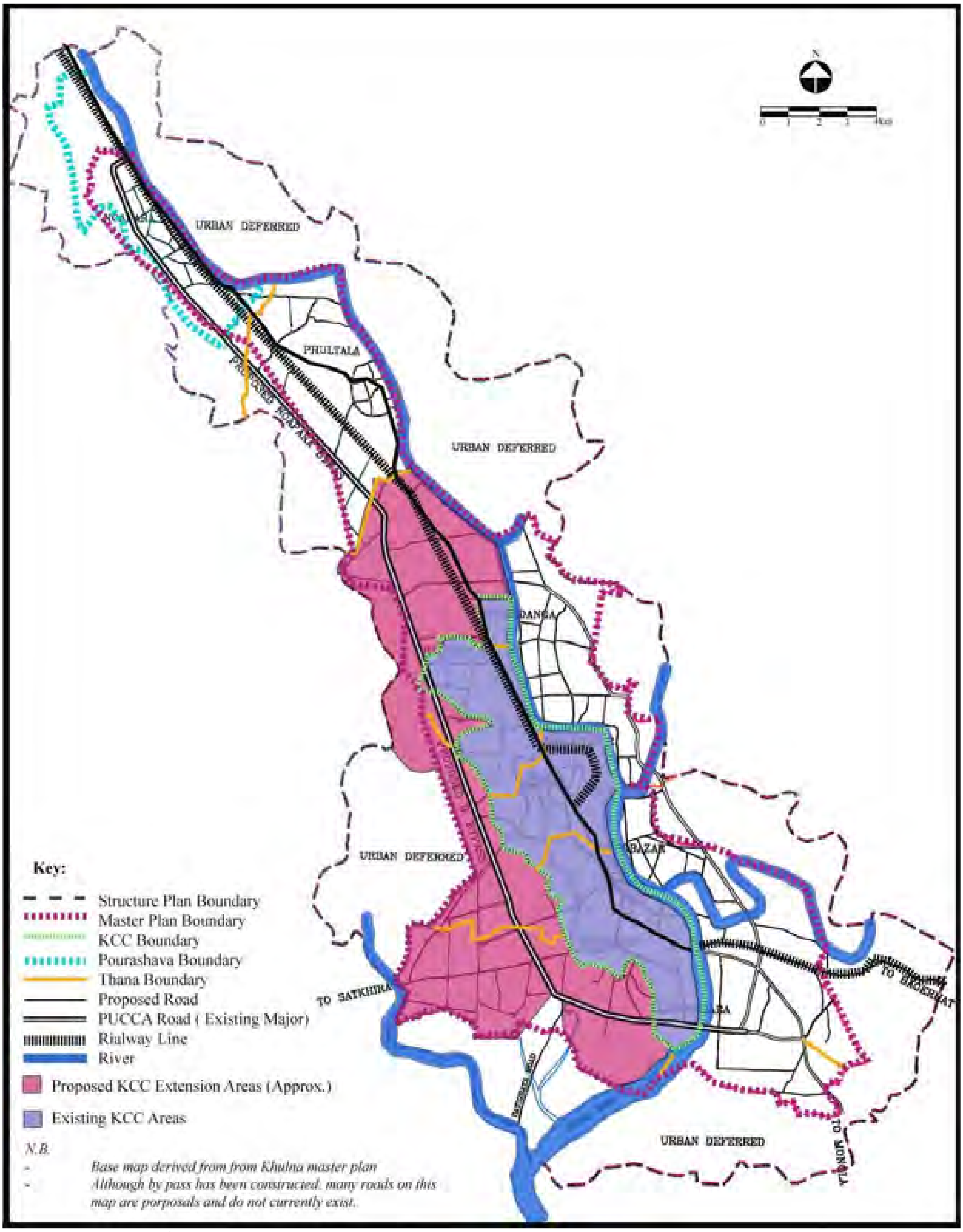
In discussion with KWASA, KDA and JICA, the current KCC area will be adopted as the study area for this project. There are two main reasons:

a) The approval of the KCC's area extension will take time and it is difficult to confirm the schedule.

[6] Prepared by Khulna Development Authority (KDA) and approved by the government.
[7] Unlike all other areas mentioned which are in Khulna district, Noapara is located in Jessore district.

b) KWASA is relatively new and is yet to be fully functional. It is desirable to devote KWASA's effort to concentrate on the current city area.

For the Long Term Development Plan up to 2030 some extensional possibility will be taken into consideration.



Source: Base Map from KMP study

Figure 2.4.1 Several Definitions Relating to the Khulna's Urban Area

2.4.2 Existing Land Use

In the late 1990s, around 80 % of the KCC area was built up as shown in the **Table 2.4.1**. Almost two thirds of the built up area was in residential use. By 2009, this land use proportions have not changed drastically. The urbanization of the Khulna City has not replaced undeveloped lands to urban ones but grown the concentration of people in existing urban areas. The main exception is Khulna University which is located between the Moyur River and the bypass on the Satkhira Road.

Table 2.4.1 Land Use, KCC Area, 1999

Land Use	Sq kms	%
Residential	23.5	51%
Mixed uses	6.6	15%
Industry (incl. railway and shipyards)	3.6	8%
Commerce/ government/ education	1.0	2%
Others	1.5	3%
Built up area	36.2	79%
Agricultural land	9.8	21%
Total	46.0	100%

2.4.3 Proposed Land Use Plan

Along the bypass on the Satkhira Road new shrimp ponds have been developed in recent years. But this new developments have been limited along the road which are out of current KCC area. In this study the land use is almost same as that was in 1999 and Khulna latest urbanization is likely to synchronise to not land use development but the population growth.

2.5 Urban Governance and Stakeholders Related to Water Supply in Khulna

2.5.1 General

A large number of government entities are in charge of various aspect of the water sector in Bangladesh. The National Water Management Plan (NWMP) lists not less than 14 ministries involves in the sector. Among them the Ministry of Local Government, Rural Development and Cooperatives (LGRD&C) is in charge of water supply in rural areas and cities.

2.5.2 Khulna Water Supply and Sewerage Authority (KWASA)

Khulna Water Supply and Sewerage Authority (KWASA) was established in accordance with the SRO issued in February 2008. The committee was formed to transfer staff, logistics, liabilities, assets of KCC involved in water supply to KWASA in April 2008. In August 2008, the LGRD&C issued an order to transfer all staff, logistics, liabilities, assets of KCC involved in water supply to KWASA in accordance with the report of the Committee. In September 2008, KWASA has taken over staffs, assets and liabilities.

Water supply in Khulna City is now managed by KWASA.

2.5.3 Khulna City Corporation (KCC)

General Information of KCC is as follows (Source: KCC HP/ http://www.khulnacity.org/):

Declared as City Corporation	6 August 1990
Area	45.65 km^2
No of wards	31
Total length of Roads	356.64 km
Total length of drains	642.18 km
Population (2007 est)	1,400,689
Density	67,994 per km^2

2.5.4 Department of Public Health Engineering (DPHE)

The Department of Public Health Engineering (DPHE), a national agency under the Ministry of Local Government, Rural Development and Co-operatives (MLGRD&C), is in charge of assisting municipalities and communities in building water supply infrastructure throughout the country except four cities, namely Dhaka including Narayanganj, Chittagong and Khulna where WASAs operate. MLGRD&C have a mandate to lead a number of municipality level water supply system managements in an integrated manner with fostering inter-ministerial collaboration.

2.5.5 Department of Environment (DOE)

There are several government departments in Bangladesh dealing with water pollution and scarcity problems. Among them, the Department of Environment (DDE), under the Ministry of Environment and Forests (MOEF), deals with pollution issues. Historically, the Environment Pollution Control Board was established. This was followed in 1977 by the establishment of the Environment Pollution Control Project, in 1985 by the establishment of the Department Pollution Control and finally, in 1989 by the restructured and **renamed** as the Department of Environment (DOE).

DOE takes its responsibilities through a head office and six Divisional offices located in Dhaka, Chittagong, Bogra, Barisal, Sylhet and Khulna.

DOE has been collecting data on surface water quality, and the Khulna Division Office monitors the water quality of following 25 locations;

Khulna Bagherhat River	1	Kirtankhola River	1
Balesher River	1	Kumar River	2
Bhoirab River	7	Madhumati River	1
Beel Dakatia	1	The Padma	2
Doratana River	1	Pashur River	1
Gabkhan River	1	Rupsha	3
Kakshialy River	2	Shugandha River	1

CHAPTER 3 EXISTING WATER SUPPLY

3.1 Organization and Activities of KWASA

3.1.1 Legislation

The government has adopted following national policies to improve the water supply sector in Bangladesh which are already been discussed in previous chapter:

1) National Water Policy (1999)
2) National Water Management Plan (2004)
3) National Policy for Arsenic Mitigation (2004)

The Department of Public Health and Engineering (DPHE) under the Ministry of Local Government, Rural Development and Co-operatives (MLGRD&C) is in charge of assisting municipalities and communities in building water supply infrastructure, exclusive Dhaka, Chittagong and Khulna.

These three metropolitan areas have Water and Sewerage Authority (WASA) that is responsible to provide water supply and sewerage facilities to the consumers.

3.1.2 Organization and Staffing of KWASA

Detailed approaches for institutional management of KWASA are to be described in **Chapter 8** and only general subject matters are mentioned in this sub-section

(1) Organization

The Government of Bangladesh established the Khulna Water Supply and Sewerage Authority (KWASA) in February 2008 through a Statutory Regulation Order (SRO)[1] to provide for “the construction, improvement, expansion, operation and maintenance of water and sewerage works and other facilities relating to environmental sanitation”. This paved the way for spinning off the water supply division of the Khulna City Corporation (KCC) into the Khulna Water Supply and Sewerage Authority, a separate, independent and legal entity by virtue of the Water Supply and Sewerage Authority Act of 1996 (WASA Act).

Several circulars have been issued by the Local Government Division (LGD), which affected the assets transfer of KCC’s water supply department to the KWASA. The first to be transferred to KWASA were KCC’s 130 permanent employees from its water supply division. Next came the transfer of the physical assets such as real property, buildings, machineries, equipment, vehicles, furniture and fixtures, and stocks (supplies and materials), including financial accounts and liabilities to the KWASA. The approved KWASA organogram is shown in **Figure 3.1.1**.

[1] Published under Gazette No. (Dhaka, 25 February 2008) S.R.O no-43-law/2008- law/division pass-2/K 1/2007

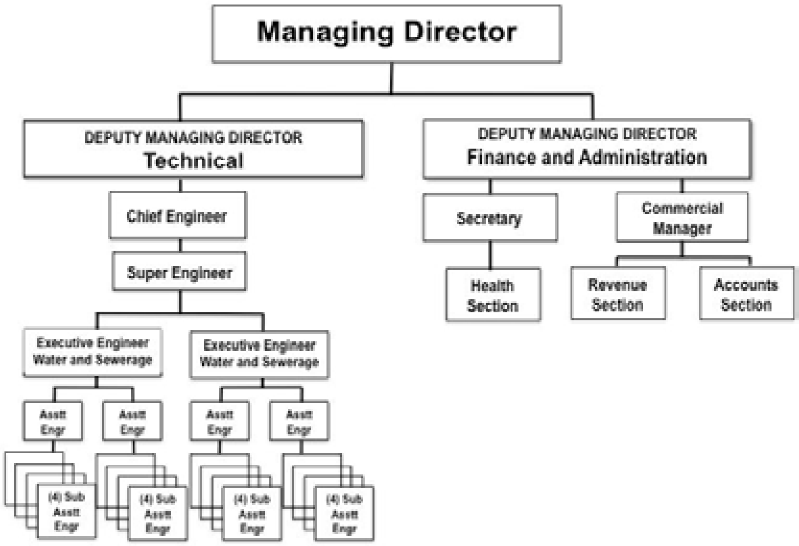


Figure 3.1.1 Approved KWASA Organogram

(2) Staff

The organization set-up of KWASA was approved in November 2008, providing for a staff complement of 157 permanent staff. To date, 130 of these positions have been filled up by former KCC employees; and two positions – the Managing Director and Deputy Managing Director for Technical – have recently been filled through deputation and contract hiring, respectively. Meanwhile, the remaining 25 positions are still undergoing the process of review and approval by the Local Government Division under the Ministry of Local Government, Rural Development and Cooperatives (MLGRD&C), after which it will move on to the Ministry of Establishment, before KWASA can start the actual recruitment process.

3.1.3 Review of Institutional Studies on KWASA

The ADB conducted several studies aimed at assessing and evaluating KWASA's institutional capacity in fulfilling its mandate under the WASA Act of 1996, as follows: Financial Management Assessment Report, July-November 2009, Diagnostic Report, July 2009, Institutional Development Report, September 2009.

Generally, the majority of the findings in these reports are similar and are organized under three main headings, including sub-headings, as shown below:

- Institutional Development
  - *Policy*: There is a need for over-all or general KWASA water policy and an institutional development policy.
- Organization Strengthening
  - *Structure*: The presently approved KWASA organogram is not reflective of a water utility's functions. Consequently, many of the important water utility management and operation areas are not functioning as effectively as it should, such as financial management and

accounting; commercial operations and consumer service; consumer accounts and billing and collection; and administration and human resources. This situation greatly affects organizational, departmental, and individual accountability.

- *Systems:* There is a lack of basic systems to support water utility operations, such as financial and commercial operations, and other general management systems, like human resources. This results to inefficiencies in these areas, which negatively affect the over-all operations (as well as revenues) of KWASA.
- *Staff:* Important middle management positions, which should bridge the managerial divide between senior directors/managers with the rank and file, still remain unfilled. This results to an overburdened senior management, as well as an unintended "span of control" or supervision problem over so many personnel, given a vertically articulated organizational set-up, where the majority of the staff members belong to the lower rungs of the organization.

➢ Capacity Building

- *Training*: The staffs is in dire need of various types of training, since many of the permanent (as well as contractual) personnel have low educational attainment, and/or hardly received any additional skills training. However, there are two issues to be resolved before actual training activities can commence; (i) The finalization and eventual approval of the water utility-type organization structure; and (ii) The definition of jobs standards, job functions and the jobholders based on the still to-be approved organization.

The recommendations contained in the studies are also similar as shown below:

➢ Institutional Development

- *Policy*: KWASA should consider having general policies, particularly in the following areas: water resources, levels of service, service to the poor, cost recovery, water conservation and metered consumption. It also recommended policies that deal with institutional development, such as organization structure, staff remuneration, organizational numbers and outsourcing, permanent vs. contract staff, pump operators and zonal management.

➢ Organization Strengthening

- *Structure*: The studies had proposed two designs of organograms (one from the financial consultant and another from the institutional consultant), based on a water utility's functions, with a brief outline only of the functions for each major or core area.
- *Systems:* The financial management assessment study, in particular, proposed the development of systems for (i) General Accounting and Financial Reporting including Chart of Accounts; (ii) Purchasing and Inventory Management; (iii) Receipts and Disbursements and Budgeting; (iv) Fixed Assets; and (v) Billing and Collection.
- *Staff:* The studies recommended for the immediate recruitment of staff to occupy the vacant positions in the permanent roll. It also recommended that a more detailed staff assessment

be done to complete the matching of current staff (and newly recruited staff) with job functions. This means that the preparatory HR activity of developing jobs standards, job functions and the jobholders be undertaken, which will have to be based on the revised organogram. In addition, it was also recommended that staff remuneration (including benefits) be increased, and that staff promotions, based on a set of criteria, be considered.

- Capacity Building
  - *Training*: It was recommended in the institutional development report that training at all levels be undertaken – general training on the functions of the utility and specific training on the functions of the job. It proposed a visit to Phnom Penh Water Supply Authority for high level personalities from the Khulna government and KWASA as part of the 'changing mindsets' training; 'big picture training' which is anchored on the functional areas of the water utility; human resource management training, skills training for pump operators and pipe and tubewell mechanics; advanced education, attendance in national and regional seminars and conferences, and a training of trainers. The financial management assessment report, on the other hand, recommended the evaluation of the skills and expertise of existing and newly recruited staff before the preparation of a customized training program which will include such priority training as computerized accounting, payroll and other systems.

3.2 Financial Status of KWASA

3.2.1 Financial Statements

Water supply operation in Khulna under the Khulna Water Supply and Sewerage Authority (KWASA) officially started in March 2008. The Khulna City Corporation (KCC) was the predecessor of KWASA. KCC's accounting records for the water supply operation are kept up to the fiscal year 2008/2009. A fiscal year of KCC and KWASA starts in July and ends in June. In the fiscal year 2008/2009 both KCC and KWASA recorded the revenue and expenditure as the transition of accounting could not be completed at the beginning of fiscal year 2008/2009. Evolution of revenues and expenditures under KCC and KWASA is summarized in **Table 3.2.1**.

Table 3.2.1 Revenue and Expenditure of Water Supply Operation in Khulna

(Tk. 000)

Period	Operator	Revenue	Expenditure	Profit/Loss
2001/2002	KCC	19,230	13,257	5,973
2002/2003	KCC	20,144	14,577	5,566
2003/2004	KCC	19,778	14,297	5,480
2004/2005	KCC	18,744	13,930	4,814
2005/2006	KCC	22,226	15,154	7,072
2006/2007	KCC	30,022	17,264	12,759
2007/2008	KCC	26,855	20,394	6,461
2008/2009*	KCC	18,354	6,165	12,190
2008/2009*	KWASA	13,186	61,547	-48,361

Sources: KCC and KWASA
* Transitional period when both KCC and KWASA recorded revenue and expenditure

Revenues during the 2001 to 2008 periods when KCC was tasked with the water supply were rather fluctuating. It is said that the reason of fluctuation was because the consumers were not satisfied with poor services of KCC and the payments tended to be erratic. In some years, the users paid more because the water supply was relatively good but in the other years, the payments were unable to rise in response to poor services. Also KCC itself was not taking a stern policy for collection from piped water users. KCC was appropriating a 20 percent of holding tax revenues for operation and maintenance expense of public hydrants and hand tube wells which were a part of the Khulna water supply system. This revenue appropriation is not included in the revenues shown above.

Although KWASA's operation officially started in March 2008, there was a time lag in actual transfer of accounting documents and water bill collection system. KWASA started collection and processing water bills in full operation from October 2008. In fact, both KCC and KWASA recorded revenues and expenditures in the fiscal year 2008/2009. This was because they were engaged in the water supply operation in a different period of the year. Existing accounting records at both organizations are not constructed to correctly provide clear-cut separation of the service periods of KCC and KWASA in the fiscal year 2008/2009. During the period of operation under KCC, the expenditures were roughly classified into salary and development expenses (mainly O&M expenses). A majority of the expenses was salary, being accounted for more than 90 percent of the total expenditures.

KWASA has started the process to ask financial audit to an accounting firm. At point of this report, the most reliable financial data, though not audited yet, are provided in Midterm Report of ADB Technical Assistance[2]. KWASA's income statements and balance sheets presented in the ADB TA report are summarized as shown in **Table 3.2.2** and **Table 3.2.3** respectively.

[2] Preparing The Khulna Water Supply, ADB TA 7385 - BAN

Table 3.2.2 KWASA Income Statements

(Tk. 000)

	FY 2010	FY 2009
Revenues		
Water sales	6,992	15,898
Other water sales	167	96
New connection fees	476	450
Non operating revenues	109	64
Total revenues	7,744	16,508
Expenditure		
Personnel expenses	36,696	17,758
Fuel	1,401	547
Electricity	9,830	4,112
Repair and maintenance	5,497	546
Administrative & general expenses	8,005	2,081
Total expenditure	61,428	25,044
Net loss	(53,684)	(8,536)

Source: Midterm Report of ADB TA 7385-BAN, 2010

Table 3.2.3 KWASA Balance Sheets

(Tk. 000)

	FY 2010	FY 2009
ASSETS		
Non-Current Assets		
Property, Plant & Equipment (net)	496,294	483,056
Capital Work in Progress		1,500
Sub-total	496,294	484,556
Current Assets		
Inventories	2,727	702
Customer Accounts Receivables	46,286	48,270
Deposits and Advances	5,173	3,668
Cash and bank accounts	27,107	55,621
Sub-total	81,293	108,260
Total Assets	577,587	592,817
EQUITY AND LIABILITIES		
Capital and Reserves		
Capital fund	629,676	590,282
Retained earnings	(62,220)	(8,536)
Sub-total	567,056	581,746
Current Liabilities		
Creditors for expenses	9,691	10,231
Other Payables	840	840
Sub-total	10,531	11,071
Total Equity and Liabilities	577,587	592,817

Source: Midterm Report of ADB TA 7385-B.

Revenues in FY 2010 showed a huge decrease from those of FY 2009. This is because the revenues of FY 2009 included capital revenues (subsidy from GOB) which were treated as revenues under the previous accounting system employed by KCC. During the FY 2010 KWASA sustained a total net loss of Tk. 54 million, which increased the accumulated loss (negative retained earnings) by the same amount.

Figures 3.2.1 and **Figure 3.2.2** respectively show the breakdown of revenues and expenditures of FY 2010.

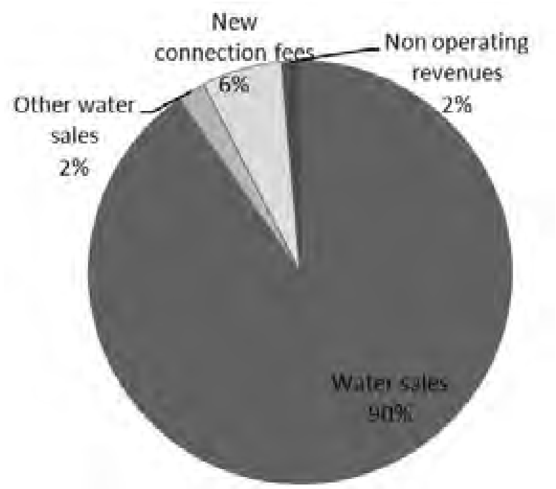


Figure 3.2.1 KWASA Revenue Structure

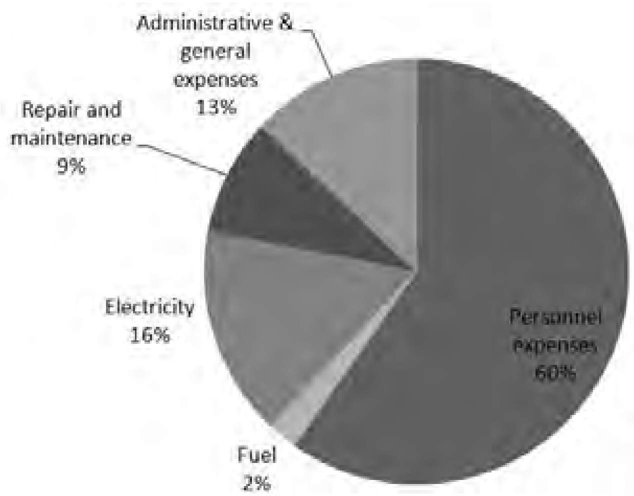


Figure 3.2.2 KWASA Expenditure Structure

A 90 percent of revenues originated from water sales to non-metered users. In the expenditure side, the majority was expended to personnel expenses (60%), followed by electricity (16%), administrative and general expenses (13%), repair and maintenance (9%) and fuel (2%). KWASA retained 134 permanent staff and 128 casual labourers in March 2010. The salary data of these staff are summarized in **Tables 3.2.4, 3.2.5** and **3.2.6.** On average, permanent staffs monthly received a basic salary of Tk. 7,948 and allowance of Tk. 6,175. The average monthly wage of a casual labourer was Tk. 5,191.

Table 3.2.4 Basic Salary of KWASA Permanent Staff

Position/title of permanent staff	No. of staff	Basic pay in 7 months (July 2009 - Jan 2010) (Tk./month)		Ave. basic salary (Tk./mth/person)
Managing Director	1	0	a	0
Deputy Managing Director, Finance & Admin.	1	187,250		26,750
Deputy Managing Director, Engineering	1	525,000		75,000
Secretary	1	180,950		25,850
Superintendent of Water	1	134,400		19,200
Executive Engineer	1	69,545	b	9,935
Sub-Assistant Engineer (Civil)	1	119,700		17,100
Sub-Assistant Engineer (Electric)	1	56,700	c	8,100
Assistant Superintendent of Water	1	62,300		8,900
Drilling Assistant	2	110,810		7,915
Pump Operator	67	3,613,524		7,705
Supervisor	4	201,940		7,212
Electric Mechanic	1	51,975		7,425
Tube well Mechanic	12	610,050		7,263
Sewerage labourer	1	32,900		4,700
Valve Operator	11	503,580		6,540
Pipeline Mechanic	4	158,235		5,651
Truck Driver	1	38,465		5,495
Pick-up Driver	1	40,390		5,770
Head Mechanic	1	38,430		5,490
Pick-up Assistant	1	32,900		4,700
Labourer	10	304,150		4,345
MLSS	4	150,955		5,391
Gate Keeper	5	175,840		5,024
Total number of staff	134			
Total basic pay for 133 staff during 7 months		7,399,989		
Average monthly basic pay for all staff		1,057,141		
Average monthly basic pay per staff		7,948		

a: This salary has not been approved by the board of Directors.
b: His salary increase has been suspended.
c: His salary is as per old scale.

Table 3.2.5 Allowance Payment for KWASA Permanent Staff

Number of permanent staff	134
Total pay for all casual laborer during 7 months (Tk.)	5,792,597
of which, house rent	2,543,548
medical allowance	479,500
conveyance	195,538
out-door allowance	5,950
washing allowance	38,150
charge allowance	10,774
tiffin allowance	80,500
festival bonus	1,444,281
employees income tax	11,952
CPF contribution	441,532
leave encashment	317,160
rest & recreation	125,712
other allowance	98,000
Average monthly allowance payment for all staff (Tk.)	827,514
Average monthly allowance pay per staff (Tk.)	6,175
Ratio of allowance/basic salary (%)	78%

Table 3.2.6 Casual Laborer Wage at KWASA

Number of casual laborer	128
Total pay for all casual laborer during 7 months (Tk.)	4,651,165
Average monthly pay for all casual laborer (Tk.)	664,452
Average monthly pay per casual laborer (Tk.)	5,191

Data of KWASA's fixed assets including property, plant and equipment was compiled under an ADB TA in 2009, which is shown in **Table 3.2.7**.

Table 3.2.7 List of KWASA's Fixed Assets

(Tk.)

Land		
Underwater Clearing water	999,999	
WASA Office	108,889	
Nirala pump house	53,965	
Car Parking	105,744	
Pump house at hospital	139	
Shahid hadis park pond	696,310	1,965,046
Tubewell		
50 Production tubewell	150,000,000	
14 Mini production tubewell	17,000,000	
Dhaka sanitary store	833,964	
MK Construction	833,964	
3270 1.5" deep Tubewell	100,000,000	
5560 1.5" shalow tubewell	40,000,000	
Tubewell-shallow and deep	409,000	
Deep tubewell	2,447,952	
Shallow Tubewell	748,524	312,273,404
Transmission and distribution lines		
220Km main pipeline	88,000,000	
Pipeline (7KM)	3,145,056	91,145,056
Buildings		
KWASA (Ground Floor)	5,000,000	
KWASA (First Floor)	3,036,543	8,036,543
Sewarage	11,000,000	11,000,000
Safety tank		
Pump house		
Nirala	4,000,000	
Pump		
Dhaka sanitary	371,668	4,371,668
Motor Vehicle		
Khulna Mettro-Kha-11-0133	850,000	
Khulna Mettro-E-11-0002	987,800	
Sprinkler	1,280,000	
Bowser	920,390	
Khulna Mettro-Mo-02-0027	725,000	4,763,190
Furniture and Fixture		
Chairman's office	33,228	
Board room	162,251	
Managing Director's office	188,693	
MD Secretary and Chief Engineer' office	35,034	
Furniture	388,300	807,506
Water Treatment Plant		
Treatment Equipment	135,900	
New material list of chlorine saved	998,800	
Spare parts list of Chlorine saved	394,500	
Mini treatment plant	11,265,500	
Chlorine equipment, pipelines and tubewell	13,800,000	
	22,098,800	48,693,500
Total		483,055,913

Source: KWASA

3.2.2 Water Tariff and Customer Profile

The non-metered users who contributed the 99 percent of KWASA revenue was an aggregate of broadly four types of users, namely residential, industrial, social, and commercial. However this customer classification is not used for tariff setting due to difficulty in designating the customer type.

The water rates and connection fees are set according to diameter size of connection pipe (**Table 3.2.8**).

Table 3.2.8 Tariffs and Fees of KWASA

Connection Diameter (inch)	Flat rate tariff (Tk./month)	Connection Fee (Tk.)
½	45	800
¾	70	1,200
1	200	1,800
1 ½	1,200	8,000
2	2,000	10,000
Other tariffs and fees: Metered connection for 1/2 – 1 inch dia. (mostly domestic): Tk.4/ m^3 Metered connection for 1 - 6 inch dia. (mostly commercial) Tk.10/ m^3 Bowser service inside service area: Tk. 200 per tanker Bowser Service outside service area: Tk. 300 per tanker Extra cost for bowser service over one hour: Tk. 50 per hour. Road cutting and repair costs: Up to Tk. 5,000		

Source: KWASA

There used to be some 2,500 water meters installed under a donor funded project but presently none of them are working properly and charged on the basis of volumetric consumption. Thus all the consumers are charged according to the diameter of the water service pipe connection, regardless of consumer classification. The water rates are Tk. 45 per month for a ½ inch connection, Tk. 70 for a ¾ inch, Tk. 200 for a 1 inch, Tk. 1,200 for a 1½ inch, and Tk. 2,000 for a 2 inch connection. The connection charges vary from Tk. 800 to 10,000 depending on the diameter. Some users, such as mosques and other religious places are not charged for water consumption.

The current volumetric water tariffs are set at Tk. 4 per cubic meter for 1/2 – 1 inch diameter pipe connection, which is mostly used by domestic users. The 1 – 6 inch diameter pipe connection, which is mostly used by non-domestic users, is charged at Tk. 10 per cubic meter. In fact there are no customers with a properly functioning meter, thus these volumetric tariffs are merely nominal. The customers are charged at fixed rates which are Tk. 45 per month for a ½ inch connection, Tk. 70 for a ¾ inch, Tk. 200 for a 1 inch, Tk. 1,200 for a 1½ inch, and Tk. 2,000 for a 2 inch connection.

The latest data of consumer distribution by the connection diameter and connection status is shown in **Table 3.2.9**. KWASA has 15,393 registered connections, of which 2,579 consumers unsatisfied with the lack of water supply by KCC and KWASA have voluntarily requested for permanent disconnections. The remaining 12,814 connections are regarded still active. However, it is believed that some of these permanently disconnected consumers are actually active but unbilled. A large majority of the connections are ¾ inch connections which comprise 82 percent of the total number of active connections. Combined with the consumers with the ½ inch size connection, 94 percent of consumers are supplied water by a small sized diameter connection.

Table 3.2.9 Distribution of Consumers by Meter Size and Connection

Diameter (inch)	Total number of registered connections	Inactive connections	Active connections	Active connections (%)
½	2,560	1,024	1,536	12.0%
¾	11,691	1,231	10,460	81.6%
1	1,015	253	762	5.9%
1 ½	70	31	39	0.3%
2	57	40	17	0.1%
Total	15,393	2,579	12,814	100.0%

Source: KWASA

Applying the consumer distribution of active connections and the corresponding flat rate tariffs, the expected monthly cash collection from active connections can be computed at Tk. 1.03 million. This number, when multiplied by six, almost coincides with Tk. 6.39 million, which is the water sale revenue of KWASA during six months from July to December 2009.

The study team attempted to estimate effective volumetric tariffs based on actual water consumption and the number of connections. Domestic customers are regarded to use ½ inch or ¾ inch connections. Non-domestic customers' connections are assumed to be 1 inch diameter or larger.

The number of active connections is 11,996 for domestic users and 818 for non-domestic users. Under the current fix tariff system, the domestic customers altogether are paying Tk. 801,320 per month. The non-domestic customers' payment total Tk. 233,200. These customers who pay the bills are using water from KWASA tube wells which is currently supplying 30,100 cubic meters per day or 903,000 cubic meters monthly. This water is shared between the domestic users and the non-domestic users at a ratio of 61.5/20.5, or 677,250 m^3 by the domestic users and 225,750 m^3 by the non-domestic users. Dividing the payment amounts by the consumption volumes, the effective volumetric tariffs are estimated at Tk. 1.2/m^3 for the domestic users and Tk. 1.0/m^3 for the non-domestic users.

3.2.3 Needs for Water Tariff Revision

The existing tariffs were set in 2003 and have been unchanged since then although annual revision of water rates is allowed in the WASA Act of 1996[3]. As a result, the tariffs are kept extremely low.

In case of domestic tariff, the existing tariff is Tk. 4 per cubic meter, assuming that a domestic user usually have a connection of 1/2 – 1 inch diameter and metered. As discussed in Section 2.3.5 (1), the domestic user's willingness to pay for good water is estimated between Tk. 21 and 30 per cubic meter. As also discussed in Section 9.1.3, the domestic user's affordability to pay for good water is estimated at Tk. 48 per cubic meter. The existing domestic tariff is one fifth to one seventh of the willingness to pay price. When compared with the affordability to pay price, it is indeed one twelfth of the affordability to pay price.

[3] Sub-section (2) of Section 22 (Revision of water, sewer and storm water rates) of the WASA Act.

The non-domestic price also shows a big gap. Both the affordability to pay price and the willingness to pay price are estimated at Tk. 54 per cubic meter (Section 2.3.5 (2)). The current non-domestic tariff is Tk. 10 per cubic meter, assuming that the connections of diameter 1 to 6 inches are mostly for non-domestic use. Therefore the existing non-domestic tariff is considered to be less than one fifth of the affordability to pay price.

Such low level of KWASA water tariff is further stands out when compared with other utility services. **Table 3.2.10** summarizes domestic tariffs of electricity, gas and mobile phone and the typical monthly bills. LP gas is the most expensive and estimated to cost over Tk. 2,000 per household. The electricity bill is estimated at over Tk. 500 per month. Even the mobile phone bill is more than Tk. 300 per month per household. At the existing water tariff (Tk. 4/m^3 for metered connection of 1/2 to 1 inch diameter), the monthly bill will be only Tk. 80, assuming a consumption of 20 m^3. If unmetered, the fix monthly tariff is merely Tk. 45 for the same sized connection.

Table 3.2.10 Utility Tariffs in Khulna

Service	Rate for Domestic User	Monthly Household Bill Estimates
Electricity	TK. 2.60 per unit up to 00-100 unit(kwh) TK. 3.30 per unit up to 101-400 unit(kwh) TK. 5.65 per unit above 400 unit(kwh) Service charge 1phase/3phase- TK. 6 & TK. 27 Demand charge- TK.12	Tk. 608, assuming monthly use of 200 kwh
LP Gas	TK. 1100-1200/ 12.kg sylinder	Tk. 2,400, assuming monthly use of 2 cylinders
Mobile phone	Assuming 2 members of 1 family use mobile phone. 9 am - 5 pm Tk. 0.69/min 5 pm - 12 am Tk. 1.25/min 12 am - 9am Tk. 0.45/min	Tk. 350, assuming monthly use of 6 hours

Source: Survey by Study Team

In spite of such low tariffs, KWASA have been hesitant to increase the tariffs because they consider that the water service must first be improved before tariff increase. This seems reasonable but it is obviously late if KWASA delay the next tariff increase until the water supply is improved by the Project, which is in 2016. KWASA should immediately increase the tariff at least by 5 percent, which the KWASA management board can approve, without having approval of LGD, under the WASA Act 1996.

Once KWASA succeed in a simple tariff increase of 5 percent per year, as the next step, they could design the tariff structure more reasonably than the current one. Tariff structure should not be necessarily complex, but KWASA's current volumetric tariff, which is not practically implemented due to absence of water meters, is too simple. It has only two customer categories with one volumetric rate band per category. There could be more customer categories and the volumetric rate could be progressive instead of flat. Those options should be examined and the most appropriate system should be selected on the basis of reliable customer survey and organized customer data base.

As discussed earlier, the current water tariff is already too low so that there is little need to consider lower rate for the low income domestic users. However when the tariffs increase and near to the affordability to pay price level, a pro-poor factor could be incorporated into the tariff structure. For example, a lifeline block[4] could be set in the tariff structure.

3.2.4 Financial Management Assessment

Financial management system is a critical success factor for the project. If KWASA, possible implementing agency of the project lacks the capacity to effectively manage its financial resources, the benefits of the project will be unsustainable. The financial management assessment is a review designed to determine whether or not KWASA's financial management arrangements are considered capable of and adequate for recording all transactions and balances, supporting the preparation of regular and reliable financial statements, safeguarding its assets, and are subject to audit. A financial management assessment of KWASA has been conducted under a recent ADB technical assistance project[5]. The Study Team reviewed and updated this assessment which result is shown in **Table 3.2.11**.

Table 3.2.11 Financial Management Assessment of KWASA

Topic		Observation	Remarks
1.	**Implementing Agency**		
1.1	What is the entity's legal status / registration?	KWASA was established under Ordinance No. Gazette No. (Dhaka, 25 February 2008; S.R.O no-43-law/2008- law/division pass-2/K 1/2007) as an autonomous entity in charge of water supply and sewerage services in Khulna. Under the ordinance, the assets and liabilities of the KCC waterworks department were transferred to KWASA, except the sewerage facility.	
1.2	Has the entity implemented an externally-financed project in the past (if so, please provide details)?	No, this project will be the first one.	
1.3	What are the statutory reporting requirements for the entity?	Externally audited accounts (income statement, balance sheet and cash flow statement) have to be submitted to the Government within two months of the end of the fiscal year. (WASA Act 40, 36)	

4 An example of tariff structure with a lifeline block is a three-block system, which is exemplified as follows: Assuming the lifeline water consumption is 30 lpcd, and 5.5 as household occupancy rate, the monthly lifeline water need will be $5m^3$/household. For the consumption block of 0-5 m^3, a certain lifeline consumption rate will be applied. Such rate will be determined so that the monthly bill will not exceed 5 percent of household income of the lowest quintile (or the lowest 10th percentile if a stronger pro-poor policy is pursued). The consumption block of 5-20 m^3 will be charged at a rate to recover the O&M costs (or a certain targeted level of O&M and capital cost recovery). The consumption of more than 20 m^3 will be charged at a higher rate, which could mean to cross-subsidize the cost recoverable from the lowest block consumption and penalize those who waste water.

5 ADB Project Number 42171 – Supporting the Establishment of the Khulna Water Supply and Sewerage Authority, December 2009

Topic		Observation	Remarks
1.4	Is the governing body for the project independent?	The Board is the governing body of KWASA. In the spirit of the 1996 WASA Act the Board should perform its functions in full autonomy.	
1.5	Is the organizational structure appropriate for the needs of the project?	The current set-up has to be reorganized to put equal importance on finance and administration. There should be a separate department handling the financial and accounting functions and the immediate recruitment of the key staff such as Chief Accountant and head of Commercial Dept should be undertaken.	
2.	**Funds Flow Arrangements**		
2.1	Describe (proposed) project funds flow arrangements, including a chart and explanation of the flow of funds from JICA, government and other financiers.	Most likely lending from JICA to GoB(Ministry of Finance & Ministry of Local Government) and on-lending from GoB to KWASA.	
2.2	Are the (proposed) arrangements to transfer the proceeds of the loan (from the government / Finance Ministry) to the entity satisfactory?	KWASA has experience of receiving funds under the Annual Development Program (ADP), which will be applicable to receipt of proceeds of the on-lent loan.	
2.3	What have been the major problems in the past in receipt of funds by the entity?	Nothing to report on this yet.	
2.4	In which bank will the Imprest Account be opened?	Most probably Janata Bank, Ltd. (state owned commercial bank) in Khulna	
2.5	Does the (proposed) project implementing unit (PIU) have experience in the management of disbursements from JICA?	No experience yet.	
2.6	Does the entity have/need a capacity to manage foreign exchange risks?	Foreign exchange risk will be assumed by GOB. KWASA will have on-lent loan or grant in local currency.	
2.7	How are the counterpart funds accessed?	Counterpart funds are likely to be allocated in the ADP with regards to the budget estimates prepared by the PIU based on the annual work plan of the project.	
2.8	How are payments made from the counterpart funds?	The Project Director of PIU who is the authorized signatory to withdraw the on-lent JICA loan proceeds can also be the Drawing and Disbursement Officer to draw the government counterpart funds. GOB funds allocated in the ADP will be released periodically. The Project Director of PIU will present the bills to the Chief Accounts Officer for actual disbursement.	
2.9	If part of the project is implemented by communities or NGOs, does the PIU have the necessary reporting and monitoring features built into its systems to track the use of project proceeds by such agencies?	No part is expected to be implemented by communities or NGOs.	
2.10	Are the beneficiaries required to contribute to project costs? If beneficiaries have an option to contribute in kind (in the form of labor), are proper guidelines formulated to record and value the labor contribution?	Beneficiary’s contribution to capital cost is not required.	

Topic		Observation	Remarks
3.	**Staffing**		
3.1	What is the (proposed) organizational structure of the accounting department? Attach an organization chart.	The existing organization has no separate Accounting dept. However there are staffs assigned to undertake accounting tasks. The proposed organization will have accounting section and treasury section separately.	
3.2	Identify the (proposed) accounts staff, including job title, responsibilities, educational background and professional experience. Attach job descriptions and CVs of key accounting staff.	The current finance unit is composed of 15 employees, 8 regular and 7 master roll undertaking a combination of financial, commercial and administrative functions. Job descriptions of the proposed new accounting sections will be prepared by KWASA in due course.	
3.3	Is the project finance and accounting function staffed adequately?	The proposed organization will be adequately staffed.	
3.4	Is the finance and accounts staff adequately qualified and experienced?	ditto	
3.5	Is the project accounts and finance staff adequately trained?	The training of new accounting system so far is inadequate. Further training will be needed for the new organization.	
3.6	What is the duration of the contract with the finance and accounts staff?	7 out of the 15 staff finance and commercial staff are on contractual basis with annual renewable contracts and have been with KWASA (KCC) for a long time already. The organization proposal is based on regular employment.	
3.7	Indicate key positions not contracted yet, and the estimated date of appointment.	Not yet applicable	
3.8	Does the project have written position descriptions that clearly define duties, responsibilities, lines of supervision, and limits of authority for all of the officers, managers, and staff?	Not yet. KWASA will prepare this based on the template.	
3.9	At what frequency are personnel transferred?	There is very little transfer of personnel as most staff have been in the job for quite some time even the casual/temporary employees.	
3.10	What is training policy for the finance and accounting staff?	Training takes place as-required basis. Accounting system and computer software training was provided to 17 staffs, yet not all of them have become conversant with the new system. KWASA is requesting a follow-up training.	
4.	**Accounting Policies and Procedures**		
4.1	Does the entity have an accounting system that allows for the proper recording of project financial transactions, including the allocation of expenditures in accordance with the respective components, disbursement categories, and sources of funds? Will the project use the entity accounting system?	KWASA has not yet successfully shifted from the old system (single entry, cash basis, manual handling) to the new system (double entry, accrual basis, computerized journal entries). Introduction of new computer softwares and relevant staff training on the new accounting and financial reporting system, payroll and inventory have been conducted by a local accounting firm, but the new accounting system and related internal control system are yet to be functional.	

Topic		Observation	Remarks
4.2	Are controls in place concerning the preparation and approval of transactions, ensuring that all transactions are correctly made and adequately explained?	Under the current system, controls exist but reporting system is inadequate. The new accounting system and related internal control system are expected to improve the situation.	
4.3	Is the chart of accounts adequate to properly account for and report on project activities and disbursement categories?	The new chart of accounts will adequately account for the project activities.	
4.4	Are cost allocations to the various funding sources made accurately and in accordance with established agreements?	The project director of PIU and the new accounting system should function as expected.	
4.5	Are the General Ledger and subsidiary ledgers reconciled and in balance?	The current accounting system has neither general ledger nor subsidiary ledgers. Thus no reconciliation has been done. The new accounting system will perform this function.	
4.6	Are all accounting and supporting documents retained on a permanent basis in a defined system that allows authorized users easy access?	The current system is manually retained and all documents are accessible. There are no specifically authorized users of the system. The new accounting system will have sufficient data retainment and access control function.	
Segregation of Duties			
4.7	Are the following functional responsibilities performed by different units or persons: (i) authorization to execute a transaction; (ii) recording of the transaction; and (iii) custody of assets involved in the transaction?	Yes, to a limited extent, since the staff complement is not yet complete. The proposed organization considers the segregation of duties.	
4.8	Are the functions of ordering, receiving, accounting for, and paying for goods and services appropriately segregated?	ditto	
4.9	Are bank reconciliations prepared by someone other than those who make or approve payments?	Periodical preparation of bank reconciliation has not been institutionalized. Under the new accounting and control system this will be considered.	
Budgeting System			
4.10	Do budgets include physical and financial targets?	They have annual budgets but these are not tied to physical targets.	
4.11	Are budgets prepared for all significant activities in sufficient detail to provide a meaningful tool with which to monitor subsequent performance?	They have annual budgets but do not provide for sufficient details.	
4.12	Are actual expenditures compared to the budget with reasonable frequency, and explanations required for significant variations from the budget?	Budget monitoring is done only casually. The form and methodology are not yet institutionalized.	
4.13	Are approvals for variations from the budget required in advance or after the fact?	Yes	
4.14	Who is responsible for preparation and approval of budgets?	Budgets are prepared by MD with support from DMD for engineering and limited involvement of DMD for finance. Budgets need approval from the Board of Directors under the current set-up.	

Topic	Observation	Remarks
4.15 Are procedures in place to plan project activities, collect information from the units in charge of the different components, and prepare the budgets?	Project activities are being done in the Engineering Division under the DMD for Engineering. The systems for planning and budgeting for various activities are not yet in place.	
4.16 Are the project plans and budgets of project activities realistic, based on valid assumptions, and developed by knowledgeable individuals?	ditto	
Payments		
4.17 Do invoice-processing procedures provide for: (i) Copies of purchase orders and receiving reports to be obtained directly from issuing departments? (ii) Comparison of invoice quantities, prices and terms, with those indicated on the purchase order and with records of goods actually received? (iii) Comparison of invoice quantities with those indicated on the receiving reports? (iv) Checking the accuracy of calculations?	The current system lacks these controls. The new accounting system will safeguard this. The new system is not yet operative. Further introductory assistance, training, and system maintenance are requested.	
4.18 Are all invoices stamped PAID, dated, reviewed and approved, and clearly marked for account code assignment?	ditto	
4.19 Do controls exist for the preparation of the payroll and are changes to the payroll properly authorized?	ditto	
Policies And Procedures		
4.20 What is the basis of accounting (e.g., cash, accrual)?	The new system is not yet operative. Further introductory assistance, training, and system maintenance are requested. Meanwhile KWASA still uses the old system (single entry, cash accounting, manual handling)	
4.21 What accounting standards are followed?	The new system will be based on Generally accepted accounted principles (GAAP) under Bangladesh Accounting Standard (BAS). International Financial Reporting Standards (IFRSs) apply where BAS does not cover.	
4.22 Does the project have an adequate policies and procedures manual to guide activities and ensure staff accountability?	The new accounting manual prepared by an accounting firm under an ADB TA is adequate.	
4.23 Is the accounting policy and procedure manual updated for the project activities?	No need for update.	
4.24 Do procedures exist to ensure that only authorized persons can alter or establish a new accounting principle, policy or procedure to be used by the entity?	Not under the current control system. The new system based on the new accounting system should be prepared and institutionalized.	
4.25 Are there written policies and procedures covering all routine financial management and related administrative activities?	Ditto	
4.26 Do policies and procedures clearly define conflict of interest and related party transactions (real and apparent) and provide safeguards to protect the organization from them?	No such conflict is assumed.	

Topic	Observation	Remarks
4.27 Are manuals distributed to appropriate personnel?	The new accounting manuals are kept at KWASA.	
Cash and Bank		
4.28 Indicate names and positions of authorized signatories in the bank accounts.	MD and DMD for finance	
4.29 Does the organization maintain an adequate, up-to-date cashbook, recording receipts and payments?	Yes	
4.30 Do controls exist for the collection, timely deposit and recording of receipts at each collection location?	Yes	
4.31 Are bank and cash reconciled on a monthly basis?	No, bank reconciliation is not currently prepared	
4.32 Are all unusual items on the bank reconciliation reviewed and approved by a responsible official?	Not applicable.	
4.33 Are all receipts deposited on a timely basis?	Yes	
Safeguard over Assets		
4.34 Is there a system of adequate safeguards to protect assets from fraud, waste and abuse?	Asset keepers are assigned in each section and the assets are numbered and listed.	
4.35 Are subsidiary records of fixed assets and stocks kept up to date and reconciled with control accounts?	Records are incomplete especially for fixed assets and are not reconciled with total ledger balance.	
4.36 Are there periodic physical inventories of fixed assets and stocks?	No	
4.37 Are assets sufficiently covered by insurance policies?	No	
Other Offices and Implementing Entities		
4.38 Are there any other regional offices or executing entities participating in implementation?	No	
4.39 Has the project established controls and procedures for flow of funds, financial information, accountability, and audits in relation to the other offices or entities?	Not applicable	
4.40 Does information among the different offices/implementing agencies flow in an accurate and timely fashion?	Not applicable	
4.41 Are periodic reconciliations performed among the different offices/implementing agencies?	Not applicable	
Other		
4.42 Has the project advised employees, beneficiaries and other recipients to whom to report if they suspect fraud, waste or misuse of project resources or property?	Not yet applicable	
5. Internal Audit		
5.1 Is there an internal audit department in the entity?	Not yet. The internal audit section will be included in the new organization proposal	

Topic		Observation	Remarks
5.2	What are the qualifications and experience of audit department staff?	The new organization proposal will deal with this.	
5.3	To whom does the internal auditor report?	The internal auditor will report to the Board.	
5.4	Will the internal audit department include the project in its work program?	Yes	
5.5	Are actions taken on the internal audit findings?	Not yet applicable	
6.	**External Audit**		
6.1	Is the entity financial statement audited regularly by an independent auditor? Who is the auditor?	There are no audited financial statements. It is envisioned that selection of external auditor will be finalized in 2010 and the external audit will take place in 2011.	
6.2	Are there any delays in audit of the entity? When are the audit reports issued?	Externally audited accounts (income statement, balance sheet and cash flow statement) have to be submitted to the Government within two months of the end of the fiscal year. (WASA Act 40, 36)	
6.3	Is the audit of the entity conducted according to the International Standards on Auditing?	Not yet applicable.	
6.4	Were there any major accountability issues brought out in the audit report of the past three years?	Not yet applicable	
6.5	Will the entity auditor audit the project accounts or will another auditor be appointed to audit the project financial statements?	Not yet applicable	
6.6	Are there any recommendations made by the auditors in prior audit reports or management letters that have not yet been implemented?	Not yet applicable	
6.7	Is the project subject to any kind of audit from an independent governmental entity (e.g., the supreme audit institution) in addition to the external audit?	No.	
6.8	Has the project prepared acceptable terms of reference for an annual project audit?	Not yet applicable	
7.	**Reporting and Monitoring**		
7.1	Are financial statements prepared for the entity? In accordance with which accounting standards?	Under the new accounting system, financial statements will be prepared according to BAS and IFRS.	
7.2	Are financial statements prepared for the implementing unit?	The new accounting system should be able to prepare financial statements for each cost center including the PIU.	
7.3	What is the frequency of preparation of financial statements? Are the reports prepared in a timely fashion so as to useful to management for decision making?	Not yet applicable.	
7.4	Does the reporting system need to be adapted to report on the project components?	Not yet applicable.	

Topic		Observation	Remarks
7.5	Does the reporting system have the capacity to link the financial information with the project's physical progress? If separate systems are used to gather and compile physical data, what controls are in place to reduce the risk that the physical data may not synchronize with the financial data?	Not yet applicable.	
7.6	Does the project have established financial management reporting responsibilities that specify what reports are to be prepared, what they are to contain, and how they are to be used?	Not yet applicable.	
7.7	Are financial management reports used by management?	Currently KWASA's key financial management report is collection report (monthly and daily), which is used by management. The new accounting system will be able to produce various reports which will be used by the management.	
7.8	Do the financial reports compare actual expenditures with budgeted and programmed allocations?	Not yet applicable.	
7.9	Are financial reports prepared directly by the automated accounting system or are they prepared by spreadsheets or some other means?	Not yet applicable	
8.	**Information Systems**		
8.1	Is the financial management system computerized?	No. In November 2010, the new computerized accounting system (com financial management system) is yet to be functional. Introductory assistance, training, and system maintenance are requested.	
8.2	Can the system produce the necessary project financial reports?	Not yet applicable	
8.3	Is the staff adequately trained to maintain the system?	Training was provided, but the trainees' skills have not reached the satisfactory level. Also the system has not been functional.	
8.4	Does the management organization and processing system safeguard the confidentiality, integrity and availability of the data?	The new computer system and the proposed organization should safeguard them.	

3.2.5 Accounting and Billing Softwares

The financial management assessment above is based on review of KWASA's systems for financial and management accounting, reporting, auditing and internal controls. Some of assessment items need special attention or precaution at this stage. Most notable item is the accounting software in association with the new accounting system to be adopted. It should be also noted that KWASA lacks a billing software that can prepare proper bills based on correct account records produced by the accounting system.

(1) Accounting Software

KWASA's accounting system is currently in a transitional stage, where a shift from a single-entry and cash based accounting system to a double-entry and accrual based accounting system is attempted.

Under the cash based, single entry system, KWASA is required only to report to the Local Government Department (LGD) of the Ministry of Local Government and Rural Development and Co-operatives (MLGRD), limited financial information which are actual revenue and expenditure on the cash basis, budget revenue and expenditure, subsidy request to fill the budget gap of revenue and expenditure. Insufficiency and disorganization of past financial records at KWASA keep them from compiling more detailed statements in a consistent manner.

To solve this problem, a technical assistance (TA) was provided by ADB in 2009 whereby Hoda Vasi Chowdry (HVC), Bangladeshi accounting firm was contracted to deliver a software for accounting, inventory management, human resource management, and a payroll system. The TA included implementation of a double-entry accounting system by introducing a new accounting software with proper training. The software was developed by BIPL, Bangladeshi software developer and had a Windows-based operating system, MySQL as its database, Visual Basic 6.0™, and PHP for report purposes. Training for KWASA accounting staff to use the software was provided by the accounting firm. The training was completed in February 2010. However, due to lack of follow-up support by the provider and capable KWASA staff to use the software, the accounting system has not been operative. To solve this situation, BIPL was requested by KWASA to provide their support in the system maintenance but the support contract has not been concluded.

Other options were presented by Grameenphone IT (GP IT), subsidiary of Bangladesh telecommunication giant. Their proposal included development of a simple general ledger module with reporting functionalities and implementation of another standard accounting software.

(2) Billing Software

In relation with the accounting software, introduction of billing software had been long considered since KWASA's establishment. The current billing system which was inherited from KCC is completely manual. Maintenance of consumer ledger and preparation of bills are done manually. Errors and omissions easily take place.

Computerization of the billing system, especially issuance of bills based on correct accounting records was obviously needed. KWASA thought to introduce billing software that was developed by the Municipal Support Unit of the Local Government Engineering Department (MSU-LGED). This software was designed for the use of municipalities mainly for billing and collection purposes and was also incorporated into the Tax Mapping Program of the Government. This software was also being installed and maintained for free by personnel of MSU-LGED. It was running on a Windows-based operating system, an SQL Server 2000™ database and used Visual Basic™ as its front end. The software allowed for volumetric billing or a flat billing system or a combination of both. It could create, maintain, and upgrade a consumer master file, capture monthly meter readings or flat rates of each individual consumer, convert these to actual bills to be delivered to consumers, record the payments collected from the banks or the office cashier from individual consumers, and prepare a daily collection report for the accounting department. This software was also capable of storing individual consumer meter readings in a meter reading file that could be accessed anytime for analysis. However, interfacing between the accounting software and the billing software remained unsolved for KWASA use. Data input in the billing software could not be automatically transferred to the accounting software to be reflected in the accounting system. KWASA could not even start using the software due to the interface inconvenience.

After the failure of the introduction of the MSU-LGED billing software, two new options have been presented to KWASA. One is another billing and collection software to be developed by an independent software house which worked on the MSU-LGED software development project. Another option is a software developed by GP IT using its mobile phone technology.

(3) Recommendation

It is obvious that selection and implementation of the proper software is the ultimate solution to accounting and billing system problem, which also improve many areas of revenue/financial management. If the accounting system is fully operational, financial reports can be generated regularly and accurately. Organization and maintenance of customer data base becomes inevitably needed as a precondition of the software operation. The attempt in the past to introduce the new softwares was not successful because of insufficient inputs (provision of hard-to-understand softwares for unqualified KWASA staffs with limited training time). At point of this report, it is known that the ADB TA 7385 earmarked a budget for the softwares and training. Selection and implementation of the proper software system with adequate training is scheduled in 2011.

3.2.6 Possible Financing Sources

The analysis of KWASA's current financial situation and the potential indicates KWASA's obvious incapability of self-financing the project. If KWASA implements the project, with a financial restriction caused by the O&M recovery tariff setting, KWASA will inevitably need to find financing source outside.

The current financial market and donor's lending situations suggest that two loans will be made available to GOB in relation with the project. Firstly JICA's yen loan may be extended to "upstream" part of the project which will cover intake, raw water transmission pipes, impounding reservoir and SWTP. A typical JICA's yen loan[6] to Bangladesh, which is classified as Low-Income LDC, will have a minimal interest rate of 0.01%. The repayment and grace periods will be

[6] Based on JICA's announcement for new terms and conditions of yen loans which will be pre-notified after April 2010.

respectively 40 years and 10 years. Secondly ADB has intention to finance "downstream" part of the project which will cover clear water transmission pipes, distribution reservoirs and overhead tanks, distribution pipe network and service pipe connection. ADB could provide a SDR loan to GOB which could have 32-year repayment period inclusive of 8-year grace period. The interest rate will be 1% p.a. during the grace period and 1.5% for every year thereafter.

GOB will on-lend these JICA and ADB loans to KWASA as subsidiary loans. According to the GOB guideline[7], terms of on-lent loan to WASAs, from originally foreign currency loan will have a 5% interest rate p.a., and repayment period of 20 years (inclusive of 5 year grace period). However, according to MOF, this is a guideline and actual application could be softer depending on borrower's financial situation and type of services the borrower will offer. KWASA should appeal to GOB for application of softer loan conditions such as lower interest rate and longer repayment period at the earliest convenience.

It should be also noted that these foreign loans will not cover the whole project cost. Some ineligible costs for the foreign loans such as land cost and tax will have to be financed by other means. KWASA may be able to ask government grants to this foreign loan ineligible cost through capital budget allocation. KWASA's appeal to GOB for softer financing will also include more generous financing mix composed of more grants and less subsidiary loans than what will be regulated by the foreign loans. KWASA should request as much government grants as possible to mitigate the debt service burden in the future.

3.3 Existing Water Supply System and Facilities

3.3.1 Water Source

(1) Groundwater Source

1) KWASA's Production Tube Wells

Production tube wells (PTW) have been constructed since 1962. Since then they have been demolished and newly constructed constantly. And currently 32 big tube wells (6 inch diameter) and 22 small tube wells (3 inch diameter) have been operated by KWASA shown in **Table 3.3.1**.

Table 3.3.1 Year of Completion of KWASA's Production Tube Wells

Big Tube Wells				Small Tube Wells			
Sr	Name	Ward	Const. Year	Sr	Name	Ward	Const. Year
1	R & H Baikali	9	1980	1	Habeliloug	26	2008
2	Nirala WF -1	24	1986	2	Khulna Circuit House	21	2002
3	Nirala WF -3	24	1986	3	Ferighat - 3	20	2002
4	Sonadanga -1	17	1987	4	Khalispur Noyabati More	10	2002
5	Arambag	25	1987	5	Mujigunni Well Field - 3	9	2002

7 Debt Service Liability (DSL) Accounts and Guidelines (up to FY 2009-2010), MOF

Big Tube Wells				Small Tube Wells			
Sr	Name	Ward	Const. Year	Sr	Name	Ward	Const. Year
6	Tarer Pukur	27	1987	6	Municipal Trank Road	29	2004
7	Zilla School	22	1994	7	Noornagar Mosque	16	2002
8	Hazi Malek College	31	1994	8	Khalispur Durbar Shanghe	10	2002
9	Shaikh Para Bazar -3	20	1994	9	Alia Madrasha	29	2002
10	250 Bed Hospital	16	1995	10	Scout Bhaban	10	2003
11	Noor Nagar Fire Service	16	1995	11	Mistripara Bazar	27	2004
12	Rupsha Kashai Khana	30	1997	12	Khalispur Maternity Hospital	10	2003
13	Sonadanga KCC Park	17	1997	13	Khalispur 12 No. Road	12	2003
14	DC Office	21	1997	14	Boyra Public College Back Side	14	2004
15	Sir Iqbal Road Park	23	2000	15	Sonadanga Sweeper Quarter	17	2004
16	Khalishpur Jheel Pukur	10	2000	16	Front of Sonadanga PS	18	2004
17	Madina Mosque Boyra	16	2000	17	Zilla School Quarter	22	2004
18	Babu Khan Road	29	2001	18	Tootpara Tahalla Hospital	30	2005
19	Nirala KCC Park	24	2001	19	Royer Mahal	14	2006
20	West Baniakhamar Urban	26	2002	20	Toyelea Mosque Khalispur	11	2006
21	Boshpara Grave Yard	25	2002	21	Charerhat Ghat	13	2008
22	Mujgunni Lebutala	9	2002	22	Nazurul Nagar Islamabad	19	2008
23	Mujgunni Battalla (MSP)	9	2003				
24	Khalishpur KCC Branch Office (MSP)	10	2003				
25	East Baniakhamar Madrasa(MSP)	27	2003				
26	KDA Approach Road (MSP)	17	2004				
27	Sher E Bangla Road Park (MSP)	26	2004				
28	West Toot para Primary School (MSP)	28	2004				
29	PTI More (MSP)	23	2004	Remarks: 1) One big tube well (Nirala WF-1) and one small tube well (Municipal Tank Road) have been stopped due to clogging. 2) KWASA has already dug 12 new tube wells under MSP and they are waiting to be operated.			
30	KCC Rest House (MSP)	29	2004				
31	Shaikh Para Bazar Mosque MSP)	20	2005				
32	Old Gallamari Road (MSP)	25	2005				

The average depth of the tube wells is approximately 270 m. There are 9 turbine pumps, 22 centrifugal pumps and 23 submergible pumps. The pump discharges are directly into the distribution systems, where the system pressure varies between zero and several meters.

In March 2009 KWASA conducted flow measurement and the result of the total abstraction from existing 54 tube wells was 35,000 m^3/d approximately.

The JICA Study Team conducted a flow measurement survey from November 2009 to December 2009 through outsourcing to a local consultant. The result indicates current total abstraction from KWASA's tube wells approximately 30,100 m^3/d as shown in the **Table 3.3.2**.

Table 3.3.2 Abstraction from KWASA's Production Wells in 2009

No	Address	Ward No.	Well No.	Operation Hr(hr/day)	Flow Rate (m^3/ hour)	Water Flow (m^3/ day)
1	Hazi Malek College	31	57	16.00	43.00	688.00
2	Rupsha Kasai Khana	30	69	16.00	9.73	155.68
3	Tootpara Taltola Hospital	30	100	16.00	22.70	363.20
4	Mistiripara Bazar	27	77	16.00	17.73	283.68
5	West Tootpara Pri School (MSP)	28	89	16.00	92.42	1478.72
6	East Baniakhamar Madrasa(MSP)	27	86	16.00	102.93	1646.88
7	Tarer Pukur	27	45	16.00	65.79	1052.64

No	Address	Ward No.	Well No.	Operation Hr(hr/day)	Flow Rate (m^3/ hour)	Water Flow (m^3/ day)
8	Alia Madrasa	29	56	16.00	20.47	327.52
9	PTI More (MSP)	23	90	16.00	34.99	559.84
10	Zilla School Quarter	22	99	16.00	31.47	503.52
11	Zilla School	22	51	16.00	9.91	158.56
12	Khulna Circuit House	21	22	16.00	10.58	169.28
13	DC Office	21	72	16.00	56.61	905.76
14	KCC Rest House (MSP)	29	91	16.00	69.22	1107.52
15	Babu Khan Road	29	78	16.00	67.13	1074.08
16	Sir Iqbal Road Park	23	74	16.00	6.88	110.08
17	Nirala WF -3	24	36	16.00	30.22	483.52
18	Nirala KCC Park	24	79	16.00	6.79	108.64
19	Arambag	25	44	16.00	49.28	788.48
20	Old Gallamari Road (MSP)	25	93	16.00	12.27	196.32
21	West Baniakhamar Urban	26	81	16.00	32.44	519.04
22	Boshupara Grave Yard	25	82	16.00	72.87	1165.92
23	Islamabad Community Center	19	104	16.00	16.74	267.84
				16.00	4.15	66.40
24	Habelibagh	26	10	16.00	19.15	306.40
25	Sher-A-Bangla Road Park (MSP)	26	88	16.00	39.51	632.16
26	Shaikpara Bazar -3	20	60	16.00	28.85	453.60
27	Shaikpara Bazar Mosque (MSP)	20	92	16.00	20.08	321.28
28	Ferryghat-3 (KCC Workshop)	20	23	16.00	7.30	116.80
				16.00	10.55	168.80
29	Sonadanga -1	17	43	16.00	65.39	1679.68
30	Sonadanga near Police Station	18	98	16.00	11.72	187.52
				16.00	13.40	214.40
31	KDA Apprach Road Park (MSP)	17	87	16.00	62.55	1000.80
32	Sonadanga Swiper Quarter	17	97	16.00	27.66	442.56
33	Sonadanga KCC Park	17	70	16.00	40.61	649.76
34	Madina Mosque Boyra	16	76	16.00	22.38	358.08
35	250 Bed Hospital	16	62	16.00	9.73	155.68
36	Boyra Public College (Back side)	14	96	16.00	33.12	529.92
37	Royer Mahol	14	101	16.00	36.35	581.60
38	Mujgunni Well Field-3	9	41	16.00	47.95	767.20
39	Mujgunni Lebutala	9	83	16.00	30.65	490.40
40	Mujgunni Battalla (MSP)	9	84	16.00	70.55	1128.80
41	R & H Baikali	9	18	16.00	67.04	1072.64
42	Khalispur KCC Branch Offic (MSP)	10	85	16.00	52.46	839.36
43	Khalispur Jheel Pukur	10	75	16.00	10.33	165.28
44	Khalishpur Durbar Shanga	10	55	16.00	57.61	921.76
45	Khalishpur Noyabati More	10	30	16.00	9.15	146.40
				16.00	10.93	174.88
46	Khalishpur Maternity (Lal) Hospital	10	94	16.00	14.25	228.00
47	Khalishpur 12 No. Road	12	95	16.00	27.32	437.12
48	Khalishpur Toyeba Mosque	11	102	16.00	9.85	157.60
				16.00	12.34	197.44
49	Khalishpur Charer Hat ghat	13	103	16.00	13.58	217.28
				16.00	11.12	177.92
50	Khalishpur Scout Bhaban	10	66	16.00	17.62	281.92
51	Noor Nagar Fire Service	16	63	16.00	18.97	303.52
52	Noor Nagar Mosque	16	50	16.00	8.47	135.52
				16.00	15.14	242.24
Total Water Supply per Day for 54 Deep Tube Wells (m^3/day) =						30,065

2) KWASA's Hand Pumps

KWASA said that they operated 3,875 deep hand pumps and 5,538 shallow hand pumps in April 2010. In October 2010 they operate 3,778 deep hand pumps and 5,380 shallow hand pumps. The decreased numbers, 97 and 158 respectively, are assumed to be due to the fact that temporal groundwater level might decline temporally in dry season.

According to ADB's Technical Assistant Consultant's report, 'about 278,500 people get water from KWASA's hand pumps and the average house hold consumption, 5.5 persons per house hold, is 7.5m^3/month. Totally 12,643 m^3/d water is supplied by KWASA's hand pumps'. [Source: consumer survey by ADB, 2009]

The JICA Study Team conducted a flow measurement survey on KWASA's 30 deep hand pumps for 3 days in November 2009 through outsourcing to a local consultant.

In Addition to the above survey, JICA Study Team conducted the 24 hours survey for water consumption measurement of 20 numbers of hand pumps (10: deep wells, 10 shallow wells) in Middle of April, 2010. Among them, five (5) numbers of hand pumps which were same as November 2009 investigation wells were selected to cross check their investigation accuracy and used different measurement method which was direct measurement of water quantity was adopted for this investigation. The methods and results are shown in **Appendix 3.3.1**.

ADB's survey concentrated on household consumption and the result might be only the flow from shallow hand pumps. Meanwhile the JICA Study Team's survey result is based on direct measurement on deep hand pumps and shallow hand pumps. Based on the JICA Study Team's survey result the total abstraction could be assumed as follows:

Deep hand pumps: 3,575[8] x 5.6 m^3/d = 20,000 m^3/d
Shallow hand pumps: 5,367[6] x 3.6 m^3/d = 19,300 m^3/d
Total abstraction from KWASA's hand pumps = 39,300 m^3/d

3) Private Wells

A large number of deep and shallow hand tube wells, fitted with hand pumps, supply water to residents, especially in the northern part of the KCC area. Many private organizations, factories, schools and other educational institutions have their own tube wells because the public supply is so unreliable. There is no legislation to control the exploitation of groundwater in Khulna. Private tube wells can be sunk without a permit.

No reliable data are available covering operation of private water supply facilities. It is difficult to estimate the actual extraction and population served by private tube wells.

In the 1997 Feasibility Report[9] the abstraction estimation is given as follows.

Shallow tube wells	nos	Abstraction
Commercial & industrial private tube wells	68	33,067 m^3/d
Small private motorised tube wells	206	
Hand tube wells (private houses)	-	15,270 m^3/d
Deep tube wells		
Commercial & industrial private tube wells	19	9,473 m^3/d

8 Those numbers are in April 2010.
9 Municipal Services Project Final Feasibility Report Khulna Water Supply Expansion Component (April 1997/LGED)

Small private motorised tube wells	25	
Hand tube wells (private houses)	424	2,748 m^3/d
Total		60,558 m^3/d

The above mentioned estimation was based on a survey result which was conducted in 1994. Based on an assumption that the increase of abstraction synchronize to the increase of population, the abstraction in 2009 can be estimated as;

From 1994 to 2001: increase rate = 2.9 %
From 2001 to 2009: increase rate = 2.2 %
Abstraction in 2009 = 88,000 m^3/d

The ADB's Technical Assistant Report[10] mentioned that, based on their consumer survey conducted in 2009, 412,000 people from 13,733 tube wells and assumed unit consumption is 120 lpcd which includes wastage from overflowing tanks. And the report calculated the total consumption as 49,700 m^3/d.

Based on the ADB's report, the abstraction from private wells can be assumed as 49,700 m3/day. It is noteworthy that the consumption of those private wells might include non-domestic consumption because many of them have been installed in precincts of, schools and other educational institutions.

(2) River Water Source

The temporary decommissioned existing surface water treatment plant is located in the same precinct of KWASA's Office. It was commissioned in 1921 located in the Old City. The intake system of this plant is as follows;

- Raw water is pumped from Bhairab River and pumped up via a rising main to a primary settling pond.
- Water is pumped from the primary settling pond (desilting basin) to two secondary settling/coagulation tanks designed for coagulation and settlement after mixing with a solution of alum.

3.3.2 Water Treatment

(1) Tube Wells

Originally for some KWASA's tube wells cylinder gas chlorinators were installed. But currently none of the existing production wells have any chlorination facilities.

(2) Water Treatment Plant

The outline of the existing surface water treatment plant (Temporary Decommissioned) is shown in **Table 3.3.3**. Rehabilitation of the plant is on the process planed and subsidy from the Government for the rehabilitation is under procedure.

[10] ADB TA 7223 BAN: Supporting the Establishment of the Khulna Water Supply and Sewerage Authority

Table 3.3.3 Outline of Existing Surface Water Treatment Plant (Temporary Decommissioned)

Facility and Item	Capacity	Remarks
River intake	90 m^3/h	Low lift pump
Rising main	-	150 mm dia cast iron pipe
Primary setting pond	45,000 m^3	Used as reservoir when river is saline (100days storage at 450 m^3/d)
Low lift pumps	90 m^3/hr	
Secondary settling tanks	360 m^3	2 nos of similar capacity between the 2 house
Filtration unit	23 m^3	1 unit. Approx. 9 m^3 filter area
Underground storage tanks	180 m^3, 90 m^3	
High lift pumps	68 m^3/hr, 100 m^3/hr	
Overhead tank	90 m^3	Height 15 m
Daily production	1,250 m^3/d	

The system of this plant is as follows;

- Water from the settling tank is lead into a single rapid-sand filter.
- Chlorination of the filtered water takes place by the introduction of bleaching powder in solution (calcium hypochlorite).
- The treated water is then passed into underground storage tanks from where it is finally pumped into a steel overhead tank.
- Water from the overhead tank is also used to backwash the filter bed.
- The capacity of the plant is desisted to produce 1,250 m^3/d.

Before pulling out operation, the plant was operated for only seven months of the year due to salinity. Photos of the existing surface water treatment plant (Temporary Decommissioned) are shown below.

Existing WTP under repairing

Primary settling pond

3.3.3 Water Transmission and Distribution

(1) Transmission Mains

As the mentioned above, raw water is pumped from Bhairab River and pumped up by a transmission main to a primary settling pond for the existing water treatment plant. It is the only transmission main in Khulna city.

(2) Pumping Facilities

In Khulna there is not pressurized system. Consumers generally have their own storage tanks (ground tanks) to provide system balancing and storage for the consumer.

(3) Overhead Tanks

There were five elevated water storage tanks with a total capacity of 2,815 m^3. Two of them were completely demolished. As to one of them, the tank itself was demolished and only the supporting stand remained. And another one is defunct and the last one is waiting to be repaired.

Consequently, no storage facilities (over head tanks) are being operated.

(4) Distribution System

As of now the handover of KCC asset is still on process and KWASA has no distribution system as-built drawings.

Based on the discussions with KWASA engineers it can be assumed that there are approximately 230 km of pipelines with pipe sizes varying from 75 mm (3 inches) in diameter to 250 mm (10 inches) in diameter in Khulna.

The distribution systems had been progressively developed over the years. Several development agencies, including DPHE, KDA, and HSD, had been responsible for design and installation, and the completed systems had been subsequently handed over to KCC for O&M. Then those distribution systems have handed over to KWASA.

(5) Street Hydrant

The majority of hydrants appear to be dry during supply hours. Some hydrants have been blanked off and some have broken taps. There is a record of 503 of street hydrant, but not many (say 100) are working and allowing that 100 persons may use each one, and then 10,000 people may be served in this way. Estimated use from public taps is 50 lpcd based on the ADB's Technical Assistance Consultant's Report.

(6) Service Connections

Records indicate that out of 15,393 connections, 2561 connections are ½" , 11546 are ¾", 1017 connections are 1", 70 connections 1 ½" and 58 connections 2". Thus 92% of connections (½" and ¾") probably serve two or three households at most. ADB's consumer survey indicates average of 2.5 households per connection and 5.5 persons per household. However 2,579 connections or 17 % of all connections are "inactive" meaning they have been disconnected or do not get water from KWASA's supply system.

The JICA Study Team conducted a flow measurement survey on 20 piped water supplied households for 3 days in November 2009 through outsourcing to a local consultant. The measurement results as shown in **Table 3.3.4**.

Table 3.3.4 Measured Water Flow of Sample Household Connections

SI. No	Name & Address	Ward No.	Users No	Total (Liter/3days)	per Day (Litre/day)
1	Petka Bazar Road, Mujgunni, Uttor Para, Khulna.	9	8	6,000	2,000
2	Goyalkhali Main Road, Khulna.	9	8	3,600	1,200
3	Mujgunni Uttor Para Road, Khulna.	9	10	7,100	2,367
4	Central West Block, Road No.- 17, Khulna.	10	20	11,700	3,900
5	Road No.- 11, West End Zone Area,Khalishpur, Khulna.	10	15	3,900	1,300
6	Road No.- 243, New Colony, Khulna.	10	8	3,800	1,267
7	Central South Block, Road No. 17, Khulna.	12	15	8,600	2,867
8	Road No.-16, Central South Block, Khalishpur, Khulna.	12	22	15,500	5,167
9	Road No.- 151, Central Block, Khalishpur, Khulna.	12	14	6,800	2,267
10	Road No.- 7, Boyra Housing, Khulna.	14	4	3,700	1,233
11	Road No.- Boyra Junction Road, Khulna.	14	5	5,100	1,700
12	Road No. -2	17	7	4,700	1,567
13	Road No.-12, Sonadanga Residential Area, Khulna.	18	25	6,900	2,300
14	1 Munshipara (3rd Lane), Khulna.	22	25	16,900	5,633
15	Road No.-1, Nirala Residential Area (Police Station), Khulna.	24	20	2,600	867
16	Road No. -1, Nirala Residential Area, Khulna.	24	16	3,800	1,267
17	West Baniya Khamar, Khulna.	26	6	2,200	733
18	Khan Jahan Ali Road, Khulna.	29	6	1,400	467
19	Gogonbabu Road, Khulna.	29	10	8,700	2,900
20	Gogonbabu Road, Khulna.	29	8	3,500	1,167
	Total for 20 Household Connections =		**252**	**126,500**	**42,167**
				Lpcd =	**167**

The result of the sampling survey was 167 lpcd. On the other hand, the above-mentioned ADB's report refers to that ccurrent consumption from piped supply is about 125 lpcd. The sample survey result exceeds as about 30% and this difference. This suggests that the sampled households are comparatively high income households and persons of those households tend to consume water extravagantly compared to the average household.

3.3.4 Water Quality of Existing Water Supply System

The JICA Study Team conducted a sample survey on water quality of following water supply systems in Khulna city.

(1) Water Quality of Production Tube Wells
(2) Water quality of Hand Pumps
(3) Water Quality of Private Wells
(4) Quality of Tap Water

(1) Production Tube Wells

The summary of the results are shown in **Table 3.3.5**. Among 54 production tube wells, 10 wells are out of pH Standard, 26 wells are out of Fe standard, one well is out of Mn standard, and three wells is out of Cl- standard. Wells that are within the standard are 22. As far as Arsenic is concerned, all wells are within the standard.

Table 3.3.5 The Summary of the Results for Water Quality Survey

Category of Wells		pH	Temp. ℃	As μg/L	Fe mg/L	Mn mg/L	Cl^- mg/L	T-coli Cfu/100mL	F-coli Cfu/100mL
Production Tube Wells	Ave.	8.2	30	1.5	1.2	0	168	0	0
	Min.	7.6	26	0.0	0.2	0	34	0	0
	Max.	8.9	33	5.5	3.6	0	475	0	0
		Number of undesirable wells; pH:8, Fe:16 out of 32 samples							
Mini Production Tube Wells	Ave.	7.8	29	1.3	1.2	0.0	327	0	0
	Min.	6.6	23	0.0	0.3	0.0	34	0	0
	Max.	8.7	33	10.5	3.3	0.6	836	0	0
		Number of undesirable wells; pH:2, Fe:10, Mn:1,Cl^-:3 out of 22 samples							
Hand Pumps	Ave.	7.5	28	3.6	1.7	0.2	228		
	Min.	6.5	26	0.0	0.3	0.0	34	0	0
	Max.	8.9	31	26.8	6.5	1.4	689	4	8
		Number of undesirable wells; pH:3, Fe:19, Mn:8, Cl^-:1, F-coli:3 out of 30 samples							
Private Wells	Ave.	8.3	28	1.2	0.9	0	146	0	
	Min.	7.8	25	0.2	0.3	0	45	0	0
	Max.	8.8	31	8.6	1.5	0.02	249	0	24
		Number of undesirable wells: pH:6, Fe:8, Cl^-:1 out of 20 samples							
Tap Water	Ave.	7.8	27	1.0	0.8	0.05	-	-	
	Min.	7.3	21	0.1	0.2	0	-	-	0
	Max.	8.5	37	6.5	1.9	.97	-	-	31
		Number of undesirable wells: Fe:6, Mn:1, F-coli:17 out of 20 samples							

(2) Hand Pumps

Among 30 Hand Pumps, three wells are out of pH Standard, 19 wells are out of Fe standard, eight wells is out of Mn standard, one well is out of Cl- standard, and three wells are out of microbiological standard. Nine wells are within the standard. As far as Arsenic is concerned, all wells are within the standard.

(3) Private Wells

Among 20 wells, six wells are out of pH Standard, eight wells are out of Fe standard, and one well is out of Cl- standard. 11 wells are within the standard. As far as Arsenic is concerned, all wells are within the standard.

(4) Tap Water

Among 20 taps, six wells are out of pH Standard, six wells are out of Fe standard, one well is out of Mn standard and 17 well is out of microbiological standard. Only one well are within the standard. The rate of Faecal coliform positive is very high (85 %). As far as Arsenic is concerned, all wells are within the standard.

3.3.5 Summary of Existing Water Supply Source in Khulna

The summary of current water source of Khulna water supply system is as follows.

Table 3.3.6 Water Resource-wise Daily Water Consumption in Khulna

Water Source		Extraction per day
Ground water	KWASA's tubewells[11]	30,100 m^3/d
	KWASA's hand pumps[12]	39,300 m^3/d
	Private pumps	49,700 m^3/d
	Sub-Total	119,100 m^3/d
Surface water		0 m^3/d
	Total	**119,100 m^3/d**

3.3.6 Definition of Salinity Standard in the Surroundings of Khulna

As to the Chloride concentration for drinking water the Environment Conservation Rules, 1997 Standards for Water prescribe two standards, 600 mg/L and 1,000 mg/L for coastal zone.

Ministry of Water Resources of GOB defines the coastal management zone in its report[13] as follows:

The coastal zone covers 19 districts facing or having proximity to the Bay of Bengal and the exclusive economic zone. The districts are Bagerhat, Barguna, Barisal, Bhola, Chandpur, Chittagong, Cox's Bazar, Feni, Gopalganj, Jessore, Jhalkati, Khulna, Lakshmipur, Narail, Noakhali, Patuakhali, Pirojpur, Satkhira and Shariatpur. Together these districts account for 32 percent of the area and 28 percent of the population of Bangladesh as shown in the **Figure 3.3.1**.

And the Ministry of Environment and Forest of GOB also refers to the same definition as the coastal zone in its report[14.]

Therefore in this report the approaches and discussions concerning to the water salinity problem the standard of the drinking water for Chloride concentration is to be specified as 1,000 mg/L.

[11] The result of KWASA's assessment is 35,000m^3/day.
[12] The result of KWASA's assessment is 60,000m^3/day.
[13] Vulnerability of Bangladesh to Climate Change and Sea Level Rise: Concepts and Tools for Calculating Risk in Integrated Coastal Zone Management, Bangladesh Centre for Advanced Studies (BCAS), Dhaka, Bangladesh, 1996.
[14] Bangladesh: National Programme of Action for Protection of the Coastal and Marine Environment from Land-Based Activities

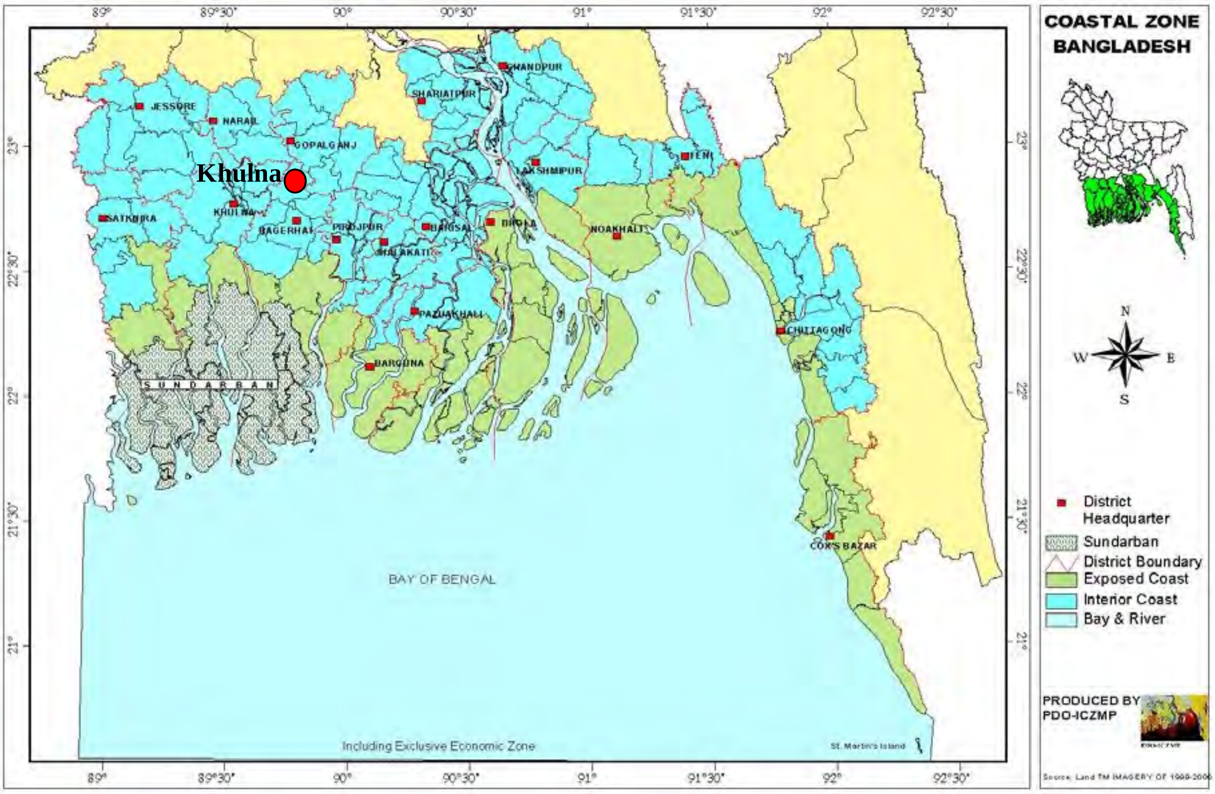


Figure 3.3.1 Map of Coastal Zone of Bangladesh

3.4 Served Population

Based on the ADB's Technical Assistance Consultant's Report current water served population in Khulna can be calculated as follows.

Table 3.4.1 Water Source-wise Population in Khulna

Calculation of Served Population	Numbers
KWASA's Tube Wells	
Registered Connections	15,251
Inactive Connections	2,579
Active Connections	12,672
Consumers per each	13.5
Served Population	171,100
Street Hydrant	
Total Connections	503
Inactive Connections	403
Active Connections	100
Consumers per each	100
Served Population	10,000
KWASA's Hand Pumps	
Number of Deep Hand Pumps	3,748

Calculation of Served Population	Numbers
Number of Shallow Hand Pumps	5,538
Consumers per each	30
Served Population	278,600
Private wells	
Number of Private Wells	13,733
Consumers per each	30
Served Population	412,000
Uncategorized Population	85,300
Total	**957,000**

3.5 Water Use

3.5.1 Water Use

Water consumption in Khulna City is impossible to count from the billing result because current billing system has not been based on metering system.

Based on the consumer survey result which had been conducted in ADB's Technical Assistance Program[15] and the Study Team current household, current water use situation can be assumed as follows:

(1) Non-Domestic Water Use

There is no reliable date to examine the amount of non-domestic water use due to a lack of reliable measurement data for water use.

ADB Technical Assistant[16] Consultant has been conducted sample survey which focuses on non-domestic consumers in Khulna. The result will be complied in November 2010.

In the 1997 Feasibility Report[17], non-domestic demand has been taken as 20% of the domestic demand.

This is considered a reasonable figure for a location where industrial demands generally provided independently and where some institutional demands are also provided by private supplies.

(2) Non-Revenue Water

Definition of NRW: Non-Revenue Water (Water Balance) is summarized in **Table 3.5.1**.

15 ADB TA 7223-BAN, Supporting the Establishment of the Khulna Water Supply and Sewerage Authority
16 ADB TA 7385-BAN, Preparing the Khulna Water Supply
17 Municipal Services Project Final Feasibility Report Khulna Water Supply Expansion Component (April 1997/LGED)

Table 3.5.1 Definition of NRW (Water Balance)

<table>
<tr><td rowspan="10">Water Source Production</td><td rowspan="9">System Input Volume</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>1) Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>2) Billed Un-metered Consumption</td></tr>
<tr><td rowspan="2">Un-billed Authorized Consumption</td><td>3) Un-billed Metered Consumption</td><td rowspan="7">Non -Revenue Water</td></tr>
<tr><td>4) Un-billed Un-metered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>5) Un-authorized Consumption</td></tr>
<tr><td>6) Metering Accuracy</td></tr>
<tr><td rowspan="3">Real Losses</td><td>7) Leakage from Service Connection</td></tr>
<tr><td>8) Leakage from Pipeline</td></tr>
<tr><td>9) Leakage & Overflow from Utilities</td></tr>
<tr><td colspan="5">Loss during Water Treatment & Evaporation</td></tr>
</table>

Note: Colored columns will be confirmed as current situation of water supply.

In the Bangladesh Water Utilities Data Book 2006-07[18], mentioned the average NRW is 22.5 % in Bangladesh. This figure has been calculated based of 11 cities in Bangladesh; (1) Dhaka, (2) Chittagong, (3) Rajshahu, (4) Bagerhat, (5) Chandpur, (6) Chapal Nawadbanj, (7) Chuadanga, (8) Gazipur, (9) Jessore, (10) Manikganji, and (11) Barsingdi.

Regarding the current Khulna water supply system there is no reliable date to examine the amount of NRW due to a lack of reliable measurement data for water use.

In the ADB's consultant report it is estimated the water loss to be 37% of production from the pumps to the piped water. In accordance with the definition of NRW, billed and un-billed consumptions shall be identifies to estimate NRW. On the other hand, there is no reliable data to examine.

Taking into consideration above-mentioned figure and definition of NRW it is assumed the NRW of Khulna water supply system as 40% for the pumps to pipe water system.

3.5.2 Summary of Water Use

Current water use situation in Khulna city is summarized as follows,

Table 3.5.2 Water Source-wise Water Use in Khulna

Water Source	Water Use	Remarks
KWASA's tubewells	No. of consumers: 171,100+10,000=181,100 Water supply amount = 30,100 m^3/d Water loss= 30,100x0.40=12,040 m^3/d Net water supply = 30,100 - 12,040 = 18,060 m^3/d Non-domestic= 18,060x0.20=3,610 m^3/d Domestic=18,060 – 3,610 = 14,450 m^3/d Lpcd = 14,450x1,000/181,100 = 80 liter/day/person	Water loss: 40%
KWASA's hand pumps	No. of consumers: 278,600 Water supply amount = 39,300 m^3/d Water loss= 39,300x0.10=3,930 m^3/d Net water supply = 39,300 – 3,930 = 35,370 m^3/d Non-domestic= 35,370x0.20=7,070 m^3/d	Water loss: 10%

[18] Benchmarking for Improving Water Supply Delivery (June 2009/LGRDC and Water and Sanitation Program-South Asia

Water Source	Water Use	Remarks
	Domestic=35,370 – 7,070 = 28,300 m^3/d Lpcd = 28,300x1,000/278,600 = 102 liter/day/person	
Private pumps	No. of consumers: 412,000 Water supply amount = 49,700 m^3/d Water loss= 49,700x0.10=4,970 m^3/d Net water supply = 49,700 – 4,970 = 44,730 m^3/d Non-domestic=20%: 44,730x0.20=8,950 m^3/d Domestic=44,730 – 8,950 = 35,780 m^3/d Lpcd = 35,780x1,000/412,000 = 87 liter/day/person	Water loss: 10%
Total	No. of consumers: 957,000 Water supply amount = 119,100 m^3/d Water loss= 20,940 m^3/d Net water supply = 98,160 m^3/d Non-domestic=19,630 m^3/d Domestic=78,530 m^3/d Lpcd = 78,530x1,000/957,000 = 82 liter/day/person	

3.6 Ongoing and Planned Water Supply Studies and Projects

Ongoing and Planned Water Supply Studies and Projects are summarized in **Table 3.6.1**.

Table 3.6.1 Ongoing and Planned Water Supply Studies and Projects

No.	Proposed Projects	Source	Status
1	Supporting the establishment of the Khulna Water supply and Sewerage Authority. Project Duration: March 2009 to July 2009 Cost: 199.50 Lakh Taka	ADB	Completed
2	Strengthening the Resilience of the Water Section in Khulna to Climate Change. Project Duration: April 2009 to August 2010 Cost: 504.00 Lakh Taka	ADB	Completed
3	Preparing Khulna Water Supply Project. Project Duration: January 2010 to December 2010 Cost: 656.64 Lakh Taka	ADB	On going
4	Development of Water Supply System in Khulna City. Project Duration: July 2010 to June 2013 Cost: 4332.57 Lakh Taka	GOB	Approved
5	Rehabilitation of Production Tube-Wells & existing water supply pipeline and expansion of water supply network for distribution of water from Phultala Source. Project Duration: July 2010 to June 2013 Cost: 2287.58 Lakh Taka	GOB	Waiting for Approval from PEC[19].
6	Development and Rehabilitation of Khulna Water Supply and Building Infrastructure Facilities for KWASA. Project Duration: 2010 to 2014 Cost: 1711.30 Million Taka (US$250.19 Million) Achievement: 66 MLD	ADB Program Loan	The DPP has been approved.
7	Survey of Raw water Quality of Mollarhat Intake Point for SWTP Project Duration: February 2009 to June 2009 Cost: 2.00 Million Taka Achievement: Preparation Survey for 13.6 MLD	KWASA Self Financed	Completed
8	Installation of 1 ½” dia 30 nos. Deep Hand Tube Well. Project Duration: July 2008 to June 2009	KWASA Self	Completed

[19] Project Evaluation Committee under Planning Section

No.	Proposed Projects	Source	Status
	Cost: 15 Lakh Taka Achievement: **-**	Financed	
9	Supply of Spare Parts for Deep Hand Tube Well Project Duration: July 2008 to June 2009 Cost: 27 Lakh Taka Achievement: **-**	KWASA Self Financed	Completed

3.6.1 Phultala Project

Interim water supply project of the Khulna City Corporation at Phultala under crash program, was prepared to increase of 28 mld in production is expected from the on-going. KCC is the implementation agency of the project and after its completion it will be handed over to KWASA.

This project lingers due to the public protest fearing adverse effect on the supply zone.

The project general scheme are is to construct 20 deep tube-wells and 5 booster stations have to be set up to abstract and send ground water to the Khulna city from Phultala, about 20 kilometres away the centre. The residents in and around Phultala fear ultimate desertification of the area with other long-term adverse effects on the environment as groundwater level will fall due to withdrawal of ground water.

Phultara project is now suspended by a court order. Following the court order, KCC submitted an EIA and a feasibility study to the court, and adjusted the design to benefit the dwellers along the transmission line. The DPP approved major components of the project are as shown in the **Table 3.6.2**.

3.6.2 Municipal Service Project

Municipal Services Project (MSP) , started in 2005, is a World Bank project implemented by LGED and under MSP lots of infrastructure works have been done in Khulna City Corporation. This project aims to help strengthen the institutional capacity of selected municipal corporations and secondary towns. The project provides urban infrastructure services and improves the environmental conditions in poor urban areas by financing critical infrastructure and services such as water supply, drainage, sanitation, urban roads, solid waste management, and bus terminals.

As to the water supply system in Khulna following physical works have been conducted.

1) An approach of ground water development surrounding Khulna
   - The exploration of up to 600m deep tube wells was to have been undertaken under the MSP groundwater studies but for cost considerations was withdrawn.
2) Introduction of metered connection
   - Under the MSP about 2,500 water meters were installed but at present most of these are no longer working.

Table 3.6.2 Major Components of Phultala Project

Budget head	Economic doce	Code description	Physical QNT/Unit	Cost				Total
				GOB (FE)	PA			
					RPA			
					T. GOB	SP Acc.	DPA	
a) Revenue component								
1	4800	Supply and services						
	4874	a) Contingency		L.S	40.00			40.00
		b) Compensa to RDH due to insta. Of pope line on their land adjacent to Highway		L.S	35.00			35.00
		c) Consultant		40 mm	39.00			39.00
		d) Price escalation		L.S	35.00			35.00
Sub-total (Revenue component)					**149.00**			**149.00**
(b) Capital component								0.00
2	6807	Vehicles & Equipment						0.00
		a) Pick-up		1 no	16.95			16.95
		b) Motor cycle		2 nos	2.50			2.50
		c) Water reserver (5000 littre)		1 no	17.60			17.60
		d) Generator (75KVA)		1 no	25.00			25.00
		e) Generator (50 KVA)		3 nos	54.00			54.00
		f) Purch of Contrifu. Pump with UGWR		2 set	1.50			1.50
Sub-total (Revenue component)					**117.55**			**117.55**
3	6901	Land acquisition		2.28 acre	161.67			161.67
4	7046	Water supply and health care						0.00
		a) Test and obser. Tubewells		45 nos	26.44			26.44
		d) Install. Of produc. Tube-wells and inter connection of pope line		20 nos	510.00			510.00
		c) Const. of pump house		20 nos	25.00			25.00
		d) Purch. And insta. Of submersible motor		20 set	150.00			150.00
		e) Electr. Connec. Of PDB		20 nos	16.55			16.55
		f) Distribution line (150 mm dia)		3 km	30.00			30.00
		g) Distritution line (300 mm dia)		5 km	375.00			375.00
		h) Bosster Pump Station						0.00
		i) Pur. & Insta. Of pump motor for booster, pump station		5 set	45.00			45.00
		ii) Const. of pump house, ware house and other related works		20 nos	60.00			60.00
		iii) Conts. Of undergro. Water reservoir shape= circular (Dia-59 ft det=20ft)		10 no	95.00			95.00
		iv) Electric items of booster station		L.S	25.00			25.00
		i) Purch. & layingof transmi, pipe line (1000 mm)		9.2 km	1156.30			1156.30
		j) Purch. And jaying of transmi pipe line (1000 mm)			0.00			0.00
		k) Purch. & laying of trans. Pipe line (600 mm)		9.2 km	1435.20			1435.20
		l) Contsr. Of under gro. Water reserver (dia= 41 ft dep= 15-20 ft)			0.00			0.00
		m) Sonst. Of under gro water reservoir (dia-87 ft, dep=20ft)		1 unit	130.00			130.00
		n) Purch. And installation of motor pump = Centrifugal (type) Motor = 50HP		5 set	45.00			45.00
		o) Constr. Of pump house and other related works		1 unit	45.00			45.00
		p) Electric items of clear water reservior		LS	25.00			25.00
		q) Install. Of chlorination equit. On prod. Tube-wells (double set)		5 set	50.00			50.00
Sub-Total					**4244.49**			**4244.49**
Grand (Total a=b)					**4672.71**			**4672.71**

3.6.3 ADB Studies and Projects

(1) TA 7223–BAN: Supporting the Establishment of the Khulna Water Supply and Sewerage Authority

Based on the following TOR this PPTA was conducted from April 2009 to January 2010.

1) To review and evaluate the adequacy and appropriateness of the existing financial management and commercial operating systems and recommend appropriate improvements/enhancements;
2) To review and evaluate KWASA’s financial condition and its potential capacity to support immediate as well as long-term improvements and expansion of the water supply system;

3) To assist KWASA develop an interim improvement program covering the 2 -year period prior to the implementation of planned investment programs in 2012 and prepare supporting business plan/financial projections; and
4) To provide initial assistance in the implementation of key priority actions in the interim period.

(2) TA 7197–BAN: Strengthening the Resilience of the Water Sector in Khulna to Climate Change

Based on the following TOR this TA was conducted from April 2009 to August 2010.

1) To identify impacts of climate change on flooding, drainage, salinity and water availability aspects;
2) To provide adaptation options based on social, economic, public health and urban planning aspects;
3) To Conduct workshops and trainings to develop capacity of relevant stakeholders/

(3) TA 7385–BAN: Preparing the Khulna Water Supply

This TA has started in June 2010.

There are two principle objectives of the TA. The first is to focus on establishment of corporate management systems and developing the capacities of KWASA staff to improve operational efficiency and to prepare it in meeting the demand for increased and expanded water services. The two key outputs of the TA are

- a 5 year Business Plan and Institutional Strengthening Program covering all aspects of the business operation – organizational, financial, human resource, management and technical aspects (these will also include assisting KWASA in the preparation for implementation of GoB funded investment projects).
- a project proposal suitable for ADB financing that will be prepared together with the other consultants of the TA.The executing agency for the TA is the Ministry of Local Government Rural Development and Cooperatives and KWASA serves as the implementing agency.

3.6.4 Other Studies and Projects

(1) JBIC Study

Prior to the Study and with a view to identifying a suitable water intake point JBIC conducted Water Resources Analysis in Khulna.

- Seven locations in the Rapsha, Nabganga, Atai, Chitra, Gorai, Bhairab and Modhumati river systems surrounding Khulna City were surveyed

- Quantitatively all locations are suitable
- Qualitatively, as to salinity, only Madhhunati river (sampling point: Gopalgonj) is feasible
- Qualitatively, all rivers' BOD and COD are above the Environmental Quality Standard (EQS) for drinking water

(2) KWASA's Study

KWASA also has conducted "Monitoring and Assessment of Water Quality and Salinity of Three Locations on the Modhumati River and Madaripur Beel Route (MBR)". The final report of this study has not been submitted yet.

- The water quality, in general, at the three monitoring points identified does not vary significantly. However, the available data-set shows that chloride concentrations remain higher, (above EQS for drinking water), for a longer period at Mollarhat and Gopalganj (Chapail Ghat) than that at Haridaspur.
- In order to substantiate the findings, KWASA may think of repeating the daily measurement of salinity for about two to three months (April to May/June) at the location for which the feasibility study is to be carried out.

Conventional treatment of raw surface water cannot significantly remove heavy metals from the influent. Therefore, any physical reason for observed high concentrations, although marginal, of Mercury and Lead found at the sampling locations, should be investigated during the feasibility study phase.

CHAPTER 4 POPULATION AND WATER DEMAND PROJECTION

4.1 Projection Horizon

"Long Term Development Plan of the Water Supply System in Khulna" is set in 2030 to meet the projected the water demand in the study area by 2030.

As for the design year for the Feasibility Study is set in year 2025 in consideration of the new water supply system capacity duration of 10 years i.e. taking into consideration that the assumed time needed for detailed design and project implementation will be up to 2016.

The project horizon for implementation of Khulna Water Supply System is set as follows:

<u>Long Term Development Plan for 2030</u>

For this year, sizing of planned facilities will be identified as a long term development plan to meet the water demand projected.

<u>Feasibility Study Project for 2025</u>

A preliminary design for the first phase implementation will be conducted to identify the details of planned facilities to meet the water demand. A feasibility study will be conducted for the project.

4.2 Service Area

4.2.1 General

Preparation of Structure plan, Master plan and Detailed Area plan for Khulna (2001-2020)" was completed with funding from GOB source in June 2001. The plan along with a set of policy provides a long term strategy for 20 years for the development of the greater Khulna and a part of Jessore sub-region. The plan covers an area of 451 sq. km. including 46 sq. km. of Khulna City Corporation (KCC) area.

KCC have formally requested the government to extend the area under its jurisdiction by incorporating most of the area lying between its current boundary and the recently constructed western bypass. This wider area, termed the Khulna City Project Area (KCPA) covers the approved Khulna Master Plan (KMP)[1] prepared by the Khulna Development Authority (KDA).

In discussion with KWASA, KDA and JICA, the current KCC area will be adopted as the study area for this project. There are two main reasons:

a) The approval of the KCC's area extension will take time and it is difficult to confirm the

[1] The KMP area also incorporates other zones to the north and east of the Rupsha River which have not been included in this study.

schedule.

b) KWASA is relatively new and is yet to be fully functional. It is desirable to devote KWASA's effort to concentrate on the current city area.

Therefore, this study focuses on the current KCC area for the priority project and will provide some provision of future growth, which will increasingly occur outside the current KCC boundary as shown in **Figure 4.2.1**.

For the Long Term Development Plan up to 2030 some extensional possibility will be taken into consideration.

Current KCC boundary is divided into 5 thana[2]; (1) Daulatpur, (2) Khalishpur, (3) Khanjahan Ali, (4) Sedar, and (5) Sonadanga. And also the KCC boundary is devided into 31 wards.

4.2.2 Land Use

Detailed land use information is only available for the KCC area. In 1999, around 80% of the KCC area was built up as shown in the **Table 4.2.1**. Almost two thirds of the built up area was in residential use. By 2009, this land use proportions have not changed drastically. The urbanization of the Khulna City has not replaced undeveloped lands to urban ones but grown the concentration of people in existing urban areas. Around 10 km^2 was in agricultural use at this time. The KCPA mouza in Dumuria and Batiaghata thana are essentially agricultural areas with villages surrounded by rice fields and, less frequently, shrimp ponds. The main exception is Khulna University which is located between the Moyur River and the bypass on the Satkhira Road.

Table 4.2.1 Distribution of Land Use, KCC Area, 1999

Land Use	km^2	%
Residential	23.5	51%
Mixed uses	6.6	15%
Industry (incl. railway and shipyards)	3.6	8%
Commerce/ government/ education	1.0	2%
Others	1.5	3%
Built up area	36.2	79%
Agricultural land	9.8	21%
Total	46.0	100%

Source: KDA Master Plan.

[2] thana: Bangladesh is divided into seven administrative divisions. Divisions are subdivided into districts (*zila*). There are 64 districts in Bangladesh, each further subdivided into *upazila* (subdistricts) or *thana*.

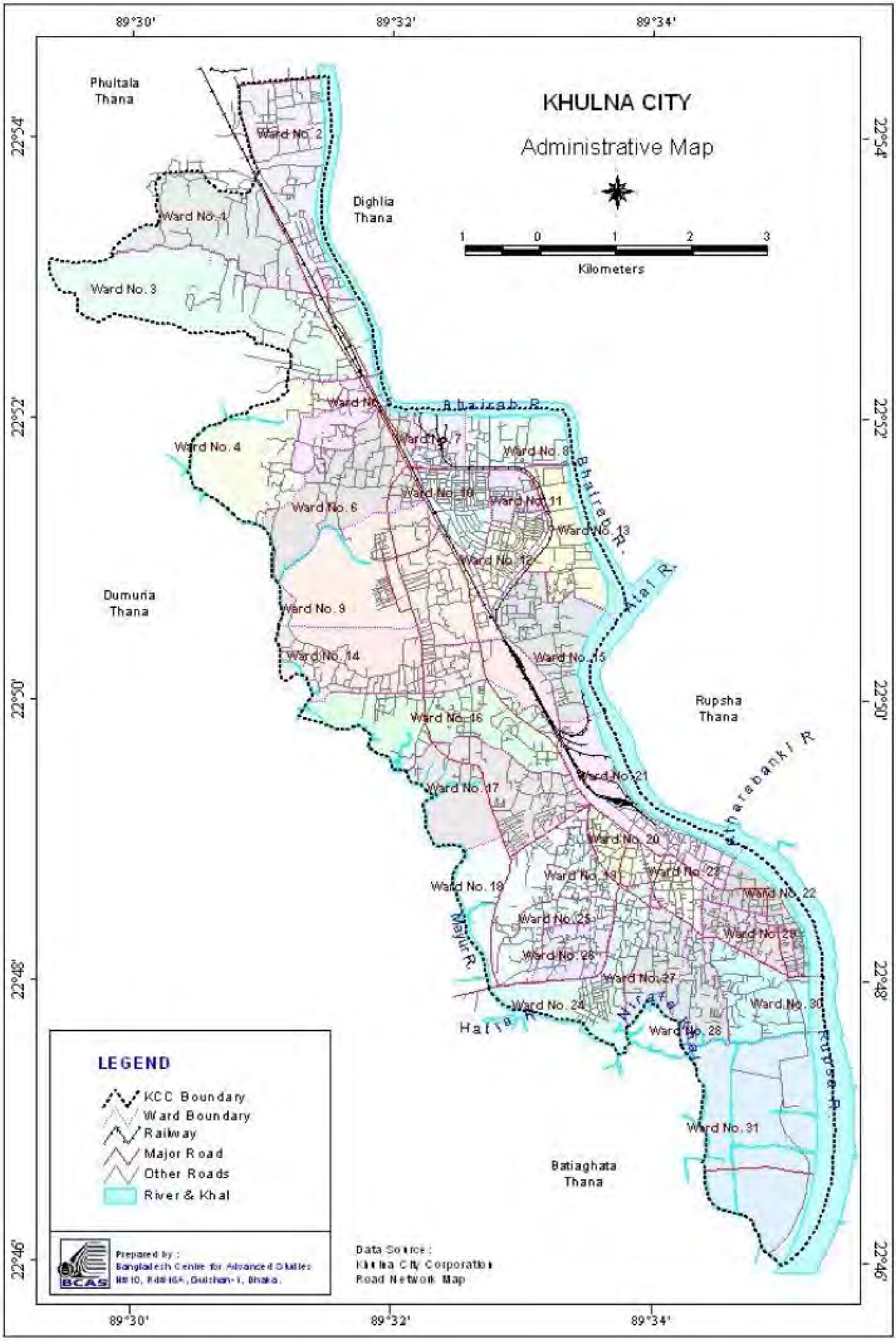


Figure 4.2.1 Current KCC boundary

4.3 Population Projection

4.3.1 Population Growth

Assessing Khulna's current population and recent growth trends is complicated by the absence of recent information with the most recent, reliable source being the 2001 Census. The situation is also complicated by boundary issues: some boundaries changed between censuses, some wards are split between thana, there are contradictions in the areas of administrative units and, most importantly the KCC boundary does not follow always thana boundaries. **Table 4.3.1** shows the change in the population of the principal thana making up the KCPA area.

Table 4.3.1 Population Change, 1981 to 2001[3]

Thana	1981	Growth rate 1981-91	1991	2001	Growth rate 1991-2001
Khan Jahan Ali	62,719	2.5%	88,659	108,317	
Daulatpur	84,920	0.5%	81,186	118,380	2.9%*
Khalishpur	168,046	0.3%	173,255	235,018	3.1%
Sonadanga	119,599	0.7%	128,330	172,079	3.0%
Khulna Sadar	177,859	0.8%	191,910	250,651	2.7%
Sub-total (main thana)	613,143	0.8%	663,340	884,445	2.9%
Dumuria (selected mauza)	6,040	1.6%	7,080	7,898	na
Batiaghata (selected mauza)	10,650	1.6%	12,486	13,929	na
Total KCPA	629,833	0.8%	682,906	906,272	2.9%
Other Khulna Urban Definitions					
KCC* **	**550,454**	**0.6%**	**578,441**	**770,498**	**2.9%**
Rupsha/ Dighalia	227,080	1.3%	258,025	288,386	1.1%
Khulna SMA	840,223	0.9%	921,365	1,172,831	2.4%
Khulna Zila (district)	na	na	2,010,643	2,378,971	1.7%
Bangladesh Total		2.2%**			1.6%**
Bangladesh Urban		4.8%**			3.3%**
Bangladesh Rural		1.6%**			1.1%**

* Growth rate for both thana as boundary changes occurred.
** These growth rates have been calculated after adjustment for under-enumeration.
*** Including small part of all of Khan Jahan Ali and excluding small part of Daulapur (Aranghata Union).
Sources: BBS, 2007, Population Census-2001, Community Series, Zila: Khulna, Dhaka, and other BBS publications (Pourshava and Statistical Metropolitan Area (SMA) series).

The population of the KCC area in 2001 was around 770,000. Allowing for an average, 6.2% undercount of the urban population in the 2001 Census[4], a more accurate estimate of the 2001 KCC's population would have been around 817,000.

During the 1990s, the growth rate in Khulna differed little from the national urban growth rate. Decennial growth rates for the thana are very similar ranging from 2.7% annually to 3.1%. Khulna's growth during the 1990s was higher than during the 1980s reflecting the decline in Khulna's jute economy in the 1980s and its subsequent rebound in the 1990s as shrimp processing expanded along with tertiary education establishments. This contrasts with the national trend which saw the urban growth

[3] ADB: Cities Development Initiative for Asia (CDIA) support to Khulna City Corporation (KCC)/June 2009
[4] BBS, undated, Bangladesh Census Results At A Glance, http://www.bbs.gov.bd/dataindex/census/bang_atg.pdf

rate decreasing from the 1980s to the 1990s.

The current population of Khulna cannot be assessed accurately owing to the absence of reliable information since the 2001 Census. A high estimate can be obtained by assuming a continuation of the observed growth rate for 1991 to 2001, i.e. 2.9%. Conversely a low estimate can be obtained by assuming that the population will only increase at the same rate as the overall national growth rate (1.5%). Both these appear unrealistic. The high estimate assumes no slow down in the rate of urban growth which would run counter to the national trend which has been estimated at below 2.4% annually since 2001; there is also little evidence that Khulna's built up area has expanded rapidly in recent years. On the other hand, the low estimate implies no rural-urban migration – which also appears unlikely. Accordingly, an intermediate estimate has been obtained in KCC's Plan as annual growth rate of 2.00%[5]. Using this assumption, the current populations (mid-2009) of the KCC would be around 957,000. In future the population there are any drastic changes which will effect on a substantial increase could not be presumed. Therefore the annual growth rate is assumed to be constantly up to 2030.

Table 4.3.2 Khulna's Population, 2001-2009

	Baseline Pop.	Growth Rate	Current Pop.
Projection	2001	2001-2009	2009
High	817,000	2.9%	1,270,000
Medium	**817,000**	**2.00%***	**957,000**
Low	817,000	1.5%	920,000

*The growth rate for the KCC area is assumed to be slightly lower as more growth will have occurred outside its boundaries.

4.3.2 Households

Households in the KCC area increased from around 92,000 in 1981, to 115,000 in 1991 and 171,000 in 2001. And actual household size in 2001 in Khulna was 4.8. Meanwhile, in Bangladesh, average household size in urban areas decreased from 5.1 to 4.7 persons between in 2000 to in 2005. It seems realistic to assume that current average household size in Khulna will be 4.4 in 2009 and taking decline future trends into consideration, i.e. average annual household size would be assumed to decline by 0.04 annually.

Using abovementioned assumption the current population and average household size of the KCC would be 957,000 and 4.4 persons/household. Another ADB consumer survey result from 3,000HH survey in 2009 is 5.46; however, it is a result of sample survey. Therefore the whole projection figure is better to be adopted. And future population and household sizes would be forecasted as follows.

[5] ADB: Cities Development Initiative for Asia (CDIA) support to Khulna City Corporation (KCC)/June 2009

Table 4.3.3 Future Population and Households

	2009	2010	2015	2020	2025	2030
Population*1)	957,000	976,000	1,078,000	1,190,000	1,314,000	1,450,000
AHS*2)	4.4	4.4	4.2	4.0	3.8	3.6
Households	217,500	223,900	259,100	300,500	349,500	407,300

*1) Annual growth rate is assumed to be 2.0% constantly.
*2) AHS/ Average Household Size: AHS will decline by 0.04% annually.

4.3.3 Consideration on Urban Poverty

Average household income is estimated at 10,600 taka per month based on the findings of household expenses from the consumer survey[6]. Twelve per cent of those households surveyed had expenses (= income) of less than 5,000 taka per month.

The major employers in Khulna have traditionally been the jute mills, mostly located in Khalishpur. This sector has however been in decline for many years and many mills have been closed.

Figure 4.3.1 Closed Daulatpur Jute Mills Ltd. in Khalishpur

In Khulna, between 2000/2001 and 2006/2007, both production and the number of operating looms decreased by over of 40 %; only one of the Bangladesh Jute Mill Corporation (BJMC) mills in Khulna is currently making a profit. Other major employers are the shrimp processing industry, the universities and KCC itself which has around 1,800 employees. Notwithstanding the existence of these major employers, the fact remains that the majority of employment in Khulna is informal and low paid – a characteristic shared by most Bangladeshi cities. Few slum dwellers had permanent occupations or ones that brought regular incomes: almost two thirds worked as day laborers or rickshaw pullers.

Housing conditions in Khulna are generally poor. In 2001, only 50 % of the population lived in pucca[7] or semi-pucca housing, and, in 2005, around 20 % of Khulna's population lived in slums.

6 ADB TA7223-BAN: Supporting the Establishment of the Khulna Water Supply and Sewerage Authority
7 Houses with cement roofs and brick walls

At present Khulna is characterized by low income areas located amongst areas of middle and high income housing[8]. Therefore for the water supply system planning in Khulna it is difficult to identify slum areas where shall be taken care of. There for in this study the target area will be dealt as a unified area generally; however, the aspect of facilitating the introduction of a system of cross-subsidies from higher to lower income plots will be considered if it is necessary.

4.3.4 Population Density and Future Ward-wise Population

Changes in population densities provide a guide to how the population distribution within an urban area will evolve in the future. The overall population density in the KCC area in 2001 was around 21,000 per km^2 (excluding non-built-up areas).

Population densities have increased in every thana as shown in **Table 4.3.4**. In conjunction with rising land values, this has meant that there has not been a major expansion of Khulna's built up area in recent years. Instead, many new households have accommodated themselves within the existing urban area through the construction of additional dwellings or the extension of existing ones.

Table 4.3.4 Population Densities, 1991 and 2001

	Density (persons per sq. km.)		Ward densities (2001)	
Thana	1991	2001	Lowest	Highest**
Khan Jahan Ali	2681	3742	na	Na
Daulatpur	10557	10024 (13900)*	3,600	42,000
Khalishpur	15105	20490	5,000	52,000
Sonadanga	15241	20437	8,850	75,000
Khulna Sadar	20308	26524	18,000	81,000
KCPA (main thana)	9,463	12,617		
KCC only	15,519 /(16,500)**	17,250/ (21,000)**		

* Density based on same area as in 1991. 2001 density includes a predominantly rural area which formed part of Khan Jahan Ali in 1991.
** Excluding areas still under cultivation; the 1991 estimate is indicative.

Based on the above-mentioned analysis the overall population density in the KCC area in 2001 was around 21,000 per square km.

To forecast future ward-wise population precisely may be it is better to assume area-wise detailed information; however, in Khulna there are no significant development after 2001 which would generate population transfer remarkably. Therefore future ward-wise population can be forecasted base on the ward-wise population in 2001 as shown in the **Table 4.3.5**.

Table 4.3.5 Future Ward-wise Population

	2001	Rate	2009	2010	2015	2020	2025	2030
Ward 1	20,311	2.6%	25,230	25,730	28,420	31,370	34,640	38,220
Ward 2	18,815	2.4%	23,370	23,830	26,320	29,060	32,090	35,410
Ward 3	23,016	3.0%	28,590	29,150	32,200	35,550	39,250	43,310

[8] ADB TA No. 6293 (REG): Managing the Cities in Asia/Cities Development Initiative for Asia (CDIA) support to Khulna City Corporation (KCC)

	2001	Rate	2009	2010	2015	2020	2025	2030
Ward 4	14,299	1.9%	17,760	18,110	20,010	22,080	24,390	26,910
Ward 5	15,314	2.0%	19,020	19,400	21,430	23,650	26,120	28,820
Ward 6	20,995	2.7%	26,080	26,590	29,370	32,430	35,800	39,510
Ward 7	14,808	1.9%	18,390	18,760	20,720	22,870	25,250	27,870
Ward 8	18,545	2.4%	23,030	23,490	25,950	28,640	31,630	34,900
Ward 9	34,614	4.5%	42,990	43,850	48,430	53,460	59,030	65,140
Ward 10	18,518	2.4%	23,000	23,460	25,910	28,600	31,580	34,850
Ward 11	19,398	2.5%	24,090	24,570	27,140	29,960	33,080	36,510
Ward 12	52,036	6.8%	64,630	65,910	72,800	80,370	88,740	97,930
Ward 13	19,959	2.6%	24,790	25,280	27,920	30,830	34,040	37,560
Ward 14	26,444	3.4%	32,840	33,500	37,000	40,840	45,100	49,760
Ward 15	25,724	3.3%	31,950	32,580	35,990	39,730	43,870	48,410
Ward 16	35,881	4.7%	44,570	45,450	50,200	55,420	61,190	67,520
Ward 17	30,352	3.9%	37,700	38,450	42,470	46,880	51,760	57,120
Ward 18	16,765	2.2%	20,820	21,240	23,460	25,890	28,590	31,550
Ward 19	26,321	3.4%	32,690	33,340	36,830	40,650	44,890	49,530
Ward 20	22,539	2.9%	27,990	28,550	31,530	34,810	38,440	42,420
Ward 21	24,984	3.2%	31,030	31,650	34,950	38,590	42,610	47,020
Ward 22	21,633	2.8%	26,870	27,400	30,270	33,410	36,890	40,710
Ward 23	18,332	2.4%	22,770	23,220	25,650	28,310	31,260	34,500
Ward 24	42,959	5.6%	53,360	54,420	60,100	66,350	73,260	80,840
Ward 25	27,106	3.5%	33,670	34,340	37,920	41,860	46,230	51,010
Ward 26	18,087	2.3%	22,470	22,910	25,310	27,930	30,850	34,040
Ward 27	31,489	4.1%	39,110	39,890	44,060	48,630	53,700	59,260
Ward 28	22,404	2.9%	27,830	28,380	31,350	34,600	38,210	42,160
Ward 29	20,431	2.7%	25,380	25,880	28,580	31,550	34,840	38,450
Ward 30	35,827	4.6%	44,500	45,380	50,130	55,330	61,100	67,420
Ward 31	32,592	4.2%	40,480	41,290	45,580	50,350	55,570	61,340
Total Population	770,498	100%	**957,000**	**976,000**	**1,078,000**	**1,190,000**	**1,314,000**	**1,450,000**

4.4 Water Demand Projection

4.4.1 Level of Water Supply

As mentioned in **Chapter 3** current water supply level is assumed as follows;

- Average unit consumption: 82 lpcd (Consumption/ capita/day)
- No-domestic use ratio: 20 %
- Un-accounted for Water ratio: 18% (average rate inclusive piped water and tube well water)

The Bangladesh Water Utilities Data Book 2006-7[9], which presents a compilation of information related to the performance of 11 water utilities in Bangladesh for 2006-7. The 11 utilities are; (1) Dhaka, (2) Chittagong, (3) Rajshahu, (4) Bagerhat, (5) Chandpur, (6) Chapal Nawadbanj, (7) Chuadanga, (8) Gazipur, (9) Jessore, (10) Manikganji, and (11) Barsingdi.

Major performance indicators of those 11 utilities are as shown in the **Table 4.4.1**.

9 Benchmarking for Improving Water Supply Delivery (June 2009/LGRDC and Water and Sanitation Program-South Asia

Table 4.4.1 Summary of 11 Utilities Performance Indicators

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	Ave.
Water coverage (%)	83.3	34.2	84.5	42.2	72	36.1	68.3	14.8	68	36.2	70.3	55.4
Water availability (hours)	23	8	12	2	20	11	7	10	9	20	7	11.7
Consumption/ capita/day (lpcd)	90.4	69.7	88.2	61.5	55.3	33.5	86.7	33.9	72.3	263.5	113.2	88
Production/capita/ day (m^3/day/c)	0.159	0.13	0.132	0.084	0.067	0.054	0.093	0.075	0.107	0.326	0.168	0.127
Unaccounted-for water (%)	37.2	33.3	25.5	3.3	16.3	15.9	2.7	52	28.2	7.2	25.4	22.5
NRW (%)	48.6	33.3	25.5	3.3	18.2	21.6	3.4	53	30.5	7.2	28.3	24.8
Connections metered (%)	70	86	0	0	0	0	0	0	0	38	0	18

(1) Dhaka, (2) Chittagong, (3) Rajshahu, (4) Bagerhat, (5) Chandpur, (6) Chapal Nawadbanj, (7) Chuadanga, (8) Gazipur, (9) Jessore, (10) Manikganji, (11) Barsingdi.

Comparative to other cities in Bangladesh current water supply level in Khulna is not unique, and it can be summarized as;

- Current feature of water supply services in Khulna, that is a combined water supply system from KWASA's piped water and direct supplied water from hand pumps, is not particular in Bangladesh.
- The sizes of water supply services, in Dhaka people-served in about 10 million, in Chittagong 1.23 million and their consumption/ capita/day are about 90 lpcd and 70 lpcd respectively. Compares to these figures the assumed KWASA's water supply level, 82 lpcd is considered reasonable.
- The average un-accounted for water in Bangladesh is 22.5 % and the assumed KWASA's water supply services' is 18%. The assumed figure is relatively smaller; however this is considered due to high dependence to hand pumps. Only for the piped water from KWASA's tube wells NRW is assumed to be 40%. Therefore averagely the un-accounted for water of entire Khulna as 18% is reasonable currently.
- As to non-domestic consumption rate existing reports for Dhaka[10] and Chittagong's[11] water supply systems describe as below;

Non-Domestic	2005	2009	2010	2015	2020	2030
Dhaka		12%	12%	15%	17%	25%
Chittagong	25%		25%		30%	

The assumed non-domestic consumption ratio for Khulna water supply system, 20%, is reasonable.

4.4.2 Future Water Demand

The demand for water is often analyzed for relatively homogeneous groups of users. In many cases, a distinction is made between domestic and nondomestic users. Furthermore, demand from domestic

[10] Feasibility Study of Pagla/Keraniganj Water Treatment Plant Project Preliminary Technical Feasibility Study Report (September 2009/DWASA)
[11] Special Assistance for Project Formation (SAPROF) for Karnaphuri Water Supply Project Final Report (November 2005/JBIC)

users is often separately analyzed for (1) users currently connected to the system (existing connections) and (2) those to be connected to the system under the proposed new system. And demand from non-domestic users is forecasted based on the future economical and/or industrial impact in the planned service area.

For the planned service area, future expansion and development impact which effect water demand is assumed to synchronize to the increase of population because of following reasons.

a) At present, private developers are undertaking small scale residential developments on Khulna's urban fringe.
b) Existing vacant plots within the urban area will be exhausted
c) Very high densities in many wards will restrict the capacity for further densification.
d) Un-accounted for water and non-domestic water will also increase only in accordance with the increase of population.

After the introduction of new water supply system unit consumption i.e. consumption/ capita/day will increase due to the upgraded water supply services will bring in increase of water consumption in daily lives of people in the served area.

However, the particularity of the Khulna water supply system is how to sift current total dependence to groundwater to surface water supply system. If consumers will shift their water consumption custom to more consumption trend, the unit consumption will surely increase. But if customers consist on their current water consumption custom, the unit consumption will not increase drastically.

In addition, in Khulna several private developers have planned and implemented housing projects in south and west peripheral areas. The potential contribution of these future housing supplies until 2015 is new households of about 47,800[12] and it could provide population increase over 200,000 if all of the projects are implemented as planned. This increase exceeds a forecasted population increase. The forecasted population in 2015 is 1,078,000 which is an increase of 121,000 from the population of 957,000 in 2009.

The forecasted increase of water demand in 2015 will be provided mainly by the domestic demand increase. This also means the ratio of non-domestic water demand compared to the domestic demand will be decrease.

In this context we can assume that the ratio of non-domestic water demand to domestic demand will be decreased from 20% in 2010 gradually and it will become to 10% in 2025 and this ratio will remain the same after 2025.

As to the Per-capita Domestic Water Demand, a future water demand in Dhaka is projected as 150 lpcd

[12] Asian Development Bank TA No. 6293 (REG): Managing the Cities in Asia Cities Development Initiative for Asia (CDIA) Support to Khulna City Corporation (KCC) / P30 Housing Supply and Demand in Khulna, 2009-2015

in 2030[13] and in Chittagong it is projected as 142 lpcd in 2020[14]. Compares to these figures it is considered reasonable that the future KWASA's water supply level is assumed as 120 lpcd. The future water demand in Khulna is summarised as shown in the **Table 4.4.2**.

Table 4.4.2 Future Water Demand in Khulna

Item/Year	Equation	2009	2010	2015	2020	2025	2030
(1) Population		957,000	976,000	1,078,000	1,190,000	1,314,000	1,450,000
(2) Per-capita Domestic Water Demand (lpcd)		82	90	97	105	113	120
(3)Proportion of Non-domestic Water Demand to Total Water Demand (%)		20	20	16	13	10	10
(4)Domestic Water Demand (m^3/d)	(1)x(2)	78,474	87,515	104,925	124,950	148,044	174,483
(5) Non-domestic Water Demand (m^3/d)	(6)-(4)	19,619	21,879	19,986	18,671	16,449	19,387
(6) Domestic & Non-domestic Water Demand (m^3/d)	(4)/(1-(3))	98,093	109,393	124,911	143,621	164,493	193,870
(7) Leakage after WTP (%)		18	18	18	18	18	18
(8) Average Day Water Requirement (m^3/d)	(6)/(1-(7)	119,625	133,407	152,331	175,147	200,602	236,427
(9) Peak Factor		1.15	1.15	1.15	1.15	1.15	1.15
(10)Maximum Day Water Requirement (m^3/d)	(8)x(9)	137,569	153,417	175,180	201,419	230,692	271,891
(11)Existing Supply Capacity (m3/d)		119,100	119,100	125,850	125,850	125,850	125,850
(12)Additional Supply Capacity to be Installed (m^3/d)					75,569	104,842	146,041
(13)Water Losses at WTP (%)					5	5	5
(14) Additional Water Treatment Capacity to be Installed (m^3/d)					80,000	110,000	150,000

4.4.3 Consideration of Peak Factor

Consumption rate varies during a day, and over a week. For example, with large communities in which a significant number of homes have house connections, water is consumed up to 17 hours per day. To carter for this, peak factors for production system and distribution system should be taken into account in the design. Especially for water supply for arid areas additionally seasonal variation shall be considered.

The peak factor will be reduced by provision of storage. The provision of intermediate storage will also result in a reduction in the peak flows in the elements prior to the intermediate storage.

Peaks can be averaged out over large townships. Many factors can affect consumption however. For example, rainfall or temperature may well affect. Metering can also reduce consumption, but whether this is long term, and what degree of meter stop occurs, makes this difficult to estimate.

In the course of determining the peak factor, water consumption records through at least ten years would

---

[13] Feasibility Study of Pagla/Keraniganj Water Treatment Plant Project Preliminary Technical Feasibility Study Report (September 2009/DWASA)
[14] Special Assistance for Project Formation (SAPROF) for Karnaphuri Water Supply Project Final Report (November 2005/JBIC)

be requested. The daily water consumption is generally obtainable from the records of water production at water treatment plants, or readings on bulk water meters installed on transmission lines and/or at service reservoirs and water meters at house connections. Water production records at Khulna cannot be collected because the resources of water in Khulna city are almost tube wells and hand pumps (KWASA and private) with no flow meters.

In this study, water demand will be considered on the daily basis. And consumption during a day can be considerably averaged due to introduction of raw water reservoirs and treated water reservoirs. Generally in planning a water supply system the daily peak factor is assumed as from 1.15 to 1.40. In Khulna the water consumption fluctuation might be alleviated by using groundwater source such as hand pumps and/or private pumps. Taking into account these points, it is considered most appropriate to adopt a samller value 1.15 as the peak factor for new system in this study.

4.5 Water Demand for Khulna Water Supply Project

4.5.1 Long Term Development Plan

Water demand for Khulna water supply system in 2030, for the Long Term Development Plan, is summarized as follows:

- Target year: 2030
- Population: 1,450,000 persons
- Consumption/ capita/day: 120 lpcd
- Water for non-domestic use: 10 %
- Leakage after WTP: 18 %
- Domestic water demand: 175,000 m^3/day
- Non-domestic water demand: 20,000 m^3/day
- Water loss: 43,000 m^3/day
- Total water demand: 238,000 m^3/day

4.5.2 Feasibility Study Project

In accordance with the two scenarios water demand for Khulna water supply system in 2025, for the Feasibility Study project, are summarized as follows respectively:

- Target year: 2025
- Population: 1,314,000 persons
- Consumption/ capita/day: 113 lpcd
- Water for non-domestic use: 10 %
- Unaccounted for water: 18 %
- Domestic water demand: 149,000 m^3/day
- Non-domestic water demand: 17,000 m^3/day
- Water loss: 37,000 m^3/day
- Total water demand: 203,000 m^3/day
- Capacity of new system: 110,000 m^3/day

CHAPTER 5 KULNA WATER SUPPLY WATER SOURECE

5.1 Necessity of Water Source Development

As shown in regard to the water demand projection in **Chapter 4**, the existing system will not be able to satisfy the future water demand in Khulna City. Expansion of water supply system is called for in many areas to improve the present inconvenient and unsanitary living conditions due to lack of safety water. To implement the water supply expansion, the water production capacity must definitely increase considering the time required for implementation.

Under the present circumstances and for achieving the stable water supply to meet the future demand, it is inevitable that new water sources stable both in quantity and quality be planned and developed.

5.2 Authorities Responsible for Water Management

5.2.1 Groundwater

The authorities responsible for groundwater management in Bangladesh are not clearly prescribed by any laws. With regard to the utilization of water for the people living in each area, the Local Government Engineering Department (LGED), Local Government Division, Ministry of Local Government and Rural Development (MLGRD&C) are the responsible agencies. As to the features of sanitation improvement inclusive safety water supply, the Department of Public Health Engineering under (MLGRD&C) is in charge of assisting municipalities and communities in building water supply infrastructure.

Groundwater is very important for the socio-economic development of Bangladesh and supply of safe drinking water and irrigation water are highly dependent on abstraction form delta plain. Despite high dependence, the management of groundwater is not properly practiced. There are many government organizations involved in development of groundwater. However, the lack of key legislation like National Water Code and groundwater laws limit the enforcement of policies.

For successful implementation of groundwater development an integrated water resources management agency will be required. This agency will manage and stress the importance of developing and enabling environment with appropriate policy and legal frameworks institutionally and technologically.

5.2.2 Basin and River Water

The Bangladesh Water Development Board (BWDB) is in charge of dealing with water issues for water resources management and development. BWDB mainly deals with;

- Flood Control and Drainage
- Irrigation
- River Bank and Town protection
- Flood Forecasting and Warning Services
- Hydro-meteorological Data Management
- Land Reclamation
- Protection Against Tidal Surge

Bangladesh has about 24,000 km. of rivers, streams and canals that together cover about 7% of the country's surface. Most part of the country is linked by a complex network of waterways which reaches its extensive size in the monsoon period. Out of 24,000 km. of rivers, streams and canals only about 5,968 km. is navigable by mechanized vessels during monsoon period which shrinks to about 3,865 km during dry period.

The area is mainly drained by a number of north-south flowing rivers. From east to west, important rivers are the Gorai-Madhumati-Baleswar, the Bhairab-Pusur, the Bhadra- Gengrail, the Hari-Teka-Mukteswari, Sibsa, the Kabadak- Betna system and the Jamuna-Ichamati-Kalindi rivers. Most of the rivers are tidal in nature. East-west rivers are interconnected with the north-south rivers. Flows of these east-west rivers are very important for the complete circulation of tide all over the tidal flat. In rainy season, water becomes fresh to slightly salty and in the dry season, it becomes salty. Most of the river waters carry appreciable amounts of suspended sediments.

The inland rivers represent the remaining channels of the old spill or regional rivers, which have lost their connection to the mother river, the Ganges. The Kumar, Nabaganga, Kabadak, Bhairab are good examples of such inland rivers. The inland and regional rivers run into tidal rivers or estuaries mentioned above. In the Khulna area, the coastal rivers or estuaries are saline because of low freshwater discharges, especially in the dry season. The river flow regimes are driven by high, variable sediment loads. The rivers of this region show a continuous process of silting gradually from the NW towards the SE direction.

To tackle to the silting problem the Bangladesh Government has decided to implement a project for dredging Gorai River[1]. After implementation of a pilot dredging during 1998 to 2002 as Phase-I, Phase –II project has been formulated as 5 years project. There project is as follows;

- Project period: 5 years
- Total dredging length: 30 km
- Volume to be dredged: 17,456,710 m^3

The project period is divided into two stages, i.e. capital dredging for years and maintenance dredging for three year. In the 1st year, an initial dredging for removal of silt from the off-take of Gorai River as shown in **Figure 5.2.1** will be conducted.

In addition to the above-mentioned project, Bangladesh Inland Water Transport Authority (BIWTA), in a proposal, identified 2,393 km of waterways on 53 major river routes for dredging, to improve and restore navigability by 2018. River routes to be dredged are including revivers around Khulna City. In the first phase, which had been scheduled to start January 2010, 23 routes are planned to be dredged. Currently BIWTA is still waiting for actual budget allocation.

[1] The Gorai River is the only remaining major spill channel of the Ganges river flowing through the Southwest Region. It has been observed that since 1989, the off-take of the Gorai fully dries up during the critical dry periods of the dry season and completely cuts off the supply of fresh water. For the last 10 years or so, the dry season (January - May) discharges in the Gorai River have decreased which has resulted in an increased salt water intrusion with negative environmental impact to the Western Southern Bangladesh Area including Khulna..

Figure 5.2.1 Map of Gorai River Dredging Project

5.3 Approach of Groundwater Source Development

5.3.1 LGED's Approach (MSP Study)

Groundwater is abundant in Bangladesh and the aquifers are highly productive. The sediments are predominantly non-indurate and easy to drill by hand, at least to shallow levels. Water tables vary across the country but are typically shallow at around 1–10 m below the ground surface. These factors have made groundwater an attractive and easily accessible resource and have led to a rapid proliferation in the use of groundwater over the last few decades. Today, 97% of the population relies on groundwater for potable supplies and groundwater is also an important source for irrigation and industry.

Groundwater levels across Bangladesh become depressed during the dry season, but the aquifers replenish fully during the monsoon. Exceptions occur beneath the major cities, especially Dhaka, where large-scale abstraction has led to long-term drawdown of the water table.

LGED conducted a study "Groundwater Resources & Hydro-Geological Investigations in and around Khulna City/ Municipal Services Project (MSP) /Final Report in May 2005)". In this study the potential resources of the project area that may contribute to the water supply of Khulna City by drilling and monitoring of more than 75 exploratory tube wells (up to 354 m. depth) within an area of more than 600 km², around Khulna city as shown in the **Figure 5.3.1**. And two years study of the perennial and non-perennial surface water up to 35 km North of Khulna, highlighted the presence of only two resources that might be used for water supply of Khulna City.

Based on the monitoring result the study found followings for the water resources potential for water supply of Khulna

<u>Groundwater Resources for Drinking Water Supply</u>

Up to the investigated depth of 350 m. the only substantial available fresh water resource is a small portion of the Deep aquifer, located S of the City centre. The others two aquifers, Shallow and Upper, are both not fit for drinking water supply due to high mineral (salt) content or the presence of toxic elements. The Arsenic concentration is normal and below the admissible ranges; however, Iron and Manganese concentrations are above the admissible limits.

<u>Surface Water Resources for Drinking Water Supply</u>

The investigations to find potable or near-potable surface water around Khulna City started in February 2003. In March 2003, following the negative results, the prospection area was expanded, up to 35 km (when the rivers were navigable) around the City. It has been found that as follows;

- The only perennial Surface water resource Bhairab River is during 5 months very highly mineralized north ward from Khulna and up to a distance of 35 km. During the seven remaining months the water is highly turbid but very lowly mineralized.

- Decreasing river discharge results in lower river water levels whereas the tidal cycles of the sea fluctuate around same average values. Depending on discharge of Bhairab River, controlled by inflow far North from Ganges the position of the salt-fresh water interface in the river does change and reduced river discharge increases the length of the season during which the river water at Khulna remains salty.

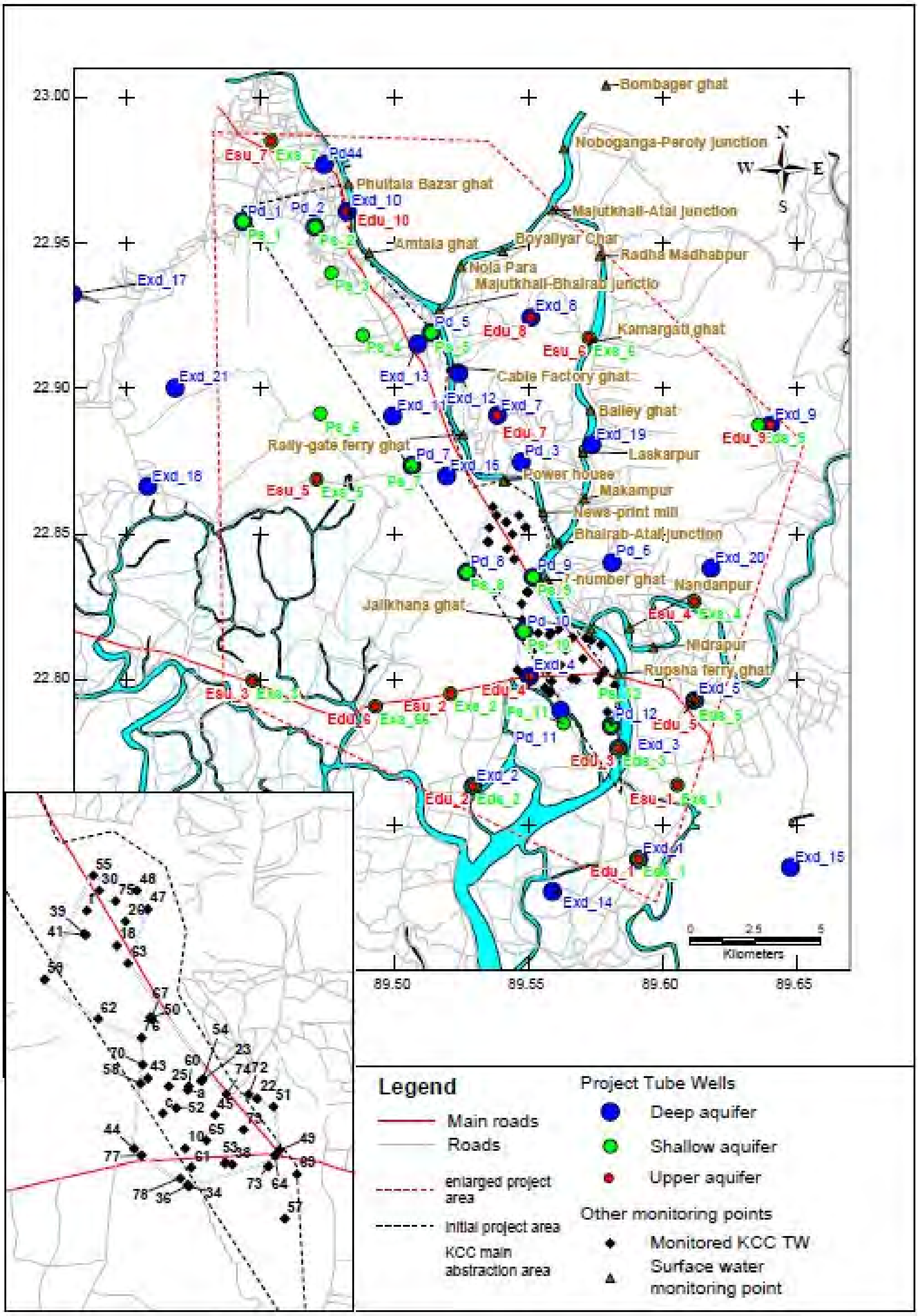


Figure 5.3.1 Monitoring Network in "Groundwater Resources & Hydro-Geological Investigations in and around Khulna City"

5.3.2 ADB's Approach

In the ADB's PPTA program, Preparing Khulna Water Supply Project, a groundwater assessment study had been conducted. In this study the potential of groundwater with a simulation model and propose a strategy to manage the groundwater in a sustainable manner was assessed.

The summary of the report are as follows[2]:

- In most cases the aquifers beneath Khulna are productive, however the distribution of salinity in the aquifers and water quality impacts due to pumping are the main constraints on increasing extractions.

- Future studies will need to consider modeling the shallow aquifer and the deep aquifer.

- The average abstractions from KWASA's tube wells over the past 25 years averages 30,000 m^3/d and is about 25,000 m^3/d during recent years due to declining well yields from older production bores.

- In the past only 22 percent of industrial wells were exploiting the deep aquifer, whereas at present about 90 percent of new wells are in the deep aquifer. Industrial usage is 15,000 m^3/d and is projected to rise to 30,000 m^3/d by 2030. It is difficult to accurately assess the number of private wells as no regulation or system of licensing deep wells is in place for Khulna. It is recommended that KWASA institute a monitoring program for the industrial and private wells that are tapping the deep aquifer along with licensing and regulating usage to minimize impacts on municipal supply wells.

- The deep aquifer at Khulna does not show any signs of deterioration in water quality, despite a significant increase in pumping by industry and private wells which suggests that additional groundwater supplies may be available from the Khulna area for new municipal supply well. Initial estimates suggest a total of 50,000 m^3/d can be extracted from the KCC and Phultala municipal supply wells. It should be noted that the above estimate is a conservative estimate and does not include DPHE, industrial and private wells which are already abstracting groundwater from the shallow and deep aquifers. Further modeling is recommended to determine the production potential of the deep aquifer so that accurate estimates can be provided for supplementary water to augment the planned surface water supplies.

And prior to this assessment in August 2009, using existing MSP study's groundwater monitoring network, a facility survey had been conducted. The results are as follows:

- The average static water level (SWL) the project area was -1.42 m from meter above sea level (MASL) in 2005 and in 2009 it became -2.06 m MASL. Thus the net average declination of SWL for the whole project area becomes 0.64 m in last five years. The maximum declination of SWL at the City Centre is 1.00 m. This declination of SWL has been taken place in the central and southern part of the City where maximum KWASA's tube wells are located.
- It is difficult to find all answers about the declination of SWL by a single monitoring session.

[2] Study on Groundwater Sources in Khulna City /ADB – RSC-C91980 (BAN) /October 2009

5.3.3 Policy of Groundwater Source Development

Groundwater is an important source of clean drinking water in Khulna City, but sustainable management has not yet been established for this resource in the aspects of quantity and quality. On the other hand, KCC and KWASA's have supplied water to their service area barely sustainably with continuous repair and renovation of their tube wells.

In this study current total groundwater abstraction is assumed as 119,100 m^3/d. Meanwhile, ADB's approach is 97,300 m^3/d[3]. And in the ADB's study a consumer survey inclusive willingness-to-pay survey had been conducted. In this consumers survey it is very difficult to find any significant complains regarding inconvenience of water quantity.

The results of MSP study and ADB's approaches are slightly deferent but both of them did not find any significant problems regarding continuous abstraction with current level.

Based on above-motioned reasons, in this study the policy of groundwater source development is specified as follows:

- To keep the level of current situation and do not propose extenuative development without any clarification of potential of groundwater development to be given in future.

5.4 Approach for River Water Source Development

5.4.1 Water Quality

Regarding river water quality of the rivers surrounding Khulna City there are five surveyed information.

i) DOE Water Quality Monitoring Data
ii) "Water Resources Analysis in Khulna: JBIC/2007
iii) "Monitoring and Assessment of Water Quality and Salinity of Three Locations on the Modhumati River and MBR": KWASA/2009
iv) JICA Study Team Water Quality Analysis /2009-2010

(1) DOE Water Quality Monitoring Data

DOE has been conducting water quality periodically, basically once a month, at the monitoring points as shown in **Figure 5.4.1**.

[3] Bangladesh: Supporting the Establishment of the Khulna Water Supply and Sewerage Authority (Financed by the ADB Technical Assistance Special Fund)/ Project Number: 42171/December 2008

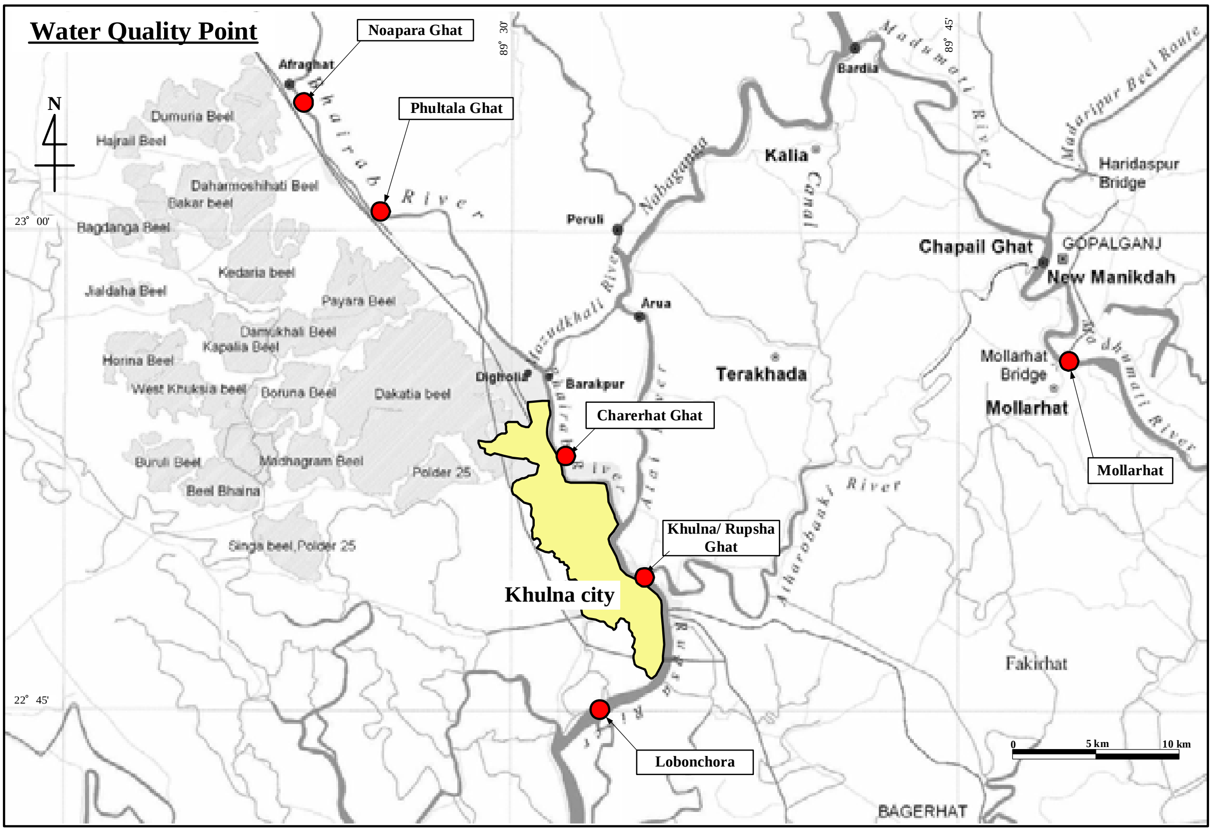


Figure 5.4.1 Location of DoE Water Quality Monitoring Points

The monitoring results of three monitoring points along the Bhairab River, at Noapara, at Phultala, and at Charerhat are as shown in **Table 5.4.1**, **Table 5.4.2** and **Table 5.4.3**, respectively. The monitoring results of two monitoring points along the Rupsha River, at Rupsa Ghat and at Lobonchora are as shown in **Table 5.4.4**and **Table 5.4.6**, respectively. And the monitoring result of a monitoring point along the Madhumati River, at Mollarhat is as shown in **Table 5.4.7**.

Table 5.4.1 Water Quality Data: Bhairab River at Noapara for 2005 - 2009 done by DOE

Water Quality Item		pH	Chloride	T Alkalinity	Hardness	Turbidity	EC	DO	BOD	TDS	SS	COD
Unit		-	mg/L	mg/L	mg/L	NTU	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L
Standard		6.5-8.5	600	-	200-500	10	`-	6	0.2	1000	10	4
2005	Jan	7.78	155	32	197	48.2	610	5.5	0.4	305	48	
	Feb	7.69	165	32	202	55.8	665	5.4	0.6	332	57	
	Mar	7.59	331	34	288	66.8	1,340	5.1	0.9	670	77	
	Apr	7.56	1,538	36	578	78.8	6,100	4.6	1.1	3,050	88	
	May	7.54	4,166	36	1,378	121	15,800	4.6	1.1	7,900	154	
	Jun	7.61	828	36	378	78.2	3,220	5.1	0.9	1,610	108	
	Jul	7.71	219	34	198	76.6	880	5.3	0.8	440	106	
	Aug	7.69	38	30	125	68.2	320	5.8	0.2	161	87	
	Sep	7.78	46	30	127	64.2	380	5.6	0.6	190	78	
	Oct	7.68	76	30	142	56.2	390	5.4	0.7	195	67	
	Nov	7.54	132	30	201	44.2	410	5.4	0.5	205	56	
	Dec	7.57	151	32	211	47.6	590	5.5	0.8	295	59	
2006	Jan	7.56	175	32	207	50.6	700	5.4	0.6	350	56	22
	Feb	7.61	220	34	242	54.6	860	5.4	0.8	430	62	32
	Mar	7.68	333	36	278	65.7	1,340	5.2	1	670	79	41
	Apr	7.56	1,784	36	588	77.6	7,200	4.7	1.2	3,600	89	120
	May	7.44	4,505	36	1,578	120.8	18,100	4.5	1	9,050	156	210
	Jun	7.61	989	36	478	79.8	3,890	5	0.8	1,945	87	140
	Jul	7.71	56	34	174	78	310	5.2	0.7	155	98	20
	Aug	7.71	36	32	124	69.4	280	5.6	0.4	140	78	21
	Sep	7.69	36	38	197	64.8	420	5.7	0.4	210	74	32
	Oct	7.58	32	32	192	56.9	430	5.3	0.5	215	76	35
	Nov	7.68	52	30	201	45.2	480	5.3	0.6	240	59	35
	Dec	7.74	154	32	211	48.6	580	5.6	0.7	290	61	34
2007	Jan	7.88	165	36	224	98.4	660	6.1	0.6	330	98	25
	Feb	7.69	228	34	231	156.2	888	5.4	0.8	444	128	22
	Mar	7.62	322	34	222	188.8	1,280	5.5	1.1	640	198	24
	Apr	7.79	3,225	38	11	198	12,800	5.4	1.1	6,400	211	210
	May	7.51	7,325	36	2,412	202	28,400	4.8	1.1	14,200	240	220
	Jun	7.6	2,353	34	793	198.1	9,200	4.9	0.9	4,600	260	200
	Jul	7.62	135	34	228	118.6	540	5.1	0.8	270	116	22
	Aug	7.72	37	30	115	77.2	290	5.5	0.6	145	78	20
	Sep	7.74	46	34	188	109.1	410	5.6	0.8	205	101	22
	Oct	7.73	56	32	198	116.2	480	5.1	0.4	240	112	20
	Nov	7.68	102	32	208	128.3	550	5.2	0.5	275	118	22
	Dec	7.65	164	34	222	127.2	670	5.4	0.8	335	120	24
2008	Jan	7.82	156	34	202	50	668	5.5	0.6	334	52	22
	Feb	7.92	215	34	228	52.6	1,040	6	0.5	520	65	26
	Mar	7.81	442	34	273	88.8	1,760	5.4	1.1	880	98	36
	Apr	7.81	3,737	36	1,236	136	14,800	4.8	1.2	7,400	176	56
	May	7.83	7,227	36	2,435	150	28,800	4.7	1.6	14,400	200	100
	Jun	7.84	4,440	34	1,433	150	17,200	4.7	0.9	8,600	260	65
	Jul	7.79	131	32	215	78.8	560	5.1	0.8	280	99	20
	Aug	7.71	41	30	125	79.2	280	5.5	0.6	140	98	20
	Sep	7.69	66	34	168	56.8	340	5.6	0.8	170	68	22
	Oct	7.73	70	32	188	61.2	400	5.1	0.4	200	70	26
	Nov	7.76	110	32	198	60	450	5.2	0.5	225	72	24
	Dec	7.81	154	34	212	58.8	620	5.4	0.8	310	69	22
2009	Jan	7.57	146	34	202	82.4	810	4.8	0.6	405	102	37
	Feb	7.76	448	34	288	122.4	1,810	4.7	1.2	905	138	40
	Mar	7.71	2,833	34	850	92.4	9,100	5.2	1.1	4,550	120	69
	Apr	7.51	6,540	36	2,135	282	18,800	4.6	1.1	9,400	187	180
	May	7.51	7,230	36	2,434	242	22,800	4.6	1.1	11,400	201	180
	Jun	7.48	8,226	34	2,740	178	28,200	4.6	1	14,100	211	178
	Jul	7.68	1,820	32	620	108.6	560	5	0.8	280	109	34
	Aug	7.67	41	30	125	79.2	280	5.2	0.6	140	78	28
	Sep	7.77	36	34	168	106.1	340	5.1	0.8	170	101	20
	Oct	7.78	55	34	156	78	310	5	0.6	155	90	22
	Nov	7.6	46	36		82	320	5.2	0.9	160	74	28
	Dec	7.6	46	36		82	320	5.2	0.9	160	74	28

Table 5.4.2 Water Quality Data: Bhairab River at Phultala for 2005 - 2009 done by DOE

Water Quality Item		pH	Chloride	T Alkalinity	Hardness	Turbidity	EC	DO	BOD	TDS	SS	COD
Unit		-	mg/L	mg/L	mg/L	NTU	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L
Standard		6.5-8.5	600	-	200-500	10	`-	6	0.2	1000	10	4
2005	Jan	7.64	192	34	235	112.8	780	5.2	0.6	390	98	
	Feb	7.68	274	34	310	123.6	1,050	5.1	0.8	525	112	
	Mar	7.54	659	38	420	145.3	2,410	5	0.7	1,205	122	
	Apr	7.56	2,087	36	720	156.1	8,100	4.7	1	4,050	167	
	May	7.48	4,571	32	1050	178.8	17,200	4.6	1	8,600	220	
	Jun	7.67	824	30	270	210	3,220	5	0.9	1,610	188	
	Jul	7.71	329	36	318	125.8	1,210	5.2	0.8	605	136	
	Aug	7.73	36	34	145	78.6	280	5.8	0.4	140	105	
	Sep	7.69	56	30	178	102.8	310	5.6	0.6	155	100	
	Oct	7.74	103	28	211	112.6	360	5.4	0.7	180	102	
	Nov	7.68	109	30	215	118.4	370	5.4	0.5	185	110	
	Dec	7.72	175	30	245	121.1	610	5.5	0.8	305	120	
2006	Jan	7.66	192	32	235	118.6	780	5.3	0.8	390	110	22
	Feb	7.61	329	34	278	122.8	910	5.2	0.8	455	126	28
	Mar	7.63	879	32	389	145.8	3,220	5.1	0.9	1,610	148	98
	Apr	7.54	2,967	36	987	156.8	10,800	4.7	1.1	5,400	155	160
	May	7.51	4,775	38	1398	179.6	15,800	4.5	0.9	7,900	187	210
	Jun	7.62	989	40	421	221	3,890	5	0.8	1,945	232	120
	Jul	7.71	331	32	271	146.8	1,250	5.2	0.7	625	125	20
	Aug	7.69	43	36	143	78.8	280	5.6	0.4	140	80	20
	Sep	7.74	87	34	132	104.6	420	5.7	0.4	210	100	20
	Oct	7.71	115	28	178	112.4	430	5.2	0.5	215	108	20
	Nov	7.69	168	30	198	120.8	580	5.3	0.6	290	124	24
	Dec	7.68	175	32	218	118.9	720	5.4	0.8	360	120	34
2007	Jan	7.81	188	34	234	88.4	740	6.6	0.8	370	88	20
	Feb	7.77	327	34	278	117.2	928	5.6	0.9	464	126	33
	Mar	7.87	705	32	328	118.4	2,820	5.6	1.1	1,410	128	47
	Apr	7.79	3,549	38	1178.9	126.5	12,800	5.4	1.1	6,400	176	110
	May	7.57	7,775	34	2612	167.8	29,400	4.7	1.1	14,700	180	210
	Jun	7.67	2,010	34	710	180	8,200	4.9	1	4,100	220	122
	Jul	7.77	336	36	322	76.8	1,250	5.1	0.8	625	98	52
	Aug	7.78	48	32	146	78.7	280	5.4	0.6	140	95	23
	Sep	7.79	76	30	176	76.9	310	5.5	0.6	155	79	22
	Oct	7.57	89	36	198	58.8	480	5.1	0.8	240	67	24
	Nov	7.74	189	30	278	53.4	750	5.2	0.7	375	62	22
	Dec	7.68	210	34	278	58.2	770	5.4	0.8	385	70	22
2008	Jan	7.75	197	34	233	50.6	784	6.1	0.6	392	68	22
	Feb	7.77	331	32	279	52.5	1,280	6.1	0.8	640	71	24
	Mar	7.68	2,307	34	742	68.8	8,600	5.5	1	4,300	79	36
	Apr	7.76	5,109	36	1730	142	20,100	4.8	1.2	10,050	186	56
	May	7.73	7,362	36	2439	150.8	24,400	4.8	1.2	12,200	200	156
	Jun	7.68	7,417	38	2480	168	24,800	4.5	1.3	12,400	210	158
	Jul	7.78	881	34	451	78.8	3,320	54.9	0.8	1,660	96	56
	Aug	7.74	55	32	124	78.9	270	5.5	0.6	135	98	24
	Sep	7.69	54	30	143	78.9	310	5.4	0.8	155	71	22
	Oct	7.66	58	34	179	58.8	370	5.8	0.4	185	68	22
	Nov	7.68	108	34	181	58.9	380	5.8	0.5	190	70	20
	Dec	7.72	133	32	210	56.6	480	5.6	0.8	240	72	22
2009	Jan	7.61	192	32	236	78.8	628	5.6	0.6	314	105	47
	Feb	7.73	338	34	298	76.4	1,240	5.4	0.8	620	138	36
	Mar	7.68	2,812	36	942	169.8	8,200	4.8	1.1	4,100	178	110
	Apr	7.67	5,769	34	1930	176.6	14,800	4.7	0.9	7,400	187	175
	May	7.52	8,681	34	2851	180	28,800	4.6	1	14,400	201	180
	Jun	7.54	8,677	36	2871	180	17,200	4.7	0.9	8,600	211	182
	Jul	7.72	1,758	32	621	78.8	6,820	4.8	0.8	3,410	109	33
	Aug	7.74	384	32	322	79.9	1,280	5.1	0.6	640	98	22
	Sep	7.73	158	30	258	76.9	620	5.6	0.8	310	89	24
	Oct	7.7	36	34	156	78	310	5.5	0.6	155	90	23
	Nov	7.7	58	36		73	320	5.4	0.6	160	50	20
	Dec	7.7	58	36		73	320	5.4	0.6	160	50	20

Table 5.4.3 Water Quality Data: Bhairab River at Charerhat for 2005 - 2009 done by DOE

Water Quality Item		pH	Chloride	T Alkalinity	Hardness	Turbidity	EC	DO	BOD	TDS	SS	COD
Unit		-	mg/L	mg/L	mg/L	NTU	μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L
Standard		6.5-8.5	600	-	200-500	10	`-	6	0.2	1000	10	4
2005	Jan	7.71	218	34	256	50.8	780	5.2	0.6	390	62	
	Feb	7.68	274	34	290	56.9	1,050	5.1	0.8	525	72	
	Mar	7.69	663	34	346	78.9	2,410	5	0.7	1,205	98	
	Apr	7.56	2,122	34	721	156.8	8,100	4.7	1	4,050	167	
	May	7.51	4,285	38	1,422	156.8	16,200	4.6	1	8,100	168	
	Jun	7.48	2,472	32	840	78.8	3,220	5	0.9	1,610	88	
	Jul	7.69	325	32	278	78.6	1,210	5.2	0.8	605	98	
	Aug	7.73	44	32	146	78.8	280	5.8	0.4	140	82	
	Sep	7.72	37	30	129	69.8	310	5.6	0.6	155	78	
	Oct	7.67	90	30	177	56.9	360	5.4	0.7	180	62	
	Nov	7.68	99	34	190	48.8	370	5.4	0.5	185	56	
	Dec	7.69	154	32	221	51.6	610	5.5	0.8	305	65	
2006	Jan	7.69	215	32	222	50.8	780	5.3	0.8	390	62	20
	Feb	7.68	325	32	288	56.9	1,210	5.2	0.8	605	72	28
	Mar	7.58	882	34	311	78.9	3,220	5.1	0.9	1,610	98	98
	Apr	7.54	4,112	34	1,399	156.8	16,100	4.7	1.1	8,050	167	168
	May	7.51	4,831	36	1,648	156.8	19,200	4.5	0.9	9,600	168	212
	Jun	7.62	3,184	38	1,053	78.8	12,300	5	0.8	6,150	88	120
	Jul	7.69	220	34	256	78.6	820	5.2	0.7	410	98	20
	Aug	7.71	46	32	146	78.8	280	5.6	0.4	140	82	22
	Sep	7.73	39	34	128	69.8	420	5.7	0.4	210	78	20
	Oct	7.69	75	32	169	56.9	430	5.2	0.5	215	62	20
	Nov	7.68	108	36	222	48.8	480	5.3	0.6	240	56	22
	Dec	7.66	187	34	244	51.6	720	5.4	0.8	360	65	34
2007	Jan	7.68	197	34	231	103.5	740	5.3	0.8	370	122	26
	Feb	7.67	438	32	327	107.4	1,620	5.2	0.9	810	126	27
	Mar	7.81	695	36	411	125.2	2,480	5.1	1.1	1,240	128	38
	Apr	7.65	4,412	38	1,458	176.8	12,800	4.6	1.1	6,400	176	125
	May	7.61	8,148	36	2,745	188.4	29,400	4.4	1.1	14,700	210	148
	Jun	7.69	5,934	40	1,983	194	8,200	4.9	1	4,100	220	155
	Jul	7.74	438	32	312	126.8	1,250	5.1	0.8	625	180	56
	Aug	7.73	45	32	142	78.8	280	5.4	0.6	140	78	52
	Sep	7.87	69	32	119	71.8	310	5.5	0.6	155	79	26
	Oct	7.79	8	34	178	77.6	480	5.1	0.8	240	108	24
	Nov	7.78	88	34	241	98.4	750	5.2	0.7	375	118	33
	Dec	7.81	196	32	243	101.7	770	5.4	0.8	385	120	26
2008	Jan	7.78	214	34	272	50.5	668	6.2	0.8	334	65	20
	Feb	7.81	383	32	308	54.6	1,240	6.4	0.8	620	68	32
	Mar	7.67	2,312	36	811	78.8	1,760	5.1	1.1	880	98	45
	Apr	7.83	5,329	38	1,759	142.4	14,800	4.8	1.2	7,400	188	76
	May	7.79	7,915	36	2,646	155.6	28,800	4.7	1.1	14,400	190	180
	Jun	7.76	8,460	40	2,734	155	17,200	4.8	0.9	8,600	190	188
	Jul	7.73	2,087	32	713	128.3	9,200	5.1	0.8	4,600	116	78
	Aug	7.69	55	32	141	78.1	280	5.5	0.6	140	78	36
	Sep	7.71	39	32	129	71.3	340	5.6	0.8	170	88	44
	Oct	7.78	45	34	189	76.9	400	5.1	0.4	200	78	36
	Nov	7.77	106	34	221	55.8	450	5.2	0.5	225	76	24
	Dec	7.78	165	32	234	48.8	620	5.4	0.8	310	55	22
2009	Jan	7.65	216	36	234	50.8	628	5.7	0.6	314	63	24
	Feb	7.71	577	34	279	55.9	1,840	5.6	0.8	920	68	24
	Mar	7.68	2,856	34	952	68.8	1,760	5.5	0.9	880	76	78
	Apr	7.48	6,265	36	2,089	175.4	14,800	4.8	1.1	7,400	187	155
	May	7.58	7,915	34	2,710	185.9	28,800	4.8	1.1	14,400	201	215
	Jun	7.61	9,613	36	3,245	188.8	17,200	4.8	0.9	8,600	211	77
	Jul	7.76	3,627	30	1,210	127.3	560	5.1	0.8	280	109	24
	Aug	7.71	1,265	34	578	77.6	280	5.2	0.6	140	78	35
	Sep	7.71	138	36	210	77.2	340	5.1	0.8	170	101	24
	Oct	7.74	38	34	157	78	310	5.6	0.6	155	90	24
	Nov	7.66	54	38		72	320	5.5	0.6	160	50	20
	Dec	7.66	54	38		72	320	5.5	0.6	160	50	20

Table 5.4.4 Water Quality Data: Rupsha River at Rupsha Ghat for 2005 - 2009 done by DOE

Water Quality Item		pH	Chloride	T Alkalinity	Hardness	Turbidity	EC	DO	BOD	TDS	SS	COD
Unit		-	mg/L	mg/L	mg/L	NTU	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L
Standard		6.5-8.5	600	-	200-500	10	`-	6	0.2	1000	10	4
2005	Jan	7.68	274	34	271	70.8	880	6.2	0.6	440	78	
	Feb	7.65	328	32	311	78.8	1,050	5.6	0.8	525	82	
	Mar	7.61	2,527	34	789.8	168.6	10,200	5.2	0.7	5,100	210	
	Apr	7.56	2,692	36	891	198.7	11,000	5.1	1	5,500	260	
	May	7.51	4,780	38	1587	188.2	18,800	4.8	1	9,400	220	
	Jun	7.53	2,582	36	832	186.5	10,300	4.8	0.9	5,150	223	
	Jul	7.69	272	36	256	82.8	1,110	5.1	0.8	555	106	
	Aug	7.71	24	32	123	80.8	280	5.5	0.4	140	90	
	Sep	7.73	23	30	112	78.8	310	5.4	0.6	155	88	
	Oct	7.69	97	34	198	68.5	360	5.4	0.7	180	76	
	Nov	7.68	134	32	211	68.8	370	5.6	0.5	185	87	
	Dec	7.69	168	30	298	70	610	5.6	0.8	305	98	
2006	Jan	7.69	281	34	271	70.8	890	6	0.6	445	78	26
	Feb	7.67	388	32	311	78.8	1,150	5.4	0.8	575	82	38
	Mar	7.68	2,568	34	789.8	168.6	10,800	5.3	0.7	5,400	210	69
	Apr	7.66	2,992	36	891	198.7	11,800	5.4	1	5,900	260	120
	May	7.58	4,780	38	1587	188.2	16,800	4.8	1	8,400	220	145
	Jun	7.66	2,982	36	832	186.5	10,800	4.8	0.9	5,400	223	65
	Jul	7.72	272	36	256	82.8	1,010	5.1	0.8	505	106	46
	Aug	7.69	24	32	123	80.8	280	5.5	0.4	140	90	26
	Sep	7.77	56	30	112	78.8	310	5.6	0.6	155	88	20
	Oct	7.76	97	34	198	68.5	360	5.6	0.7	180	76	24
	Nov	7.71	134	32	211	68.8	370	5.5	0.5	185	87	20
	Dec	7.68	168	30	298	70	670	5.8	0.8	335	98	22
2007	Jan	7.62	329	34	311.5	85.8	1,150	5.3	0.8	575	98	34
	Feb	7.56	823	32	456.8	109.6	2,420	5.2	0.9	1,210	122	46
	Mar	7.64	2,121	36	753.3	143.5	7,840	5.1	1.1	3,920	168	118
	Apr	7.69	5,943	34	2011	148.9	21,000	4.8	1.1	10,500	176	122
	May	7.63	8,351	36	2823	188	28,200	4.8	1.1	14,100	211	165
	Jun	7.59	6,643	34	2245	189	24,200	4.8	1	12,100	200	103
	Jul	7.58	217	36	276.8	79.9	790	5.1	0.8	395	90	56
	Aug	7.66	46	38	145	78.9	340	5.4	0.6	170	88	34
	Sep	7.75	57	32	167	82.8	310	5.5	0.6	155	98	24
	Oct	7.74	58	32	178.6	68.9	320	5.2	0.8	160	82	23
	Nov	7.68	156	30	208.8	70.3	510	5.1	0.7	255	85	34
	Dec	7.76	168	34	278.3	71.4	620	5.6	0.8	310	88	56
2008	Jan	7.78	278	34	298	80.9	840	5.6	0.8	420	102	45
	Feb	7.91	1,040	32	489	88.4	4,100	5.1	0.9	2,050	116	58
	Mar	7.88	2,311	36	789	106.8	9,100	4.8	1.1	4,550	128	68
	Apr	7.66	6,758	34	2312	175.7	18,800	4.8	1.1	9,400	196	122
	May	7.67	7,912	38	2776	203	25,400	4.8	1.2	12,700	211	188
	Jun	7.78	8,463	34	2867	212	29,100	4.7	1.2	14,550	260	178
	Jul	7.67	2,637	36	876	178.8	9,480	4.7	0.8	4,740	210	45
	Aug	7.62	75	30	167.8	78.6	280	4.9	0.6	140	88	48
	Sep	7.73	57	32	124.6	72.6	310	4.9	0.6	155	88	23
	Oct	7.68	55	34	136	68.8	480	5.1	0.8	240	72	22
	Nov	7.77	219	34	225	72.8	750	5	0.7	375	78	20
	Dec	7.69	247	34	276	70.8	770	5.2	0.8	385	78	26
2009	Jan	7.72	247	34	298	82.8	628	5.1	0.6	314	105	37
	Feb	7.71	1,510	32	489	120.8	5,840	4.7	1.2	2,920	138	41
	Mar	7.68	3,846	36	789	136.8	11,400	4.8	1.1	5,700	178	122
	Apr	7.35	6,713	34	2312	178	18,800	4.6	1.2	9,400	187	165
	May	7.36	10,779	38	2776	188	28,800	4.6	1.3	14,400	201	220
	Jun	7.35	11,273	34	2867	212	32,400	4.8	1	16,200	211	230
	Jul	7.51	4,653	36	1524	178.8	18,400	4.9	0.8	9,200	200	170
	Aug	7.55	1,113	30	167.8	118.8	4,100	4.9	0.9	2,050	78	110
	Sep	7.78	174	32	184.6	78.6	560	5.1	0.8	280	101	34
	Oct	7.71	39	34	124	74.8	310	5	0.6	155	90	24
	Nov	7.67	59	38		78	380	5.3	0.6	190	50	20
	Dec	7.67	59	38		78	380	5.3	0.6	190	50	20

Table 5.4.5 Water Quality Data: Rupsha River at Lobonchora for 2005 - 2009 done by DOE

Water Quality Item		pH	Chloride	T Alkalinity	Hardness	Turbidity	EC	DO	BOD	TDS	SS	COD
Unit		-	mg/L	mg/L	mg/L	NTU	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L
Standard		6.5-8.5	600	-	200-500	10	`-	6	0.2	1000	10	4
2005	Jan	7.68	274	34	271	70.8	880	6.2	0.6	440	78	
	Feb	7.65	328	32	311	78.8	1,050	5.6	0.8	525	82	
	Mar	7.61	2,527	34	789.8	168.6	10,200	5.2	0.7	5,100	210	
	Apr	7.56	2,692	36	891	198.7	11,000	5.1	1	5,500	260	
	May	7.51	4,780	38	1587	188.2	18,800	4.8	1	9,400	220	
	Jun	7.53	2,582	36	832	186.5	10,300	4.8	0.9	5,150	223	
	Jul	7.69	272	36	256	82.8	1,110	5.1	0.8	555	106	
	Aug	7.71	24	32	123	80.8	280	5.5	0.4	140	90	
	Sep	7.73	23	30	112	78.8	310	5.4	0.6	155	88	
	Oct	7.69	97	34	198	68.5	360	5.4	0.7	180	76	
	Nov	7.68	134	32	211	68.8	370	5.6	0.5	185	87	
	Dec	7.69	168	30	298	70	610	5.6	0.8	305	98	
2006	Jan	7.69	281	36	278	70.8	890	5.8	0.9	445	78	24
	Feb	7.67	388	34	311	78.8	1,150	5.4	0.8	575	82	34
	Mar	7.68	2,568	32	823	168.6	10,800	5.1	1	5,400	210	42
	Apr	7.66	2,992	36	994	198.7	11,800	5	1	5,900	260	122
	May	7.58	4,780	38	1560	188.2	16,800	4.8	1	8,400	220	67
	Jun	7.66	2,982	36	998	186.5	10,800	4.8	0.9	5,400	223	45
	Jul	7.72	272	36	211	82.8	1,010	5.1	0.8	505	106	44
	Aug	7.69	24	32	123	80.8	280	5.2	0.4	140	90	34
	Sep	7.77	56	34	156	78.8	310	5.3	0.6	155	88	36
	Oct	7.76	97	34	167	68.5	360	5.4	0.7	180	76	32
	Nov	7.71	134	36	201	68.8	370	5.4	0.5	185	87	22
	Dec	7.68	168	32	221	70	670	5.6	0.8	335	98	22
2007	Jan	7.68	349	34	311.5	87.9	1,190	5.3	0.8	595	102	36
	Feb	7.56	873	32	456.8	89.7	2,230	5.2	0.9	1,115	113	46
	Mar	7.64	2,321	36	753.3	116.8	9,100	5.1	1.1	4,550	128	67
	Apr	7.72	5,993	34	2011	148.9	22,300	4.8	1.1	11,150	176	122
	May	7.68	8,551	36	2823	187	28,200	4.8	1.1	14,100	211	211
	Jun	7.71	6,843	34	2245	145	24,700	4.9	1	12,350	168	166
	Jul	7.53	247	36	276.8	78.7	980	5.1	0.8	490	88	56
	Aug	7.68	46	38	145	78.9	310	5.4	0.6	155	98	38
	Sep	7.65	57	32	167	77.7	320	5.5	0.6	160	89	22
	Oct	7.76	73	32	178.6	58.9	380	5.1	0.8	190	67	24
	Nov	7.65	116	30	208.8	68.9	420	5.2	0.7	210	86	22
	Dec	7.63	298	34	278.3	72.9	780	5.4	0.8	390	88	22
2008	Jan	7.71	298	34	298	88.8	940	5.3	0.8	470	102	32
	Feb	7.81	1,080	34	489	105.5	3,400	5.2	0.9	1,700	126	34
	Mar	7.84	2,341	36	789	136.8	9,400	5.1	1.1	4,700	188	68
	Apr	7.67	6,821	34	2312	175.7	19,200	4.8	1.1	9,600	200	132
	May	7.77	7,990	38	2776	183	30,400	4.7	1.1	15,200	210	161
	Jun	7.73	8,479	34	2867	188.2	8,900	4.8	1	4,450	220	186
	Jul	7.64	2,637	36	876	108.8	1,250	5	0.8	625	140	165
	Aug	7.62	75	30	167.8	79.8	380	5.2	0.6	190	106	56
	Sep	7.73	57	34	124.6	78.9	310	5.2	0.6	155	109	23
	Oct	7.68	75	34	136	78.6	480	5.1	0.8	240	108	24
	Nov	7.74	229	34	225	68.8	850	5.1	0.7	425	88	27
	Dec	7.65	277	34	276	56.8	970	5.3	0.8	485	66	26
2009	Jan	7.6	247	34	298	80.8	628	5.1	1	314	125	56
	Feb	7.71	1,610	32	489	105.2	1,240	4.9	1.1	620	138	66
	Mar	7.65	3,946	36	789	180	1,760	4.9	1.1	880	260	122
	Apr	7.51	8,950	34	2312	188	14,800	4.7	1.1	7,400	210	180
	May	7.65	11,473	34	2867	198	17,200	4.8	0.9	8,600	211	230
	Jun	7.58	5,639	36	876	156.8	560	4.9	0.8	280	109	126
	Jul	7.68	1,153	30	167	145.8	280	5.1	0.6	140	78	68
	Aug	7.75	194	32	184.6	112.6	340	5.1	0.8	170	101	34
	Sep	7.67	57	36	124.6	78.8	310	5.3	0.6	155	90	24
	Oct	7.71	39	34	124	74.8	310	5	0.6	155	90	24
	Nov	7.67	58	38		79.0	340	5.1	0.8	170	50	24
	Dec	7.67	58	38		79.0	340	5.1	0.8	170	50	24

Table 5.4.6 Water Quality Data: Modhumati River at Mollarhat for 2005 - 2009 done by DOE

Water Quality Item		pH	Chloride	T Alkalinity	Hardness	Turbidity	EC	DO	BOD	TDS	SS	COD
Unit		-	mg/L	mg/L	mg/L	NTU	μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L
Standard		0	6.5-8.5	600	-	200-500	10	`-	6	0.2	1000	10
2005	Jan	7.51	12	36		32.8	300	5.4	0.6	150	25	25
	Feb	7.41	16	32		32.3	320	5.5	0.7	155	25	20
	Mar	7.41	121	36		45.8	740	5.3	0.8	360	30	25
	Apr	7.61	226	36		52.8	1030	5.2	0.8	520	50	40
	May	7.61	251	34		56.8	1370	5.2	0.9	650	50	45
	Jun	7.71	110	34		52.8	530	5.3	0.8	260	40	32
	Jul	7.41	7	30		22.8	280	5.1	0.8	135	15	25
	Aug	7.56	7	36		32.8	275	5.2	0.8	112	25	25
	Sep											
	Oct	7.65	7	36		62.8	265	5.2	0.8	135	41	42
	Nov	7.81	13	36		32.8	280	5.3	0.7	140	20	20
	Dec	7.69	24	36		42.8	320	5.4	0.8	160	20	30
2006	Jan	7.41	25	36		42.8	360	5.6	0.6	180	20	25
	Feb	7.51	60	36		52.8	570	5.4	0.6	285	25	30
	Mar	7.71	219	36		57.8	1070	5.3	0.6	535	65	25
	Apr	7.81	313	36		52.8	1490	5.3	0.9	740	40	35
	May	7.67	381	32		57.8	1590	5.3	0.8	790	40	55
	Jun	7.71	413	36		62.8	1720	5.2	0.9	845	55	55
	Jul	7.73	241	46		62.8	880	5.3	0.8	440	60	58
	Aug	7.71	152	36		62.8	680	5.3	0.8	340	60	26
	Sep	7.68	12	36		42.8	360	5.2	0.9	180	30	25
	Oct	7.71	9	36		52.8	300	5.3	0.6	145	30	25
	Nov	7.65	6	36		42.8	290	5.5	0.8	140	30	25
	Dec	7.56	14	36		32.8	320	5.5	0.7	165	25	21
2007	Jan	7.61	109	36		22.8	570	5.4	0.7	270	130	25
	Feb	7.61	179	36		22.8	740	5.3	0.8	370	30	25
	Mar	7.61	271	36		42.8	1380	5.1	0.8	690	30	45
	Apr	7.71	420	36		52.8	1750	5.2	0.9	850	70	55
	May	7.64	471	34		42.3	2140	5.3	0.9	1070	50	55
	Jun	7.68	490	36		41.8	2350	5.3	0.9	1175	35	55
	Jul	7.73	60	36		38.7	480	5.3	0.9	240	40	35
	Aug	7.51	24	36		58.9	370	5.4	0.8	190	50	25
	Sep	7.67	6	36		45.8	320	5.8	0.7	160	50	25
	Oct	7.49	8	36		43.7	310	5.4	0.8	150	50	28
	Nov	7.71	13	36		45.8	340	5.3	0.7	160	30	22
	Dec	7.68	24	36		52.8	540	5.3	0.7	270	50	24
2008	Jan	7.65	104	56		32.8	600	5.2	0.9	300	40	25
	Feb											
	Mar	7.64	319	36		32.8	1380	5.6	0.9	690	50	35
	Apr											
	May	7.63	519	36		42.8	2170	5.3	0.8	1085	55	55
	Jun											
	Jul	7.67	539	36		43.8	2450	5.4	0.8	1220	50	55
	Aug											
	Sep	7.68	14	36		43.8	480	5.4	0.9	240	40	28
	Oct											
	Nov											
	Dec	7.61	9	36		32.8	360	5.3	0.7	180	30	28
2009	Jan	7.64	75	34	188	36.5	320	6.2	0.6	160	48	24
	Feb	7.62	125	36	211	38.8	520	6.1	0.8	260	52	35
	Mar	7.61	225	38	234	56.8	950	5.3	0.8	475	68	35
	Apr	7.56	467	38	389	78.7	1,620	5.4	0.9	810	89	45
	May	7.56	894	38	397	80.8	3,280	5.3	1	1,640	93	45
	Jun	7.62	944	36	401	81.8	3,890	5.2	0.9	1,945	85	22
	Jul	7.69	125	36	208	78.8	520	5.6	0.8	260	85	20
	Aug	7.71	24	32	123	80.8	280	5.5	0.4	140	90	20
	Sep	7.73	23	30	112	78.8	310	5.4	0.6	155	88	20
	Oct	7.69	37	34	174	48.5	340	5.4	0.7	170	56	20
	Nov	7.76	13	36		20	260	5.6	0.6	130	26	20
	Dec	7.76	13	36		20	260	5.6	0.6	130	26	20

(2) "Water Resources Analysis in Khulna: JBIC/2007

JBIC conducted a water quality analysis in 2007 at the point as shown in **Figure 5.4.2**.

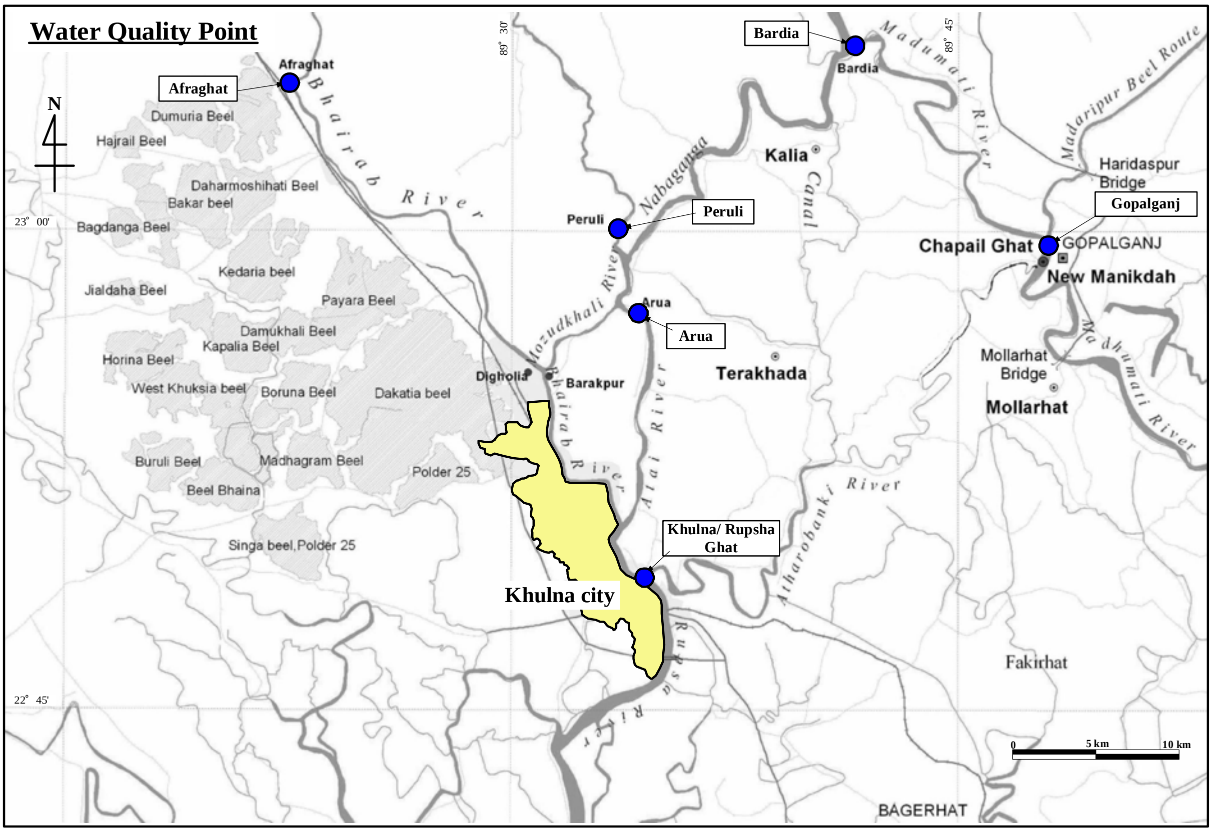


Figure 5.4.2 Locations of Water Quality Analysis by JBIC in 2007

Table 5.4.7 shows the results of water quality analysis conducted by JBIC.

Table 5.4.7 Water Quality Analysis done by JBIC in 2007

Laboratory test results of water samples collected from 6 sampling stations

SL	Date of Sampling	Tide condition	P^H	(Chloride) Cl^-	Turbidity	Ammonia (NH_3-N)	Ammonium (NH_4^+-N)	Nitrate (NO_3-N)	Nitrite (NO_2-N)	Sulfate (SO_4^{2-})	Phosphate (PO_4^{3-})	TDS	TSS	COD	BOD_5	Mercury (Hg)	Lead (Pb)	Chromium (Cr)
				mg/l	NTU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	mg/l	mg/l
Standard Allowable Value**			6.5-8.5	600	10	0.50		10	<1	400	6	1000	10	4	0.200	1.00	0.05	0.05
River: Rupsa. Station: Khulna																		
1	17/04/2007	HWL	7.70	6,875	305.0	0.02	0.74	0.70	0.0070	1,480	0.930	14,694	709	55	36	8.60	0.291	0.034
2	17/04/2007	LWL	7.75	6,500	600.0	0.01	0.42	0.60	0.0030	1,360	0.580	12,779	1,716	65	48	2.60	0.282	0.032
3	27/04/2007	HWL	7.70	7,700	93.0	0.01	0.19	0.90	0.0080	1,245	0.250	13,919	292	11	6	<0.1	0.242	0.013
4	27/04/2007	LWL	7.90	7,350	169.0	0.01	0.20	0.70	0.0100	1,223	0.250	14,041	519	12	8	0.40	0.246	0.016
5	25/05/2007	HWL	7.78	10,750	97.0	0.01	0.21	0.80	0.0100	1405	0.441	17,642	198	16	10	0.30	0.326	0.016
6	08/06/2007	HWL	7.91	9,150	184.0	0.01	0.18	1.10	0.0061	1423	0.367	17,928	216	21	16	1.60	0.354	0.019
River: Atai. Station: Arua																		
7	17/04/2007	HWL	7.80	5,650	650.0	0.01	0.31	0.80	0.0060	1,210	0.640	10,350	2,435	19	12	0.30	0.301	0.049
8	17/04/2007	LWL	7.91	4,500	525.0	0.01	0.18	0.70	0.0050	350	0.380	8,980	1,800	12	8	1.00	0.261	0.032
9	27/04/2007	HWL	7.90	6,200	270.0	0.01	0.26	0.50	0.0050	968	0.280	11,110	764	10	6	0.10	0.235	0.020
10	27/04/2007	LWL	8.00	5,250	183.0	0.01	0.21	0.90	0.0050	823	0.300	9,782	927	9	6	0.60	0.217	0.017
11	25/05/2007	HWL	7.95	7,450	190.0	0.00	0.06	1.00	0.0530	1128	0.345	13,663	420	25	16	0.40	0.279	0.011
12	08/06/2007	HWL	8.01	7,000	310.0	0.01	0.18	1.00	0.0041	1243	0.329	13,727	463	14	10	1.20	0.269	0.022
River: Chitra Station: Peruli																		
13	17/04/2007	HWL	7.91	5,150	500.0	0.02	0.40	0.80	0.0020	790	1.100	9,663	1,535	28	20	1.00	0.246	0.038
14	17/04/2007	LWL	7.97	4,100	310.0	0.02	0.45	0.70	0.0060	710	0.310	7,496	800	20	12	0.50	0.210	0.027
15	27/04/2007	HWL	7.90	5,250	155.0	0.01	0.20	0.60	0.0050	893	0.190	10,034	656	7	4	<0.10	0.258	0.015
16	27/04/2007	LWL	7.90	4,350	220.0	0.01	0.24	0.50	0.0060	765	0.270	7,628	632	4	2	<0.10	0.178	0.020
17	25/05/2007	HWL	7.37	10,600	104.0	0.01	0.25	1.00	0.0080	1158	0.201	13,410	380	28	20	0.30	0.240	0.008
18	08/06/2007	HWL	8.08	5,950	280.0	0.01	0.15	0.90	0.0038	1078	0.226	11,870	283	21	14	1.30	0.251	0.022
River: Nabaganga Station: Bardia																		
19	17/04/2007	HWL	8.10	2,925	94.0	0.05	0.69	0.70	0.0060	640	0.150	5,627	228	62	40	0.30	0.168	0.013
20	17/04/2007	LWL	8.10	2,000	131.0	0.04	0.65	0.50	0.0060	550	2.510	4,206	361	32	24	0.40	0.118	0.009
21	27/04/2007	HWL	8.30	3,200	74.0	0.02	0.16	0.60	0.0060	593	0.480	5,762	376	7	4	0.60	0.156	0.009
22	27/04/2007	LWL	8.30	2,900	56.0	0.02	0.20	0.40	0.0070	555	0.430	5,229	248	9	6	0.70	0.146	0.008
23	25/05/2007	HWL	8.17	6,200	51.0	0.01	0.14	0.60	0.0060	825	0.251	9,432	145	28	16	0.30	0.323	0.012
24	08/06/2007	HWL	8.34	3,900	44.0	0.02	0.14	0.70	0.0143	835	0.173	7,741	146	22	14	1.20	0.187	0.015
River: Bhairab Station: Afraghat																		
25	17/04/2007	HWL	7.80	2,900	320.0	0.02	0.57	1.40	0.0390	570	1.350	5,884	792	58	40	0.70	0.174	0.036
26	17/04/2007	LWL	7.73	2,125	190.0	0.01	0.49	1.30	0.0250	310	0.270	4,288	361	30	24	11.80	0.143	0.024
27	27/04/2007	HWL	8.00	2,575	123.0	0.01	0.15	0.90	0.0060	603	0.230	5,762	518	5	2	1.50	0.144	0.019
28	27/04/2007	LWL	7.90	2,550	98.0	0.01	0.17	0.60	0.0160	533	0.410	4,408	481	4	2	0.70	0.125	0.012
29	25/05/2007	HWL	7.88	6,400	73.5	0.01	0.17	1.00	0.0090	875	0.339	9,534	362	15	7	<0.10	0.257	0.013
30	08/06/2007	HWL	7.98	5,900	110.0	0.01	0.19	1.20	0.0098	1108	0.241	11,612	342	35	28	0.80	0.239	0.018
River: Modhumati Station: Gopalganj																		
31	25/05/2007	HWL	8.32	15	38.5	0.01	0.05	0.30	0.0020	19.4	0.231	122	45	16	11	<0.10	0.051	0.007
32	08/06/2007	HWL	8.15	7	83.5	0.01	0.18	0.50	0.0065	36.5	0.317	83	118	7	<1	1.00	0.131	0.010

Notes:
** Standard Allowable Values prescribed in the Environmental Quality Standard (EQS) for drinking water by the Government of Bangladesh in 1997.
mg/L: milligram per liter
TSS: Total Suspended Solid
TDS: Total Dissolved Solid
µg/l: Microgram per liter

(3) "Monitoring and Assessment of Water Quality and Salinity of Three Locations on the Modhumati River and MBR": KWASA/2009

KWASA conducted a water quality analysis in 2007 at the point as shown in **Figure 5.4.3**.

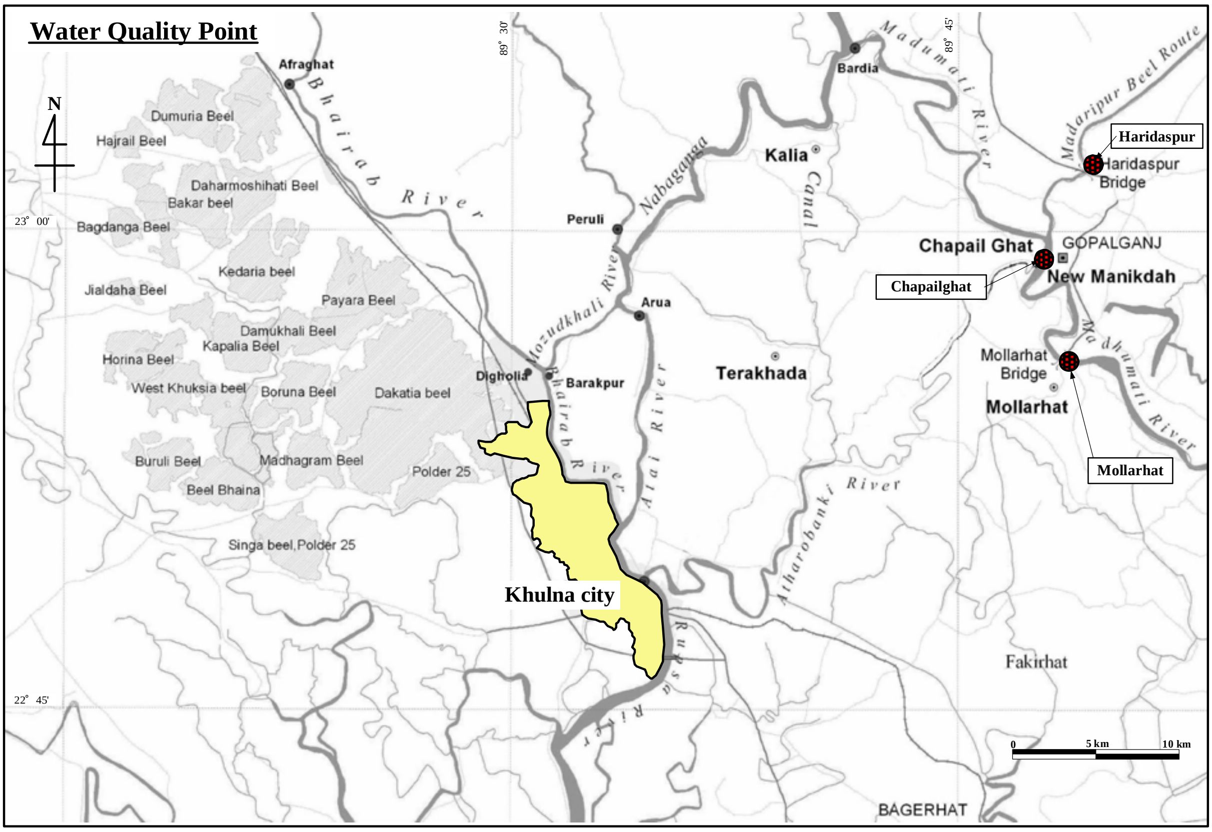


Figure 5.4.3 Locations of Water Quality Analysis by KWASA in 2009

Table 5.4.8 shows the results of water quality analysis conducted by KWASA.

Table 5.4.8 Water Quality Analysis done by KWASA in 2007

Parameter	Allowable Limit	Summary Test Results		
		Mollarhat Br	ChapaH Ghat	Haridaspur
BOD, mg/L	<.3	Max. 21.6 Mm. 1.0	Max.20.0 Mm. 1.0	Max.16.0 Min. 0.4
Coliform (total), NOS./100 mL	<5000	Not tested*		
DO, mg/L	>6	Max. 9.05 Min. 6.23	Max. 8.6 Min. 6.77	Max. 8.18 Min. 6.19
pH	6.5 - 8.5	Max. 7.75 Min. 6.86	Max. 8.51 Min. 6.67	Max. 8.03 Min. 6.52

(4) JICA Study Team Water Quality Analysis

JICA Study Team has conducted water quality analysis in 2010 at the point as shown in **Figure 5.4.4**.

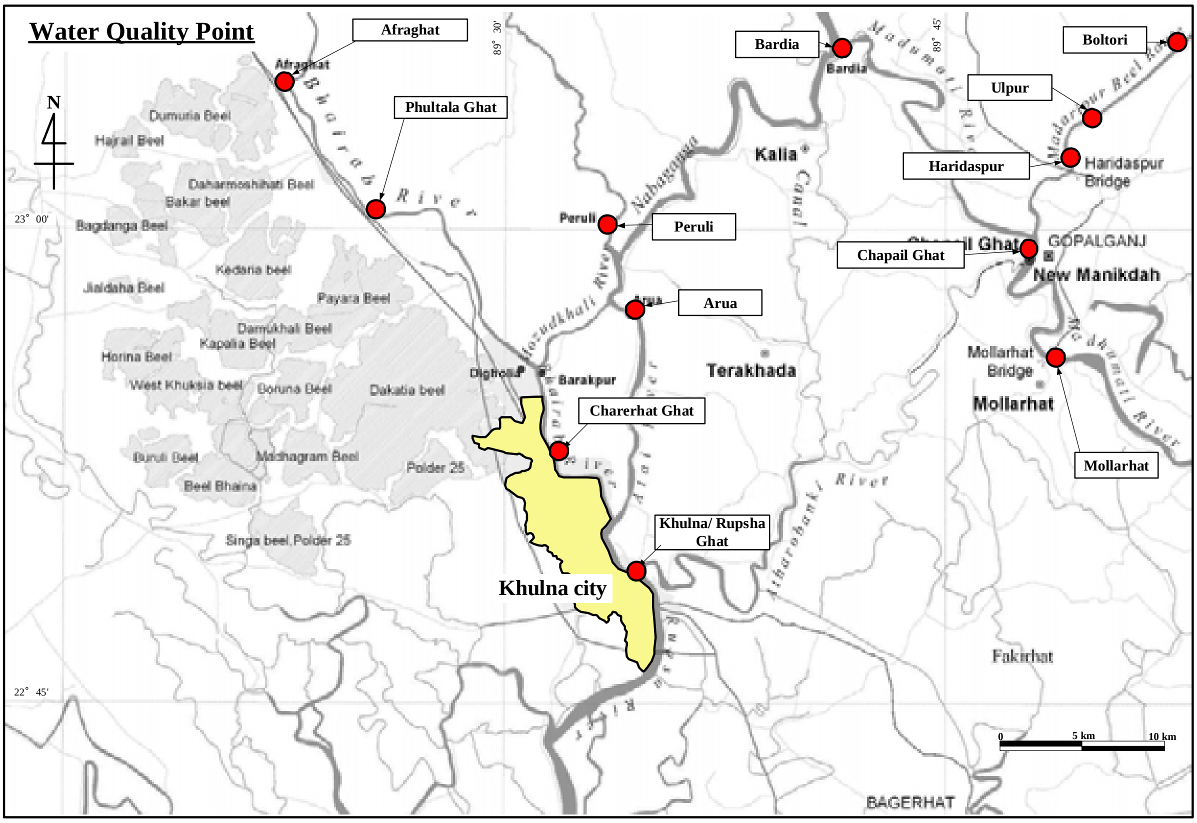


Figure 5.4.4 Locations of Water Quality Analysis by JICA Study Team 2009 - 2010

JICA Study Team conducted three times, in October 2009 at nine locations, in February 2010 at eleven locations and in March at three locations.

1) JICA Study Team Water Quality Analysis in October 2009

JICA Study Team conducted water quality analysis at nine locations in October 2009. The results of water quality analysis are as shown in the **Table 5.4.9**.

Chloride of all the samples are very low, and less than standard values, because the samples were taken in February. Harmful constituents such as Arsenic, Lead, Cadmium and Hexavalent Chromium are all less than the standard values, except Mercury. The samples were analysed by BUET.

JICA Study Team cross checked with the samples which had been taken at same location at same time at three laboratories inclusive one in Tokyo, Japan i.e. DPHE in Dahka, DPHE in Khulna, BUET and Kankyo Kannri Center, Tokyo. As to the Mercury all laboratories' result are under the standard level except the one of BUET. Therefore it can be assumed to be under the standard.

Table 5.4.9 Result of Water Quality Analysis done by JICA Study in October 2009

Locations / Parameters		Standard	Mollarhat	Chapailghat	Haridaspur	Khulna	Arua	Peruli	Bardia	Afraghat	Ulpur
Sampling Date.time	Unit		10/10. 2009	10/10. 2009	10/10. 2009	10/11. 2009	10/12. 2009	10/12. 2009	10/12. 2009	10/10. 2009	10/11. 2009
pH	-	6.5-8.5	7.6	7.5	7.3	7.8	7.9	7.9	8.1	7.6	8.01
Turbidity	NTU	10	72	87	101	270	207	85	152	55	240
TDS	mg/L	1,000	151	164	134	157	122	142	131	223	143
SS	mg/L	10	36	39	41	105	85	43	77	82	89
COD(Cr)	mg/L	4	5	7	14	<5	<5	<5	<5	21	8
BOD_5	mg/L	0.2	0.6	1.2	1.2	0.2	<0.2	<0.2	<0.2	3.6	2
Mercury (Hg)	mg/L	0.001	0.0028	0.002	<0.0005 *)	0.002	0.002	0.0015	0.0033	0.0038	0.002
Lead (Pb)	mg/L	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic (As)	mg/L	0.05	0.006	0.007	0.007	0.004	0.002	0.003	0.003	0.007	0.015
Hexavalent Chromium (Cr^{6+})	mg/L	0.05	(0.003)	(0.007)	(0.008)	(0.01)	(0.01)	(0.003)	(0.008)	(0.007)	(0.008)
Calcium (Ca^{2+})	mg/L	75	32	33	35	35	32	32	33	37	35
Copper (Cu)	mg/L	1	0.04	0.05	0.06	0.14	0.05	0.04	0.04	0.05	0.04
Zinc (Zn)	mg/L	5	0.08	0.06	0.14	0.17	0.05	0.05	0.05	0.07	0.06
Cadmium (Cd)	mg/L	0.005	0.001	<0.001	0.001	0.001	0.001	0.001	<0.001	<0.001	0.001
Chloride (Cl^-)	mg/L	600	10	12	10	19	9	11	7	30	9
Sulfate (SO_4^{2-})	mg/L	400	<7	<7	9.4	11	15	14	14	<7	12
Phosphate (PO_4^{3-})	mg/L	6	0.15	0.15	0.19	0.43	0.26	0.18	0.30	0.29	0.32
Nitrate (NO_3^-)	mg/L	10	1.8	1.8	1.8	2.2	1.8	2.2	2.2	1.3	2.2
Nitrite (NO_2^-)	mg/L	<1	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.10	<0.03
Ammonia (NH_4^+)	mg/L	0.5	0.17	0.36	0.38	0.05	0.27	0.36	0.03	0.18	0.20
Iron (Fe)	mg/L	0.3-1.0	0.77	0.67	1.1	3.2	1.5	0.75	2.6	0.86	2.5
Manganese (Mn)	mg/L	0.1	0.05	0.05	0.07	0.16	0.11	0.03	0.06	0.05	0.15
Dissolved Oxygen (DO)	mg/L	6	5.8	6.3	6.0	7.4	6.6	7.0	7.2	5.3	6.3

Note: Mercury at Haridaspur shows the data analysed at Laboratory in Tokyo. The other data is analysed by BUET.
Chromium data shows ( ) as Total Cr.

2) JICA Study Team Water Quality Analysis in February 2010

JICA Study Team conducted water quality analysis at nine locations in February 2010. The results of water quality analysis are as shown in the **Table 5.4.10**.

The sample with Turbidity of over 50 NTU shows high Iron concentration, ranging from 1.46-9.38 mg/L. Because the samples were taken in dry season, Chloride of Khulna and Phultala are high and higher than the standard, and the others are less than standard. Arua and Peruli are close to the standard; however those are still under the limitations. Harmful constituents such as Arsenic, Lead, Cadmium and Mercury are all less than the standard value. Hexavalent Chromium concentration of three locations, Khulna and Bardica and Afraghat are less than the standard values, however, the other locations are higher than the standard.

At three expected ware intake point (Mollarhat, Phultala and Khulna), water quality in term of Chloride, Zinc, Iron, Manganese, Copper, Arsenic, Turbidity, SS, COD and BOD is good , while water quality in terms of SS and Turbidity shall be take care of.

Table 5.4.10 Result of Water Quality Analysis done by JICA Study in February 2010

Sample ID		Bangladesh Standared	Khulna	Arua	Peruli	Bardica	Afraghat	Mollarhat	Chapailgh	Haridaspu	Ulpur	Boltori	Phultola
			21/2/10	20/2/10	20/2/10	23/2/10	20/2/10	22/2/10	22/2/10	21/2/10	21/2/10	21/2/10	21/2/10
pH		6.5-7.5	7.2	7.8	7.8	8.8	7.7	8.6	8.7	8.3	8.4	8.4	7.6
Turbidity	NTU	10	105	69	88	51	57	16	25	7	4	3	90
TDS	mg/L	1000	978	290	254	210	243	198	186	145	156	162	752
SS	mg/L	10	30	9	16	11	6	5	11	8	7	3	15
COD(Cr)	mg/L	4	65	26	30	41	36	29	42	34	19	15	55
BOD_5	mg/L	0.2	15	4	4.8	6.5	5.4	3.5	4.6	4.7	2.5	2.7	12
Mercury(Hg)	mg/L	0.001	0	0	0	0	0	0	0	0	0	0	0
Lead(Pb)	mg/L	0.05	0	0	0	0	0	0	0	0	0	0	0
Arsenic(As)	µg/L	50	2.96	2.75	2.9	1.8	2.8	1.86	1.95	3.24	3.08	2.86	3.74
Cr^{6+}	mg/L	0.05	0.04	0.05	0.05	0.04	0.02	0.07	0.06	0.07	0.05	0.05	0.06
Calcium(Ca)	mg/L	75	87	31	16	15	9	18	9	9	15	8	85
Copper(Cu)	mg/L	1	0.07	0.04	0.07	0.05	0.04	0.04	0.03	0.04	0.05	0.05	0.05
Zinc(Zn)	mg/L	5	0.48	0.44	0.27	0.18	0.12	0.12	0.22	0.18	0.07	0.18	0.25
Cadmium(Cd)	mg/L	0.005	0	0	0	0	0	0	0	0	0	0	0
Chloride(Cl^-)	mg/L	1000	1706	598	452	147	248	79	67	34	22	22	802
Sulfate(SO_4)	mg/L	400	18	24	10	13	15	11	14	16	9	10	13
Phosphate (PO_4^{3-})	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitrate(NO_3)	mg/L	10	5.23	3.89	4.53	6.35	2.45	3.55	5.85	2.45	3.56	4.25	3.54
Nitrite(NO_2)	mg/L	<1	0.009	0.005	0.008	0.007	0.006	0.008	0.009	0.007	0.005	0.005	0.008
Ammonia(NH_4)	mg/L	0.5	0.23	0.15	0.45	0.34	0.3	0.3	0.45	0.42	0.44	0.34	0.22
Iron(Fe)	mg/L	0.3-1.0	7.38	4.82	7.4	1.46	4.4	0.42	0.52	0.38	0.05	0.02	9.38
Manganese(Mn)	mg/L	0.1	0.11	0.04	0.09	0.04	0.04	0	0	0	0.03	0.03	0.1
Dissoluved Oxygen(DO)	mg/L	6	8.60	2.30	2.00	4.00	1.70	3.90	8.70	5.30	5.40	9.40	8.60

3) JICA Study Team Water Quality Analysis in March 2010

JICA Study Team conducted water quality analysis at three locations in March 2010. The results of water quality analysis are as shown in the **Table 5.4.11**.

Table 5.4.11 Result of Water Quality Analysis done by JICA Study in March 2010

Parameters / Locations		Standard	Mollarhat		Phultola		Khulna	
	Unit		15/03	28/3	15/03	28/3	15/03	28/3
pH	-	6.5-8.5	7.6	8.1	8.5	6.9	6.8	7.7
Turbidity	NTU	10	8	14	110	180	135	195
TDS	mg/L	1,000	726	880	4,180	7,150	5,472	10,725
SS	mg/L	10	9	15	16	24	30	35
COD(Cr)	mg/L	4	25	35	104	123	95	138
BOD_5	mg/L	0.2	6.2	8.9	16	29	14	23
Mercury (Hg)	mg/L	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Lead (Pb)	mg/L	0.05	0	0	0	0	0	0
Arsenic (As)	mg/L	0.05	0.001	0.001	0.004	0.003	0.004	0.002
Cr^{6+}	mg/L	0.05	0.01	0.03	0.03	0.02	0.06	0.05
Calcium (Ca^{2+})	mg/L	75	78	29	48	329	379	388
Copper (Cu)	mg/L	1	0.07	0.02	0.03	0.05	0.09	0.06
Zinc (Zn)	mg/L	5	<0.05	<0.05	<0.05	0.06	0.4	0.1
Cadmium (Cd)	mg/L	0.005	0	0	o	0	0	0
Chloride (Cl^-)	mg/L	600	373	554	2,568	7,150	3,842	5,650
Sulfate (SO_4^{2-})	mg/L	400	18	23	15	19	24	29
Phosphate (PO_4^{3-})	mg/L	6	0	0	0	0	0	0
Nitrate (NO_3^-)	mg/L	10	5.9	5.4	6.4	3.3	5.2	4.0
Nitrite (NO_2^-)	mg/L	<1	0.007	0.012	0.009	0.01	0.008	0.006
Ammonia ($NH3^+$)	mg/L	0.5	0.2	0.4	0.2	0.5	0.7	0.5
Iron (Fe)	mg/L	0.3-1.0	0.3	0.3	11	12	16	15
Manganese (Mn)	mg/L	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
DO	mg/L	6	3.4	3.6	3.4	3.7	4.2	3.3

Heavy metals at three locations are all under the Standard.

In terms of Turbidity, COD and BOD it is clear that Mollarhat is better than Phultala and Khulna. Mollarhat is also better than other two in terms of Arsenic, Zinc and Manganese.
The better water quality is required to produce good water. Bad water quality (higher Turbidity, COD and BOD) causes higher chlorine and coagulant dose, higher running cost.
Good water quality also helps prevent from algal proliferation that causes becoming bad water quality during impoundment. Therefore it is very important to withdraw water from Mollarhat rather than from other locations, Phultala and Khulna.

(3) Treatment Implication for Raw Water Quality

According to the above-mentioned results of water quality analysis, Turbidity, BOD, COD, TSS, etc. are characteristically high, and Fe and Mn are partially detected at same investigation points.
These high valued parameters are not good for water source; however, the normal purification process such as "Coagulation-sedimentation + Rapid Sand Filter + Chlorination and Pre-chlorination by Breakpoint Dosing Method" will be able to purify the river water, because the most of COD and BOD seem to come from particulate substances in the water (TSS concentration is relatively high except Madhumati River).
Selection of the most suitable purification method is decided considering from the total point of view such as countermeasure of salinity.

5.4.2 Salinity Intrusion

(1) DOE Salinity Monitoring Result

The results of saline water intrusion survey conducted by DOE are as shown in the **Table 5.4.12**. **Figure 5.4.5** shows clearly the salinity intrusion gradually increasing into the river water surrounding Khulna City.

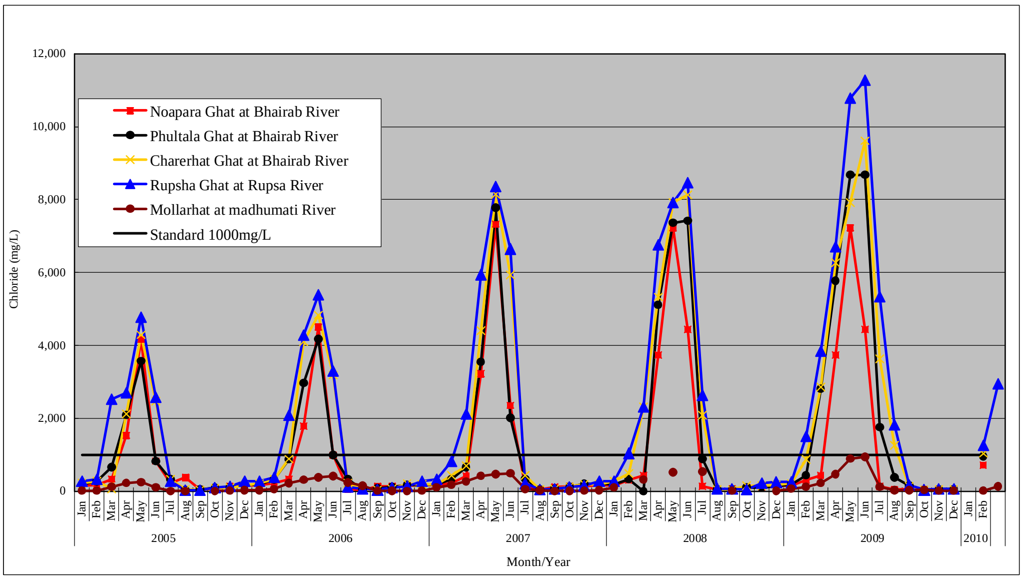


Figure 5.4.5 Monthly Chloride Data from 2005 to 2010

Table 5.4.12 Chloride Monitoring Data from 2005 to 2010 done by DOE

River		Bhairab River			Rupsa River	Madhumati River
Site:		Noapara Ghat	Phultala Ghat	Charerhat Ghat	Rupsha Ghat	Mollarhat
2005	Jan	155	192	219	275	12
	Feb	165	275	275	329	16
	Mar	332	659	67	2,527	121
	Apr	1,538	2,088	2,122	2,692	226
	May	4,166	3,571	4,286	4,780	251
	Jun	828	824	2,473	2,583	110
	Jul	220	330	326	272	7
	Aug	378	36	44	24	7
	Sep	46	56	37	23	
	Oct	76	103	87	97	7
	Nov	132	110	99	135	13
	Dec	151	175	154	269	24
2006	Jan	175	192	215	273	25
	Feb	220	330	326	386	60
	Mar	334	879	882	2,088	219
	Apr	1,784	2,967	4,112	4,278	313
	May	4,505	4,175	4,831	5,385	381
	Jun	989	989	3,184	3,298	413
	Jul	57	331	221	124	241
	Aug	37	43	46	59	152
	Sep	136	87	39	38	12
	Oct	133	115	75	99	9
	Nov	152	168	209	136	6
	Dec	175	175	187	269	14
2007	Jan	165	188	198	329	109
	Feb	228	327	439	824	179
	Mar	423	661	695	2,122	271
	Apr	3,225	3,549	4,412	5,943	420
	May	7,326	7,776	8,148	8,352	471
	Jun	2,353	2,011	5,934	6,644	490
	Jul	136	337	439	218	60
	Aug	37	49	45	46	24
	Sep	120	76	69	57	6
	Oct	136	125	129	124	8
	Nov	142	207	188	157	13
	Dec	165	210	196	269	24
2008	Jan	156	198	275	279	104
	Feb	312	331	484	1,040	
	Mar	442	23.7.6	2,313	2,311	319
	Apr	3,737	5,110	5,330	6,759	
	May	7,227	7,363	7,915	7,912	519
	Jun	4,440	7,418	8,132	8,463	
	Jul	131	882	2,087	2,638	539
	Aug	41	55	55	75	
	Sep	66	54	39	57	14
	Oct	110	108	145	55	
	Nov	120	108	156	220	
	Dec	154	133	165	248	9
2009	Jan	156	192	217	248	75
	Feb	312	439	878	1,510	125
	Mar	442	2,812	2,856	3,846	225
	Apr	3,737	5,769	6,266	6,714	467
	May	7,227	8,681	7,915	10,779	894
	Jun	4,440	8,677	9,613	11,274	944
	Jul	131	1,758	3,627	5,340	125
	Aug	41	385	1,265	1,813	24
	Sep	66	159	139	175	23
	Oct	55	36	38	39	37
	Nov	46	58	54	59	13
	Dec	46	58	54	59	13
2010	Jan					
	Feb	718	956	1,040	1,268	13
	Mar	2,013	2,258	5,880	2,945	133

: Over 1000 mg/L

(2) JBIC Salinity Monitoring Result in 2007

The results of saline water intrusion survey conducted by JBIC in 2007 are as shown in the following table.

Table 5.4.13 Chloride Monitoring Data done by JBIC in 2007

Date	Khulna		Arua		Peruli		Bardia		Afraghat		Gopalganj	
	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
3-Apr-07	5,359	5,222	-	-	3,492	55	-	-	2,513	2,222	-	-
7-Apr-07	5,316	5,269	4,102	3,547	3,248	2,991	-	-	2,479	2,179	-	-
10-Apr-07	5,538	5,261	4,038	3,432	3,333	2,988	1,581	1,624	2,530	2,158	-	-
14-Apr-07	-	5,521	-	3,573	-	2,972	1,709	1,624	3,141	2,487	-	-
17-Apr-07	6,081	5,538	4,085	-	3,162	3,162	2,863	2,179	3,141	2,500	-	-
21-Apr-07	6,466	6,068	4,649	4,026	4,273	3,896	3,205	2,906	3,162	2,568	-	-
24-Apr-07	-	6,107	-	4,085	-	3,718	2,906	2,906	3,145	2,594	-	-
28-Apr-07	6,581	6,453	4,743	-	4,007	3,761	2,778	2,692	3,145	2,581	-	-
1-May-07	6,795	6,196	5,598	5,470	4,178	3,962	3,034	2,820	2,564	3,248	-	-
5-May-07	7,094	6,496	5,726	5,000	4,701	4,134	3,461	3,205	3,077	2,778	-	-
8-May-07	7,008	6,624	5,897	5,256	5,128	4,743	3,547	3,162	3,419	2,991	-	-
12-May-07	7,179	7,137	5,299	5,769	5,299	4,615	3,547	3,376	3,632	3,077	43	-
15-May-07	7,649	7,393	6,709	5,598	5,342	4,671	4,444	3,718	4,188	3,974	342	-
19-May-07	8,333	8,162	6,966	6,325	5,555	5,684	4,957	4,658	5,128	4,530	427	385
22-May-07	7,948	7,692	6,666	6,196	6,581	4,658	4,701	4,316	5,000	4,444	171	299
26-May-07	8,034	7,820	6,367	5,897	6,325	3,504	4,359	3,974	4,530	3,889	43	43
29-May-07	7,582	7,250	-	-	5,983	3,553	4,102	3,761	4,743	3,761	43	43
2-Jun-07	7,637	7,139	6,666	5,598	5,769	3,442	4,487	4,145	4,593	3,874	43	43
5-Jun-07	7,360	6,807	6,325	5,555	4,317	2,988	4,316	3,846	4,649	4,317	43	43
9-Jun-07	7,194	1,826	5,897	5,256	4,333	2,761	3,846	3,590	4,593	4,151	43	43
12-Jun-07	6,862	1,826	4,649	4,040	4,040	1,599	2,933	2,656	4,649	3,652	44	44
16-Jun-07	4,759	277	3,486	2,601	3,752	1,682	2,048	2,048	1,162	775	33	44
19-Jun-07	4,649	221	2,048	1,826	1,926	111	885	332	221	111	44	50
23-Jun-07	1,439	166	166	111	1,550	55	111	55	166	111	50	50
26-Jun-07	55	55	55	55	55	55	55	55	166	166	55	50
30-Jun-07	55	55	55	55	55	55	55	55	-	221	44	44

Note: The figures show Chloride calculated from measured salinity; however, the conversion formula used is Cl^- = Salinity x 0.55. This formula generally used for sea water. It is not appropriate to be used in case of river water..

The results of JBIC survey are:

- At survey points of Khulna, Arua, Prruli, Bardia, Afraghat, Chloride is exceeding the standard value continuously up to the middle of June
- In Gopalganji, all the data show Chloride lower than the Bangladesh standards value of 1,000 mg/L.

(3) KWASA Salinity Monitoring Result in 2009

The results of saline water intrusion survey conducted by KWASA in 2009 are as shown in **Table 5.4.14**.

The results of this survey indicate the followings (The figures show Chloride calculated from measured salinity; however, the conversion formula used is Cl^- = Salinity x 0.55. This formula generally used for sea water. It is not appropriate to be used in case of river water.) :

- Chloride was exceeding the Bangladesh standards of 1,000 mg/L during April to May at survey points of Mollarhat/Madhumati River, Chapailghat/Madhumati river and Haridaspur/ MBR,
- The survey was up to 15 May 2009, this means the annual total days with higher Chloride is not obvious; however, recorded total days with higher concentration were 38 days, 39 days and 22 days at survey points of Mollarhat, Chapailghat and Haridaspur, respectively.

Table 5.4.14 Chloride Monitoring Data done by KWASA in 2009

Date	Chloride (mg/L) Mollarhat Low	High	Ave	Max	Min	Chapailghat Low	High	Ave	Max	Min	Haridaspur Low	High	Ave	Max	Min
20-Feb	105	100				105	105				111	111			
21-Feb	105	100				105	105				105	105			
22-Feb	105	100				105	105				105	105			
23-Feb	105	100				105	105				105	105			
24-Feb	100	105	101	105	100	105	105	110	144	105	105	105	106	111	105
25-Feb	100	100				105	105				105	105			
26-Feb	100	100				111	105				111	105			
27-Feb	100	100				122	111				105	105			
28-Feb	105	100				133	144				111	105			
1-Mar	111	105				149	138				105	111			
2-Mar	127	111				149	155				111	105			
3-Mar	122	111				149	149				111	111			
4-Mar	149	116				177	166				111	111			
5-Mar	144	133				177	166				111	111			
6-Mar	160	160				149	177				111	116			
7-Mar	149	138				183	122				116	138			
8-Mar	133	133				183	188				122	127			
9-Mar	160	138				188	194				155	149			
10-Mar	138	133				188	260				138	166			
11-Mar	166	138				205	210				160	177			
12-Mar	172	149				221	243				172	188			
13-Mar	199	172				271	266				183	194			
14-Mar	210	172				293	304				183	188			
15-Mar	255	188				299	343				188	199			
16-Mar	304	199	263	459	105	332	354	366	957	122	199	188	232	531	105
17-Mar	343	238				354	410				177	199			
18-Mar	393	271				376	415				177	183			
19-Mar	410	332				371	382				160	177			
20-Mar	398	371				398	387				194	199			
21-Mar	421	382				415	365				172	199			
22-Mar	410	349				443	454				249	216			
23-Mar	354	410				448	454				221	315			
24-Mar	410	327				454	487				255	371			
25-Mar	421	310				448	459				310	387			
26-Mar	387	343				459	520				354	426			
27-Mar	437	349				542	598				398	432			
28-Mar	343	382				592	647				432	465			
29-Mar	443	354				764	819				470	515			
30-Mar	459	410				753	885				509	531			
31-Mar	432	432				957	908				498	520			
1-Apr	570	437				786	1,013				531	520			
2-Apr	802	481				791	974				498	509			
3-Apr	935	609				819	902				465	426			
4-Apr	980	697				908	852				410	426			
5-Apr	902	659				996	985				476	443			
6-Apr	963	647				1,051	1,140				553	498			
7-Apr	930	714				1,079	1,134				537	576			
8-Apr	1,002	736				1,057	1,107				841	825			
9-Apr	1,051	841				1,096	1,201				642	908			
10-Apr	1,079	924				1,162	1,289				703	531			
11-Apr	1,157	1,024				1,300	1,439				764	537			
12-Apr	1,007	1,107				1,323	1,472				564	930			
13-Apr	1,217	1,079				1,444	1,561				902	974			
14-Apr	1,300	1,146				1,478	1,638				814	957			
15-Apr	1,345	1,146	1,223	2,396	437	1,594	1,638	1,538	2,446	786	736	941	880	1,704	410
16-Apr	1,179	1,184				1,666	1,527				902	980			
17-Apr	1,428	968				1,721	1,760				880	991			
18-Apr	1,433	1,356				1,594	1,572				609	996			
19-Apr	1,566	1,372				1,682	1,716				836	897			
20-Apr	1,489	1,168				1,738	1,738				1,251	1,074			
21-Apr	1,444	1,173				1,749	1,799				1,068	1,234			
22-Apr	1,444	1,140				1,843	1,865				1,306	1,400			
23-Apr	1,467	1,074				1,887	2,037				1,267	1,561			
24-Apr	1,511	1,146				1,920	1,992				1,533	1,588			
25-Apr	1,610	1,339				1,948	1,976				1,118	1,704			
26-Apr	1,854	1,544				2,269	2,197				730	1,649			
27-Apr	2,053	1,727				1,959	1,494				564	1,389			
28-Apr	1,771	1,782				2,092	2,335				719	1,256			
29-Apr	2,335	1,854				2,014	2,424				675	1,256			
30-Apr	2,396	2,070				2,064	2,446				930	1,018			
1-May	2,562	2,258				1,749	2,263				581	957			
2-May	2,728	2,457				1,704	1,876				426	736			
3-May	2,773	2,601				1,350	1,577				282	288			
4-May	2,745	2,706				1,090	957				127	122			
5-May	2,579	2,750				1,046	1,400				160	144			
6-May	2,380	2,690				1,096	1,478				149	293			
7-May	2,131	2,579				1,085	1,621				144	194			
8-May	1,976	2,396	2,324	2,773	1,527	1,212	1,865	1,300	2,263	1,300	205	271	266	957	266
9-May	1,915	2,081				1,295	1,799				105	681			
10-May	1,920	1,976				1,262	1,372				100	636			
11-May	2,059	1,954				1,278	1,173				133	570			
12-May	2,507	2,308				1,107	786				61	122			
13-May	2,413	2,424				664	1,129				66	83			
14-May	2,108	2,396				769	1,289				77	105			
15-May	1,815	1,527				753	941				83	72			
Salinity Days more than 1000ppm	**38days**					**39days**					**11 days**				

: Salinity more than 1000 ppm

(3) JICA Study Team Salinity Monitoring Result in 2010

JICA Study Team has conducted salinity monitoring in 2010 at the points as shown in **Figure 5.4.6**.

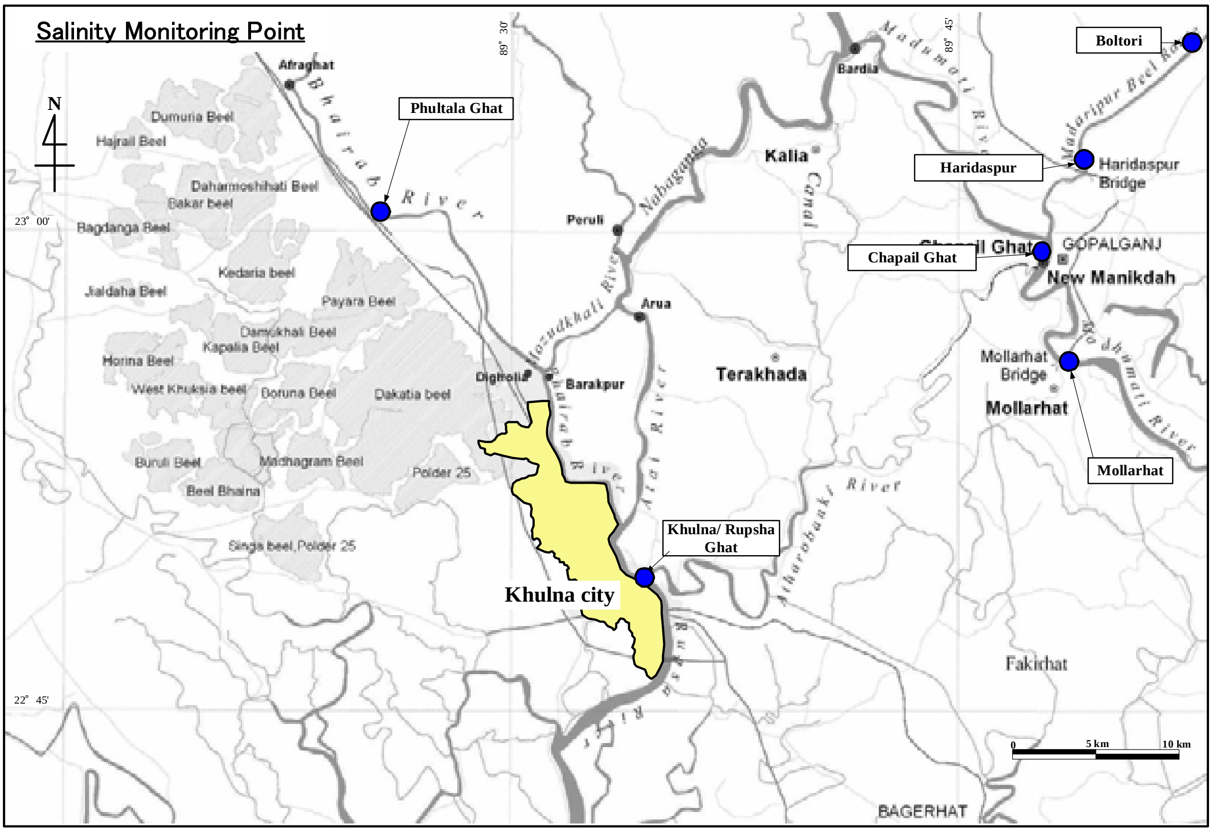


Figure 5.4.6 Locations of Salinity Monitoring Points by JICA Study Team in 2010

The results of saline intrusion survey conducted by JICA Study Team in 2010 are as shown in **Table 5.4.15**, **Table 5.4.16** and **Table 5.4.17**.

Table 5.4.15 Chloride Monitoring Results at Mollarhat, Phultala and Rupsha in March 2010

Mollarhat	Chloride (mg/l)		Phultala	Chloride (mg/l)		Rupsha	Chloride (mg/l)	
Date	High	Low	Date	High	Low	Date	High	Low
3/1	360	240	3/1	2,250	1,875	3/1	3,600	3,400
3/2	360	240	3/2	3,000	2,250	3/2	4,100	3,050
3/3	360	320	3/3	3,700	2,125	3/3	4,650	3,750
3/4	320	360	3/4	3,400	2,750	3/4	4,900	3,500
3/5	340	300	3/5	3,700	3,150	3/5	4,950	3,750
3/6	360	320	3/6	2,600	2,350	3/6	4,200	4,100
3/7	340	360	3/7	3,500	2,400	3/7	4,050	3,650
3/8	380	360	3/8	3,400	2,350	3/8	3,950	3,450
3/9	360	380	3/9	2,900	2,650	3/9	3,750	3,550
3/10	400	360	3/10	2,900	2,450	3/10	3,200	3,050
3/11	380	400	3/11	3,300	1,700	3/11	4,100	3,950
3/12	360	380	3/12	3,250	2,450	3/12	4,450	4,050
3/13	400	360	3/13	3,150	2,800	3/13	4,200	4,300
3/14	380	400	3/14	3,400	2,700	3/14	4,150	4,350
3/15	350	460	3/15	3,850	3,250	3/15	4,550	4,450
3/16	360	400	3/16	4,300	3,050	3/16	4,800	4,450
3/17	420	350	3/17	4,000	3,200	3/17	4,900	4,150
3/18	460	400	3/18	4,200	3,300	3/18	4,950	4,750
3/19	460	420	3/19	4,000	3,350	3/19	5,000	4,700
3/20	500	450	3/20	3,950	3,500	3/20	5,000	4,800
3/21	480	400	3/21	4,000	3,400	3/21	4,700	5,000
3/22	480	460	3/22	4,650	4,600	3/22	6,600	5,000
3/23	500	460	3/23	4,200	3,600	3/23	8,100	7,400
3/24	490	460	3/24	4,750	3,750	3/24	7,400	5,700
3/25	440	420	3/25	3,600	3,650	3/25	7,800	6,800
3/26	450	440	3/26	4,700	4,300	3/26	7,700	7,100
3/27	480	480	3/27	3,700	3,850	3/27	5,100	4,500
3/28	420	570	3/28	4,450	4,300	3/28	5,100	5,900
3/29	440	560	3/29	4,000	3,750	3/29	8,900	6,600
3/30	420	640	3/30	5,000	4,700	3/30	8,300	6,000
3/31	480	560	3/31	4,850	4,450	3/31	9,700	9,100
Average	411	410	Average	3,763	3,161	Average	5,382	4,784
Min.	320	240	Min.	2,250	1,700	Min.	3,200	3,050
Max.	500	640	Max.	5,000	4,700	Max.	9,700	9,100

Table 5.4.16 Chloride Monitoring Results at Mollarhat, Phultala and Rupsha in April 2010

Mollarhat	Chloride (mg/l)		Phultala	Chloride (mg/l)		Rupsha	Chloride (mg/l)	
Date	High	Low	Date	High	Low	Date	High	Low
4/1	520	690	4/1	4,900	3,250	4/1	9,600	9,900
4/2	580	720	4/2	5,000	4,750	4/2	8,900	8,900
4/3	630	880	4/3	8,400	7,700	4/3	6,200	5,500
4/4	890	1,000	4/4	5,500	6,500	4/4	9,500	8,700
4/5	2,750	2,500	4/5	5,700	5,000	4/5	7,800	6,100
4/6	3,500	3,000	4/6	6,400	6,100	4/6	8,200	7,100
4/7	1,600	1,380	4/7	7,000	6,500	4/7	7,800	5,900
4/8	1,340	1,200	4/8	7,100	6,400	4/8	7,600	4,300
4/9	1,420	1,260	4/9	8,000	6,300	4/9	7,300	6,500
4/10	1,200	1,000	4/10	10,000	6,600	4/10	8,100	6,500
4/11	940	960	4/11	10,000	9,400	4/11	7,500	6,200
4/12	1,070	990	4/12	9,000	10,000	4/12	8,400	8,900
4/13	1,120	920	4/13	7,700	8,300	4/13	7,800	5,900
4/14	840	1,020	4/14	10,000	8,000	4/14	6,600	5,700
4/15	990	1,000	4/15	9,800	9,500	4/15	6,700	5,500
4/16	1,230	1,120	4/16	10,000	8,600	4/16	7,500	6,100
4/17	1,340	1,260	4/17	9,400	7,300	4/17	7,200	6,500
4/18	1,400	1,180	4/18	10,000	10,000	4/18	6,800	5,900
4/19	1,260	1,320	4/19	9,300	10,000	4/19	6,400	5,600
4/20	1,000	880	4/20	10,000	9,000	4/20	7,200	6,700
4/21	940	760	4/21	10,000	10,000	4/21	8,900	6,500
4/22	920	780	4/22	9,200	8,000	4/22	8,200	5,700
4/23	840	820	4/23	9,500	8,300	4/23	6,500	5,200
4/24	760	780	4/24	9,800	6,700	4/24	6,900	6,100
4/25	360	410	4/25	9,500	7,700	4/25	6,800	5,600
4/26	560	480	4/26	8,700	7,000	4/26	7,200	6,100
4/27	520	420	4/27	10,000	10,000	4/27	6,900	5,800
4/28	490	570	4/28	10,000	10,000	4/28	7,100	5,700
4/29	420	360	4/29	10,000	9,700	4/29	7,500	5,900
4/30	510	440	4/30	9,900	9,800	4/30	7,600	5,600
Average	1,065	1,003	Average	8,660	7,880	Average	7,557	6,353
Min.	360	360	Min.	4,900	3,250	Min.	6,200	4,300
Max.	3,500	3,000	Max.	10,000	10,000	Max.	9,600	9,900

Table 5.4.17 Chloride Monitoring Results at Boltori, Haridaspur, Chapali Ghat in April 2010

Boltori	Chloride (mg/l)	
Date	High	Low
4/1	40	40
4/2	40	40
4/3	40	40
4/4	40	40
4/5	40	40
4/6	40	40
4/7	40	40
4/8	40	40
4/9	40	40
4/10	40	40
4/11	40	40
4/12	40	40
4/13	40	40
4/14	40	40
4/15	40	40
4/16		
4/17	40	40
4/18		
4/19	40	40
4/20		
4/21	40	40
4/22		
4/23	40	40
4/24		
4/25	40	40
4/26		
4/27	40	40
4/28		
4/29	40	40
4/30		
Average	40	40
Min.	40	40
Max.	40	40

Haridaspur	Chloride (mg/l)	
Date	High	Low
4/1	390	280
4/2	380	240
4/3	320	220
4/4	250	100
4/5	150	80
4/6	90	70
4/7	90	50
4/8	90	50
4/9	100	50
4/10	90	50
4/11	90	40
4/12	90	40
4/13	60	30
4/14	70	40
4/15	50	30
4/16		
4/17	50	30
4/18		
4/19	50	40
4/20		
4/21	50	40
4/22		
4/23	40	30
4/24		
4/25	40	30
4/26		
4/27	40	30
4/28		
4/29	40	30
4/30		
Average	119	73
Min.	40	30
Max.	390	280

Chapali Ghat	Chloride (mg/l)	
Date	High	Low
4/1	870	790
4/2	850	810
4/3	860	780
4/4	890	860
4/5	880	830
4/6	750	720
4/7	760	720
4/8	740	690
4/9	590	570
4/10	640	590
4/11	630	580
4/12	640	580
4/13	650	590
4/14	670	570
4/15	690	630
4/16		
4/17	790	720
4/18		
4/19	830	750
4/20		
4/21	560	510
4/22		
4/23	460	420
4/24		
4/25	340	310
4/26		
4/27	410	350
4/28		
4/29	320	300
4/30		
Average	674	621
Min.	320	300
Max.	890	860

(4) Treatment Implication for Salinity Intrusion

According to these data confirmed through abovementioned salinity surveys, the following subjects shall be taken into account upon raw water intake facility and water treatment plant planning:

- Chloride higher than the Bangladesh standards of 1,000mg/L were observed in the Rupsha river during the period of 4 to 7 months
- Mollarhat, Chapailghat and Haridaspur are located 28 km to 36 km apart from Khulna City, higher Chloride days were observed.
- As salinity countermeasure, salinity-free-water reservoir or saline water treatment process is needed.

5.5 Water Source Development for Khulna Water Supply System

5.5.1 Policy of Water Source Development

Currently Khulna water supply system entirely depends on groundwater source actually and as of now there are no noteworthy problems regarding continuous extraction of groundwater in the aspects of quantity and quality. Facing to the increasing water demand in Khulna KWASA has already to take action. KWASA planned to dig new tube wells utilizing GOB fund and the DPP has been approved. An important thing to be considered for the groundwater development is that the extraction capacities of tube wells decline constantly even if they are operated and maintained well. This means continuous new tube well development is required to keep the total extraction flow in future.

To meet the further increasing future water demand an extension of groundwater development is possible but it is not clear very limited[4].

Therefore, it is inevitable to develop surface water source to be developed to satisfy the future water demand increase in Khulna due to the limitation of groundwater development extent.

Meanwhile salinity intrusion during several months of surface water surrounding rivers is the most significant issue for development of future drinking water resource for Khulna people.

Taking into consideration above mentioned unsustainable conditions of groundwater and surface water; it is desirable to keep the both resources in well balanced shared to satisfy future water demand in Khulna.

In this context, combined usage of groundwater and surface water is necessary to meet the future water demand in Khulna. And to keep the groundwater resource capacity, in other word, to keep the total abstraction flow from KWASA's tube wells, KWASA's hand pumps and private wells continuous renovations and rehabilitations are required.

Water source-wise development policies are to be summarised as follows;

<u>Groundwater development policy</u>

- Both KWASA and private owners shall keep the present abstraction flow in future.

<u>Surface water development policy</u>

- KWASA shall take care of necessary facilities for necessary water resource development to meet the future surplus water demand.

5.5.2 Water Source Development

To meet the future water demand in Khulna water resource development in accordance with two scenarios as mentioned in **Chapter 4.4.2**, water source development schedules are summarized as follows.

Table 5.5.1 Water Resource Development for Khulna Water Supply System

Item	Unit	2009	2010	2015	2020	2025	2030
Demand (inclusive Peak Factor)	(m^3/d)	138,000	154,000	176,000	202,000	231,000	272,000
Groundwater							
KWASA's tubewells	(m^3/d)	30,100	30,100	30,100	30,100	30,100	30,100
KWASA's hand pumps	(m^3/d)	39,300	39,300	39,300	39,300	39,300	39,300
Private pumps	(m^3/d)	49,700	49,700	49,700	49,700	49,700	49,700
Surface water							

[4] ADB – RSC-C91980 (BAN) Study on Groundwater Sources in Khulna City proposed to examine the resource potential of deep aquifer.

Item	Unit	2009	2010	2015	2020	2025	2030
Existing KWASA's Plant	(m^3/d)			1,250	1,250	1,250	1,250
KWASA's New Plant	(m^3/d)			5,500	5,500	5,500	5,500
New Plant	m^3/d)				75,600	110,000	220,000
Groundwater Total	(m^3/d)	119,100	119,100	119,100	119,100	119,100	119,100
Surface water Total	(m^3/d)	0	0	6,750	82,350	116,750	226,750
Total Production	(m^3/d)	119,100	119,100	125,850	201,450	235,850	345,850

In this study a new water production plant is to be highlighted and up to 2025 its design capacity shall be 110,000 m^3/d and up to 2030 it shall be increased to be doubled as 220,000 m^3/d; however, this additional facility shall be justified before design and implementation of the extension works as described in **Chapter 6**.

The comparison of the JICA Study Team's production and demand forecast and the one of ADB TA Study Team is as shown in the flowing figure. Both studies forecasted future demand on the same trend. As to the production the JICA Study Team forecasted new production system to be constructed; on the other hand, the ADB Study Team forecasted based on capacity utilization of the new production system. Consequently both studies have forecasted the same necessary new water production system of 110,000 m^3/day.

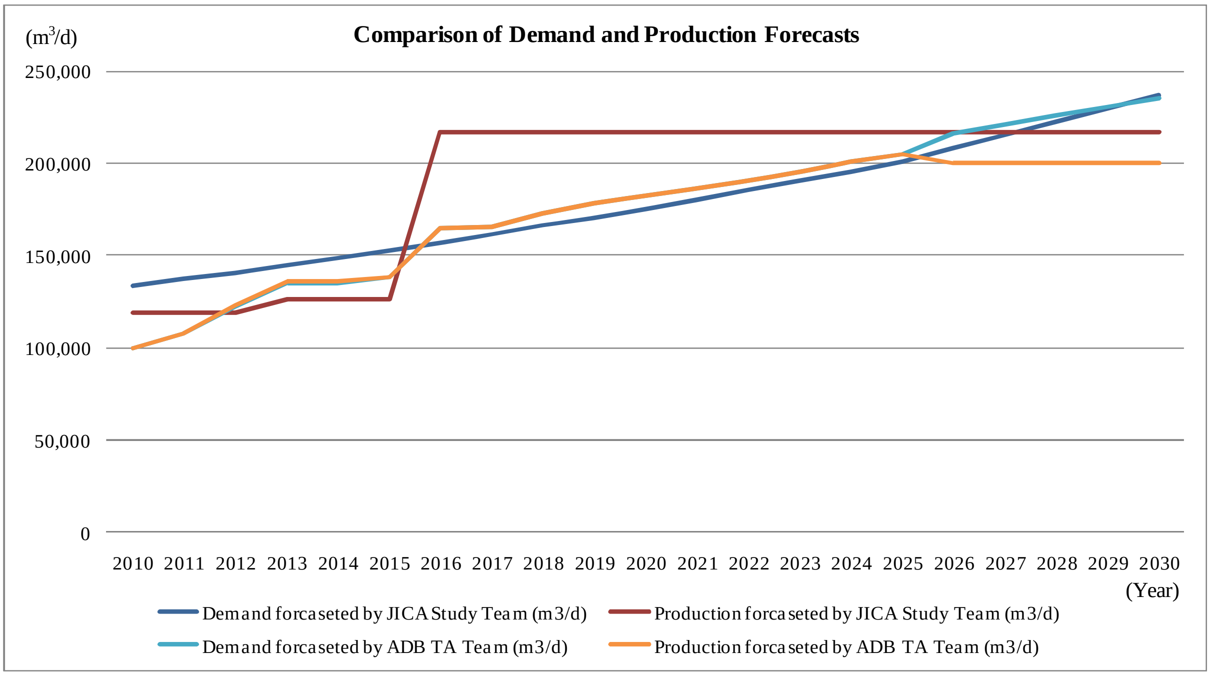


Figure 5.5.1 Comparison of Production and Demand Forecasted

CHAPTER 6 PROPOSED LONG TERM DEVELOPMENT PLAN

6.1 Scenario of Long Term Development Plan

The most important factor to propose a long term development plan for the water supply system in Khulna is to make a clear scenario to establish its integrated sound water supply system in future.

KAWASA is a new established organization and its both capacities in terms of financial and in terms of technical have not completely established yet. This means it is necessary that to plan sound and balanced development scenario which will synchronize KWASA's financial and technological capacity development.

Especially for the early stage of the development it is recommended that to utilize existing water supply system as far as possible to evade over investment. As to the water resource development, specifically up to 2025, the target year of the Feasibility Study, to keep the present abstraction flow and current utilize existing groundwater resource and to develop new surface water resource only to satisfy the exceed water demand as expected. Taking into consideration of this point all alternative comparisons and discussions in the section are based on what will be required up to 2025. And technologies are discussed conventionally and universally basis and evaded to introduce costly state-of-art methods.

6.2 Design Criteria and Condition

6.2.1 Design Manual

For designing purpose on structures and related facilities, any "Design Manuals on Urban Water Supplies" have not been prepared in Bangladesh. In this sturdy proposed water sully facilities will be designed basically referring to other water supply project design reports. In addition, Design Criteria for Water Works Facilities, Japan Water Works Association, and other design criteria in UK and USA are also referred when needed to supplement design criteria.

6.2.2 Intake

(1) Intake Mouth

Passing Velocity:	15 - 30 cm/sec

(2) Grit Chamber

Surface Loading:	500 min
Horizontal Velocity:	2 - 7 cm/sec
Effective Water Depth:	3 - 4 m

6.2.3 Treatment

(1) Planned Capacity

Taking into consideration of peak factor as 1.15 as given in **Chapter 4**, the design capacity of the new plant for 2025 will be 110,000m3/day and the one for 2030 will be 220,000m3/day to meet the maximum day demands respectively.

(2) Design Water Standard

The standards for water quality in Bangladesh are based on the Environment Conservation Rules (1997) which stipulates as **Table 6.2.1** and **Table 6.2.2**.

The result of discussion with DOE, standard for the chlorine concentration is confirmed 1,000mg/L since Khulna is belonged coastal area.

Table 6.2.1 Standards for Water/ (A) Standard for Inland Surface Water

Best Practice based classification	pH	BOD mg/L	DO mg/L	Total Coliform number/100
a. Source of drinking water for supply only after disinfecting	6.5-8.5	2 or less	6 or above	50 or less
b. Water usable for recreational activity	6.5–8.5	3 or less	5 of more	200 or less
c. Source of drinking water for supply after conventional treatment	6.5–8.5	6 of less	6 or more	5000 or less
d. Water usable by fisheries	6.5–8.5	6 of less	5 or more	---
e. Water usable by various process and cooling industries	6.5–8.5	10 or less	5 or more	5000 or less
f. Water usable for irrigation	6.5–8.5	10 or less	5 or more	1000 or less
Notes: 1. In water used for pisiculture, maximum limit of presence of ammonia as Nitrogen is 1.2 mg/L. 2. Electrical conductivity for irrigation water – 2250 μmhoms/cm (at a temperature of 25°C); Sodium less than 26 %; boron less than 0.2 %.				

Table 6.2.2 Standards for Water/ (B) Standard for Drinking Water

Parameter	Unit	Standards	Parameter	Unit	Standards
1. Aluminum	mg/L	0.2	26. Hardness (as CaCO3)	mg/L	200 – 500
2. Ammonia (NH3)	mg/L	0.5	27. Iron	mg/L	0.3 – 1.0
3. Arsenic	mg/L	0.05	28. Kjeldhl Nitrogen (total)	mg/L	1
4. Balium	mg/L	0.01	29. Lead	mg/L	0.05
5. Benzene	mg/L	0.01	30. Magnesium	mg/L	30 – 35
6. BOD5 20°C	mg/L	0.2	31. Manganese	mg/L	0.1
7. Boron	mg/L	1.0	32. Mercury	mg/L	0.001
8. Cadmium	mg/L	0.005	31. Manganese	mg/L	0.1
9. Calcium	mg/L	75	32. Mercury	mg/L	0.001
10. Chloride	mg/L	150 – 600*	33. Nickel	mg/L	0.1
11. Chlorinated alkanes			34. Nitrate	mg/L	10
carbontetrachloride	mg/L	0.01	35. Nitrite	mg/L	<1
1.1 dichloroethylene	mg/L	0.001	36. Odor	mg/L	Odorless
1.2 dichloroethylene	mg/L	0.03	37. Oil and grease	mg/L	0.01
tetrachloroethylene		0.03	38. pH	--	6.5 – 8.5
trichloroethylene		0.09	39. Phenolic compounds	mg/L	0.002
12. Chlorinated phenols			40. Phosphate		6
pentachlorophenol	mg/L	0.03	41. Phosphorus	mg/L	0

Parameter	Unit	Standards	Parameter	Unit	Standards
2.4.6 trichlorophenol	mg/L	0.03	42. Potassium	mg/L	12
13. Chlorine (residual)	mg/L	0.2	43. Radioactive materials (gross alpha activity)	Bq/L	0.01
14. Chloroform	mg/L	0.09	44. Radioactive materials (gross beta activity)	Bq/L	0.1
15.Chromium (hexavalent)	mg/L	0.05	45. Selenium	mg/L	0.01
16. Chromium (total)	mg/L	0.05	46. Silver	mg/L	0.02
17. COD	mg/L	,, 4	47. Sodium	mg/L	200
18. Coliform (fecal)	n/100mL	0	48. Suspended particulate matters	mg/L	10
19. Coliform (total)	n/100 mL	0	49. Sufide	mg/L	0
20. Color	Hazen unit	15	50. Sulfate	mg/L	400
21. Copper	mg/L	1	51. Total dissolved solids	mg/L	1000
22. Cyanide	mg/L	0.1	52. Temperature	°C	20-30
23. Detergents	mg/L	0.2	53. Tin	mg/L	2
24. DO	mg/L	6	54. Turbidity	JTU	10
25. Fluoride	mg/L	1	55. Zinc	mg/L	5

6.2.4 Transmission and Distribution

(1) General

Friction Formula: Hazen-Williams Formula

$$H = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$$

where, H: friction loss (m)

C: friction coefficient — 110 for cement lined DIP and SP
110 for PVC pipe

D: diameter of pipe (m)

Q: flow rate (m^3/sec)

L: pipe length (m)

Maximum flow rate 2.0 m/sec

(2) Transmission

Pipe Material: Ductile iron pipe (DIP) or steel pipe (SP)

Internal Lining: Cement mortar lining

(3) Distribution

Pipe Material: Ductile iron pipe (DIP) for diameter 200 mm or larger
PVC pipe and/or HDPE pipe for diameter less than 150 mm

6.3 Basic Unit Cost

6.3.1 Exchange Rate

Exchange rates for the recent six month are shown in **Table 6.3.1**.

In this report the latest rate (1.0 US$ = 90.14 Yen and 1.0 Taka =1.328 Yen) in February 2010 is adopted.

Table 6.3.1 Exchange Rates with Yen for the Recent Six Month

Country / Month	2009/Sept.	2009/Oct.	2009/Nov.	2009/Dec.	2010/Jan.	2010/Feb.
USA (US$)	93.13	89.98	90.87	86.66	91.45	90.14
Bangladesh (Taka)	1.382	1.326	1.342	1.259	1.346	1.328

6.3.2 Unit Cost for Construction and Land Acquisition

Basic unit costs for land acquisition, direct construction works, and O&M works has been studied for the selection of best alternative as described below.

- Water Intake
- Raw Water Transmission Pipe
- Impounding Reservoir
- Surface Water Treatment Plant (SWTP)
- Clear Water Transmission Pipe
- Distribution Reservoir
- Overhead Tank
- Distribution Pipe Network

The estimate in the master plan review stage was approached by the unit cost basis for the civil works and land acquisition, and lump sum cost basis for mechanical and electrical works. The unit costs for major items of direct construction works and land acquisition were preliminary determined referring to the Schedule of Rate 2008 for civil works (Public Works Department/ OB), records of similar water supply projects, prevailing current market prices and other sources as presented in **Table 6.3.2**. It should be noted that these unit construction costs are preliminary which have to be further reviewed in the feasibility study stage for the financial cost estimate on the selected plan. An explanation of unit costs of civil works and cost for mechanical and electrical works is briefly given as follows.

(1) Direct Construction Cost

1) Civil Works

Unit costs of civil works are shown in **Table 6.3.2**.

Table 6.3.2 Unit Costs of Civil Works

Item	Specifications	Unit	Costs	
			Taka (LC)	US$ (FC)
Reinforced Concrete	f’c=19 MPa	m^3	5,620 to 5,973	-
	f’c=22 MPa	m^3	6,687 to 7,040	-
	f’c=25 MPa	m^3	7,099 to 7,452	-
Form Work	Foundation Beam, Ground Floor, etc.	m^2	231 to 420	-
Reinforcing Steel bar	40 Grade Deformed M.S. rod	ton	64,000	-
	60 Grade Deformed M.S. rod	ton	67,000	-
DIP	Φ300, Pipe + Construction	m	-	280
	Φ500, Pipe + Construction	m	-	350

	Φ600, Pipe + Construction	m	-	420
	Φ800, Pipe + Construction	m	-	550
	Φ900, Pipe + Construction	m	-	600
	Φ1100, Pipe + Construction	m	-	800

Source: Schedule of Rates, 2008, For Civil Works, Twelfth Edition, Public Works Department, Government of the People's Republic of Bangladesh. DIP Cost from Quotation of Japanese Company

2) Mechanical and Electrical Works

The costs for mechanical and electrical works were estimated on the lump sum basis assuming the required components and its capacity. Applied cost for comparison is site delivery plus erection costs basis excluding custom duties.

(2) Land Acquisition Cost[1]

The unit costs for land acquisition are provided as shown in **Table 6.3.3** for alternative comparison. Data source for the unit cost of the land is the hearing from local people (15 to 20 nos). Local government price is uniformity 150 Taka /m^2.

Table 6.3.3 Unit Costs of Land Acquisition

Place	Area Details	Unit	Costs	
			Taka	US$
Dakatia Beel	House Area	m^2	299	-
	Paddy with Fish Pond, Fish Pond	m^2	187	-
	Paddy	m^2	112	-
Bahirdia	Road side Land	m^2	374	-
	Inside Land	m^2	224	-
	More Inside Land	m^2	150	-
	Fish Pound Land	m^2	187	-

6.3.3 Unit Cost for Labor, Power and Chemicals

The unit costs for labor, power and chemicals for O&M works are provided referring mainly to the costs records of O&M of the existing KWASA's facilities and market price on Khulna as tabulated in **Table 6.3.4**.

Table 6.3.4 Unit Costs of Labor, Power and Chemicals

Item	Specifications	Unit	Costs	
			Taka	US$
Labour Cost	Ordinary Labour	Per Day	150	-
	Skilled Labour	Per Day	200	-
	Electrical Labour	Per Day	300	-
Power	For All	Per kWh	3.5	-
Chemicals	Alum	Per ton	-	247
	Lime	Per ton	-	145
	Chlorine	Per ton	-	363

Source: Schedule of Rates, 2008, For Civil Works, Twelfth Edition, Public Works Department, Government of the People's Republic of Bangladesh. Chemical Cost from Bangladesh WTP

[1] These costs have been used only for optional comparison analysis.

6.4 Alternative Approach for Water Supply System for 2025 Water Demand

6.4.1 Water Intake

Khulna City is located in west bank of Rupsha River and its tributary Bhairab River. Rupsha River is tributary of Gorai River and Gorai River is tributary of Ganges River inflowing from India.

This area is part of the world's largest delta and therefore, flooding is frequently occurred. In 1975, as India government constructed Faracca Dam, river flow volume decrement during dry season has become a serious social problem. By contraries, saline water intrusion phenomenon has been observed. Saline water is brought from Bengal bay by ocean current. Especially during dry season, intensive saline water intrusion has been occurred and high concentration in Chloride exceeding the Bangladesh standards has been detected in rivers near by Khulna City for several months.

Consequently, impact of saline water intrusion and countermeasures against it shall be deliberated upon selection of intake point.

(1) Water Intake Alternatives

Considering the impact of saline water intrusion and necessary countermeasures, the following three intake areas are proposed:

- Gapalganj: Less impact of saline intrusion
- Phultala: Existing Beel can be diverted to reservoir
- Khulna City: Saline water treatment process is needed

Providing these 3 areas as 3 Cases, 8 raw water intake points (8 Options) are proposed and their details and locations are indicated in **Table 6.4.1** and **Figure 6.4.1**. Alternative study is to be conducted theses 8 options.

Further, as to Arua, Peruli and Bardia located in upstream of Mozudkali River are excluded from options since they are strongly affected by salinity even they are far away from Khulna city.

Table 6.4.1 Outline of Water Intake Options

CASE	Option	Intake Source Point	River	Distance from Khulna	Impounding Reservoir	Desalination Process	No. of SWTP
CASE-A	Option -1	Boltori	MBR	47 km	-	Not Necessary	1
	Option -2	Ulpur		39 km	-	Not Necessary	1
	Option -3	Haridaspur		36 km	15 days	Not Necessary	1
	Option -4	Chapail Ghat	Madhumati River	30 km	30 days	Not Necessary	1
	Option -5	Mollarhat		28 km	45 days	Not Necessary	1
CASE -B	Option -6	Phultala	Bhairab River	15 km	150 days	Not Necessary	1
CASE -C	Option -7	Khulna	Rupsha River	4 km	-	Necessary	1
	Option -8	Khulna (2 Intake Points)		4km, 4 km	Not Necessary	Necessary	2

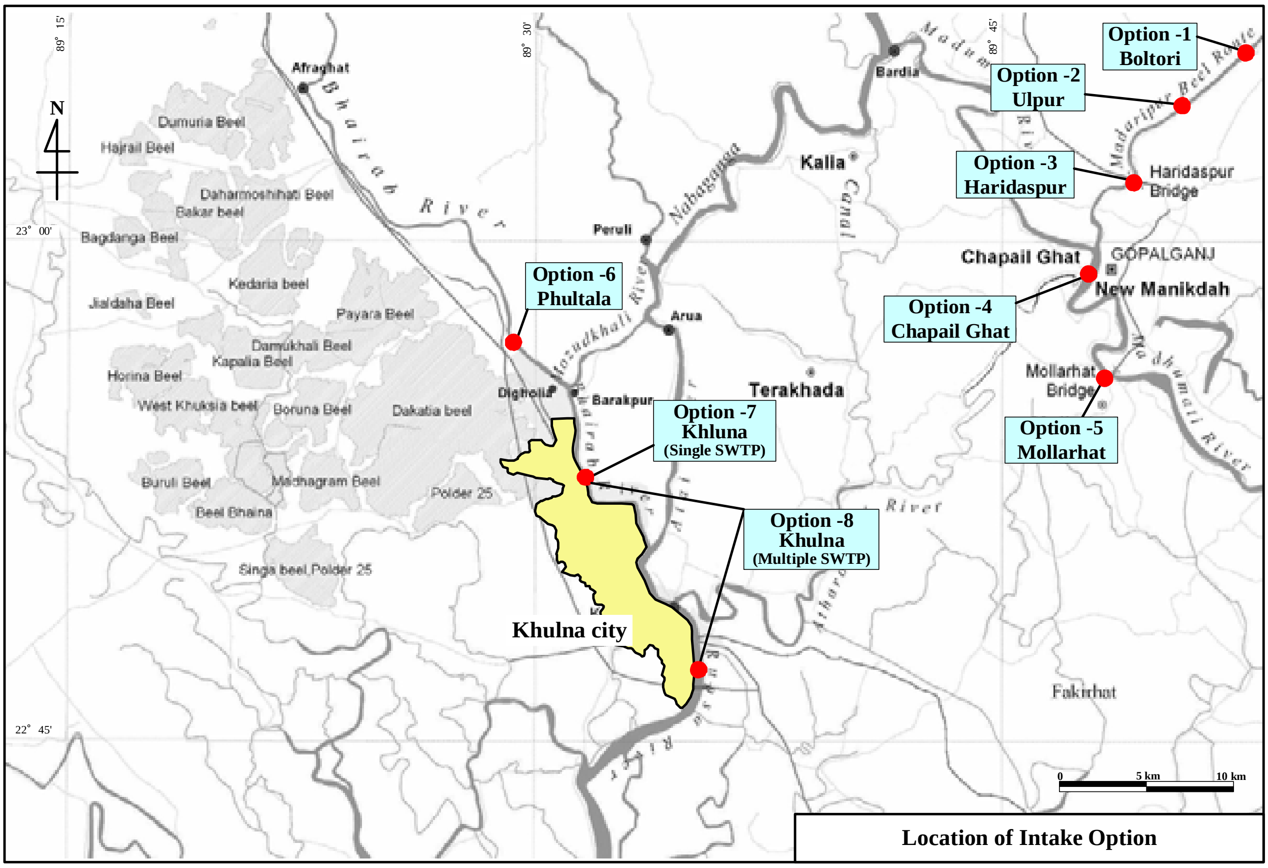


Figure 6.4.1 Locations of Water Intake Options

(2) Outline of each Option for CASE-A (Gopalganji Area, Option-1 to 5)

To minimize the salinity impact, raw water intake points were proposed along with MBR/Madhumati River in Gopalganji District, 28 to 47 km away from Khulna city. However, large-scaled impounding is needed for the period when chloride concentration is higher than standard (1000 mg/L) is detected through salinity survey conducted in 2009 by KWASA.

In addition, as proposed water intake points are far away from Khulna city, long length of raw water transmission pipe (33km to 62km) is necessary. 1 or 2 river crossing points with width of 200 to 600 m is also expected as well.

CASE -A is classified following five (5) Options by locations of water intake respectively and shown in **Figure 6.4.2**.

Option -1: Boltori
Option -2: Ulpur
Option -3: Haridaspur
Option -4: Chapail Ghat
Option -5: Mollarhat

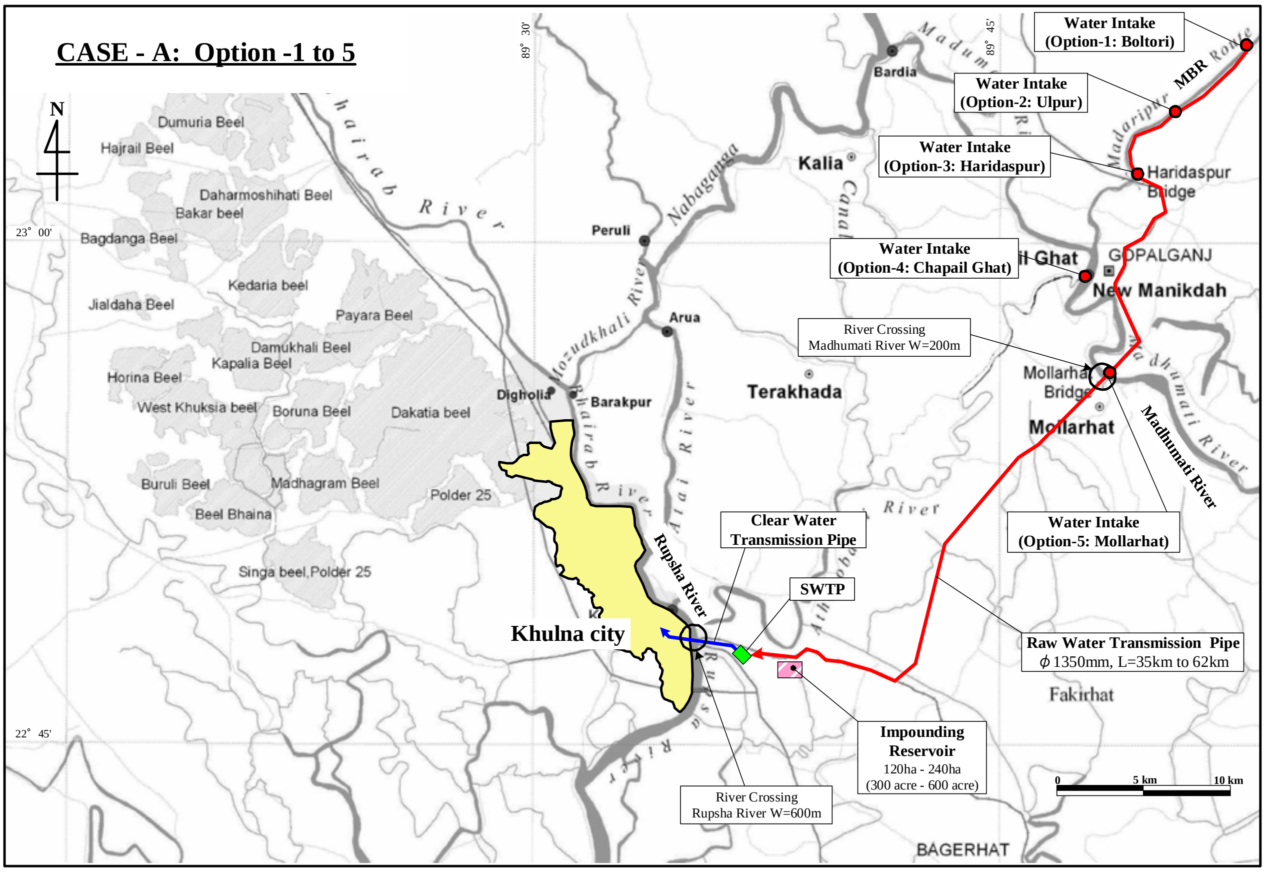


Figure 6.4.2 Outline of CASE-A (Option-1 to Option-5)

1) Option -1: Boltori

a) Water Intake Point

Proposed water intake point of Option-1 is set at Boltori, 47km north-east from Khulna city in order to reduce salinity influence. Raw water is taken from MBR. This site is about 7 km upstream from Ulpur bridge along MBR where near by small market in Gopalganji District. Latitude and longitude is N23° 06’ 17.8”, E89° 53’ 17.7” respectively.


Photo 6.4.1 Intake Site of Option -1: Boltori

b) Amount of River Water

River water flow at MBR was measured by IWM on February 2009 as follows;

- Measurement Point: Haridaspur
- Time of the peak water level: 15:00 o'clock
- Observation hours to be studied: 18:00-19:00
- Average River Water Flow: (47.27+66.06+75.19) / 3 = 62.8 m^3/sec

Note: This measurement point is the Haridaspur site (MBR) which is located at approximately 13 km downstream from the Boltori site. However Haridaspur site is the nearest site to the Boltori site among the observed sites.

Design intake water flow is calculated as follows considering 10% as water loss at raw water transmission pipe and at SWTP;

110,000m^3/day = 1.27m^3/sec

The MBR possesses enough water flow as water intake since the intake water flow accounts for only 2.02 percent of river water flow at MBR shown below.

1.27 / 62.8 = 0.0202 = 2.02% < 5% *) OK

Note: 5% is considered safety amount to intake water from the river

c) Land Acquisition for Water Intake

Approval by the Land Ministry is necessary for land acquisition of water intake, since water intake is located at Gopalganji Division. It is considered that approval will take a lot of time because Gopalganji Division is different district from Khulna Division where is target service area in this project.

d) Salinity Condition

According to salinity (Chloride concentration) investigation conducted JICA Study Team in 2010 the salinity of the river water has not exceeded EQS level: 1,000 mg/L.

e) Water Quality

According to water quality analysis conducted by JICA Study on February 2010 shown in **Chapter 5**, important water quality items for this option is shown in following **Table 6.4.2**. .

Table 6.4.2 Water Quality Data at Boltori

Items	Turbidity	pH	BOD	Mercury (HG)	Iron (Fe)	Manganese (Mn)	Chloride (Cl^-)
Standard	10 JTU	6.5 – 8.5	< 0.2mg/L	< 0.001mg/L	< 0.3 - 1.0mg/L	< 0.1mg/L	< 1,000mg/L
Water Quality	3	8.4	2.7	0	0.02	0.03	22

Some water quality data is exceeded standard value. But these can be purified by normal water treatment process. Some water quality is exceeded standard value. But these can be purified by universal water treatment process.

f) Electricity Power Service

Leading electricity service line to the water intake is supposed to be easy and shared cost will not be costly (less than 120,000 TK) because there is 11 kV electricity main cable within 1 km from water intake point.

g) Surface Water Treatment Plant (SWTP)

Normal water treatment process (Rapid Sand Filter Process) is applied because SWTP for Option-1 doesn't need to treat raw water which contains chloride. Impounding reservoir collects raw water from river during non-salinity period, and sends water to SWTP during salinity period. Some water quality data is exceeded standard value shown in **Table 6.4.2**. But these can be purified by normal water treatment process.
Proposed SWTP location is Samanto Sena along Bahirdia-Baghmara Road outside of Khulna. Required land for SWTP is estimated about 10ha for normal water treatment process.

h) Raw Water Transmission Pipe

Long distance raw water transmission pipe line, diameter of 1350mm and the length of 62 km, is required. Larger diameter pipe is required in order to reduce pipe friction loss which occurred by long length pipe.
Pipeline starts from Boltori water intake point and passes through river bank along MBR, by way of Ulpur, Haridaspur, Gopalgangi, across the Madumati River, passes Dhaka road and abolished railway route, then arrives at SWTP.

i) Clear Water Transmission Pipe

Clear water transmission pipe starts from SWTP and across the Rupsha River, then into Khulna city. This pipeline branches off in Khulna city and leads to distribution reservoir.

j) Construction Work

River Crossing

River crossing is necessary for Option-1 at two rivers shown below.

	River Name	Width	Crossing Pipe
1	Madhumati River	200m	Raw Water Transmission Pipe, Dia 1350mm
2	Rupsha River	600m	Clear Water Transmission Pipe, Dia 1100mm

Photo of river crossing points are shown in **Photo 6.4.3** and **6.4.4**.

As river crossing method, attached pipe on the existing bridge, construction of water pipe bridge and installation of pipe under the river by tunnelling method such as shield method or pipe jacking method are conceivable.

Photo 6.4.3 River Crossing Point (Madhumati River)

Photo 6.4.4 River Crossing Point (Rupsha River)

Pipe cannot be attached existing bridge since existing bridge was not designed to support the pipe load. Considering construction cost, easiness of construction work and environmental aspect, pipe jacking method is supposed to be the most suitable method for river crossing. However river crossing work by pipe jacking method will make construction cost higher than other the CASEs, and whole construction work in this project will be more complicated due to this special work (Pipe Jacking Method)

k) Construction Cost

Rough estimate construction cost for Option-1 is calculated as follows. This cost includes all facilities for water supply system and all kinds of work such as pipe work, civil work, architecture work, mechanical work and electrical work.

Water Intake:	10,800 thousand USD
Raw Water Transmission Pipe:	155,000 thousand USD
River Crossing:	5,600 thousand USD
SWTP:	45,000 thousand USD
Clear Water Transmission Pipe:	14,480 thousand USD
Distribution Reservoir	20,380 thousand USD
Overhead Tank	5,500 thousand USD
Distribution Pipe Network:	20,000 thousand USD
Service Pipe Connection:	15,000 thousand USD
Others:	4,000 thousand USD
Total Construction Cost	294,960 thousand USD
	Roundup ⇒ 295 million USD

l) Operation and Maintenance (O&M) Cost

Anticipated yearly expenditures as operation and maintenance for Option-1 is estimated 2,570 thousand USD/year which contains personnel expense, power cost, chemical cost, maintenance cost and others.

2) Option -2: Ulpur

a) Water Intake Point

Proposed water intake point of Option-2 is set at Ulpur, 39km north-east from Khulna city in order to reduce salinity influence. Raw water is taken from MBR. This site is at Ulpur bridge on the MBR in Gopalganji District. Latitude and longitude is N23° 03' 49.8", E89° 50' 18.8" respectively.

Photo 6.4.5 Intake Site of Option -2: Ulpur

b) Amount of River Water

River water flow at MBR was measured by IWM on February 2009 as follows;

- Measurement Point: Haridaspur
- Time of the peak water level: 15:00 o'clock
- Observation hours to be studied: 18:00-19:00
- Average River Water Flow: (47.27+66.06+75.19) / 3 = 62.8 m^3/sec

Note: This measurement point is the Haridaspur site (MBR) which is located at approximately 5 km downstream from the Ulpur site. However Haridaspur site is the nearest site to the Ulpur site among the observed sites.

Design intake water flow is calculated as follows considering 10% as water loss at raw water transmission pipe and at SWTP;

110,000m^3/day = 1.27m^3/sec

The MBR possesses enough water flow as water intake since the intake water flow accounts for only 2.02 percent of river water flow at MBR shown below.

1.27 / 62.8 = 0.0202 = 2.02% < 5% *) <u>OK</u>

Note: 5% is considered safety amount to intake water from the river

c) Land Acquisition for Water Intake

Approval by the Land Ministry is necessary for land acquisition of water intake, since water intake is located at Gopalganji Division. It is considered that approval will take a lot of time because Gopalganji Division is different district from Khulna Division where is target service area in this project.

d) Salinity Condition

According to salinity (Chloride concentration) investigation conducted JICA Study Team in 2010 the salinity of the river water has not exceeded EQS level: 1,000 mg/L.

e) Water Quality

According to water quality analysis conducted by JICA Study on February 2010 shown in **Chapter 5**, important water quality items for this option is shown in following Table.

Table 6.4.3 Water Quality Data at Ulpur

Items	Turbidity	pH	BOD	Mercury (HG)	Iron (Fe)	Manganese (Mn)	Chloride (Cl^-)
Standard	10 JTU	6.5 – 8.5	< 0.2mg/L	< 0.001mg/L	< 0.3 - 1.0mg/L	< 0.1mg/L	< 1,000mg/L
Water Quality	4	8.4	2.5	0	0.05	0.03	22

Some water quality data is exceeded standard value. But these can be purified by normal water treatment process. Some water quality is exceeded standard value. But these can be purified by universal water treatment process.

f) Electricity Power Service

Leading electricity service line to the water intake is supposed to be easy and shared cost will not be costly (less than 120,000TK) because there is 11kV electricity main cable within 1 km from water intake point.

g) Surface Water Treatment Plant (SWTP)

Normal water treatment process (Rapid Sand Filter Process) is applied because SWTP for Option-2 doesn't need to treat raw water which contains chloride. Impounding reservoir collects raw water from river during non-salinity period, and sends water to SWTP during salinity period.
Some water quality data is exceeded standard value shown in **Table 6.4.3**. But these can be purified by normal water treatment process.
Proposed SWTP location is Samanto Sena along Bahirdia-Baghmara Road outside of Khulna city.
Required land for SWTP is estimated about 10ha for normal water treatment process.

h) Raw Water Transmission Pipe

Long distance raw water transmission pipe line, diameter of 1350mm and the length of 54km, is required. Larger diameter pipe is required in order to reduce pipe friction loss which occurred by long length pipe.
Pipeline starts from Ulpur water intake point and passes through river bank along MBR, by way of Haridaspur, Gopalgangi, across the Madumati River, passes Dhaka road and abolished railway route, then arrives at SWTP.

i) Clear Water Transmission Pipe

Clear water transmission pipe starts from SWTP and across the Rupsha River, then into Khulna city. This pipeline branches off in Khulna city and leads to distribution reservoir.

j) Construction Work

River Crossing

River crossing is necessary for Option-2 at two rivers shown below.

	River Name	Width	Crossing Pipe
1	Madhumati River	200m	Raw Water Transmission Pipe, Dia 1350mm
2	Rupsha River	600m	Clear Water Transmission Pipe, Dia 1100mm

Photo of river crossing points are shown in **Photo 6.4.3** and **6.4.4**.

As river crossing method, attached pipe on the existing bridge, construction of water pipe bridge and installation of pipe under the river by tunnelling method such as shield method or pipe jacking method are conceivable. Pipe can not be attached existing bridge since existing bridge wasn't designed pipe load as structure calculation. Considering construction cost, easiness of construction work and environmental aspect, pipe jacking method is supposed to be the most suitable method for river crossing.

However river crossing work by pipe jacking method will make construction cost higher than other the CASEs, and whole construction work in this project will be more complicated due to this special work (Pipe Jacking Method).

k) Construction Cost

Rough estimate construction cost for Option-2 is calculated as follows. This cost includes all facilities for water supply system and all kinds of work such as pipe work, civil work, architecture work, mechanical work and electrical work.

Water Intake:	10,000 thousand USD
Raw Water Transmission Pipe:	135,000 thousand USD
River Crossing:	5,600 thousand USD
SWTP:	45,000 thousand USD
Clear Water Transmission Pipe:	14,480 thousand USD
Distribution Reservoir	20,380 thousand USD
Overhead Tank	5,500 thousand USD
Distribution Pipe Network:	20,000 thousand USD
Service Pipe Connection:	15,000 thousand USD
Others:	4,000 thousand USD
Total Construction Cost	274,960 thousand USD
	Roundup ⇒ 275 million USD

l) Operation and Maintenance (O&M) Cost

Anticipated yearly expenditures as operation and maintenance for Option-2 is estimated 2,520 thousand USD/year which contains personnel expense, power cost, chemical cost, maintenance cost and others.

3) Option -3: Haridaspur

a) Water Intake Point

Proposed water intake point of Option-3 is set at Haridaspur, 36 km north-east from Khulna city in order to reduce salinity influence. Raw water is taken from MBR. This site is at Haridaspur bridge on the MBR in Gopalganji District. Latitude and longitude is “N23° 01’ 50.9”, E89° 49’ 01.4” respectively.

Photo 6.4.6 Intake Site of Option -3: Haridaspur

b) Amount of River Water

River water flow at MBR was measured by IWM on February 2009 as follows;

- Measurement Point: Haridaspur
- Time of the peak water level: 15:00 o’clock
- Observation hours to be studied: 18:00-19:00
- Average River Water Flow: (47.27+66.06+75.19) / 3 = 62.8 m^3/sec

Design intake water flow is calculated as follows considering 10 % as water loss at raw water transmission pipe and at SWTP;

110,000 m^3/day = 1.27 m^3/sec

The MBR possesses enough water flow as water intake since the intake water flow accounts for only 2.02 percent of river water flow at MBR shown below.

1.27 / 62.8 = 0.0202 = 2.02% < 5% $^{*)}$ OK

Note: 5% is considered safety amount to intake water from the river

c) Land Acquisition for Water Intake

Approval by the Land Ministry is necessary for land acquisition of water intake, since water intake is located at Gopalganji Division. It is considered that approval will take a lot of time because Gopalganji Division is different district from Khulna Division where is target service area in this project.

d) Salinity Condition

Based on the analysis on the previous measured records and current JICA Study Team's measuring record for the new water supply system it is better to provide an impounding reservoir of which retention period is 15 days.

e) Water Quality

According to water quality analysis conducted by JICA Study on February 2010 shown in **Chapter 5**, important water quality items for this option is shown in following Table.

Table 6.4.4 Water Quality Data at Haridaspur

Items	Turbidity	pH	BOD	Mercury (HG)	Iron (Fe)	Manganese (Mn)	Chloride (Cl^-)
Standard	10 JTU	6.5 - 8.5	< 0.2mg/L	< 0.001mg/L	< 0.3 - 1.0mg/L	< 0.1mg/L	< 1,000mg/L
Water Quality	7	8.3	4.7	0	0.38	0	34

Some water quality data is exceeded standard value. But these can be purified by normal water treatment process. Some water quality is exceeded standard value. But these can be purified by universal water treatment process.

f) Electricity Power Service

Leading electricity service line to the water intake is supposed to be easy and shared cost will not be costly (less than 120,000 TK) because there is 11 kV electricity main cable within 1 km from water intake point.

g) Impounding Reservoir

An Impounding reservoir, of which retention period is 15 days, requires land 26 ha.

h) Surface Water Treatment Plant (SWTP)

Normal water treatment process (Rapid Sand Filter Process) is applied because SWTP for Option-3 doesn't need to treat raw water which contains chloride. Impounding reservoir collects raw water from river during non-salinity period, and sends water to SWTP during salinity period.
Some water quality data is exceeded standard value shown in **Table 6.4.4**. But these can be purified by normal water treatment process.
Proposed SWTP location is Samanto Sena adjoining to the impounding reservoir. Required land for SWTP is estimated about 10 ha for normal water treatment process.

i) Raw Water Transmission Pipe

Long distance raw water transmission pipe line, diameter of 1350mm and the length of 49km, is required. Larger diameter pipe is required in order to reduce pipe friction loss which occurred by long length pipe.

Pipeline starts from Haridaspur water intake point and passes through river bank along MBR, by way of Gopalgangi, across the Madumati River, passes Dhaka road and abolished railway route, then arrives at SWTP.

j) Clear Water Transmission Pipe

Clear water transmission pipe starts from SWTP and across the Rupsha River, then into Khulna city. This pipeline branches off in Khulna city and leads to distribution reservoir.

k) Construction Work

Impounding Reservoir

A large scale construction work will be necessary to construct huge impounding reservoir. Construction period is estimated about eight (8) months.

River Crossing

River crossing is necessary for Option-3 at two rivers shown below.

	River Name	Width	Crossing Pipe
1	Madhumati River	200m	Raw Water Transmission Pipe, Dia 1350mm
2	Rupsha River	600m	Clear Water Transmission Pipe, Dia 1100mm

Photo of river crossing points are shown in **Photo 6.4.3** and **6.4.4**.

As river crossing method, attached pipe on the existing bridge, construction of water pipe bridge and installation of pipe under the river by tunnelling method such as shield method or pipe jacking method are conceivable. Pipe can not be attached existing bridge since existing bridge wasn't designed pipe load as structure calculation. Considering construction cost, easiness of construction work and environmental aspect, pipe jacking method is supposed to be the most suitable method for river crossing.

However river crossing work by pipe jacking method will make construction cost higher than other the CASEs, and whole construction work in this project will be more complicated due to this special work (Pipe Jacking Method)

l) Construction Cost

Rough estimate construction cost for Option-3 is calculated as follows. This cost includes all facilities for water supply system and all kinds of work such as pipe work, civil work, architecture work, mechanical work and electrical work.

Water Intake:	8,000 thousand USD
Raw Water Transmission Pipe:	112,700 thousand USD

River Crossing:	5,600 thousand USD
Impounding Reservoir	25,000 thousand USD
SWTP:	45,000 thousand USD
Clear Water Transmission Pipe:	14,480 thousand USD
Distribution Reservoir	20,380 thousand USD
Overhead Tank	5,500 thousand USD
Distribution Pipe Network:	20,000 thousand USD
Service Pipe Connection:	15,000 thousand USD
Others:	4,000 thousand USD
Total Construction Cost	275,660 thousand USD
	Roundup ⇒ 276 million USD

m) Operation and Maintenance (O&M) Cost

Anticipated yearly expenditures as operation and maintenance for Option-3 is estimated 2,490 thousand USD/year which contains personnel expense, power cost, chemical cost, maintenance cost and others.

4) Option -4:Chapail Ghat

a) Water Intake Point

Proposed water intake point of Option-4 is set at Chapail Ghat, 30 km north-east from Khulna city in order to reduce salinity influence. Raw water is taken from the Madhumati River. This site is at Chapail Ghat near small ferry port on the Madhumati River in Gopalganji District. Latitude and longitude is “N22° 59’ 01.3”, E89° 47’ 49.7” respectively.


Photo 6.4.7 Intake Site of Option -4: Chapail Ghat

b) Amount of River Water

River water flow at the Madhumati River was measured by IWM on March 2009 as follows;

- Measurement Point: Gopalganji
- Time of the peak water level: 10:30 o’clock
- Observation hours to be studied: 13:30-16:30
- Average River Water Flow:
  $(43.28+47.38+46.67+39.47+50.2+45.76+45.76+50.01)/8 = 46.1\ m^3/sec$

Design intake water flow is calculated as follows considering 10 % as water loss at raw water transmission pipe and at SWTP;

110,000 m^3/day = 1.27 m^3/sec

The Madhumati River possesses enough water flow as water intake since the intake water flow accounts for only 2.75 percent of river water flow at MBR shown below.

1.27 / 46.1 = 0.0275 = 2.75% < 5% [*)] OK

Note: 5% is considered safety amount to intake water from the river

c) Land Acquisition for Water Intake

Approval by the Land Ministry is necessary for land acquisition of water intake, since water intake is located at Gopalganji Division. It is considered that approval will take a lot of time because Gopalganji Division is different district from Khulna Division where is target service area in this project.

d) Salinity Condition

Based on the analysis on the previous measured records and current JICA Study Team's measuring record for the new water supply system it is better to provide an impounding reservoir of which retention period is 30 days.

e) Water Quality

According to water quality analysis conducted by JICA Study on February 2010 shown in **Chapter 5**, important water quality items for this option is shown in following Table.

Table 6.4.5 Water Quality Data at Chapail Ghat

Items	Turbidity	pH	BOD	Mercury (HG)	Iron (Fe)	Manganese (Mn)	Chloride (Cl^-)
Standard	10 JTU	6.5 - 8.5	< 0.2mg/L	< 0.001mg/L	< 0.3 - 1.0mg/L	< 0.1mg/L	< 1,000mg/L
Water Quality	25	8.7	4.6	0	0.52	0	67

Some water quality data is exceeded standard value. But these can be purified by normal water treatment process. Some water quality is exceeded standard value. But these can be purified by universal water treatment process.

f) Electricity Power Service

Leading electricity service line to the water intake is supposed to be easy and shared cost will not be costly (less than 120,000 TK) because there is 11 kV electricity main cable within 1 km from water intake point.

g) Impounding Reservoir

An Impounding reservoir, of which retention period is 30 days, requires land 43 ha.

h) Surface Water Treatment Plant (SWTP)

Normal water treatment process (Rapid Sand Filter Process) is applied because SWTP for Option-4 doesn't need to treat raw water which contains chloride. Impounding reservoir collects raw water from river during non-salinity period, and sends water to SWTP during salinity period.
Some water quality data is exceeded standard value shown in **Table 6.4.5**. But these can be purified by normal water treatment process.
Proposed SWTP location is Samanto Sena along Bahirdia-Baghmara Road outside of Khulna city shown in **Figure 6.4.3**. Required land for SWTP is estimated about 10ha for normal water treatment process.

i) Raw Water Transmission Pipe

Long distance raw water transmission pipe line, diameter of 1350 mm and the length of 43km, is required. Larger diameter pipe is required in order to reduce pipe friction loss which occurred by long length pipe.
Pipeline starts from Chapail Ghat water intake point and passes Gopalgangi, across the Madumati River, passes Dhaka road and abolished railway route, then arrives at SWTP.

j) Clear Water Transmission Pipe

Clear water transmission pipe starts from SWTP and across the Rupsha River, then into Khulna city. This pipeline branches off in Khulna city and leads to distribution reservoir.

k) Construction Work

<u>Impounding Reservoir</u>

A large scale construction work will be necessary to construct huge impounding reservoir. Construction period is estimated about eight (8) months.

<u>River Crossing</u>

River crossing is necessary for Option-4 at two rivers shown below.

	River Name	Width	Crossing Pipe
1	Madhumati River	200m	Raw Water Transmission Pipe, Dia 1350mm
2	Rupsha River	600m	Clear Water Transmission Pipe, Dia 1100mm

Photo of river crossing points are shown in **Photo 6.4.3** and **6.4.4**.

As river crossing method, attached pipe on the existing bridge, construction of water pipe bridge and installation of pipe under the river by tunnelling method such as shield method or pipe jacking method are conceivable. Pipe can not be attached existing bridge since existing bridge wasn't designed pipe load as structure calculation. Considering construction cost, easiness of construction work and environmental aspect, pipe jacking method is supposed to be the most suitable method for river crossing.

However river crossing work by pipe jacking method will make construction cost higher than other the CASEs, and whole construction work in this project will be more complicated due to this special work (Pipe Jacking Method)

l) Construction Cost

Rough estimate construction cost for Option-4 is calculated as follows. This cost includes all facilities for water supply system and all kinds of work such as pipe work, civil work, architecture work, mechanical work and electrical work.

Water Intake:	5,800 thousand USD
Raw Water Transmission Pipe:	90,300 thousand USD
River Crossing:	5,600 thousand USD
Impounding Reservoir	45,600 thousand USD
SWTP:	45,000 thousand USD
Clear Water Transmission Pipe:	14,480 thousand USD
Distribution Reservoir	20,380 thousand USD
Overhead Tank	5,500 thousand USD
Distribution Pipe Network:	20,000 thousand USD
Service Pipe Connection:	15,000 thousand USD
Others:	4,000 thousand USD
Total Construction Cost	271,060 thousand USD
	Roundup ⇒ 272 million USD

m) Operation and Maintenance (O&M) Cost

Anticipated yearly expenditures as operation and maintenance for Option-4 is estimated 2,440 thousand USD/year which contains personnel expense, power cost, chemical cost, maintenance cost and others.

5) Option -5: Mollarhat

In this section, the planning criteria are based on preliminary assumptions. After the adequate option is adopted, these criteria have been modified as described on **Clause 6.4.4**.

a) Water Intake Point

Proposed water intake point of Option-5 is set at Mollarhat, 28 km north-east from Khulna city in order to reduce salinity influence. Raw water is taken from the Madhumati River. Impounding reservoir is required since salinity influence is expected for 80 days at this area. This site is at Mollarhat bridge on the Madhumati River in Bagerhat District. Latitude and longitude is “N22° 55’ 53.7”, E89° 48’ 30.8” respectively.


Photo 6.4.8 Intake Site of Option -5: Mollarhat

b) Amount of River Water

River water flow at the Madhumati River was measured by IWM on March 2009 as follows;

- Measurement Point: Mollarhat
- Time of the peak water level: 14:00 o'clock
- Observation hours to be studied: 17:00-19:00
- Average River Water Flow:
  (215.07+251.97+267.29+250.85+214.94) / 5 = 240.0 m^3/sec

Design intake water flow is calculated as follows considering 10% as water loss at raw water transmission pipe and at SWTP;

110,000m^3/day = 1.27m^3/sec

The Madhumati River possesses enough water flow as water intake since the intake water flow accounts for only 0.52 percent of river water flow at MBR shown below.

1.27 / 240.0 = 0.00529 = 0.52% < 5% *) <u>OK</u>

Note: 5% is considered safety amount to intake water from the river

c) Land Acquisition for Water Intake

Land acquisition procedure is not complicated because water supply facilities are located in Khulna Division.

d) Salinity Condition

Based on the analysis on the previous measured records and current JICA Study Team's measuring record for the new water supply system it is better to provide an impounding reservoir of which retention period is 45 days.

e) Water Quality

According to water quality analysis conducted by JICA Study on February 2010 shown in **Chapter 5**, important water quality items for this option is shown in following Table.

Table 6.4.6 Water Quality Data at Mollarhat

Items	Turbidity	pH	BOD	Mercury (HG)	Iron (Fe)	Manganese (Mn)	Chloride (Cl^-)
Standard	10 JTU	6.5 - 8.5	< 0.2mg/L	< 0.001mg/L	< 0.3 - 1.0mg/L	< 0.1mg/L	< 1,000mg/L
Water Quality	16	8.6	3.5	0	0.42	0	79

Some water quality data is exceeded standard value. But these can be purified by normal water treatment process. Some water quality is exceeded standard value. But these can be purified by universal water treatment process.

f) Electricity Power Service

Leading electricity service line to the water intake is supposed to be easy and shared cost will not be costly (less than 120,000 TK) because there is 11 kV electricity main cable within 1 km from water intake point.

g) Impounding Reservoir

An Impounding reservoir, of which retention period is 45 days, requires land 60 ha.

h) Surface Water Treatment Plant (SWTP)

Normal water treatment process (Rapid Sand Filter Process) is applied because SWTP for Option-5 doesn't need to treat raw water which contains chloride. Impounding reservoir collects raw water from river during non-salinity period, and sends water to SWTP during salinity period.
Some water quality data is exceeded standard value shown in **Table 6.4.6**. But these can be purified by normal water treatment process.
Proposed SWTP location is Samanto Sena along Bahirdia-Baghmara Road outside of Khulna city shown in **Figure 6.4.3**. Required land for SWTP is estimated about 10 ha for normal water treatment process.

i) Raw Water Transmission Pipe

Long distance raw water transmission pipe line, diameter of 1350 mm and the length of 35 km, is required. Larger diameter pipe is required in order to reduce pipe friction loss which occurred by long length pipe.
Pipeline starts from Mollarhat water intake point and passes Dhaka road and abolished railway route, then arrives at SWTP.

j) Clear Water Transmission Pipe

Clear water transmission pipe starts from SWTP and across the Rupsha River, then into Khulna city. This pipeline branches off in Khulna city and leads to distribution reservoir.

k) Construction Work

Impounding Reservoir

A large scale construction work will be necessary to construct huge impounding reservoir. The construction period of the reservoir is estimated about eight (8) months.

River Crossing

River crossing is necessary for Option-5 at one river shown below.

	River Name	Width	Crossing Pipe
1	Rupsha River	600m	Clear Water Transmission Pipe, Dia 1100mm

Photo of river crossing points are shown in **Photo 6.4.4**.

As river crossing method, attached pipe on the existing bridge, construction of water pipe bridge and installation of pipe under the river by tunnelling method such as shield method or pipe jacking method are conceivable. Pipe can not be attached existing bridge since existing bridge wasn't designed pipe load as structure calculation. Considering construction cost, easiness of construction work and environmental aspect, pipe jacking method is supposed to be the most suitable method for river crossing.

However river crossing work by pipe jacking method will make construction cost higher than other Option-6 and 7, and whole construction work in this project will be more complicated due to this special work (Pipe Jacking Method)

l) Construction Cost

Rough estimate construction cost for Option-5 is calculated as follows. This cost includes all facilities for water supply system and all kinds of work such as pipe work, civil work, architecture work, mechanical work and electrical work.

Water Intake:	5,800 thousand USD
Raw Water Transmission Pipe:	70,000 thousand USD
River Crossing:	4,200 thousand USD
Impounding Reservoir	65,000 thousand USD
SWTP:	45,000 thousand USD
Clear Water Transmission Pipe:	14,480 thousand USD
Distribution Reservoir	20,380 thousand USD
Overhead Tank	5,500 thousand USD
Distribution Pipe Network:	20,000 thousand USD
Service Pipe Connection:	15,000 thousand USD
Others:	4,000 thousand USD
Total Construction Cost	269,360 thousand USD
	Roundup ⇒ 270 million USD

m) Operation and Maintenance (O&M) Cost

Anticipated yearly expenditures as operation and maintenance for Option-5 is estimated 2,390 thousand USD/year which contains personnel expense, power cost, chemical cost, maintenance cost and others.

(3) Outline of CASE-B: Phultala (Option-6)

1) Option -6: Phultala

a) Water Intake Point

Proposed raw water intake point is located at Phultala Ghat, along with Bhairab River located north to Khulna City 15 km away. Raw water is taken from the Bhairab River. Though this intake point is supposed to be affected by salinity around 150 days a year, huge Beel as shallow lake is located nearby, converting this into large-scaled impounding reservoir is possible as countermeasure to saline water intrusion. Latitude and longitude is “N22° 56’ 26.1”, E89°29’ 39.8” respectively.

Photo 6.4.9 Intake Site of Option -6: Phultala

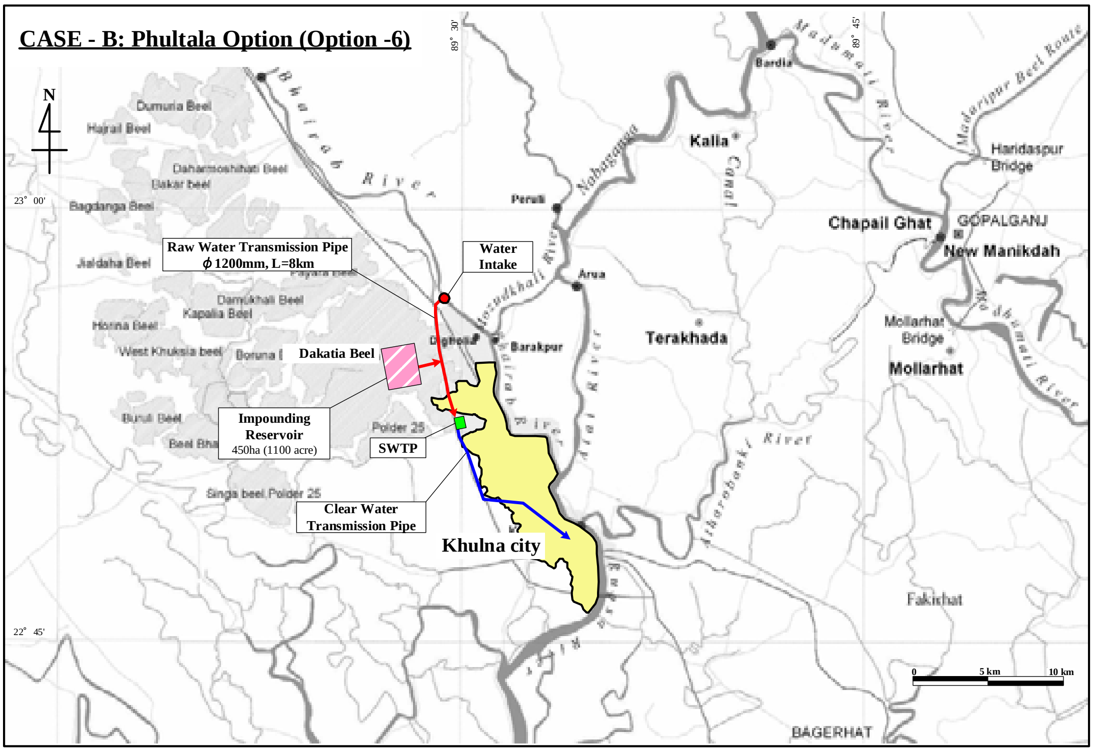


Figure 6.4.3 Outline of CASE-B (Option-6)

b) Amount of River Water

River water flow at the Bhairab River was measured by IWM on April 2009 as follows;

- Measurement Point: Phultala
- Time of the peak water level: 15:30
- Observation hours to be studied: 18:30
- Average River Water Flow: 149.0 / 1 = 149.0 m^3/sec

Design intake water flow is calculated as follows considering 10 % as water loss at raw water transmission pipe and at SWTP;

110,000 m^3/day = 1.27 m^3/sec

The Bhairab River possesses enough water flow as water intake since the intake water flow accounts for only 0.85 percent of river water flow at Bhairab River shown below.

1.27 / 149.0 = 0.00852 = 0.85% < 5% $^{*)}$ OK

Note: 5% is considered safety amount to intake water from the river

c) Land Acquisition for Water Intake

Land acquisition procedure is not complicated because water supply facilities are located in Khulna Division.

d) Salinity Condition

According to salinity investigation at Phultala conducted by DOE on 2005 to 2009 exceeded Chloride concentration day can be supposed as 150 days.

e) Water Quality

According to water quality analysis conducted by JICA Study on February 2010 shown in **Chapter 5**, important water quality items for this Option is shown in following Table.

Table 6.4.7 Water Quality Data at Phultala

Items	Turbidity	pH	BOD	Mercury (HG)	Iron (Fe)	Manganese (Mn)	Chloride (Cl^-)
Standard	10 JTU	6.5 - 8.5	< 0.2mg/L	< 0.001mg/L	< 0.3 - 1.0mg/L	< 0.1mg/L	< 1,000mg/L
Water Quality	90	7.6	12	0	9.38	0.1	802

Some water quality data is exceeded standard value. But these can be purified by normal water treatment process. Some water quality is exceeded standard value. But these can be purified by universal water treatment process.

f) Electricity Power Service

Leading electricity service line to the water intake is supposed to be easy and shared cost will not be costly (less than 120,000 TK) because there is 11 kV electricity main cable within 1 km from water intake point.

g) Impounding Reservoir

Impounding reservoir is necessary since salinity influence period is considered about 150 days based on DOE data done in 2005 to 2009 at Phultala. Required land for impounding reservoir to storage raw water for salinity period is estimated about 450 ha (1100 acre).
Impounding reservoir is proposed at Dakatia Beel about 2km to the west of the Khulna Bypass Road

h) Surface Water Treatment Plant (SWTP)

Normal water treatment process (Rapid Sand Filter Process) is applied because SWTP for Option-6 doesn't need to treat raw water which contains chloride. Impounding reservoir collects raw water from river during non-salinity period, and sends water to SWTP during salinity period.
Some water quality data is exceeded standard value shown in **Table 6.4.7**. But these can be purified by normal water treatment process.
Proposed SWTP location is Arangghata at the crossing of Khulna Bypass Road and Satkhiro Road. Required land for SWTP is estimated about 10ha for normal water treatment process.

i) Raw Water Transmission Pipe

Raw water transmission pipe line, diameter of 1200 mm and the length of only 8 km, is required. Pipeline starts from Phultala water intake point and passes Khulna Bypass, then arrives at SWTP. There is no big river crossing for this raw water transmission pipe.

j) Clear Water Transmission Pipe

Clear water transmission pipe starts from SWTP to Khulna city. There is no big river crossing for this clear water transmission pipe.

k) Construction Work

Impounding Reservoir

A large scale construction work will be necessary to construct huge impounding reservoir. Yearly construction period is estimated about eight (8) months because construction work, especially earth work for impounding reservoir, won't be conducted during rainy season in Bangladesh. But the construction work will be able to complete within three (3) years construction period to set to work one reservoir by one reservoir for 20 reservoirs in total.

l) Construction Cost

Rough estimate construction cost for Option-6 is calculated as follows. This cost includes all facilities for water supply system and all kinds of work such as pipe work, civil work, architecture work, mechanical work and electrical work.

Water Intake:	4,560 thousand USD
Raw Water Transmission Pipe:	18,300 thousand USD
Impounding Reservoir	50,600 thousand USD
SWTP:	45,000 thousand USD
Clear Water Transmission Pipe:	12,230 thousand USD
Distribution Reservoir	20,380 thousand USD
Overhead Tank	5,500 thousand USD
Distribution Pipe Network:	20,000 thousand USD
Service Pipe Connection:	15,000 thousand USD
Others:	3,000 thousand USD
Total Construction Cost	194,570 thousand USD
	Roundup ⇒ 195 million USD

m) Operation and Maintenance (O&M) Cost

Anticipated yearly expenditures as operation and maintenance for Option-5 is estimated 2,120 thousand USD/year which contains personnel expense, power cost, chemical cost, and others.

(4) Outline of CASE -C: Khulna city (Option -7, 8)

Proposed raw water intake point is set by Rupsha River located within Khulna city area. The length of raw water transmission pipe can be minimized compared with the other 2 Cases. On the other hand, water intake in Khulna city is located nearer to the sea than those of the other cases and therefore the expected saline infected days was counted as 180 days a year. Further, as there are no available lands which can be utilizes for vast impounding reservoir within the city and its surroundings, some desalination process, is required in SWTP.

As to CASE-C, Option-7 and Option-8, they shall be examined and compared respectively by their proposed number of SWTP:

- Option -7 : Khulna city, One SWTP
- Option -8 : Khulna city, Two SWTPs

1) Option -7:Khulna city (One SWTP)

a) Water Intake Point

Proposed raw water intake point is located at Khulna city, along with Bhairab River.


Photo 6.4.11 Intake Site of Option -7 at the Bhairab River

Raw water is taken from the Bhairab River. Though this intake point is supposed to be affected by salinity around 180 days a year. Latitude and longitude is “N22° 52’ 57.4, E89°31’ 20.9” respectively.

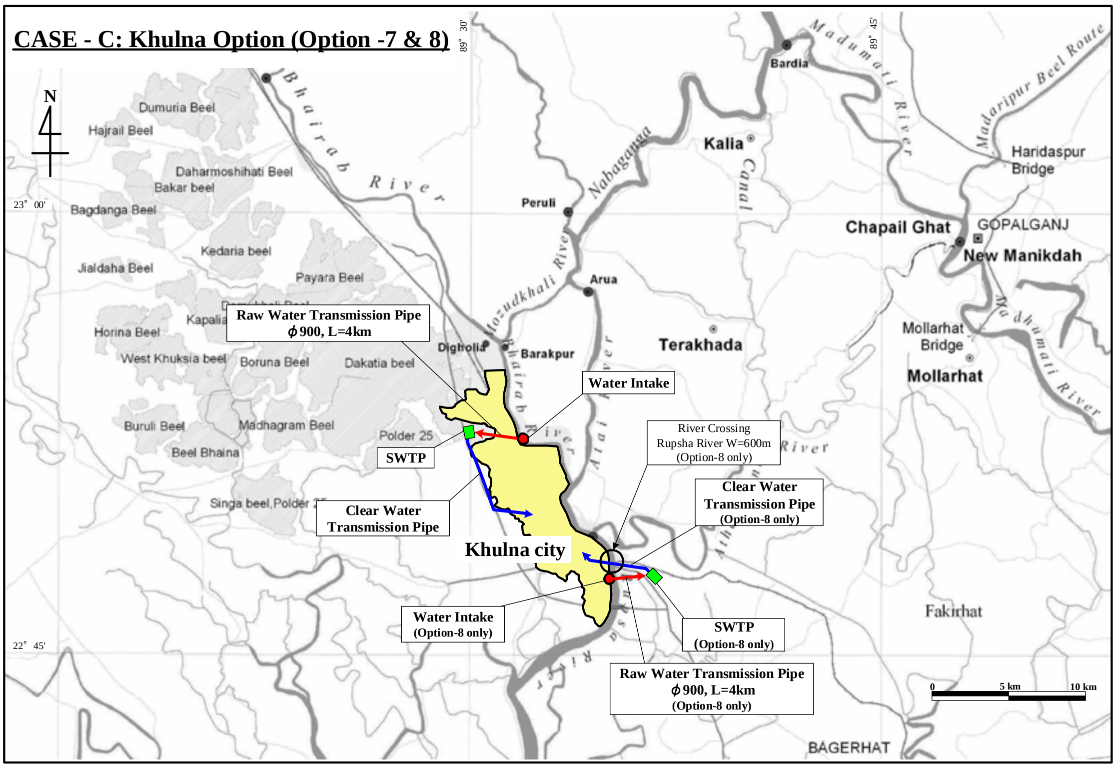


Figure 6.4.4 Outline of CASE-C (Option-7 and Option-8)

b) Amount of River Water

River water flow at the Bhairab River at Khulna city was measured by IWM on April 2009 as follows;

- Measurement Point: Khulna city
- Time of the peak water level: 19:00
- Observation hours to be studied: 13:00 - 10:00
- Average River Water Flow:

$$(2{,}692+2{,}695+2{,}650+2{,}859+2{,}690+2{,}530+2{,}380) / 7 = 2{,}640 \text{ m}^3/\text{sec}$$

Design intake water flow is calculated as follows considering 60 % as water loss at raw water transmission pipe and at SWTP and for desalination process;

$$100{,}000 \text{ m}^3/\text{day (Water Demand)} \times 160\ \% = 160{,}000 \text{ m}^3/\text{day} = 1.85 \text{ m}^3/\text{sec}$$

The Bhairab River at Khulna city possesses enough water flow as water intake since the intake water flow accounts for only 0.070 percent of river water flow at MBR shown below.

$$1.85 / 2{,}640 = 0.00070 = 0.070\% < 5\%^{*)} \quad \underline{\text{OK}}$$

Note: 5% is considered safety amount to intake water from the river

c) Land Acquisition for Water Intake

It is considered that acquisition of certain land for water supply facilities in Khulna city is difficult.

d) Salinity Condition

According to salinity investigation in Khulna city conducted by DOE on 2005 to 2009 shown in **Chapter 5**, salinity influence is conceived as follows;

- Exceeded Chloride Concentration: 180 days
- Maximum Chloride Concentration: 11,274 mg/L

e) Water Quality

According to water quality analysis conducted by JICA Study on February 2010 shown in **Chapter 5**, important water quality items for this Option is shown in following Table.

Table 6.4.8 Water Quality Data at Bhairab River in Khulna city

Items	Turbidity	pH	BOD	Mercury (HG)	Iron (Fe)	Manganese (Mn)	Chloride (Cl^-)
Standard	10 JTU	6.5 - 8.5	< 0.2mg/L	< 0.001mg/L	< 0.3 - 1.0mg/L	< 0.1mg/L	< 1,000mg/L
Water Quality	105	7.2	16	0	7.38	0.11	1,706

Some water quality data is exceeded standard value. But these can be purified by normal water treatment process. Some water quality is exceeded standard value. But these can be purified by universal water treatment process.

f) Electricity Power Service

Leading electricity service line to the water intake is supposed to be easy and shared cost will not be costly (less than 120,000 TK) because there is 11 kV electricity main cable within 1 km from water intake point.

g) Impounding Reservoir

Impounding Reservoir is not necessary because chloride will be treated desalination process in SWTP.

h) Surface Water Treatment Plant (SWTP)

Desalination process such as reverse osmosis (RO) process, similar to the membrane filtration treatment process, will be required in addition to Normal water treatment process (Rapid Sand Filter Process). Turbidity of water inflows to RO process must be less than 1 JTU (Jackson turbidity unit), and Moving Bed Bioreactor (MBBR) shall also be installed as pre-treatment process. Some water quality data is exceeded standard value shown in **Table 6.4.8**. But these can be purified by normal water treatment process. Outline of water treatment process for Option-7 is shown below;

Normal water treatment process (Rapid Sand Filter Process) + MBBR + Desalination Process (RO)

Proposed SWTP location is Arangghata at the crossing of Khulna Bypass Road and Satkhiro Road. Required land for SWTP is estimated about 20ha for normal water treatment process and desalination process. SWTP land area for Option-7 is larger than Option-1 to 6 since desalination process and MBBR is added to normal water treatment process.

i) Raw Water Transmission Pipe

Raw water transmission pipe line, diameter of 1200 mm and the length of only 4 km, is required. Pipeline starts from Khulna water intake point and passes Khulna city, then arrives at SWTP. There is no big river crossing for this raw water transmission pipe.

j) Clear Water Transmission Pipe

Clear water transmission pipe starts from SWTP to Khulna city. There is no big river crossing for this clear water transmission pipe.

k) Construction Work

Option-7 is not required a large scale construction work such as impounding reservoir and long distance pipe installation and special work for river crossing. But construction work of some facilities for desalination process and MBR in SWTP is necessary.

l) Construction Cost

Rough estimate construction cost for Option-7 is calculated as follows. This cost includes all facilities for water supply system and all kinds of work such as pipe work, civil work, architecture work, mechanical work and electrical work.

Water Intake:	4,540 thousand USD
Raw Water Transmission Pipe:	7,500 thousand USD
SWTP:	219,000 thousand USD
Clear Water Transmission Pipe:	12,230 thousand USD
Distribution Reservoir	20,380 thousand USD
Overhead Tank	5,500 thousand USD
Distribution Pipe Network:	20,000 thousand USD
Service Pipe Connection:	15,000 thousand USD
Others:	6,000 thousand USD
Total Construction Cost	308,650 thousand USD
	Roundup ⇒ 310 million USD

m) Operation and Maintenance (O&M) Cost

Anticipated yearly expenditures as operation and maintenance for Option-7 is estimated 10,150 thousand USD/year which contains personnel expense, power cost, chemical cost, maintenance cost and others.

2) Option -8:Khulna city (Two SWTPs)

a) Water Intake Point

Proposed raw water intake point is located at Khulna city. One is along with the Bhairab River and the other is along with the Rupsha River. Raw water is taken from the Bhairab River and the

Rupsha River. Though this intake point is supposed to be affected by salinity around 180 days a year. Latitude and longitude for the Bhairab River Intake is "N22° 52' 57.4, E89°31' 20.9" respectively, and for the Rpsha River Intake is "N22° 47' 09.0", E89°35' 13.8" respectively,


Photo 6.4.12 Intake Site of Option -8 for the Rupsha River

Photo for Intake Site of Option -8 for the Bhairab River is shown in **Photo 6.4.11**.

b) Amount of River Water

Intake from the Bhairab River

River water flow at the Bhairab River at Khulna city was measured by IWM on April 2009 as follows;

- Measurement Point: Khulna city
- Time of the peak water level: 19:00
- Observation hours to be studied: 13:00 - 10:00
- Average River Water Flow:

(2,692+2,695+2,650+2,859+2,690+2,530+2,380) / 7 = 2,640 m^3/sec

Design intake water flow is calculated as follows considering 60 % as water loss at raw water transmission pipe and at SWTP and for desalination process;

100,000 m^3/day (Water Demand) × 160 % =160,000 m^3/day = 1.85 m^3/sec (for two SWTPs)

The Bhairab River at Khulna city possesses enough water flow as water intake since the intake water flow accounts for only 0.070 percent of river water flow at MBR shown below.

1.85 / 2,640 = 0.00070 = 0.070% < 5% *) OK

Note: 5% is considered safety amount to intake water from the river

c) Land Acquisition for Water Intake

It is considered that acquisition of certain land for water supply facilities in Khulna city is difficult.

d) Salinity Condition

According to salinity investigation in Khulna city conducted by DOE on 2005 to 2009 shown in **Chapter 5**, salinity influence is conceived as follows;

- Exceeded Chloride Concentration Days: 180 days
- Maximum Chloride Concentration: 11,274 mg/L

e) Water Quality

According to water quality analysis conducted by JICA Study on February 2010 shown in **Chapter 5**, important water quality items for this Option is shown in following Table.

Table 6.4.9 Water Quality Data at Bhairab River in Khulna city

Items	Turbidity	pH	BOD	Mercury (HG)	Iron (Fe)	Manganese (Mn)	Chloride (Cl^-)
Standard	10 JTU	6.5 - 8.5	< 0.2mg/L	< 0.001mg/L	< 0.3 - 1.0mg/L	< 0.1mg/L	< 1,000mg/L
Water Quality	105	7.2	16	0	7.38	0.11	1,706

Some water quality data is exceeded standard value. But these can be purified by normal water treatment process. Some water quality is exceeded standard value. But these can be purified by universal water treatment process.

f) Electricity Power Service

Leading electricity service line to the water intake is supposed to be easy and shared cost will not be costly (less than 120,000 TK) because there is 11 kV electricity main cable within 1 km from water intake point.

g) Impounding Reservoir

Impounding Reservoir is not necessary because chloride will be treated desalination process in SWTP.

h) Surface Water Treatment Plant (SWTP)

Desalination process such as reverse osmosis (RO) process, similar to the membrane filtration treatment process, will be required in addition to Normal water treatment process (Rapid Sand Filter Process). Turbidity of water inflows to RO process must be less than 1 JTU (Jackson turbidity unit), and Moving Bed Bioreactor (MBBR) shall also be installed as pre-treatment process. Some water quality data is exceeded standard value shown in **Table 6.4.9**. But these can be purified by normal water treatment process.
Outline of water treatment process for Option-8 is shown below;

Normal water treatment process (Rapid Sand Filter Process) + MBBR + Desalination Process (RO)

Option-8 is proposed two SWTPs considering in case big problem in SWTP will be occurred. When one SWTP will be breakdown by some accident, the other SWTP can be used. Although two SWTPs is very safety by system wise, initial construction cost and O&M cost should be higher than one SWTP system. Proposed one SWTP site is at Arangghata at the crossing of Khulna Bypass Road and Satkhiro Road, and the other proposed SWTP site is at Bahirdia along Bahirdia-Baghmara Road outside of Khulna city.

Required land for SWTP is estimated about 30 ha for two SWTPs for normal water treatment process and desalination process. SWTP land area for Option-8 is larger than Option-1 to 7 since desalination process and MBBR is added to normal water treatment process and two SWTPs are is considered.

i) Raw Water Transmission Pipe

Two lines of raw water transmission pipe, diameter of 1200 mm and the length of 4 km for the Bhairab River Intake and 4 km for the Rupsha River Intake respectively, is required.

One Pipeline starts from water intake point at the Bhairab River and passes Khulna city, then arrives at SWTP at Arangghata, and the other pipeline starts from water intake point at the Rupsha River and arrives at SWTP at Bahirdia. There is no big river crossing for this raw water transmission pipe.

j) Clear Water Transmission Pipe

One clear water transmission pipe starts from SWTP at Arangghata into Khulna city, and the other pipeline starts from SWTP at Bahirdia and across the Rupsha River, then into Khulna city. These pipelines branch-off in Khulna city and lead to distribution reservoir.

k) Construction Work

Option-8 is not required a large scale construction work such as impounding reservoir and long distance pipe installation. But construction work of some facilities for desalination process and MBBR for two SWTPs are necessary. Also there is one river crossing for clear water transmission pipe mentioned below.

River Crossing

River crossing is necessary for Option-8 at one river shown below.

	River Name	Width	Crossing Pipe
1	Rupsha River	600m	Clear Water Transmission Pipe, Dia 1100mm

Photo of river crossing points are shown in **Photo 6.4.4**.

As river crossing method, attached pipe on the existing bridge, construction of water pipe bridge and installation of pipe under the river by tunnelling method such as shield method or pipe jacking method are conceivable. Pipe can not be attached existing bridge since existing bridge wasn't designed pipe load as structure calculation. Considering construction cost, easiness of construction work and environmental aspect, pipe jacking method is supposed to be the most suitable method for river crossing.

However river crossing work by pipe jacking method will make construction cost higher than Option -6 and 7, and whole construction work in this project will be more complicated due to this special work (Pipe Jacking Method)

l) Construction Cost

Rough estimate construction cost for Option-8 is calculated as follows. This cost includes all facilities for water supply system and all kinds of work such as pipe work, civil work, architecture work, mechanical work and electrical work.

Water Intake:	6,200 thousand USD
Raw Water Transmission Pipe:	12,000 thousand USD
SWTP:	284,700 thousand USD
Clear Water Transmission Pipe:	15,700 thousand USD
Distribution Reservoir	20,380 thousand USD
Overhead Tank	5,500 thousand USD
Distribution Pipe Network:	20,000 thousand USD
Service Pipe Connection:	15,000 thousand USD
Others:	7,000 thousand USD
Total Construction Cost	387,350 thousand USD
	Roundup ⇒ 390 million USD

Construction cost is the highest in Option-1 to 7 since initial cost for desalination process and MBBR for two SWTPs are considerably expensive.

m) Operation and Maintenance (O&M) Cost

Anticipated yearly expenditures as operation and maintenance for Option-8 is estimated 10,900 thousand USD/year which contains personnel expense, power cost, chemical cost, maintenance cost and others.
O&M cost is the highest in Option-1 to 7 since power cost and chemical cost for desalination process for two SWTPs are beyond acceptable price.

(5) Social And Environmental Consideration

Those categorized shall be justified in accordance with DOE guidelines for a project in Bangladesh. The project for a new water supply system is assumed to utilize international aid fund; i.e. JICA and ADB. This means the new project also shall be justified in accordance with JICA and ADB guidelines in addition to DOE guidelines. Those guidelines require that social and environmental impact of the project shall be taken into considered for three categories (1) Social Environment, (2) Natural Environment, and (3) Pollution Aspect. And each category shall be considered following subjects;

(1) Social Environment

- Land Acquisition/Resettlement
- Economic Activities
- Traffic and Public Facilities

- Split of Communities
- Cultural Property
- Water Rights and Rights of Common
- Public Health Condition
- Waste
- Hazards (Risk)

(2) Natural environment

- Topography and Geology
- Soil Erosion
- Groundwater
- Hydrological Situation
- Coastal Zone
- Fauna Flora and Protected Area
- Meteorology
- Landscape

(3) Pollution aspect

- Air Pollution
- Water Pollution (Surface &Groundwater)
- Soil Contamination
- Noise and Vibration
- Land subsidence
- Offensive Odour

The result of the justifications of the subjects of three categories as follows. (Referring to Appendix 6-2)

(6) Comparison of Alternative

As to Option -1 to 8, the following items was examined to compare these eight options.

- Intake River Flow Amount
- Water Intake Site
- Certainty in Water Treatment
- Raw Water Transmission Pipe Diameter & Length
- Impact of Salinity and Necessity of Impounding Reservoir
- Difficulty of Construction Work
- Easiness of Water Intake Control
- Easiness of SWTP O & M
- Construction Cost
- O & M Cost
- Social Environment
- Natural Environmental

➢ Pollution Aspect

Results of alternative comparison study are shown in **Table 6.4.10**.

According to comparison of water intake Option shown in **Table 6.4.11**, Option-5 is considered as the best option.

Table 6.4.10 Summary of Social and Environmental Justification Result

		Guidelines			Option 1-5			Option 6			Option 7-8		
		DOE	JICA	ADB	Project Components			Project Components			Project Components		
					IF	IR	WT	IF	IR	WT	IF	IR	WT
Social Environment	Land Acquisition/Resettlement	√	√	√	B	B	B	B	B	B	B	B	B
	Economic Activities	√	√	√	D	C	C	D	C	C	D	C	C
	Traffic and Public Facilities	√	√	√	D	D	D	D	D	D	D	D	D
	Split of Communities	√	√	√	D	C	C	D	C	C	D	C	C
	Cultural Property	√	√	√	D	D	D	D	D	D	D	D	D
	Water Rights and Rights of Common	√	√	√	C	C	C	C	C	C	C	C	C
	Public Health Condition	√	√	√	C	D	D	C	D	D	C	D	D
	Waste	√	√	√	D	D	D	D	D	D	D	D	D
	Hazards (Risk)	√	√	√	D	D	D	D	D	D	D	D	D
Natural Environment	Topography and Geology	√	√	√	D	C	C	D	C	C	D	C	C
	Soil Erosion	√	√	√	D	D	D	D	D	D	D	D	D
	Ground Water	√	√	√	D	D	D	D	D	D	D	D	D
	Hydrological Situation	√	√	√	D	D	D	D	D	D	D	D	D
	Coastal Zone	√	√	√	D	D	D	D	D	D	D	D	D
	Fauna Flora and Protected Area	√	√	√	C	C	C	C	C	C	C	C	C
	Meteorology	√	√	√	D	D	D	D	D	D	D	D	D
	Landscape	√	√	√	C	C	C	C	C	C	C	C	C
Pollution	Air Pollution	√	√	√	D	D	D	D	D	D	D	D	D
	Water r Pollution(Surface & Ground)	√	√	√	D	D	D	D	D	D	D	D	D
	Soil Contamination	√	√	√	D	D	D	D	D	D	D	D	D
	Noise and Vibration	√	√	√	D	D	D	D	D	D	D	D	D
	Land subsidence	√	√	√	D	D	D	D	D	D	D	D	D
	Offensive Odor	√	√	√	D	D	D	D	D	D	D	D	D

A: Serious impact will be expected
B: Some impact will be expected
C:Extent of impact is unknown(Further study will be required)
D:No impact will be expected

IF: Water Intake Facility
IR: Impounding Reservoir
WT: Water Treatment Plant

Table 6.4.11 Comparison of Water Intake Options

Comparison Issue	CASE -A (Option -1 to 5)		CASE -B (Option -6)		CASE -C (Option -7 & 8)	
Intake River Flow Amount	Ratio of Intake Flow to River Flow : 0.52 - 2.02%	D	Ratio of Intake Flow to River Flow : 0.85%	D	Ratio of Intake Flow to River Flow : 0.07 %	D
Certainty in Water Treatment	Some water quality is exceeded standard value; however these can be purified by universal process.	D	Some water quality is exceeded standard value; however these can be purified by universal process.	C	Some water quality is exceeded standard value; however these can be purified by universal process.	C
Raw Water Transmission Pipe Diameter	φ1,350mm、33km - 62km	C	φ1,200mm 、8km	C	φ1,200mm 、4km	C
Impact of Salinity and Necessity of Impounding Reservoir	Salinity Influence Period: 0- 30 days Larger Impounding Reservoir is necessary./ 0 -60 ha	B	Salinity Influence Period: 150 days Very large Impounding Reservoir is necessary. / 450 ha	A	Chloride is treated by desalination process in SWTP.	C
Difficulty of Construction Work	- Large Impounding Reservoir shall be constructed. - Special work (Pipe Jacking Method) is required for River Crossing	B	- Very Large Impounding Reservoir shall be constructed in a huge marsh. - Very difficult to be constructed with construction machines.	A	- No large scale of construction work - River Crossing work is necessary for Option-8.	B
Easiness of Water Intake Control	Water Intake far from Khulna city	C	Water Intake near Khulna city	D	Water Intake in Khulna city	D
Easiness of SWTP O&M	Normal Treatment Process is adopted.	D	Normal Treatment Process is adopted.	D	O&M for desalination process is very complicated.	A
Construction Cost	Option 1=295, Option 2= 275, Option 3=276, Option 4=272, Option 5=270 mil.USD	B	195 mil.USD Construction cost might be higher depending on construction method for Impounding Reservoir.	B	Option 7=310, Option 8= 390 mil.USD Due to Desalination Process, construction cost is the most expensive.	A
O&M Cost	2.39 – 2.57 mil.USD/year	C	2.17 mil.USD/year	C	10.15 – 10.90 mil.USD/year Due to Desalination Process	A
Social Environment	Land acquisition will have some impact	B	Land acquisition will have some impact	B	Land acquisition will have some impact	B
Natural Environmental	Topographical and landscape impact may possible to occur	C	Topographical and landscape impact may possible to occur	C	Topographical and landscape impact may possible to occur	C
Pollution Aspect	No impact will be expected	D	No impact will be expected	D	No impact will be expected	D
Evaluation	First Priority (Option 5)		Second Priority		Third Priority	

A: Serious issue will be expected, B: Some issue will be expected, C: Extent of issue is unknown, D: No issue will be expected

6.4.2 Water Treatment Plant

(1) Design Principle for Treatment

It is envisaged that conventional technologies such as found in the industrialized countries may sometimes be inappropriate, since the ability of the consumers to pay for water is small. So that plants constructed with expensive and imported technologies are not economically feasible. Even where capital costs are subsidized, operation and maintenance cost, which are born by the country concerned, increase proportionately with the complexity and sophistication of the treatment plant, resulting higher water charges for the consumer.

In general there is a shortage of skilled personnel to operate and maintain treatment plant in communities in Bangladesh. On the other hand, there is an abundance of unskilled labor, which makes labor-intensive technologies more attractive.

Accordingly, the following technical principles are recommended:

1) To the extent of possible, the utilization of mechanical equipment should be limited to that produced locally.
2) Hydraulically based device that use gravity for such work as mixing, flocculation, and filter rate control are preferred over mechanized equipment.
3) Mechanization and automation are appropriate only where operations are not readily done manually, or where they greatly improve reliability.
4) Indigenous materials and manufactures should be used to reduce costs and to bolster the local economy and expand industrial development.

(2) Conditions for Treatment Process

Broad choices available in water treatment make it possible to produce virtually any desired quality of finished water from any sources. Therefore, economic and operational considerations become the limiting constraints in selection of treatment units.

Water quality varies from place to place and forms season to season. And the resources for construction and operation vary from place to place, so that treatment plant selected must be based on the particular situation on respective site.

The primary influencing the selection of treatment process are:

1) Standard for potable water
2) Raw water quality and its variations
3) Local constraints
4) Relative costs of different treatment process.

The required raw water and treated water qualities are as shown in **Table 6.2.1** and **Table 6.2.2** in the previous section. The waters of the surrounding rivers of Khulna are highly turbid (exceed the potable water standard) having very high TDS and TSS.

(3) Basic Approach for Selection of Unit Process

1) Rapid Mixing

The function of a rapid mix system is to disperse coagulant uniformly throughout the entries mass of water with maximum possible rapidity in order to ensure that the coagulation process is as effective as possible. Rapid mix units are located at the head end of the plant and are designed to generate intense turbulence in the raw water by cither mechanical or hydraulic means.

The primary difference between mechanical and hydraulic rapid mixing devices is the manner by which they import turbulence in the incoming raw water. For mechanical rapid mixers the degree of turbulence is a function of the equipment’s horsepower and is largely independent of flow, whereas the degree of turbulence for hydraulic mixers is measured by the loss in head and is dependent on flow. Mechanical mixers are generally proprietary devices whose major technical advantages are the mixing is not a function of flow and they are flexible in adjusting the degree of turbulence to suit particular treatment needs. However, this advantage is of little consequence in places where the equipment cannot be kept in repair and where skilled operators are unavailable to make necessary adjustments.

Hydraulic rapid mixers are designed for either of two types of low conditions; open channel flow or pressure flow in pipes. When feasible, open channel flow in gravity channels is preferred; as such designs criminate costly pipes and fittings, and can reduce the total capital cost of the plant. The general types of open channel hydraulic mixers are 1) Hydraulic jump mixers, 2) flumes and 3) weirs.

2) Flocculation

Flocculation is the process of gentle and continuous agitation; during which suspended particles in the water coalesce into larger masses so that they may be removed from the water in subsequent treatment process and like rapid mixing, the agitation may be induced wither by mechanical or hydraulic means.

Mechanical flocculators are preferred in the industrialized countries because of their greater versatility; that is the speed of the mechanically operated paddles can be adjusted to suit variations in flow, temperature, or raw water quality. The principal elements of mechanical flocculator systems are agitator impellers, drive motors, speed controllers and reducers, transmission systems, shafts and bearings.

A more practical approach is to use hydraulic flocculators that do not require mechanical equipment, or continuous power supply if gravity flow is available, and which can be built primarily from concrete, brick, wood or masonry by local labor at relatively low cost.

In baffled channel flocculation, mixing is accomplished by reversing the flow of water through channels formed by around the end or over-and-under baffles. Baffled channel flocculators are limited to relatively large treatment plants, say greater that 10000 m^3/day capacity, where the flow rates can maintain sufficient head losses in the channels for slow mixing with requiring that baffles be spaced too close together, which would make cleaning difficult.

Horizontal-flow flocculators with around-the-end baffles are sometimes preferred over vertical-flow flocculators with over-and-under baffles because they are easier to drain and clean; also, the head loss which governs the degree of mixing, can be changed more easily be installing additional baffles or removing portions of existing ones.

3) Sedimentation

The sedimentation process in water treatment provides for the settling and removal of heavier and higher suspended particles from water. Most commonly, it is used for removal of flocculated particles prior to filtration. The removal efficiency in the sedimentation basin determines the subsequent loading on the filters and, accordingly, has a marked influence on their capacity, the length of filter runs, and the quality of the filtered water.

The two major classifications for the design of sedimentation basins are:

- Horizontal-flow units
- inclined-plate unit
- up-flow units

The advantage of up-flow units are, by combining the pre-treatment process that precede filtration, that substantial savings can be realized in construction costs and manpower requirements. Up-flow clarifiers perform quite well under suitable conditions and skilled supervision, provided their hydraulic capacity is not exceeded. When up-flow clarifiers are overloaded, sludge escapes from the blanket in large volumes and clogs the filters, interfering with the entire treatment process.

Horizontal-flow tanks without mechanical sludge removal are much to be preferred, because they require no importation of equipment, and labour for cleaning the tanks is readily available. Equally important, when horizontal-flow tanks are overloaded, most of the settle-able solids will still be removed, so that the filters can continue to operate normally.

<u>Horizontal-flow Sedimentation</u>

Horizontal-flow sedimentation is a gravity separation process in which a settling basin provides a quiescent of the tank. A well designed horizontal-flow sedimentation basin can remove up to 95 percent of raw water turbidity following effective coagulation and flocculation; the remaining turbidity is removed in the filters.

Rectangular horizontal-flow clarifiers without mechanical sludge removal are advantageous for small- or medium-scale plants because of their simplicity and ability to adapt to various raw water conditions, such as sudden changes in turbidity, flow increases, or too-high flow rates.

Circular-shaped basins are not appropriate, and their main advantage over rectangular basins is where circular mechanical sludge removal equipment is to be used.

<u>Sedimentation with Inclined-plates</u>

When inclined-plate is installed in either up-flow sludge blanket-type clarifiers or horizontal-flow basins, the unit can improve clarifier performance and increase the capacity of conventional clarifiers by 50 to 150 percent. Furthermore, it may also be incorporated into the design of new sedimentation basins, reducing the settling are to one-fourth to one-sixth of that required by conventional basins.

However, for communities in small countries, the use of inclined-plate should be limited, in most cases, to expand settling basin capacity and/or improving plant effluent quality and the use may be limited in hot and sunny climates where algae growth on plates can be a troublesome maintenance problem. The incorporation of settlers in the design of new plants for communities in small countries to reduce basin size and cost is usually not justified, because land is generally not restricted and low-cost labor and materials are available for construction of the settling tanks.

Further, when conventional settling tanks are installed during initial plant construction, the option remains for installing inclined-plate in the future.

<u>Up-flow Sedimentation</u>

Combining sludge-blanket type clarifiers with flocculation may be an appropriate technology for larger plants in urban centres. These clarifiers have no moving parts and, except for a few valves, require no mechanical equipment. They may be appropriate under the following conditions:

- Relatively constant raw water quality with turbidity not less that 10 NTU and not exceeding 900 NTU.
- Plants that are designed with enough excess capacity so that the unit process will not be overloaded, and
- Availability of skilled supervision.

In general, the surface loading rate and detention time, though they may be variant depending on the types such as slurry circulation type, sludge blanket type including palpitation type and compound type, are likely to be 50-85 m/day and 1.5 – 20 hr.

4) Filtration

Filtration is a physical, chemical, and in some instance biological process for separating suspended impurities for water by passage through porous media. Two general types of filters are commonly used in water treatment; the slow sand filter and the rapid sand filter. Because of higher filtration rates, the space requirement for a rapid filtration plant is about 20 percent of that required for slow sand filters.

The design variables for rapid filtration include 1) type of filter rate control, 2) type of filter media, 3) filter bottoms and under-drains, 4) backwashing arrangements and 5) auxiliary score wash systems. The principal consideration for 1), 2), 3) and 4) is given as follows:

Type of filter Rate Control

There are two ways of filtration, namely constant-rate filtration and declining-rate filtration. Applying these ways of filtration, only four types of filtration-rate control system have been often introduced and performed properly. These types are:

(a) Constant-rate filter with a flow meter and a flow control valve.
(b) Constant-level filter with an influent weir, a level sensor and a control valve
(c) Rising-level filter with an influent weir and without control and backwash valve
(d) Declining-rate filter with a flow restriction and without an influent weir

Among these types, (a) to (c) are categorized into constant-rate filtration, while (d) into declining-rate filtration.

The first constant-rate filter is highest in its cost and skill for maintenance due to precise devices among four types and has been losing its popularity. Another disadvantage of this type is that, when the control system is damaged, the filter is changed to the declining-rate filter, particularly at water treatment plants in developing countries.

The second constant-level filter is secondly highest in its cost and skill for maintenance.

The third rising-level filter is capable of backwashing a filter using the rest of filters in the same train and is referred to as a self-backwash filter. This type is always highly evaluated in developing countries because of its limited use of mechanical equipment such as backwash pumps and valves.

The fourth declining-rate filter is very simple to design and build and generally produces the good quality of water, if the initial filtration rate at the beginning of filtration cycle is properly controlled by an orifice etc. the disadvantage of this filter is that there is no clear indication for filter backwashing which is regularly done based on the duration time of filtration, even though the filter is still clean.

Through the above studies, the rising-level, constant filter with a self-backwash system is recommended.

Type of Filter Media

Sand has been used traditionally as the filter medium in water treatment plants because of its wide availability, low cost, and the satisfactory results that it has given. Sand filters remain the predominant method of filtration in many countries.

Dual-media filters possess several distinct advantages over conventional sand filters, 1) higher filtration rates (10 to 15 m/hr) that for conventional filters, resulting in a reduction in the total filters area and cost for a given design capacity; 2) longer filter runs at any given loading; and 3) the capacity of existing sand filters can be easily increased at low cost by the conversion to dual-media beds.

The latter advantage may be exceedingly beneficial to those communities in developing countries that are burdened with overloaded and inefficient treatment plants. Dual-media beds can be incorporated into an existing filtration system without changes in plant structure or method operation if the hydraulic capacity of the influent and effluent piping is adequate.

Filter Under Drain

The major requirements of the filter under drain system are the support of the filter media and the uniform distribution of the waste water across the entire filter bed. In many cases, bottoms can be reinforced concrete slabs with plastic strainers, pre-cast concrete percolated block, or glass-tube orifices, or simple perforated-pipe lateral systems.

The precast concrete perforated under drain systems, as commonly adopted, is constructed with long reinforced concrete V-blocks that are inverted and supporting graded gravel layers. The advantages of this under drain are simplicity of design and low head loss duding back washing.

The perforated pipe lateral system consists of a central manifold pipe to which are attached a series of lateral pipes with orifices to distribute waste water or to collect the filtered water. The losses through the orifices are kept comparatively high (about 1 to 3 m) to maintain uniform distribution of backwash water.

The number and depths of the gravel layers, both to support of the media during filtration and to contribute to uniform distribution of backwash water, depend on the size of openings in the under drain. Larger openings require a deep gravel layer, and hence a deeper filter box, but have reduced head loss during backwashing. Smaller openings, such as the slots in nozzles, require only the finer gravel layers but have higher head loss.

Backwash Arrangements

The purpose of backwashing is to remove the suspended material that has been deposited in the filter bed during the filtration cycle. When a filter is backwashed, and upward flow is introduced at a rate sufficient to fluidize the filter media. Rates of backwash need to be high enough to fluidize all the filter media, but not to be higher. The percent of expansion that accompanies any rate is a function of the size and specific gravity of the media, and temperature of the water.

Most of the head loss occurs in the under drain system (1 to 3m), although self-backwash or inter-filter-washing units are designed with relatively low head losses in the under drains (20 to 30 cm).

Three types of backwash arrangements that are suitable in this project will be (1) elevated waste water tanks, (2) taking waste water from the high-pressure distribution system tank, which is wasteful of energy but lower in installation costs, and (3) self-backwash or inter-filter-washing units. Further study regarding selection of these will, after arrangement of surveys and subsequent layouts of the facilities, be carried out.

5) Provision of Desalination Process Introduction

General

RO membrane has been globally adopted especially in isolated islands and Middle East Countries where fresh potable water source is scarce. Their major water source is seawater.

The water resource problem in Khulna City is while surface water and groundwater are abundantly available those resources are vulnerable to saline water intrusion. The saline water intrusion introduces raw water quality fluctuation. This will be the key issue when the introduction of RO membrane system is discussed.

In this report, issues on introduction of RO membrane in Khulna water supply system are summarized.

Conditions to be examined upon RO membrane introduction

Upon RO membrane introduction, normal water treatment procedure comprised of Flocculation Basin, Sedimentation Tank and Rapid Filter is needed at minimum as pre-treatment method. Further, if raw water contamination is accelerated, bioreactor is needed in addition to avoid membrane clogging. Typical diagrams of the RO membrane system are as shown below:

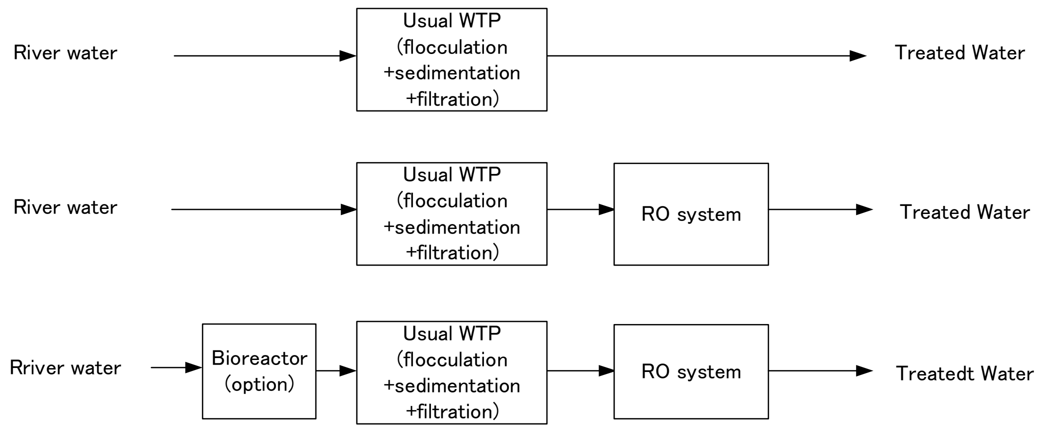


Figure 6.4.5 Diagrams of RO Membrane System

Current River Water Quality

Results of river water quality show high TDS, Total Dissolved Solids during dry season. Moreover, duration of high TDS period is considerably long.

According to JBIC report, chlorine ion concentration of river water in this area is increasing from 2005 to 2009. Comparing Bangladesh water quality standard of 1000 mg/L, chlorine ion concentration exceeds this standard in 4 to 6 months per year. Water quality data from April to June in 2007 shows extremely high concentration in Cl-, Turbidity, BOD and SO4-.

Major Design Conditions and Conceptual Diagram of RO Membrane

Figure 6.4.6 shows a conceptual diagram of RO membrane. Major design conditions are water temperature, water pressure at membrane inlet, water supply amount, recovery rate, raw water quality such as TDS and design treated water quality.

Depending on raw water quality typified by saline concentration, counting raw water amount as 100%, treated water amount is 70% and remaining 30% is concentrated drain to be disposed.

In case of RO membrane system, the water treatment plant capacity of 110,000 m^3/day (equivalent to water demand in 2025) will mean the capacity of 180,000 m^3/day for pre-treatment process.

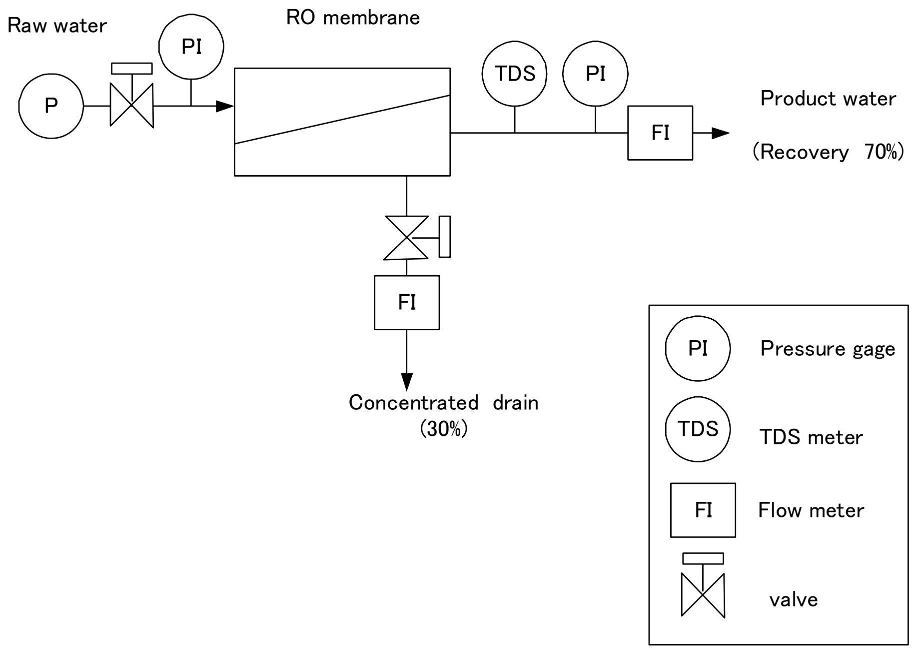


Figure 6.4.6 Conceptual Diagram of RO Membrane

Issues on RO Membrane Introduction

As shown in **Figure 6.4.7**, daily saline concentration in raw water is expected to be fluctuated largely by saline water intrusion. This makes plant operation very difficult; if saline concentration rises, treated water amount decreases, and if saline concentration decreases, treated water amount increases. This means fluctuation in saline content of raw water effects the whole plant operation including RO membrane and pre-treatment process.

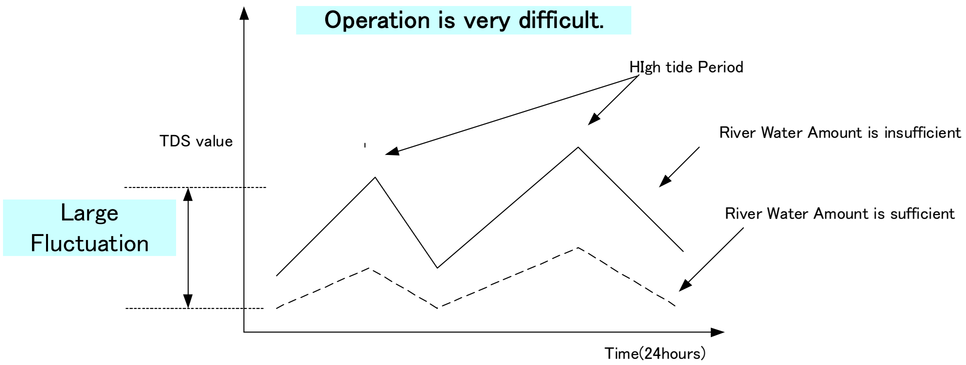


Figure 6.4.7 Conceptual Diagram of TDS Fluctuation

Technical issues and economic efficiency of RO system are summarized as follows:

i) System design and plant operation

- Design conditions and plant operation is not established providing large fluctuation of TDS concentration in raw water
- To prevent RO membrane clogging, turbidity of effluent from pre-treatment process shall be less than 1 NTU but it is remarkably difficult. 10 NTU is set by Bangladesh Standard.
- Membrane is vulnerable to organic matters and apt to be clogged if BOD and COD in raw water is high
- Daily chemical cleansing and periodical cleansing is needed. Handling of plural cleansing chemical is also complicated.
- Daily and yearly fluctuation record of water quality data on several ion contained in TDS is needed

ii) Construction Cost

- Normal water treatment process comprised of Coagulated Sedimentation and Sand Filtration is needed as pre-treatment process. As usual plant without RO membrane, necessary plant capacity is 110,000 m^3/day but if RO membrane is employed, capacity of 180,000 m^3/day is needed for pre-treatment process. Unit construction cost increases.
- If contamination of raw water is accelerated, bio-reactor is needed in addition. This also makes unit construction cost high.

iii) Operation and Maintenance Cost

- RO membrane replacement is needed every 3 to 5 years
- Consumable security filter shall be replaced several times a year
- Cleansing chemical cost
- Power consumption is 30 times compared with normal water treatment process
- Large-scaled generator is needed depending on power supply conditions

iv) Adoption of RO Membrane

Theory of RO membrane for sea water has been established and small – medium scaled plants have been constructed mainly by private sectors all over the world. However, RO system adoption in large-scaled plant and public sector is still scarce. Further, even the existing plants have insufficient operation period.

In Bangladesh, there is no RO membrane plant for public potable water. They are not also available in India. However, India has several small-scaled RO membrane plants for industrial use. Most of them have capacity of several thousand m^3/day.

v) Information on Ceramic Membrane

Experimental plant of MF membrane plant for potable water is available in Chang Mai, Thailand. Target raw water source is high turbidity river water and experiment has just started with period of 2009 to 2011.

There is possibility of introduction of MF membrane as pre-treatment of RO membrane and as alternative of usual water treatment process in future but it is not recommendable at present because its construction cost is three-times of usual plant.

vi) Conclusion

RO membrane is not recommendable owing to the following technical issues and economic efficiency:

- There is no RO membrane plant for potable water in Bangladesh
- RO membrane is not applicable for raw water with large saline concentration fluctuation
- Due to RO clogging caused by high BOD and turbidity, TDS fluctuation in raw water and combination with pre-treatment process, plant design and operation is quite difficult
- Construction and operation and maintenance cost is also high

As preparatory study, data collection by pilot plant is recommended; for example, to utilize the existing water treatment plant (capacity of 450 m^3/day) as a pilot plant, and collect yearly-wise and process-wise water quality data of raw water and treated water.

6.4.3 Water Distribution System

Water distribution pipeline is essential lifeline facility to supply safety potable water treated in surface water treatment plant to Khulna citizen, the consumers. To realize stable water supply with appropriate pressure and amount even in case of accident or natural calamities, the following items are indispensable:

- Whole service area shall be divided into several water distribution zones
- Distribution pipeline shall be earthquake resisting
- Deteriorated pipeline shall be replaced
- Expansion of direct supply area
- Formulation of distribution pipeline network including intercommunication pipes between plural water distribution zones

"Water distribution zone" means area comprised of distribution pipeline network, reservoir and overhead tank. In each zone, water pressure and supply amount is managed independently.

(1) Current Water Supply Status and Issues

Since the existing water distribution pipeline in Khulna City has been installed almost same period in 1960 when DPHE constructed groundwater tube wells pumps, 49 years has passed from then and they have been already deteriorated. Breakdown of the existing pipeline is shown below:

Table 6.4.12 Diameter-wise Total Pipe Length

Diameter	75mm	100mm	150mm	200mm	250mm	300mm	Total
Length(km)	2.64	150.1	72.5	-	2.5	-	227.74

The following 4 types of pipe materials are confirmed so far:

- GI Pipe (Galvanized Iron Pipe)
- AC Pipe (Asbestos Cement Pipe)
- MS Pipe (Mild Steel Pipe)
- PVC Pipe

However, their pipe diameter and installation locations are not obvious.

As Khulna City has flat topographic feature, pumping water supply is predominant. Total length of existing pipeline is still scarce and therefore only small area is served so far. Issues in current water supply are as follows:

- Pipe materials of existing pipeline are unknown
- Compared with population and city area, existing pipe length is quite insufficient
- Salinity, Bacillus Coli and high concentration Iron is detected from faucet water
- As public toilet and gutters are located near to groundwater wells, there is high risk of sewage infiltration to water distribution pipeline during well pump ceases
- Total water consumption amount can not be estimated since no water meters are installed
- As existing service area is not divided into distribution zones, supply water pressure management and prompt response against accident is seemed to be troublesome

According to the abovementioned, basic policy in water supply system improvement plan for Khulna City shall be as follows:

- Replacement of all deteriorated existing pipes
- Formulation of water distribution zones that ease to comprehend flow direction, water amount, water pressure and facilitate O&M activities, for not only in normal status but also in accidental status

(2) Concept of Water Distribution Zone Plan

Basic concept in water distribution zone plan of Khulna City is as follows:

1) Easiness in Present Status Comprehension

- Monitoring devises can be installed suitably
- Water management related data such as water amount, water pressure, flow direction and water quality can be easily acquired : Ease in data collection, management and analysis
- Water demand fluctuation monitoring in each zone will be easy and facilitate future water demand projection
- Water distribution pipeline development will be enabled in further systematic and rational manner

2) Upgrading in Water Distribution Management and O&M Activities

- Ease management in water pressure, water amount and water quality
- As leakage points and leakage amount can be easily detected and measured, water leakage inspection will be further efficient. Water outage area can also be minimized.

3) Advancement in Accidental Countermeasures

- By installation of intercommunication pipes between plural zones, water supply status in each zone will be stabilized even in natural calamity or accidental cases
- In case of natural calamities and accident, affected area can be ultimately specified. Further, their impacts can be estimated in advance.
- Early restoration will also be facilitates

4) Others

- Monitoring of water consumption in each zone will contribute to further efficient and rational water management covering all water distribution zones

(3) Comparison Study on Water Distribution Zone Alternatives

Khula City has slender area prolonged North to South. Jessore-Khulna Road and railway is crossing the central area. Khulna Bypass Road located in the West, branched from Jessore-Khulna Road at Phultala and connected to Rupsha Bridge.

Proposed construction site of SWTP is planned along with Khulna Bypass Road located City north and transmission pipe is also planned to be installed in the said road. Whole service area is divided into 3 to 10 distribution zone by each alternative and results of their comparison study is tabulated in **Table 6.4.13**. Outline of distribution zone in each alternative is summarized below:

Alternative-A : Assuming railway and trunk road as boundary, western area is divided into 2 zones and eastern area was planned to be 1 zone

Alternative-B : Whole city area is divided into 3 zones, namely North, Central and South zones

Alternative-C : Assuming railway and trunk road as boundary, western area is divided into 3 zones, while eastern area was divided into 2 zones

Alternative-D : Assuming railway and trunk road as boundary, western area is divided into 4 zones, while eastern area was divided into 3 zones

Alternative-E : Assuming railway and trunk road as boundary, western area is divided into 6 zones, while eastern area was divided into 4 zones

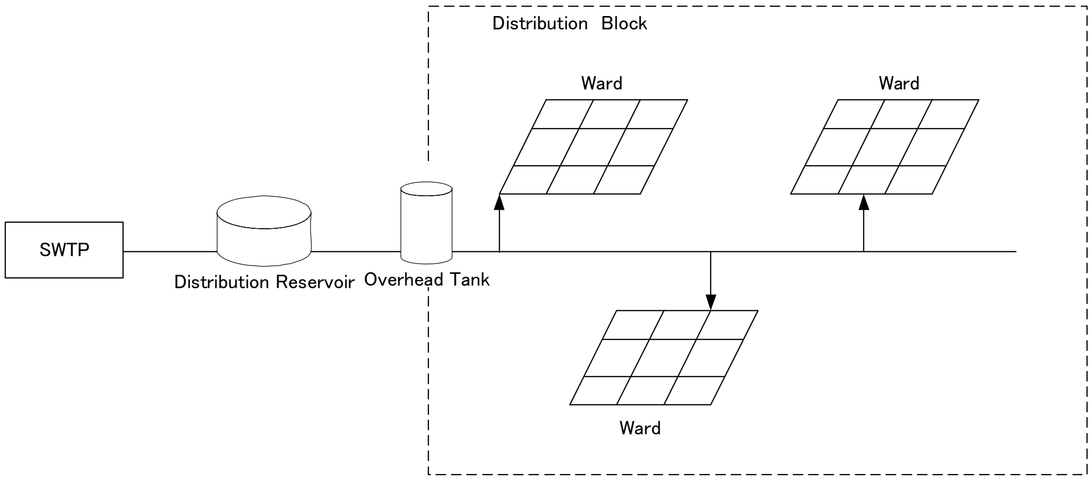


Figure 6.4.8 Outline of Water Distribution Zone Planning

(4) Recommended Alternative in Water Distribution Zone Plan

Khula City has slender area prolonged North to South like Japan. Jessore-Khulna Road and railway is crossing the central area. Khulna Bypass Road located a detour of the Khulna city through the West area. There is no undulation and almost flat in the land. Thus the distribution zones for the water supply are preferable balanced alternative plan for each supply area.

Now focus on the population of Khulna city, Central to South area of which is concentrated. Consequently, water demand of Central to South area is also concentrated and required the large amount. The results of alternative study on water distribution zone planning are shown in **Table 6.4.36**.

Alternative-A : The distribution area is becoming slender shape and difference in water pressure will effect among distribution reservoir, overhead tank and around the end point. Also design capacity will be higher due to the wide distribution area. Therefore, the initial stage of construction with less water demand must be affected water quality deterioration because of longer Hydraulic Retention Time (HRT) of distribution reservoir. Moreover, surface water resourced area and groundwater resourced area will be coexisted and it cause to the difficulty of steady water quality control.

Alternative-B : The distribution area is becoming equality shape compare with Alternative-A. However, the difference of the population and the water demand between North area and Middle-South area will be increased. Therefore, design capacity of each water supply facilities will be imbalanced and operation adjustment for distribution pumps will be difficult. Also, water quality deterioration will be concerned same as Alternative-A.

Alternative-C : The distribution area is becoming more equality shape than Alternative-A and B. However, the population and the water demand in Middle-South area will be balanced except for North area. Therefore, design capacity of each water supply facilities will be balanced and operation adjustment for distribution pumps will be easier except for North area. Furthermore, to meet the increasing future water demand, it is easier to adopt the supply area due to the finely divided zones.

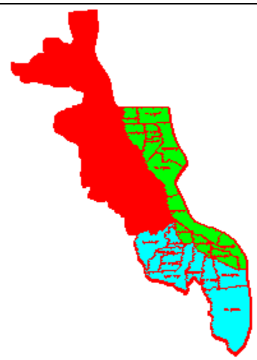
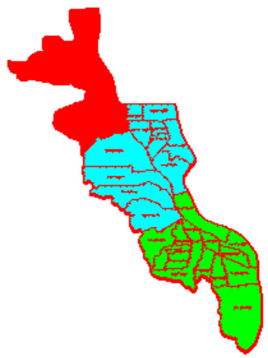
Alternative-D : The distribution area is becoming more equality shape than Alternative-A, B and C. The population and the water demand will be balanced except for Jute Mills area. However, number of check point for daily operation and maintenance will be increased due to its increasing facility numbers. Smaller size of water main pipe installation will be considered due to the small zones (area), in that case, newly installation of pipe or increase of pipe diameter may be required in the future expansion or update.

Alternative-E : The distribution area is the best equality shape among the all Alternatives. The population and the water demand will be balanced and no problem in the all area. However, the numbers of facilities are increased and design capacities are decreased along to the South area. Also, number of check point for daily operation and maintenance will be increased due to its increasing facility numbers. Smaller size of water main pipe installation will be considered due to the small zones (area) separation, therefore it is difficult to meet the future expansion or update such as initial cost increase along with the larger diameter installation for future.

- The propriety of initial cost investment
- Ease of expansion in the future
- Balance among zones
- Sensitive water management is difficult by 3 zones
- In reverse, as Alternatives composed by 7 to 10 zones have too many facilities, O&M activities become too complicated. Number of facilities might increase by future water demand growth.

Considering above study, Alternative-C is selected as the optimum Alternative.

Table 6.4.13 Alternative Study on Water Distribution Zone Planning

		Alternative-A	Alternative-B	Alternative-C	Alternative-D	Alternative-E
Outline		Assuming the railroad and trunk road as boundary, western area was divided into 2 zones and eastern area was planned to be served by 1 zone	As Khulna City has elongated service area ranging from north to south, area was divided into 3 zones, namely north, south and central zones	Assuming the railroad and trunk road as boundary, western area was divided into 3 zones and eastern area was divided into 2 zones	Assuming the railroad and trunk road as boundary, western area was divided into 4 zones and eastern area was divided into 3 zones	Assuming the railroad and trunk road as boundary, western area was divided into 6 zones and eastern area was divided into 4 zones
Zone Map						
Zone Population (2020year)	No1	409,370	192,290	192,290	192,290	130,370
	No2	432,400	505,270	336,790	217,080	120,950
	No3	472,230	616,440	312,690	90,920	158,050
	No4	-	-	288,190	223,820	119,710
	No5	-	-	184,040	184,040	157,810
	No6	-	-	-	208,580	154,880
	No7	-	-	-	197,270	153,400
	No8	-	-	-	-	90,920
	No9	-	-	-	-	124,920
	No10	-	-	-	-	102,990
No. of Distribution Reservoir		3	3	5	7	10
Distribution Reservoir Capacity (Retention Time=12h)	No1	17,000	8,000	8,000	8,000	5,000
	No2	18,000	21,000	14,000	9,000	5,000
	No3	20,000	26,000	13,000	4,000	7,000
	No4	-	-	10,000	9,000	5,000
	No5	-	-	8,000	8,000	7,000

		Alternative-A		Alternative-B		Alternative-C		Alternative-D		Alternative-E	
	No6	-		-		-		9,000		7,000	
	No7	-		-		-		8,000		6,000	
	No8	-		-		-		-		4,000	
	No9	-		-		-		-		5,000	
	No10	-		-		-		-		4,000	
Reservoir Location		No. of Reservoirs is 3, the minimum and design capacities of reservoirs are also well-balanced. Necessary site area is approx. 1 ha/reservoir.		No. of Reservoirs is 3, the minimum but design capacities of reservoirs are imbalanced. Necessary site area varies depending on capacity, ranging from approx. 0.6 to 1.2 ha/reservoir.		No. of Reservoirs is 5 and No.2 reservoir has the maxumum capacity. Necessary site area varies depending on capacity, ranging from approx. 0.6 to 1.0 ha/reservoir.		No. of Reservoirs is 7 and aside from No.3 reservoir with the minimum capacity, design capacities of other reservoirs are well-balanced. Necessary site area is ranging from approx. 0.6 to 0.9 ha/reservoir.		No. of Reservoirs is 10, the maximum but unit design reservoir capacity is the minimum. Necessary site area is ranging from approx. 0.3 to 0.5 ha/reservoir.	
No. of Overhead Tank		10		10		11		11		10	
Water Quality		・Surface water resource area and groundwater resource area are coexisted = difficulty of steady water quality control ・Larger volume and longer HRT of distribution reservoir cause water quality deterioration	△	・Surface water resource area and groundwater resource area can be separated = easy to control the steady water quality ・Distribution reservoir with larger volume and longer HRT cause water quality deterioration	△	・Surface water resource area and groundwater resource area can be separated = easy to control the steady water quality	◎	・Surface water resource area and groundwater resource area can be separated = easy to control the steady water quality	◎	・Surface water resource area and groundwater resource area can be separated = easy to control the steady water quality	◎
O&M		・Number of facilities are three (3), daily O&M check points are the minimum. ・Capacity balance of distribution reservoirs are good and easy to maintain the pump facilities.	○	・Number of facilities are three (3), daily O&M check points are the minimum. ・Capacity balance of distribution reservoirs are <u>not</u> good and difficult to maintain the pump facilities.	△	・Number of facilities are five (5), daily O&M check points are more than Alternative-A and B. The efficiency is good. ・Capacity balance of distribution reservoirs are good and easy to maintain the pump facilities.	◎	・Number of facilities are seven (7), daily O&M check points are more than Alternative-A, B and C. ・Capacity balance of distribution reservoirs are good except for one (1) reservoir and easy to maintain the pump facilities.	○	・Number of facilities are ten (10), daily O&M check points are the most. ・Capacity balance of distribution reservoirs are <u>not</u> good and difficult to maintain the pump facilities.	△
Expansion and Update		・Area of distribution zone are wide, therefore it takes long time for the expansion and update.	△	・Area of distribution zone are wide, therefore it takes long time for the expansion and update.	△	・Area of distribution zone are small, therefore the expansion and update are easier. ・Distribution zone can be divided to meet future population growth.	◎	・Area of distribution zone are small, therefore the expansion and update are easier in the zone.	○	・Area of distribution zone are small, therefore the expansion and update are easier. ・Distribution zone can be divided to meet future population growth.	○

	Alternative-A		Alternative-B		Alternative-C		Alternative-D		Alternative-E	
Emergency Correspondence	・Suspension of water supply area becomes wide = High damage ・Concentrate of citizens may cause some accident	△	・Suspension of water supply area becomes wide = High damage ・Concentrate of citizens may cause some accident	△	・Suspension of water supply area becomes small = Less damage	○	・Suspension of water supply area becomes small = Less damage	○	・Suspension of water supply area becomes small = Less damage	○
Balance of Water distribution	・Distribution volume is evenly. Less burden of SWTP and pump facilities. ・Water pressure difference effect distribution reservoir, overhead tank and end point	○	・Due to the wide distribution area, water pressure difference effect distribution reservoir, overhead tank and end point	△	・Distribution area is smaller than Alternative-A and B, larger than D and E. Balance of water distribution is moderation	○	・Distribution balance is good because of its small distribution area.	◎	・Distribution balance is very good because of its small distribution area.	◎
Effect on the Environment	・Requirements of huge area = felling of field and forest are required ・Large buildings effect a feeling of coercion to the inhabitants	△	・Requirements of huge area = felling of field and forest are required ・Large buildings effect a feeling of coercion to the inhabitants	△	・Requirements of area is smaller than Alternative-A and B. Environmental Impact is comparatively less.	◎	・Requirements of area is smaller than Alternative- A and B. Environmental Impact is comparatively less.	◎	・Requirements of area is smaller than Alternative- A and B. Environmental Impact is comparatively less.	◎
Land Acquisition	・Requirements of huge area , it is difficult to find it in the KCC area.	△	・Requirements of huge area , it is difficult to find it in the KCC area.	△	・Requirements of area is smaller than Alternative-A and B. Land acquisition is comparatively easier.	○	・Requirements of area is smaller than Alternative- A and B. Land acquisition is comparatively easier.	○	・Requirements of area is smaller than Alternative- A and B. Land acquisition is comparatively easier.	○
Construction Cost	44.0 mil.USD	△	41.4 mil.USD	○	40.3 mil.USD	○	44.4 mil.USD	△	51.8 mil.USD	△
Evaluation	△		△		◎		○		○	

Figure 6.4.9 Outline of Distribution System (Alternative-A)

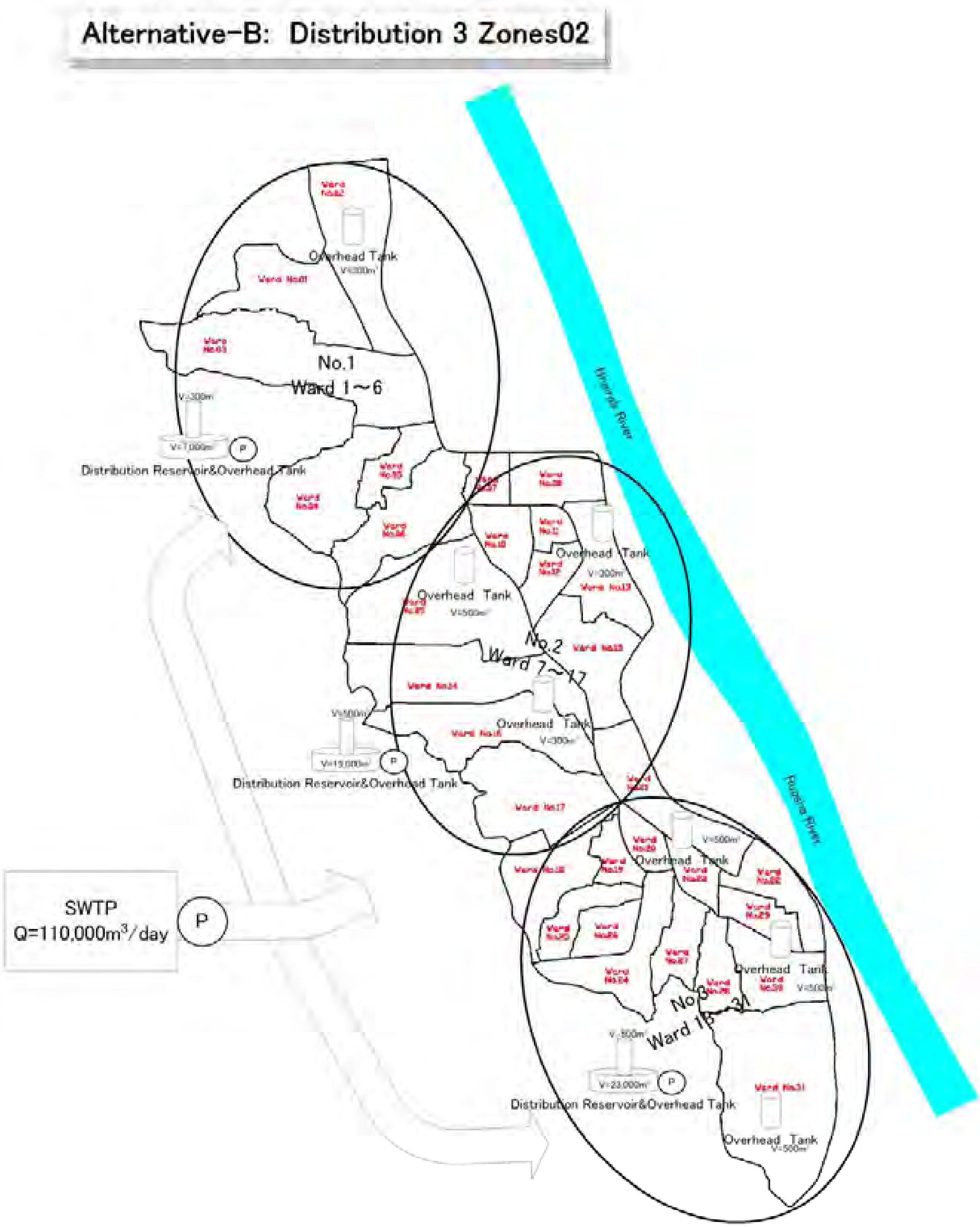


Figure 6.4.10 Outline of Distribution System (Alternative-B)

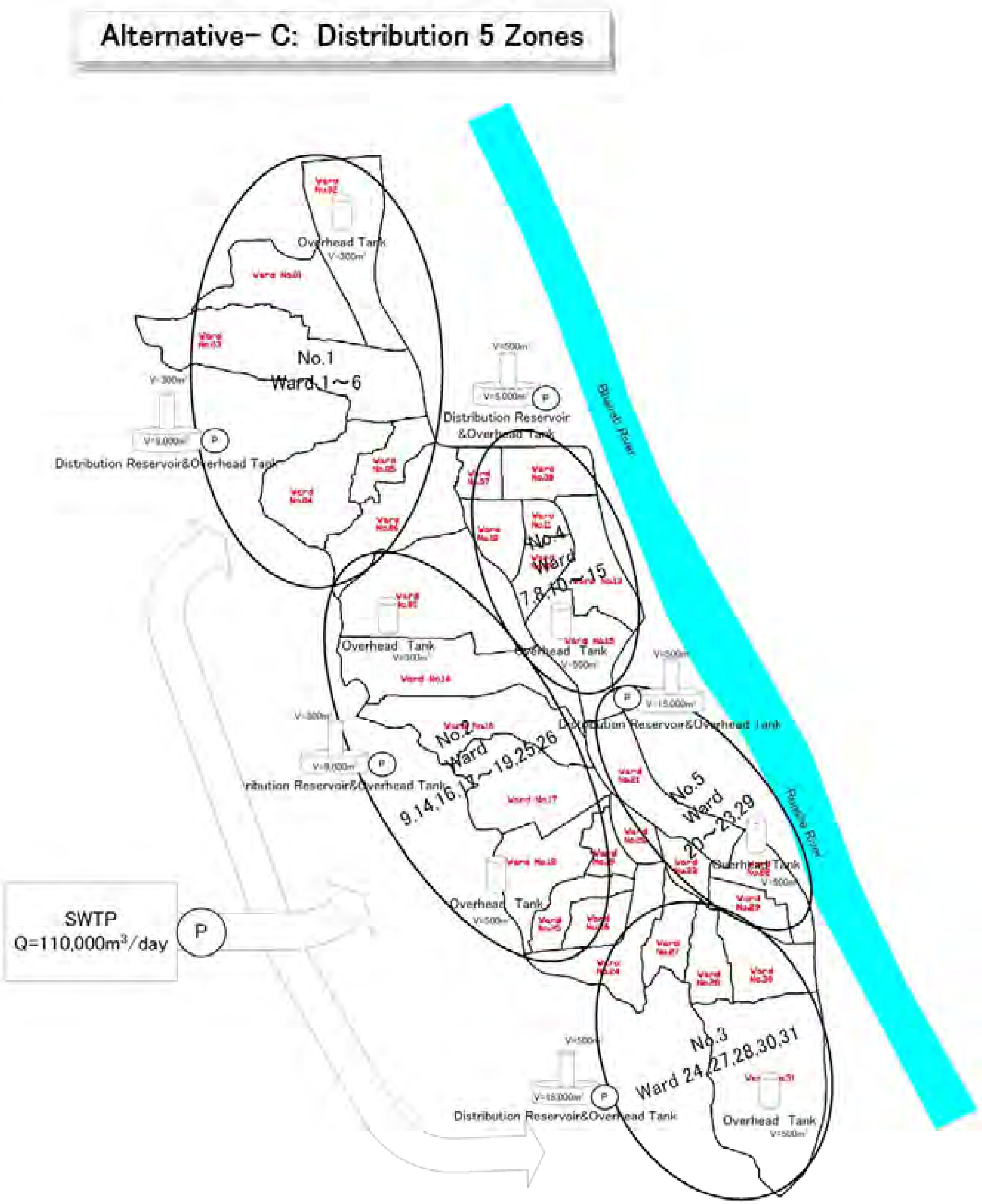


Figure 6.4.11 Outline of Distribution System (Alternative-C)

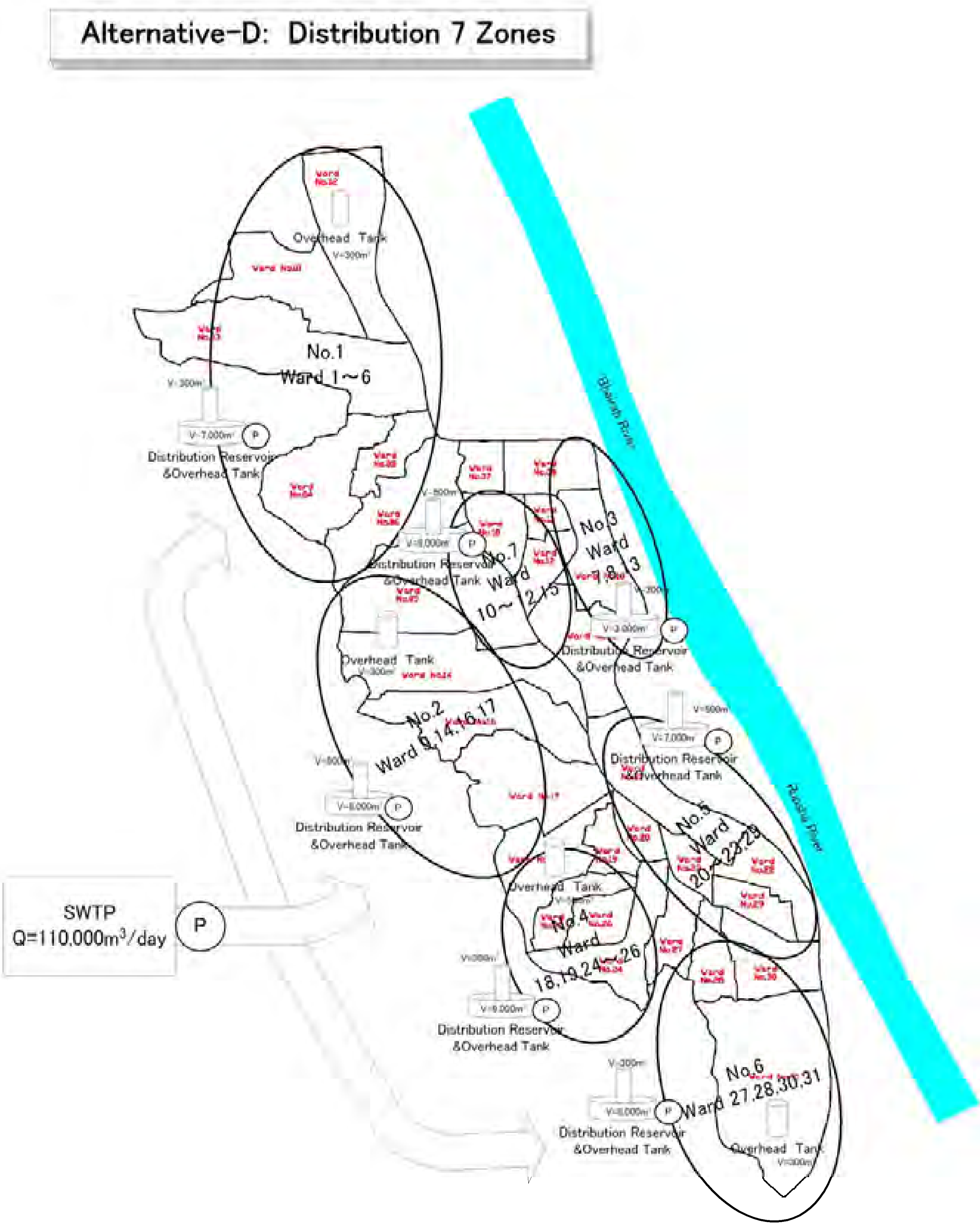


Figure 6.4.12 Outline of Distribution System (Alternative-D)

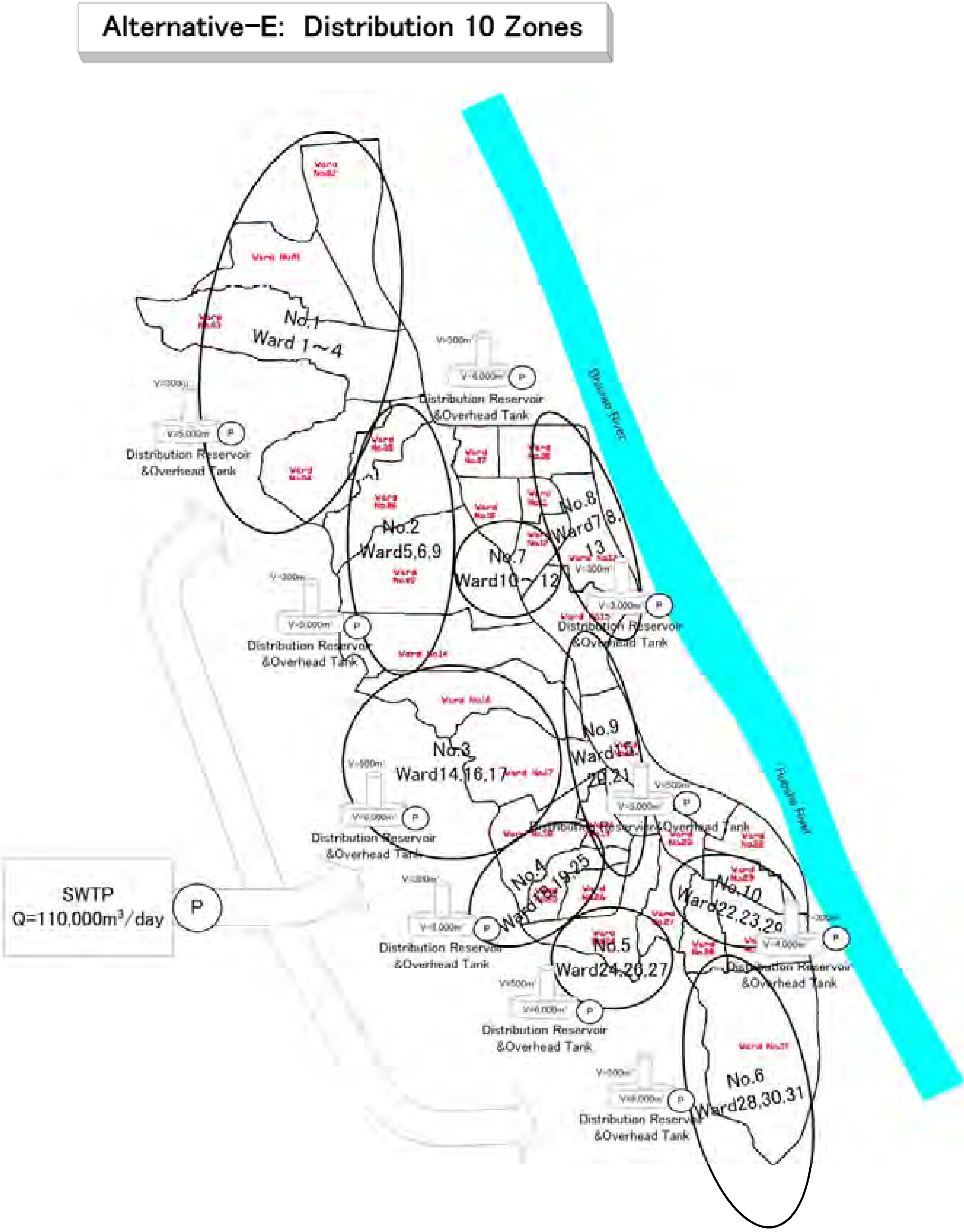


Figure 6.4.13 Outline of Distribution System (Alternative-E)

Table 6.4.14 Distribution Zone List

Alternative-A Distribution 3_Zones-01

Block	Ward	Population (2025)	Water Demand (m^3/day)	Reservoir Capacity (m^3)	Overhead Tank Capacity (m^3)
No.1	Ward 1	34,640	2,900	17,000	400
	Ward 2	32,090	2,700		
	Ward 3	39,250	3,300		
	Ward 4	24,390	2,000		300
	Ward 5	26,120	2,200		
	Ward 6	35,800	3,000		
	Ward 9	59,030	4,900		400
	Ward 14	45,100	3,800		
	Ward 16	61,190	5,100		400
	Ward 17	51,760	4,300		
No.2	Ward 18	28,590	2,400	18,000	400
	Ward 19	44,890	3,800		
	Ward 25	46,230	3,900		
	Ward 24	73,260	6,100		600
	Ward 26	30,850	2,600		
	Ward 27	53,700	4,500		
	Ward 28	38,210	3,200		500
	Ward 30	61,100	5,100		
	Ward 31	55,570	4,700		
No.3	Ward 7	25,250	2,100	20,000	500
	Ward 8	31,630	2,600		
	Ward 10	31,580	2,600		
	Ward 11	33,080	2,800		
	Ward 13	34,040	2,800		
	Ward 12	88,740	7,400		600
	Ward 15	43,870	3,700		
	Ward 21	42,610	3,600		
	Ward 20	38,440	3,200		500
	Ward 22	36,890	3,100		
	Ward 23	31,260	2,600		
	Ward 29	34,840	3,000		

Alternative-B Distribution 3_Zones-02

Block	Ward	Population (2025)	Water Demand (m^3/day)	Reservoir Capacity (m^3)	Overhead Tank Capacity (m^3)
No.1	Ward 1	34,640	2,900	8,000	400
	Ward 2	32,090	2,700		
	Ward 3	39,250	3,300		
	Ward 4	24,390	2,000		300
	Ward 5	26,120	2,200		
	Ward 6	35,800	3,000		
No.2	Ward 7	25,250	2,100	21,000	400
	Ward 8	31,630	2,600		
	Ward 9	59,030	4,900		
	Ward 10	31,580	2,600		500
	Ward 11	33,080	2,800		
	Ward 12	88,740	7,400		
	Ward 13	34,040	2,800		400
	Ward 14	45,100	3,800		
	Ward 15	43,870	3,700		
	Ward 16	61,190	5,100		400
	Ward 17	51,760	4,300		
No.3	Ward 18	28,590	2,400	26,000	500
	Ward 19	44,890	3,800		
	Ward 25	46,230	3,900		
	Ward 26	30,850	2,600		
	Ward 20	38,440	3,200		500
	Ward 21	42,610	3,600		
	Ward 22	36,890	3,100		
	Ward 23	31,260	2,600		
	Ward 24	73,260	6,100		600
	Ward 27	53,700	4,500		
	Ward 28	38,210	3,200		
	Ward 29	34,840	3,000		500
	Ward 30	61,100	5,100		
	Ward 31	55,570	4,700		

Alternative-C Distribution 5_Zones

Block	Ward	Population (2025)	Water Demand (m^3/day)	Reservoir Capacity (m^3)	Overhead Tank Capacity (m^3)
No.1	Ward 1	34,640	2,900	8,000	300
	Ward 2	32,090	2,700		
	Ward 3	39,250	3,300		
	Ward 4	24,390	2,000		300
	Ward 5	26,120	2,200		
	Ward 6	35,800	3,000		
No.2	Ward 9	59,030	4,900	14,000	300
	Ward 14	45,100	3,800		
	Ward 16	61,190	5,100		300
	Ward 17	51,760	4,300		
	Ward 18	28,590	2,400		500
	Ward 19	44,890	3,800		
	Ward 25	46,230	3,900		
No.3	Ward 26	30,850	2,600	13,000	500
	Ward 24	73,260	6,100		
	Ward 27	53,700	4,500		
	Ward 28	38,210	3,200		500
	Ward 30	61,100	5,100		
	Ward 31	55,570	4,700		
No.4	Ward 7	25,250	2,100	10,000	500
	Ward 8	31,630	2,600		
	Ward 10	31,580	2,600		
	Ward 11	33,080	2,800		
	Ward 12	88,740	7,400		500
	Ward 13	34,040	2,800		
	Ward 15	43,870	3,700		
No.5	Ward 20	38,440	3,200	8,000	300
	Ward 21	42,610	3,600		
	Ward 22	36,890	3,100		500
	Ward 23	31,260	2,600		
	Ward 29	34,840	3,000		

Alternative-D Distribution 7_Zones

Block	Ward	Population (2025)	Water Demand (m^3/day)	Reservoir Capacity (m^3)	Overhead Tank Capacity (m^3)
No.1	Ward 1	34,640	2,900	8,000	400
	Ward 2	32,090	2,700		
	Ward 3	39,250	3,300		
	Ward 4	24,390	2,000		300
	Ward 5	26,120	2,200		
	Ward 6	35,800	3,000		
No.2	Ward 9	59,030	4,900	9,000	400
	Ward 14	45,100	3,800		
	Ward 16	61,190	5,100		400
	Ward 17	51,760	4,300		
No.3	Ward 7	25,250	2,100	4,000	300
	Ward 8	31,630	2,600		
	Ward 13	34,040	2,800		
No.4	Ward 18	28,590	2,400	9,000	500
	Ward 19	44,890	3,800		
	Ward 24	73,260	6,100		
	Ward 25	46,230	3,900		300
	Ward 26	30,850	2,600		
No.5	Ward 20	38,440	3,200	8,000	600
	Ward 21	42,610	3,600		
	Ward 23	31,260	2,600		
	Ward 22	36,890	3,100		
	Ward 29	34,840	3,000		
No.6	Ward 27	53,700	4,500	9,000	300
	Ward 28	38,210	3,200		
	Ward 30	61,100	5,100		400
	Ward 31	55,570	4,700		
No.7	Ward 10	31,580	2,600	8,000	700
	Ward 11	33,080	2,800		
	Ward 12	88,740	7,400		
	Ward 15	43,870	3,700		

Alternative-E Distribution 10_Zones

Block	Ward	Population (2025)	Water Demand (m^3/day)	Reservoir Capacity (m^3)	Overhead Tank Capacity (m^3)
No.1	Ward 1	34,640	2,900	5,000	500
	Ward 2	32,090	2,700		
	Ward 3	39,250	3,300		
	Ward 4	24,390	2,000		
No.2	Ward 5	26,120	2,200	5,000	400
	Ward 6	35,800	3,000		
	Ward 9	59,030	4,900		
No.3	Ward 14	45,100	3,800	7,000	600
	Ward 16	61,190	5,100		
	Ward 17	51,760	4,300		
No.4	Ward 18	28,590	2,400	5,000	400
	Ward 19	44,890	3,800		
	Ward 25	46,230	3,900		
No.5	Ward 24	73,260	6,100	7,000	600
	Ward 26	30,850	2,600		
	Ward 27	53,700	4,500		
No.6	Ward 28	38,210	3,200	7,000	500
	Ward 30	61,100	5,100		
	Ward 31	55,570	4,700		
No.7	Ward 10	31,580	2,600	6,000	500
	Ward 11	33,080	2,800		
	Ward 12	88,740	7,400		
No.8	Ward 7	25,250	2,100	4,000	300
	Ward 8	31,630	2,600		
	Ward 13	34,040	2,800		
No.9	Ward 15	43,870	3,700	5,000	400
	Ward 20	38,440	3,200		
	Ward 21	42,610	3,600		
No.10	Ward 22	36,890	3,100	4,000	400
	Ward 23	31,260	2,600		
	Ward 29	34,840	3,000		

6.4.4 Size of Impounding Reservoir

(1) Necessity of Consideration

The proposed impounding reservoir requires a huge land of 60 ha for 45 days storage at Samanto Sena and also it demands a huge cost for construction and land acquisition. The size of the reservoir has been determined by the simplified statistic analysis based on the DOE's monthly chloride concentration monitoring record; however, its size shall be defined not by monthly base information but by a daily monitoring record. Meanwhile the JICA Study Team has conducted a continuous monitoring of chloride concentration in the river water at Mollarhat from the beginning of March in 2010. The monitoring will continue up to the end of June 2010.

It is necessary to consider to further possibility to reduce the size of the impounding reservoir for avoiding over investment and the risk of delay or stuck in the progress of the project due to lingering in land acquisition.

Hereinafter based on the result of the chloride concentration monitoring by the JICA Study Team an approach to reduce the size of the impounding reservoir is described.

(2) Original Scheme

In the Final Report the original scheme of the impounding reservoir is to reserve water for 45 days, is to serve water to the new Khulna water supply system for the high saline river water period at water intake point, Mollarhat. The required land at Samanto Sena is expected as for SWTP 10 ha and for the impounding reservoir 60 ha totally 70 ha as shown in **Figure 6.4.14**.

The high saline water period of 45 days is forecasted in future based on the DOE monitoring result for Chloride concentration at Mollarhat. The total cost of the option that to take water from Mollarhat is estimated as 270 million USD and only for the impounding reservoir it is estimated as 65 million USD. This expensive cost is caused by deep reservoir construction method with long steel sheet pile. The depth of the reservoir is planned to be 12 m.

Water Intake:	5,800 thousand USD
Raw Water Transmission Pipe:	70,000 thousand USD
River Crossing:	4,200 thousand USD
Impounding Reservoir	65,000 thousand USD
SWTP:	45,000 thousand USD
Clear Water Transmission Pipe:	14,480 thousand USD
Distribution Reservoir	20,380 thousand USD
Overhead Tank	5,500 thousand USD
Distribution Pipe Network:	20,000 thousand USD
Service Pipe Connection:	15,000 thousand USD
Others:	4,000 thousand USD
Total Construction Cost	269,360 thousand USD
	Roundup ⇒ 270 million USD

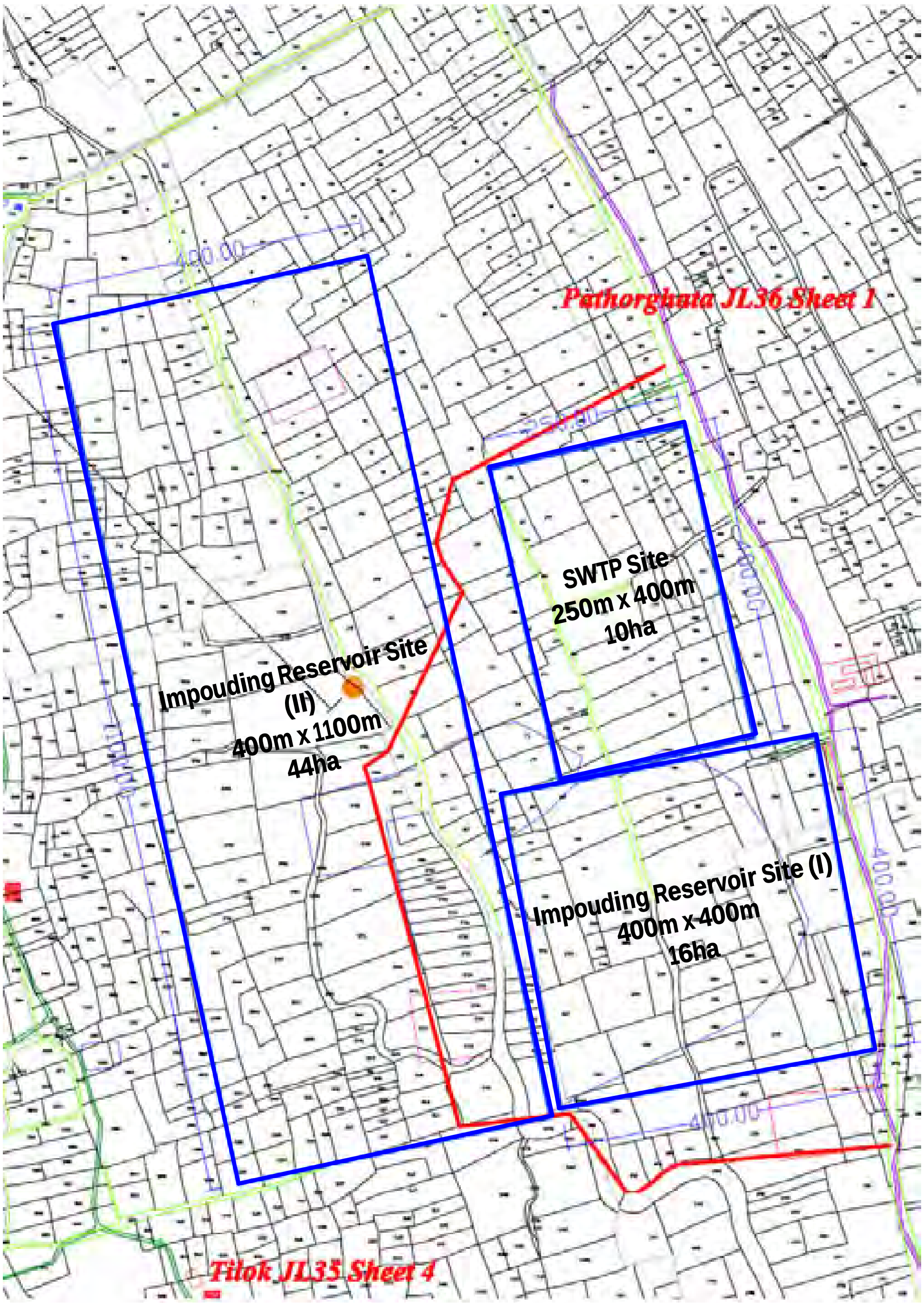


Figure 6.4.14 General Plan of Required Land at Samanto Sena

(3) Monitoring Result of Chloride Concentration

Monitoring of Chloride concentration of river water at Mollarhat has been conducted abut 4 months since March to July in 2010. In April, from 5th to 19th, for 15 days the Chloride concentration exceeded EQS limitation, 1,000 mg/L. After that the Chloride concentration has been decreasing continuously as shown in **Figure 6.4.15**.

Mollarhat	Chloride (mg/l)	
Date	High	Low
3/1	360	240
3/2	360	240
3/3	360	320
3/4	320	360
3/5	340	300
3/6	360	320
3/7	340	360
3/8	380	360
3/9	360	380
3/10	400	360
3/11	380	400
3/12	360	380
3/13	400	360
3/14	380	400
3/15	350	460
3/16	360	400
3/17	420	350
3/18	460	400
3/19	460	420
3/20	500	450
3/21	480	400
3/22	480	460
3/23	500	460
3/24	490	460
3/25	440	420
3/26	450	440
3/27	480	480
3/28	420	570
3/29	440	560
3/30	420	640
3/31	480	560

Mollarhat	Chloride (mg/l)	
Date	High	Low
4/1	520	690
4/2	580	720
4/3	630	880
4/4	890	1,000
4/5	2,750	2,500
4/6	3,500	3,000
4/7	1,600	1,380
4/8	1,340	1,200
4/9	1,420	1,260
4/10	1,200	1,000
4/11	940	960
4/12	1,070	990
4/13	1,120	920
4/14	840	1,020
4/15	990	1,000
4/16	1,230	1,120
4/17	1,340	1,260
4/18	1,400	1,180
4/19	1,260	1,320
4/20	1,000	880
4/21	940	760
4/22	920	780
4/23	840	820
4/24	760	780
4/25	360	410
4/26	560	480
4/27	520	420
4/28	490	570
4/29	420	360
4/30	510	440

Mollarhat	Chloride (mg/l)	
Date	High	Low
5/1	390	410
5/2	430	280
5/3	100	120
5/4	110	60
5/5	80	80
5/6	100	70
5/7	120	60
5/8	150	170
5/9	80	60
5/10	110	60
5/11	70	60
5/12	80	50
5/13	60	40
5/14	70	50
5/15	120	150
5/16	210	200
5/17	410	390
5/18	340	300
5/19	260	310
5/20	180	150
5/21	70	60
5/22	60	50
5/23	50	60
5/24	50	40
5/25	50	40
5/26	50	50
5/27	60	50
5/28	50	80
5/29	100	90

Mollarhat	Chloride (mg/l)	
Date	High	Low
6/1	60	50
6/2	50	60
6/3	50	40
6/4	60	50
6/5	50	50

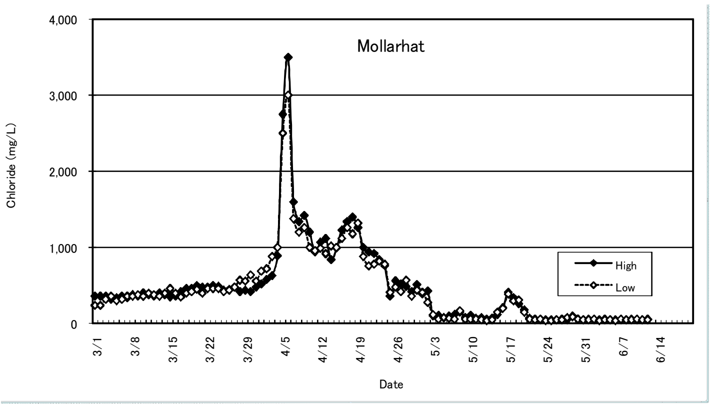
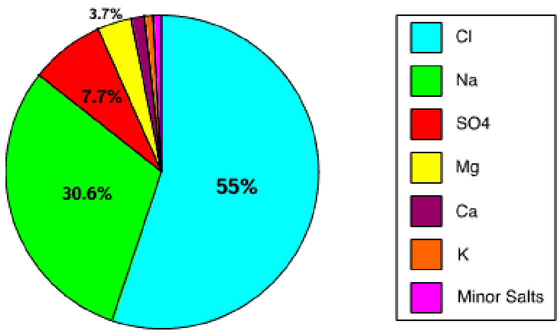


Figure 6.4.15 Monitoring Result of Chloride Concentration at Mollarhat

(4) Previous Monitoring Data for Forecast of Future Salinity Intrusion



Except for DOE's Chloride concentration mentoring result, IWM conducted monitoring in 2007 and 2009. But those monitored result is difficult to utilize for forecast future salinity intrusion for following reasons:

- Monitored result in 2007 shows only Salinity. The Chloride concentration had not been measured.
- In 2009 Salinity was measured also. And the Salinity measured result was converted into Chloride Concentration on the condition that the Chloride concentration would be 55 % of the

total salinity.

- This concentration rate, 55 %, is an internationally authorised rate; however this is utilized when to discuss about seawater.
- It is irrelevant to utilize this rate when discuss about river water especially for water with high turbidity like water of rivers which flow surrounding Khulna.
- Therefore it is impossible to forecast future salinity intrusion based on the existing monitored result of Salinity.

Only DOE's Chloride concentration mentoring result can be utilized to discuss about forecast future water quality in terms of Chloride concentration.

(5) Relative Project and Study for Madhumati River

1) Gorai River Restoration Project

Many of the rivers in the South-Western Region (SWR) of Bangladesh are dependent on discharge from the Ganges, but suffer from low flows during the dry season. Due to several reasons, mainly being the withdrawal of water up-stream, many spill-channels are now disconnected from the Ganges River. Gorai, a right bank distributaries of Ganges, is an important source of fresh water supply to SWR and the only remaining major spill channel of the river flowing through the region. For at least 20 years or so, the dry season flows (December-April) in Gorai River have been decreasing, the environmental impact of which is very serious in terms of increased salt water intrusion in the coastal area, especially around Khulna, Mongala Port and the Sundarbans Reserved Forests. There was a time that the dry season flow in the Gorai River had been ceased for two to three months (January to March) in the period of 1988-98. The take-off was reopened by pilot dredging in 1999. Since then it has been tried to keep open; however, sedimentation of the river is gradually increasing. The GOB has decided to commence another new project, Goral River Restoration Project Phase-II. The main component of the project is to implement maintenance dredging from the take-off to 30 km upstream every year for five years.

The Gorai River flow to east south and its downstream is renamed as Madhumati River after joining with MBR. The water intake point locates at Mollarhat of which distance from the Gorai off-take is approximately 140 km. It is not clear the impact of the dredging project to the quality of the river water at Mollarhat because of this long distance and its complex flow networks involving many connected inflows and outflows. However it can be predicted very easily that there is some positive impact as to the river quality even the difficultly of impact could be figured out precisely.

Figure 6.4.16 Location Map of Gorai Off-Take

2) West Gopalgonj Integrated Water Management Project

The West Gopalgonj Integrated Water Management Project area is served by the major distributory system of the Madhumoti River in the southern and western part and the Madaripur Beel Route (MBR) channel and Kumar River in eastern and northern parts.

The main objectives of the project are flood and drainage management in an integrated way in the project area, to improve irrigation facilities by using surface water during dry season and protection of saline water intrusion. The study will also cover environmental and social impact, preservation of bio-diversity, promotion of culture fisheries and flood forecasting. The proposed intervention will improve dry season irrigation facilities and sustain monsoon season crops. The proposed project interventions should be sustainable to provide best possible outcomes for navigation.

As of June 2010 BWDB, the project implementation agency, has been on the process of selection of eligible consultants for providing the required services. "Salinity intrusion and its effectiveness in project area" is included in one of expected out puts of the project.

(6) Necessity of River Water Quality Monitoring of Madhumati River at Mollarhat

Salinity intrusion is a significant issue for the Khulna water supply system. Traditionally DOE has measured chloride concentration at Mollarhat every month. The result of DOE mentoring is very useful to plan necessary facilities for the water supply system. However, for planning necessary system, such as impounding reservoir, daily basis water quality monitoring is necessary. For example, in 2010, from April 5th to April 19th, the chloride concentration in river water at Madhumati River exceeded the acceptable limit of the standards, 1,000 mg/L for 15 days. This result could not get without daily monitoring.

Especially the impounding reservoir is one of the facilities which require huge area and the capacity and size shall be justified by specific daily basis. This means the capacity and size of the impounding reservoir shall be decided by not monthly monitoring result but a daily consecutive mentoring result.

(7) Things to be considered to decide Impounding Reservoir Capacity at Detail Design Stage

To clarify precisely a detailed and extensive consideration for the detail design period is required; however, it is clear that to construct a large impounding reservoir of which capacity, reserving duration period of 45 days, is planned only depending on the result of a simply statistical approach.

The discussion hereafter will be required; at present, two measurements can be proposed.

1) To justify the necessary capacity of the impounding reservoir

To measure the chloride concentration in dry season at least in the next two years (2011 and 2012) adding by KWASA to the monitoring result up to the end of June 2010. And based on the three years consecutive monitoring result justification of the raw water quality variation and impact of relative projects which would be conducted upstream from Mollarhat shall be carried out and the actual necessary capacity of the impounding reservoir shall be justified. Then if it is required necessary extension of the capacity of the impounding reservoir shall be discussed at the detail design period.

2) To minimize the impounding reservoi

Secondly, to measure the chloride concentration in dry season at least in the next two years adding to the monitoring result up to the end of June 2010. And based on the three years consecutive monitoring result justification of the raw water quality variation and impact of relative projects which would be conducted upstream from Mollarhat shall be carried out and the actual necessary capacity of the impounding reservoir shall be justified. Then if it is required necessary extension of the capacity of the impounding reservoir shall be discussed.

(8) Approach to Minimize Impounding Reservoir Construction

Reservoirs have basically been planned, designed and operated on the assumption that they have a finite retention period i.e. how long the reserved water will be utilized. In case of the impounding reservoir for Khulna water supply system the retention period is assumed how long the river water at the intake keep high chloride concentration which exceed the EQS for drinking water.

It is assumed that some comprehensive operation to control the water quality; chloride concentration, of the water before introduction into the SWTP could make the duration of impounding reservoir be longer than originally planned period. Followings are trail approaches for the minimizing the capacity of the impounding reservoir.

1) Cases of Required Area of Impounding Reservoir

Based on the original scheme of the impounding reservoir, adding a minimal modification in accordance with the land features, following 4 cases can be assumed. The depth of the impounding reservoir is set 12m which can be constructed by sheet pile method.

<u>Case-1: Assumed that chloride concentration will be beyond the EOQ standards about 45 days</u>

- Land for SWTP = 10 ha
- Land for Impounding Reservoir = 60 ha (2 ponds are examined considering land shape)
  - Impounding Reservoir (1) = 16 ha
  - Impounding Reservoir (2) = 44 ha
- Necessary Land = 70 ha

<u>Case-2: Assumed that chloride concentration will be beyond the EOQ standards about 30 days</u>

- Land for SWTP = 10 ha
  - Impounding Reservoir (1) = 16 ha
  - Impounding Reservoir (2) = 22 ha
- Land for Impounding Reservoir = 38 ha (2 ponds are examined considering land shape)
- Necessary Land = 48 ha

<u>Case-3: Assumed that chloride concentration will be beyond the EOQ standards about 15 days</u>

- Land for SWTP = 10 ha
- Land for Impounding Reservoir = 16 ha
- Necessary Land = 26ha

<u>Case-4: Assumed that chloride concentration will be beyond the EOQ standards about 10 days</u>

- Land for SWTP = 10 ha
- Land for Impounding Reservoir = 10 ha
- Necessary Land = 20ha

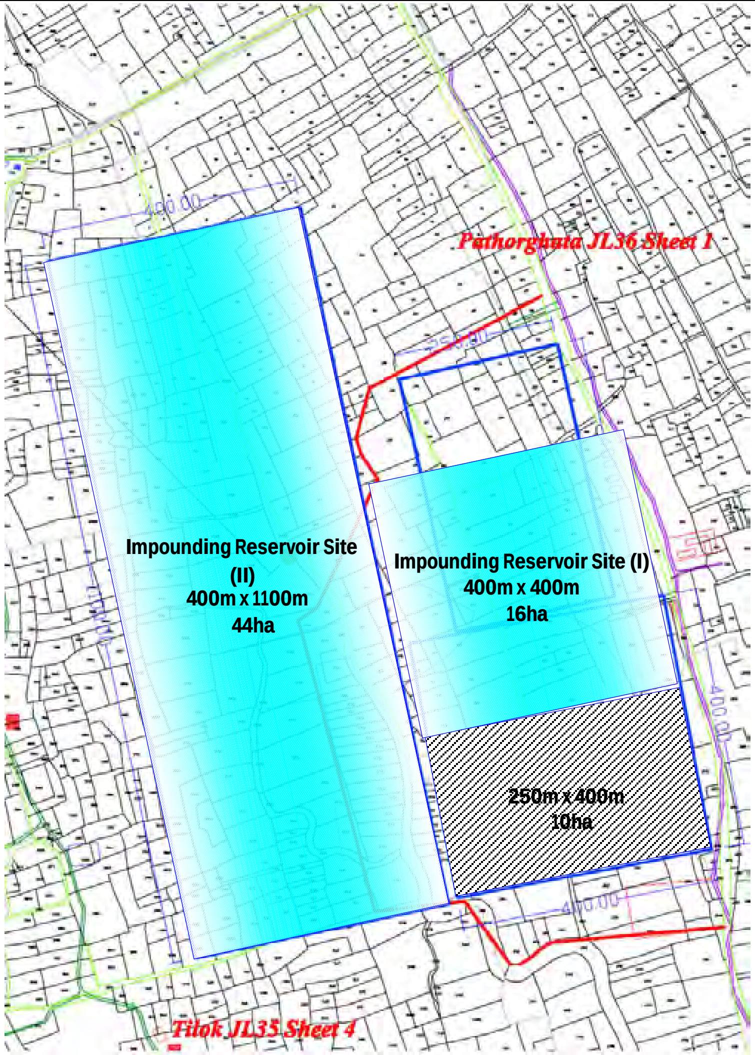


Figure 6.4.17 Plan of Case-1 at Samanto Sena

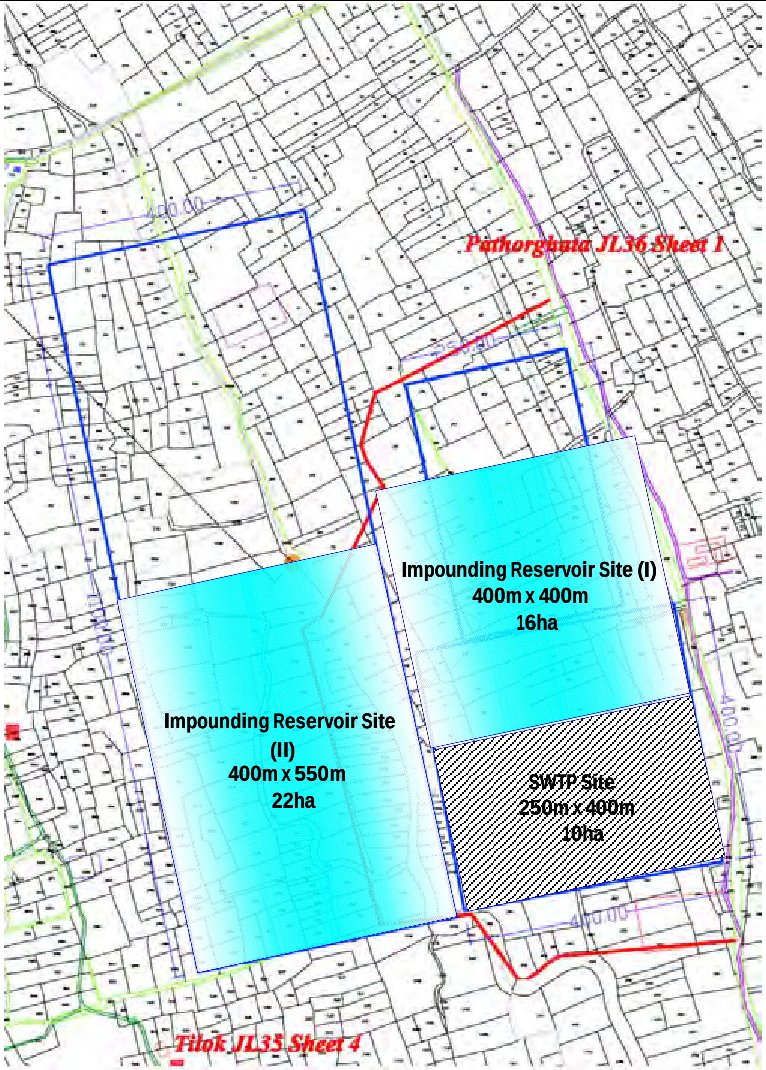


Figure 6.4.18 Plan of Case-2 at Samanto Sena

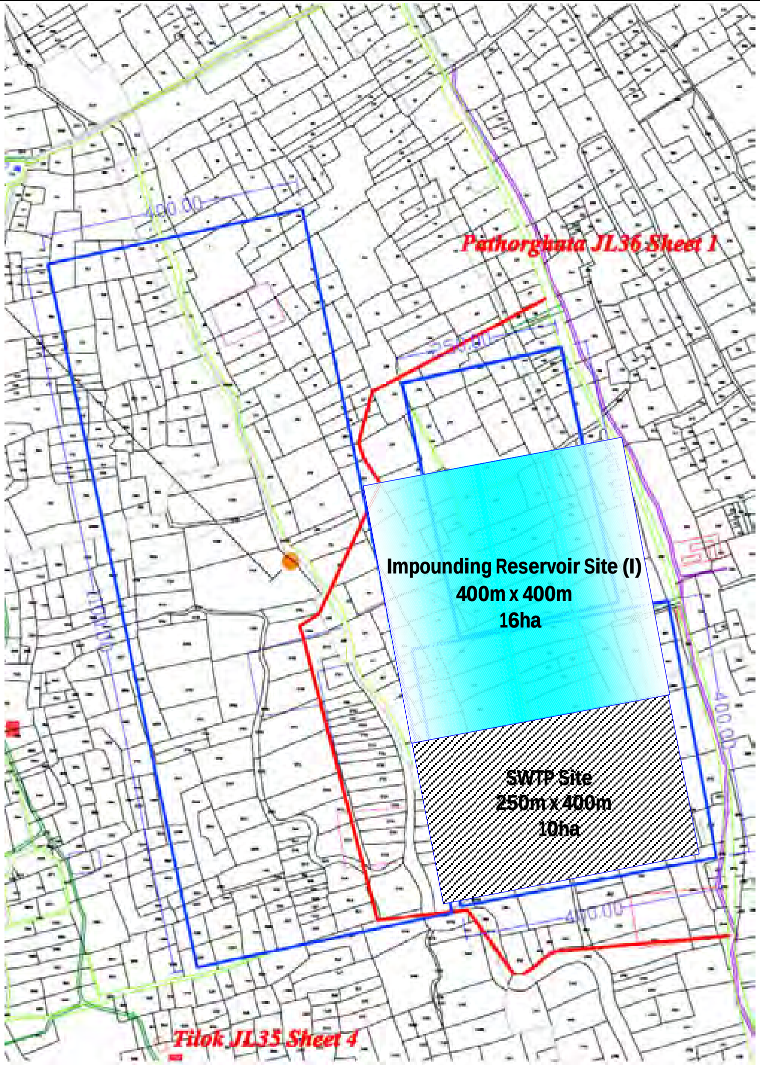


Figure 6.4.19 Plan of Case-3 at Samanto Sena

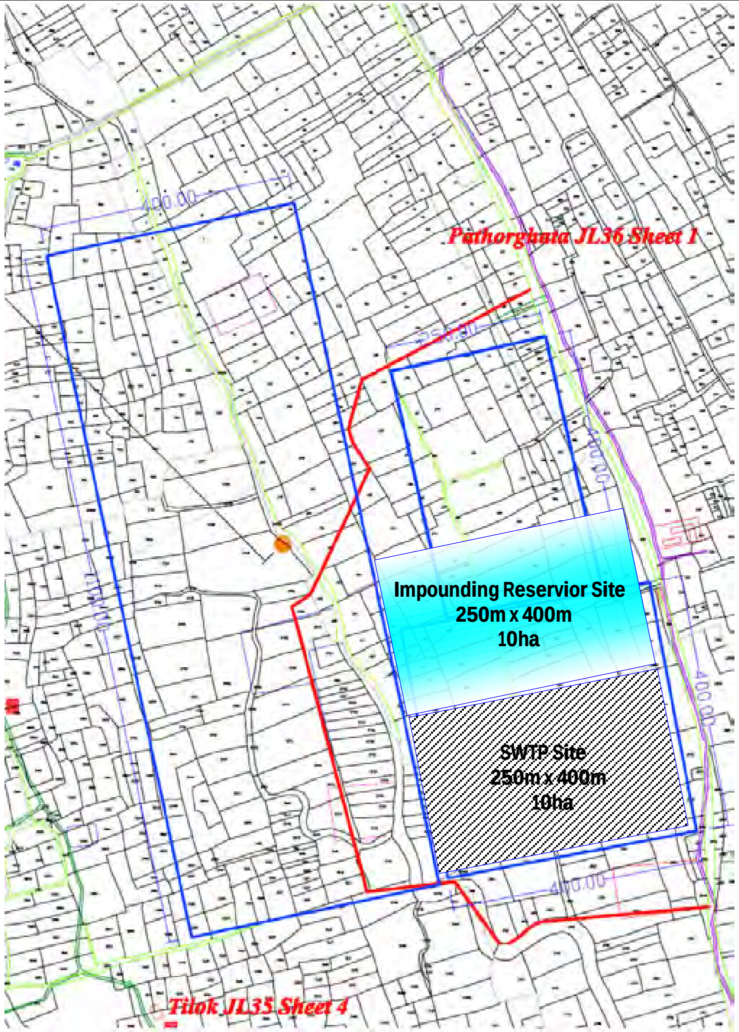


Figure 6.4.20 Plan of Case-4 at Samanto Sena

3) Retention Period by Single Line Management

Basically the impounding reservoir is planned to be operated by single line management; to utilize reserved water for trouble period. In this management the retention period of the reservoir is directly link to the capacity of the reservoir. **Table 6.4.15** shows the retention period of the impounding reservoir for each case.

Table 6.4.15 Retention Period of Impounding Reservoir by Single Line Management

	Reservoir Capacity	Retention Period
Case-1	5,630,400 m^3	45 days
Case-2	3,794,400 m^3	30 days
Case-3	1,387,200 m^3	11 days
Case-4	775,200 m^3	6 days

4) Retention Period by Developed Management

The retention period of the reservoir can be extended by some developed consideration into management of water quality of the reserved water.

Duration of the reservoir can be extended by introduction of a developed management which provides continued performance monitoring and evaluation of the overall control system.

Developed management system requires overall control management.

For example the water quality (chloride concentration) of the raw water is monitored and also to be evaluated as its acceptable or not for the impounding reservoir.

For instance, in April, from 5th to 19th, for 15 days chloride concentration of the water at Mollarhat exceeded the EQS limitation as mentioned above. Depending on the single line management only Case-1 and Case-2 are durable for this phenomenon.

If a simple developed operational control is introduced the duration of the impounding reservoir will increase drastically.

A simple structural mixing pond in which raw water and reserved water to be mixed with a proper mixing ratio will be very effective measurement to extend the retention period of the impounding reservoir drastically.

For example, in case the chloride concentration of the raw water is 1,900 mg/L and the reserved water in the impounding reservoir is 50 mg/L, if those two waters are to be mixed in the ratio of one to one the chloride concentration of the mixed water will become 975 mg/L.

If the mixed water’s chloride concentration to be kept as 1,000 mg/L, the limitation of EQS, during the same troubled days measured at Mollarhat, for 15 days, in all above-mentioned cases the reserved water are enough to be managed.

The results are as shown in **Table 6.4.16** and **Figure 6.4.21** for Case-1, **Table 6.4.17** and **Figure 6.4.22** for Case-2, **Table 6.4.18** and **Figure 6.4.23** for Case-3, and **Table 6.4.19** and **Figure 6.4.24** for Case-4, respectively.

Table 6.4.16 Trial Result of Developed Management Case-1

Sr	Date	CL in Raw Water (mg/L)	CL in Reserved Water (mg/L)	CL in Mixed Water (mg/L)	Intake Water to be Mixed (m^3)	Reserved Water to be Mixed (m^3)	Reserved Water (m^3)
	4-Apr	1,000	50				5,630,400
1	5-Apr	2,750	50	1,000	38,000	72,000	5,558,400
2	6-Apr	3,500	50	1,000	29,800	80,200	5,478,200
3	7-Apr	1,600	50	1,000	65,300	44,700	5,433,500
4	8-Apr	1,340	50	1,000	77,900	32,100	5,401,400
5	9-Apr	1,420	50	1,000	73,500	36,500	5,364,900
6	10-Apr	1,200	50	1,000	87,000	23,000	5,341,900
7	11-Apr	960	50	960	110,000	0	5,341,900
8	12-Apr	1,070	50	1,000	97,600	12,400	5,329,500
9	13-Apr	1,120	50	1,000	93,300	16,700	5,312,800
10	14-Apr	1,020	50	1,000	102,400	7,600	5,305,200
11	15-Apr	1,000	50	1,000	104,500	5,500	5,299,700
12	16-Apr	1,230	50	1,000	84,900	25,100	5,274,600
13	17-Apr	1,340	50	1,000	77,900	32,100	5,242,500
14	18-Apr	1,400	50	1,000	74,600	35,400	5,207,100
15	19-Apr	1,320	50	1,000	79,100	30,900	5,176,200
	20-Apr	1,000	50				5,176,200

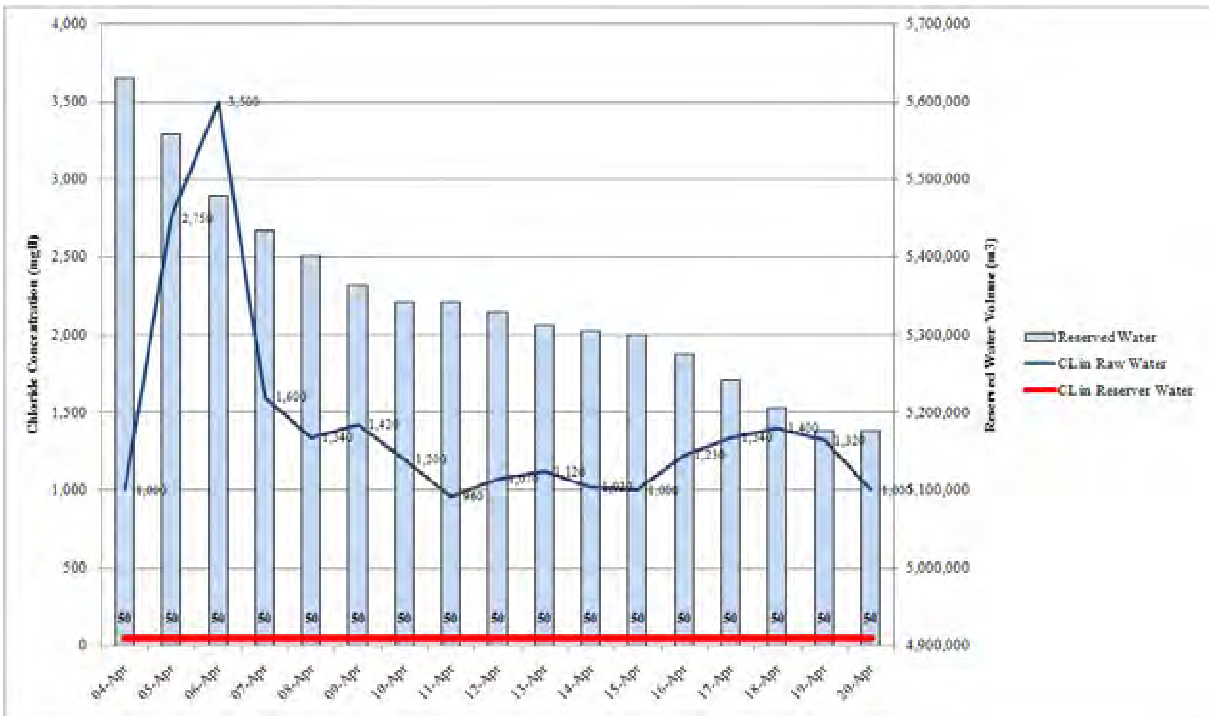


Figure 6.4.21 Trial Result of Developed Management Case-1

Table 6.4.17 Trial Result of Developed Management Case-2

Sr	Date	CL in Raw Water (mg/L)	CL in Reserved Water (mg/L)	CL in Mixed Water (mg/L)	Intake Water to be Mixed (m^3)	Reserved Water to be Mixed (m^3)	Reserved Water (m^3)
	4-Apr	1,000	50				3,794,400
1	5-Apr	2,750	50	1,000	38,000	72,000	3,722,400
2	6-Apr	3,500	50	1,000	29,800	80,200	3,642,200
3	7-Apr	1,600	50	1,000	65,300	44,700	3,597,500
4	8-Apr	1,340	50	1,000	77,900	32,100	3,565,400
5	9-Apr	1,420	50	1,000	73,500	36,500	3,528,900
6	10-Apr	1,200	50	1,000	87,000	23,000	3,505,900
7	11-Apr	960	50	960	110,000	0	3,505,900
8	12-Apr	1,070	50	1,000	97,600	12,400	3,493,500
9	13-Apr	1,120	50	1,000	93,300	16,700	3,476,800
10	14-Apr	1,020	50	1,000	102,400	7,600	3,469,200
11	15-Apr	1,000	50	1,000	104,500	5,500	3,463,700
12	16-Apr	1,230	50	1,000	84,900	25,100	3,438,600
13	17-Apr	1,340	50	1,000	77,900	32,100	3,406,500
14	18-Apr	1,400	50	1,000	74,600	35,400	3,371,100
15	19-Apr	1,320	50	1,000	79,100	30,900	3,340,200
	20-Apr	1,000	50				3,340,200

Figure 6.4.22 Trial Result of Developed Management Case-2

Table 6.4.18 Trial Result of Developed Management Case-3

Sr	Date	CL in Raw Water (mg/L)	CL in Reserved Water (mg/L)	CL in Mixed Water (mg/L)	Intake Water to be Mixed (m^3)	Reserved Water to be Mixed (m^3)	Reserved Water (m^3)
	4-Apr	1,000	50				1,387,200
1	5-Apr	2,750	50	1,000	38,000	72,000	1,315,200
2	6-Apr	3,500	50	1,000	29,800	80,200	1,235,000
3	7-Apr	1,600	50	1,000	65,300	44,700	1,190,300
4	8-Apr	1,340	50	1,000	77,900	32,100	1,158,200
5	9-Apr	1,420	50	1,000	73,500	36,500	1,121,700
6	10-Apr	1,200	50	1,000	87,000	23,000	1,098,700
7	11-Apr	960	50	960	110,000	0	1,098,700
8	12-Apr	1,070	50	1,000	97,600	12,400	1,086,300
9	13-Apr	1,120	50	1,000	93,300	16,700	1,069,600
10	14-Apr	1,020	50	1,000	102,400	7,600	1,062,000
11	15-Apr	1,000	50	1,000	104,500	5,500	1,056,500
12	16-Apr	1,230	50	1,000	84,900	25,100	1,031,400
13	17-Apr	1,340	50	1,000	77,900	32,100	999,300
14	18-Apr	1,400	50	1,000	74,600	35,400	963,900
15	19-Apr	1,320	50	1,000	79,100	30,900	933,000
	20-Apr	1,000	50				933,000

Figure 6.4.23 Trial Result of Developed Management Case-3

Table 6.4.19 Trial Result of Developed Management Case-4

Sr	Date	CL in Raw Water (mg/L)	CL in Reserved Water (mg/L)	CL in Mixed Water (mg/L)	Intake Water to be Mixed (m^3)	Reserved Water to be Mixed (m^3)	Reserved Water (m^3)
	4-Apr	1,000	50				775,200
1	5-Apr	2,750	50	1,000	38,000	72,000	703,200
2	6-Apr	3,500	50	1,000	29,800	80,200	623,000
3	7-Apr	1,600	50	1,000	65,300	44,700	578,300
4	8-Apr	1,340	50	1,000	77,900	32,100	546,200
5	9-Apr	1,420	50	1,000	73,500	36,500	509,700
6	10-Apr	1,200	50	1,000	87,000	23,000	486,700
7	11-Apr	960	50	960	110,000	0	486,700
8	12-Apr	1,070	50	1,000	97,600	12,400	474,300
9	13-Apr	1,120	50	1,000	93,300	16,700	457,600
10	14-Apr	1,020	50	1,000	102,400	7,600	450,000
11	15-Apr	1,000	50	1,000	104,500	5,500	444,500
12	16-Apr	1,230	50	1,000	84,900	25,100	419,400
13	17-Apr	1,340	50	1,000	77,900	32,100	387,300
14	18-Apr	1,400	50	1,000	74,600	35,400	351,900
15	19-Apr	1,320	50	1,000	79,100	30,900	321,000
	20-Apr	1,000	50				321,000

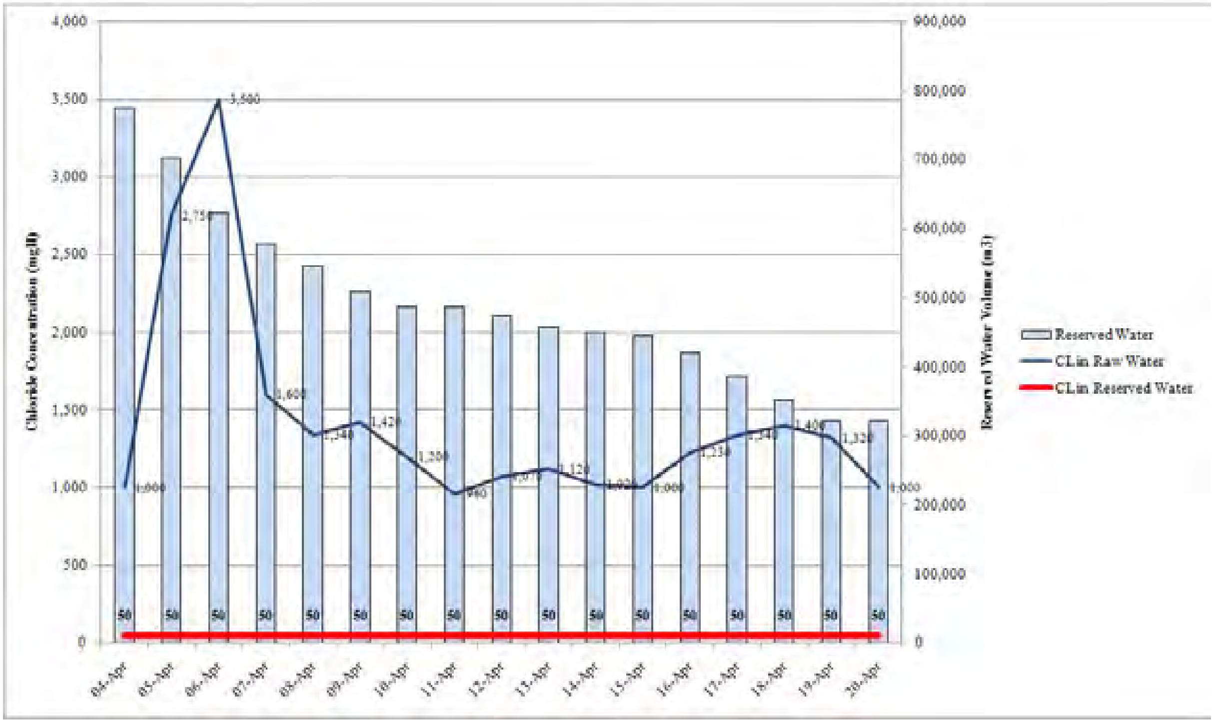


Figure 6.4.24 Trial Result of Developed Management Case-4

And for Case-4 if the troubled days, chloride concentration of the water at the water intake exceed the EOQ limitation, extend further than 15 days the duration of the impounding reservoir will extend 23 days as shown in **Table 6.4.20** and **Figure 6.4.25**.

Table 6.4.20 Modified Trial Result of Developed Management Case-4

Sr	CL in Raw Water (mg/L)	CL in Reserved Water (mg/L)	CL in Mixed Water (mg/L)	Intake Water to be Mixed (m^3)	Reserved Water to be Mixed (m^3)	Reserved Water (m^3)
	1,000	50				775,200
1	2,750	50	1,000	38,000	72,000	703,200
2	3,500	50	1,000	29,800	80,200	623,000
3	1,600	50	1,000	65,300	44,700	578,300
4	1,340	50	1,000	77,900	32,100	546,200
5	1,420	50	1,000	73,500	36,500	509,700
6	1,200	50	1,000	87,000	23,000	486,700
7	960	50	960	110,000	0	486,700
8	1,070	50	1,000	97,600	12,400	474,300
9	1,120	50	1,000	93,300	16,700	457,600
10	1,020	50	1,000	102,400	7,600	450,000
11	1,000	50	1,000	104,500	5,500	444,500
12	1,230	50	1,000	84,900	25,100	419,400
13	1,340	50	1,000	77,900	32,100	387,300
14	1,400	50	1,000	74,600	35,400	351,900
15	1,320	50	1,000	79,100	30,900	321,000
16	1,320	50	1,000	79,100	30,900	290,100
17	1,320	50	1,000	79,100	30,900	259,200
18	1,320	50	1,000	79,100	30,900	228,300
19	1,320	50	1,000	79,100	30,900	197,400
20	1,320	50	1,000	79,100	30,900	166,500
21	1,320	50	1,000	79,100	30,900	135,600
22	1,320	50	1,000	79,100	30,900	104,700
23	1,320	50	1,000	79,100	30,900	73,800
	1,000	50				73,800

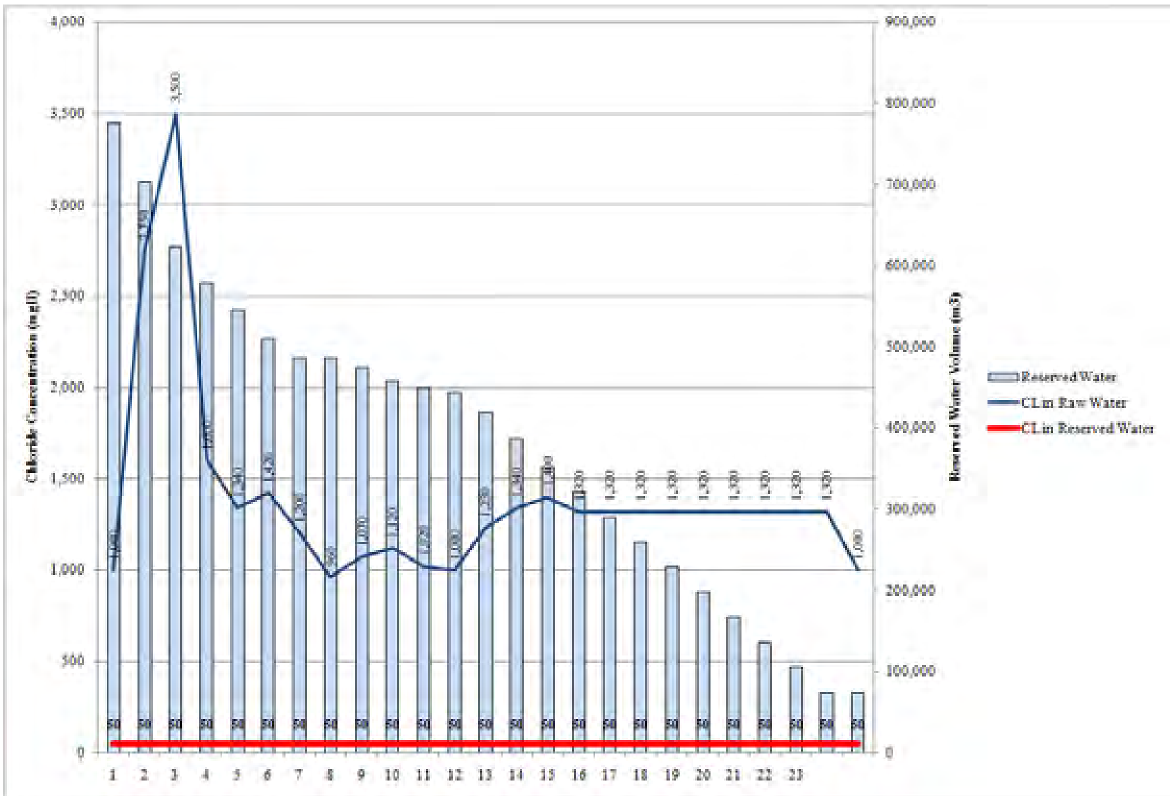


Figure 6.4.25 Modified Trial Result of Developed Management Case-4

(9) Justification for the Necessary Capacity of Impounding Reservoir

Since the proposed reservoir of 60 ha for 45 days storage seemed to be huge, so trials to minimize the impounding reservoirs have been conducted as mentioned before. It is verified that introducing of developed management is very useful to extend the duration of reservoir, and this result ensures to minimize the impounding reservoir.

Considering raw water allocation plan which mixing raw water and reserved water which stored in the impounding reservoir, above 4 Cases can correspond to salinity period for the result of monitoring in 2010. Based on the study, land area for the impounding reservoir keeps as Case-3 capacity, and facility plan is conducted for Case-4 capacity.

6.4.5 Summary of Proposed Water Supply Facilities

(1) Proposed Water Supply System

Location of proposed water supply facilities in Khulna city is shown in **Figure 6.4.26** and **Figure 6.4.27**. Raw water is taken from the Madhumati River at Mollarhat and sent to SWTP by raw water transmission pipe of the diameter 1350mm and the length 33km. Impounding reservoir is necessary to store raw water during non salinity influence period and release and to send to SWTP during salinity influence period (45 days).

Raw water is treated in SWTP and sent treated water to five distribution reservoirs inside Khulna city by clear water transmission pipe of the diameter 300mm - 1100mm and the length 25km in total. Distribution reservoir keeps clear water in order to conduct proper water distribution in response to water demand for five service area in Khulna city. Clear water is sent to 11 overhead tanks by pumping from distribution reservoir for the purpose of storage enough water pressure, and send water to houses, schools, office, factories and public facilities etc. by distribution pipe network. The list of proposed water supply facilities is shown in Table below.

Table 6.4.21 List of Proposed Water Supply Facilities for Year 2025

	Facility Name	Capacity	Quantity
1	Water Intake	110,000m^3/day	1 nos
2	Raw Water Transmission Pipe	-	ϕ 1350mm, L=33km
3	Impounding Reservoir	775,200m^3	1 nos
4	SWTP	110,000m^3/day	1 nos
5	Clear Water Transmission Pipe	-	ϕ 300mm-1100mm, L=25km
6	Distribution Reservoir	10,000m^3 - 20,000m^3	5 nos
7	Overhead Tank	300m^3 - 500m^3	11 nos
8	Distribution Pipe Network	-	ϕ 50mm-400mm, L=700km [2]
9	Service Pipe Connection	-	90,000

[2] Inclusive fixing pipe making a new connection to distribution network (0.7 m×140,000 =98 km)

(2) Proposed Site for Water Supply Facilities

The list of proposed sites for water supply facilities is shown in below. Land acquisition is necessary as the list below.

Table 6.4.22 Proposed Site for Water Supply Facilities for Year 2025

Name	Dimension (m)	Area	Proposed Location
Water Intake	75 x 125 + Access road	1.0ha	Mollarhat (Madhumati River)
Impounding Reservoir	400 x 400	16 ha	Samanto Sena
Samanto Sena SWTP	250 x 400	10ha	Samanto Sena
Deana West Para Reservoir	100 x 70	0.7ha	Paddy land
Ward No.16 office Reservoir	100 x 70	0.7ha	KCC land
Sonadanga Moha Sarak Reservoir	100 x 90	0.9ha	Personal land
Beside of No.7 Ward office Reservoir	100 x 70	0.7ha	Personal land
Khalishpur Charerhat River Ghat Reservoir	100 x 90	0.9ha	Government land (KASS)
Rab Sarani Over Head Tank	45 x 30	0.14ha	Personal land
Mujgunni Over Head Tank	45 x 30	0.14ha	KCC land
Ferry Ghat Power House Over Head Tank	45 x 30	0.14ha	KCC land
Andir Pukur Over Head Tank	50 x 35	0.18ha	Personal land
South Side of Ward No. 31 Office Over Head Tank	50 x 35	0.18ha	Paddy land
DPHE Rupsha Over Head Tank	50 x 35	0.18ha	DPHE

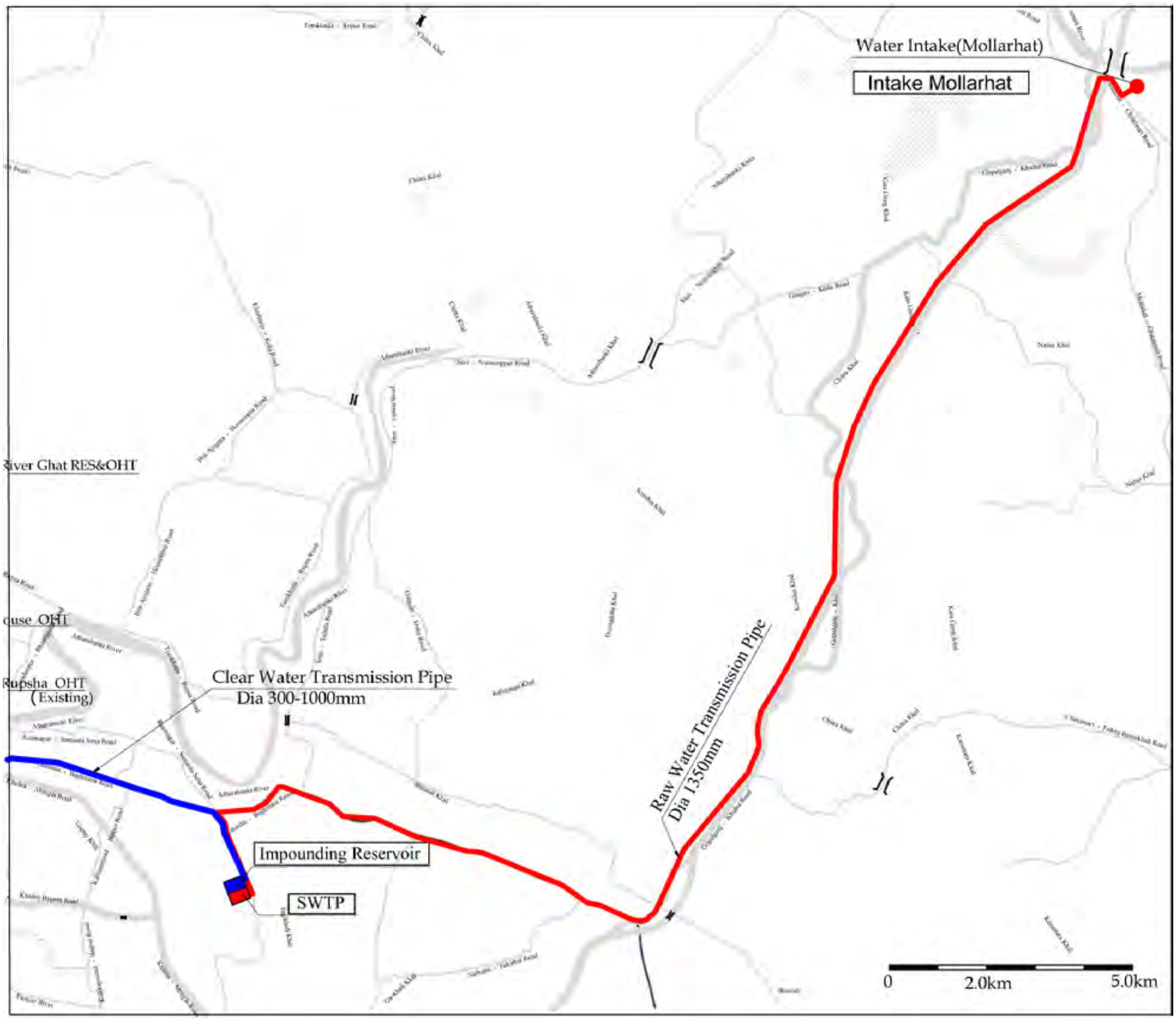


Figure 6.4.26 Proposed Water Supply System in Khulna City

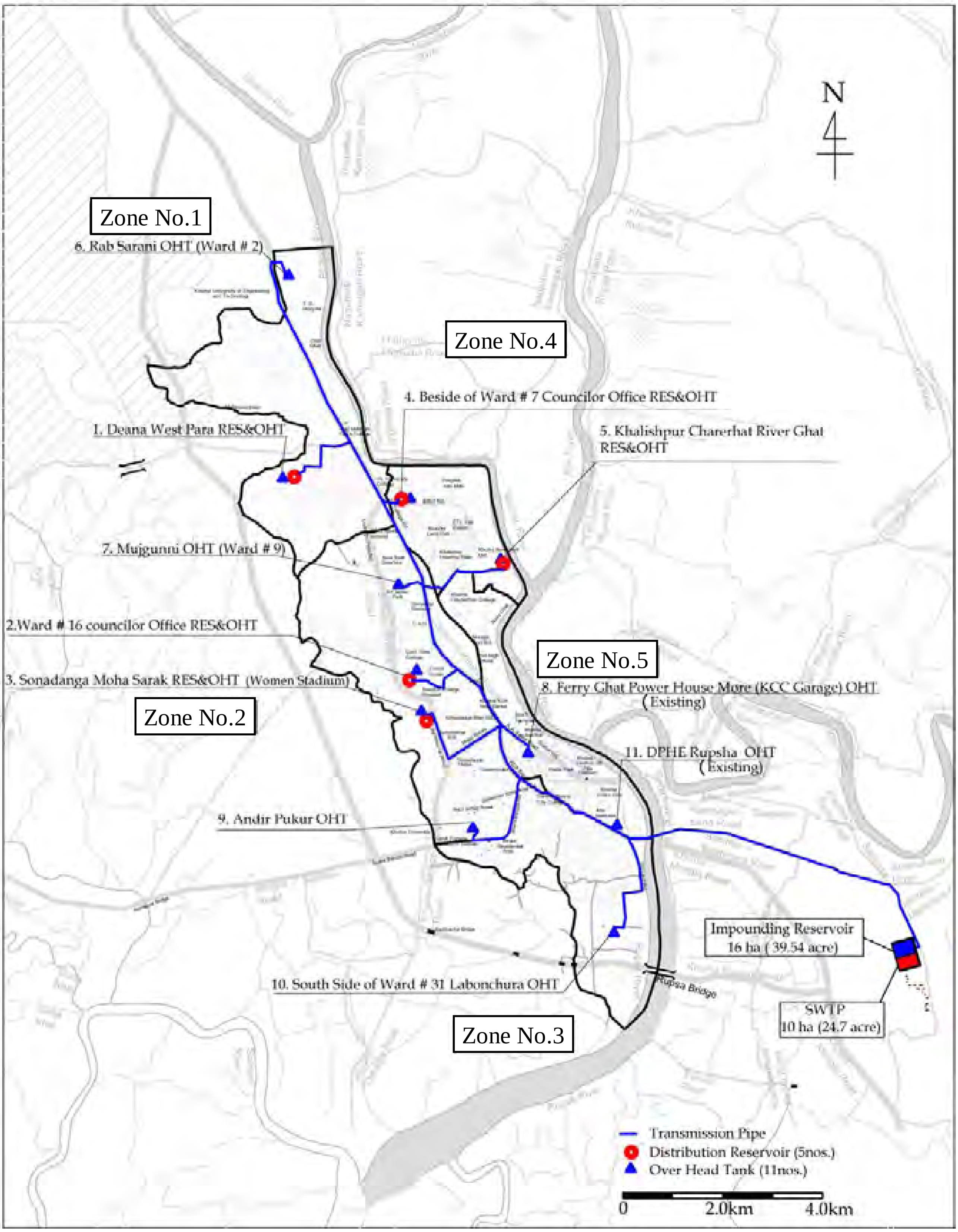


Figure 6.4.27 Proposed Water Supply System in Khulna City

6.5 Implementation Schedule

6.5.1 General

The project is planned to be implemented divided into three stages based on the design target years of 2025 (Stage I) as for the feasibility study project and 2030 (Stage II) as for the long term development plan with the following size of requirement shown in **Table 6.5.1**.

Table 6.5.1 Staging of the Project

Basic Parameter	Stage I Feasibility Study Project	Stage II Long Term Development Plan
Target Year	2025	2030
Proposed SWTP Capacity	110,000 m^3/day	220,000 m^3/day

6.5.2 Implementation Schedule

In connection with the target years for this Study, Stage I: Feasibility Study Project is an urgent and priority project and is expected to be completed by the end of 2025, while Stage II: Long Term Development Plan to complete the overall project are considered to be achieved by the end of 2030.

Stage I: Feasibility Study Project (2010 to 2020)

2009 - 10	Feasibility Study
2011	Financial Arrangement, Selection of Consultant
2012	Detailed Design
2012 - 13	P/Q and Tender
2013 - 16	Construction & Procurement of Equipment
2016	Commencement of Operation

Stage II: Long Term Development Plan (2025 - 2030)

2025	Preparation of Project
2026	Financial Arrangement, Selection of Consultant
2027	Detailed Design
2028	P/Q and Tender
2024 - 29	Construction & Procurement of Equipment
2030	Commencement of Operation

6.5.3 Recommendations

(1) Necessity of Comprehensive Master Plan

In order to insure that future water supplies are adequate for the expected growth of Khulna City, a comprehensive long-term Mater Management in Khulna City shall be developed. This comprehensive Master Plan shall be covered water supply system, sewerage system and storm water drainage system in Khulna. To develop the comprehensive Master Plan KWASA, KCC and other relative organization should be involved.

Prior to the comprehensive Master Plan a preliminary study is necessary to define the target of the long-term system and to discuss how to organize the study team, how to demarcate the study subjects and define the study TOR of the .comprehensive Mater Plan.

An assumed time line of the comprehensive Master Plan in Khulna is as follows.

1) Preliminary Study and definition of TOR for consulting services: 2012-2013
2) Definition of TOR and selection of consultants: 2014
3) Development of the comprehensive Master Plan: 2015-2016
4) Feasibility Study on priority projects: 2017-2018

In the priority projects the extension works of water treatment plant for the water supply system shall be included.

And also within this comprehensive Master Plan future provision of saline water intrusion shall be discussed. ADB' Report[3] suggests to replace the water intake point to the upstream of the river would be required if current tidal level continue rising with the latest years tendency. This issue shall be studied and clarified further and measures to be taken shall be decided.

(2) Careful Introduction of State-of-Art Technology

As described in the **Clause 6.4.2** prior to an introduction of the state-of-art technology such as RO membrane technology for desalination.

A number of factors shall be taken into consideration to determine the introduction of the RO membrane technology such as capital and operating costs for desalination: capacity and type of facility, location, feed water, labor, energy, financing, and concentrate disposal.

Regarding the RO membrane cost per volume of water production it has been reduced to be as half in recent decade due to demand increase and technology progress.

In the above-mentioned comprehensive Master Plan the introduction of the state-of-art technologies such as RO membrane shall be discussed and analysed carefully then decided to be introduced or not.

---

[3] A-7197 BAN Strengthening the Resilience of the Water Sector in Khulna to Climate, August 2010

CHAPTER 7 PROJECT SCOPE AND FACILITIES

Location of proposed water supply system in Khulna city is shown in **Figure 7.1.1**.

7.1 Raw Water Allocation Plan

(1) Basic Concept

Surface water of the Madhumati River is the proposed water source for this study. If river water is stable all around year in terms of qualitative and quantitative, no significant affect is anticipated in water treatment and water distribution. But chloride concentration exceeds 1,000 mg/L, the upper limit of the Bangladesh water quality standard and the maximum in dry season and it was recorded more than 3,500 mg/L in 2010. If such water is applied as water source of potable water, it cannot be treated by conventional method.

To deal with this issue, following “Raw Water Allocation Plan” can be proposed:

- During rainy season, surface water with lower chloride concentration is stored in impounding reservoir
- Mixing the raw water with high chloride concentration and the reserved water with low chloride concentration during salinity influenced period to lessen the concentration within the standard

This impounding reservoir is proposed to be constructed near to the SWTP from viewpoint of O&M convenience and to reduce the installation cost of raw water conveyance pipe. The advantage of the impounding reservoir is to ease the subsequence water treatment process with steady raw water quality stabilized by water storage.

Three cases for actual operation of raw water allocation through the year are to be considered. In this study, facilities of water intake, raw water transmission pipe, impounding reservoir and SWTP are designed by taking into account of following raw water allocation cases.

<u>CASE -1</u>: Non Salinity Period (Chloride Concentration: less than 1000 mg/L)

<u>CASE -2</u>: Store Raw Water into the Impounding Reservoir (During low chloride concentration period for 3 month/year)

<u>CASE -3</u>: Salinity Period (Chloride Concentration: more than 1000 mg/L)

(2) CASE -1: Non Salinity Period (Chloride Concentration: less than 1000 mg/L)

Raw water amount of 110,000 m^3/day is sent to SWTP directly. Reserved water in impounding reservoir doesn’t use. Flow diagram of raw water allocation is shown in **Figure 7.1.2**.

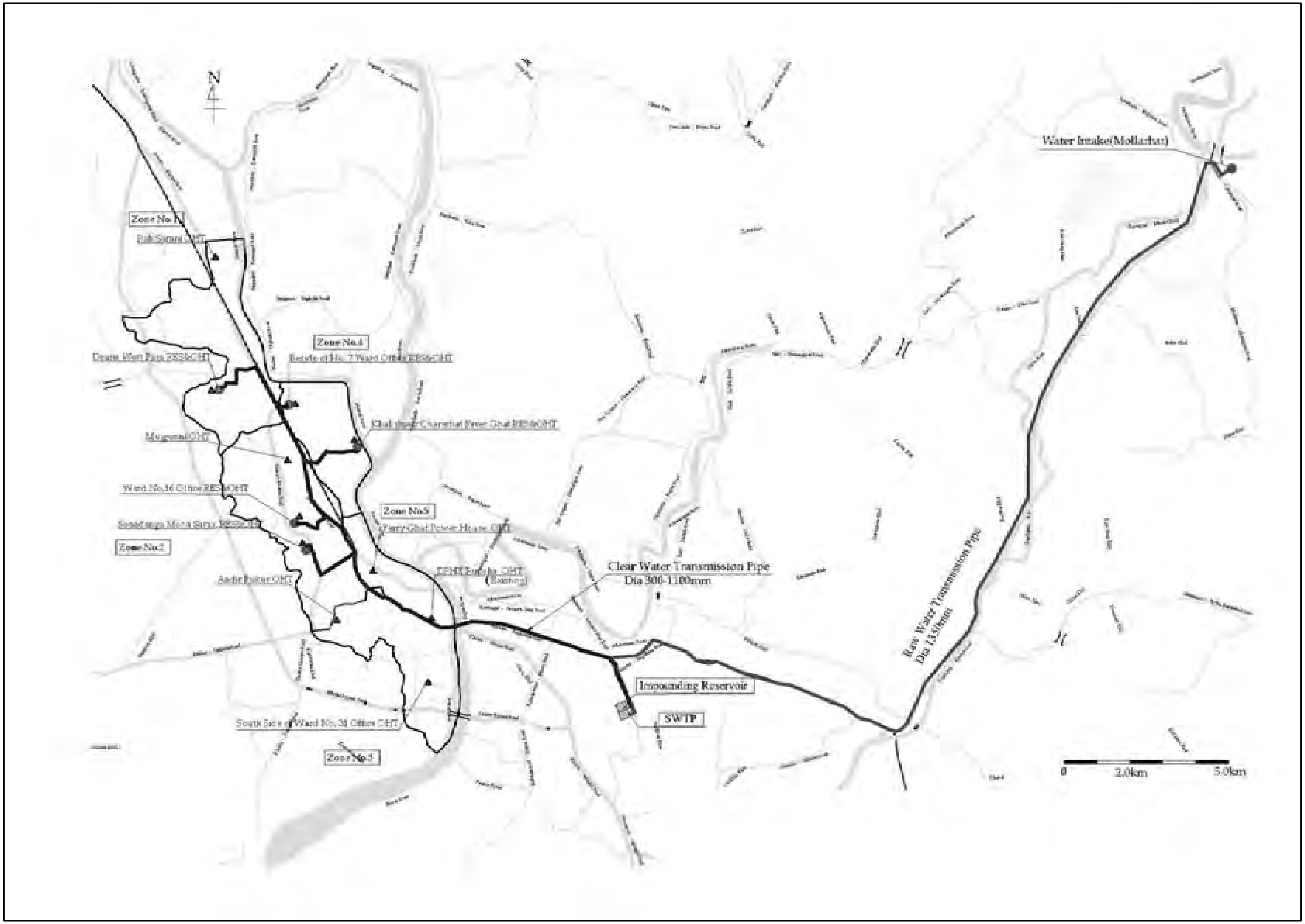


Figure 7.1.1 Location Map of Water Supply System

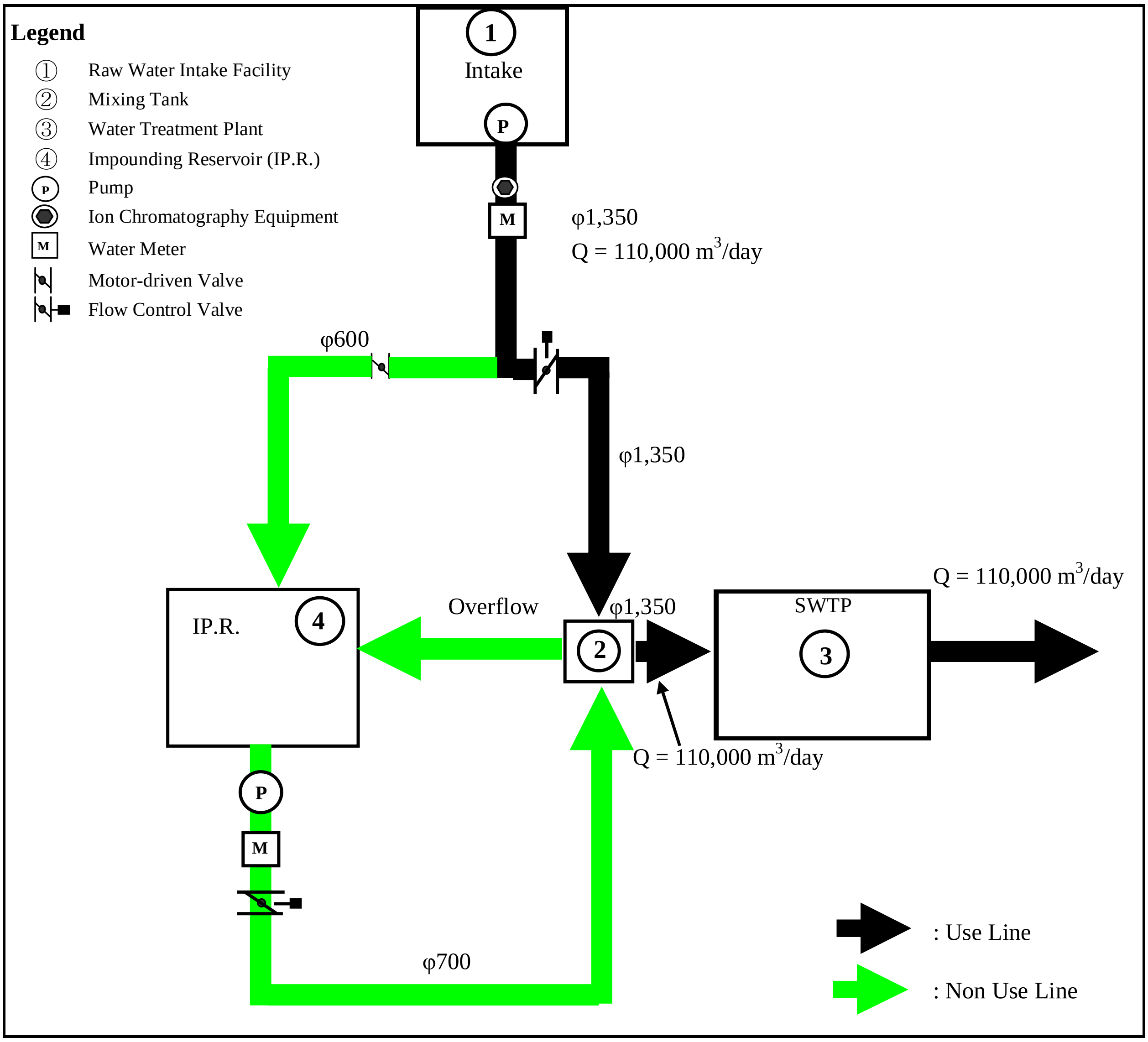


Figure 7.1.2 Flow diagram of raw water allocation (CASE -1)

(3) CASE -2: Store Raw Water into the Impounding Reservoir (During low chloride concentration for 3 month/year)

During rainy season, chloride concentration of raw water decreases. Water amount of 110,000 m^3/day and is sent to the SWTP, and water amount of 8,000 m^3/day is to be stored during 3 months in a year while the chloride concentration of the raw water is low. Capacity of intake pump and raw water transmission pipe is designed including this flow (8,000 m^3/day) for storage. Therefore, raw water amount of 118,000 m^3/day is taken from the Madhumati River, and 110,000 m^3/day is sent to the SWTP and 8,000 m^3/day is stored in the impounding reservoir in three month in a year during low salinity period. Flow diagram of raw water allocation is shown in **Figure 7.1.3**.

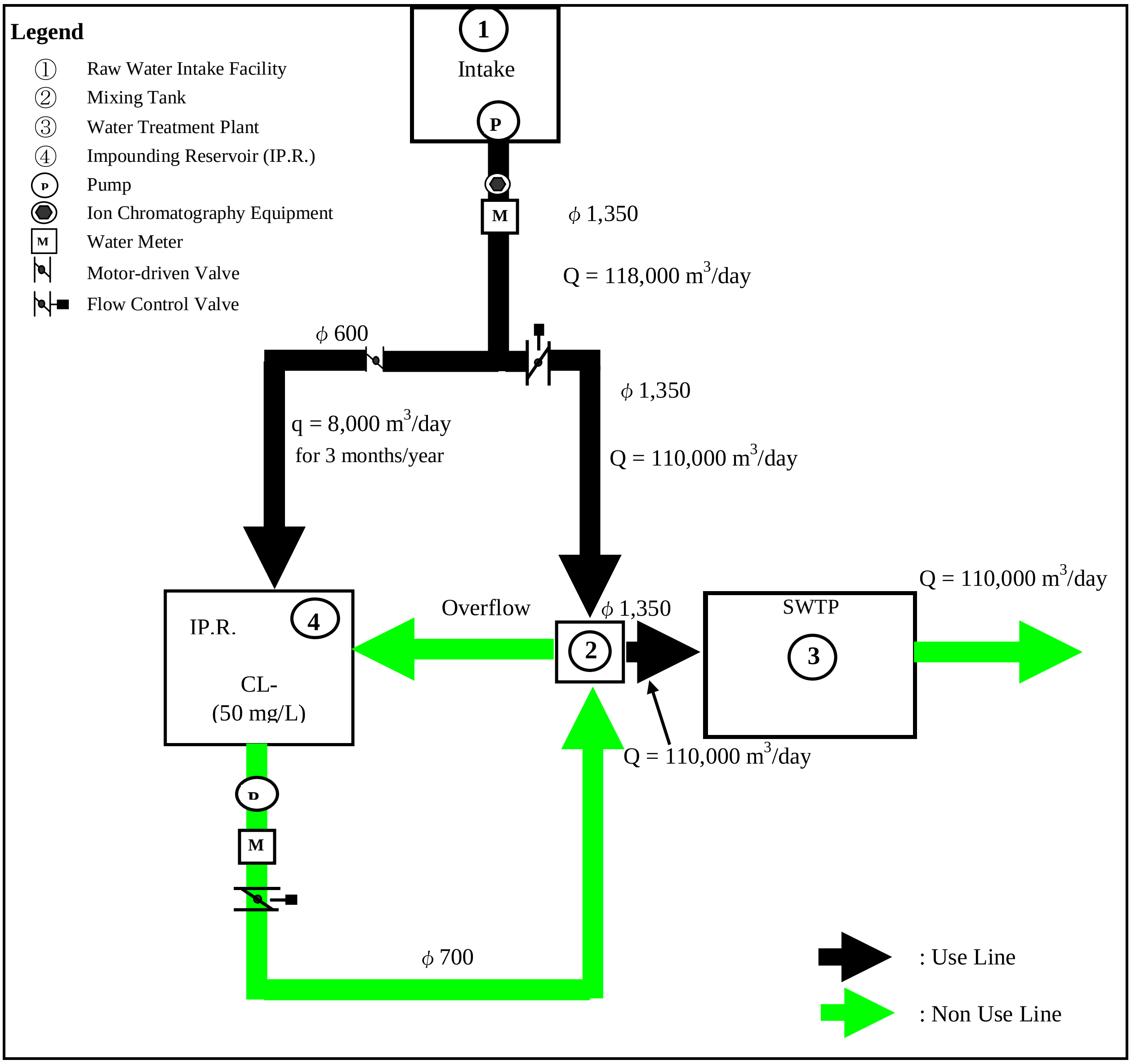


Figure 7.1.3 Flow diagram of raw water allocation (CASE -2)

(4) CASE -3: Salinity Period (Chloride Concentration: more than 1000 mg/L)

A certain amount of raw water is sent from intake to SWTP and some amount of reserved water is sent from impounding reservoir to SWTP. A mixing tank in which raw water and reserved water to be mixed with a proper mixing ratio will be very effective measurement to extend the retention period of the impounding reservoir drastically.

For example, in case the chloride concentration of the raw water is 1,000 to 3,500 mg/L and the reserved water in the impounding reservoir is 50 mg/L, raw water amount of 110,000 to 29,800 m^3/day is sent from intake to SWTP and the reserved water amount of 0 to 80,200 m^3/day is sent from impounding reservoir to SWTP. Then those two waters are to be mixed in the mixed tank, and chloride concentration will become 1,000 mg/L for total raw water amount of 110,000 m^3/day. Flow diagram of raw water allocation is shown in **Figure 7.1.4**.

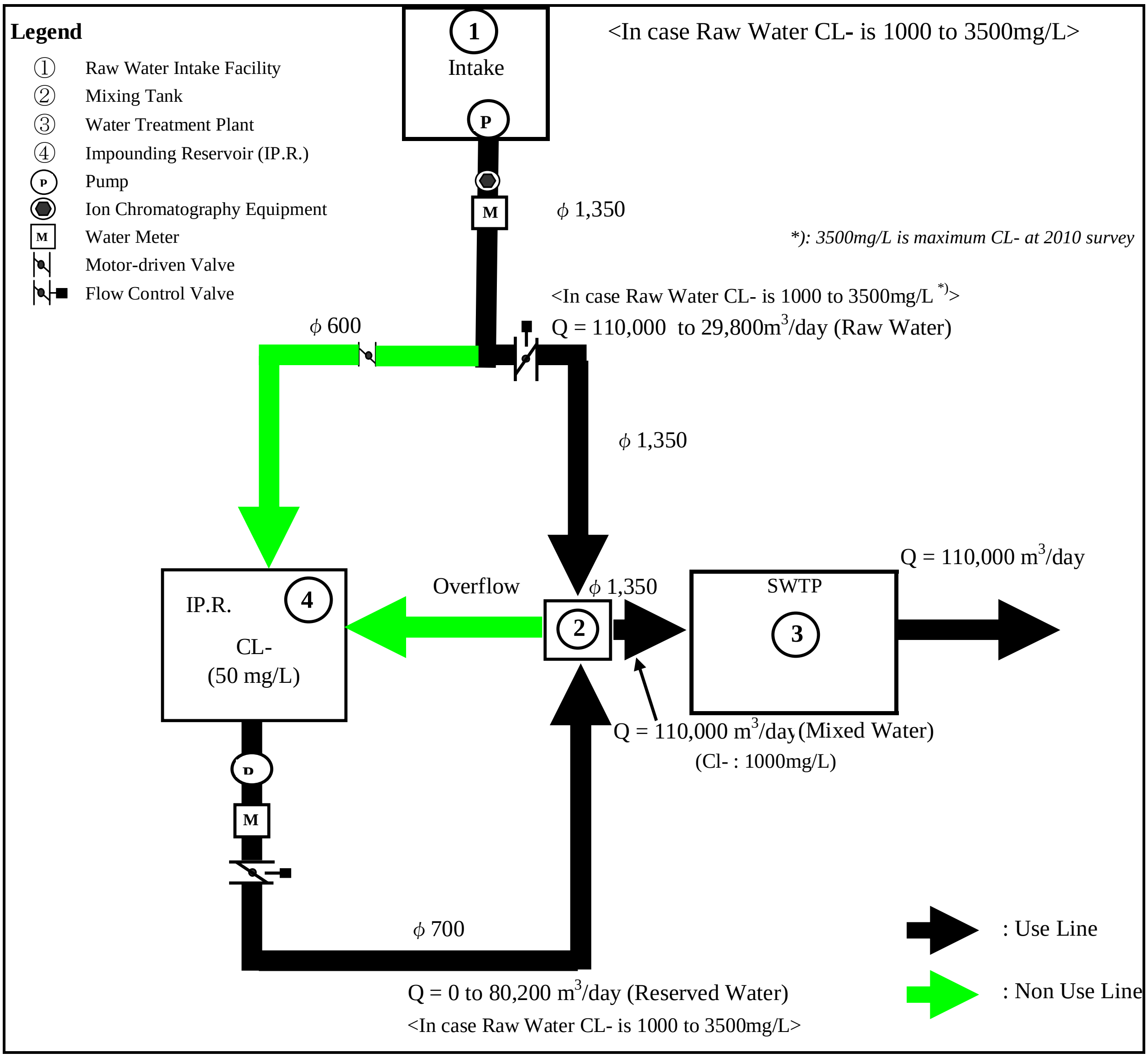


Figure 7.1.4 Flow diagram of raw water allocation (CASE -3)

7.2 Conceptual Design of Facilities

7.2.1 Water Intake

(1) Selection of Water Intake Point

Water intake site was selected at Mollarhat by the optional comparison in **Chapter 6**. Detail location of water intake is selected Site-I2 (0.1 km downstream from the Mollarhat Bridge) shown in **Figure 7.2.1** considering river flow/velocity, water flow amount and distance of raw water transmission pipe.

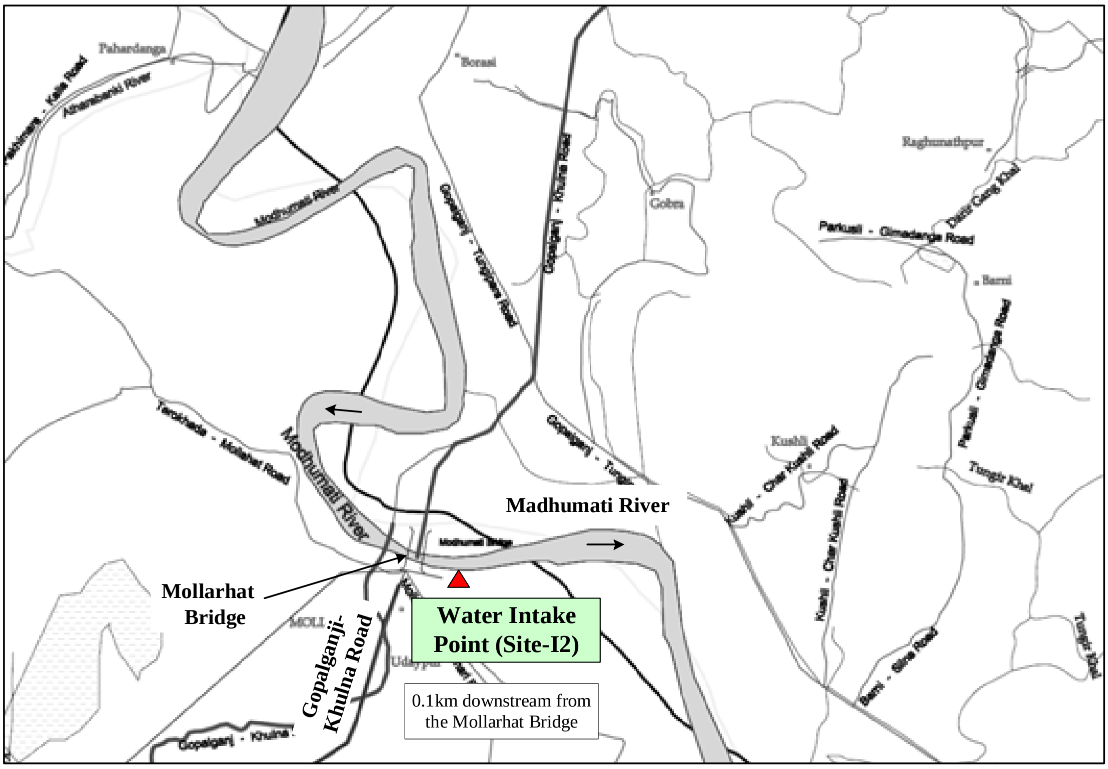


Figure 7.2.1 Location of Alternative Water Intake Point

(2) Selection of Intake Method

Intake gate method and intake tower method are supposed to be suitable for water intake. Comparison study is conducted for two methods and intake gate method is selected by following reason.

- For water intake tower 10 m of water depth is required to take water stable and continuously. Such water depth is only available at the point 40 m away from river bank.
- To construct a water intake tower pre-fabricated caisson is to be settled by cram shell excavator is required. Inner drainage works, lubricant injection work and sand caisson inclination control need intricate and complex construction technology.
- Total construction cost for intake tower method comprised of many work items includes earth works, temporally works, structural works, etc. will become 2 to 3 times of that needed for intake gate method.
- For intake tower, completion of the works within a dry season is required. But it is very difficult.
- During the construction work of intake tower, as 25 % of river section will be blocked by temporally earth platform

(3) River Water Level

BWDB has been conducted water level measurement at Mollarhat along the Madhumati River from 1929 to present. High and low water level at Mollarhat is set as follows, based on BWDB

Measurement data.

High Water Level (HWL):	+ 4.60 m (PWD)
Low Water Level (LWL):	- 0.20 m (PWD)

(4) Proposed Ground Level

Ground level of water intake facility is proposed +6.00 m (PWD) based on following investigation and examination.

- Existing road level in front of water intake is +5.50 m.
- Past record of flood level based on interview of 10 residents around proposed water intake site is +4.50 m. (1m below from existing Road)
- High water level measured by BWDB from 1929 to 2008 is +4.53 m.

Layout plan of water intake is shown in **Figure 7.2.2.**

In the discussion with the JICA Study Team BIWTA (Bangladesh Inland Water Transport Authority) accepted to construct the water intake facility at the right bank of Madhumati River near the Mollarhat Bridge. But BIWTA required preparing more than 60m length river protection at the water intake point.

Detail measures and protection method shall be discussed and determined in the detailed design stage through discussion with relative authorities inclusive BIWTA.

(5) Mechanical Equipment

1) Selection of Intake Pump Selection

Intake pumps are Vertical double suction volute pump with dry sump selected by safety against flood, high efficiency, superior cavitations characteristic, O&M, etc.

2) Inflow Screen and Grit Chamber

The raw water will be introduced from the river to pump well through the gate, inflow screen with opening 100 mm, grit chamber. Inlet and outlet gates will be provided with each chamber for maintenance.

3) Flywheel and Surge Tank

Water hammer will be expected at the raw water transmission pipe based on the analysis result considering of transmission flow and pipe diameter, length and profile. A flywheel and/or a surge tank will be equipped at the water intake pump to measure the assumed water hammer in the pipeline between water intake and SWTP.

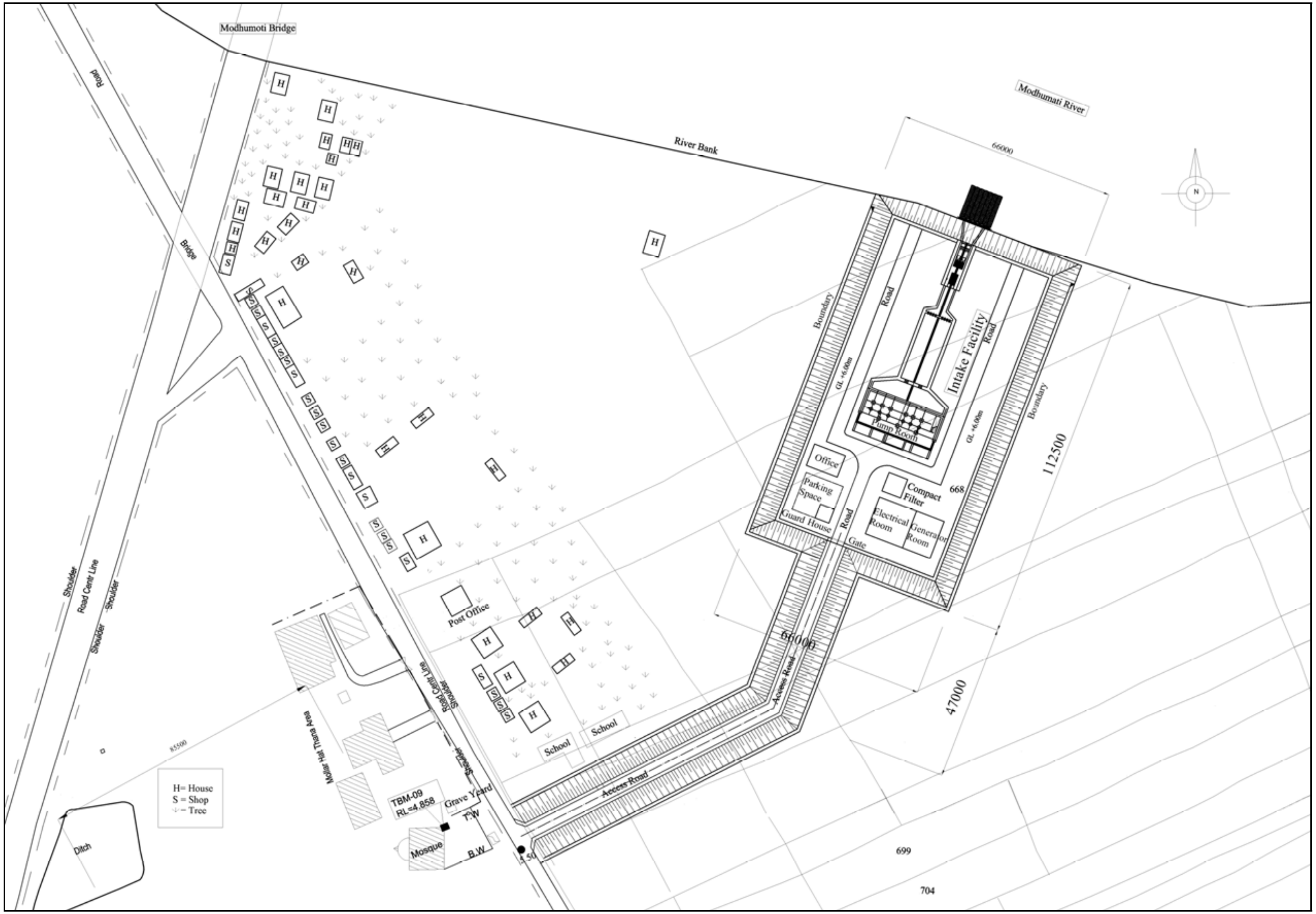


Figure 7.2.2 Layout of Water Intake

(6) Electrical Equipment

1) Planning of Power Receiving Facilities

Taking into account the situation of power distribution one line incoming system is applied for the power receiving method with power generator for backup in case of power failure. The total capacity is 1.5 times of the calculated capacity. Two transfers are to be installed; in case one of them is out of order the other one will cover 75 % of the total capacity.

2) Standby Generator

Diesel engine generator will be applied for standby power generator. For water intake, one set of diesel engine generator cubicle package type will be applied so as to ensure the failure of the synchronizer and or one strain operation.

3) Motor Control and Operation

Power control panel will be applied for water intake because the loads number is comparatively few and almost loads are large capacity that is not able to built-in the motor control center (MCC).

Automatic operation should be applied for water intake facilities and central operation from the surface water treatment plant will not be adopted.

For water intake, the river water level meter, pump pit water level meter and water transmission flow meter will be installed. The type of river water level meter is submersible and pump pit water level meters are both submersible type and differential pressure type. Water transmission flow meter is applied for electro-magnetic type.

7.2.2 Raw Water Transmission Pipe

(1) Pipe Material for Raw Water Transmission Pipe

For the proposed raw water transmission pipe diameter of 1,350 mm, ductile cast iron pipes (DIP) and steel pipes (SP) are considered as alterative materials. Ductile cast iron pipes (DIP) is selected for raw water transmission pipe considering durability, pipe joint work, soft soil condition and cost.

(2) Route of Raw Water Transmission Pipe

Two alternative routes, Route-1 (Gopalganji-Khulna Road and Bahirdia-Baghmara Road) and Route-2 (Paddy Field and Bahirdia-Baghmara Road), are considered for raw water transmission pipe.

Route-1, installed pipe on the Gopalganji-Khulna Road and Bahirdia-Baghmara Road, is selected by taking into account followings; safety of water quality, no land acquisition, easiness of construction works, short construction period, easiness of O&M and possibility of future expansion

Proposed raw water transmission pipe route is shown in **Figure 7.2.3**.

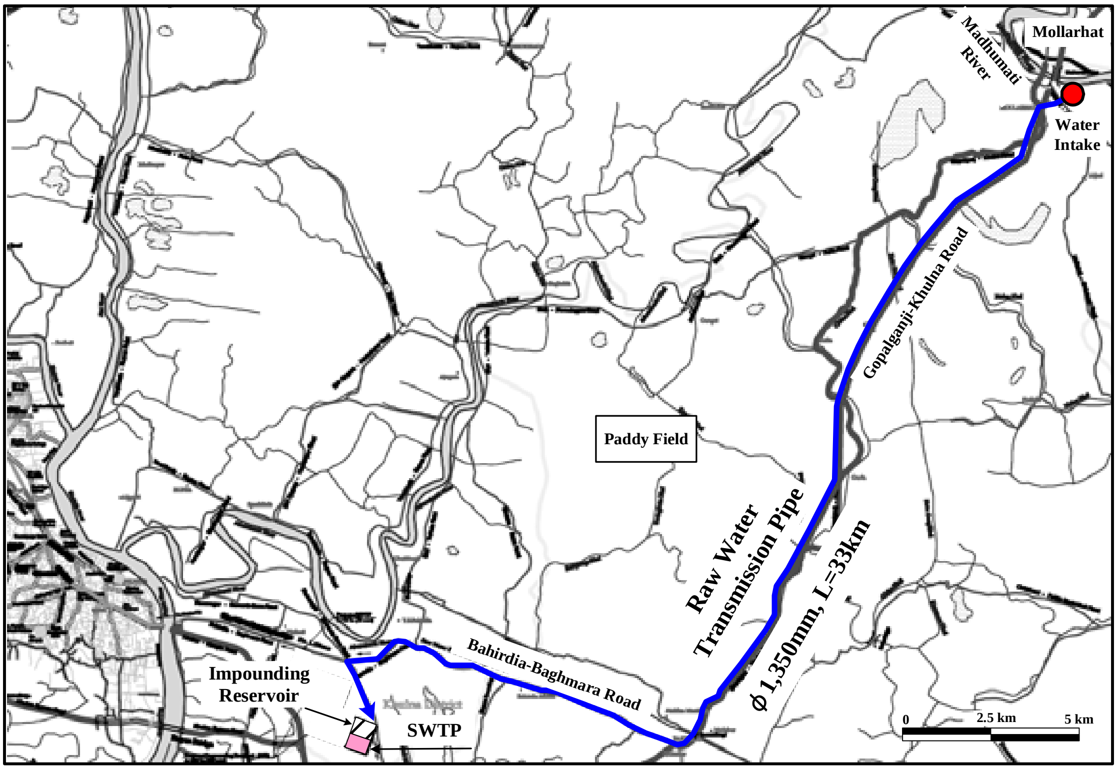


Figure 7.2.3 Selected Route of Raw Water Transmission Pipe

(3) Pipe Diameter

Pipe diameter of 1,350mm is adopted considering water flow, pipe length, flow velocity and capacity/number of pump, furthermore water hummer. Flow velocity is set more than 1.0m/sec to prevent sedimentation in the pipe.

(4) Pipe Bridge

There are 26 pipe bridges will be necessary to across rivers, channels and a middle size of box culverts. π shape flange support type will be adopted for pipe bridge by inner and external coating steel pipe because the crossing length is not very long. Details are shown in Drawing "RWT-PB-001 and 002.

7.2.3 Impounding Reservoir

(1) Location of Impounding Reservoir

Location of proposed impounding reservoir is at Samanto Sena near Bahirdia-Baghmara Road southern of Khulna city, adjacent SWTP.

(2) Design Condition of Impounding Reservoir

Preliminary design for impounding reservoir is conducted based on the following design condition.

- Effective Water Depth: 12.0 m
- Required Land Area: 16 ha (including 6 ha for expected future expansion)
- Area of Impounding Reservoir: 10 ha

(3) Mechanical Equipment

A single pipe of 1,100 mm dia. and about 100 m long will be installed for the project flow of 110,000 m^3/day from the impounding reservoir to the SWTP, which would transfer raw water to receiving well in the SWTP by Raw Water Pump.

(4) Electrical Equipment

1) Planning of Power Receiving Facilities

Taking into account the situation of power distribution one line incoming system is applied for the power receiving method with power generator for backup in case of power failure. The total capacity is 1.5 times of the calculated capacity. Two transfers are to be installed; in case one of them is out of order the other one will cover 75 % of the total capacity.

2) Standby Generator

Diesel engine generator will be applied for standby power generator.

3) Motor Control and Operation

Power control panel will be applied for impounding reservoir because the loads number is comparatively few and almost loads is large capacity that is not able to built-in the motor control centre (MCC) same as water intake.

4) Instrumentation

For impounding reservoir, the reservoir water level meter and raw water transmission flow meter will be installed. The type of level meter is submersible and raw water transmission flow meter is applied for electro-magnetic type.

7.2.4 Surface Water Treatment Plant (SWTP)

(1) Water Treatment Method

"Coagulation-Sedimentation + Rapid Filter Process" is applied as a water treatment method for the reason of lower construction cost, high turbidity, evaporated residue and large water flow. Flowchart of water treatment is illustrated as follows:

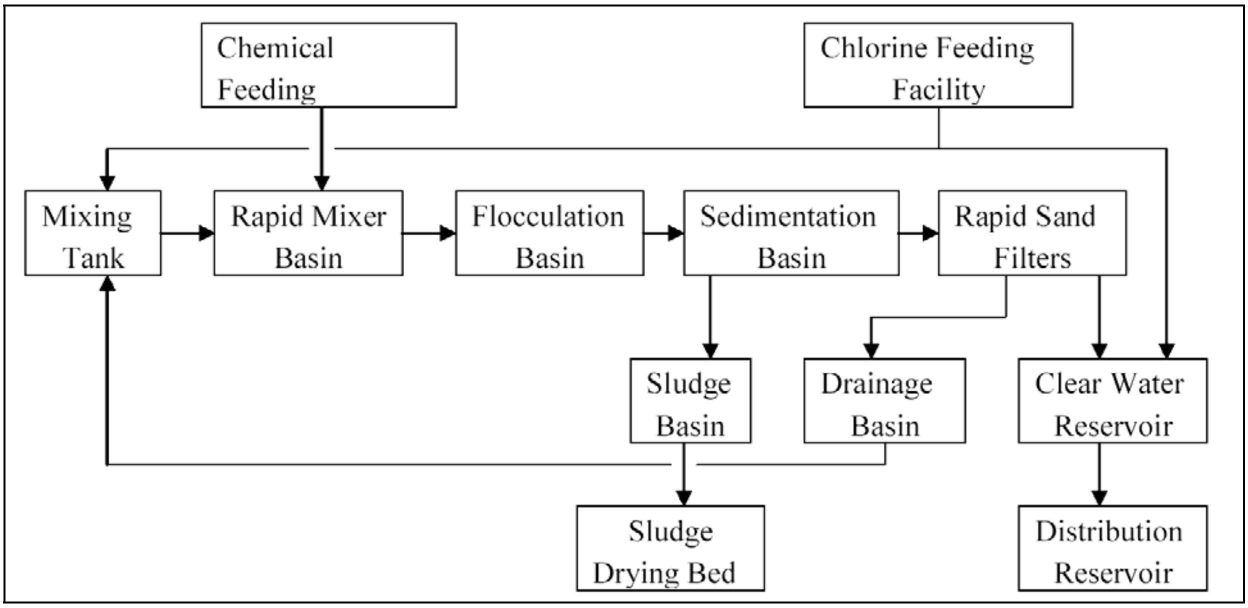


Figure 7.2.4 Flow Chart of SWTP

(2) Location of SWTP and Ground Level

Selection of SWTP location is considered that easy land acquisition and connection of raw water transmission pipe. Required land for SWTP is 10ha (250 m × 400 m). Location of proposed SWTP is at Samanto Sena near Bahirdia-Baghmara Road southern of Khulna city.

Ground level of SWTP is set +4.10 m (PWD) considering road level (+4.059 m) near by SWTP and the highest flood level (+3.360 m) in past record.

(3) Layout Plan of SWTP

SWTP layout plan is conducted by following conditions.

- Buffer zone is ensured at north side area since the impounding reservoir constructed neighboring SWTP is 12 m of depth
- Layout plan is considered future expansion plan. Expansion area is used for the sludge drying bed, dry sludge stock yard and construction materials storage yard at present.
- As facility arrangement, administration building and power receiving facility are arranged near the entrance gate, sludge drying bed is arranged deep into SWTP site, and clear water reservoir will be constructed near the clear water transmission pipe route considering water flow.

Proposed SWTP layout is illustrated in **Figure 7.2.5**.

(4) Design Criteria of SWTP

Preliminary design of SWTP for each facility is conducted based on the following criteria.

Table 7.2.1 Design Criteria of SWTP

	Mixing Tank	Flocculation Basin	Sedimentation Basin	Rapid Sand Filter	Clear Water Reservoir
Type/ Shape	Vertical Channel Bend	Vertical Channel Bend	Rectangular	Gravity Type	Rectangular
GT Value *)	More than 23,000	-	-	-	-
Retention Time	3 min	30 min	-	-	More than 1.0 hr
Velocity	-	15 – 30 cm/sec	Less than 0.28 m/min	-	-
Surface Loading	-	-	26 mm/min	120 m/day	-
Effective Depth	-	-	4.0 m	-	4.0 m

*) GT Value: Indicator for effectiveness of flocculation mixing

(5) Mechanical Equipment

1) Clear Water Pump

A single pipe of 1,100 mm diameter and about 10km long will be installed for the project flow of 110,000 m^3/day from the clear water pump station to distribution reservoir, which would transfer clear water to the five distribution reservoir, by clear water pump.

2) Chemical Dosing Facilities

- Alum: As coagulation, alum dosing facilities consist of dissolving tanks and dosing devices. Diaphragm pump is recommended for chemical pump due to simple and economy.
- Lime: As pH control, lime dosing facilities consist of dissolving tanks and dosing devices. Diaphragm pump is recommended for chemical pump, due to less clogging.
- Chlorination: The chlorination will be done at two dosing points in the proposed SWTP. One of the dosing points is at receiving well as pre-chlorination and the other is at filter outlet as post-chlorination.

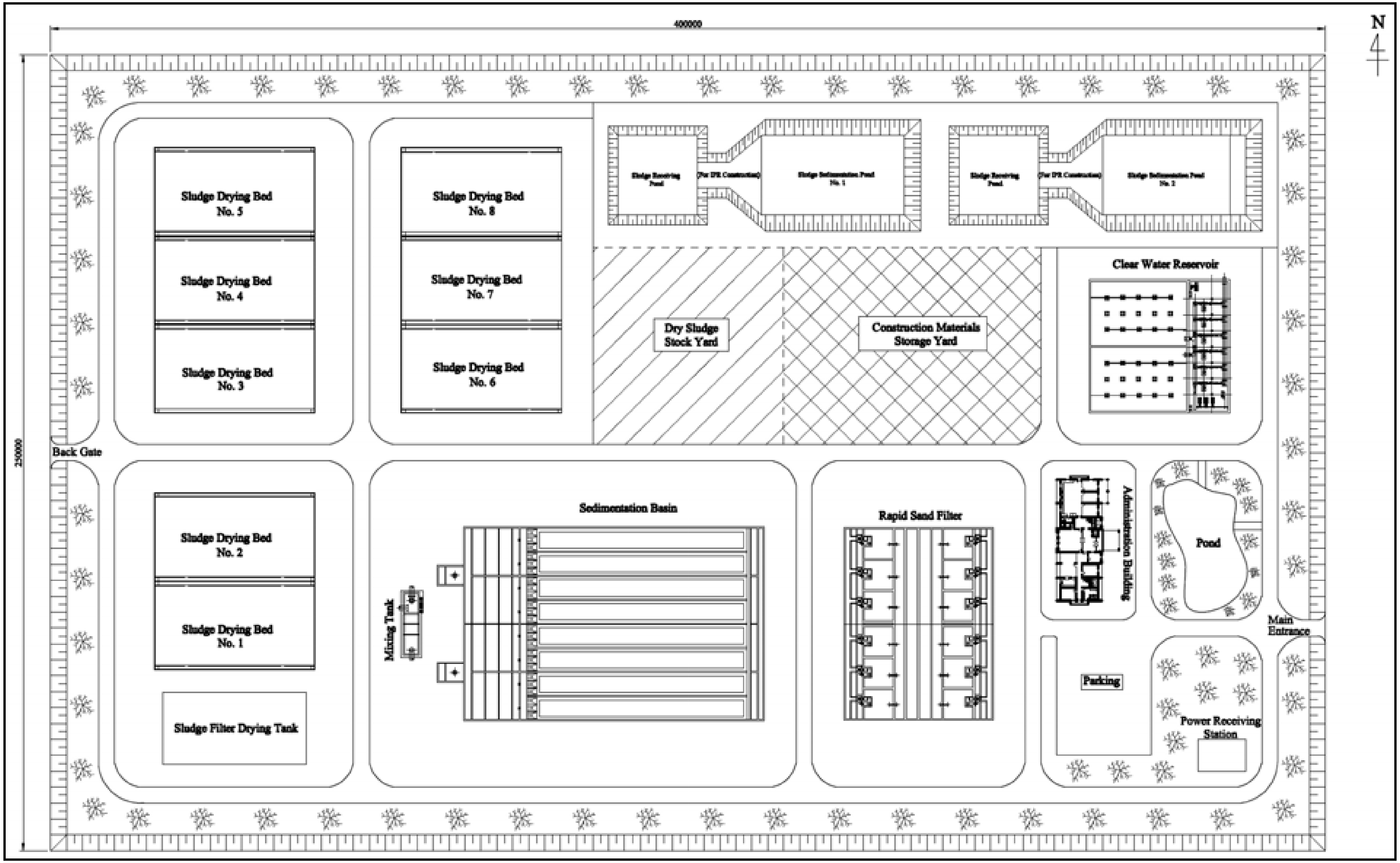


Figure 7.2.5 Layout Plan of SWTP

(6) Electrical Equipment

1) Planning of Power Receiving Facilities

Taking into account the situation of power distribution, medium voltage one line incoming system is applied for the power receiving method with power generator for backup in case of power failure same as water intake. The total capacity is 1.5 times of the calculated capacity. Two transfers are to be installed; in case one of them is out of order the other one will cover 75 % of the total capacity.

2) Standby Generator

Diesel engine generator will be applied for standby power generator.

3) Motor Control and Operation

Motor control center (MCC) will be applied for the facilities there locate many numbers and small load like a rapid filter of SWTP. Site control panel will be applied for the load; the starter of it is installed in MCC.

4) Instrumentation

For SWTP, inflow meter, wash waste return water flow meter, clear water transmission flow meter and water level meter for each tank will be installed. Water turbidity, pH, water temperature, salinity, chromaticity, conductivity, alkalinity measurements for raw water, salinity for filtrated water and turbidity and residual chlorine will be measured once a day by laboratory instrument equipment.

5) Supervisory System

SCADA system will be applied for the Surface Water Treatment Plant. And on this supervisory system, to ensure the reliability of control, only the monitoring should be applied.

Five sets of PLC (Programmable Logic Controller) will be installed. Site electrical information will be collected to the PLC and this information will be transmitted to the data server and OWS (Operators Work Stations) to using in-plant LAN network.

Quantitative measurements signal from instrument panel, potential free contact signal of the ON-OFF, open-close and failure from power control panel and/or auxiliary relay panel, electrical measurements and condition of facility like a circuit breaker will be coming to PLC.

7.2.5 Clear Water Transmission Facility

(1) Diameter and Route of Clear Water Transmission Pipe

For the route of clear water transmission pipe is considered two routes, Route-A (mainly installed under Khan-A-Sabur Road) with pipe length of 24.6 km and Route-B (mainly installed under Sonadanga Bypass Road) with pipe length of 41.8 km. The result of comparison study, Route-A is selected by reason of advantage of construction cost and O&M cost.

(2) River Crossing Method

As river crossing method, three construction methods are considered: open-cut method, water-bridge and pipe-jacking method. The result of comparison study for these methods, pipe jacking method is selected by the advantage of construction work taking into account of environmental impact, simplified of temporary work and construction cost.

(3) Transmission Method

Clear water transmission facility is the pipeline to send clear water form SWTP to five distribution reservoirs. Direct transmission method by pump is adopted since ground level from SWTP to Khulna city is almost flat.

(4) Mechanical Equipment

1) Distribution Pumps

A single pipe of 250 - 400 mm dia and about 100 - 8200 m long will be installed for the project total amount flow of are 110,000 m^3/day from the distribution reservoir to overhead tank, which would transfer clear water to the eleven overhead tanks by distribution pump. Dry well horizontal end suction volute pumps are recommended for the clear water transmission. The proposed specifications for the Distribution Pumps will be as follows;

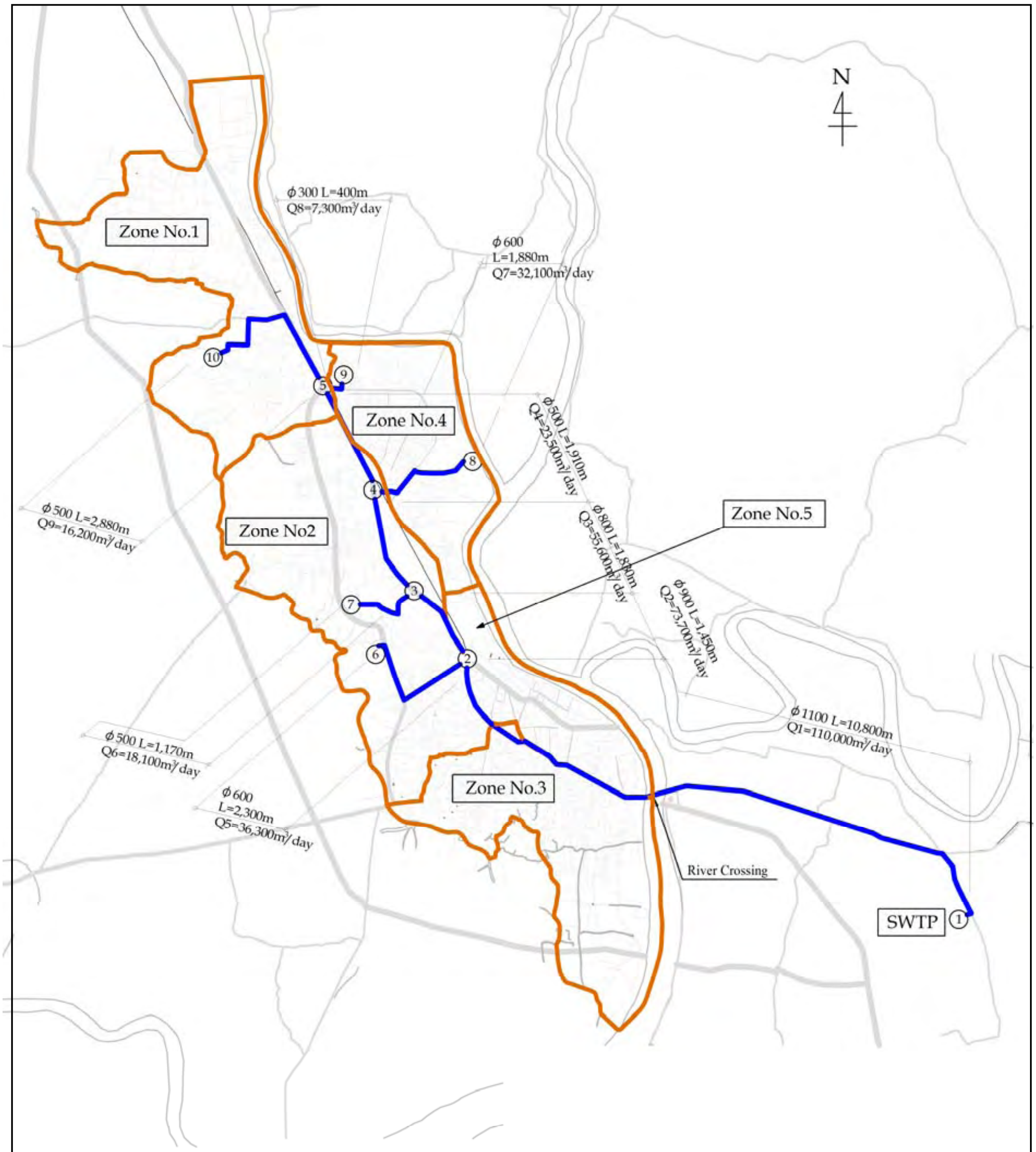
Table 7.2.2 Proposed Specification of Distribution Pump

Reservoir zone	Zone 1	Zone 1	Zone 2	Zone 2	Zone 3	Zone 3	Zone 3	Zone 4	Zone 5	Zone 5	Zone 5
Overhead Tank Name	Rab Sarani	Deana West Para	Mujgunni	Ward No.16 Office	Sonadanga Moha Sarak	Andir Pukur	South Side of Ward No.31 Office	Beside of No.7 Ward Office	Khalishpur Charehat River Ghat	Ferry Ghat Power House More	DPHE Rupsha
Pump Type	End suction	End suction	End suction	End suction	End suction	End suction	End suction	End suction	End suction	End suction	End suction
q : Capacity (m3/min)	3.2	5	3.1	3.3	4.5	3.7	2.3	5.1	4.6	2.6	2.8
Pump Number	2D +1S	1D +1S	2D +1S	2D +1S	2D +1S	2D +1S	4D +1S	1D +1S	2D +1S	2D +1S	3D +1S
Rated Head	56.0	35.0	53.0	34.0	34.0	52.0	72.0	33.0	34.0	70.0	65.0
Motor Power (kW)	55	45	45	30	45	55	45	45	45	55	55

* D means duty, S meam standby regarding Pump Number.

2) Chlorination

The chlorination facilities shall be installed in five distribution reservoirs because underground water is also transferred to the distribution reservoir from existing tube well. The chlorination facilities consist of chlorine cylinders, weighing devices, chlorinators, injectors and safety devices. Specification of chlorinator shall be design considering wide range.



①	SWTP
②～⑤	Junction
⑥	Sonadanga Moha Sarak Reservoir
⑦	Ward No.16 Office Reservoir
⑧	Khalishpur Charerhat River Ghat Reservoir
⑨	Beside of No.7 Ward Office Reservoir
⑩	Deana West Para Reservoir

Clear Water Transmission Pipe

0 2.0km 5.0km

Figure 7.2.6 Clear Water Transmission Pipe

(5) Electrical Equipment

1) Planning of Power Receiving Facilities

Taking into account the situation of power distribution, one line incoming system is applied for the power receiving method with power generator for backup in case of power failure for each distribution reservoir. One transformer will be installed because of the small scale facility and also damage scale is comparatively small when the accident will occur.

2) Standby Generator

Diesel engine generator will be applied for standby power generator for each distribution reservoir. Fuel storage capacity is the tank capacity that is built-in the cubicle package.

3) Motor Control and Operation

Power control panel will be applied for distribution reservoir because the loads number is comparatively few. Automatic operation should be applied for distribution reservoir and overhead tank facilities. The water level of distribution reservoir is controlled mechanically by float valve.

4) Instrumentation

For distribution reservoir and overhead tank, inlet water flow, distribution water flow, distribution reservoir water level and the water level of overhead tank will be installed. The type of water level meter is differential pressure type because of its simple mechanism and high accuracy.

Residual chlorine shall be measured once a day by laboratory instrument equipment.

5) Supervisory System

The overhead tank water level will be sent to the distribution reservoir by radio telemeter and this information will be sent to SWTP with the information of distribution reservoir like water level, inlet water flow etc., two or four times a day.

An emergency such as failure, alarm information and the signal that is necessary to control pump will be sent at any time to the SWTP.

7.2.6 Water Distribution System

(1) Distribution Reservoir and Overhead Tank

1) Distribution Reservoir

Distribution reservoir is functioning to respond to the time fluctuation, it also retains a role of reservation of water for emergency. Therefore following points shall be taken into account to determine its location and capacity.

- Distribution reservoir is located centre or near each distribution zone.

- The volume of distribution reservoir is aimed at 12 hours for storage, which considered time fluctuation and countermeasure for emergency
- Structure is considered durability, quake proof and water proof.

2) Overhead Tank

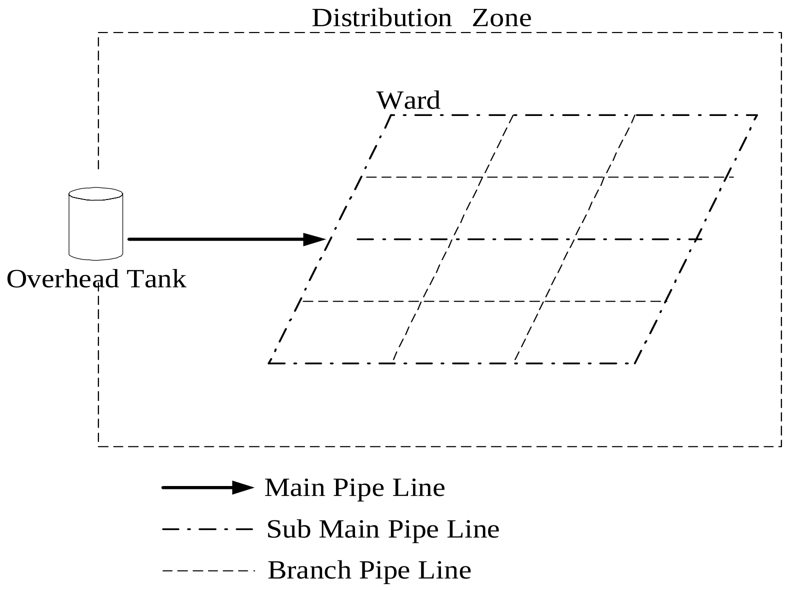
Overhead tank is installed on the ground in order to adjust distribution flow and water pressure. The purposes of overhead tank installation are as follows.

- To adjust water distribution amount
- To adjust water pressure in pump pressurization area
- To use adjustment of both as distribution amount and pressurization

(2) Water Distribution Network

1) Basic Design Concept of Water Distribution Network

Distribution Trunk Pipe:	Installation of Overhead Tank to Water Supply Zone, ϕ 350 to 400mm
Distribution Main Pipe:	Installation of Pipeline as Circular or to the Centre in the Zone, ϕ 300 to 250 mm
Distribution Branch Pipe:	Pipeline is diverged from Distribution Main Pipeline, φ200 to 150 mm



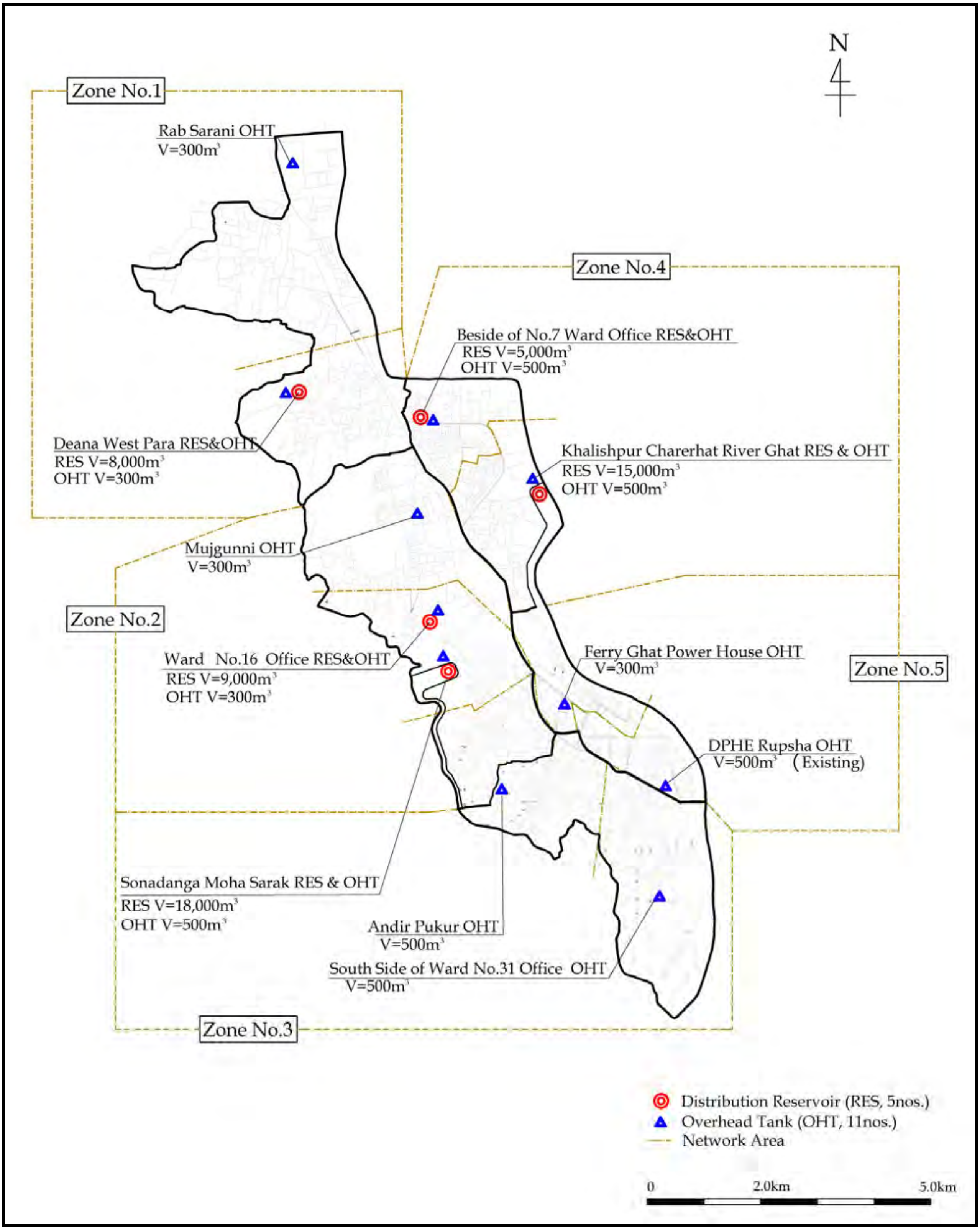
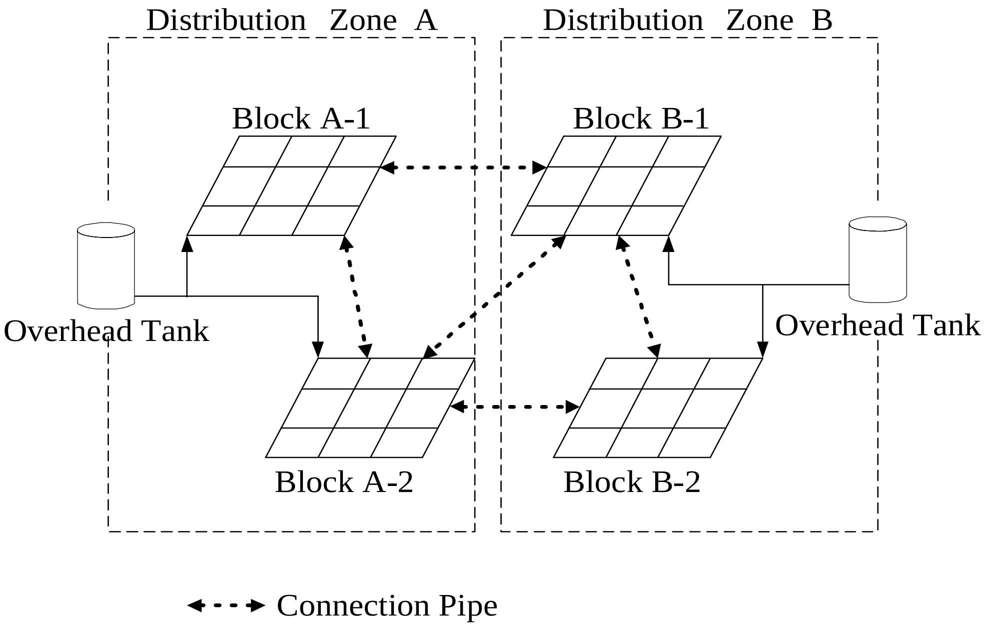


Figure 7.2.7 Distribution Reservoir & Over Head Tank

2) Mutual Backup Concept of Water Distribution Zones

The zones adjoin is connected by connection pipe each other to avoid the risk in order that water distribution network can be distributed or supply a certain volume of water at an emergency.



(3) Distribution System Plan (Common)

Distribution system is functioning storage, transmission, distribution and supply for clear water. It consists of distribution reservoir, overhead tank, distribution pipe network, pumps, valve and other equipment. Distribution system is designed taking into account of following matters.

- Water must be supplied with safety and proper water pressure corresponding to the demand which changes hourly
- Operation and maintenance is done by effective and simple
- To prevent clear water from pollution and change in water quality

(4) Volume of Distribution Reservoir and Over Head Tank

Distribution reservoir is constructed by reinforced concrete. Volume of distribution reservoir is calculated following formula.

$$V = \text{Daily Maximum} \times (12 / 24)$$

The volume of distribution reservoir and over Head tank is shown in **Table 7.2.3**.

Table 7.2.3 Distribution Reservoir & Over Head Tank

Zone	Block	Distribution Capacity (m^3)	Over Head Tank Capacity (m^3)
No.1	No.1-1	8,000	300
	No.1-2		300
No.2	No.2-1	9,000	300
	No.2-2		300
	No.2-3		500
No.3	No.3-1	18,000	500
	No.3-2		500
No.4	No.4-1	5,000	500
	No.4-2		500
No.5	No.5-1	15,000	300
	No.5-2		500

(5) Water Level

1) Distribution Reservoir

Distribution reservoir will be constructed in underground, and the level of upper slab is set 1.0 m lower than average ground level GL+4.0 m. On the condition that thickness of upper slab is 0.3 m, allowance to the HWL is 0.3 m and effective depth is 5.0 m. Then the water levels of distribution reservoir are HWL +2.40 m, and LWL -2.60 m

2) Overhead Tank

Many buildings in Khulna city are two-story and three-story buildings. To supply water properly the height of overhead tank is set about 30 m from +4.0 m average ground level in Khulna city. Considering effective water depth 4.0 m the water levels of overhead are; HWL +27.4 m and LWL +23.4 m.

(6) Distribution Network

1) Pipe Diameter and Length

Pipe diameter and length are decided by distribution network basis, and repetitious calculation is conducted until necessary water pressure is acquired.

Distribution pipeline is classified four types; distribution trunk pipe, distribution main pipe, distribution branch pipe and small distribution pipe.

2) Pipe Material

Pipe material of distribution network is adopted DIP (ductile cast iron pipe) for main pipes. Pipe material of small distribution pipe with diameter of less than ϕ200 mm is used PVC pipe and/or HDPE pipe.

CHAPTER 8 INSTITUTIONAL AND MANAGEMENT CONSIDERATIONS

This chapter provides the background of KWASA as an institution and examines its current administrative and organization structure and its future organizational growth path or institutional development. It also assesses KWASA's ability to fulfil its legal mandate and institutional mission, and provides recommendations on how it can develop itself in the light of processes that would support and facilitate its evolution into an efficiently and effectively run modern water utility, particularly by 2017 when the proposed Khulna Water Supply Improvement Project will be implemented, see completion, and eventually become operational.

Institutional development at KWASA is an internal process that involves people (human resources) and developing their capacities to perform at optimum levels. This includes codified policies and procedures (management systems) in the major functional areas of water utility management to ensure high standards of efficiency. It entails the appropriate structure (organization) that clearly delineates unit and individual authority, responsibility, and accountability, as well as coordinative and communications flows, from the top to bottom (horizontally) and across (vertically) the entire organization spectrum. The recommendations presented in this chapter would encompass the KWASA organization structure, human resources, capacity building plan and project implementation arrangements.

8.1 Current Institutional Set-Up

8.1.1 History and Background of KWASA

The Government of Bangladesh established the Khulna Water Supply and Sewerage Authority (KWASA) in February 2008 through a Statutory Regulation Order (S.R.O no-43-law/2008-law/division pass-2/K 1/2007) to provide for "the construction, improvement, expansion, operation and maintenance of water and sewerage works and other facilities relating to environmental sanitation." This paved the way for spinning off the water supply division of the Khulna City Corporation (KCC) into the Khulna Water Supply and Sewerage Authority, a separate, independent and legal entity, by virtue of Section 3 of the Water Supply and Sewerage Authority Act of 1996, thus enabling the Government to establish any Authority for any local area to carry out the mandate of the WASA Act, and where such action, by notification in the official Gazette, shall be recognized by its regional, metropolitan, or by its main city.

With the establishment of KWASA, several circulars have been issued by the Local Government Division (LGD) effecting the transfer of the assets and resources of KCC's water supply department to KWASA. The first to be transferred to KWASA were KCC's 127 permanent employees from its water supply division. Next came the transfer of the physical assets such as real property, buildings, machineries, equipment, vehicles, furniture and fixtures, and stocks (supplies and materials), including financial accounts and liabilities to the KWASA.

8.1.2 The Administrative Structure of KWASA

The administrative structure of KWASA is based on the Water and Sewerage Authority Act of 1996

(WASA Act). It is this same Act that governs the establishment of all existing (and future) WASAs in Bangladesh, such as those already set up in cities of Dhaka, Chittagong and Rajshahi, including Khulna. With KWASA's establishment, its administrative structure has been clearly defined. The Authority is led by a KWASA Board, and the delegation of day-to-day operational matters to its Managing Director.

(1) KWASA Board

The KWASA Board is composed of 13 members coming from both the public and private sectors. The Government has representatives from the Ministry of Local Government, Rural Development and Cooperatives as well as the Ministry of Finance. Other members come from the local government, as well as private citizens representing a cross section of the local community. Board members hold office for a term of three years from the date of appointment, and are eligible for reappointment. The Government, however, may remove a member at any time if it is found that such a member is guilty of misconduct, or is negligent in the discharge of his/her duties and responsibilities. The current members of the Board are a shown in the **Table 8.1.1**.

Table 8.1.1 KWASA Members and Offices/Sectors Represented, 2010

	Name / Designation	Office / Sector Represented	Position
1.	Hafisur Rahman	Users of Water Supplied by Authority	Chairman
2.	Ms. Zuena Aziz	Ministry of Local Government, Rural Dev and Coop	Member
3.	Fakrul Ahsan	Ministry of Finance	Member
4.	Mr. Shaharuzzaman Mortoza	Chamber of Commerce and Industry in the Area	Member
5.	Md. Saiful Islam	Institute of Chartered Accountants	Member
6.	Dr. Md. Alamgir	Institute of I. E, Bangladesh	Member
7.	Md. Aminul Islam (Munna)	One Male representing City Corporation	Member
8.	Shaikh Amena Halim Babi	One Female representing City Corporation	Member
9.	Dr. Shaikh Baharul Alam	Medical Association of Bangladesh	Member
10.	Advocate Sha Md. Sabirur Rahman Faruk	Bar Council, Bangladesh	Member
11.	Md. Abdullah P. Eng	Managing Director, KWASA	Member
12.	M.R. Khairul Ulmam	Institute of Diploma Engineers, Bangladesh	Member
13.	*Not yet named*	Federal Journalist Union	Member

Authority/Function and Duties of the KWASA Board

As the highest policy-making body of KWASA, the Board is vested with the broad-spectrum powers to set the general direction and administration of the affairs and functions of the Authority. It may exercise all these powers and perform all functions, which may be exercised or performed by the Authority. The Board is tasked with the important function of ensuring that the Authority operates in a commercial manner. Its specific functions, which are stated in Section 10, WASA Act of 1996, can be categorized as:

Formulation of Policy

- Formulates policies necessary for the attainment of the objectives and purposes of the Authority;
- Makes regulations governing the manner by which the general administration and business of the Authority is to be conducted and its finances managed;
- Adopts rules of procedure for Board meetings.

Appointing

- Appoints the key officers such as the Managing Director and Deputy Managing Directors and defines their functions.

Corporate Strategy – Organizational

- Determines the organizational set-up of the Authority and approve modifications;
- Approves the creation of posts and determines the remuneration and privileges of the officers and employees of the Authority

Corporate Strategy – Business / Financial

- Approves the corporate plan and annual and mid-term investment plan;
- Approves the annual budget of the Authority, and supplemental budget, where necessary;
- Approves self-financed investments of the Authority and the financial arrangements;
- Approves contracts within the limits set by the Government, except in cases of contracts under investment form Authority's own resource;
- Approves proposals for adjustment of rates and charges for the services of the Authority.

Government Reporting

- Approves audit reports;
- Submits to the Government annual reports and other required reports;
- Submits to the Government fiscal plans and statements of financial conditions for incorporation in the budget plans subject to prescribed rules;
- Submits to the Government for approval all proposals for investments requiring Government finance or guarantee for approval.

<u>The Power and Authority of the Government</u>

Notwithstanding the powers vested by the WASA Act on the KWASA Board, the Government still exercises considerable power and authority over KWASA. These powers are specified in Chapter III (Sec 14) Chapter IV, Sec 16 and 17, and Chapter VI, Sec 32 and 38 of the WASA Act, as: (i) policy guidance, stating that the Authority, when discharging its functions, shall be guided by general policy statements to be issued by Government; (ii) monitoring, through submission of reports on the conduct of its affairs in the context of the performance agreement, and through reporting mechanisms; (iii) supervision, through the signing of an annual performance contract with Government, definition of specific performance targets, formulation of schemes, determination of program of works and authorization of expenditures; and (iv) approval, when raising rates/tariffs, borrowing and determining the terms of conditions of borrowing, especially if the Government guarantees the loans.

The Conduct of Business of the Board

The conduct of business of the Board is governed by Chapter III of the WASA Act through Board meetings, which shall be held “as frequently as may be necessary for the Board to discharge its functions and responsibilities”. However, the Board should meet at least once every two months. Normally, it is the Chairman, or in his absence, the Vice-Chairman, that convenes the meetings of the Board. However, the Board can also be convened if: (i) the Chairman, or in his absence, the Vice-Chairman deems it desirable; (ii) the Managing Director so requests; (iii) or a majority of the members so request. The quorum at a meeting of the Board is the presence of not less than five of its members.

(2) The Managing Director (MD)

The Managing Director of KWASA is appointed by the Board with the approval of the Government. The MD holds a term of three years, and is eligible for reappointment. He serves the Authority on a full-time basis as its chief executive officer, and is the legal representative of the Authority in all dealings with any person or authority. He is also a member of the Board, and can participate in all its deliberation, although he holds no voting power.

The policies and measures, including financial and operational objectives, approved by the Board are executed, administered and implemented on a day-to-day basis through the Managing Director. As such, he shall be held accountable for the Authority’s performance; responsible for meeting agreed performance targets, and responsible for the orderly conduct of the business of the Authority. The MD is given sufficient powers to enable him to discharge his functions and responsibilities, as enumerated in Chap 5, Sec 28, of the WASA Act, 1996.

Powers and Functions:

General Management and Supervision

- To execute and manage the affairs and business of the Authority in a financially and administratively sound manner, in compliance with the provisions of the WASA Act and the terms and conditions of any contract approved by the Board;
- To formulate operational policies and internal work systems for the conduct of the day-to-day affairs of the Authority, including performance incentives for the staff, and to implement them with the approval of the Board.
- To appoint, with the approval of the Board, all officers and employees of the Authority, and to take disciplinary action against them in accordance with the relevant service rules and regulations;

- To transfer officers and employees within the Authority.

Corporate Plan and Performance Targets

- To submit to the Board for approval the corporate plans and annual and mid-term investment plans showing justifications and benefits, as well as technical, financial and economic viability;
- To set, subject to the approval of Government, the performance targets relative to the implementation of its corporate plans and programmes;
- To recommend to the Board any change in the rates and charges of the Authority by way of adjustment based on an evaluation of expected performance in the next financial year.

Board Reporting

- To submit to the Board, within three months after the close of the financial year, an Annual Report that details the yearly conduct of the affairs, business and performance of the Authority, together with audit reports and other reports as may be required.

Legal

- To institute, defend or withdraw any proceeding and compound any offence;
- To obtain legal advice in any matter of the Authority.

(3) Deputy Managing Director

The Board may, with the approval of Government, appoint one or more Deputy Managing Directors, who shall perform functions as may be assigned to him by the Board or as may be delegated to him by the Managing Director.

8.1.3 The Organization Structure / Organogram of KWASA

(1) The Current Organogram

In early 2008, KWASA recommended an organogram to LGD, as shown in **Figure 8.1.1**. This received administrative approval by LGD on 25 November 2008, however, the organogram did not undergo the entire process of official approval. The LGD-approved organogram is now referred to as the “Draft KWASA Organogram”.[1]

[1] Meeting with MD Abdullah, Managing Director, KWASA, dated 19 July 2010.

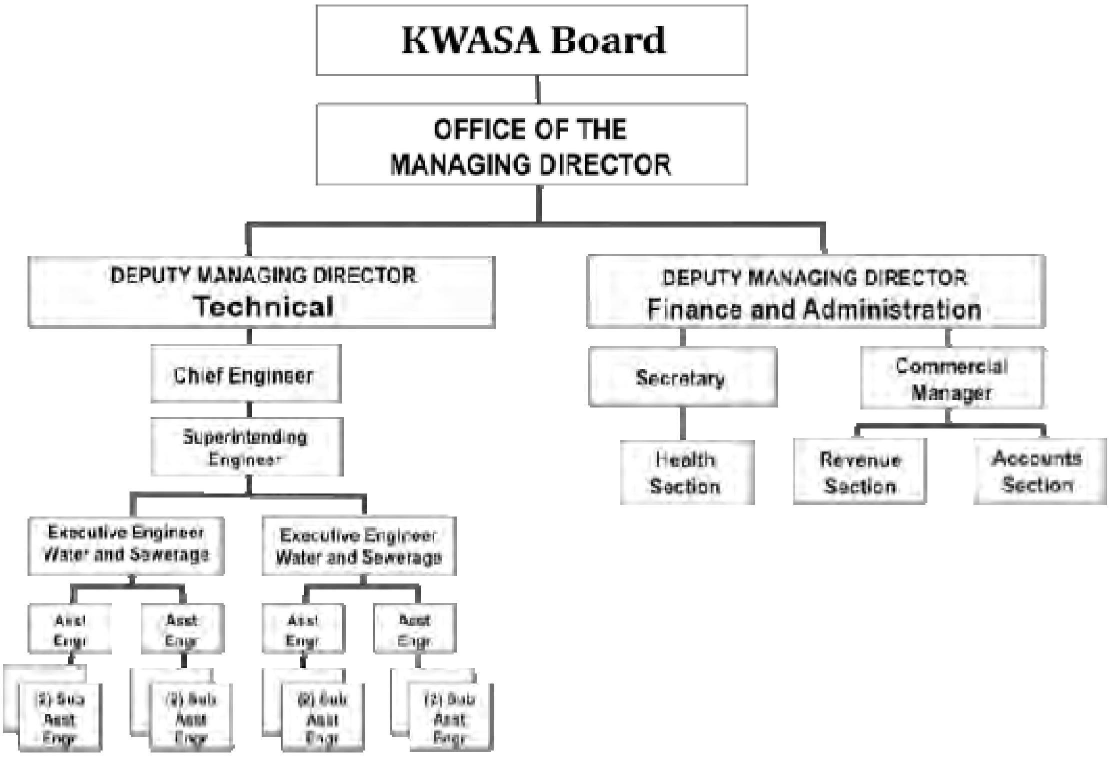


Figure 8.1.1 Draft KWASA Organogram (LGD-Approved), 2008

It should be noted that upon its establishment, KWASA's initial organogram must have the official seal of approval by the Government (Prime Minister)[2], which is still to be achieved. The WASA Act (Chap II, Sec 10 [1][d]) clearly states that the KWASA Board shall "determine the organizational set-up of the Authority and approve modifications therein", meaning that only revision(s) to the initial (Government-approved) organization set-up can pass Board approval. The process of official approval for the initial KWASA organogram is shown in **Figure 8.1.2**.

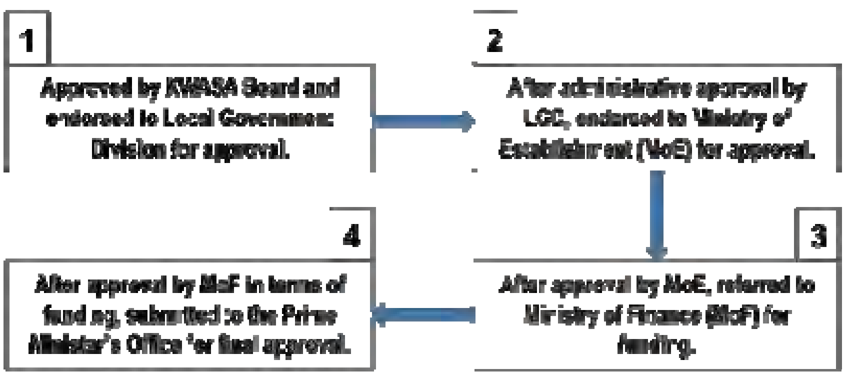


Figure 8.1.2 Process of Official Approval for Initial Organogram of KWASA

KWASA prepared another organogram, as shown in **Figure 8.1.3**, tentatively called "chart of duties",

2 Meeting with Syeda Salma Jafreen, Senior Assistant Secretary, Local Government Division (MLGRD&C), dated 22 July 2010.

and is, for all intents and purposes, a semi functional organogram. This is the organogram presently in use.

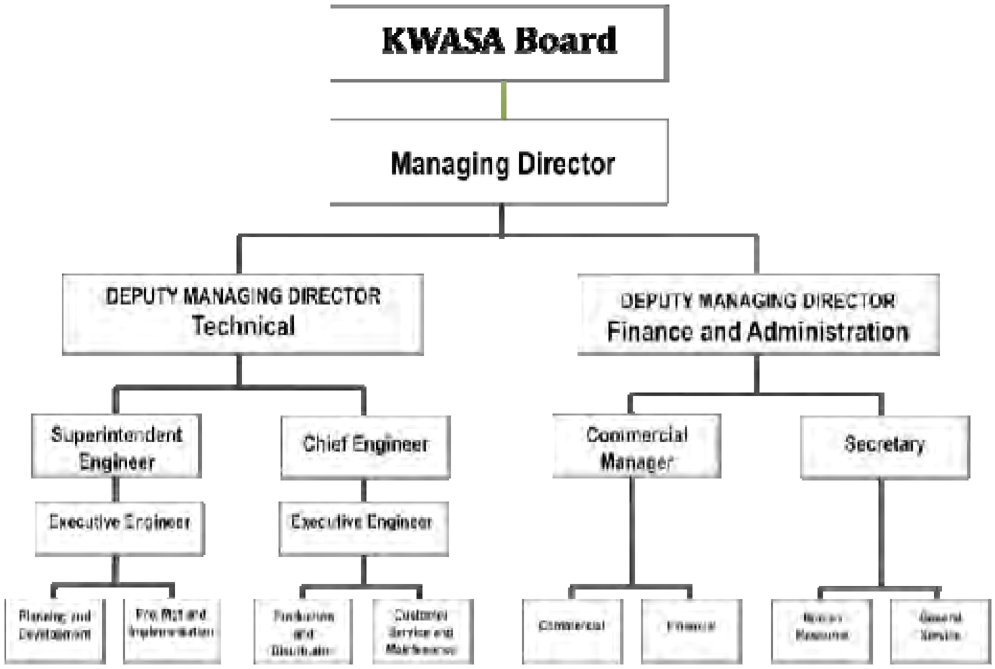


Figure 8.1.3The KWASA Organogram, 2010

(2) The Succeeding Organograms

The succeeding organization structure/s of KWASA, after the first or initial one, may be revised, and will need only the approval of the Board, depending on the "enforcement of any performance agreement, or the adoption of new project, or for addition of new areas, or expansion of the activities of the Authority" as spelled out in Chap 5, Sec 30 of the WASA Act.

(3) The Current Human Resources Inventory

Shortly after the approval of the KWASA organogram came the LGD-issued document-guideline entitled "Creation of 157 Permanent Revenue Posts for KWASA". This is the TOE, or Table of Organization and Equipment, which provides for the type of positions, the number of posts for each position, the minimum qualifications required for each post, and the promotion criteria for KWASA to operate the Authority. It also included. See **Appendix 8.1.3:** Creation of 157 Posts for KWASA [English translation].

To date, of the 157 posts created, 130 have been filled up by former KCC employees; two posts – the Managing Director and Deputy Managing Director for Technical – have been filled through contract; and one post, that of the Secretary, was filled through deputation. Recently, seven posts [executive engineer (1), commercial manager (1), revenue officers (3), assistant chief (1) and accounts officer (1)] have been filled through direct recruitment and hiring. Eight other posts [assistant engineer (2), budget officer (1) and sub-assistant engineer (5)] will be filled up through direct recruitment and hiring before the end of the year.

The official transfer of the 130 KCC permanent staff to KWASA follows the country's "Absorption Rule / Law", a process that guarantees how a newly established entity (KWASA) absorbs the old entity's (KCC) personnel. As of this time, the review by the LGD has already been completed, thus, staff absorption is currently also on its final stages, having been approved and endorsed by LGD to the Ministry of Establishment.

In addition to the 157 revenue posts, there is the so-called "Master Roll" of 128 casual or daily-based personnel from KCC, for which KWASA has continued to provide employment. The master roll personnel have been distributed to the different departments/offices of KWASA.

8.1.4 The KWASA Organogram, 2010

There are three levels (hierarchy) of units in the newest version of the KWASA organogram. From highest to lowest levels, these are: division, department, and section.[3] Using the KWASA-released Chart of Duties per Organogram (July 2010), the units in the KWASA functional organogram are as shown in Table below:

Table 8.1.2 Hierarchy of Units in the KWASA Organogram, 2010

DIVISION	DEPARTMENT	SECTION
Office of the DMD for **TECHNICAL**	Office of the Superintending Engineer	Planning and Development
		Project Management and Implementation
	Office of the Chief Engineer	Production and Distribution
		Customer Service and Maintenance
Office of the DMD for **FINANCE AND ADMINISTRATION**	Office of the Commercial Manager	Commercial
		Financial
	Office of the Secretary	Human Resource
		General Services

(1) The Technical Division

According to the chart of duties, the Technical Division, headed by a Deputy Managing Director (DMD), is in charge of "operation and maintenance". The management and accomplishment of this function are distributed to two departments (offices), headed by the Chief Engineer and the Superintendent Engineer, respectively, and under whom one Executive Engineer each is assigned.

a) The Office of the Chief Engineer (department level) – In charge of carrying out two sets of functions through two sections, namely: (i) *Production and Distribution*, and (ii) *Customer Service and Maintenance*.
b) The Office of the Superintendent Engineer (department level) – In charge of carrying out two sets of functions through two sections, namely: (i) Planning and Development, and (ii) Project Management and Implementation.

3 Meeting with MD Abdullah, Managing Director, KWASA, dated 19 July 2010.

(2) The Finance and Administration Division

According to the chart, the Finance and Administration Division, headed by a Deputy Managing Director, is in charge of "finance and administration". The management and accomplishment of this function are distributed to two departments (offices) headed by the Commercial Manager and the Secretary, respectively

a) The Office of the Commercial Manager (department-level) – In charge of two sets of functions through two sections, namely: (i) Financial, in charge of "accounts and budgets" with sub-functions as transaction and bookkeeping, general accounts, financial reporting, project cost accounting, financial planning and budgets, and cash management; and (ii) Commercial, in charge of "customer accounts and revenue" with sub-functions in billing, customer database and ledger keeping, meter reading, revenue collection, customer relation and marketing.

b) The Office of the Secretary (department-level) – In charge of two sets of functions through two sections, namely: (i) Human Resource, in charge of the sub-functions of administration, personnel, board and law; and (ii) General Service, in charge of the sub-functions in stores, procurement / purchasing, transport service and medical.

8.1.5 Distribution of Posts in the Organization

(1) Permanent Roll (LGD- Approved Posts)

The 157 LGD-approved posts have been distributed to the KWASA organization based on the 2010 KWASA organogram. **Table 8.1.3** shows the distribution of approved posts under the Office of the Managing Director.

Table 8.1.3 Distribution of Posts – Office of the Managing Director

POSTS	OFFICE OF MANAGING DIRECTOR
Managing Director	1
CA/ Computer Operator	1
MLSS	2
Total	**4**

For the Finance and Administration Division, 46 personnel have been distributed to various approved posts as shown in **Table 8.1.4** below.

Table 8.1.4 Distribution of Posts – Finance and Administration Division

POSTS	Office of the DMD for Finance and Admin	Office of the Commercial Manager	Financial Section	Commercial Section	Office of the Secretary	Human Resource Section	General Service Section	Total
Deputy Managing Director	1							**1**
Commercial Manager		1						**1**
Secretary					1			**1**
Section Managers								**0**
Accounts Officers			1					**1**
Budget Officer			1					**1**
Accountant			1					**1**
Assistant Accountant			1	1				**2**
Cashier			1					**1**
Cash Sarkar			1					**1**
Revenue Officer				3				**3**
Revenue Investigator				4				**4**
Revenue Supervisor				2				**2**
Admin Officer						1		**1**
Medical Officer							1	**1**
Nurse							1	**1**
Warehouse Keeper							3	**3**
Dresser							2	**2**
Compounder							1	**1**
UD Assistant						1	1	**2**
Computer Operator	1	1			1			**3**
LDA Typist			1	1				**2**
Security						2		**2**
Cleaner/ Mali						4		**4**
MLSS	1	1	1	1	1			**5**
TOTAL	**3**	**3**	**8**	**12**	**3**	**8**	**9**	**46**

The Technical Division's 107 personnel have been distributed to various approved posts, as shown in **Table 8.1.5**.

Table 8.1.5 Distribution of Posts – Technical Division

POSTS	Office of the DMD for Technical	Office of the Chief Engineer	Office of the Executive Engineer	Production and Distribution Section	Customer Service and Maintenance Section	Office of the Superintendent Engineer	Office of the Executive Engineer	Planning and Development Section	Project Management and Implementation Section	Total
Deputy Managing Director	1									**1**
Chief Engineer		1								**1**
Superintendent Engineer						1				**1**
Executive Engineer			1				1			**2**
Section Managers										**0**
Assistant Engineer				1	1			1	1	**4**
Sub-Assistant Engineer				2	2			2	2	**8**
Pump Operator				30						**30**
Assistant Pump Operator				30						**30**
Electrician				2	2					**4**
Head Tubewell Mechanic				1	1					**2**
Filter Operator				3						**3**
Plumber				2	2					**4**
Surveyor					1				1	**2**
Assistant Chief								1		**1**
Draftsman								1		**1**
Computer Operator	1									**1**
LDA/ Typist		1			1	1				**3**
Foreman					1					**1**
MLSS	1	1	1	1	1	1	1	1		**8**
Total	**3**	**3**	**2**	**72**	**12**	**3**	**2**	**6**	**4**	**107**

(3) Master Roll (Casual)

The 127 casual employees, under the master roll, are distributed as shown in **Table 8.1.6**.

Table 8.1.6 Distribution of Posts for the Master Roll (Casual)

POST	TECHNICAL DIVISION	FINANCE AND ADMINISTRATION DIVISION	TOTAL
Office Staff	7	10	**17**
Pump Operators	82	0	**82**
Tubewell Mechanics	21	0	**21**
Drivers/Helpers	0	1	**1**
Pipeline Mechanics	2	0	**2**
Gateman	0	1	**1**
Laborer	3	0	**3**
TOTAL	**115**	**12**	**127**

8.1.6 Rules on Human Resources Administration

KWASA follows the central government's rules and regulations when it comes to human resources management and administration. The Government may issue addendums to these rules as required.

(1) Personnel of KWASA

The personnel of KWASA are considered civil servants. Civil servants can be vertically classified into four categories, namely class-I, class-II, class-III and class-IV, based on such variables as levels of responsibility, educational qualification and pay range, with class-I as the highest category. They can also be broadly classified into two broad categories, i.e. gazetted and non gazetted. The employees whose appointment, transfer, promotion, posting and so on, are notified in the official gazette, or a public document published periodically by the government, are known as gazetted officers and all class-I and most class-II government servants are treated as gazetted officers.

Within the public service is a very small number of civil servants who belong to the cadre service. Cadre services are those services, which are constituted under law with a number of positions or structure, recruitment and promotion rules. On the other hand, non-cadre services are mostly based on position, with no definite structure of mobility either horizontally or vertically.

(2) Recruitment / Appointment

Recruitment in KWASA follows the Bangladesh Service Rules (Part I and II), which provides the terms and conditions to be followed by a person being appointed as an employee of Government. Recruitment can be done through: (i) direct recruitment or through open competitive examinations, where the approval of the KWASA Board is required and is deemed sufficient; (ii) recruitment through promotion, which is based on the criteria set by the Creation of 157 Post for KWASA, 2008; (iii) recruitment through transfer on deputation, for government civil servants serving non-specific terms provided the transfer is outside the normal field of deployment and is in the public interest; (iv) recruitment by contract, which is an open-for-all type of recruitment with a contract period of usually three years, subject to re-appointment; and (v) absorption, which is based on the WASA Act, wherein a number of staff, by virtue of their office being abolished, are transferred to the newly established office/unit, in this case KWASA.

KWASA has two levels of selection boards when it comes to direct staff recruitment. The Lower Selection Board recommends the approval of recruits below officer level, while the Higher Selection Board recommends the approval of recruits to officer level personnel. Both these selection boards have five members each, four from KWASA, and one member from the LGD. It is the Managing Director who appoints all officers and employees of KWASA, subject to the approval of the KWASA Board.

(3) Promotion

Promotion in KWASA follows the Bangladesh Civil Service (Examination for Promotion) Rules 1986. The criteria for promotion are stated in the Creation of 157 Post for KWASA, 2008.

(4) Code of Conduct

As KWASA has not yet established its own employee code of conduct, it follows The Government Servants (Conduct) Rule 1979, which regulates the conduct and behavior of a Government employee, during the performance of his duties and in his private life. The staff and the officers of the Government are to abide by these rules either working inside or outside of Bangladesh, whilst on leave or on deputation to any other institution, authority or agency.

(5) Code of Discipline

The violation of any of the Government Servants (Conduct) Rules is considered as misconduct. For such violation, an employee is accused of breach of discipline and subjected to being punishable under The Government Servants (Discipline and Appeal) Rules 1985.

A Government servant is subjected to this rule when, in the opinion of the authority he is (i) inefficient; (ii) guilty of misconduct; (iii) guilty of desertion; (iv) corrupt, or may reasonably be considered corrupt; (v) engaged, or is reasonably suspected to be engaged in subversive activities.

A Government servant under this rule, may appeal against any order of: (i) imposing upon him any penalty; (ii) altering, varying or denying to his disadvantages his pay, allowances, pension or other condition; or (iii) interpreting to his advantage, the provision of any rule or contract of service whereby his pay, allowance, pensions etc. are regulated.

To ensure punctual attendance and to eradicate incidences of unauthorized absence and late attendance by the officers and staff, the Public Employees Discipline (Punctual Attendance) Ordinance, 1982 was promulgated. Under this ordinance the authority (appointing authority or designated person) has been given the power to impose penalty (deduction in pay) on any employee coming to the office late or remaining absent from the office without authorization or leaving the office without permission. No consultation with the Public Service Commission will be necessary in imposing a penalty and no proceeding or order under this ordinance shall be called into question in any Court of Law. However, the employee concerned may appeal within 48 hours to the authority for revision of the order.

Another ordinance is the Public Servants (Dismissal on Conviction) Ordinance, 1985 and under the provisions of this ordinance, actions are taken by the administrative authority when a public servant commits a serious criminal offence and a sentence is awarded by the Court of Law for example: capital punishment, imprisonment for life, and imprisonment for more than six months and/or a fine of more than Taka 1000 (one thousand).

(6) Benefits

KWASA abides by the Prescribed Leave Rules '59, Fundamental Rules (FR) and Bangladesh Service Rules (BSR) in granting of leaves, in the manner that these rules apply to Government servants. There are different kinds of leave, for example: Earned Leave, Recreation Leave, Leave Preparatory to Retirement (LPR), Maternity Leave, Casual Leave, Public Holiday etc. Before availing leave, a Government servant should obtain approval for the same, but it cannot be claimed as a matter of right. In the case of public exigencies, the leave granting authority may cancel or reduce any leave previously granted

An employee cannot take a job during leave of absence, except on LPR with the permission from the appropriate authority. The leave for a Gazetted officer cannot be entertained, without an admissibility report for leave from the concerned audit office where leave records are kept.

As for retirement, KWASA follows the Public Servants (Retirement) Act. 1974 & Rules 1975 are in effect. Under this rule, a Government servant must retire from service on attainment of 57 years of age. In fact, leave preparatory to retirement (LPR) for a period of one year is allowed to an employee, from the date of superannuation, provided that such leave is earned/accumulated to his credit and he finally retires at the attainment of 58 years of age. Re-appointment or extension of service under this rule is completely prohibited. However, the President, in the interests of public service has special powers to appoint any suitable person on a contract basis for which there is no age-bar. After retirement, a Government servant receives pension, gratuity, medical allowances medical facilities, and benefits under the benevolent and group insurance fund.

It should be noted that since KAWASA is an independent authority, it can formulate or develop its own human resources management / administration policies, so long as these do not go against the basic government rules. Rather, these HR policies should complement and/or enhance those currently prevailing in the sector. Such policies will need approval by the KWASA Board prior to implementation.

8.2 Assessment of the Present Organization

Created out of the WASA Act towards the end of 2008, KWASA is a new organization with a big mandate to fulfill. Unfortunately, it is saddled with many problems – technical, financial and commercial, organization and management – pointed out in previous studies. Its new legal and administrative personality as an autonomous institution means that it should, once again, go through the developmental stages of organizational growth and maturity. In this sense, the institutional development of KWASA should be viewed in the light of processes that would facilitate its progression into an efficiently and effectively run modern water utility.

KWASA needs consistent support toward strengthening its capacity to carry out its functions on a sustainable basis. The concrete results of institutional development do emerge over time, thus, the approach calls for a long-term perspective. Physical facilities' improvement has to be matched with changes on how activities are performed in order to realize what these changes are meant to achieve. This is an internal process involving each one (at every level of the KWASA's organization) in the improvement processes and requiring their commitment to a chosen direction. Thus, decision-making in institutional development must also be clear as to what the rules and procedures are, and how and by whom decisions will be taken. It is in this context that this section presents the current institutional assessment of KWASA on three main areas – organization structure, human resources, and systems.

8.2.1 Assessments of Past Studies

The current KWASA management and organization has been the subject of recent review and assessment by the Asian Development Bank in six separate studies / surveys under the special technical assistance TA 7223: Bangladesh: Supporting the Establishment of the Khulna Water Supply and Sewerage Authority in 2008. The SSTA carried out the following: (i) diagnostic analysis; (ii) institutional capacity assessment; (iii) willingness-to-pay survey; (iv) financial assessment; (v) preparation of opening balance sheet; and (vi) development of corporate management systems (computerized accounting, payroll, human resource, and inventory management systems).

The diagnostic analysis and institutional capacity assessment of KWASA operations examined basic water service data of KWASA, such as service levels and service coverage, number of connections, tariff schedules, and affordability and willingness-to-pay of the public. It reviewed current water supply data such as water sources, production volume, water quality, distribution, and consumption volume. The report also diagnosed the management side of KWASA, that is, it institutional, financial, commercial and operating performance as a water utility.

This particular study recommended urgent actions that need to be taken in the interim, premised on supporting the preparation of the Khulna Water Supply Masterplan by JICA. The recommendations encompassed technical, commercial and financial, and institutional areas. The latter included a proposal on revising the organization structure, a projection on the number of staff given interim improvements, staffing qualifications, and staff training.

The financial studies zeroed in on reviewing / evaluating the existing financial management and commercial operating systems of KWASA, and its financial condition and potential capacity to support the proposed long-term expansion and improvements for its water supply system. The study recommended broad institutional strengthening measures in the areas of organization and staffing, staff development, customer service, financial and commercial systems and billing and collection.

In addition, it also recommended specific actions in the interim period before the long-term development improvement and expansion project is implemented. These are: (i) actions to improve financial management, such as developing a comprehensive KWASA business plan with targets, the adoption of performance indicators for financial, operational and service standards; (ii) actions geared at revenue improvement to generate additional funds, such as conducting a full customer inventory, review of tariff system leading to tariff re-adjustment, and improving collection system and enforcement; and (iii) the improving cost effectiveness and operating efficiency.

8.2.2 The Current ADB Study

ADB is currently providing technical assistance (TA) to KWASA through ADB TA 7385 BAN

Preparing the Khulna Water Supply aimed at developing KWASA's institutional capacity. The TA commenced mid-2010 and will run through September 2011.

The on-going ADB project focuses on important interim measures / activities such as the preparation of KWASA's Five-Year Business Plan and the Institutional Strengthening Program. The former comprises of mission, vision, objectives (VMO) and key performance indicators (KPIs); the preparation of a human resource development plan; the preparation of a financial plan, where a new tariff structure will be introduced based on metered consumption; the establishment of corporate management systems; the improvement of operational efficiency and service delivery by examining how to optimize the operation of the distribution network, tubewells, and pumps; the enhancement of revenues by improving customer database and billing system; and the development of the capacity of KWASA by implementing the aforementioned activities through hands-on training and guidance.

The ADB recommendations, to be borne out of the TA (particularly the Five-Year Business Plan), will cover and see implementation during the period (2012/13-2016/17), which corresponds to the construction stage of this project.

8.2.3 KWASA's Organizational Structure

As was echoed and recognized in past studies, the LGD-approved organization structure (Draft KWASA Organogram, 2008) leaves so much to be desired. The common observation, which KWASA also acknowledges, is that the structure does not reflect the main functions of a water utility. Given the fact that there is still no Government-approved organization structure since its establishment as an autonomous authority provides KWASA has an excellent opportunity to improve on the LGD-approved organogram of 2008, as well as KWASA's 2010 organogram version.

(1) The Existing Organization (Before Project Implementation)

In an effort to make the present organization structure reflective of the functions of a water utility, KWASA has issued the KWASA Organogram (2010) with a "chart of duties" or a brief enumeration of the functions of its departments. It aims to somehow delineate the functions of the organization as a water utility, to distribute its personnel based on these functions, and to guide both the supervisors and their personnel in the discharge of their duties. This organogram can also be seen as transitory move before the on-going ADB TA can finalize a more suitable organization structure for Government approval as a result of the on-going TA . (Refer back to **Figure 8.1.1**).

(2) The Organization from 2013-2016 (during Project Implementation)

During the implementation of the project, ADB will be in the midst of its technical assistance project. Taking into consideration the results coming in from its various TA activities, a more suitable organization structure will be prepared by ADB for this particular period. As of the present time, ADB has proposed two-phased organization structure – Phase 1 for FY 2013/14 and Phase 2 for FY2016/17.

ADB's Phase 1 structure contains all the organizational elements to enable KWASA to seamlessly transition to the 2016/17 JICA/ADB proposed structure, which incorporates the organizational requirements of the newly constructed water supply facilities / distribution network. This is particularly true with commercial services and its subordinate units – customer revenue and customer service – which will be adopted in the zonal distribution concept. Phase 1 also uses common nomenclatures, as well as the hierarchical levels familiar to KWASA critical for stability in the face of organizational growth. ADB's Phase 2 structure, on the other hand, corresponds to JICA's organizational structure and HR Plan recommendations.

(3) The Organization from 2017 (after Project Implementation)

By 2017, there will be a need to rationalize the KWASA organization structure to cope with the impacts brought about by: (i) the construction of new water supply facilities (ii) the resultant steady increase in KWASA's customer base; (iii) the program of full metering of service connections; and (iv) the requirement for efficient operation and maintenance of the new water supply facilities.

An implementation time frame for putting in place the appropriate organizational structure(s) for KWASA to effectively respond to and efficiently manage predetermined stages of organizational growth and maturity, is presented below.

IMPLEMENTATION OF KWASA ORGANIZATION STRUCTURE(S)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
KWASA Organogram (2010-2011)[1]	■	■									
ADB-Proposed Organogram (2012-2014)[2]			■	■	■	■	■				
Proposed KWASA Organogram (2017)[3]								■	■	■	■

1/ The latest version of the KWASA organogram.

2/ The ADB-Proposed Organogram (from the *Five-Year Business Plan*) can be recommended as the initial KWASA Organogram to be submitted to the Government for official approval.

3/ A revised KWASA organogram shall be approved by the KWASA Board based on JICA and ADB's proposal(s) shortly before the completion of the project.

8.2.4 Proposed KWASA Organization Structure (2017)

Shortly before the completion of the project and commissioning of the new water supply/treatment facilities and the zonal distribution network, KWASA should have in place an appropriate organization structure with right number and quality of human resources, and with systems and processes suitable to its size, goals and strategic objectives.

(1) Organization Design

The proposed organizational design will allow KWASA to (i) efficiently identify and allocate tasks and resources among its various units; (ii) establish efficient and logical patterns of inter-relationships within and across the organization; (iii) smoothly coordinate activities of component parts – divisions, departments, sections and sub-sections – to facilitate goal realization; and (iv) effectively monitor tasks and activities of each member of the organization in relation to goal accomplishment.

(2) Organization Structure Principles

The proposed KWASA organization structure will be anchored on the following organization structure principles:

a) As to the type of organization structure, it shall be functional, therefore, based on the functions of a modern water utility.
b) It shall be a divisionalized organizational structure with line and staff relationships.
c) In terms of vertical differentiation, the structure will be comprised of six hierarchical (unit) levels as shown in **Table 8.2.1**.

Table 8.2.1 Organizational Unit Hierarchy (Levels) of KWASA Organization Structure

Level	Organizational Unit Hierarchy		Position Title of Unit Head	
	Existing	Proposed	Existing	Proposed
1	Board of Directors	Board of Directors	Board Director	Board Director
2	Top Management	Top Management	Managing Director	Managing Director
3	Division	Division	Deputy Managing Director	Deputy Managing Director
4	Department	Department	Superintendent Engineer Chief Engineer Secretary Commercial Manager	Superintendent Engineer Chief Engineer Secretary (Name of Unit) Manager
5	Section	Section	Executive Engineer	Executive Engineer (Name of Unit) Chief
6	None	Sub-Section	None	Assistant Engineer (Name of Unit) Supervisor

d) From this hierarchy will also flow the authority structure such as decision-making, responsibility, accountability, and communication.
e) In terms of horizontal differentiation, that is, the orientation of KWASA's organizational members (employees), the nature of tasks performed and education and training, it shall basically retain the Government-approved posts (Ref #: LGD/PAS-2/K-1/2007(Part-1)/832), without prejudice to the creation of new posts, and the upward adjustment in pay required for these posts. As far as practicable, the nomenclatures already in use at KWASA shall also be retained.
f) In terms of spatial differentiation, the organization structure will take cognizance of the location of the old and new facilities, including their personnel: such as, but not limited to the following: (i) the KWASA main office, (ii) the water treatment facilities; and (iii) the creation of zonal offices to match the distribution zones as per network design.
g) It will provide for a strategic management group, which is the unit heads within each hierarchical level, to ensure KWASA's achievement of vision, accomplishment of mission, and attainment of corporate and unit objectives.
h) Each unit will be named after, or will correspond to, the particular and identified main function/s, and not by the position or designation of the officer-occupant. **Figure 8.2.1** below presents the proposed KWASA organogram for 2017.

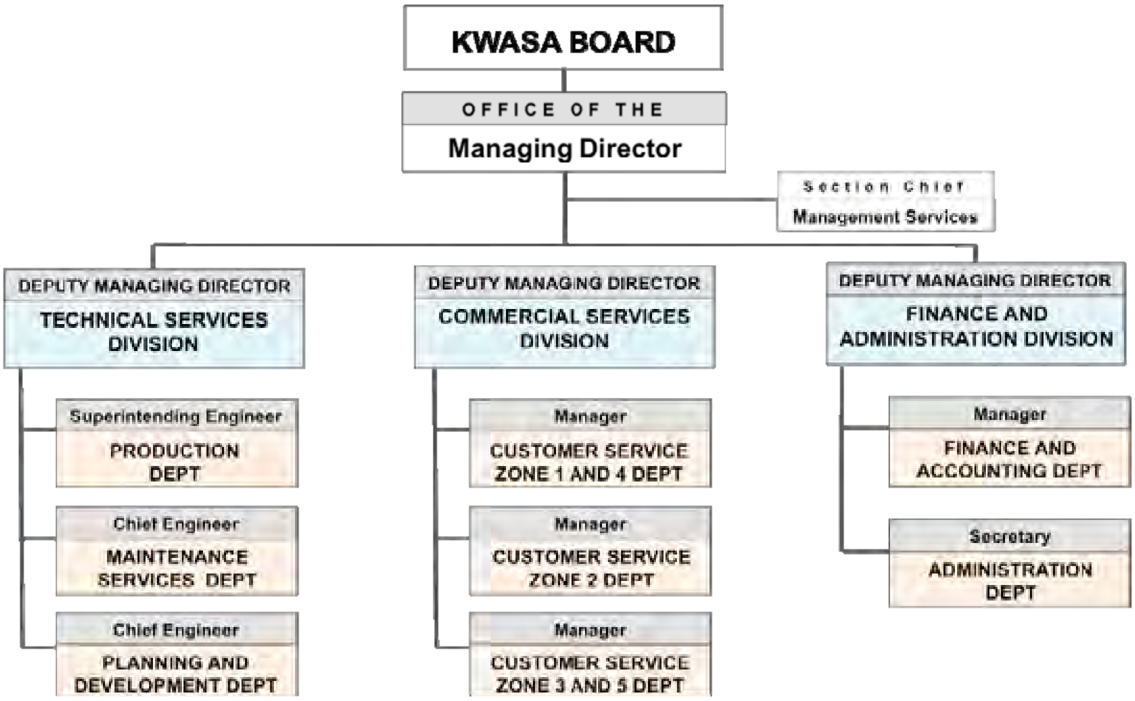


Figure 8.2.1 Proposed KWASA Organogram (2017)

8.2.5 The Organizational Units

(1) The Technical Services Division

In general, the Technical Services Division will be organized along:

- The basic functional lines of water utility operations, particularly production, water utility planning and development, and maintenance services, all of which are necessary and essential technical functions and responsibilities;
- Adherence to the principle of horizontal differentiation for technical tasks, which will result in (i) greater organizational efficiency and effectiveness; (ii) better aligned staff growth and development; and (iii) providing for the accumulation of relevant experience and the building up technical expertise in water supply operations;

The Technical Services Division shall be headed by a Deputy Managing Director, who will assist the Managing Director in:

- Setting and implementing the short, medium and long-term priority water supply development strategies, policies, plans and programs of KWASA;
- Producing safe, adequate and reliable water supply for KWASA's service area / customers;
- Operating and maintaining all surface and ground water production facilities of KWASA.

Under this division are three departments – the Production Department and the Maintenance Service Department, with each department to be led by Superintending Engineer, and the Planning and

Development Department to be led by the Chief Engineer. **Figure 8.2.2** shows the proposed structure of the Technical Services Division.

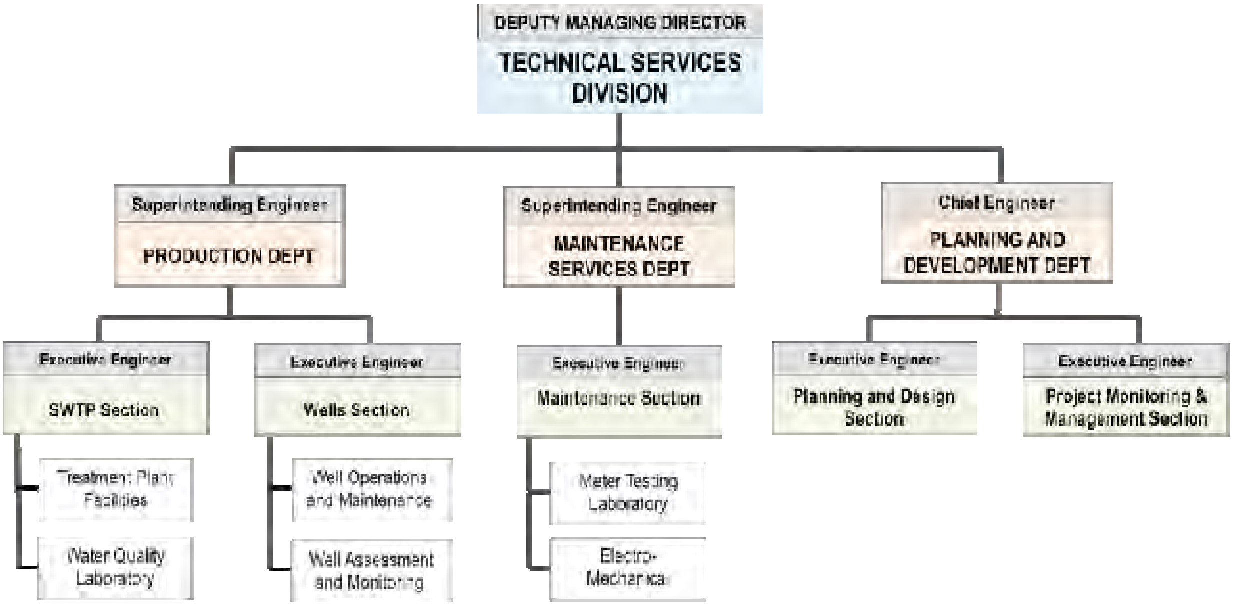


Figure 8.2.2 Proposed KWASA Technical Services Division, 2017

i) The Production Department: The Superintending Engineer for the Production Department shall assist the DMD of the Technical Services Division in developing and implementing the Production Operations Manual to ensure the proper and efficient operation of the entire surface water and groundwater production and treatment systems and processes, together with all its facilities and appurtenances. The department will be divided into two sections:

(a) The SWTP Section, headed by an Executive Engineer, shall be divided into two sub-sections – Treatment Plant Facilities and Water Quality Laboratory. The SWTP section shall be responsible for the:

- Efficient and effective operation and maintenance of the surface water production systems and processes including treatment facilities;
- Quality of water supplied by KWASA and its conformance to the national drinking standards for water quality;
- Security, protection and conservation of all surface water supply sources.

(b) The Wells Section, headed by an Executive Engineer, shall be divided into two sub-sections – Well Operations and Well Assessment and Monitoring. The section shall be responsible for the:

- Efficient and effective operation of all production wells, particularly pumps and other related electro-mechanical equipment and pump/well facilities;
- The proper assessment and monitoring of all public and private tube wells to ensure ground water quality and sustainability;
- Security, protection and conservation of all groundwater water supply sources.

ii) The Maintenance Services Department: The Superintending Engineer for the Maintenance Services Department shall assist the DMD Technical Services Division in developing and implementing a Maintenance Manual for the production facilities, the entire distribution network / system, together with the distribution reservoirs and related facilities; and in developing leak reduction policies and programs. The department will have one section:

(a) The Maintenance Section, headed by an Executive Engineer, will be responsible for the:
- Proper maintenance of production facilities, including buildings and grounds;
- Proper maintenance of all major mechanical and electrical equipment, related equipment and appurtenances, in accordance with both the manufacturers' and KWASA's approved standards;
- Testing for the accuracy of customer meters before these are installed or re-installed in the customers' premises.

iii) The Planning and Development Department. The Chief Engineer for the Planning and Development Department shall assist the DMD Technical Services Division in developing KWASA's strategies, policies, as well as investment plans and programs for implementation in the short, medium and long-term. This department will be further divided into:

(a) The Planning and Design Section shall be headed by an Executive Engineer. This section will be responsible for:
- Development of short, medium and long term water supply investment plans in coordination with the other departments / offices of KWASA;
- Design, evaluation and recommendation of appropriate water supply projects for implementation based on approved plans and strategies;
- Development and adoption of technical standards for water supply plans, designs and construction, and the dissemination of strategic plans and development programs to the entire organization.

(b) The Project Management and Monitoring Section shall be headed by an Executive Engineer and will be responsible for the:
- Formulation of KWASA's water supply investment plan;
- Management and/or implementation of KWASA water supply projects and ensuring that these comply with the set technical standards;
- Monitoring the compliance of the social, natural, physical environmental components of KWASA project(s) with Bangladeshi standards and policies.

The summary of the units under the Technical Services Division is shown below:

DIVISION		DEPARTMENT		SECTION		SUB-SECTION	
1	**TECHNICAL SERVICES**	1	Production	1	SWTP Operations	1	Treatment Plant Facility
						2	Water Quality Laboratory
				2	Wells	3	Well Operations and Maintenance
						4	Well Assessment and Monitoring
		2	Maintenance Services	3	Maintenance	5	Facilities / Electro-Mechanical Equipment
						6	Meter Testing Laboratory
		3	Planning and Development	5	Planning and Design	0	None
				6	Proj Monitoring & Mgt	0	None

(2) The Commercial Services Division

The Commercial Services Division will take off from current arrangement as just being a part of the Finance and Administration, to being a full and independent division after the implementation of this project. The rationale behind this organizational upgrade is:

- Commercial service operations are an essential water utility function because this is where the revenues are raised and should be separated from other utility functions for proper check and balance;
- KWASA customers should be given necessary focus since the water customers are the lifeblood of the business, and all activities related to customer service are deemed very important especially at this stage when KWASA is building a stable customer base to sustain its financially viability and autonomy as water supply authority, not to mention the fact that the growth in customers for will be rapid during this period;
- The Commercial Services Division will be structured following the organizational principle of spatial differentiation, to enable faster response capability to KWASA customers both in service provision and in revenue generation. It will follow the proposed creation of customer service zones (offices) structured along the water supply distribution zones, which will take into consideration: (i) geographical contiguity of the service zones; (ii) the need for customer service response; and (iii) the capacity of the distribution reservoir. The proposed zones are: Customer Service Zones 1 and 4 (18,000 cum^3 reservoir capacity), Customer Service Zone 2 (14,000 cum^3 reservoir capacity), and Customer Service Zones 3 and 5 (21,000 cum^3 reservoir capacity).

The Commercial Services Division shall be headed by a Deputy Managing Director, and will have the following responsibilities:

- Developing and implementing customer-centric revenue generation strategies, policies and plans, particularly with regard to metering and meter reading as well as billing and collection;
- Developing and implementing customer service connection, reconnection and disconnection policies of the Authority;
- Marketing the services of KWASA to all customer classes, including the poor, and connecting them to the system and/or providing them affordable service.

Under this division shall be three departments – the Zones 1 and 4 Services Department; Zone 2 Services Department and Zones 3 and 5 Services Department – to be led by their respective Department Managers. **Figure 8.2.3** shows the proposed structure of the Commercial Services Division.

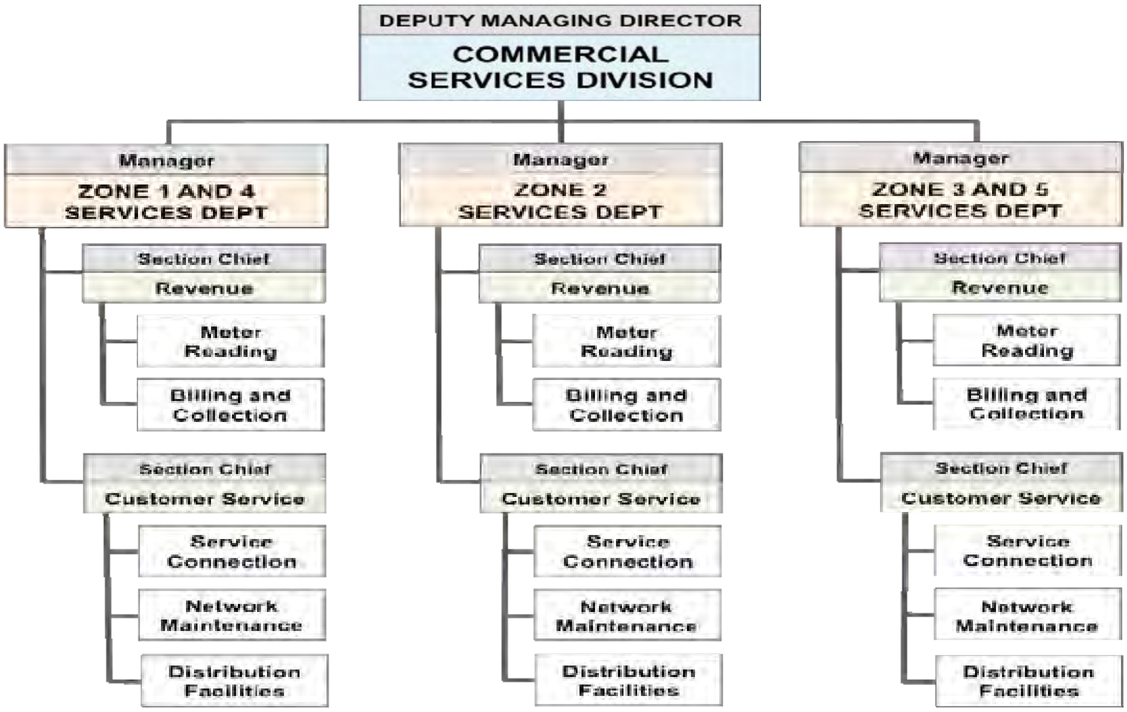


Figure 8.2.3 Proposed Commercial Services Division Structure, 2017

i) The Zone Services Departments. The Managers for each Zone Service Department will assist the DMD Commercial Services in ensuring the highest efficiency in KWASA's revenue generation activities, comprised of meter reading, billing and revenue collection and in developing and implementing policies and strategies aimed at connecting, reconnecting, and disconnecting KWASA customers. Each service zone department shall have two sections, namely:

(a) The Revenue Section shall be led by a Section Chief, and will be comprised of two sub-sections. This section will be responsible for the:
- Accurate reading of the water meter of each customer in order to ascertain the actual water consumption for bill preparation;
- Timely delivery of the water bill to each customer, and for ensuring the highest collection efficiency;
- Proper management of the customers' account database/s, its physical and electronic security, and its protection from any form of attack.

(b) The Customer Service Section shall be led by a Section Chief, and will be comprised of two sub-sections. It will be responsible for the:
- Processing of customer service applications for new connections and reconnections; as well as sending of service disconnection notices, and the actual disconnection of delinquent customers from the system;
- Physically linking or connecting new customers, and reconnecting old customers to the water supply distribution system, including the installation and/or replacement of water meters;
- Maintenance of the distribution network, particularly the repair of pipe leaks using approved technical standards and procedures;

- Operation and maintenance of distribution reservoirs and overhead tanks and other distribution facilities;
- Proper management of the customers' account database/s, its physical and electronic security, and its protection from any form of attack.

In the event that KWASA outsources service connection / reconnection / disconnection works, the zone services manager(s) shall oversee the outsourced contractors' work plan and implementation to ensure adherence to KWASA standards. The decision to outsource, however, should be dependent on final cost efficiency and practicability.

The summary of the units under the Commercial Services Division is shown below:

DIVISION		DEPARTMENT		SECTION		SUB-SECTION	
1	COMMERCIAL SERVICES	1	Zone 1 and 4 Services	1	Revenue	1	Meter Reading
						2	Billing and Collection
				2	Customer Service	3	Service Connection
						4	Network Maintenance
						5	Distribution Facilities
		2	Zone 2 Services	3	Revenue	6	Meter Reading
						7	Billing and Collection
				4	Customer Service	8	Service Connection
						9	Network Maintenance
						10	Distribution Facilities
		3	Zone 3 and 5 Services	5	Revenue	11	Meter Reading
						12	Billing and Collection
				6	Customer Service	13	Service Connection
						14	Network Maintenance
						15	Distribution Facilities

(3) The Finance and Administration Division

The Finance and Administration Division will be organized:

- As a strategic business service support-partner, providing management and control over financial resources, human resources, physical assets, and information/communication resources of KWASA;
- Following the organizational principle of horizontal differentiation, thus, the nature of the tasks performed as well as the required staff education and training will fall under business administration and management, accounting and finance, organizational development and human resources;
- As separate division from the revenue function (which is under the Commercial Services Division) to ensure check and balance as well as fiscal control.

The Finance and Administration Division shall be headed by a Deputy Managing Director, who will assist the Managing Director in:

- Managing and controlling the Authority's financial operations and resources towards sustained financial viability;
- Managing KWASA's human resources and developing their potentials;
- Managing and securing KWASA's physical facilities and assets;
- Providing essential general support services to KWASA, such as procurement, stores, security, health and safety.

Under this division shall be two departments – the Finance and Accounting Department and the Administration Department to be led by the Finance Manager and the Secretary, respectively. **Figure 8.2.4** shows the proposed structure of the Finance and Administration Department.

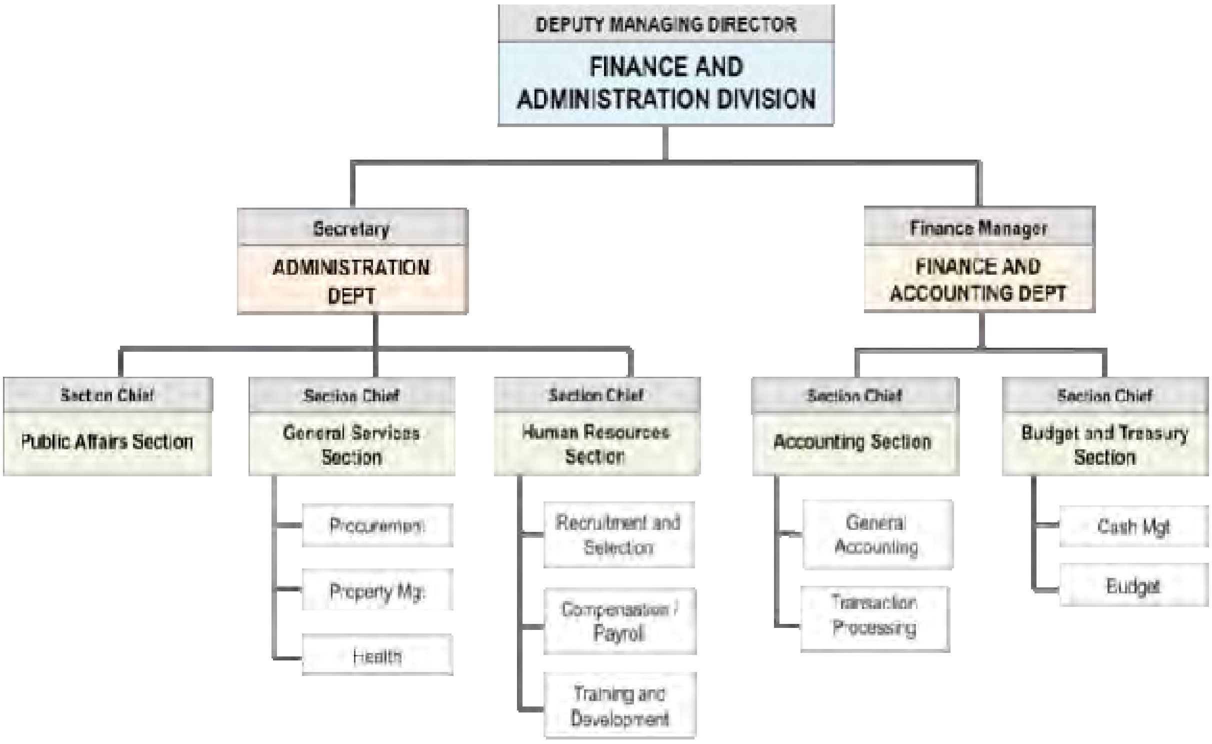


Figure 8.2.4 Proposed Finance and Administration Division Structure, 2017

i) Finance and Accounting Department. The Manager for the Finance and Accounting Department shall assist the DMD Finance and Administration in managing KWASA's business / financial operations towards sustained financial viability; and building up KWASA's financial resources to be utilized for future expansion works. There shall be two sections under this department, namely:

(a) The Accounting Section shall be headed by a Section Chief (or Chief Accountant) and will have two sub-sections – general accounting, and transactions processing. The major functions of the Accounting Section shall be the:

- Development of the Authority's accounting policies, including the Accounting Manual, which adhere to Bangladeshi accounting standards;
- Recording, monitoring and controlling – on a daily, monthly, quarterly, semi-annual and annual basis – the income and expenditure of KWASA using Bangaladeshi accounting standards and reporting systems;

- Preparation of official financial reports for Top Management, the KWASA Board and the Government, for information and decision-making purposes;
- Disbursement of salaries and other payables based on the approved policies, systems, and rules and regulations;
- Acceptance of payments from customers and the preparation of regular collection reports; and
- Proper management of the financial database/s, that these are physically and electronically secure, and are adequately protected from any form of attack.

(b) The Budget and Treasury Section, which shall be headed by a Section Chief (or Chief Budget Officer), will be divided into two sub-sections – budget and cash management. The major functions of this section shall be the:

- Development of the Authority's financial policies, plans and targets;
- Carrying out tariff studies based on Authority's service policies;
- Preparation of the yearly business plan and corresponding budgets in coordination with all department and office heads;
- Monitoring the plan's realization and providing timely information to KWASA's senior management of deviations;
- Prudent and judicious management of and investment decisions for the Authority's cash assets.

ii) The Administrative Department. The Secretary of the Administrative Department shall assist the DMD Finance and Administration in human resource planning, management and development to match and/or respond to the Authority's present and emerging needs; the development, implementation and management of systems and processes for procurement, inventory and fixed assets; and providing essential general services to support the efficient functioning of KWASA water utility. The department shall have two sections:

(a) The Human Resources Section, to be led by a Section Head (or HR Chief), shall be comprised of three sub-sections, namely, recruitment and selection, compensation and payroll, and training and other benefits. It shall be responsible for the:

- Development of the Authority's HR policies, rules and regulations, including the KWASA HR Manual, based on Bangladeshi civil service laws and regulations;
- Preparation of the HR plan based on the required positions, quantity and qualifications together with the concurrence of department/office heads due to current and future demand;
- Development of training policies, plans and programs;
- Implementation of the short term, medium term and long term training and development plan aimed at improving and/or enhancing the capacities of KWASA's human resources to perform their tasks;
- Compensation planning, and development of other employee benefits;
- Preparation of KWASA's payroll;
- The proper management of HR database/s, its physical and electronic security; and that the database is adequately protected from any form of attack.

(b) The General Management Section shall be headed by a Section Head (or Chief Administrative Officer) and will be comprised of three sub-sections – procurement, property management, general services and health. It shall be responsible for the:

- Preparation of a procurement plan, in coordination with the departments and offices heads;
- Timely procurement of goods and services based on Bangladeshi systems and processes, and on terms that are most advantageous to KWASA;
- Development and implementation of the inventory management system, and the fixed asset management system;
- Provision of general medical and dental health services;
- Provision of the following general services: (i) transport, (ii) security, and (iii) general maintenance;
- Provision of secretariat services for the KWASA Board.

The summary of the units under the Finance and Administration Division is shown below:

DIVISION		DEPARTMENT		SECTION		SUB-SECTION	
1	**FINANCE AND ADMINISTRATION**	1	Finance and Accounting	1	Accounting	1	General Accounting
						2	Transaction Processing
				2	Budget and Treasury	3	Cash Management
						4	Budget
		2	Administration	3	Human Resources	5	Recruitment and Selection
						6	Compensation and Payroll
						7	Training and Development
				5	General Services	8	Procurement
						9	Property Management
						10	Health Services

(4) Management Services

The Management Services Section will be placed directly under the Office of the Managing Director and will be led by a Section Head. He/She shall assist the Managing Director by performing the following functions:

- Corporate Planning – drawing up the detailed action plans to achieve KWASA's objectives, and ultimately its vision, mission and legal mandates.
- Internal Audit – analyzing KWASA's systems and processes, procedures and activities in accomplishing organizational goals through efficient and effective use of resources, and recommending solutions to organizational problems and/or deficiencies.
- Management Information Systems – developing information systems, using appropriate technologies, to link KWASA's business and operational processes and activities, in support of organizational efficiency and to aid decision-making.

- Legal Services – providing legal advice to the MD particularly with regards to service contracts, contracts on the procurement of goods, performance / management contracts, among others.
- Public Affairs – developing and implementing marketing, advertising, promotional strategies aimed at increasing the number of new connections and reconnections to the system; developing information and education materials for dissemination utilizing the most appropriate media of communication, such as but not limited to, face-to-face communications, print and broadcast media, and new (digital) media in support of KWASA policies, plans and programs.

8.2.6 Human Resources Plan

Much of the success of any water utility, KWASA included, depends on the quality of its human resources – their knowledge (from education and experience), skills (from training and development), and abilities (character, work ethic and competencies). Equally important, is how human resource potential can be further developed and enhanced to support the growing needs of the organization. Given the new organization structure, the increase in the number of customers, and the expansion of KWASA's operations, additional human resources are required.

The human resources plan after the implementation of the project has take into important consideration the following:

- The integration of the total number of existing personnel, both under the permanent roll and master roll, into the HR plan;
- The organization structure principles, as enumerated in the previous section;
- That the ADB-supported management information systems such as the financial management information system, the commercial practices/management system, and the human resources management system will be in place;
- Organizational measures such as the staff productivity index (SPI), or the number of personnel per 1,000 service connection, to ensure that the growth in the number of personnel is within appropriate limits. (Refer to **Appendix 8.2.6 (1)** for the Selected Indicators of Bangladesh Water Utilities with KWASA; and **Appendix 8.2.6 (2)** for the Selected Indicators of Asian Water Utilities with KWASA).

The low educational qualification of staff, and the fact that a large majority of the personnel belong to the pump operator / assistant pump operator levels, will mean that training will be a mission-critical activity. The implementation of the HR plan should further consider the following:

- A detailed training needs analysis to reveal who among the staff are trainable, and in what area they can be trained;
- To review who among the staff can be retired, and then replaced with more experienced and/or more educated newly hired staff;
- Future training designs and approaches should be longer term, on-the-job, competency-based and output oriented.

(1) Proposed Management Levels (2017-2025)

Based on the preceding organization structure, four management levels are proposed effective 2017 to 2025 (end of plan period). Presently, there is vertical gap between top management and staff in terms of responsibility and accountability. Thus, the defined management levels are aimed at strengthening of middle and entry-level management levels, thereby easing the burden of top management, as well ensuring more efficient and effective management and leadership fit, as middle and entry-level managers will be also empowered to train their own staff to achieve performance objectives.

The management levels are top management (MD and DMDs), senior management (executive engineer / department managers or equivalent), mid-management (assistant engineer / section chief or equivalent), and entry-level management (supervisor / team leader or equivalent). The total number required to fill up these management positions are shown below:

ORGANIZATIONAL UNIT	Top Mgt		Senior Mgt	Mid Mgt	Entry Mgt
	MD	Division	Dept	Section	Sub-Section
Office of the Managing Director	1	0	0	1	0
Technical Services Division	0	1	3	5	6
Commercial Services Division	0	1	3	6	15
Finance and Administration Division	0	1	2	4	10
	1	**3**	**8**	**16**	**31**
TOTAL	**4**		**8**	**16**	**31**

However, for 2017, it is recommended that up the mid-management levels (assistant engineer / section chiefs or equivalent) be filled up. The entry-level management positions can be filled up by 2020 when the number of connections, as projected, will be realized.

(2) Proposed Human Resources Plan by Organizational Unit

To support the proposed organization structure, is the human resources plan for KWASA's major organizational units, which is shown in **Table 8.2.2** below:

Table 8.2.2 KWASA Human Resources Plan (2017)

ORGANIZATIONAL UNIT	NUMBER OF PERSONNEL		TOTAL
	EXISTING	PROPOSED	
THE MANAGING DIRECTOR			
Managing Director and Staff	4	0	4
Management Services Section	0	10	10
TECHNICAL SERVICES DIVISION			
Office of the Deputy Managing Director	3	0	3
Production Department	117	29	146
Maintenance Services Department	30	12	42
Planning and Development Department	15	1	16
FINANCE AND ADMINISTRATION DIVISION			
Office of the Deputy Managing Director	3	0	3

Finance and Accounting Department	8	10	18
Administration Department	32	18	50
COMMERCIAL SERVICES DIVISION			
Office of the Deputy Managing Director	3	0	3
Customer Service Zone 1 & 4 Department	27	42	69
Customer Service Zone 2 Department	22	47	69
Customer Service Zone 3 & 5 Department	20	49	69
TOTAL	***284***	***218***	***502***

(3) The Human Resources Plan Breakdown

The following tables present the human resources plan is based on the major organizational units, which are: (i) Office of the Managing Director (ii) Technical Services Division; (iii) Finance and Administration Division and (iv) Commercial Services Division.

1) Office of the Managing Director

In 2017, the Office of the Managing Director will have one section under it, providing management services such as corporate planning, internal audit and management information systems. This will section will support mandate KWASA's mandate to be run as a business entity or commercially and financially viable water authority. The corporate growth and performance targets should continue to be prepared even beyond the ADB-supported business plan, which ends in 2016-17. The HR plan for the MD's office is shown in **Table 8.2.3**.

Table 8.2.3 HR Plan, Office of the Managing Director, 2017

OFFICE OF THE MANAGING DIRECTOR	# OF PERSONNEL		TOTAL
	EXISTING	PROPOSED	
Office of the DMD	4	0	*4*
Management Services Section			
Office of the Section Head	0	1	*1*
Internal Control/Audit	0	2	*2*
Corporate Planning	0	2	*2*
Legal	0	1	*1*
Public Affairs and Information	0	2	*2*
Management Information Systems	0	2	*2*
TOTAL	*4*	*10*	**14**

2) Technical Services Division

The construction of new supply facilities, water treatment plant will mean additional personnel who will manage, operate and maintain the new (and existing) facilities. The types and number of personnel required for the water treatment plant, the impounding reservoir, the intake area, the transmission pipelines are shown in **Table 8.2.4** below.

Table 8.2.4 Personnel Required for Newly Constructed Water Supply Facilities

POST	SWTP	INTAKE, TRANSMISSION PIPELINE, AND IMPOUNDING RESERVOIR			TOTAL
		INTAKE	IMPOUNDING RESERVOIR	TRANSMISSION PIPE	
Executive Engineer	1				1
Assistant Engineer	1	1			2
Sub-Assistant Engineer	2	1			3
Water Laboratory Technician	1	0	0	0	1
Water Laboratory Assistant	1	0	0	0	1
Foreman	6	1	1	1	9
Pipeline Mechanic Level	0	0	0	2	2
Plumbing Mechanic Level	0	4	3	3	10
Filter Operator Level	3	0	0	0	3
Pump Operator Level	18	4	3	5	30
Assistant Pump Operator Level	2	0	0	0	2
MLSS	1	0	0	0	1
Guard	6	3	3	0	12
TOTAL	42	12	12	11	77
		35			

The HR plan for the Technical Services Division (**Table 8.2.5**) shows that only 42 personnel will be hired by 2017. Most of those hired will be for the SWTP, where positions needing technical education and training (such as the engineers and water quality staff) are required. These positions will not only be integrated within the approved KWASA posts and pay scales, but also within in the HR Plan.

Also, it should be noted that the present KWASA technical posts are already occupied, and there is no recourse but to integrate them into the HR plan, and to provide these staff with massive training and/or retraining after a careful review of the qualifications of the job-holder, and matching them with job to be done. This will necessitate the drafting of job descriptions for all positions (technical, business and administrative) within the ADB business plan TA period of 2013-2016.

Those to be appointed to the proposed positions (above) shall be initially sourced from the existing personnel. Next would be to see the feasibility of absorbing the technical personnel from the PIU after the project's completion. Then, if none is found, new personnel shall be hired following KWASA HR policies and relevant government regulations.

Table 8.2.5 HR Plan, Technical Services Division, 2017

TECHNICAL SERVICES DIVISION	NUMBER OF PERSONNEL		TOTAL
	EXISTING	PROPOSED	
Office of the Deputy Managing Director	3	0	*3*
Production Department			
Office of the Department Manager	3	0	*3*

TECHNICAL SERVICES DIVISION	NUMBER OF PERSONNEL		TOTAL
	EXISTING	PROPOSED	
SWTP Operations Section	50	12	*62*
Wells Section	64	17	*81*
Maintenance Services Department			
Office of the Department Manager	0	3	*3*
Maintenance Section	30	9	*39*
Planning and Development Department			
Office of the Department Manager	3	0	*3*
Planning and Design Section	7	0	*7*
Project Monitoring and Management Section	5	1	*6*
TOTAL	*165*	*42*	**207**

3) Finance and Administration Division

The human resources for finance and administration division will increase by 28 staff from its existing number of 43 in 2017. This is because of added responsibility in: (i) human resource management, not only because of the administering increased number of staff, but also in the conduct of capacity building, training and development activities; (ii) procurement, asset and property (facilities) management, which increase the responsibilities in general administration; (iii) financial management and budgeting, and (iv) accounting and cashiering, given the increase in service connections, although the implementation of the financial management information system helps keeps staff number to a minimum.

Table 8.2.6 HR Plan, Finance and Administration Department, 2017

FINANCE AND ADMINISTRATION DIVISION	NUMBER OF PERSONNEL		TOTAL
	EXISTING	PROPOSED	
Office of the Deputy Managing Director	3	0	*3*
Finance and Accounting Department			
Office of the Department Manager	2	1	*3*
Accounting Section	5	5	*10*
Budget and Treasury Section	1	4	*5*
Administration Department			
Office of the Department Manager	3	0	*3*
Human Resources Section	2	8	*10*
General Services Section	27	10	*37*
TOTAL	*43*	*28*	**71**

4) Commercial Services Division

The HR plan of the commercial services division, shown in **Table 8.2.7**, shows a high jump in the number of personnel because of the upgraded organizational stature of commercial services, being a main water utility function with its own deputy managing director. During this stage, commercial services will be organized along the zonal distribution concept, where each zone service department will have its own revenue section and customer service section

Table 8.2.7 HR Plan, Commercial Services Division, 2017

COMMERCIAL SERVICES DIVISION	NUMBER OF PERSONNEL		TOTAL
	EXISTING	PROPOSED	
Office of the Deputy Managing Director	3	0	*3*
Zone 1 & 4 Service Department			
Office of the Department Manager	3	0	*3*
Revenue Section	5	21	*26*
Customer Service Section	19	21	*40*
Zone 2 Service Department			
Office of the Department Manager	0	3	*3*
Revenue Section	3	23	*26*
Customer Service Section	19	21	*40*
Zone 3 & 5 Service Department			
Office of the Department Manager	0	3	*3*
Revenue Section	1	25	*26*
Customer Service Section	19	21	*40*
TOTAL	*72*	*138*	**210**

(4) Staff Productivity Index (SPI)

The HR plan for 2017 projects 502 KWASA personnel to service close to 56,000 connections. This will mean a staff productivity index of 8.9 (8.9 staff to 1,000 service connections). As a measure of staff productivity and organizational efficiency, SPI ratio should decrease in the future, and this can be achieved by implementing measures such as full automation of commercial systems such as billing and collection, and financial management and HR systems. Another way to reduce staff is in outsourcing of certain modules like billing and meter reading, service connection and disconnection, even leak repair. Projected SPI is as shown below:

	Current		**Projected**	
	2009-2010		**2017**	**2025**
Service Population	946,129	946,129	1,122,800	1,314,090
Number of Active Connections	[1/]12,673		[2/]55,933	90,000
		[3/]27,917		
Number of Staff	259	259	[3/]502	630
Staff Productivity Index (SPI)	20.43	9.30	8.90	7.00

1/ Active connections only, from ADB Report, 2009

2/ ADB Midterm Report. PPTA 7385-BAN: Preparing Khulna Water Supply, October 2010.

3/ Is actually the number of households served by each (legal and illegal) connection. Computed by multiplying number of connections times 2.72 households. From ADB Midterm Report, PPTA 7385-BAN, Oct 2010.

When compared to the other WASAs currently in operation in Bangladesh, KWASA has a better (projected) SPI using the proposed number of personnel in the HR Plan for 2017, as indicated in the comparative table below:

WASA	No. of Connections	No. of Personnel	SPI	Remarks
Dhaka WASA	266,555	4,375	16.41	As of June 2009
Chittagong WASA	48,291	589	12.20	As of July 2010
Khulna WASA	55,933	502	8.90	Projection for 2017

(5) Personnel Ratios

KWASA, being a technically-oriented organization, should maintain a personnel ratio of not lower than 60 technical to 40 business/ finance/ administrative. The table below shows the projected ratio of technical to business / administration, in terms of nature of work and/or staff orientation, as 65:35. However, this ratio can change if full automation, and/or outsourcing are resorted to.

ORGANIZTIONAL UNIT	NATURE OF WORK	
	TECHNICAL STAFF	BUS / ADM STAFF
Office of the Managing Director	**-**	**14**
Technical Services Division	**207**	**-**
Commercial Services Division	**120**	**90**
Finance and Administration Division	**-**	**71**
TOTAL	**327**	**175**

8.2.7 Management Systems

Management systems are the backbone of water utility operations, as human resources are the brain of the organization. Not only do management systems link the entire organization, these also ensure higher efficiency and more effective organizational performance. Management systems should reflect the country's water sector policies and laws, and the downstream policies and procedures enacted and approved by the KWASA Board.

The mission of KWASA is to produce, supply and distribute safe and potable water supply and maintain reliable 24-hour water service to Khuna City. Thus, it can be assumed that KWASA's water policies should explicitly be:

- Level of Service – Distribute potable water and have a reliable 24-hour water service for all households, businesses and institutional consumers within its service area / jurisdiction.

- Water Sources – Development of water sources should take into consideration conservation, preservation and sustainability of water resources, the maximization of safe sources, and cost efficiency.
- Water Improvement – Aim for interim (short term) improvements and long-term water supply expansion projects that adhere to Bangladesh's water resources and other related environmental laws.
- Tariff – Adopt a consumption-based tariff structure that is fair for all – residential/domestic, commercial/business and institutional consumers.
- Metered Consumption – Metering of all connections to ensure that users not only pay on the basis of actual consumption, but also encourage them to conserve water as a precious resource.
- Cost Recovery – Aim for operational and financial viability where there is full cost recovery, meaning, revenues from tariffs cover O&M costs, capital development plus debt servicing.
- Service to the Poor and Vulnerable – Being poor and vulnerable should not hamper access to safe water; but rather, water should be made affordable to the poor, and water service should be readily available to help vulnerable and disadvantaged members of the community.
- Professional Work Force – Aim for a professional, highly trained and motivated work force to ensure highest productivity, and ultimately, customer satisfaction.

1) Human Resources System

KWASA has HR policies and procedures in place, but these are based on existing laws, as discussed in the earlier section. It should be noted that the WASA Act allows KWASA to formulate and issue its own HR policies to address recruitment and selection, compensation and benefits, as well as training and development, so long as these are not inconsistent with law. A good reference for KWASA would be the HR policies drawn up by Dhaka WASA and Chittagong WASA, as these two WASAs have had a headstart compared to KWASA.

In addition, ADB, as part of its technical assistance project, is poised to continue providing KWASA with HR management advisory services, which will include the drafting of job descriptions for each position. This activity will be central to the HR system, as there is clearly a need to delineate responsibility and accountability for each staff member not only for individual and organizational efficiency and effectiveness, but also to enable better and more objective performance management and evaluation.

2) The Financial Management System

The financial management information system is presently being drawn up by ADB, again as part of its continuing technical assistance to KWASA.

3) Commercial Practices Systems

The development of a commercial practices systems is part of a proposed technical assistance project by ADB for 2013/14. This will align and integrate policy formulation and systems development on customer revenue (meter reading, billing and collection) and customer service quality and efficiency (service connection, reconnection, disconnection, and actions on customer complaints). Other recommended tasks are the mapping/zoning of present and potential service areas to confirm the type and number of residential and business customers connected and not yet connected to the system; and the development of a more holistic billing and collection information system that links with the financial management information system (FMIS).

4) Water supply operations systems

Water production and distribution systems must be codified and/or "manualized". These include operation and maintenance policies and procedures with regard to water demand and production, water loss and monitoring, water quality, distribution and leakage control, service connection, among others. Also planning and design parameters need to be established. Codifying and writing operations and maintenance manuals become even more imperative considering that many of those in water production and distribution, as well as in planning and technical departments are not engineering graduates, and therefore lack the fundamental educational and skills requirements. Such manuals will allow key and support personnel to uphold basic standards and follow procedures in their jobs.

8.3 The Project Implementation System

8.3.1 Government Institutions and Other Stakeholders and their General Linkage with the Water Supply Sector

There is a need, at this point, to have a macro perspective of the environment where KWASA operates by examining the functions of selected ministries and agencies of government in the water (and sanitation) sector, and determining the extent of their current institutional linkage with KWASA. This will subsequently allow for the identification of the priority or key stakeholder-institutions when implementing the Khulna water supply improvement project, and the definition of their respective roles and responsibilities in project implementation.

The different agencies, instrumentalities and institutions of Government have various functions and interests in the water supply (and sanitation) sector in Bangladesh and these may be in the area/s of policymaking and regulation; project planning, design and implementation; monitoring, evaluation, information management; awareness raising, public information and education; training and capacity building; the establishment and maintenance of institutional framework and mobilization of resources. In brief, the general division of responsibilities between and among the various government institutions is:

Ministry of Local Government, Rural Development and Co-operatives (MLGRD&C): It is the over-all agency in charge of ensuring the growth of the countryside through strengthening local governments ability to provide government services to the people. Under this Ministry is the Local Government Division (LGD), which prepares strategic plans for the water supply and sanitation sector, establishes governance, regulatory and monitoring mechanisms in providing access to water and sanitation. Under the LGD are departments that also have roles in the sector: (i) Department of Public Health Engineering (DPHE) – responsible for providing water and sanitation services in rural and urban areas not served by WASAs; and of technical assistance to local bodies responsible for water and sanitation including urban areas not served by WASAs; (ii) Local Government Engineering Department (LGED)

– responsible for rural infrastructure and assists municipalities in implementing infrastructure including water and sanitation on donor supported projects; (iii) Local Government Institutions (LGIs) – responsible for managing implemented communal water and sanitation systems; and (iv) National Institute for Local Government (NILG) – capacity development of local government bodies including Pourashavas.

Ministry of Finance (MoF): It mobilizes, allocates and releases funds for the water supply and sanitation sector. It also negotiates for donor contributions for the sector programmes and projects from bi-lateral and multi-lateral sources through technical assistance as well as concessional loans. The division whose linkage is closely aligned with the sector is the Economic Relations Division (ERD), which is the Government's aid coordinating authority. It examines and scrutinizes proposals for foreign aid, such as loans and grants, etc. received from Ministries/Divisions for allocation and identification of sources.

Ministry of Planning (MoP): Is the over-all planning agency of the country that approves sector plans, programmes and projects received from the line agencies through the respective Ministries and includes them in five-year plans and Annual Development Program (ADP). Under the Ministry are the Implementation Monitoring and Evaluation Division, the Planning Commission, the Bangladesh Bureau of Statistics, and the Bangladesh Social Science Research Council. Under this Ministry are the Planning Commission determines the objectives, goals and strategies of medium and short-term plans within the framework of long-term perspective and formulates policy measures for the achievement of planned goals and targets, including that of the water sector and the Implementation Monitoring and Evaluation Division, or IMED, which is the central and apex organization of the Government for monitoring and evaluation of the public sector development projects included in the ADP including ODA projects. It reports the progress of these projects to the National Economic Council (NEC).

Ministry of Water Resources (MoWR): Is the focal body for the development, management and monitoring of the entire water resources and the allocation of water rights by formulating policies, plans, strategies, guidelines, instructions and acts, rules, regulations. It prepares and implements development projects relating to flood control and drainage; irrigation, riverbank erosion control; delta development and land reclamation facilities by constructing barrages, regulators, sluices, canals, cross-dams, embankments and sea-dykes along the banks of the rivers and the coast. Its other functions relate to anti-salinity measures and anti-desertification, storage of water and construction of reservoirs, hydrological survey and data collection and international cooperation in the field of flood control and development of water resources.

Ministry of Environment and Forests (MoEF): Oversees all environmental matters in the country. It plans, promotes, coordinates and oversees the implementation of environmental and forestry programmes to achieve its mission of helping secure a clean and healthy environment for the benefit of present and future generations of Bangladeshis. The major departments under the MoEF are (i) the Department of Environment, which is the Ministry's technical wing and responsible for the implementation of the Environment Conservation Act, 1995; and (ii) the Bangladesh Forest Department, which has multi-dimensional functions of forest resource conservation and management, protection and management of biodiversity and watersheds along with economic and ecological development of the country.

Local stakeholders: The local stakeholders are composed of local government units and the local offices of national-level ministries: (i) Khulna City Corporation (KCC): the local government institution in charge of Khulna City. It used to manage, operate and maintain the Khulna City water supply system before this was transferred to KWASA; (ii) Khulna Development Authority (KDA): responsible for the development of Khulna under three broad areas – urban planning, city development and development control. It has set its sectoral policies on water, sanitation and environmental management, among others; (iii) Department of Environment, Khulna Division: responsible for enforcing all laws and ordinances aimed at protecting, conserving, and preserving the physical and natural environment in its jurisdiction; (iv) Land Authority (Local): oversees the legal process in land acquisition and just compensation of people and business that may be displaced or affected as a result of the Project.

Other stakeholders: Apart from the governmental stakeholders are the other sector stakeholders, such as: (i) Non-Government Organizations (NGOs) who work at the grassroots level in different fields, together with participation of the local people through education programmes targeting the communities; (ii) Private sector entities, such as private contractors, suppliers and consultants involved directly or indirectly in sector development; (iii) Community Based Organizations (CBOs) that operate and maintain rural water systems through self-elected committees and groups; and (iv) Donors who are known to make a significant contribution to the sector through their technical and financial assistance, guided by policies of their governments or organizations. The donors channel their assistance mostly through government agencies although direct support to NGOs is also common.

8.3.2 The Key Stakeholder-Institutions in KWASA Project Implementation

There are several key stakeholder-institutions with complementary interests over the successful implementation of the Khulna water supply improvement project. These are the following: (i) the Ministry of Finance, through its Economic Relations Division, the Government’s arm that will guarantee the loan to KWASA, and will, therefore, want to ensure that the loan will be repaid, (ii) the Ministry of Local Government, Rural Development and Cooperatives, through the Local Government Division, which has administrative supervision over KWASA, particularly over its future plans and projects involving government-guaranteed loans, and would, therefore monitor project implementation; and, (iii) The Ministry of Planning, through the Planning Commission, which will review, include and recommend the Project to the National Economic Commission (iv) the Khulna WASA, which is the project beneficiary, the re-payer of the loan, and the project implementer; (v) Khulna City Corporation, since the location of the Project is within the City’s political jurisdiction; (vi) the Khulna Development Authority, since it has water and environment policies to pursue to ensure the proper planning and development of the entire Khulna City; (vii) Local Land Authority, because this project has components related to land acquisition, resettlement and compensation; and (viii) Department of the Environment, Khulna Division since the Project will affect the social, natural and physical environment within its control area.

(1) Economic Relations Division, MOF

The Economic Relations Division (ERD) is one of the four divisions under the Ministry of Finance, with the vision of building Bangladesh as an economically self-reliant country, thereby reducing the level of poverty. It is responsible for mobilizing external resources for the socio-economic development of Bangladesh, taking the lead in interfacing with development partners and coordinating all external assistance inflows into the country. To do so, ERD assesses the needs for external assistance; devises strategies for negotiations and for mobilizing foreign assistance; formalizes and enables aid mobilization through the signing of loans and grant agreements; and determines and executes Bangladesh's external economic policy.

According to Section 33 of the WASA Act, if KWASA borrows from any financial institution, then Government will determine the terms and conditions of such borrowing. Since this Project is borne out of ODA funds, compliance to the Loan Agreement will be of special interest to the ERD, which coordinates all aid coming into GOB, including repayment.

In effect, ERD is a major stakeholder for this Project, as it undertakes aid programming and budgeting, initiating, negotiating and signing agreements, and informing the development partners of the use of development assistance. In fact, the Government appoints a representative of the MoF to sit as a member of the KWASA Board.

The ERD is divided into eight Wings, and each Wing has a number of Branches (considered as a self-contained unit consisting of Desks and Sections). Wing 1, which is headed by an Additional Secretary, is of special interest to this Project. (Refer to **Appendix 8.3.2 (1)** for The ERD Organogram and **Appendix 8.3.2 (2)** for the Basic Steps for Mobilizing Foreign Aid)

(2) The Local Government Division, MLGRD&C

The Local Government Division (LGD) is under the Ministry of Local Government, Rural Development and Cooperatives is one of the major sector stakeholders, particularly in the implementation of this Project. It implements various development and service-oriented activities for poverty alleviation up to the grass root level and mobilizes local resources to provide civic and utility services, to develop rural and urban infrastructure, and to supply safe drinking water, solid waste disposal and sanitation throughout Bangladesh.

At national level, the LGD is the overall responsible for the water and sanitation sector through the DPHE. It provides general monitoring and governance in relation to providing access to water and sanitation, policy formulation, regulation and overall strategic planning for the sector. In the urban areas, the DPHE was originally responsible for water and sanitation services, until the Pourashavas and City Corporations became more involved in planning, implementation and management of the water systems.

Water Supply and Sewerage Authorities (WASAs) were established in Dhaka and Chittagong cities to provide water supply, sewerage, drainage and solid waste management services to the people of those two large cities Under the East Pakistan Ordinance No. XIX of 1963. But with the enactment of the Water Supply and Sewerage Authority Act of 1996, the roles and responsibilities of Dhaka WASA and Chittagong WASA, together with the newly established Khulna WASA and Rajshahi WASA, have been re-defined and have, since then, undergone some organizational changes, giving the WASAs a greater degree of self-autonomy.

It is in this light that the WASAs remain under administrative control of MLGRD&C through the LGD. Approval of tariffs for water and sewer is still sought by WASAs from the LGD, as well as the approval of performance targets. KWASA also submits annual reports to LGD. The LGD also reviews and periodically monitors the WASA's performance relative to the implementation of corporate plans, programmes and performance agreements. The Government appoints a representative of the MLGRD&C to sit as a member of the WASA Board. (Refer to **Appendix 8.3.2 (3)** for the LGD Organogram)

(3) The Planning Commission

As the central planning organization of the country, the Planning Commission determines the objectives, goals and strategies of medium and short-term plans within the framework of long-term perspective and formulates policy measures for the achievement of planned goals and targets following the elements of development planning – policy, sectoral and programme planning. In addition, the Planning Commission serves as the Secretariat for major economic policy questions and for initiating the appraisal of development projects and programmes by the National Economic Council (NEC).

The Planning Commission is considered a key stakeholder because of its function in appraising and evaluating all development projects and their impact on the country's economic development. Furthermore, it recommends development project proposals for the approval of the Executive Committee of the National Economic Council (headed by the Prime Minister). (Refer to **Appendix 8.3.2 (4)** for Linkages of the Planning Commission with Government Agencies)

(4) The Khulna Development Authority

The Khulna Development Authority (KDA) was created as semi-autonomous body on 21 January 1961 by the then East Pakistan Government through an ordinance, The Khulna Development Authority Ordinance, 1961, for the planned development and expansion of Khulna City and its suburb areas. At present, KDA works under the Ministry of Housing and Public Works of the Government. It has an Executive Body consisting of a Chairman, who is the Authority's Chief Executive, and 12 members tackling issues related to development policies, projects and controls; land acquisitions, land disposals and organizational matters.

The functions of KDA fall under three broad areas – urban planning, city development and development control. It formulates the master plans of Khulna City taking off from plans made in 1961, and another that was prepared in 2001. Sectoral policies exist on economy and employment, traffic and transportation, drainage, sanitation, solid waste management, social services, open space and recreation, conservation of urban heritage, environmental management and urban governance, and capacity building.

For this Project, KDA is also considered a major stakeholder as it has clear sectoral policies on water, sanitation and environmental management, where the Project also must synchronize. These are: (i) water supply – exploration of the new sources of ground water supply; proper investigation on arsenic, salinity and iron contents of the groundwater and creation of an independent agency for water and sewerage management; (ii) sanitation – sufficient production and supply of components of single and twin pit latrines; promotion of public toilet facilities through out the city and development of an integrated sanitary sewerage network with treatment plants; and (iii) environmental management – proper treatment of water logged areas; protection and maintenance of surface water bodies including rivers and canals, and ensuring the strict implementation and enforcement of environmental laws.

(5) Khulna City Corporation

Khulna, declared a city corporation in 1990, is the third largest city in Bangladesh. It is the second port of entry in the country and is located on the banks of the Rupsha and Bhairab rivers at the Southwest part of the country. There are 31 wards that comprise KCC.

The water supply department of KCC is the precursor of KWASA. Former KCC employees are now KWASA's, and the KCC water supply facilities have been turned over to KWASA as well. Therefore, KCC has a very big stake in the improvement of KWASA as a water utility because not only does the latter's service area correspond to the KCC's political jurisdiction, but also the people served are KCC's constituents. Improving the quality of water supply will contribute to increased health and productivity for Khulna and water borne diseases and infant mortality.

(6) Local Land Authority

Since the Project will see the construction of an impounding reservoir and five distribution reservoirs, the possibility of having to acquire either government or private land for these facilities exists. Therefore, the Local Land Authority is an important stakeholder of the Project, as it enforces the Acquisition and Requisition of Immovable Property Ordinance of 1982, together with other laws, rules and ordinances, as well as customs and traditions. It oversees the legal process in land acquisition and just compensation of people and business that may be displaced or affected as a result of the Project. It is also the final approving authority on land acquisition (depending on the size of land to be acquired – Divisional, up to 50 bighas, and Government, areas over 50 bighas) and gives possession of the land to the requiring body after payment of compensation.

(7) Department of Environment, Khulna Division

The Department of Environment (Khulna Division) is under the Ministry of Environment and Forestry. It is responsible for enforcing all laws and ordinances aimed at protecting, conserving, and preserving the physical and natural environment in its jurisdiction. It promotes sustainable environmental development through environmental regulations and control. DOE Khulna Division is a key stakeholder as this Project must comply with the DOE requirements for EIA and must support Bangladeshi environmental laws.

8.3.3 The Project Organizations

There is a need to organize a project implementation system, with centers of responsibility, to ensure the successful completion of the Project. Given the scope of the Project, the implementation system will be comprised of two organizational levels – project coordination, and project management.

(1) Project Coordination: The Project Steering Committee

The existing Steering Committee for Feasibility Study for the Khulna Water Supply Improvement Project (SC) shall be re-named into the "Steering Committee for the Implementation of the Khulna Water Supply Project". Its membership shall be reconstituted as follows: (i) all existing members of the SC (F/S) will remain as members of the Steering Committee, the project's development partners, JICA and ADB will be advisors; (ii) the chairperson of the SC shall be the Secretary of LGD; (iii) membership to the SC shall be increased to include a senior representative of the Planning Commission, the DOE (Khulna Division); (iv) the SC shall be re-established by the Government after the signing of the loan agreement, or by year 2011/2012.

The SC, as one center of responsibility, shall be the inter-agency coordinating committee charged with the main role of providing policy guidelines for strategic coordination for Project implementation. As such, it has no supervisory authority, but its existence is for over-all coordination and oversight of project implementation among the major stakeholders, as well as for resolving emerging concerns, major issues and conflicts that may arise during project implementation.

(2) Project Implementation

1) KWASA through the Project Management Unit (PMU)

As the project beneficiary, and ultimately the institution responsible for repaying the loan, KWASA will have the primary role of being directly responsible for undertaking actual field supervision and management of the project's implementation. For this purpose, it will establish a project management unit (PMU) under the Deputy Managing Director for Technical Services for the duration of project implementation.

Although KWASA has yet to implement a project of the scale and cost of the proposed Khulna Water Supply Improvement Project, by managing project implementation, it will receive valuable experience in having to undergo international loan procedures to finance its project, thereby enabling it to build on, strengthen and develop its institutional capacity on project execution, project coordination, project monitoring and supervision, and project management.

2) The Project Consultants' Team(s) (PCT)

The project consultants' team(s) (PCT) consist(s) of a team of international and local experts selected on the basis of their academic training, specialization and experience in their respective disciplines that suit the demands of the Project. The consultants' work / services are defined and detailed in a "Terms of Reference (TOR)" for the purpose, which normally encompasses two categories of services – the task concept and the assistance concept.

Under the task concept, the Project Consultant Team(s) deliver(s) services to KWASA-PMU that generally involve the following activities (i) the preparation of project management guidelines; (ii) detailed design services; (iii) construction management services; and (iv) knowledge transfer on detailed design and construction management services to KWASA counterparts. In the assistance concept, the Project Consultant Team(s) provide(s) vital assistance to KWASA on the tendering phase of the Project.

Table 8.3.1 Role of Project Organizations in Project Implementation

Responsibility Centre	Project Organization	Membership or Institution / Department	Role in Project Implementation
Project coordination	Project Steering Committee (SC)	Project Steering Committee • Local Government Division (MLGRD&C)External Relations Division (MOF) • The Planning Commission • Implementation, Monitoring and Evaluation Department (IMED) • Khulna City Corporation • Khulna Development Authority • Khulna WASA • Department of Environment, Khulna Division (Advisors: JICA and ADB)	Provision of policy guidelines for **strategic inter-agency coordination** for Project implementation
Project implementation	Project Management Unit (PMU)	KWASA	Directly responsible for **undertaking actual field supervision and management** of Project implementation
	Project Consultants Team (PCT)	KWASA	Provides KWASA with services in **detailed design and construction management** during project implementation per Contract of Consulting Services

8.3.4 General Project Implementation System Framework

The roles of the key stakeholder organizations are situated within the project implementation framework. There is a need to graphically situate the roles of the key stakeholder-institutions that have been identified for project implementation in a framework. This "implementation framework" shall define and govern the general and specific interactions among the project organizations, given their responsibilities for project implementation.

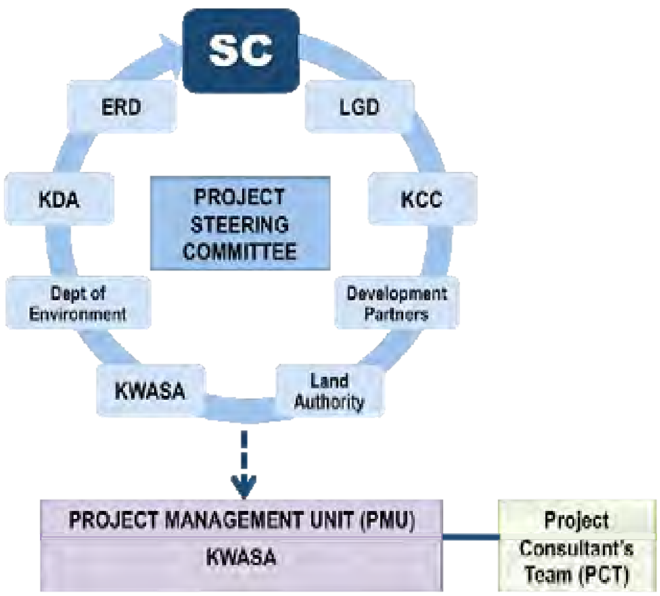


Figure 8.3.1 Project Implementation Framework

As shown in the framework / figure above, the SC has no supervisory authority over the project implementing unit, or KWASA, as indicated by a "line of coordination". The SC's role is one of strategic policy and inter-agency coordination.

The project management unit is KWASA. Its link with the project consultants' team (PCT) is one of a working relationship toward the achievement of project objectives based on the TOR for consulting services by undertaking actual field supervision and management.

(1) General Project Implementing Guidelines

General project implementation and management shall be spelled out in, and governed by, the Loan Contract/Agreement between GOB and GOJ / ADB, as follows:

- Strict adherence to the Loan Contract / Agreement specifying the mutual rights and obligations of each party;
- Abide by and respect all relevant laws in the GOB;
- Provide for project implementation structure that includes setting up of the SC and the PMU for the duration of project implementation; and
- Strengthen the project management unit as primary consideration in all initiatives at developing project implementation processes.

8.3.5 Responsibilities of the Project Organizations

The organizations in the project implementation system have specific responsibilities to discharge for the smooth implementation of the Project, as shown in the table below:

Table 8.3.2 Project Organizations and Responsibility Areas

	PROJECT ORGANIZATION	RESPONSIBILITY AREAS
1.	Project Steering Committee	General
		Financial
		Implementation
		Legal
2.	Project Management Unit	General
		Disbursement
		Implementation

(1) The Project Steering Committee

The responsibilities of the SC fall under four categories – general, financial, implementation and legal responsibilities.

<u>General Responsibilities</u>

- Identify and set-up mechanisms for systematic and coordinated delivery of services by providing assistance and information on possible resources from their own Ministries and/or Agencies and its sub-offices or departments that can be tapped to augment and support the process of project implementation;

- Formulate and/or recommend on policy issues referred to it because of legal or other conflicts that may arise;
- To hold regular monthly meetings for the duration of Project implementation, and call for special meetings as the need arises;
- To regularly report to their respective Ministers on the progress of the Project;
- To report to the Government on the over-all progress of the Project, if and when required.

<u>Financial Responsibilities</u>

- To make recommendations on investments related to the Project and include these in the Government's priority investment program – either the Three Year Rolling Investment Programme and/or the Annual Development Programme;
- To include in the yearly budget call / budget estimates and the Annual Development Programme of the concerned Ministry / Agency on the national and local levels, the priority list of projects that may be required for the Project;
- To identify and ensure the inclusion in each Ministry's priority list of projects for the duration of the Project's implementation, all related facilities not covered under the loan proceeds, but may be part of the responsibility of the Government of Bangladesh under the Loan Agreement, that may fall under the concerned Ministry's jurisdiction;
- To ensure the timely release of counterpart (local) funds, if and when needed, for the Project to the appropriate Ministry.

<u>Implementation Responsibilities</u>

- To facilitate timely release of construction and other licenses and permits needed for the Project;
- To coordinate environmental and social requirements and/or considerations related to the Project;
- To follow-up solutions to project implementation bottlenecks, problems and issues; and/or course these to the concerned agencies for proper resolution;
- To ensure that the causes of delays in the implementation/construction of related facilities financed out of loan proceeds and/or local funds, if any, are identified and directed to the appropriate agency for resolution.

<u>Legal and Other Responsibilities</u>

- To monitor land acquisition procedures on their compliance to law;
- To coordinate and find resolution to any legal issues that may arise during the course of the implementation of the Project.

(2) The Project Management Unit

KWASA has sufficient autonomy to discharge its day-to-day responsibilities as the project implementation unit. These responsibilities will fall under general, disbursement, and implementation.

The WASA Act specifies that Government and KWASA sign an annual performance agreement with performance targets, where LGD is mandated to periodically review and monitor KWASA's performance relative to the implementation of corporate plans, programmes and performance agreements, particularly over future plans and projects involving government-guaranteed loans. Therefore, KWASA will provide the LGD with the required reports for: (i) the latter's proper action and/or correction measures on deviations so that project implementation can be put on track; and (ii) submission to Implementation Monitoring and Evaluation Division (IMED) under the Ministry of Planning, which monitors and evaluates all public sector development projects, and to other government offices, as required.

The KWASA shall be tasked to provide the day-to-day supervision and management over the project at the field level. While it shall be working very closely with the project consultants, KWASA's tasks relate to application of project management concepts, tools and techniques. Since its recent establishment, KWASA has not yet implemented a project of the scale and cost as the proposed project. It has yet to experience undergoing international loan procedures to finance any of its projects. This means that its institutional capacity as an implementing agency needs to be developed, and then strengthened, especially on project execution, project coordination, project monitoring and supervision, and project management.

Project implementation and management must address the full range of activities from the beginning (initiating) to the end (closure) of a project and the management of multiple sub-activities within the Project. KWASA shall be involved in the entire cycle of the project as reflected in the whole range of services to be provided by the consultants. Providing day-to-day supervision over the implementation of the project means addressing technical skills like scheduling, cost estimating, and risk management; and also encompasses other disciplines such as scope definition, procurement management, financial management, asset management, human resource management, environmental and social considerations, and communications.

<u>General Responsibilities</u>

The general responsibilities borne out of the Loan Agreement are:

- Selection and employment, negotiation with, awarding and signing of the contract with the winning Consultant based on the Guidelines for the Selection and Procurement of Consultants for JICA ODA Loans, and ADB's Procurement Guidelines (2010) and Guidelines on the Use of Consultants (2010) where the signatory to the contract will be either be the KWASA Managing Director or the Chairman of the KWASA Board, or both.
- With the assistance of the Consultant, performs the prequalification of tender, tender calling and evaluation, contract negotiation for the civil works contractors, as well as on the procurement of goods and other services, based on the Guidelines for Procurement under JICA ODA Loans, and ADB's Procurement Guidelines (2010) and Guidelines on the Use of Consultants (2010) where the signatory to the contract will

be either be the KWASA Managing Director or the Chairman of the KWASA Board, or both.

- Undertakes Project compliance to covenants stipulated in the Loan Agreement.

<u>Responsibilities in Disbursement</u>

Since disbursement of JICA funds follow the principle of payment against invoice and other evidences, together with the certification of completed work, GOB, through the MoF, shall advance the funds to start the Project activities, and then claim reimbursement from JICA every time a certain portion of the work is completed. The responsibilities of GOB (represented by MoF) in disbursement are specified in the Loan Agreement, and GOB will abide by the disbursement procedures such as Commitment Procedures, the Reimbursement Procedure, and Transfer Procedures. In addition, ADB disbursement procedures will also be adhered to.

For smooth disbursement of loan proceeds, the MoF may delegate some of its authority directly to KWASA, as the project implementer. This means that KWASA-PMU, with the assistance of the project consultants' team, will carry out the final review and approval of all documents submitted to it by the contractors and suppliers and submit the same to the Managing Director, who will affix his signature prior to its transmittal to JICA.

<u>Implementation Responsibilities</u>

- Provides day-to-day supervision and management over the implementation of the Project.
- Reviews billing and expenditure statements. Prepares request for loan availment according to GOB and JICA / ADB disbursement procedures.
- Prepares and submits comprehensive work and financial plans (WFP) and upon approval of DMD for Technical.
- Undertakes project implementation within the approved work plans; and closely monitors scope, time or schedule, quality, and performance as well as cost (budget), procurement, and disbursements.
- Prepares and submits to LGD periodic reports on the progress of the project for the Government.
- Assists and participates in coordinating with the SC and JICA / ADB concerning project implementation.
- Prepares and submits, with the assistance of the PCT, Quarterly Reports to JICA until the completion of the project using specified official forms as required by JICA's monitoring system for ODA projects.
- Prepares and submits, with the assistance of the PCT, regular reports ADB until the completion of the project using specified official forms as required by ADB's monitoring system for ODA projects.
- Prepares and submits a Project Completion Report not later than six months after the project's final completion, conducts closing workshop and prepares project acceptance certificate.

8.3.6 Proposed Organization Structure of Project Management Unit (PMU) in KWASA

The Project Management Unit (PMU) shall serve as the technical arm in managing, supervising and controlling day-to-day project activities, including the work of the Consultants and contractors, in activities such as project planning and management, project construction supervision, procurement and disbursements, and preparation of reports, among others.

(1) General Guidelines Governing KWASA as the PMU

An office within KWASA will have to be designated as the PMU for the Project. Logically, it should be set-up within the supposed "Project Management and Implementation Department" under the Deputy Managing Director for Technical. However, this department is not yet officially in existence, as it has not gone through the process of approval by the KWASA Board.

The following shall be the guidelines in setting up the PMU:

a) The PMU shall be set up as an adjunct / separate office under the DMD Technical Services for the reason that Project falls under the jurisdiction and purview of this office. In addition, there is no other office, for the moment, within KWASA, that can transform itself into and take on the responsibilities required of a PMU.
b) The PMU will be established directly under the Office of the Chief Engineer, and shall be headed by a Project Director. While the DMD Technical Services will provide over-all operational guidance to the Unit, the Chief Engineer will concentrate on supervising the day-to-day project activities with the PMU Project Director.
c) The Project Consultant Team(s) (PCT) of JICA and ADB will report to the PMU Project Director. (For more on the PCT, refer to 8.3.7 in this section.)
d) Considering the scale and scope of the project packages, there shall be a total of 39 personnel for the PMU – 14 personnel to take charge of the JICA portion/package, 14 personnel to take charge of the ADB portion/package, and 11 shared personnel, that include the PMU Project Director. **Table 8.3.3** below provides the positions and number of personnel required for the PMU.

Table 8.3.3 Positions and Number of Personnel Required for PMU

	POSITION	Shared Personnel	JICA Portion	ADB Portion
1.	Project Director	1		
2.	Project Manager		1	1
3.	Accounting Officer		1	1
4.	Executive Engineer		1	1
5.	Assistant Engineer		2	2
6.	Sub-Assistant Engineer		4	4
7.	Project Technician		4	4
8.	Computer Operator		1	1
9.	Office Assistant	3		
10.	Miscellaneous Assistant	3		
11.	Driver	4		
	Total	**11**	**14**	**14**

e) As much as practicable, the positions for the PMU shall be filled from among the qualified KWASA personnel. Others that cannot be sourced from the existing KWASA ranks shall be hired on a contractual basis for the duration of the project. Recruitment and selection, however, will follow the government regulations on hiring and shall be based on the qualifications and experience required for the positions.

f) After the completion of the project, KWASA will have the option of retaining the PMU staff to appoint them in vacant technical posts, if warranted.

g) The PMU will be organized and structured as shown in **Figure 8.3.2** below:

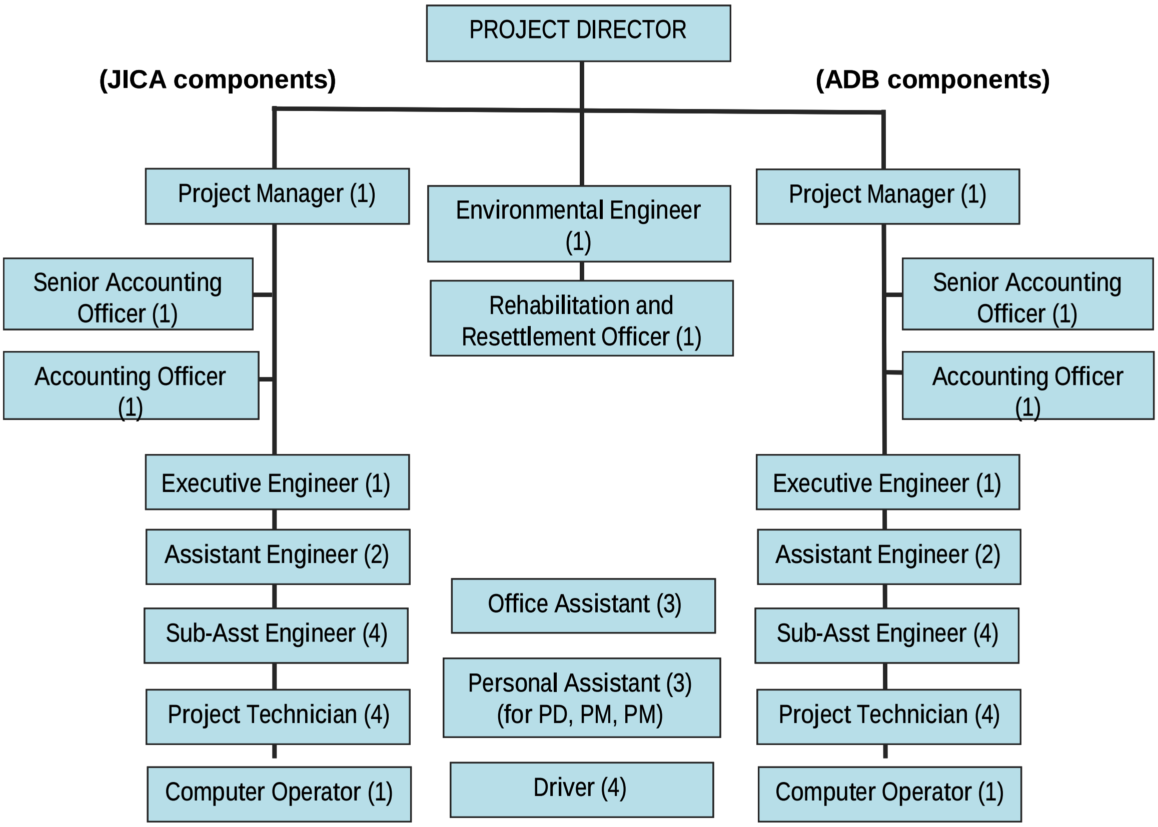


Figure 8.3.2 Proposed Organization Structure of PMU

(2) Responsibilities of MD, DMD (Technical) and Chief Engineer in Project Implementation

a) On the operating level, the Managing Director will ensure that objectives / targets of Project are achieved efficiently and effectively and according to plan. On the monitoring level, the MD will attend the regular meetings to be called by LGD on the implementation of this ODA project and bring to its attention urgent issues for immediate resolution. On the policy level, the MD, as a member of the SC, will proactively coordinate with the key stakeholders especially on matters that may need policy decisions and/or actions.

b) The Deputy Managing Director of the Technical Services Division will be the over-all in charge of project implementation and coordination activities. He shall ensure that the project is implemented in accordance with the schedules, plans and procedures agreed upon by JICA /ADB and the GOB. In addition, as a member of the Evaluation Committee which will be set up at in KWASA, he shall establish the important linkage and coordination with all stakeholders on project-related activities.

c) The Chief Engineer works under the supervision of the DMD Technical Services. As such, he shall be responsible for reviewing all documents and communications going to the KWASA MD, through the DMD Technical Services, for approval or endorsement to external offices. He shall be responsible for the management and supervision of technical tasks and studies, such as the review of detailed design of the new treatment plant and the distribution reservoirs; basic conceptual studies on local water distribution network expansion; and construction management. He shall bring to the attention of the DMD, and the MD important issues and/or implementation conflicts that need immediate resolution on the level of legal, financial, and policy formulation.

(3) Responsibilities / Functions of PMU Staff

The Project Director (PD) is a position equivalent to chief engineer or superintending engineer that requires excellent project management and leadership skills to ensure the achievement / completion of the project within approved technical and financial plans. This position also requires collaborative and coordinative skills to balance project stakeholders' interests (GOB, JICA, ADB, SC, LGD, local authorities, project beneficiaries, and other interested parties) without compromising over-all project goals and objectives. The PD for the PMU is expected to perform the following tasks/responsibilities:

a) Provides direction and guidance to the project managers (PMs) of the project packages (JICA and ADB portions), and other key personnel of the PMU by reviewing and defining the scope and objectives of the project(s), including the timetable, budget, etc. and securing the agreement of all stakeholders on the stated scope and objectives;
b) Develops policies/rules and procedures to manage the implementation of all the components of both project packages (JICA and ADB portions).
c) Manage and monitor all pertinent project activities, such as (but not limited to) the development and implementation of standards, guidelines and regulations; human resource development and training to support development and implementation objectives; community participation, as the need arises; as well as workflow and data management, administrative coordination and financial transactions.
d) Set ups and maintains database and monitoring system that will enable quick and accurate downloading of information on the progress of the project implementation, including those that concern the natural and social environments;
e) Provides regular progress and performance evaluation reports to the Deputy Managing Director Technical, Managing Director, KWASA Board, LGD and GOB, SC, and JICA / ADB, as required.

The position of Project Manager (PM) , equivalent to superintending engineer or executive engineer, requires ad hoc adjustments, based on moment-to-moment assessments of current conditions, within the context of a comprehensive plan created using sound and consistent methods from relevant past experience. The PM is expected to perform the following tasks/responsibilities:

a) Assists the PD in providing guidance and direction to the key PMU staff under their respective project package / portion by:

- Developing a work plan and program for their respective project portion(s) and determining the resource and logistical constraints to achieve the objectives of the project;
- Together with the each member of the team, defining / determining their specific roles and responsibilities;
- Defining / determining the outputs (and the expected quality of the outputs), the required resource, and timelines by each team member.

b) Develops the work and financial plans of his portion of the project for approval of the PD, and for submission to the KWASA Chief Engineer / DMD (Technical Services), to include the following:
   - Managing, monitoring and evaluating the progress of each project package/portion and their specific components;
   - Implementation progress reporting;
   - Annual planning and evaluation;
   - Procurement;
   - Disbursements (or the release of loans and funds).

c) Develops and manages the project monitoring system, such as:
   - Monitoring benchmarks to evaluate the progress of the project;
   - Monitoring the progress of the consultants and contractors in terms of scope, time and budget using the appropriate software;
   - Monitoring administrative and financial transactions.

d) Assists the PD developing policies, standards, guidelines rules and regulations and implements these.

e) Reviews all the reports of the consultants and recommends the appropriate action to be taken, where necessary;

f) Reviews post-field reports and identifies issues with the necessary recommendations for submission to the KWASA Chief Engineer;

g) Ensures the timelines and quality of outputs of the consultants, contractors and suppliers;

h) Reviews and recommends invoices, including certification of work completion/acceptance of consultants, contractors and suppliers for billing purposes.

The Accounting Officer(s) (AO) shall perform all delegated finance, accounting and administrative functions at the level of the project manager, such as:

a) Project financial / accounting functions:
   - Prepares the financial portion of the WFP;
   - Maintains all project book of accounts;
   - Keeps all project accounts up-to-date;
   - Ensures timely preparation of report of disbursements and periodic accounting reports of the project;
   - Processes vouchers and documents for disbursement of project funds.

b) Project administrative functions:
   - Develops, maintains and manages the project’s records system, project office documents and communications system, as well as physical facilities and supplies;

- Coordinates and processes procurement of goods and services for the PMU;
- Processes request for payments from suppliers and reviews compliance with GOB and JICA / ADB procedures;
- Prepares request for payment for suppliers, contractors and consultants based on the field-level disbursement procedures.

The Executive Engineer(s) (EE) will report directly to the PM, and will be responsible for supervising the technical projects and activities of the PMU, developing various systems and procedures for the smooth implementation of the project, installing and/or developing project management processes for the PMU.

The specific tasks of the EE are the following:

- Assists the PM in his responsibility for the management and supervision of technical studies / work to be undertaken;
- Directly oversees and supervises the implementation of field-level activities, particularly in civil works construction;
- Certifies the completion of work and payments of suppliers;
- Develops and undertakes planning activities, such as but not limited to, the work (technical) and financial plans for submission to and approval of higher officials and undertakes the implementation of the approved work plan;
- Monitors project activities and accomplishments;
- Prepares supporting reports on the progress of the project for KWASA Board, SC, LGD, and JICA / ADB, as required;
- Reviews monitoring report of consultants and contractor’s work and submits this to through the PMU’s chain of command.

The Assistant Engineer(s) (AE) shall report directly to the EE and shall have the following functions:

- Is responsible for the field-level implementation and management by providing direction for the effective and efficient field implementation of the different components of the project, while also monitoring the performance of the contractor and the field experts of the consultant;
- Validates the progress of implementation of each activity in the work plan;
- Assists in monitoring the activities and accomplishments of the project;
- Assists in preparing regular supporting reports for various users;
- Facilitates the preparation of the work (technical) and financial plan;
- Reports and/or find solutions to problems encountered in the field.

The Sub-Assistant Engineer/s (SubAE) will report directly to the EE through the AE for tasks on the field-level / technical side of the Project. The specific field functions are:

- Assists in monitoring the performance of the contractor and the field experts of the consultant;
- Prepares regular field inspection reports;
- Reports any deviations and problems to AE and/or EE.

The Project Technician(s) (PT) shall report directly to the EEs through the AE. They will assist in detailed field-level operations, as well as assist the SubAEs in delegated technical tasks from the PM.

The Office Assistant(s) shall be under the direction of the PD. They will provide support and assistance in the areas of project finance and accounting, and in project administration such as records and data management.

The Miscellaneous Assistant(s) shall be under the direction of the PD. They will provide support and assistance in the area of general services, as well as in financial and technical documentation for the project.

The Driver(s) shall be pooled under the Office of the PD. They will ensure the safe transport of passengers and goods within and around the project sites. The drivers will also perform daily maintenance works on the vehicles assigned to them.

The proposed qualifications of the PMU staff are shown in the **Table 8.3.4** below:

Table 8.3.4 Proposed Qualifications of the Staff for PMU

POSITION	Q U A L I F I C A T I O N	
Project Director	Academic	• BSc in Civil Engineering graduate • Masters Degree in Civil / Structural Engineering an advantage • Project Management Professional (PMP) Certification an advantage
	Experience	• At least 15 years experience in construction management of water supply and/or sewerage projects, as follows: - At least 10 years experience as project manager (PM) of water supply and/or sewerage construction project(s); and - At least 5 years experience as project manager of water supply and/or construction project(s) of a similar scale as this Project.
Project Manager	Academic	• BSc in Civil Engineering graduate • Masters Degree in Civil / Structural Engineering an advantage • Project Management Professional (PMP) Certification also an advantage
	Experience	• At least 12 years experience as project manager in water supply and/or sewerage projects, as follows: - At least 8 years experience as project manager of water supply and/or sewerage construction projects; and - At least 4 years experience as project manager or senior project engineer of water supply and/or construction project(s) of a similar scale as this Project.
Accounting Officer	Academic	• BSc in Accountancy graduate • Chartered Accountant certification an advantage
	Experience	At least 8 years total work experience, and five years as accountant
Executive Engineer	Academic	BSc in Civil Engineering graduate
	Experience	At least 10 years experience as engineer, five of which is in the sub-divisional engineer level in construction projects.
Assistant Engineer	Academic	BSc in Civil, Mechanical or Electrical Engineering graduate

POSITION	QUALIFICATION	
	Experience	At least 7 years experience as project or assistant project engineer in water supply and/or sewerage construction projects
Sub-Assistant Engineer	Academic	At least a Diploma Course in Engineering (of not less than three years) from any reputable engineering university/college
	Experience	At least 5 years experience as sub-assistant project engineer in water supply and/or sewerage projects
Project Technician	Academic	At least a Diploma Course in Engineering (of not less than three years) from any reputable engineering university/college
	Experience	At least 3 years experience as sub-assistant project engineer or project technician in water supply and/or sewerage projects
	Academic	BSc in Civil, Mechanical or Electrical Engineering graduate
	Experience	At least five years experience as materials estimator/ contract/quantity surveyor for water supply and/or sewerage construction projects
Office Assistant	Academic	Relevant Diploma Course (at least two years) from any reputable university/college
	Experience	At least three years work experience as office clerk
Miscellaneous Assistant	Academic	HSC or equivalent
	Experience	At least two years work experience as office clerk
Driver	Academic	HSC or equivalent
	Experience	At least five years driving experience Must possess professional driving license

8.3.7 The Project Consultants Team(s)

There shall be two Project Consultants' Teams, which shall correspond to the JICA and ADB portions of the project. These teams shall report to the Project Director of the PMU.

As for the consultants of the JICA-funded portion of the project, they shall provide consulting services as prescribed in the Terms of Reference, in areas such as preparation of detailed design, financial studies for water tariff determination, tendering, construction and project management services, and pre-operation and maintenance. Its services include, but shall not limited to, project planning and management; project supervision; transfer of technology, and the development of appropriate implementation strategies, work processes and procedures consistent with the fundamental principles espoused by the Project.

It is apparent that KWASA does not have the staff required as PMU as it has limited technical capability to take charge of the project. The consultant, therefore will actively participate and provide inputs to the PIU during the initial phase of project implementation. This will serve as a training medium for the PIU personnel until such time that the PMU-seconded personnel are able to handle project implementation by themselves.

Where feasible, KWASA staff will be seconded to selected PMU and consultant's positions in order for said staff to obtain actual or on-the-job training, which will prove to be very invaluable in the future. Seconding or providing counterpart personnel from KWASA to that of the consultant's will mean reviewing the existing qualifications of all KWASA personnel and matching them with the requirements of each position. This "exposure-assignment" method will ensure that the KWASA personnel selected is the best counterpart for the consultant, and is technically trainable to get the utmost benefits from the transfer of technology.

At the start of the consulting activities, the PMU should undergo orientation on their roles in both the detailed design and construction management stages – including contract administration, review and due diligence roles. It is envisioned that the PMU staff should be able to "inherit" the additional capability from the consultant and act as the co-lead personnel during the construction supervision stage. The structure and manning of the PCT is found in Chapter 11 of this Report.

8.4 Capacity Building

8.4.1 ADB's Proposed Corporate Management Consulting

ADB is proposing a Corporate Management Consultancy for KWASA, which will provide training (on-the-job) to KWASA management and staff in the implementation of the business plan; advisory services on (i) operations and management, (ii) compliance with ADB safeguard policies, and (iii) establishment of sound practices in program monitoring and evaluation and results management; and assistance in expanding and institutionalizing sustainable service provision to low income consumers. These services are set to start in July 2011 and will run for a period of three years, or until 2014/15.

Several tasks under this consultancy package will also be performed, particularly in KWASA operations and management systems and reform initiatives, such as: business planning, tariff design, HR management, communications and public awareness, O&M systems and procedures, UFW management, IT systems, GIS mapping, corporate governance, management advisory in all aspects of utility management, engineering and planning capacity development, social safeguards, assistance on implementing Gender Action Plan, sustainable service provision to low income consumers, connection procedures, alternative service delivery approaches, and mainstreaming low income customer approaches into KWASA planning.

It is expected that, considering the scale and scope of the ADB management consultancy project, the majority of the KWASA personnel, in almost every functional area would have been trained, from 2011/12 to 2014/15. This intensive on-the-job training approach will guarantee KWASA staff readiness in assuming the tasks that will accompany the completion of the project in 2017.

8.4.2 Proposed Capacity Development

In 2017, KWASA will commence with the management, operation and maintenance of the SWTP, as well as the distribution network and facilities. Training will be required on the operation and maintenance of all these equipment and facilities and will have to be suitably designed to the level of the participants and their current job-related functions.

(1) General Approach

It is proposed that the general approach to training is to acknowledge that all technical staff will require various types of training immediately before, and after project implementation, covering production operations and maintenance, distribution facilities' operation and maintenance and network installation and maintenance. It is proposed that a general training be conducted for all technical (O&M) personnel by batches of 25, so as to familiarize them the water production and distribution process of KWASA. To be included in this familiarization training will be a tour of the facilities, for the personnel to see first-hand the operations of the water system.

The general approach will also cover individual skills training, which requires a more in-depth training needs assessment (TNA), subjecting the candidate(s) to more detailed review of qualifications and aptitude, to ensure the matching of the proposed training with job presently held, skills and competency requirements for the job-holder to perform at minimum acceptable standard, the supervisor's performance assessments, and top management's current directions. The TNA requires three things: (i) the evaluation of all jobs / positions in KWASA; (ii) the development of job qualification standards; and (iii) writing or drafting of job or position descriptions for each job family. These requirements are outputs in the previously discussed three-year ADB management consultancy contract with KWASA.

(2) Specific Approaches

The specific approaches to capacity development encompass training objectives and design and methodology appropriate to the level of participants. For KWASA personnel, mixed methods are proposed to be utilized to develop specific competencies and skills on the job. Training should not be limited to lectures, workshops and familiarity (learning) tours to impart knowledge, and improve skills; but can be extended using the on-the-job methods, such as coaching and mentoring, counterparting with consultants and advance education, to ensure that training has the desired long lasting effects on behavioral change that positively impacts on how KWASA personnel should do their jobs. Other approaches are:

Trainer's training – all heads of departments, and key personnel will receive continuous on-the-job training through counterpart-basis with consultants. Towards the end of the training, the officers and key personnel will undergo a short course on how to be effective trainers, including the development training materials under the supervision of the consultants. These will then translated to Bangla language for staff training, and be archived in a knowledge database for future use.

Language of instruction – must be seriously considered, since many of the staff are not proficient in the English language. Training provided by consultants is usually in English, and it would be expected that retention and understanding by trainees would be low, defeating the training objectives. Therefore, the language of instruction, depending on the level of English proficiency of the staff, will be in Bangla language.

Advance education – KWASA can, in the future, provide well-performing staff with opportunity for advanced education in their respective fields, such as diploma courses in engineering, overseas training, or graduate (master's) degrees.

Training as an investment – since training of personnel has financial costs, it must be looked upon as an investment, and its "return on investment" must translate into efficiency and effectiveness for each employee trained, the bottom-line of which is that organizational objectives are met.

(3) Proposed Training

The following are the proposed water production operations and maintenance training to be conducted by the consultants, together with the contractor, shortly before the turnover of SWTP facilities to KWASA: (i) O&M training on the raw water intake facility and intake pump station; (ii) Training on the operations of the impounding reservoir, (iii) O&M training on the grit chamber, flocculation and sedimentation processes and facilities; (iv) O&M training of filtration process and facilities; (v) Training on the operations of the clear water reservoir; (vi) O&M training on chlorination process and facilities; (vii) O&M on water quality laboratory.

In addition, the proposed water distribution operations and maintenance training are: (i) Training on network installation, rehabilitation and maintenance; (ii) Training on leak repair/ reduction; and (iii) O&M training on distribution facilities, such as the distribution reservoirs, pumping stations and overhead tanks.

On-the-job training should also be given to personnel in charge of the operation and maintenance of all mechanical and electrical equipment, such as pumps, generators, blowers, vacuum regulators. The training will be provided by the consultants in tandem with manufacturers' representatives, and must be complimented manufacturers' brochures, complete with procedural diagrams to support daily operations and repairs.

CHPTER 9 FINANCIAL AND ECONOMIC CONSIDERATION

9.1 Financial Evaluation

9.1.1 Methodology and Assumptions

The financial internal rates of return (FIRR) and the financial net present value (FNPV) are calculated for financial evaluation of a project from the perspective of the operating entity, rather than the economy as a whole. The FIRR is the discount rate that equalizes the present values of costs and revenues over the project life. The FIRR calculated on the net cash flows shows the project's profitability.

The financial viability of a project can be evaluated based on a comparison of its FIRR with the financial opportunity cost of capital (FOCC). If the FIRR exceeds the FOCC, the project is regarded financially viable. This also means that the FNPV computed by using a discount rate equal to the FOCC will be positive when the project is financially viable.

To estimate financial cash flows, parameters and assumptions are set, distinguishing between "with project" and "without project" situations. Key parameters and assumptions used are set out as follows.

(1) Project Life

The initial capital investment for the project will take place over 6 years from the year 2011 to 2017. The economic life of the project is assumed to be 30 years, ending in the year 2046. The project analysis period is from 2010 to 2046.

(2) Capital Costs

The initial capital cost of the project totals Tk. 23,451 million (in 2010 constant price, without including price escalation). This amount will be disbursed from the year 2011 to 2017 (**Table 9.1.6**). The disbursement schedule is detailed in the cost estimate section.

(3) O&M Costs

As a result of the project, new O&M costs to be incurred in the peak years are estimated at US$3.08 million (in 2010 constant price) or Tk. 214 million. This O&M costs are composed of personnel expense (11.6%), power cost (56.8%), chemical cost (22.6%), and maintenance & others (9.1%). The new SWTP capacity utilization will be at the peak from the year 2025 onwards. Before reaching the peak, the O&M costs will be incurred in proportion to the water produced at the SWTP.

The new O&M costs include costs for tube well operation. The O&M costs for tube well operation before the new system starts are estimated at Tk. 31 million in 2010 constant price (**Table 9.1.1**).

This present O&M costs will be replaced by the new O&M costs from 2017 when the new SWTP starts the operation.

Table 9.1.1 Estimated O&M Costs for Present Tube Well Operation

	Expenditure in FY 2010 (Tk. 000)	Estimated * Tubewell O&M share	Tubewell O&M cost (Tk. 000)
Personnel Expenses	36,695	58%	21,100
Fuel	1,401	80%	1,121
Electricity	9,830	80%	7,864
Repair & Maintenance	5,497	80%	602
Plant & machinery	753	80%	602
Office	4,744	0%	0
Administrative and General Expenses	8,005	0%	0
Total	61,428		30,687

* O&M cost shares are estimated. The share in personnel expenses are assumed as follows.

Personnel expenses comprise permanent staff salary (75%) and temporary staff (25%).

Permanent staffs are mostly management and technical staffs. And 70% of the permanent staff costs are allocated for tubewell operation.

Temporary staffs are mostly administration and commercial staff. And 20% of the temporary staff costs is allocated for tubewell operation.

(4) Replacement cost

Replacement of capital assets is required for mechanical and electrical works. This is because their usable lives are considered as 15 years. Thus the mechanical and electrical works are assumed to be replaced in 2032. As civil structures and pipes are considered to have a 50 year usable life, the replacement will not take place during the project analysis period. Mechanical and electrical works account for 24 percent of the initial capital works.

(5) Residual value

The same percentages used to compute the replacement costs are applied to compute residual values of the capital assets. Mechanical and electrical works have a usable life of 15 years, and its replacement will take place in 2032. Civil structures and pipes have 50 year usable life. The residual values of those assets at the end of 2046 are computed by using these attrition rates. The residual value of land is the full market value at the acquisition timing.

(6) Water Supply and Non Revenue Water

- Under the "with project" situation, water is demanded and supplied as shown in **Table 9.1.2**. Water supplied by the KWASA network, KWASA HTW and private wells are used by domestic use, non-domestic use and NRW. And this composition will gradually change from 2010 to 2025. Water supply projects already budgeted are included in the supply sources. The new SWTP will start providing water from 2016.

Table 9.1.2 Water Demand and Supply under "With-project" Situation

(m3/day)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025-
Water demand																
KWASA network *1																
Domestic	16,629	21,120	29,143	35,827	38,347	40,867	76,053	84,749	92,000	96,779	99,659	102,539	105,539	108,539	114,131	117,251
Non-domestic	2,341	2,973	4,403	6,514	6,499	6,811	11,701	12,107	13,143	13,826	14,237	14,648	15,077	15,506	16,304	16,750
NRW	10,670	13,552	18,870	22,799	20,148	20,433	29,251	24,214	26,286	27,651	28,474	29,297	30,154	31,011	32,609	33,500
Total	29,640	37,644	52,416	65,139	64,994	68,111	117,005	121,070	131,429	138,255	142,370	146,484	150,770	155,055	163,044	167,501
KWASA HTW + private well																
Domestic *2	45,845	46,304	46,762	47,221	47,679	48,138	30,657	29,159	27,278	27,435	28,419	28,656	28,893	29,130	27,329	27,566
Non-domestic *2	11,462	11,003	10,545	10,086	9,628	9,169	8,185	7,200	6,216	5,231	4,247	4,010	3,773	3,536	3,300	3,063
NRW *2	12,580	12,580	12,580	12,580	12,580	12,580	8,526	7,981	7,352	7,171	7,171	7,171	7,171	7,171	6,723	6,723
Total *1	69,887	69,887	69,887	69,887	69,887	69,887	47,368	44,340	40,846	39,837	39,837	39,837	39,837	39,837	37,352	37,352
All systems																
Domestic	62,474	67,423	75,906	83,047	86,026	89,004	106,711	113,908	119,278	124,214	128,078	131,195	134,432	137,668	141,459	144,816
Non-domestic	13,802	13,976	14,948	16,600	16,127	15,980	19,885	19,307	19,359	19,057	18,484	18,658	18,850	19,042	19,604	19,813
NRW	23,250	26,132	31,449	35,378	32,728	33,013	37,778	32,195	33,638	34,822	35,645	36,467	37,325	38,182	39,332	40,223
Total	99,527	107,531	122,303	135,026	134,881	137,998	164,373	165,411	172,275	178,092	182,206	186,320	190,606	194,892	200,395	204,853
Water supply *1																
KWASA tubewell	30,100	27,090	24,080	21,070	19,565	21,070	24,080	27,090	30,100	30,100	30,100	30,100	30,100	30,100	30,100	30,100
KWASA hand pump	20,187	20,187	20,187	20,187	20,187	20,187	10,093	7,065	6,056	5,047	5,047	5,047	5,047	5,047	5,047	5,047
Private pumps	49,700	49,700	49,700	49,700	49,700	49,700	37,275	37,275	34,790	34,790	34,790	34,790	34,790	34,790	32,305	32,305
Others *3	0	10,769	28,877	44,536	46,250	47,250	47,250	47,250	47,250	46,750	46,750	46,750	46,750	46,750	46,750	46,750
SWTP of Project							45,675	46,730	54,079	61,405	65,520	69,634	73,920	78,205	86,194	90,651
Total	99,987	107,746	122,844	135,492	135,702	138,207	164,373	165,411	172,275	178,092	182,206	186,320	190,606	194,892	200,395	204,853

*1: Estimate by ADB TA
*2: Estimate by JICA FS
*3: Included are KCC mini tubewell (3.5MLD), GOB approved (20MLD), Phultala well field (20MLD) and Additional SWTP (6.75 MLD).

(7) Tariff

As an initial tariff analysis, three sets of tariffs were considered, where (i) only O&M cost should be recovered, and (ii) O&M cost and initial capital cost should be recovered, and (iii) full costs are recoverable including, initial capital cost, O&M cost, and replacement cost. The recoverable costs and the tariff settings under the three cases are summarized in **Table 9.1.3**.

Table 9.1.3 Cost Recoverable Tariff Options

(Tk/m3 in 2010 constant price)

Recoverable cost	
O&M cost	5.9
Initial Capital cost	23.0
M&E replacement cost	5.4
Required tariff	
Option 1 (Only OM cover)	
Domestic tariff	4.7
Non-domestic tariff	9.4
Average tariff	5.9
Option 2 (OM + initial capital cost)	
Domestic tariff	23.1
Non-domestic tariff	46.2
Average tariff	28.9
Option 3 (OM + initial capital cost + M&E replace)	
Domestic tariff	27.4
Non-domestic tariff	54.9
Average tariff	34.3

The ratio of non-domestic tariff to domestic tariff was set at 2. This ratio is smaller than 2.5, the ratio currently computable at the KWASA tariff and further smaller than other WASA tariffs[1]. However it is not unreasonable as non-domestic tariffs for industrial and commercial users in many Asian developing countries are priced about twice of tariffs for domestic user.

After considering these tariff options, we set tariffs to be applied in the base case scenario at the O&M cost recovery level which are Tk. 5/m^3 for domestic customers and Tk. 10/m^3 for non-domestic users. These tariff levels are determined from viewpoints of KWASA's tariff increasability and political acceptability for tariff increase. Under the WASA Act, KWASA can raise the tariffs up to 5 percent a year. It should be unproblematic to raise the tariff for domestic connection to Tk. 5/m^3 in the near future from Tk. 4/m^3 which was set in 2003.

The Local Government Division (LGD), competent authority of KWASA operation also opines that KWASA should bear only O&M costs, not capital costs. KWASA is currently dependent on subsidy from GOB. Revenues from water sales are not sufficient to even cover the operating expenses. Under such financial status and tariff levels, it is obvious that KWASA cannot pay any material capital project.

(8) Revenues from Water of SWTP

Using the tariff setting above mentioned, revenues derived from water supplied by the new SWTP are computed as shown in **Table 9.1.4**.

[1] DWASA' non-domestic volumetric tariff is Tk. 20.11/m^3 and the domestic tariff is Tk. 6.04/m^3, where the ratio is 3.3. In Chittagong, the ratio is 2.8, being Tk. 16.09/m^3 for non-domestic customers and Tk. 5.68/m^3 for domestic customers.

Table 9.1.4 Revenue from SWTP Water

(Tk values in 2010 constant price)

Year	Domestic water use (m3/day)	Non-domestic water use (m3/day)	NRW (m3/day)	Total Incremental water (m3/day)	Revenue water Domestic (m3/year)	Domestic tariff (Tk/m3)	Revenue water Non-domestic (m3/year)	Non-domestic tariff (Tk/m3)	Collection efficiency	Financial revenue (Tk million)
2016	14,826	2,763	5,249	22,838	5,411,508	5.0	1,008,420	10.0	100%	37
2017	32,180	5,455	9,096	46,730	11,745,836	5.0	1,990,900	10.0	100%	79
2018	37,442	6,077	10,559	54,079	13,666,496	5.0	2,218,040	10.0	100%	91
2019	42,828	6,571	12,006	61,405	15,632,304	5.0	2,398,289	10.0	100%	102
2020	46,056	6,647	12,817	65,520	16,810,288	5.0	2,425,979	10.0	100%	108
2021	49,032	6,973	13,629	69,634	17,896,542	5.0	2,545,209	10.0	100%	115
2022	52,134	7,310	14,475	73,920	19,029,018	5.0	2,668,256	10.0	100%	122
2023	55,243	7,641	15,321	78,205	20,163,647	5.0	2,788,971	10.0	100%	129
2024	60,844	8,432	16,917	86,194	22,208,181	5.0	3,077,685	10.0	100%	142
2025	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2026	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2027	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2028	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2029	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2030	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2031	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2032	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2033	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2034	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2035	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2036	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2037	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2038	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2039	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2040	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2041	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2042	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2043	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2044	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2045	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
2046	64,084	8,768	17,800	90,651	23,390,576	5.0	3,200,156	10.0	100%	149
Total					657,156,500		91,525,178			4,201

(9) Incremental Revenues from Tube Well Water

Currently water from KWASA tube wells is distributed through pipe system. However, as analyzed in Section 3.2.1, the effective tariffs are Tk. 1.2/m^3 for the domestic users and Tk. 1.0/m^3 for the non-domestic users. The situation will be surely improved after the project implementation. The existing pipe system of the tube well water will be replaced by a new system and the tube well water will be distributed through the new system together with the water produced at the SWTP. At the customer sites, with a new water meter installed by the project, real volumetric tariffs can be applied. The difference between the new volumetric tariff and the current effective tariff will bring incremental revenues to KWASA. The incremental revenues from tube well are computed as shown in **Table 9.1.5**.

Table 9.1.5 Incremental Revenue from Tube Well Water

(Tk million in 2010 constant price)

Year	Domestic water use (m3/day)	Non-domestic water use (m3/day)	NRW (m3/day)	Total tube well water (m3/day)	Revenue water Domestic (m3/year)	Incremental domestic tariff (Tk/m3)	Revenue water Non-domestic (m3/year)	Incremental non-dom. tariff (Tk/m3)	Collection efficiency	Financial revenue (Tk million)
2016	15,633	2,913	5,534	24,080	5,705,916	3.8	1,063,282	9.0	100%	31
2017	18,655	3,162	5,273	27,090	6,809,151	3.8	1,154,140	9.0	100%	36
2018	20,840	3,382	5,877	30,100	7,606,741	3.8	1,234,556	9.0	100%	40
2019	20,994	3,221	5,885	30,100	7,662,742	3.8	1,175,608	9.0	100%	40
2020	21,158	3,053	5,888	30,100	7,722,734	3.8	1,114,507	9.0	100%	39
2021	21,194	3,014	5,891	30,100	7,735,984	3.8	1,100,195	9.0	100%	39
2022	21,229	2,977	5,894	30,100	7,748,610	3.8	1,086,513	9.0	100%	39
2023	21,262	2,941	5,897	30,100	7,760,681	3.8	1,073,433	9.0	100%	39
2024	21,248	2,945	5,908	30,100	7,755,387	3.8	1,074,768	9.0	100%	39
2025	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2026	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2027	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2028	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2029	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2030	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2031	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2032	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2033	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2034	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2035	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2036	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2037	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2038	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2039	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2040	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2041	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2042	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2043	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2044	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2045	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
2046	21,279	2,911	5,910	30,100	7,766,675	3.8	1,062,589	9.0	100%	39
Total					237,374,803		33,453,963			1,203

(10) Connection Fee

The current connection fees vary from Tk. 800 to Tk. 10,000 depending on the pipe diameter and needs of road cutting and replacement. It is assumed that KWASA will charge new customers only actual cost for connection. This means that in the financial evaluation, the net cash flow from connections is neither positive nor negative.

(11) User Charge Collection Efficiency

Revenue data of KCC and KWASA in the past were rather erratic, showing considerable fluctuation. In some years, the users paid more and other years they paid less. Past years' arrears are collected in the following years. As a result, nominal collection efficiency in the recent past is nearly 100 percent. We therefore assume that the collection efficiency can be maintained at 100 percent.

9.1.2 Analysis of Financial Viability

The financial opportunity cost of capital (FOCC) was estimated by referring to the latest inflation rate and the latest interest rate of treasury bill. The inflation rate of general CPI in July 2010 was 7.63 percent. The weighted average yield of 5-year Bangladesh Government Treasury Bill in August 2010 was 7.88 percent. The FOCC was computed at 0.23 percent [= (1+0.0788) / (1+0.0763)-1].

Financial cash flows of the project are presented in **Table 9.1.6**. The FIRR in real terms resulted in minus 6.09 percent. This FIRR is inferior to the FOCC of 0.23 percent, meaning that the project is not financially viable.

Table 9.1.6 Financial Cash Flows of Project

(Tk million in 2010 constant price)

Year	Construct. Procuremt. Consultant	Land	Tax on capital cost	New O&M cost	O&M cost saving	Residual Value	Revenue SWTP water	Revenue Tube well water	Net benefit
2010	0	0	0	0	0	0	0	0	0
2011	17	179	9	0	0	0	0	0	-205
2012	615	212	92	0	0	0	0	0	-919
2013	3,397	57	763	0	0	0	0	0	-4,217
2014	6,531	0	1,528	0	0	0	0	0	-8,059
2015	4,905	0	1,100	0	0	0	0	0	-6,006
2016	2,814	0	471	27	15	0	111	51	-3,135
2017	675	0	86	110	31	0	236	127	-477
2018	0	0	0	128	31	0	272	141	315
2019	0	0	0	145	31	0	306	140	332
2020	0	0	0	154	31	0	325	139	340
2021	0	0	0	164	31	0	345	139	350
2022	0	0	0	174	31	0	365	138	360
2023	0	0	0	184	31	0	386	138	371
2024	0	0	0	203	31	0	425	138	391
2025	0	0	0	214	31	0	447	138	402
2026	0	0	0	214	31	0	447	138	402
2027	0	0	0	214	31	0	447	138	402
2028	0	0	0	214	31	0	447	138	402
2029	0	0	0	214	31	0	447	138	402
2030	0	0	0	214	31	0	447	138	402
2031	0	0	0	214	31	0	447	138	402
2032	4,549	0	970	214	31	0	447	138	-5,117
2033	0	0	0	214	31	0	447	138	402
2034	0	0	0	214	31	0	447	138	402
2035	0	0	0	214	31	0	447	138	402
2036	0	0	0	214	31	0	447	138	402
2037	0	0	0	214	31	0	447	138	402
2038	0	0	0	214	31	0	447	138	402
2039	0	0	0	214	31	0	447	138	402
2040	0	0	0	214	31	0	447	138	402
2041	0	0	0	214	31	0	447	138	402
2042	0	0	0	214	31	0	447	138	402
2043	0	0	0	214	31	0	447	138	402
2044	0	0	0	214	31	0	447	138	402
2045	0	0	0	214	31	0	447	138	402
2046	0	0	0	214	31	5,409	447	138	5,811
Total	23,504	448	5,018	5,993	936	5,409	12,603	4,187	-11,827

B/C = 0.64 FNPV (discount rate 0.23%) = -12,298 FIRR (real terms) = -2.72%

Obvious reason of this financial inviability is that the water tariffs are set at the O&M cost recovery level. The FIRR will never be positive unless the tariffs are set at the full cost recovery level. Change in the water tariffs and its effect on the project financial viability is examined by sensitivity analysis in **Section 9.1.3**.

9.1.3 Sensitivity Analysis of Financial Viability

Sensitivity analysis was performed to evaluate possible effects of adverse changes on the financial viability of the project under the base case. The adverse changes assumed are (i) 20 percent increase in capital cost, (ii) 20 percent increase in O&M costs; and (iii) 20 percent decrease in revenues. Each adverse change represents a further situation. For example, the capital cost increase may represent cost over-run caused by construction delay and price increase of major construction materials. The O&M cost increase may be due to change of unit prices of major cost components such as personnel expenses and electricity. The revenue decrease may have multiple causes such as insufficient tariff increase and deterioration in user charge collection efficiency. Results of the computation are summarized in **Table 9.1.7**. As the base case has already shows a negative FIRR, all the three scenarios make the FIRR even worse. The capital cost increase aggravates the most the financial viability among these three adverse scenarios.

Table 9.1.7 Summary of Financial Sensitivity Analysis

	FIRR (real terms)	FNPV (Tk. million)
Base case	-6.09%	-23,108
Capital cost increased by 20%	-6.81%	-28,787
O&M cost increased by 20%	-6.51%	-24,244
Revenue decreased by 20%	-6.46%	-24,130

It is said that the financial evaluation required in Development Project Proposal (DPP), the project application form for KWASA to get a GOB approval, should show a sensitivity analysis under a financially viable scenario. One of such scenarios could be simulated under the full cost recovery tariff setting. In order to examine if the financial viability is achievable under different tariff settings, we attempted to apply higher tariffs to the financial evaluation model and see changes in FIRR and FNPV. The results are summarized in **Table 9.1.8**. The FIRR and the FNPV will rise to 0.37% and Tk. 673 million respectively and become a satisfactory level when the full cost recovery tariffs (Tk. 27/m^3 for domestic and Tk. 54/m^3 for non-domestic) are adopted. The financial cash flows under the full cost recovery tariff setting are shown in **Table 9.1.9**.

Table 9.1.8 Summary of Sensitivity Analysis in Changing Tariff

	FIRR (real terms)	FNPV (Tk. million)
Base case (O&M cost recovery tariff) Domestic tariff – Tk. 5/m^3 Non-domestic tariff – Tk. 10/m^3	-6.09%	-23,108
Full cost recovery tariff Domestic tariff – Tk. 27/m^3 Non-domestic tariff – Tk. 54/m^3	0.37%	673
O&M plus partial capital cost recovery Domestic tariff – Tk. 15/m^3 Non-domestic tariff – Tk. 30/m^3	-2.72%	-12,298

Table 9.1.9 Financial Cash Flows of Project (Full Cost Recovery Tariff)

(Tk million in 2010 constant price)

Year	Construct. Procuremt. Consultant	Land	Tax on capital cost	New O&M cost	O&M cost saving	Residual Value	Revenue SWTP water	Revenue Tube well water	Net benefit
2010	0	0	0	0	0	0	0	0	0
2011	17	179	9	0	0	0	0	0	-205
2012	615	212	92	0	0	0	0	0	-919
2013	3,397	57	763	0	0	0	0	0	-4,217
2014	6,531	0	1,528	0	0	0	0	0	-8,059
2015	4,905	0	1,100	0	0	0	0	0	-6,006
2016	2,814	0	471	27	15	0	201	91	-3,005
2017	675	0	86	110	31	0	425	237	-179
2018	0	0	0	128	31	0	489	262	654
2019	0	0	0	145	31	0	552	260	697
2020	0	0	0	154	31	0	585	258	719
2021	0	0	0	164	31	0	621	258	745
2022	0	0	0	174	31	0	658	257	772
2023	0	0	0	184	31	0	695	257	798
2024	0	0	0	203	31	0	766	257	850
2025	0	0	0	214	31	0	804	257	878
2026	0	0	0	214	31	0	804	257	878
2027	0	0	0	214	31	0	804	257	878
2028	0	0	0	214	31	0	804	257	878
2029	0	0	0	214	31	0	804	257	878
2030	0	0	0	214	31	0	804	257	878
2031	0	0	0	214	31	0	804	257	878
2032	4,549	0	970	214	31	0	804	257	-4,641
2033	0	0	0	214	31	0	804	257	878
2034	0	0	0	214	31	0	804	257	878
2035	0	0	0	214	31	0	804	257	878
2036	0	0	0	214	31	0	804	257	878
2037	0	0	0	214	31	0	804	257	878
2038	0	0	0	214	31	0	804	257	878
2039	0	0	0	214	31	0	804	257	878
2040	0	0	0	214	31	0	804	257	878
2041	0	0	0	214	31	0	804	257	878
2042	0	0	0	214	31	0	804	257	878
2043	0	0	0	214	31	0	804	257	878
2044	0	0	0	214	31	0	804	257	878
2045	0	0	0	214	31	0	804	257	878
2046	0	0	0	214	31	5,409	804	257	6,287
Total	23,504	448	5,018	5,993	936	5,409	22,686	7,785	1,853

B/C = 1.02 FNPV (discount rate 0.23%) = 673 FIRR (real terms) = 0.37%

This full cost recovery tariff setting is not practical because it necessitates huge tariff increase from the current level in a short period. However, they are not completely unrealistic as the domestic tariff is far below the user's affordability to pay (ATP) price and the non-domestic tariff only slightly exceeds the ATP price[2].

Although the tariffs are set at an intermediary level, meaning that O&M cost and part of capital costs are recoverable, for example at Tk. 15/m^3 for domestic connection and Tk. 30/m^3 for non-domestic connection, the financial viability will be still unachievable. Both the FIRR and the FNPV remain to be a negative value.

9.1.4 Financial Projection

The object of financial projection is set as the project unit, instead of entire KWASA. At the time of the report preparation, none of basic financial statements of KWASA have been audited externally. In the absence of reliable financial data, it is hardly sensible to forecast the financial situation of KWASA assuming that the project is implemented under the base case scenario where the tariffs are set at the O&M cost recovery levels (Tk. 5/m^3 for domestic connection and Tk. 10/m^3 for non-domestic connection). Thus the financial projection was attempted, highlighting financial activity and outputs attributable only to the project.

The financial projection is prepared in forms of income statements (**Table 9.1.10**), balance sheets (**Table 9.1.11**), and cash flow statements (**Table 9.1.12**). Major operating indicators are summarized in **Table 9.1.13**. The annual inflation rate during the project implementation period (2011 to 2016) is assumed to be 4.8 percent, the same as used in the cost estimation. We assume that after the implementation period, the inflation will be halved. Due to increasing uncertainty of inflation and other parameters used, we limit time horizon of the financial projection as 2036, which is 20 years from the end of project implementation period. It is also assumed that cash shortage of KWASA will

---

2 When estimating the affordability to pay for water, the "5 percent rule" is useful. The "5 percent rule" is generally accepted as a norm by international development banks and financial institutions. This rule recommends that a household water and sewerage (or sanitation) bill should be less than 5 percent of the household income. The allocation between water and sewerage within the 5 percent is rather discretionary depending on the location. We can assume that this allocation is 4 percent for water and 1 percent for sanitation as the sanitation issue in Khulna is not as notable as the water.

The consumer survey of 2009 showed that the average household expenditure is Tk. 10,586 per month. However the household income was not surveyed. In order to estimate the household income in Khulna, we referred to data from "Household Income and Expenditure Survey" conducted by Bangladesh Bureau of Statistics in 2005. This survey indicated that the average monthly household income and expenditure in urban Bangladesh were Tk. 10,463 and Tk. 8,533 respectively. This means that the average household income in urban Bangladesh is 1.23 times the expenditure. Applying this ratio to the household expenditure in Khulna, or Tk. 10,586, we can estimate the household income in Khulna as Tk. 13,021 per month. A 4 percent of Tk. 13,021 is Tk. 521, which is considered as affordability to pay for new water per household per month. This is further computed at a Tk. 48 per cubic meter when the household size of 4.4 and the water consumption of 82 lpcd are applied.

The affordability of non-domestic users for better water supply is analyzed in Section 2.3.5. We assumed Tk. 18,446 as reasonably acceptable water cost for an average non-domestic user. As the average monthly consumption of non-domestic users is 341 cubic meter, the affordable tariff is computed as Tk. 54 per cubic meter.

be financed by GOB through contribution of capital grants. GOB will inject such capital grants when the KWASA cash position becomes negative due to debt servicing and replacement of mechanical and electric facilities. This is because KWASA cannot bear these costs under the O&M cost recoverable tariff setting, by definition. Considering the inflation, KWASA will have to achieve tariff levels of Tk. 6.6/m^3 for domestic and Tk. 13.2 for non-domestic connection in 2016.

Due to depreciation expenses and debt services which are not covered by the tariff revenues, KWASA's operation will stay in the red. The loss will cumulatively increase but the grant equity to finance the cumulative loss will also increase. As a result of the capital equity injection by GOB, the KWASA' cash position will balance.

Table 9.1.10 Income Statements under O&M Cost Recovery Scenario

(Tk million in nominal terms)

Year	Revenues			Expenses				Earning before Income tax	Income Tax	Net earning after tax
	Domestic Water	Nondomestic Water	Total	O&M	Depreciation	Financial Expenses	Total			
2016	74	27	101	36	377	1	414	-313	0	-313
2017	126	43	169	149	771	1	922	-754	0	-754
2018	148	48	196	177	771	360	1,308	-1,113	0	-1,113
2019	166	51	217	206	771	357	1,335	-1,118	0	-1,118
2020	179	52	230	225	771	347	1,343	-1,113	0	-1,113
2021	191	54	246	245	771	331	1,347	-1,101	0	-1,101
2022	205	57	262	266	771	314	1,352	-1,090	0	-1,090
2023	218	60	279	288	771	298	1,358	-1,079	0	-1,079
2024	240	67	306	326	771	281	1,378	-1,072	0	-1,072
2025	256	70	325	351	771	265	1,387	-1,062	0	-1,062
2026	262	72	333	359	771	249	1,379	-1,046	0	-1,046
2027	268	73	341	368	771	232	1,371	-1,030	0	-1,030
2028	274	75	349	376	771	216	1,364	-1,014	0	-1,014
2029	281	77	358	385	771	200	1,357	-999	0	-999
2030	288	79	366	395	771	183	1,349	-983	0	-983
2031	295	81	375	404	771	167	1,343	-967	0	-967
2032	302	83	384	414	771	151	1,336	-952	0	-952
2033	309	85	393	424	771	134	1,330	-936	0	-936
2034	316	87	403	434	771	118	1,323	-920	0	-920
2035	324	89	413	444	771	102	1,317	-905	0	-905
2036	332	91	422	455	771	85	1,312	-889	0	-889
2037	340	93	433	466	771	69	1,306	-874	0	-874
2038	348	95	443	477	771	52	1,301	-858	0	-858
2039	356	97	454	489	771	36	1,296	-843	0	-843
2040	365	100	464	500	771	20	1,292	-827	0	-827
2041	373	102	476	512	771	6	1,290	-814	0	-814
2042	382	105	487	525	771	-0	1,296	-809	0	-809
2043	392	107	499	537	771	-0	1,309	-810	0	-810
2044	401	110	511	550	771	-0	1,322	-811	0	-811
2045	411	112	523	563	771	-0	1,335	-812	0	-812
2046	420	115	535	577	771	-0	1,348	-813	0	-813

Table 9.1.11 Balance Sheets under O&M Cost Recovery Scenario

(Tk million in nominal terms)

Year	Assets				Equity and liabilities			
	Current assets	Capital assets	Land	Total	Grant equity	Loan payable	Accumulated earnings	Total
2016	0	23,229	593	23,822	6,666	17,469	-313	23,822
2017	0	23,401	607	24,008	7,085	17,989	-1,066	24,008
2018	0	23,172	622	23,794	7,984	17,989	-2,179	23,794
2019	0	22,919	637	23,556	9,101	17,752	-3,297	23,556
2020	0	22,641	652	23,293	10,769	16,934	-4,410	23,293
2021	0	22,336	668	23,004	12,399	16,117	-5,512	23,004
2022	0	22,004	684	22,688	13,990	15,299	-6,602	22,688
2023	0	21,642	700	22,343	15,542	14,481	-7,680	22,343
2024	-0	21,251	717	21,968	17,057	13,664	-8,752	21,968
2025	0	20,829	734	21,563	18,531	12,846	-9,814	21,563
2026	0	20,373	752	21,125	19,957	12,028	-10,860	21,125
2027	-0	19,884	770	20,655	21,334	11,211	-11,890	20,655
2028	0	19,360	789	20,149	22,661	10,393	-12,905	20,149
2029	-0	18,800	807	19,607	23,935	9,575	-13,904	19,607
2030	-0	18,201	827	19,028	25,157	8,757	-14,887	19,028
2031	0	17,562	847	18,409	26,323	7,940	-15,854	18,409
2032	-0	25,691	867	26,558	36,242	7,122	-16,806	26,558
2033	-0	25,180	888	26,068	37,506	6,304	-17,742	26,068
2034	-0	24,630	909	25,539	38,715	5,487	-18,662	25,539
2035	-0	24,039	931	24,970	39,868	4,669	-19,567	24,970
2036	-0	23,405	953	24,358	40,964	3,851	-20,457	24,358
2037	-0	22,727	976	23,703	42,000	3,034	-21,330	23,703
2038	-0	22,003	1,000	23,003	42,976	2,216	-22,189	23,003
2039	-0	21,231	1,024	22,255	43,888	1,398	-23,031	22,255
2040	-0	20,410	1,048	21,458	44,736	580	-23,858	21,458
2041	-0	19,537	1,073	20,610	45,282	-0	-24,672	20,610
2042	-0	18,610	1,099	19,709	45,190	-0	-25,481	19,709
2043	-0	17,627	1,125	18,753	45,044	-0	-26,291	18,753
2044	-0	16,587	1,152	17,739	44,842	-0	-27,102	17,739
2045	-0	15,486	1,180	16,666	44,581	-0	-27,914	16,666
2046	-0	14,323	1,208	15,532	44,259	-0	-28,727	15,532

Table 9.1.12 Cashflow Statements under O&M Cost Recovery Scenario

(Tk million in nominal terms)

Year	Cash flows from operating activities:				Cash flows from financing activities:						Cash flows from investing activities:			Cash and cash equivalents		
	Cash received from customers	O&M costs	Tax Payment	Net cash flow from these activities	Capital grants contributed by GoB	Net borrowing (repayment) for capital financing	Proceeds from sale of capital assets	Acquisition & construction of capital assets	Interest paid on capital financing	Net cash flow from these activities	Purchase of investment securities	Proceeds from sale of investment securities	Net cash flow from these activities	Net increase (decrease) for period	Balances at the year beginning	Balances at the year ending
2016	101	36	0	65	842	2,379	0	3,285	1	-65			0	0	0	0
2017	169	149	0	19	222	521	0	761	1	-19			0	0	0	0
2018	196	177	0	19	341	0	0	0	360	-19			0	0	0	0
2019	217	206	0	11	584	-237	0	0	357	-11			0	0	0	0
2020	230	225	0	5	1,159	-818	0	0	347	-5			0	0	0	0
2021	246	245	0	1	1,148	-818	0	0	331	-1			0	0	0	0
2022	262	266	0	-4	1,136	-818	0	0	314	4			0	-0	0	0
2023	279	288	0	-10	1,125	-818	0	0	298	10			0	-0	0	0
2024	306	326	0	-19	1,118	-818	0	0	281	19			0	-0	0	-0
2025	325	351	0	-25	1,108	-818	0	0	265	25			0	0	-0	0
2026	333	359	0	-26	1,092	-818	0	0	249	26			0	0	0	0
2027	341	368	0	-26	1,076	-818	0	0	232	26			0	-0	0	-0
2028	349	376	0	-27	1,061	-818	0	0	216	27			0	0	-0	0
2029	358	385	0	-28	1,045	-818	0	0	200	28			0	-0	0	-0
2030	366	395	0	-28	1,029	-818	0	0	183	28			0	0	-0	-0
2031	375	404	0	-29	1,014	-818	0	0	167	29			0	0	-0	0
2032	384	414	0	-30	6,517	-818	0	5,519	151	30			0	-0	0	-0
2033	393	424	0	-30	982	-818	0	0	134	30			0	0	-0	-0
2034	403	434	0	-31	967	-818	0	0	118	31			0	-0	-0	-0
2035	413	444	0	-32	951	-818	0	0	102	32			0	-0	-0	-0
2036	422	455	0	-33	936	-818	0	0	85	33			0	-0	-0	-0
2037	433	466	0	-33	920	-818	0	0	69	33			0	-0	-0	-0
2038	443	477	0	-34	904	-818	0	0	52	34			0	0	-0	-0
2039	454	489	0	-35	889	-818	0	0	36	35			0	0	-0	-0
2040	464	500	0	-36	873	-818	0	0	20	36			0	0	-0	-0
2041	476	512	0	-37	623	-580	0	0	6	37			0	0	-0	-0
2042	487	525	0	-38	38	0	0	0	-0	38			0	0	-0	-0
2043	499	537	0	-39	39	0	0	0	-0	39			0	0	-0	-0
2044	511	550	0	-39	39	0	0	0	-0	39			0	0	-0	-0
2045	523	563	0	-40	40	0	0	0	-0	40			0	0	-0	-0
2046	535	577	0	-41	41	0	0	0	-0	41			0	0	-0	-0

Table 9.1.13 Operating Indicators under O&M Cost Recovery Scenario

Year	Operating ratio * (O&M only)	Operating ratio * (O&M + int. payment)	Operating ratio * (O&M + int. payment + depreciation)	Water tariff for domestic (Tk/m3)	Water tariff for nondomestic (Tk/m3)	Revenue water** used by domestic (m3/day)	Revenue water** used by nondomestic (m3/day)	User charge collection efficiency
2016	0.35	0.37	4.09	6.6	13.2	30,459	5,676	100%
2017	0.89	0.89	5.47	6.8	13.6	50,836	8,617	100%
2018	0.91	2.74	6.68	6.9	13.9	58,283	9,459	100%
2019	0.95	2.60	6.16	7.1	14.2	63,822	9,791	100%
2020	0.98	2.48	5.83	7.3	14.6	67,214	9,700	100%
2021	1.00	2.34	5.49	7.5	14.9	70,226	9,987	100%
2022	1.02	2.22	5.16	7.6	15.3	73,363	10,287	100%
2023	1.03	2.10	4.87	7.8	15.6	76,505	10,582	100%
2024	1.06	1.98	4.50	8.0	16.0	82,092	11,377	100%
2025	1.08	1.89	4.26	8.2	16.4	85,362	11,679	100%
2026	1.08	1.82	4.14	8.4	16.8	85,362	11,679	100%
2027	1.08	1.76	4.02	8.6	17.2	85,362	11,679	100%
2028	1.08	1.70	3.90	8.8	17.6	85,362	11,679	100%
2029	1.08	1.64	3.79	9.0	18.0	85,362	11,679	100%
2030	1.08	1.58	3.68	9.2	18.5	85,362	11,679	100%
2031	1.08	1.52	3.58	9.5	18.9	85,362	11,679	100%
2032	1.08	1.47	3.48	9.7	19.4	85,362	11,679	100%
2033	1.08	1.42	3.38	9.9	19.8	85,362	11,679	100%
2034	1.08	1.37	3.28	10.2	20.3	85,362	11,679	100%
2035	1.08	1.32	3.19	10.4	20.8	85,362	11,679	100%
2036	1.08	1.28	3.11	10.6	21.3	85,362	11,679	100%
2037	1.08	1.24	3.02	10.9	21.8	85,362	11,679	100%
2038	1.08	1.20	2.94	11.2	22.3	85,362	11,679	100%
2039	1.08	1.16	2.86	11.4	22.9	85,362	11,679	100%
2040	1.08	1.12	2.78	11.7	23.4	85,362	11,679	100%
2041	1.08	1.09	2.71	12.0	24.0	85,362	11,679	100%
2042	1.08	1.08	2.66	12.3	24.5	85,362	11,679	100%
2043	1.08	1.08	2.62	12.6	25.1	85,362	11,679	100%
2044	1.08	1.08	2.59	12.9	25.7	85,362	11,679	100%
2045	1.08	1.08	2.55	13.2	26.4	85,362	11,679	100%
2046	1.08	1.08	2.52	13.5	27.0	85,362	11,679	100%

* Operating ratio = Operating expenses / Operating revenue
** Revenue water = Water supplied by SWTP + Water supplied by tube wells - NRW

9.2 Economic Evaluation

9.2.1 Methodology and Assumptions

The time frame for economic evaluation was set at 2010-2046, which was the same as the financial evaluation. The economic evaluation was based on the comparison between the "with project" and "without project" situations. Economic internal rate of return (EIRR) and economic net present value (ENPV) were computed. The analysis compared the calculated EIRR to the economic opportunity cost of capital (EOCC), which was assumed to be the standard 12 percent per annum. Economic cash flows were discounted at the same 12 percent to compute the project ENPV.

The domestic price numeraire was used in the economic evaluation. Financial costs were converted to economic costs in 2010 constant prices. For this purpose, the capital and O&M costs were apportioned into tradable and nontradable components. Financial prices of tradable components as reduced by duties and taxes were converted to economic prices by a shadow exchange rate factor (SERF). The SERF is used to remove the trade distortion effect under the system using the official exchange rate. The SERF is defined as follows:

$$\text{SERF} = \frac{(M + t_m - s_m) + (X - t_x + s_x)}{M + X}$$

Where:

M & X are total imports and exports, respectively, in a particular year at world prices and converted into local currency at the official exchange rate.

t_m & t_x are the tax collected to M and X, respectively.

s_m & t_x are the subsidy paid to M and X, respectively.

According to data of the World Trade Organization, Bangladesh imported goods and services of US$23,860 million in 2008. The export amounted US$15,370 million in the same year. Import duties collected during the 2005-2007 period was 11.8 percent to imports on average. Other trade taxes and subsidies were considered negligible. Based on these data, the SERF was computed at 1.07.

Financial prices of nontradable components were reduced by taxes only because trade distortion effects were irrelevant when domestic price numeraire was adopted. The computation process of conversion factors and the results are summarized in **Table 9.2.1**.

We assumed that foreign currency portion of the procurement/construction component was tradable. The local currency portion of the procurement/construction component was assumed to comprise nontradable components (89%), skilled labor (1%), and unskilled labor (10%). It was assumed that there were no significant distortions in the wage rates for skilled labor. In the case of unskilled labor, a conversion factor of 0.8 was used to reflect Bangladesh economy where underemployment existed resulting in the opportunity cost of unskilled labor being less than the minimum wage.

The financial cost of land acquisition and compensation also needs conversion to the economic cost because from the viewpoint of economic valuation, any land diverted to the project is necessarily taken away from some other use. The land market exists in Khulna and the market is regarded sufficiently active and representative of alternative use values for the lands acquired for project use. The lands for intake, SWTP, and impounding reservoir are currently plain or swampy land whose predominant use is agriculture, fishery, or combination of both[3]. The lands for distribution reservoirs

[3] Various crops are cultivable in Khulna and its vicinity. However, without considering subsistence crops and catch crops, rice is the single major cash crop that can be commercially profitable. Among varieties of rice, boro is now predominant. Also high yield varieties (HYV) boro rice is by far popular compared with other types such as local boro and hybrid boro. Pisciculture is also possible land use although it is not as popular as rice cultivation. Some lands are used as both paddy field and fish pond, differentiating according to season. Many of the fish cultivation are small-scaled where several species of fish are mix-cultivated. The fish cultivable in the project lands may include Galda prawn (*Macrobrachium rosenbergii*), Rui carp (*Labeo rohita*), Catla carp (*Catla catla*), Mrigal carp (*Cirhinus mrigala*), Grass carp (*Ctenopharyngodon idella*) and Silver carp (*Hypophthalmicthys molitrix*).

and overhead tanks which are located mainly in the town area, could be used for agricultural, residential, or industrial purposes. Those lands are valuated using the prices to be paid. However there are government lands which will be provided gratuitously to the project. Such free lands are valued in the economic evaluation at the price of similar lands to be purchased. Adding the prices of these free lands, the economic land value (base cost) is increased by 80 percent from the financial land value.

Table 9.2.1 Computation of Conversion Factors

Computation of Conversion Factors

(1) Conversion factor of capital cost (procurement/construction/consultant)

	Direct cost (not including tax) (US$)	Cost composition	Conversion factor
FC of procurement/construction (Tradable)	161,855,701	72.9%	1.07
LC of procurement/construction	41,908,931		
Non-tradable *1	37,298,948	16.8%	1.00
Skilled labor *2	419,089	0.2%	1.00
Unskilled labor *3	4,190,893	1.9%	0.80
Consulting service			
FC	8,889,029	4.0%	1.07
LC	9,321,573	4.2%	1.00
Total	221,975,234	100.0%	1.05

*1: Non-tradable portion is assumed to account for 89% of procurement/construction local cost.
*2: Skilled labor portion is assumed to account for 1% of procurement/construction local cost.
*3: Unskilled labor portion is assumed to account for 10% of procurement/construction local cost.

(2) Conversion factor of O&M cost

	Annual O&M (including tax) (US$)	Tax rate included in cost	Conversion factor	Economic O&M cost (US$)
Personnel Expense	357,000	10.0%	0.90	289,170
Power Cost	1,748,000	20.0%	1.07	1,496,288
Chemical Cost	695,000	20.0%	1.07	594,920
Maintenance & Others	280,000	20.0%	1.00	224,000
Total	3,080,000			2,604,378
Conversion Factor of O&M Cost				0.85

(3) Conversion factor of land 1.80
(4) Conversion factor of admin cost 1.00

In estimating the overall conversion factor of O&M cost, conversion factor of each cost component was assumed to be 0.90 for personnel cost, 1.07 for power cost, 1.07 for chemical cost and 1.00 for maintenance and others. The administration cost was all local costs and nontradable, therefore the conversion factor was regarded as 1.0.

9.2.2 Economic Benefits of Project

Water that will be generated by the project in fact consists of two types of water, incremental and nonincremental water. The incremental water is the amount of new and additional demand induced or generated by the project. The nonincremental water is equivalent to the amount of existing water supplied by alternative sources that will be displaced by the project. Summarized in **Table 9.2.2** is forecast of the incremental and nonincremental water in contrast with the water demand and supply data that was used in the project financial evaluation.

Table 9.2.2 Incremental and Nonincremental Water Forecast

(m3/day)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025-
New Water Supply by Project SWTP																
Incremental							10,353	21,184	25,038	31,355	35,469	39,584	43,869	48,155	53,659	58,116
Non-incremental							12,485	25,546	29,041	30,050	30,050	30,050	30,050	30,050	32,535	32,535
Total							22,838	46,730	54,079	61,405	65,520	69,634	73,920	78,205	86,194	90,651
Water Demand																
Domestic	62,474	67,423	75,906	83,047	86,026	89,004	106,711	113,908	119,278	124,214	128,078	131,195	134,432	137,668	141,459	144,816
Non-domestic	13,802	13,976	14,948	16,600	16,127	15,980	19,885	19,307	19,359	19,057	18,484	18,658	18,850	19,042	19,604	19,813
NRW	23,250	26,132	31,449	35,378	32,728	33,013	37,778	32,195	33,638	34,822	35,645	36,467	37,325	38,182	39,332	40,223
Total	99,527	107,531	122,303	135,026	134,881	137,998	164,373	165,411	172,275	178,092	182,206	186,320	190,606	194,892	200,395	204,853
Water Supply																
KWASA tubewell	30,100	27,090	24,080	21,070	19,565	21,070	24,080	27,090	30,100	30,100	30,100	30,100	30,100	30,100	30,100	30,100
KWASA hand pump	20,187	20,187	20,187	20,187	20,187	20,187	10,093	7,065	6,056	5,047	5,047	5,047	5,047	5,047	5,047	5,047
Private pumps	49,700	49,700	49,700	49,700	49,700	49,700	37,275	37,275	34,790	34,790	34,790	34,790	34,790	34,790	32,305	32,305
Others *	0	10,769	28,877	44,536	46,250	47,250	47,250	47,250	47,250	46,750	46,750	46,750	46,750	46,750	46,750	46,750
SWTP of Project **	0	0	0	0	0	0	22,838	46,730	54,079	61,405	65,520	69,634	73,920	78,205	86,194	90,651
Total	99,987	107,746	122,844	135,492	135,702	138,207	141,536	165,411	172,275	178,092	182,206	186,320	190,606	194,892	200,395	204,853

* Included are KCC mini tubewell (3.5MLD), GOB approved (20MLD), Phultala well field (20MLD) and Additional SWTP (6.75 MLD).
** Supply in 2016 is adjusted as half-year operation.

(1) Economic Value of Nonincremental Water

Economic benefit brought by the nonincremental water is resource cost savings which is a result of switching from alternative supplies to new water of SWTP. Results of the domestic water consumer survey indicate that households using KWASA hand pump tube wells spend on average 91 minutes per day to fetch water. This labor can be valued at Tk. 455 per month considering the minimum wage[4]. Additionally a 44 percent of the pump tube well users hires somebody to fetch water with an average cost of Tk. 123 per month. The weighted average of fetching cost is Tk. 509/household/month. The average consumption from KWASA hand pump tube wells is 7.45 m^3/household/month. Therefore the resource cost saving by stop using the hand pump tube wells and newly connecting to the KWASA pipe system is computed at Tk. 68.3 per cubic meter. The nonincremental water consumed by domestic customers can be valued at this price.

Also the non-domestic water consumer survey indicate that private water vendors are the water supply source used by non-domestic consumers as alternative of KWASA tube wells, KWASA hand pump tube wells, and private tube wells. According to the survey, 35 of non-domestic users altogether consume vendor water of 180 m^3 and pay Tk.202,790 per month. The average price of the vendor water at each non-domestic consumer ranges from Tk. 10 to 24,000 per cubic meter. The median and

4 Bangladesh has no national minimum wage. The minimum wage for garment workers is set at Tk. 3,000/month. Assuming that the water fetching costs half of Tk. 3,000 and the monthly working hour is 150 hours, the hourly rate is calculated at Tk.10.

mode value is Tk. 2,000 per cubic meter. Therefore we considered this Tk. 2,000 as the value of nonincremental water consumed by non-domestic customers.

(2) Economic Value of Incremental Water

Incremental water is valued in terms of willingness to pay (WTP), which is regarded as proxy for demand price of new water. Based on results of the domestic consumer survey results, newly connected domestic user's WTP for new water is estimated at Tk. 24.9 at the connection fee of Tk. 1,000, Tk. 22.2 at the connection fee of Tk. 3,000, and Tk. 21.4 at the connection fee of Tk. 5,000. The connection fee for the majority of domestic users is currently priced at Tk. 1,800 as ¾ inch diameter connection. Considering that actual connection works will incur a certain additional outlay, we can assume that Tk. 3,000 is the average connection costs for a domestic customer. This implies that Tk. 22.2 per cubic meter is the WTP for the incremental water.

For non-domestic users, the WTP of Tk. 54 per cubic meter is applied. This WTP was deduced from the ability to pay price (Section 2.3.5).

(3) Economic Value Added to KWASA Tube Well Water

Households which already have connection with KWASA will benefit from the new system as it will provide those households with surer and cleaner water than the current system does. The domestic consumer survey indicates that the WTP of those already connected is Tk. 29.7 per cubic meter.

(4) Administrative Loss

Unlike physical (technical) water loss, existence of administrative water loss (e.g., water theft, metering result alteration and low billing) means that the lost water is consumed by someone who does not pay for the use. In fact the benefits from use of the administratively lost water are enjoyed by them, therefore recognizable as benefit in the economic evaluation. The benefits are valued also at the WTP price. The percentage of administrative loss within total KWASA water loss is assumed to be 50 percent throughout the project period.

(5) O&M Cost Resource Saving

The O&M costs for tube well operation before the new system starts were considered a financial benefit. This is considered as a financial benefit too as resource can be saved by switching the new system. The economic value is converted from the financial value by multiplying the O&M cost conversion factor of 0.85.

(6) Residual Value at the End of Project Life

Residual value of the project at the end of the project life is regarded as positive cash flow in the economic evaluation. Civil structures and pipes are regarded to have 50 year life and mechanical and electrical equipment have 20 years after the replacement. The conversion factor used to arrive in economic value is set at 1.04.

9.2.3 Analysis of Economic Viability

Economic cash flows of the project are presented in **Table 9.2.3**. The EIRR in real terms resulted in 14.41 percent and the ENPV was Tk. 2,529 million. The project is considered economically viable as the EIRR exceeds 12 percent.

9.2.4 Sensitivity Analysis of Economic Viability

Sensitivity analysis was conducted to determine possible effects of adverse changes on the economic viability of the base case. The adverse changes assumed are (i) 20 percent increase in total cost factors composed of capital cost, O&M cost, and facility replacement cost, and (ii) 20 percent decrease in total benefit factors, derived from output of nonincremental water, output of incremental water, use of commercial water loss, and residual value of facilities. The results of computation are summarized in **Table 9.2.4**. A change (increase) of 20 percent in the investment cost will decrease the EIRR but still keep it above the 12 percent, meaning that the economic viability of the project is robust. A decrease of 5 percent in the benefits lowers the EIRR to 11.55 percent. This is below 12 percent but still over 10 percent which is regarded as a minimum viability level.

Table 9.2.4 Summary of Economic Sensitivity Analysis

	EIRR (real terms)	ENPV (Tk. million)
Base case	14.41%	2,529
Economic costs increased by 20%	12.05%	60
Economic benefits decreased by 20%	11.55%	-448

Table 9.2.3 Economic Cash Flows of Project

(Tk million in 2010 constant price)

Year	Construct. Procuremt. Consultant	Land	New O&M cost	O&M cost saving	Residual Value	Domestic Already conn. to KWASA	Non-domestic Already conn. to KWASA	Nonincre. water value domestic	Nonincre. water value non-domes	Use of nonincre. water loss domestic	Use of nonincre. water loss non-domes.	Increment. water value domestic	Increment. water value non-domes	Use of incremental water loss domestic	Use of incremental water loss non-domes.	Net economic benefit
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	18	322	0	0	0	0	0	0	0	0	0	0	0	0	0	-340
2012	646	381	0	0	0	0	0	0	0	0	0	0	0	0	0	-1,027
2013	3,567	102	0	0	0	0	0	0	0	0	0	0	0	0	0	-3,669
2014	6,858	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-6,858
2015	5,151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-5,151
2016	2,955	0	23	13	0	169	57	202	1,103	30	165	54	25	8	4	-1,148
2017	709	0	93	26	0	202	62	439	2,177	53	263	118	49	14	6	2,607
2018	0	0	108	26	0	226	67	501	2,382	61	289	140	55	17	7	3,664
2019	0	0	122	26	0	228	63	522	2,347	63	285	177	66	22	8	3,686
2020	0	0	131	26	0	229	60	527	2,225	64	271	202	71	25	9	3,578
2021	0	0	139	26	0	230	59	527	2,197	64	267	226	78	27	10	3,573
2022	0	0	147	26	0	230	59	528	2,169	64	264	251	86	31	10	3,571
2023	0	0	156	26	0	230	58	529	2,143	64	261	276	93	34	11	3,570
2024	0	0	172	26	0	230	58	573	2,323	70	284	307	103	37	13	3,853
2025	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2026	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2027	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2028	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2029	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2030	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2031	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2032	4,777	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	-925
2033	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2034	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2035	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2036	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2037	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2038	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2039	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2040	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2041	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2042	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2043	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2044	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2045	0	0	181	26	0	231	57	573	2,297	70	281	333	111	41	14	3,852
2046	0	0	181	26	6,378	231	57	573	2,297	70	281	333	111	41	14	10,230
Total	24,681	805	5,067	791	6,378	7,050	1,807	16,963	69,603	2,075	8,522	9,075	3,063	1,109	375	96,259

B/C = 1.20 ENPV (discount rate 12%) = 2,529 EIRR (real terms) = 14.41%

9.3 Important Financial Conditions

There are certain conditions on which the financial sustainability of the Project is particularly dependent.

(1) Imposition of O&M recovery tariff ----- At least the tariff should be set at the O&M cost recovery level. At this level the tariffs will be Tk. 5/m^3 for domestic users and Tk. 10/m^3 for non-domestic users. The rates are quoted in 2010 prices, meaning that in 2016 for example, the actual rates should be Tk. 6.6/m^3 for the domestic and Tk. 13.2 for the non-domestic, taking into account a modest inflation from 2010 to 2016.

(2) Soft loan and grants ----- The financial projection under the above tariff scenario is presented in Section 9.1.4. It is assumed in the financial projection that GOB will finance the cash shortage of KWASA, because obviously KWASA cannot service the subsidiary loan on-lent by GOB unless a full cost recovery tariff is set. It is also assumed that such financing will be made available through contribution of capital grants by GOB. Such financing however, is not promised at this point. KWASA should appeal to GOB for application of softer loan terms such as lower interest rate and longer repayment period. Also KWASA should request as much government grants as possible to mitigate the debt service burden in the future

(3) Debt rescheduling and restructuring ----- The GOB subsidiary loan guideline stipulates the terms of subsidiary loans that will be on-lent by GOB to DWASA and CWASA, but the conditions to KWASA has not yet be established. The terms are based on the assumption that the WASAs can impose full cost recovery tariffs to the customers, which is actually unrealistic. The GOB guideline also remarks that equity participation or limited grants may be considered as the financing to the WASAs because of public interest in terms of urbanization/human settlement. KWASA should negotiate with MOF through LGD for softer terms such as lower interest rate and longer repayment period than those suggested in the guideline. KWASA, being newly established and much smaller in size than DWASA and CWASA, should obtain not only concessionary terms but also reduction of debts through grant receipt and equalization.

CHAPTER 10 Environmental and Social Consideration

10.1 Summarization of the Project required for Environmental Procedures in Bangladesh

10.1.1 Obtaining Environmental Clearance Certificate

As reviewed in the item 2.2.3 in Chapter 2, a Site Clearance Certificate (SCC) and an Environmental Clearance Certificate (ECC) shall be obtained from regional and/or central (Dhaka) DOE (Department of Environment) for certain kinds of development projects in Bangladesh. Projects which are required to obtain both SCC and ECC shall prepare IEE report and EIA repot respectively, are stipulated in relevant laws, regulations and guidelines. The following shows those rule and guidelines especially applied for water supply projects in Bangladesh.

- Environmental Conservation Rules (ECR) 1997 (amended in 2000)
- EIA Guidelines for Industries 1997, DOE
- Guidelines for Environmental Assessment of Water Management (FCD/I) Projects 2005 WARPO

In accordance with those rules and guidelines all water supply projects in Bangladesh are classified as category “Red”, which naturally are required IEE and EIA studies for getting SCC and ECC from a proper DOE office.

The project proposed by “the JICA Feasibility Study for Khulna Water Supply Improvement Project” is in the field of water supply project which therefore falls under the Category “Red” in Bangladesh. Consequently the project proponent (KWASA) shall prepare IEE and EIA reports according to relevant laws and guidelines which are specified in Item 2.3.3.

10.1.2 Summary of Proposed Project Component

Based on the JICA Feasibility Study, possible project components have been proposed as follows:

- Raw water is collected from the Madhumati River at Mollarhat
- The collected water is sent to a Surface Water Treatment Plant (SWTP) at Samanto Sena by a raw water transmission pipe of the diameter 1,350 mm and the length 33km.
- An impounding reservoir at Samanto Sena is necessary to store non saline raw water during wet season when salinity concentration is less than 1000 mg/L in the river.
- Treated water at the SWTP is sent to five distribution reservoirs in Khulna city by clear transmission pipe of diameter 300 mm to 1,100 mm.
- The length of clear water transmission pipe is about 25 km in total.
- Store clear water in distribution reservoir in order to proper distribution of water in response to water demand for five service area in Khulna city.
- Eleven (11) overhead tanks are use for sufficient water pressure and also for some water reserve

required for the consumers. The overhead tanks are filled with clear water pummping from distribution reservoir.

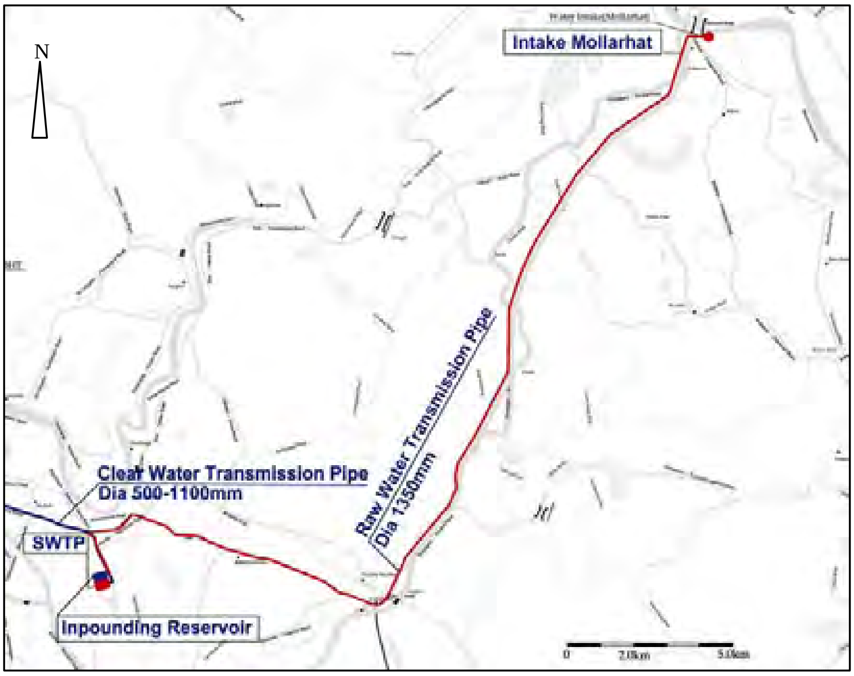
- Ddistribution pipe will be constructed to supply water to the consumer end.

Table 10.1.1 shows a summary of the proposed water supply facilities for year of 2025. **Figure 10.1.1** and **Figure 10.1.2** show each location of project components.

Table 10.1.1 Summary of Proposed Water Supply Facilities

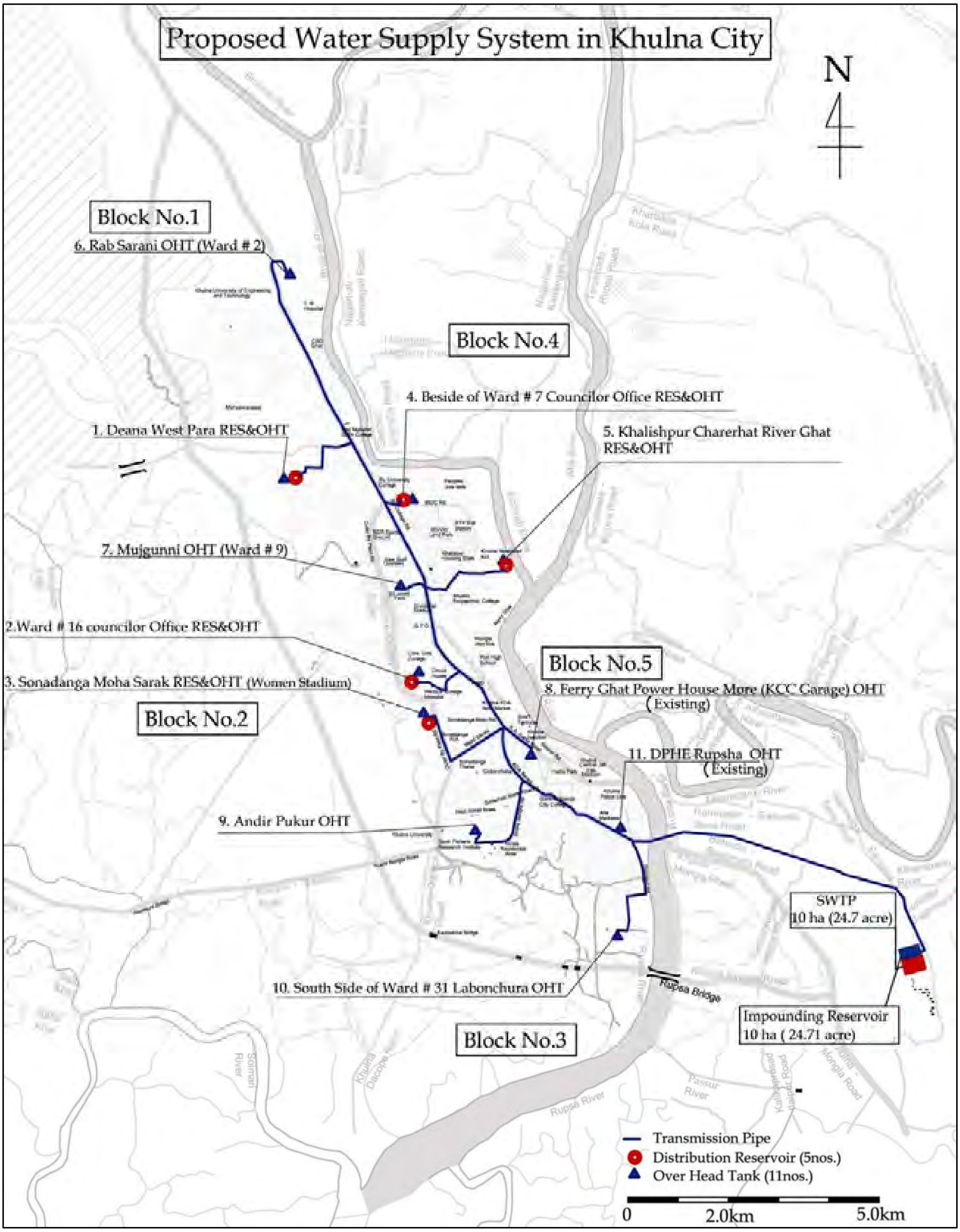
	Project Components	Capacity	Quantity	Dimension (m)	Area	Location
1	Water Intake	110,000m^3/day	1 nos	75 x 125 + Access Road 120m	1.0ha	Madhumati River at Mollarhat
2	Raw Water Transmission Pipe	-	φ1350mm, L=33km	See Figure 10.1.1		
3	Impounding Reservoir	775,200m^3	1 nos	400 x 400	16ha	Samanto Sena
4	SWTP	110,000m^3/day	1 nos	250 x 400	10ha	Samanto Sena
5	Clear Water Transmission Pipe	-	Φ300mm-1100mm, L=25km	See Figure 10.1.2		
6	Distribution Reservoir & Overhead Tank (5 nos)	Reservoir (5,000m^3 - 18,000m^3 OHT (300m^3 - 500m^3)	Deana West Para Reservoir	100 x 70	0.7ha	Paddy Land
			Ward No.16 Office Reservoir	100 x 70	0.7ha	KCC Land
			Sonadanga Moha Sarak Reservoir	100 x 90	0.9ha	Private Land
			Beside of No.7 Ward Office Reservoir	100 x 70	0.7ha	Personal Land
			Khalishpur Charerhat River Ghat Reservoir	100 x 90	0.9ha	Government Land (KASS)
7	Overhead Tank (6 nos)	300m^3	Rab Sarani OHT	45 x 30	0.14ha	Private Land
		300m^3	Mujgunni OHT	45 x 30	0.14ha	KCC land
		300m^3	Ferry Ghat Power House OHT	45 x 30	0.14ha	KCC land
		500 m^3	Andir Pukur OHT	50 x 35	0.18ha	Private Land
		500 m^3	South Side of Ward No.31 Office OHT	50 x 35	0.18ha	Paddy land
		500 m^3	DPHE Rupsha OHT	50 x 35	0.18ha	DPHE
8	Distribution Pipe Network	-	φ50mm-400mm, L=700km	See Figure 10.1.2		

JICA Study Team



JICA Study Team

Figure 10.1.1 Proposed Project Location from Intake to SWTP/IR



JICA Study Team

Figure 10.1.2 Proposed Project Location from SWTP/IR to OHT

10.2 SCC/ECC Issuance

10.2.1 Issuance of SCC

(1) Application for SCC

Table 10.2.1 shows principal documents/Fee which were submitted to the Khulna DOE Office at the time of applying for SCC.

Table 10.2.1 Documents/ Fee for SCC

Documents/Fee	Status	Month in 2010
1. F/S Report of the Project	Prepared by the JICA Study Team	May
2. IEE Report	IEE report was prepared and be approved by KWASA	August
3. NOCs/ Land Use Certificates	NOCs were issued by Bagerhat, & Khulna DC's offices and KCC	September
4. Application for SCC	Submitted by KWASA to DOE Khulna	September
5. Application Fee for SCC/ ECC	Allocated by KWASA and remitted to DOE	September

Note; NOC: No Objection Certificate, DC: District Commissioner, ECR: Environmental Conservation Rules 1997
Source: DOE、KWASA、JICA Study Team

1) Feasibility Study (F/S) Repot

A F/S report for the project was prepared by the JICA Study Team on May 2010 and submitted to the steering committee (SC). It was approved by the SC.

2) IEE (Initial Environmental Examination) Repot

An IEE report (Draft Final) for the project was prepared by a local consultant in the end of June 2010 which was approved by the MD KWASA on August 2010 (See Appendix 10.1). The IEE has been prepared considering the following relevant guidelines for future necessary coordination among GOB (Government of Bangladesh) and funding agencies of JICA and ADB as required for one of the necessary conditionality.

- EIA Guidelines for Industries 1997, DOE
- JBIC Guidelines for Confirmation of Environmental and Social Consideration 2002, JBIC
- Safeguard Policy Statement 2009, ADB

3) NOCs (No Objection Certificates)/ Land Use Certificate

The necessary NOCs issued for this project are summarized in **Table 10.2.2** (attached in EIA repot).

Table 10.2.2 NOCs for the Project

Issuer	NOCs	Date Issued (2010)
Bagharhat DC	Land Acquisition and Land Use Certificate for the water intake in Mollarhat	6th September
Khulna DC	Land Acquisition and Land Use Certificate for the IR and WTF in Samanto Sena	6th September
KCC Mayor	Land Acquisition and Land Use Certificate for the DR and OHT in KCC area	2nd September

Note: DC: District Commission, IR: Impounding Reservoir, WTF: Water Treatment Facility, DR: Distribution Reservoir, OHT: Over Head Tank
Source; KWASA

4) Application form for SCC

The official Application form for SCC/ECC is the form 3 attached in the Environmental Conservation Rules 1997 as shown in **Figure 10.2.1** The title of the form 3 is for ECC, but this form is utilized for the application of SCC as it is (to be changed the title from ECC to SCC). The form was prepared by KWASA attaching necessary documents and submitted to DOE Khulna on 8th September 2010.

FORM – 3

Application for Environmental Clearance Certificate
[See Rule 7(5)]

Director/Deputy Director,
Department of Environment,
Dhaka Division/Chittagong Division/Khulna Division/Rajshahi Division (Bogra).

Sir,

I do hereby apply for Environmental Clearance Certificate for my proposed industrial unit or project, or for the existing industrial unit or project, and enclose papers and furnish information as follows :

1.(a) Name of the industrial unit or project
Address of location of the industrial unit or project
(b) Address of present office
2.(a) Proposed industrial unit or project
: Expected date of starting construction
: Expected date of completion of construction
: Expected date of trial production in case of industrial unit, in other cases, date of starting operation of the project
(b) Existing industrial unit or project
: Date of starting trial production in case of industrial unit, in other cases, date of starting operation of the project
3. Name of product and quantity to be produced (daily/monthly/yearly)
4.(a) Name of raw materials and quantity required (daily/monthly/yearly)
(b) Source of raw material
5.(a) Quantity of water to be used daily
(b) Source of water

E.C.R. '97

6.(a) Name of fuel and quantity required (daily/monthly/yearly)
(b) Source of fuel
7.(a) Probable quantity of daily liquid waste
(b) Location of waste discharge
(c) Probable quantity of daily emission of gaseous substance
(d) Mode of emission of gaseous substance
8. Mouza (village) map indicating "Daag" (plot) number and "Khatiyan" (land tax account) number
9. Approval of Rajdhani Unnayan Katripakkhya/ Chittgong Development Authority/Khulna Development Authority/ Rajshahi Development Authority (if applicable)
10.(a) Design & time schedule of proposed Effluent Treatment Plant
(b) Fund allocated
(c) Area
11. Process Flow Diagram
12.(a) Location map of industrial unit or project
(b) Layout plan (with location of Effluent Treatment Plant)
13.(a) IEE/IEA report* (if applicable)
(b) Environmental Management Plan* (if applicable)
14. Feasibility Report (if applicable)

Seal

Signature of the entrepreneur
Name
Address
Phone
Date

-: Declaration :-

I do hereby declare that all information provided by me in this application are true to the best of my knowledge and no information has been concealed or distorted herein.

(Name & signature of entrepreneur)

* Each page be countersigned by the person who fills out this application form and by the entrepreneur.

Source; Environmental Conservation Rules 1997

Figure 10.2.1 Application form for SCC/ECC

The Schedule 13 attached in the Environmental Conservation Rules 1997 stipulates the application fees (Chalan) for ECC by the total investment (Industrial unit or project) cost as shown in **Table 10.2.3**. For applying the SCC/ECC for the project of which total cost is estimated at more than

Tk. 500,000,000, thus the fee required for ECC is Tk. 100,000, which was allocated and remitted by KWASA to DOE on 13th September 2010(Copy of the Fee is attached in EIA report).

Table 10.2.3 SCHEDULE 13 Fees for Environmental Clearance Certificate or Renewal

Investment (in Taka)	Fees for Environmental Clearance Certificate (in Taka)	Renewal Fee
(1)	(2)	(3)
(a) Between Tk. 100,000 and 500,000	Tk. 1,500	One-fourth of the fees in Column (2)
(b) Between Tk. 500,000 and 1000,000	Tk. 3,000	-Do-
(c) Between Tk. 1000,000 and 5000,000	Tk. 5,000	-Do-
(d) Between Tk. 5000,000 and 10000,000	Tk. 10,000	-Do-
(e) Between Tk. 10000,000 and 200,000,000	Tk. 25,000	-Do-
(f) Between Tk. 200,000,000 and 500,000,000	Tk. 50,000	-Do-
(g) Above Tk. 500,000,000	Tk. 100,000	-Do-

[1] *Schedule-13 was substituted by Notification S.R.O. No. 234-Law/2002 dated 24/08/2002 and came into force on 26/08/2002 being the date of publication in Bangladesh Gazette extraordinary issue.*

Source; The Schedule 13 attached in the Environmental Conservation Rules 1997

(2) Environmental Clearance Committee convened at DOE HQ for the SCC

All SCC application documents reviewed by the DOE Khulna were transferred to DOE HQ in Dhaka dated on 16th Sept. 2010. On 22nd Sept. 2010, an Environmental Clearance Committee was convened at DOE HQ Office for evaluating the SCC application of KWASA in which MD of KWASA made a presentation on the project and environmental and social aspects to the committee member. For the presentation the committee member asked the project framework and so on, but there was no negative comment and opinion from the committee side at all. (See Photo 1 &2).

Photo 1 Committee Member of DOE

Photo 2 IEE Presentation by MD KWASA

(3) Issuance of SCC

DOE issued SCC for the project dated on 18th October 2010 to KWASA of which No. is DoE/Clearance/5021/2010/343 with terms and conditions as follows, which can be considered general ones (terms and conditions) as follows.

The validity of the SCC is one year from the data of issuance. KWASA shall apply for renewal to DOE Khulna with a copy to DOE HQ at least 30days ahead of expiry, if any (Renewal fee: See **Table 10.2.3**).

Terms and Conditions written in SCC

1. This site clearance shall only be applicable for the said project only.
2. The project authority shall submit a comprehensive Environmental Impact Assessment (EIA) report considering the overall activity of the said project in accordance with the TOR and time schedule indicated in the Initial Environmental Examination (IEE) Report.

1. ENVIRONMENTAL BASELINE DATA

1.1 Project Data Sheet

a.	**Project location and area**
	The location of the project and area involved.
b.	**Project Concept**
	An outline of description of the concept and objectives of the project, the types of activities expected, and the development plans for achieving the objectives.
c.	**Project Components**
	Components of the project concerning the types of activities proposed to be located in the area, the number and distribution of underground and overhead tanks, other infrastructure, utilities and service requirements.
d.	**Project Activities**
	A list of the activities to be undertaken during: site clearing and construction, operation of activities and associated developments.
e.	**Project schedule**
	The phase and timing for development of the surface water treatment plant, transmission line, underground and overhead tanks in Khulna, infrastructure and other facilities required
f.	**Resources and utilities demand**
	Resources required to develop the project, such as soil and construction material and demand for utilities (water, electricity, sewerage, waste disposal and others), as well as infrastructure (road, drains, and others) to support the project.

1.2. Physical and chemical components

a.	Map and survey information
	Location map
	Cadastral map showing land plots (project and adjacent area)
	Topographic map for identifying catchment boundaries, general land use and terrain
	survey map showing contour information
	Aerial photograph
b.	**Geology and soil**
	Geological map showing geological units, fault zone, and other natural features
	Soil map and soil profile analysis. This may only be established from soil survey and geotechnical investigation (important for analysis for soil stability, cut and fill)
	Soil properties and composition
c.	**Hydrology and drainage**
	Catchment boundaries of rivers/lakes/canals which drain the project
	Hydrological characteristics of rivers in and around the project area, including flow, salinity and sediment load for varies return period
	Flood characteristics and historical records of flood events covering areas affected, height of flood and frequency
	Ground water potential and aspects of aquifer, such as recharge zones, ground water abstraction etc.
	Drainage system and drainage characteristics in the project area
	Coastal zone characteristics
d.	**Water quality and use**
	Water quality of the receiving water bodies likely to be affected by the project
	Beneficial uses of the water need to be established for rivers or any other water bodies likely to be impacted by the development. The locations of these water utilization should be identified in the map
	Sources of pollutants from existing and known future activities within the catchment of the rivers
e.	**Air quality and noise**
	Baseline data of the project site with respect to air quality and noise level
	Air pollutant and noise sources from existing and known sources

1.3. Ecological components

a. Habitats

Aquatic habitat likely to be impacted by the project
Terrestrial habitat likely to be impacted by the project

b. Species and Population

Identification of population of flora and fauna to asses their conversation status of being rare, endemic and endangered.
Identification of population of flora and fauna to asses their conversation status of being rare, endemic and endangered.
Biodiversity of the project site

1.4. Social and Economic Factors

a. Population

Population within and around the project area
Organizational structure of communities and the degree of public awareness and response to the proposed project

b. Human settlement

Size and distribution of human settlement
Community infrastructure, utilities and services available
Housing and future requirements within the impacted area
Historical/archaeological features of significance

c. Economic activities

Economic activities of population in and around the project area. Activities should include those that are dependent on resources which may be impacted.
Income dependence on economic activities impacted directly or indirectly by the project
Employment and economic returns to the population by the project

1.5. Infrastructure and utilities

a. Availability of infrastructure to support the proposed project. Attention should focus on different transportation requirements due to project increase in traffic to and from the project area.
b. Availability of utilities and services, especially water, gas and electricity supply, sewerage and waste disposal facilities to cater to the projected demand for such utilities and services

2. PREDICTION OF IMPACTS
2.1 Soil erosion and sedimentation
2.2 Floods
2.3 Water quality
2.4 Air quality
2.5 Noise
2.6 Solid, Toxic and Hazardous waste
2.7Ecology
2.8 Traffic
2.9 Socio-Economy

3. EVALUATION OF IMPACTS
The judgment of significance of impacts can be based on one or more of the following, depending on the environmental factor being evaluated. These are :
i. comparison with laws, regulation or accepted national or international standards
ii. reference to pre-set criteria such as conservation or protected status of a site, feature or species
iii. consistency with pre-set policy objectives
iv. Consultation and acceptability with the relevant decision makers, local community or the general public.

4. MITIGATION OF IMPACTS
Mitigation measures which may be considered including:
i. changing project layout, transport routes, disposal routes or locations, timing or engineering design
ii. introducing pollution controls, waste treatment, phased implementation and construction, engineering measures, monitoring, landscaping, social services or public education;
iii. compensation to restore, relocate or provision of concession for damage

SI.	ITEM	REQUIREMENT
a.	Soil erosion prevention	An outline of measures to control soil erosion and river sedimentation.
b.	Water pollution	Treatment of sewage water. The concept of centralized treatment of sewage should be the preferred option to be adopted.
c.	Air pollution	During construction: measures to minimize fugitive dust from exposed soil surface and those caused by motor vehicles. During operations: measures to minimize air pollution through selection of types of industries allowed in the area.
d.	Noise:	During construction: measures to minimize noise from traffic and construction activities. During operation: application of buffer zones to minimize noise as well as that due to traffic.
e.	Solid and hazardous waste	Management options need to be identified. The need for centralized waste collection, treatment and disposal facilities need to be given due consideration.
f.	Flood/Tidal surge	An outline of measures to minimize flooding. A diagram to show likely drainage system and flood retention sites and diversion channels, etc.
g.	Land use	The project area should be effectively zoned for different categories of activities and types of recommendation should be outlined. A diagram showing land use distribution for the project activities and buffer zones.
h.	Habitat and species	Measures to protect or conserve habitat and species with recommended buffer zones. A diagram showing conservation.
i.	Socio-economic issues	Outline of steps or measures to be taken to resolve social conflicts and related socio-economic issues.
j.	Utilities and services	A diagram to show additional utilities and services required to satisfy projected demands of the project area.
k.	Road and traffic	Road access and improvements required to meet projected traffic densities.

5. ENVIRONMENTAL MANAGEMENT PLAN
The responsibilities and actions required of the project initiator or implementing body should be identified in the EMP. Some of those responsibilities and actions include: allocation of institutional responsibilities for planning and management of environmental requirements, allocate responsibility to execute mitigation action, implement a programme of monitoring to check the effectiveness of mitigation measures, and if necessary, taking additional measures to correct or overcome the impact in question, in-house monitoring capacity building and allocation of budget.

The EMP should recognize and include the following:
i) Management of soil erosion, landslides and siltation during site clearance and earth work
ii) Management of runoff
iii) Regulation of the types of activities allowed in the project area
iv) Management of liquid, solid and gaseous wastes generated from the project area
v) Environmental monitoring requirements
vi) Responsibilities and role of the project proponent for protection of environment

The program for monitoring should generally identify:
i. the type of monitoring required
ii. the location of monitoring
iii. the types of measures to be undertaken (e.g. dissolve oxygen, if fisheries is important in a river)

6. Without obtaining approval of EIA report by the Department of Environment, the project authority shall not be able to start the physical activity of the project and also not be able to open L/C in favour of importable machineries.
7. Rehabilitation of human settlement or compensation for any sort of activity which will incur damage or loss of public or private property shall be addressed as per Government of Bangladesh rules and regulations.
8. Appropriate permission would be required to obtain from the forest department in favour of cutting/felling of any plant/tree/sapling forested by any individual or government before doing such type of activity.
9. The project authority shall submit the EIA to the divisional office of DOE in Khulna along with a filled-in application for Environmental Clearance in prescribed form, the feasibility report, the applicable fee in a treasury Chalan, the no objection certificates (NOCs) from the local authorities, NOC from forest department (if it is required in case of cutting any forested plant/trees-private or public) and NOC from other relevant agencies for operational activity of the project.
10. A soft copy of the image data as well as the maps to be generated from the image shall be submitted to DOE Head Office along with the EIA.
11. This clearance is valid for one year from the date of issuance and the project authority shall apply for renewal to the Divisional Office of DOE in Khulna with a copy to Head Office in Dhaka at least 30 days ahead of expiry.

Source: SCC for Khulna Water Supply Improvement Project, 18th October 2010 DOE

10.2.2 Issuance of ECC

(1) Application for ECC

Table 10.2.4 shows principal documents which were submitted to the Khulna DOE Office at the time of applying for ECC most of which are the same document for SCC excluding EIA report and ECC appreciation form.

Table 10.2.4 Documents for ECC

Documents	Status	Month in 2010
1. F/S Report of the Project	Prepared by the JICA Study Team	May
2. EIA Report	EIA report was prepared and be approved by KWASA	November
3. NOCs/ Land Use Certificates	NOCs were issued by Bagerhat, & Khulna DC's offices and KCC	September
4. Application for ECC	Submitted by KWASA to DOE Khulna	November
5. Receipt Copy for Application	Application fee for SCC/ECC was remitted to DOE by KAWASA	September

Note; NOC: No Objection Certificate, DC: District Commissioner, ECR: Environmental Conservation Rules 1997
Source: DOE、KWASA、JICA Study Team

1) EIA (Environmental Impact Assessment) Repot

An EIA report (Draft Final) for the project was prepared by a local consultant in November 2010 which was approved by MD KWASA on November 2010 (See **Appendix 10.2**). The EIA has been prepared considering the followings

- EIA Guidelines for Industries 1997, DOE
- JBIC Guidelines for Confirmation of Environmental and Social Consideration 2002, JBIC
- Safeguard Policy Statement 2009, ADB
- Scoping Result of IEE
- Terms and Conditions written in SCC

2) Application form for ECC

The official Application form for ECC is the form 3 attached in the Environmental Conservation Rules 1997 as shown in **Figure 10.2.1**. The form was prepared by KWASA attaching necessary documents and submitted to DOE Khulna on 4th November 2010.

(2) Environmental Clearance Committee convened at DOE HQ for the SCC

All ECC application documents reviewed by the DOE Khulna were transferred to DOE HQ in Dhaka dated on 7th November 2010. On 24th November 2010, an Environmental Clearance Committee is scheduled to be convened at DOE HQ Office for evaluating the ECC application of KWASA in which a representative of KWASA will make a presentation on the project and environmental and social aspects to the committee member.

(3) Issuance of ECC

In accordance with Environmental Conservation Rules, DOE shall issue the ECC for the project within 30 working days (See **Table 2.2.8**), in which terms and conditions will generally be included for the issuance. And, on 1st February 2010DOE issued ECC for the project.

The validity of the ECC is one year from the data of issuance. KWASA shall apply for renewal to DOE Khulna with a copy to DOE HQ at least 30days ahead of expiry, if any (Renewal fee: See **Table 10.2.4**).

10.3 LAP & RAP

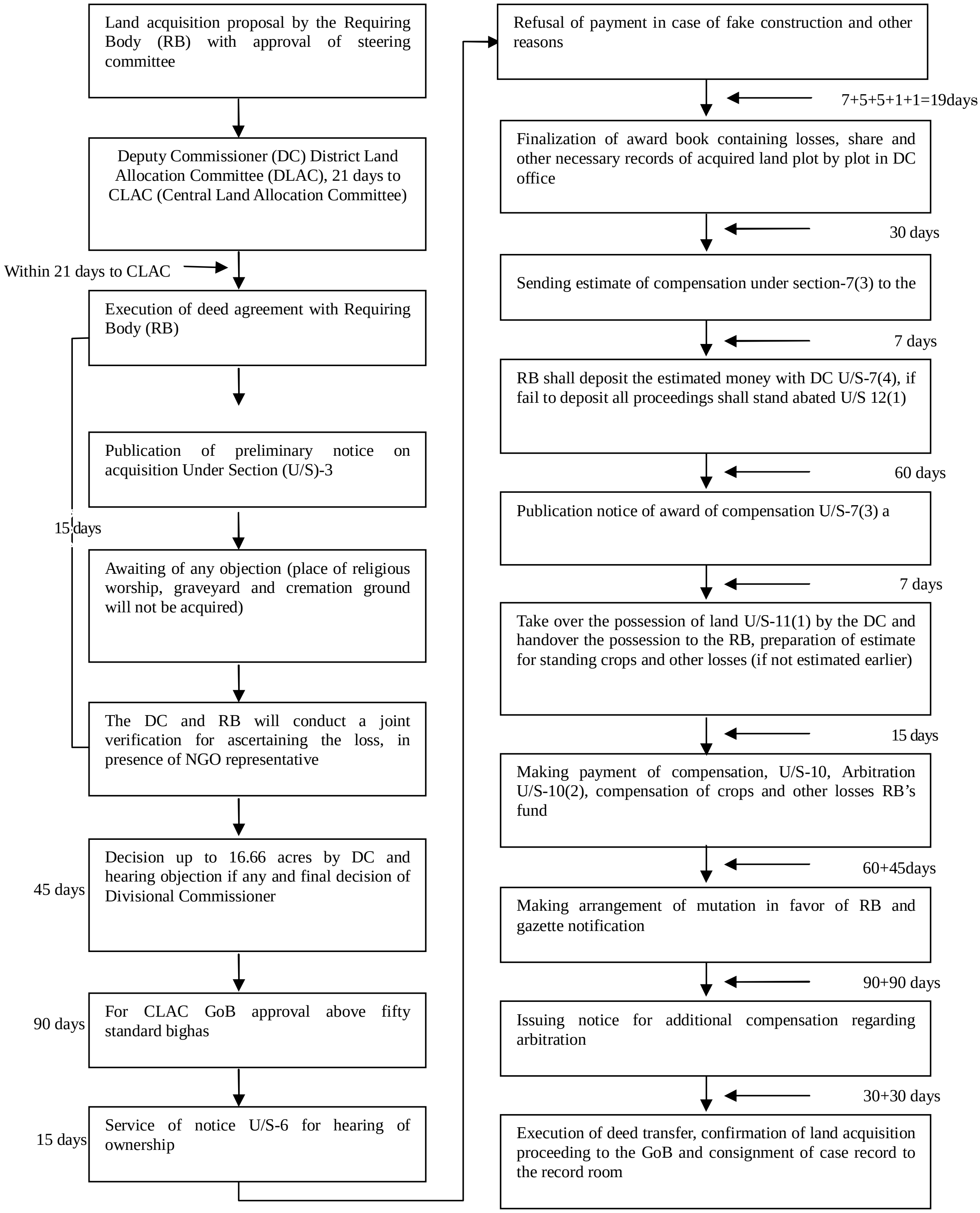
With regard to necessary land acquisitions for the project, based on rules in Bangladesh related to land acquisition and its companion such as "Acquisition and Requisition of Immovable Property Ordinance 1982" as well as from point of view of environmental and social consideration, Land Acquisition Plan (LAP) & Resettlement Action Plan (RAP) shall be elaborated for proceeding suitable official procedures in Bangladesh and to fill relevant environmental guidelines of DOE, JICA and ADB on a parallel with the EIA study.

For this project, lands for the following some of the project components need to be acquired and compensated by KWASA accordingly. Exact locations of the lands to be acquired are shown in **Table 10.4.1** and **Table 10.4.2**.

- Water intake facility
- SWTP
- Impounding/ Distribution Reservoirs
- Overhead Tanks

In November 2010, a LAP/RAP report (Draft Final) for the project was prepared by a local consultant, which was approved by the MD KWASA on 5th November 2010 (See **Appendix 10.3**). The EIA has made reference to LAP&RAP report as mutually complementary form.

Figure 10.2.2 shows a summary of practical flow chart for land acquisition and compensation to be followed by KWASA.



Source: LAP/RAP Report, KWASA

Figure 10.2.2 Practical Flow Chart of Land Acquisition and Compensation

10.4 Specific Environmental and Social Aspects in the Projects Sites

10.4.1 Social Aspects

(1) Necessary Land Acquisition

Lands for the project components to be acquired are as summarized in **Table 10.4.1** and **Table 10.4.2**.

Table 10.4.1 Summary of Project Components and Land Issue (1) from WI to SWTP/IR

Facility & Location		Land Type	Ownership	Land Issue	GPS
1. WI	Mollarhat	Paddy + River bank	Private Land	To be acquired	$22^0$55'43"N $89^0$48'35"E
2. RWT P	Mollarhat to Samanto Sena	National Highway	RHD	Not necessary for Land Acquisition	-
		Local Government Roads	LGED		
3.SWTP **4.IR**	Samanto Sena	Paddy + Fish Pond	Private & Govt. Land	To be acquired	$22^0$46'49"N $89^0$38'09"E

Note; 1. WI: Water Intake Facility 2. RWTP: Raw water Transition Pipe 3. SWTP: Surface Water Treatment Plant
4. IR: Impounding Reservoir 5. RHD: Road & Highway Dept. 6. LGDE: Local Government Engineering Dept.

JICA Study Team

Table 10.4.2 Summary of Project Components and Land Issue (2) of DR and OHT in KCC

Facility & Location			Land Type	Ownership	Land Issue	GPS
DR & OHT	1	Deana West Para Reservoir and Over Head Tank	Paddy+ Fish Land (Low Land)	Private Land	To be acquired	$22^0$52'05"N $89^0$30'45"E
	2	Ward # 16 Councilor office Reservoir and Over Head Tank	Plain Land	Govt. Land	To be acquired	$22^0$49'51"N $89^0$32'08"E
	3	Sonadanga Moha Sarak Reservoir and Over Head Tank (Women Stadium)	Paddy+ Fish Land (Low Land)	Private Land	To be acquired	$22^0$49'23"N $89^0$32'24"E
	4	Beside of 7 No. Wrd Councilor Office Reservoir and Over Head Tank	Marshy Land	Private Land	To be acquired	$22^0$51'48"N $89^0$32'01"E
	5	Khalishpur Chorerhat River Ghat Reservoir and Over Head Tank	Plain Land	Govt. Land	To be acquired	$22^0$51'02"N $89^0$33'18"E
OHT	1	Rab Sarani Over Head Tank (Word # 2)	Cultivable Land Plain Land	Private Land	To be acquired	$22^0$54'16"N $89^0$30'40"E
	2	Mujgunni Over Head Tank (Word # 9)	Plain Land	Govt. Land	To be acquired	$22^0$50'53"N $89^0$31'56"E
	3	Ferry Ghat Power House More (KCC Garage) Over Head Tank	Plain Land	Govt. Land	To be acquired	$22^0$49'05"N $89^0$33'30"E
	4	Andir Pukur Over Head Tank	Plain Land	Private Land	To be acquired	$22^0$48'11"N $89^0$32'54"E
	5	South side of Word # 31office Labonchura Over Head Tank	Paddy Land (Low Land)	Private Land	To be acquired	$22^0$47'07"N $89^0$34'36"E
	6	DPHE Rupsha Over Head Tank	Plain Land	Govt. Land	To be acquired	$22^0$43'13"N $89^0$34'33"E

Note: DR: Distribution Reservoir OHT: Over Head Tank
JICA Study Team

On the one hand, however, Raw Water Transmission Pipes (RWTP) and Clear Water Transmission Pipes (CWTP) are planed to be constructed under the existing roads. Therefore, land acquisitions for RWTP and CWTP are not requited at all.

(2) Local People Affected by the Land Acquisitions

According to the EIA and LAP/RAP reports as well as the project design prepared by the JICA study team, **Table 10.4.3 - Table 10.4.6** summarize local people who will immediately be affected by land acquisitions for the project.

1) Mollarhat for Water Intake Facility

Table 10.4.3 shows the land owners and land areas to be acquired for the water intake facility in Mollarhat. Total 30 private owners have been identified for the necessary land acquisition for the water intake facility.

Table 10.4.3 Land Owners List in Garfa Mouza for Intake Point

Sl. No.	Dag No.	Land Owners Name	Land Owners Number	Land Area (Acre)
1	658	*Omitted*	1,2	0.001
2	663	*Omitted*	3,4, 5, 6	0.123
3	664	*Omitted*	3	0.552
4	665	*Omitted*	7	0.436
5	668	*Omitted*	8, 9, 10	0.872
6	669	*Omitted*	8, 9, 10	0.025
7	672	*Omitted*	11, 12, 13, 14	0.008
8	673	*Omitted*	15	0.132
9	678	*Omitted*	16	0.150
10	679	*Omitted*	11, 12, 13, 17	0.033
11	680	*Omitted*	11, 17	0.051
12	681	*Omitted*	18	0.100
13	688	*Omitted*	19,20,21,22, 23, 24, 25	0.001
14	689	*Omitted*	25, 26, 27, 28, 29, 30	0.038
Total			30	2.522

JICA Study Team

2) Samanto Sena for SWTP and Impounding Reservoir

Table 10.4.4 and **Table 10.4.5** show the land owners and land areas to be acquired for the SWTP and Impounding Reservoir in Samanto Senta. Total 72 private owners and one public owner (DC of Khulna) have been identified for the necessary land acquisition for the facilities.

Table 10.4.4 Land Owners List in Patharghata Mouza for SWTP & IR

Sl. No.	Mouza Name	Dag (Land Unit) No.	Name of Owners	Owners Number	Name of Co-owners	Co-Owners Number	Area to be aquired (Acer)
1	Patharghata	219	*Omitted*	1	*Omitted*	Co1	1.0537
2	Patharghata	170	*Omitted*	2	-	-	0.8035
3	Patharghata	162	*Omitted*		-	-	0.9164
4	Patharghata	163	*Omitted*		-	-	1.6104
5	Patharghata	164	*Omitted*		-	-	0.5303
6	Patharghata	166	*Omitted*		-	-	0.9109
7	Patharghata	168	*Omitted*		-	-	1.4519
8	Patharghata	169	*Omitted*		-	-	0.4803
9	Patharghata	174	*Omitted*		-	-	0.3976
10	Patharghata	218	*Omitted*		-	-	1.0330
11	Patharghata	220	*Omitted*		-	-	0.7287
12	Patharghata	221	*Omitted*		-	-	0.2568
13	Patharghata	222	*Omitted*		-	-	0.2956
14	Patharghata	223	*Omitted*		-	-	0.7162
15	Patharghata	224	*Omitted*		-	-	1.5289
16	Patharghata	225	*Omitted*		*Omitted*	10	0.9550
17	Patharghata	226	*Omitted*		*Omitted*	10, Co2	1.0340
18	Patharghata	227	*Omitted*		*Omitted*	10, Co2	0.258
19	Patharghata	228	*Omitted*		*Omitted*	10, Co2	0.222
20	Patharghata	230	*Omitted*		-	-	0.125
21	Patharghata	234	*Omitted*		-	-	0.62
22	Patharghata	1502	*Omitted*		-	-	0.6
23	Patharghata	1503	*Omitted*		-	-	0.932
24	Patharghata	1504	*Omitted*		-	-	0.2066
25	Patharghata	1505	*Omitted*		-	-	0.744
26	Patharghata	1506	*Omitted*		-	-	1.3886
27	Patharghata	1509	*Omitted*		-	-	1.1869
28	Patharghata	1516	*Omitted*		-	-	0.478
29	Patharghata	1517	*Omitted*		-	-	0.81
30	Patharghata	1518	*Omitted*		-	-	1.2241
31	Patharghata	1519	*Omitted*		*Omitted*	Co3,Co4	0.6639
32	Patharghata	1520	*Omitted*		-	-	0.6098
33	Patharghata	1521	*Omitted*		-	-	0.4668
34	Patharghata	1522	*Omitted*		-	-	0.6335
35	Patharghata	1523	*Omitted*		-	-	0.2935
36	Patharghata	1524	*Omitted*		-	-	0.606
37	Patharghata	1525	*Omitted*		-	-	0.2829
38	Patharghata	1526	*Omitted*		-	-	1.6706
39	Patharghata	1527	*Omitted*		-	-	0.4729
40	Patharghata	1528	*Omitted*		-	-	0.376
41	Patharghata	1539	*Omitted*		-	-	0.4
42	Patharghata	1788	*Omitted*		-	-	0.1664
43	Patharghata	1789	*Omitted*		-	-	0.0803
44	Patharghata	1802	*Omitted*		-	-	0.619
45	Patharghata	161	*Omitted*		*Omitted*	Co5	0.2
46	Patharghata	171	*Omitted*		*Omitted*	Co6	0.8420
47	Patharghata	214	*Omitted*	3	-	-	1.0944
48	Patharghata	159	*Omitted*	4	-	-	0.3000
49	Patharghata	1531	*Omitted*	5	-	-	1.0744
50	Patharghata	1507	*Omitted*	6	-	-	1.0250
51	Patharghata	155	*Omitted*	7	*Omitted*	Co7	0.29
52	Patharghata	216	*Omitted*	8	*Omitted*	Co8	1.0688
53	Patharghata	233	*Omitted*	9	-	-	0.88
54	Patharghata	179	*Omitted*		*Omitted*	15	0.1446
55	Patharghata	199	*Omitted*		*Omitted*	15	1.3318
56	Patharghata	197	*Omitted*		*Omitted*	Co9,Co10,Co11 & 15	0.1
57	Patharghata	1529	*Omitted*	10	-	-	1.8928
58	Patharghata	1530	*Omitted*		-	-	0.2387
59	Patharghata	1532	*Omitted*		-	-	0.4855
60	Patharghata	1533	*Omitted*		-	-	0.312
61	Patharghata	1554	*Omitted*		-	-	1.35
62	Patharghata	1555	*Omitted*		-	-	0.48
63	Patharghata	160	*Omitted*		*Omitted*	2, Co5	0.115
64	Patharghata	231	*Omitted*	11	*Omitted*	Co12	0.65
65	Patharghata	231	*Omitted*		-	-	0.6147
66	Patharghata	181	*Omitted*		*Omitted*	Co10,Co12,Co13 Co14	1.03
67	Patharghata	1511	*Omitted*	12	-	-	1.28
68	Patharghata	1816	*Omitted*		-	-	0.66
69	Patharghata	172	*Omitted*	13	-	-	0.0463
70	Patharghata	173	*Omitted*	14	-	-	0.2203
71	Patharghata	217	*Omitted*	15	-	-	0.8798
72	Patharghata	1818	*Omitted*		-	-	1.4049
73	Patharghata	217	*Omitted*		-	-	0.8798
74	Patharghata	1510	*Omitted*		-	-	1.1496
75	Patharghata	232	*Omitted*	16	*Omitted*	Co15	0.4924
76	Patharghata	1535	*Omitted*	17	-	-	0.32
77	Patharghata	215	*Omitted*	18	-	-	0.6938
78	Patharghata	167	*Omitted*		-	-	0.2562
79	Patharghata	631	*Omitted*		*Omitted*	Co16	0.185
80	Patharghata	177	*Omitted*	19	*Omitted*	Co17,Co18,Co19,Co20	1.2983
81	Patharghata	178	*Omitted*	20	*Omitted*	Co21,Co22	0.3157
82	Patharghata	200	*Omitted*	21	*Omitted*	4	0.375
83	Patharghata	156	*Omitted*		*Omitted*	4	0.365
84	Patharghata	158	*Omitted*		*Omitted*	4	0.31
85	Patharghata	202	*Omitted*	22	-	-	0.203
86	Patharghata	152	*Omitted*	23	*Omitted*	22	0.22
87	Patharghata	175	*Omitted*		-	-	0.6749
88	Patharghata	203	*Omitted*		*Omitted*	22	0.142
89	Patharghata	204	*Omitted*		*Omitted*	22	0.26
90	Patharghata	207	*Omitted*		*Omitted*	22, 16	0.75
91	Patharghata	155	*Omitted*		*Omitted*	16	0.29
92	Patharghata	176	*Omitted*		-	-	0.83
93	Patharghata	208	*Omitted*	24	*Omitted*	Co23,Co24, 5, Co25	0.3838
94	Patharghata	213	*Omitted*	25	*Omitted*	Co26,Co27,Co28,Co15,Co29,Co30	0.5096
95	Patharghata	1501	*Omitted*	26	*Omitted*	Co31,Co32	0.2
96	Patharghata	1515	*Omitted*	27	-	-	0.37
97	Patharghata	209	Bangladesh Govt. Land*	28	-	-	0.2100
98	Patharghata	180	Bangladesh Govt. Land*		-	-	0.5050
99	Patharghata	198	Bangladesh Govt. Land*		-	-	0.5519
100	Patharghata	210	Bangladesh Govt. Land*		-	-	0.9145
101	Patharghata	211	Bangladesh Govt. Land*		-	-	0.9665
102	Patharghata	212	Bangladesh Govt. Land*		-	-	0.0813
103	Patharghata	182	Bangladesh Govt. Land*		-	-	0.77
104	Patharghata	1513	Bangladesh Govt. Land*		-	-	0.72
105	Patharghata	151	*Omitted*	29	*Omitted*	Co33,Co34,Co35,Co36,Co37	0.05
106	Patharghata	195	*Omitted*	30	*Omitted*	C10, C11	0.065
107	Patharghata	1536	*Omitted*	31	*Omitted*	16, Co38	0.3
108	Patharghata	1537	*Omitted*	32	*Omitted*	Co39	0.11
109	Patharghata	206	*Omitted*	33	*Omitted*	Co40	0.32
Sub Total of Individual Owner				33	Sub Total of Co-Owner	40	
Ground Total of Owners						73	
						Total in acre =	67.89
						Total in hectare =	27.16

*Note: Bangladdesh Govt. Land means this land is owned by DC of Khulna

JICA Study Team

Table 10.4.5 Land Owners List in Tilok Mouza for SWTP & IR

Sl. No.	Mouza Name	Dag (Land Unit) No.	Name of Owners	Owners Number	Name of Co-owners	Co-Owners Number	Area to be aquired (Acer)
110	Tilok	3774	*Omitted*	**2**	-	-	0.125
111	Tilok	3775	*Omitted*		-	-	0.17
112	Tilok	3776	*Omitted*		-	-	0.11
113	Tilok	3777	*Omitted*		-	-	0.115
114	Tilok	3778	*Omitted*		-	-	0.49
115	Tilok	3783	*Omitted*		-	-	0.18
116	Tilok	3784	*Omitted*		-	-	0.15
						Total in acre =	**1.34**
						Total in hectare =	**0.54**

JICA Study Team

3) KCC area for Over Head Tanks and Distribution Reservoirs

Table 10.4.6 shows the land owners and land areas to be acquired for the Overhead Tanks (OHT) and Distribution Reservoirs in KCC area. Total five (5) private owners and three (3) public owners (KCC, BIWTA and DPHE) have been identified for the necessary land acquisition for the facilities.

Table 10.4.6 Land details of proposed Over Head Tank (OHT) and Distribution Reservoir

No.	Facility Name	District	Thana	Mouza	SA#	Area (Acre)	Proposed Area (Acre)	Land Owners Name	Land Owners Number
1	Deana West Para Reservoir and Over Head Tank	Khulna	Doulatpur	Deyana	1386	0.3	1.7	*Omitted*	1
					1387	0.3			
					1254	0.23			
					1255	0.12			
					1256	0.14			
					Total	1.09			
2	Ward # 16 Councilor office Reservoir and Over Head Tank	Khulna	Sonadanga	Choto Boira	1711	1.02	1.7	KCC	2
					1712	0.67			
					Total	1.69			
3	Sonadanga Moha Sarak Reservoir and Over Head Tank (Women Stadium)	Khulna	Sonadanga	Choto Boira	2157	0.98	2.2	*Omitted*	3
					2155	0.79			
					Total	1.78			
4	Beside of 7 No. Ward Councilor Office Reservoir and Over Head Tank	Khulna	Khalishpur	Goalpara	261	0.17	1.7	KCC	2
					262	0.33			
					263	0.59			
					Total	1.09			
5	Khalishpur Chorerhat River Ghat Reservoir and Over Head Tank	Khulna	Khalishpur	Goalpara	3284	0.1	2.2	BIWTA	4
					3286	0.27			
					3287	0.17			
					3283	0.31			
					3285	0.19			
					3288	0.1			
					3227	0.77			
					3355	0.22			
					Total	2.13			
6	Rab Sarani Over Head Tank (Word # 2)	Khulna	Khan Jahan Ali	MirerDanga	140	0.4	0.33	*Omitted*	5
					141				
					Total	0.4			
7	Mujgunni Over Head Tank (Word # 9)	Khulna	Khlishpur	Boira	1051	0.63	0.33	KCC	2
					Total	0.63			
8	Ferry Ghat Power House More (KCC Garage) Over Head Tank	Khulna	Khulna Sadar	Baniakhamar	2405	0.83	0.33	KCC	2
					Total	0.83			
9	Andir Pukur Over Head Tank	Khulna	Khulna Sadar	Baniakhamar	5659	0.24	0.43	*Omitted*	6
					5658	0.14			
					5657	0.1			
					Total	0.48			
10	South side of Word # 31office Labonchura Over Head Tank	Khulna	Khulna Sadar	Labanchora	139	7.92	0.43	*Omitted*	7
					Total	7.92			
11	DPHE Rupsha Over Head Tank	Khulna	Khulna Sadar	Tutpara	1160	1.49	0.43	DPHE	8
					Total	1.49			
Total Proposed land for Over Head Tank (OHT) and Underground Reservoir							**11.78**		**8**

JICA Study Team

(3) Other Social Environment in the Project Sites

Figure 10.4.1 and **Figure 10.4.2** show location maps indicating Physical Infrastructures (such as High ways, Roads and others) and Socio Economic Infrastructures (such as Rural Markets, Upazila Health Complexes, Family Welfare Centres, Community Clinics, Schools, Mosques, Temples and others) in Upazila Mollarhat and Upazila Rupsha respectively, where the water intake facility, raw water transmission pipes, SWTP, Impounding Reservoir, clear water transmission pipe are planned to be constructed.

Figure 10.4.3 shows archeological sites in Bangladesh. In addition, several historical sites have been identified in KCC as follows.

- The Khulna divisional Archaeological Museum
- Bir Bangali sculpture (Marks of War of Liberation Sculpture)
- More on five monuments and three mass graves of the martyrs of liberation war

Based on the review and basic recognitions of socially and culturally important sites, perambulatory surveys were conducted by the JICA study team and the EIA study on and around the project sites, and the existing roads under which Raw & Clear Water Transmission Pipes are proposed to be constructed. **Table 10.4.7** show survey locations surveyed in and around the proposed project components (See **Table 10.4.1** and **Table 10.4.2** the project locations surveyed).

Table 10.4.7 Survey Locations from Mollarhat Water Intake Point to Rupsha River

No.		Survey Location	GPS	
1	Mollarhat to Rupsha River	Water Intake – Mollarhat, Bagarhat	22^{0}55’43”N	89^{0}48’35”E
2		Bridge- Joydihi New bazaar, Mollarhat, Bagarhat	22^{0}53’33”N	89^{0}46’35”E
3		Crossing Semonto Sena Mor	22^{0}47’38”N	89^{0}37’44”E
4		SWTP and Reservoir	22^{0}46’49”N	89^{0}38’09”E
5		Pipe Jacking Shaft Area (East Side)	22^{0}48’11”N	89^{0}35’06”E
6		Left-bank of Rupsha River (East Side)	22^{0}48’11”N	89^{0}25’05”E
7		Pipe Jacking Shaft Area (West side)	22^{0}48’09”N	89^{0}34’53”E
8		River Ghat (Near At Passengers Shade) (Right-bank of Rupsha River)	22^{0}48’07”N	89^{0}34’52”E
9	KCC	Railway Crossing (Khaslispur)	22^{0}50’32”N	89^{0}32’32”E
10		Road Crossing (Boikali Cenema Hall)	22^{0}50’31”N	89^{0}32’21”E
11		Road Crossing (Deana to main road)	22^{0}52’24”N	89^{0}31’24”E

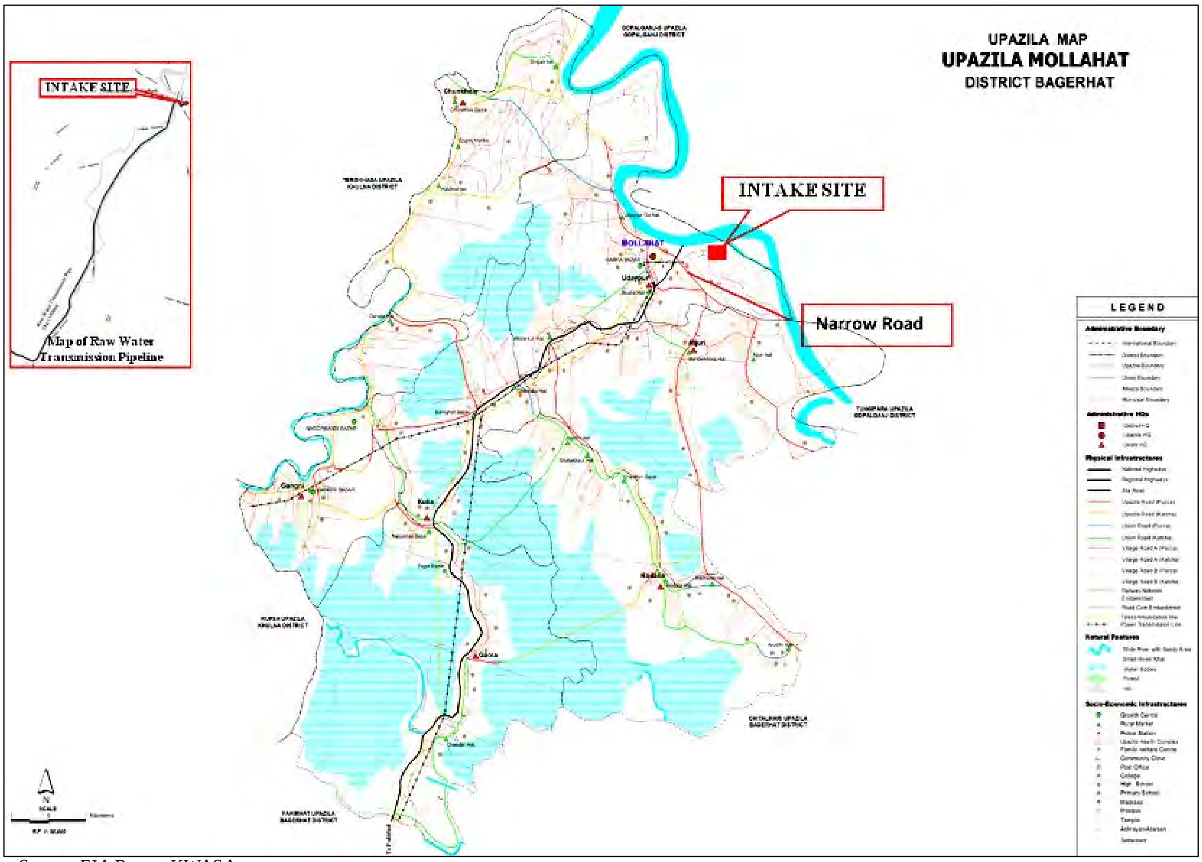
JICA Study Team

Table 10.4.8 River Crossing with Road from Mollahat to Rupsha River

Facility	From Mollahat to Fakirhat Crossing	From Fakirhat Crossing to Rupsha River
Box Culvert	4	**23**
Bridge (for irrigation cannel and stream)	**14**	**3**

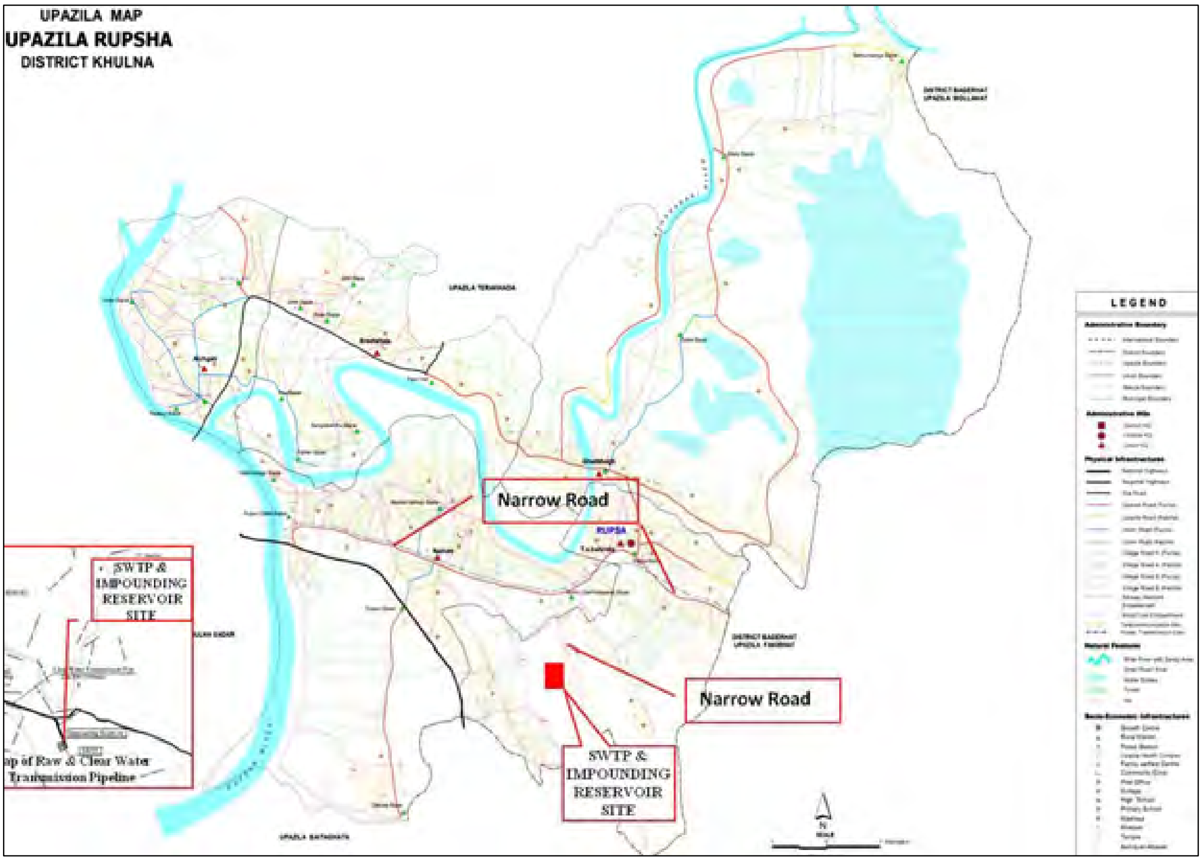
Source; JICA Study Team, EIA Study

As a result of the surveys, illegal settlement, socially and culturally important sites in and around the project sites and the existing roads are not identified at all. However, some minor points of river, railway road crossings and narrow road sections have been identified by the surveys as shown in **Table 10.4.7**. & **10.4.8** and **Figure 10.4.1** and **10.4.2**.



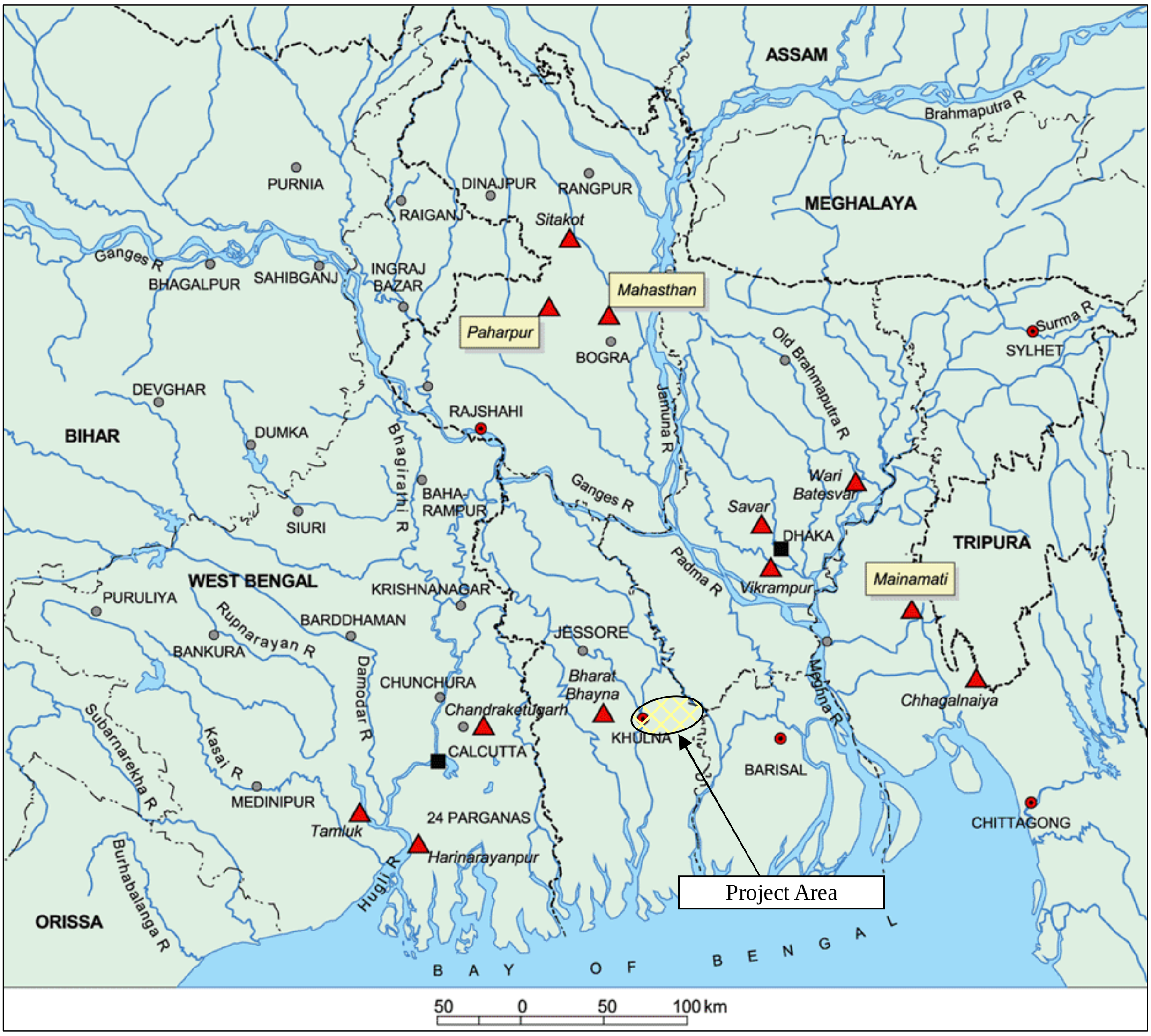
Source; EIA Report KWASA

Figure 10.4.1 Infrastructure Map of Upazila Mollarhat



Source; EIA Report KWASA

Figure 10.4.2 Infrastructure Map of Upazila Rupsha



Source; EIA Report KWASA

Figure 10.4.3 Archeological Sites in Bangladesh and Project Area

10.4.2 Physical Environmental Aspects

(1) Protected Areas and Ecosystem

The Khulna division is prominent to the world for the largest mangroves forest called "Sundarban" is defined as an ecologically critical area (ECA) by the Ministry of Environment and Forest.

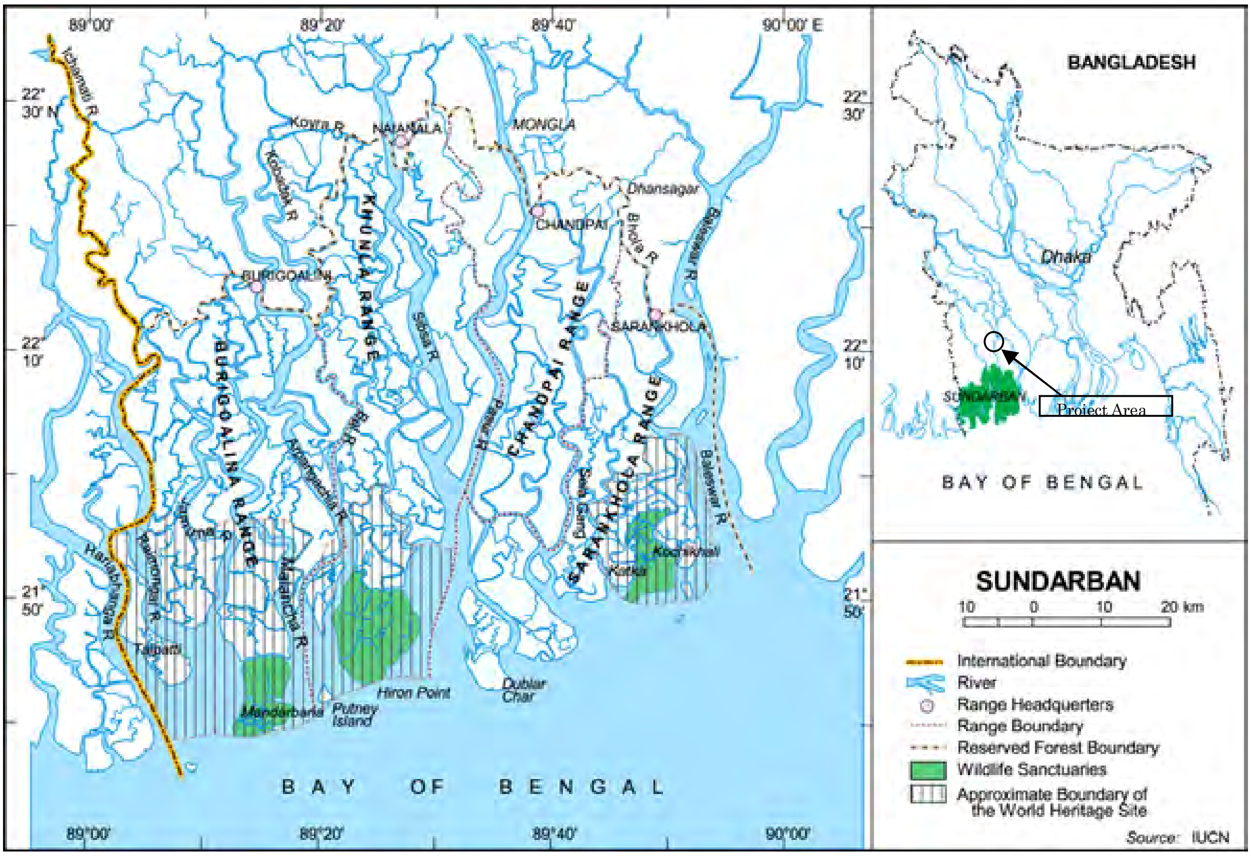
Sundarban is located in the south west corner of Bangladesh, where is home to 80% of reptiles, 40% of mammals spices of Bangladesh. Globally 35 mangrove plant species have been spotted, 14 of which are found in Sundarban. UNESCO designated Sundarban as a World Heritage site in 1997 (Source; Bangladesh Parhatan Corporation). Area of Sudarban is shown in Table 10.4.9.

Table 10.4.9 Sundarban

Sundarban	Area (km²)
Total Area	5,772.85
Forest	4,016.85
River, Canals & Channels	1,756.00

Source: Bangladesh Parhatan Corporation

The Government of Bangladesh has kept the Sundarban area as a wildlife sanctuary and has provided protection accordingly as shown in **Figure 10.4.4**.



Source; IUCN

Figure 10.4.4 Sundarban Area Map

Figure 10.4.5 shows locations of the project area in a satellite image map. It is evident that the project activities be out of the Sundarban, namely approximately 85 km from the Intake Facility in Mollarhat and 65km from KCC area to the north edge of the reserved forest boundary of Sundraban. Therefore, impact on Sundarban is not expected by the project at all.

.

Base Map; Google Earth

Figure 10.4.5 Sundarban and Project Area

(2) Fauna and Flora

The habitats of the study area sustain wildlife as well as plant communities. But many of these remain unrecognized. Verities of plant species and wild animals have been identified and recorded during the IEE and EIA study for the project.

1) Fauna

According to the 1985 Kazi Zakir Hossain and Shorab Hossain studies, there are twelve (12) extinct species in Bangladesh. The extinct spicies include Great One – horned Rhinoceros (R. unicornis), Lesser One – horned Rhinoceros (r. sondasicus), Asiatic Two – horned Rhinocerus (Didermoceros sumatrensis), Nilgai(Bos gaurus), Bantong (Bos javnicus), Swamp Dear (Carvus duvauceli), Hog Dear (Axis porcinus), Wolf (Canis lupustris), Pink Head Duck (Rhodonessa caryophyllacea), and Marsh Crocodile (Crocodylus palustris).

The endangered and threatened terrestrial species are Marbled Cat (Felis Marmorator), Golden Cat (Felis Temmuncki), Common Langur (Presbytes entallus), Hisped Hare, Serow, Asiatic Elephant, Comb Duck (Sarkidiornis melantos), Pea Fowl, Wood Duck, Greater Adjutant (Leptoptilos dubius), Garial (Garialis Gangeticus), Bengal Florican, and Bostormi Turtle (Trionix nigricarns). In addition, there are 20 mammals, 19 reptiles and 20 avifaunas in Bangladesh are either threatened or endangered. (Source: Kazi Zakir Hussain and Shorab Hussain (1985))

In the study area no endangered species is found as studied from different sources. The IUCN study has not identified any endangered species in the study area.

In addition, a number of terrestrial species have been identified during the brief and rapid assessment by IEE/EIA studies in the project area as shown in **Table 10.4.10** to **Table 10.4.13**. Those are commonly seen in the project area.

Table 10.4.10 Terrestrial Fauna Reptiles

No.	Local Name	Scientific Name	Status
1.	Anjila	*Mabuya carinata*	Common
2.	Dhura Shap	*Amphiesma stolata*	Common
3.	Matia Shap	*Atretium schistosum*	Common
4.	Tiktiki	*Hemidactylus brooke*	Common
5.	Daraish Shap	*Ptyas mucosus*	Fairly Common
6.	Gui Shap	*Varanus nubulosus*	Fairly Common

Note: Common = seen commonly

Source: Field Investigation by IEE/EIA team

Table 10.4.11 Terrestrial Fauna Mammals

No.	Local Name	Scientific Name	Status
1.	Babur	*Pteropus giganteus*	Common
2.	Idur	*Mus musculus*	Common
3.	Shial	*Vulpes bengalensis*	Common
4.	Chika	*Pipistrellus. Sp*	Common
5.	Beji	*Herpestes*	Fairly Common

Note: Common = seen commonly

Source: Field Investigation by IEE/EIA team

Table 10.4.12 Terrestrial Fauna Birds

No.	Local Name	Scientific Name	Status
1.	Choroi	*Passer domesticus*	Common
2.	Doyel	*Opsychus sularis*	Common
3.	Kak	*Carvus splendens*	Common
4.	Ghugho	*Streptapelia Orientalis*	Common
5.	Shalik	*Stuma contra*	Common
6.	Tuntuni	*Orthotomus sutorius*	Common
7.	Machranga	*Helcyon smyrrensis*	Fairly Common
8.	Haludpakhi	*Oriolus xanthornus*	Fairly Common
9.	Katthokra	*Picus canus*	Fairly Common
10.	Pecha	*Tyto alba*	Not so common (not rare species)

Note: Common = seen commonly

Source: Field Investigation by IEE/EIA team

Table 10.4.13 Terrestrial Fish

No.	Local Name	Scientific Name	Status
1.	Rui	*Labeo rohita*	Common
2.	Katal	*Catla catla*	Common
3.	Thai Puti	-	Common
4.	MInar Cup	*Cyprinus carpio*	Common
5.	Silver Cup	-	Common
6.	Shrimp	*Macrobrachium rosenbergii*	Common

Note: Common = seen commonly

Source: Field Investigation by IEE/EIA team

2) Flora

a. Wetland Flora

Wetland flora plays a vital role in nature. It grows mainly in aquatic habitats viz. beels, ponds, canals ditches or low lying cultivated fields. From different wetland and aquatic habitat, a number of species have been identified as shown in **Table 10.4.14**.

Table 10.4.14 Aquatic flora seen in the Project Area

No.	Local Name	Scientific Name	Status
1.	Dholkalmi	*Ipomoea fistulosa*	Common
2.	Sheola	*Biysca octandra*	Common
3.	Shapla	*Nymphaea nouchali Burm,f*	Common
4.	Kachuripana	*Lemna Spp*	Fairly Common
5.	Kalmi	*Ipomoea albo.L*	Fairly Common

Note: Common = seen commonly

Source: Field Investigation by IEE/EIA team

b. Terrestrial Flora

In the study area, terrestrial floras are present mainly in the homestead regions, roadsides, village groves, playgrounds, upland/high cultivated lands. Human being as well as wildlife uses these floral species for different purposes. They play an important role in the socio-economic and ecological balance. Namely, rare and endangers flora species are not identified in the project area at all.

From a rapid field survey in the study area, a number of species have been identified by the IEE/EIA study team as follow.

Homesteads and Orchards: betel nut, kadam, Coconut, Date palm, Sofeda, Mango, Jackfruit, Fig, Pome granade, Guava, Grapefruit, Lemon, Blackberries, Plum, Toddy palm, Koroi, Shisoo, Shirish, Rain tree, evcaiytta, bamboo, babla, jeol, neem, tamarind, banana, ipil-ipil, papya, mehgani, debdaru, shimul, akashmoni, khai babla, jamrul, chalta, bel, amra, amloki, segun, etc. Roadside Plantation: datepalm, road chambol, koroi, krishnachura, rain free, banian, shisoo, babla, akashmoni, banian, eucalyptus, mango, blackberries, raj koroi, etc.

Table 10.4.15 Terrestrial Flora

No.	Local Name	Scientific Name	Status
1.	Betel nut	*Areca catechu*	Fairly Common
2.	Mashkalai (one kind of pulse)	-	Fairly Common
3.	Potato	*Solanum tuberosum*	Fairly Common
4.	Ground nut	*Arachis hypogea*	Fairly Common
5.	Ginger	*Zingiber officinale*	Fairly Common
6.	Wheat	*T. aestivum*	Fairly Common
7.	Til	-	Fairly Common
8.	Kumra	*Cucurbita maxima*	Fairly Common

Note: Common = seen commonly

Source: : Banglapedia

Table 10.4.16 Crop flora in the Project Area

No.	Local Name	Scientific Name	Status
1.	Sesame	*Sesamum indicum*	Not planted recently
2.	Indigo	*Indigofera sumatrana*	Not planted recently
3.	Tobacco	*Nicotiana tabacum*	Not planted recently
4.	Sugarcane	*Saccharum bengalense*	Not planted recently
5.	Masnia	-	Not planted recently

Source: Field Investigation by IEE/EIA team

10.4.3 Sensitive Areas

As reviewed **item 10.4.1**, and **(1) & (2) of 10.4.2** above, socially, culturally and environmentally sensitive areas in all projects areas are not identified at all.

10.5 Identification of Possible Impacts by the Projects

By considering the characteristics of environmental and social aspect in the project area and project components, the following environmental and social impacts are predicted during construction and operation stages.

10.5.1 Social Impacts

In addition, proposed the project components have been reconnoitred from Mollarhat to KCC area through Rupsha River for observing surrounding social conditions and evaluating possible social impacts to be caused by the implementation of each project component. The result of the findings and evaluations are summarized in **Table10.5.1**. As the result, critical social impacts have not initially been identified excluding necessary land acquisitions for the project sites which have correspondingly been identified in the EIA study.

Table 10.5.1 Assessment of Possible Social Impacts

Project Components	Possible Impacts					
	Resettlement		Land Acquisition		Living and Livelihood	
	Construction	Operation	Construction	Operation	Construction	Operation
Water Intake	No	No	Yes	No	In some degree	No
R. Water T. Pipe	No	No	No	No	In some degree	No
SWTP	No	No	Yes	No	In some degree	No
I. Reservoir	No	No	Yes	No	In some degree	No
C. Water T. Pipe	No	No	No	No	In some degree	No
OHT	No	No	Yes	No	In some degree	No
D. Reservoir	No	No	Yes	No	In some degree	No

Note; 1. Water Intake: Water Intake Facility 2. R. Water T. Pipe: Raw water Transition Pipe 3. SWTP: Surface Water Treatment Plant 4. I. Reservoir: Impounding Reservoir 5. C. Water T. Pipe: Clear water Transition Pipe 6. OHT: Over Head Tank 7. D. Reservoir: Distribution Reservoir

JICA Study Team

(1) Resettlement

All project sites proposed by the JICA Study, which have been selected to avoid physical resettlement. As for the water distribution pipes are proposed to be constructed under the existing roads. Therefore, resettlement by this project is not predicted at all.

(2) Land Acquisition

As summarized in **Table 10.1.1**, one (1) ha for Water Intake Facility, 16ha for Impounding Reservoir, 10ha for SWTP, 4.86 ha for Distribution Reservoirs and OHTs are required for the project. Land owners identified are summarized as follows (See **Table 10.4.3 - Table 10.4.6**).

- Mollarhat for Water Intake Facility : 30 private owners
- Samanto Sena for SWTP and Impounding Reservoir: 72 private owners and 1 public owner

- KCC area for Distribution Reservoirs and OHTs: 5 private owners and 3public owners

Therefore, those lands shall be acquired from total 107 private owners and 4 public owners in accordance with relevant laws and regulations reviewed in Chapter 2 of the EIA report and LAP/RAP report. **Figure 10.2.2** shows Practical Flow Chart of Land Acquisition and Compensation.

As for land acquisition for public purposes, based on the Acquisition of Immovable Property Rules of 1982, monetary compensation (CCL: Cash Compensation under Law) is general rule in Bangladesh (See Item 2.2.4 of Chapter 2 of this report)

(3) Living and Livelihood during Construction Stage

During constriction stage of the projects, heavy vehicles and equipment are used for excavations and constructions. Therefore, road traffics will be increased in some degree and will especially be cordoned for the raw/clear water pipes' constructions which cause to negative impacts on living and livelihood such as circumvention of daily transportation routes in some narrow roads as well as occurrence of traffic accidents.

10.5.2 Environmental Impact

The proposed project components from Mollarhat to KCC area through Rupsha River have been reconnoitred for observing surrounding environmental conditions and evaluating possible environmental impacts caused by the implementation of the projects. The result of the findings and evaluations are summarized in **Table 10.5.2.**

As the result, critical environmental impacts have not initially been identified which have correspondingly been identified in the EIA study.

Table 10.5.2 Possible Environmental Impacts

Project Components	Possible Impacts					
	Noise, Vibration		Air pollution (Exhaust Gases)		River Water Quality/Quantity	
	Construction	Operation	Construction	Operation	Construction	Operation
Water Intake	In some degree	No	In some degree	No	In some degree	No
R. Water T. Pipe	In some degree	No	In some degree	No	No	No
SWTP	In some degree	No	In some degree	No	No	No
I. Reservoir	In some degree	No	In some degree	No	No	No
C. Water T. Pipe	In some degree	No	In some degree	No	No	No
OHT	In some degree	No	In some degree	No	No	No
D. Reservoir	In some degree	No	In some degree	No	No	No

Note; 1. Water Intake: Water Intake Facility 2. R. Water T. Pipe: Raw water Transition Pipe 3. SWTP: Surface Water Treatment Plant
4. I. Reservoir: Impounding Reservoir 5. C. Water T. Pipe: Clear water Transition Pipe 6. OHT: Over Head Tank
7. D. Reservoir: Distribution Reservoir

JICA Study Team

(1) Noise and Vibration during Construction and Operation Stages

- During the constriction stage of all project components, heavy vehicles and equipment are used for excavations and constructions. Therefore, road traffics volume will be increased which cause to emergence of noise and vibration.

- During the operation stage of SWTP, de-sludge operation and transportation of the sludge will generate noise and vibration in some degree.

(2) Air pollution during Construction and Operation Stages

- During the constriction stage of the project, heavy vehicles and equipment are used for excavations and constructions. Therefore, the use of the vehicles and equipment will generate exhaust gases and dusts, especially for dry season.

- During the operation stage of the project, de-sludge and dry up of sludge, and transportation of sludge will generate exhaust gases in some degree.

(3) River Water pollution

- During the constriction stage of the project, earthwork is necessary for the construction of the Water Intake Facility. Therefore, some soil and construction debris may pollute the river water if the construction is not implemented properly.

(4) Generation of Sludge during operation Stage

- During the operation stage of the project, sludge will especially be generated from SWTP. However, the SWTP sludge is not like sewage sludge and not included industrial wastewater (heavy metals and human waste). Therefore, if those are properly treated, no significant impact is expected.

10.6 Environmental and Social Considerations for the Projects

10.6.1 Land Acquisition and Compensation

Land acquisition for public purposes which shall follow the Acquisition of Immovable Property Rules of 1982 and relevant rules reviewed in Chapter 2 in this report. Generally, Public consultation and stakeholders meetings initiate the land acquisition in Bangladesh for the smooth implementation of the acquisition and compensation. For this project, KWASA, EIA and LAP/RAP studies conducted such consultations and meetings including focus group discussions in various levels as follows

(1) Public Consultation

KWASA and local consultant for EIA and LAP/RAP studies arranged such consultation meetings with the local stakeholders for information dissemination and community participation with the concerned entities and probable affected persons. The consultant and investigators investigated all the relevant matters regarding the project by arranging these meetings and group discussions for people's awareness. In this study, public consultation principally consisted of "Stakeholders Meeting" and "Focus Group Discussion" as following sections

(2) Stakeholders Meeting and Focus Group Discussion

According to EIA and LAP/RAP reports, these meetings were held at 5 different places of the 2 districts commencing from 21st August, 2010 during the field surveys. These public consultation meetings of the land owners, local elite and general members of the public were also attended on occasions by the City Mayor, ADC Revenue Bagerhat, Managing Director, KWASA, ADC (Land Acquisition) Khulna and the officials of JICA Study Team & KWASA including elected representatives, local leaders, women groups, representatives of professional groups like businessmen, farmers, teachers, religious leaders and public representatives as well as members and chairman of the Union and Upazila Councils and the consultant as shown in the following tables.

Table 10.6.1 Stakeholders Meeting

No.	Date	Places	PAP & Focus Group/ Local People	KWASA	JICA Study Team	Others	Total
1	12-08-2010	KWASA office	2	4	4	14	24
2	21-08-2010	Patharghata High School, Rupsha	150	3	3	3	159

Source: Field Survey EIA, LAP/RAP Report KWASA

Table 10.6.2 Focus Group Discussion

No.	Date	Places	PAP & Focus Group/ Local People	KWASA	JICA Study Team	Others	Total
1	7-10-2010	Patharghata	7	1	1	-	9
2	9-10-2010	Samonto Sena Bazar	7	1	1	-	9
3	9-10-2010	Mollarhat Technical College	7	1	1	-	9

Source: Field Survey EIA, LAP/RAP Report KWASA

Table 10.6.3 Focus Group Discussion at Patharghata

Date: 7.10.2010		Interviewer: Mr. Humayon kabir		Venue: Patharghata
No	**Name & Address of Key Informants**	**Profession**	**Issues Discussed/ Suggestion**	**KWASA Response**
1	Md. habibur Rahman Samontosena	Farmer	Proper Compensation	Compensation
2	Abdus sobhan,Samontosena	,,	Manage alternative land	Not beyond the Law
3	Krisnapad roy, pathorghata	,,	Full compensation	Compensation
4.	Shubrata kumar sarke, pathorghatar	,,	Manage alternative land	Not beyond the Law
5	Prokash halder patorghata	,,	Manage alternative land	Not beyond the Law
6.	Nani Gopal dutt, pathorghata	,	Manage alternative land	Not beyond the Law
7	Md. rani,Lakpur	Share cropper	Manage alternative land	Not beyond the Law

Source: Field Survey EIA, LAP/RAP Report KWASA

Table10.6.4 Focus Group Discussion at Samontosena Bazar

Date: 09.10.2010		Interviewer: Mr. Humayon kabir		Venue: Samonto Sena Bazar
No	**Name & Address of Key Informants**	**Profession**	**Issues Discussed/ Suggestion**	**KWASA Response**
1	Abdul majid fakir, samontosena	Ag/Shrimp	Proper compensation	Compensation
2	Md. Jakir hossain Sh,samontosena	Up member	Under ground water extraction, rumor	Good response
3	Moju Shekh,Pathorghata	Share cropper	Provide job	Under Consideration
4.	Palash Halder, pathorghata	Ag/Sharecropper	Livelihood damage	Under Consideration
5	Jahangir Shekh, pathorghata	Shrimp gher	They will be landless	Under Consideration
6.	Shawapan, pathorghata	Shrimp gher	Proper compensation	Compensation
7	Satter shekh	Farmer	Proper compensation	Compensation

Source: Field Survey EIA, LAP/RAP Report KWASA

Table10.6.5 Focus Group Discussion at Mollarhat Technical College

Date: 09.10.2010		Interviewer: Mr. Humayon kabir		Venue: Mollarhat Technical College
No	**Name & Address of Key Informants**	**Profession**	**Issues Discussed/ Suggestion**	**KWASA Response**
1	Shekh Mosta Gausul Hoq, Garfa	Chairman, Garfa UP	Land price should be at least upto market level, previous RHD rate was Tk.18,000 per decimal Demand of pure drinking water, the area is arsenic contaminated	Under Consideration
2	Md.Jummul, Mollarhat	UP member	Proper compensation at market price	Compensation
3	Mr. Al Mamun Shimul, Mollarhat	College teacher	Full compensation and project for the community	Compensation
4.	Md. Faruque, Mollarhat	businessman	Timely and proper compensation	Compensation
5	Chowdhury Ziaul Islam, Mollarhat	Local elite	Public in getting payment shouldn't be harassed	Good idea
6.	Sri Amitosh,Mollarhat	Service	Proper compensation	Compensation
7	Md. Shahidul Islam, mollarhat	Service	Proper compensation, road side land price is Tk.1,00,000	Under Consideration

Source: Field Survey EIA, LAP/RAP Report KWASA

(3) Summary of Stakeholder Metering and Focus Group Discussion

Participants in these consultation meetings were the land owners and available the local people along the intake and impounding reservoir site. **Table 10.6.6** shows major issues among others were raised in the Focus Group Discussion for three sites.

Table 10.6.6 Opinions by Project Site

Project Site	Opinion from Stakeholders
Water Intake	- Agricultural products like rice, jute and including vegetation were affected. Due compensation of which should be paid on the spot to the affected people before the construction starts. Trees and vegetation compensation should be included for the affected people. - There will be enhanced soil erosion particularly on the river banks, which should be addressed properly. - Traffic management should be controlled at day time may affect movement of people, especially women, children and disabled persons from one place to another. - Environmental pollution like air pollution (due to dust and gaseous emission), water pollution (Madhumoti river) as natural water bodies may be aggravated and should be taken care of as this water is used for agriculture and domestic purposes and through sanitation and waste materials as well as other social nuisance should be controlled.
SWTP & Impounding Reservoir	- Shrimp cultivation is the main business of this locality. This will affected a lot due to this project. So proper reimbursement like fish development cost to land compensation cost like double or triple or sometimes five times payment to the affected people. - Agricultural products including vegetation were affected. Due compensation of which should be paid on the spot to the affected people before the construction starts. Trees and vegetation compensation should be included for the affected people. - Assembly of worker (Labour) during project activities may damage crops and other trees. - Noise pollution from vehicles and equipment at the project sites may cause disturbance to human being and wild life. - Air pollution due to dust and gaseous emission should be controlled. - Compensation for land as per government rate would not be a fair compensation to the affected person as it is far below prevailing market rate and should be minimized this issue as per market prices. - There will be enhanced soil quality degradation particularly for the after project construction activities, which should be addressed properly. - Water pollution of the natural water bodies may be aggravated and should be taken care of as this water is used for agriculture and domestic purposes. - Movement of vehicles may affect movement of people, especially women, children and disabled persons from one place to another due to the project activities. - Environmental pollution through sanitation and waste materials as well as other social nuisance should be controlled. - They also raise issues that what will be benefit of the land owners for this project implementation. - Moreover this land is their life and without these pieces of land they will lose everything, so if possible or not do not take this land instead of this land use government (khas) land.
Distribution Reservoir & OHT	- Most of the land inside the city is valuable and costly, so if possible then take government land. - Proper compensation should be paid for the land inside the city sites.

Source: Field Survey EIA, LAP/RAP Report KWASA

It can be considered that these opinions shown in **Table 10.6.6** concentrate mainly on the compensation for land acquisition and lives and livelihood (Noise, Air pollution during constructions and traffic management) which can be manageable as discussed in the EIA report.

As well, the EIA and LAP/RAP reports have concluded that these opinions are basically the general opinion that is found the similar situation in any development project work in any parts of the country of Bangladesh.

In addition, the following shows expectations of the local people expressed during the consultations.

- Local personnel should be employed in different activities of the project on a priority basis.
- Preference should be given to engage local businessmen/ contractors in different phases of the project for construction and development depending in their suitability for such engagements.
- Compensation payment, it should be in the rate of market prices and also with the negotiation of the affected people, should be properly and promptly distributed so that the actual affected person gets his full share and in right time.
- Supply of produced water would help improving their social life as drinking safe water conditions and therefore water should be made available in the areas through which water line would be passing through.

(4) Public Consultation Results

The EIA and LAP/RAP reports summarize the public consultation shown in **Table 10.6.7** with the suggestions. It can be evaluated the suggestion by EIA and LAP/RAP are acceptable in general which shall be followed by KWASA appropriately.

Table 10.6.7 Public Consultations

Issue Raised	Suggestions
1. Development	Area will be developed by new access road, land scarping.
2. Reduce Unemployment	Labour should be taken from that locality.
3. Social & Economic development	Living status will be high.
4. Land & property damage	Due compensation to be paid according to the latest approval price list.
5. Crop damage	Due compensation to be paid on the spot.
6. Fruit trees damage	Due compensation to be paid on the spot.
7. Saline free water	Discuss with superior person of the locality for providing water.
8. Compensation assessment	Compensation assessment by DC and local leader.
9. Shrimp Cultivation	Proper compensation will be paid as land development to shrimp Cultivation.
10. Fish breeding	Must avoid breeding time
11. Pollution of air and surface water	Due Compensation to be given, Monitoring shall be adopted.
12. Sanitary problem	Sanitary system should be developed during construction.

Source: EIA, LAP/RAP Report KWASA

(5) Social Survey with Project Affected Person

A structured questionnaire was prepared to collect all relevant socio-economic condition of the Project Affected Person (PAP) in the project areas of which results are summarized in **Table 10.6.8 to Table 10.6.10**.

Table 10.6.8 Summary of PAP Response to the Project (Mollarhat)

Comments	H/H No.	%
Positive without any condition	-	
Positive on conditions of proper compensation, providing job etc	7	100
Alternate suggestion	-	
Negative	-	
Total	**7**	100

Source: LAP/RA Report

Table10.6.9 Summary of PAP Response to the Project (Samonto Sena)

Comments	H/H No.	%
Positive without any condition	6	19.35
Positive on conditions of proper compensation, providing job etc	6	19.35
Alternate suggestion	9	90.00
Negative	10	32.26
Total	**31**	100.00

Source: LAP/RA Report

Table 10.6.10 Summary of PAP Response to the Project (KCC Area)

Comments	H/H No.	%
Positive without any condition	-	-
Positive on conditions of proper compensation, providing job etc	2	66.67
Alternate suggestion	1	33.33
Negative	-	-
Total	**3**	100

Source: LAP/RA Report

(6) Conclusion

EIA and LAP/RAP reports concluded on the land issues as follows:

- Ensure institutional capacity of KWASA for implementing and monitoring EMP and LAP/RAP including formation of Grievance Redress Committee (GRC) with due representation from PAP and the authority and ensure budget provision in KWASA for implementing the LAP/RAP with due importance to social management plan as placed and the recommendations made at the LAP/RAP report. Provide them with due adequate manpower, logistic supports and the fund as required.

- Arrange all preparatory works so that compensations are paid to all of the eligible PAP well before carrying out of any works at site with interventions in their properties and ensure adequacy of the grievance redress mechanism during post project evaluation and take care of the residual impact, if any, under the GOB regulations & the JICA and ADB policy frame work. But as per GOB regulation KWASA cannot pay any excess money to the PAP for land acquisition. KWASA is under considering the point that the PAP raise during the stakeholders meeting and FGD period and KWASA will discuss this issue with the LGD to mitigate.

- Ensure incorporation of the provision of all mitigation measures including but not limited for due reinstatement of all public roads and protection of river banks etc from erosion. Ensure identification and inclusion of all items relating to EMP to be carried out by the EPC contractor in their scope of work.

- Monitor progress of implementation of both EMP and LAP/RAP through Owner’s Engineer including deployment of Environmental Specialist/Social Specialist of the independent Consulting Group with their placement in the organization chart recommended at of this report and ensure progress reporting to the management of KWASA and other concerned authorities e.g. DOE, JICA and ADB etc as applicable.

- Acquisition under this project is a bulk nature. However, if any found during execution of works he/ they will have to be duly compensated. All these issues will be taken special care of by the GRC about their due compensation and grant as applicable.

10.6.2 Living and Livelihood during Construction Stage

(1) Traffic Management

Raw and Clear water Transmission Pipes are proposed to be constructed under the existing roads. During the construction, a traffic management plan and all the relevant information is shared with the relevant official entities shown in **Table 10.6.11**.

Table 10.6.11 List of Authorities

No.	Name of the Authorities
1	Bangladesh Inland Transport Authorities (BIWTA)
2	Bangladesh Water Development Board (BWDB)
3	Roads and Highway Department (R& H)
4	Local Government Engineering Department (LGED)
5	Khulna City Corporation (KCC)
6	Khulna Development Authority (KDA)
7	District Commissioner (Khulna and Bagerhat)
8	Department Public Health Engineering (DPHE)
9	Bangladesh Railway
10	Bangladesh Telecommunication Company Limited
11	Upazila and Union Chairman office

Source: EIA report KWASA

These entities shall react in order to maintain the traffic flow and collaborate with Traffic Police department in each Upazila and KCC.

In this regard, the EIA report identifies the impacts and mitigation measures on the following critical points, which can be considered as the most appropriate manners for the possible impacts (See Chapter 6 of the EIA report).

- River, Canal, Box Culvert, Bridge Crossing, Market Place (for raw water transmission pipe)
- Narrow Road Section (for raw/clear water transmission pipes)
- Water Canal Management (for especially Impounding reservoir and SWTP site*)*
- Transportation / Traffic Management and Truck Use (for all project sites)
- Interference with Navigation /Fisheries (for all project sites)
- Transportation and Traffic Congestion (for project components in KCC)
- Railway crossing (for project components in KCC)

Therefore, KWASA shall follow the recommendations in the EIA regarding Traffic Management. As well, contractors to be selected shall be responsible for showing all the safety signs and other related information regarding traffic management.

(2) Signboards, Warning Boards and Safe Guards

These issues of preparation of signboards, warning boards and deployment of safe guards shall be addressed by the constructors/contractors in accordance with relevant construction regulation and norms reviewed in the EIA report. Some sample pictures of traffic signs and warning signs to be used during the construction are shown in the EIA as follows.

Source EIA report KWASA

(3) Coordination with Solid Waste Management

In the construction stage, solid waste management issues are addressed by the constructor and the proponent. According to lessons learnt from past experiences of development projects in cities in Bangladesh, KWASA shall collaborate with KCC and SWM department, and arranges the transportation of collection vehicles of domestic waste along the roads during construction stage for the clear water transmission pipes for the excavations.

(4) Occupational Safety

As reviewed in Chapter 2 of the EIA report, Bangladesh Labour Law 2006 stipulates working environment, work place conditions and sanitary facilities for the workers. Based on the law and relevant regulation reviewed in Chapter 2 of the EIA, Chapter 6 in the EIA recommends the followings.

- Protective clothing, earplug, hamlets, shoes and accessories (PPE) should be provided to the workers, who would be subjected to adverse safety situation.
- Adverse impact on worker's safety would be minimized by implementing an occupational health and safety training program (see Chapter 2 of the EIA report).
- Periodically medical check-up would be done to ensure the soundness of health of employees and workers (see Chapter 2 of the EIA report).
- Periodically health education to labours, drivers shall be done especially HIV/AIDS issues.

Based on the law and regulations shown in and above measures discussed in Chapter 2 of the EIA, it is evaluated that workers are protected and educated accordingly.

10.6.3 Noise and Vibration

Most of the noise and vibration are generated from vehicles and heavy equipment during construction stage. In Bangladesh there is an environmental standard of Noise and Vibration. The present situation in Noise level monitored in the EIA study in Rupsha River construction project shows that the noise levels monitored around the project site in KCC area were over the standard noise (See Chapter 4 of the EIA report). However, based on relevant laws and regulations reviewed in Chapter 2 of the EIA report, Chapter 6 in the EIA recommends on Noise and vibration as follows.

- To avoid local traffic impact, time restriction for construction and diversion routes (if necessary) shall be considered.
- Selecting 'quiet' working methods and use of low noise equipment must be specified in construction contract tender documents (See Chapter 2 of the EIA report)
- Construction activities should not take place at night times due to noise (See Chapter-2 of the EIA report). If this is absolutely unavoidable, the contractor shall advise/ consult with local community leaders.
- Local community should be consulted beforehand and reach an agreement over appropriate timing for noisy activities.
- Working hour's duration is mention in Chapter2 of the EIA report; special cases can be done with consult with KWASA and local authorities and public consultation.

Based on the law and regulations shown in and above measures discussed in Chapter 2 of the EIA, it is evaluated that noise and vibration impact can be managed accordingly.

In addition, a pump to be used for the water intake is constructed and installed in the facility building which is a standard structure seen in Bangladesh. In addition, according to KWASA there has been no complaint on the noise and vibrations cased by existing relevant facilities from public at all so far.

10.6.4 Air Pollution during Construction and Operation Stages

(1) Air Pollution

Same as Noise and Vibration above, the principal air quality impacts will arise from dust generation from excavation of soil, pipe laying and vehicle movement during construction stage. Heavy vehicles may cause exhaust gas emissions, but these impacts are temporary and for short duration in the construction stage most of which will diffuse into environment especially in the Intake Facility site, the Highway and roads for pipe laying and SWTP and Impounding reservoir where the location of relatively open air rural areas.

Based on relevant laws and regulations reviewed in Chapter 2 of the EIA report, Chapter 6 in the EIA recommends on the Air pollution as follows.

- Excavated materials, stockpiles and haul roads shall be dampened with water spraying during dry ambient conditions;
- Vehicle speed restrictions shall be imposed to reduce dust generation and dispersion;
- Transport vehicles shall not be overloaded,
- Transport vehicles shall be covered by triple/plastic
- Periodical maintenance of the vehicle should be ensured.
- Visual inspections of equipment and vehicles shall be conducted on a periodical basis to ensure no excessive emissions of black smoke (see Chapter 2 of the EIA report).
- Education to the driver to keep traffic regulation and manner.

Based on the law and regulations shown in and above measures discussed in Chapter 2 of the EIA, it is evaluated that air pollution caused by the construction can be managed accordingly.

10.6.5 Generation of Sludge during Operation Stage

(1) Sludge Treatment and Disposal

The treatment sludge is periodically cleaned up from the SWTP, which is dry up under the sunshine at several sludge drying beds, and then to the transfer it to a solid waste landfill site located in KCC to be used as covering soil for the site

In addition, KWASA plans to utilize it for soil conditioner for the agricultural purposes in near future.

10.6.6 Other Possible Impacts

(1) Surplus Soils

Surplus soils generated during construction of each project are planed to be utilized for the embankment, and especially surplus soils generated from SWTP and Impounding Reservoir sites green are planned to principally be used for access road and a buffer zone construction of the sits, furthermore the remaining soil is planned to be used for cover soil at the solid waste dumping site located in KCC area (near the Khulna National University).

(2) Protected Areas and Heritage

- Proposed Intake facility is constructed on the river bed where has basically been used as agriculture purposes
- Proposed raw water transmission pipe is constructed under the existing roads
- Proposed SWTP and Impounding Reservoir are constructed in the existing farming and fish pond firm areas
- Proposed clear water transmission pipe is constructed under the existing roads

- Proposed OHT and Distribution tanks are constructed in KCC private and public lands

No such protected areas, archeological, historical, cultural, and religious heritage sites identified at all proposed sites.

(3) Landscape

- Proposed raw and clear transmission pipes are constructed under the existing roads
- Proposed intake facility is constructed in a semi basement structure and all facility of pump and other equipment are set inside the structure.
- Proposed SWTP and Impounding Reservoir are excavated the existing paddy and fish cultivating area in which some embankment and green plantation zone are planed to be constructed.
- Proposed transmission reservoirs are constructed in a semi basement structure and covered.
- Proposed OHTs which are planed to be constructed in KCC area are general structure and common figure seen in most of the urban areas.

10.7 Environmental Monitoring

10.7.1 Environmental Monitoring discussed in EIA Report

An environmental management plan including environmental monitoring required by the EIA system of Bangladesh which shall be prepared in the EIA report. For the getting the ECC for the project, Environmental Evaluation Committee by DOE Head Office will scrutiny the environmental management plan including environmental monitoring plan written in the EIA report to be submitted at the time of ECC application. The committee will issue the ECC with terms and conditions in which recommendations and environmental monitoring and reporting methods will generally be discussed.

Items to be monitored may generally be discussed in an Environmental Management Plan (EMP) based on the negative impacts to be assessed in the EIA report for the Projects. In this regard, in this study stage, initial assessments of possible impacts caused by the projects have been discussed in the EIA and in this chapter. Therefore, the following are the possible items to be monitored;

- Social Impacts relating to the land acquisition for the Intake facility, SWTP, Impounding reservoir, Distribution reservoirs and Over head Tanks.
- Social Impacts on living and livelihood during the construction stage such as noise and vibration by equipment and vehicles, traffic safety and management, dust control, etc.
- Environmental Impacts relating to sludge treatment during the operation stage of the projects

10.7.2 Environmental Monitoring

The EIA report discussed an environmental monitoring plan in Chapter 7 of Environmental Management Plan, which consists of three part of Environmental Monitoring system, Environmental Monitoring Function for the project and Reporting as follows.

(1) Environmental Monitoring System

In the EIA report, it is identified several environmental impacts caused by the project among which the “Land Acquisition” is the main possible impact, in which the compensation and mitigations is discussed in the Land Acquisition Plan and resettlement Action Plan.

Therefore, KWASA shall have an environmental monitoring system for the project to deal with such impacts as follows:

a. Grievance function: to take complaints and take necessary action.
b. Emergency function: rapidly increases the BOD, COD, DO and etc, indentify and remedial action in corporation with DOE (for emergency only).
c. Leakage: Identify and corrective action.
d. Periodic Inspection of the facilities including the water stolen by the farmer.

After getting the Environmental Clearance Certificate (ECC), there may be certain terms and condition to full fill by the KWASA of drinking and river water quality monitoring at the intake site in Mollarhat.

In addition, the following shows the periodically monitoring other than the monitoring to be required by EIA. Therefore, a reasonable condition between the Environmental monitoring in the Environmental monitoring system in the EIA and Operational monitoring required by DOE.

On this account, KWASA shall take the initiative to coordinate with the DOE to avoid overlap of similar monitoring (required by DOE, by ECC and the EIA follow), double assignment of the personnel and so on.

- **Drinking water, Ground and Surface Water Quality Monitoring by KWASA**

  In the Feasibility Study Report, it is recommended that at the construction stage DOE will monitor the river water quality at the intake point. DOE is monitoring the Modhumati river water quality but not at the actual point where the water will collect for supply. So, proper coordination with DOE by KWASA, to change the sampling point to the intake facility site.

  After the commencement of the SWTP, KWASA should monitor the Modhumati River and the SWTP water quality every day. There is around 23 parameters shown in the Feasibility Study

Report that have to check by that time.

However in Chapter 6 (of the EIA report), the initial assessment of possible impact caused by the impacts has been discussed. Therefore, the following are the possible items to be monitored:

a. Complaints from the water users.
b. Social awareness of the water uses.
c. Monitoring the Modhumoti river at intake site and the water quality of SWTP
d. Checking the ground water and drinking water quality

- **River Water Quality Monitoring by DOE**

According to the Environmental Conservation Rule 1997, DOE has the authority to monitor the different environmental aspects as stated in **Chapter 2** (of the EIA report). DOE have their own laboratory for environmental parameter checking. Under the organizational responsibilities the DOE check the river water quality monthly at different parameters (i.e. BOD, COD, pH, SS, TDS and DO etc.). So, proper coordination with KWASA is required for monitoring of river water at the intake point in Mollarhat.

(2) Environmental Monitoring Function for the Project

The JICA Feasibility Study Report has proposed a new KWASA Organization as follows.

- Technical Services Division: headed by Deputy Managing Director.
- Planning and Development department: Under the Technical services division, there is a headed by Chief Engineer.
- Section of Project Management and Monitoring: Planning and Development department, there is the section headed by executive engineer. This section is responsible for the Environmental and Social monitoring.

If any observation or complaint find in the field level during the construction and operation stage, the Executive Engineer shall coordinate to the respective department or authorities (like DOE, KCC and etc.). The **Table 10.7.1** shows the proposed Environmental Monitoring Organization.

Table 10.7.1 Proposed Environmental Monitoring Organization

Stages	Construction	Post-Construction
Responsible Organization	PMU of KWASA	KWASA (Selection of Project management and Monitoring)
Monitoring	PMU of Planning and Development Department	KWASA
Responsibilities	Coordinate between the DOE	Reporting to the DOE as per ECC requirement
	Handling the environmental monitoring items discussed in the EIA report, ECC, JICA, ADB (If any), coordination is necessary	Handling the periodic monitoring items done by the DOE (ECC), JICA, ADB (If any), coordination is necessary
Personal	One person	One person

Source; EIA report KWASA

(3) Reporting

In the terms and conditions to be written in the ECC, there generally may suggest reporting system for the environmental monitoring activities.

In addition, such reporting shall be followed based on relevant guidelines of external funding donors like JICA and ADB. For the monitoring items, frequency and period of the reporting, KWASA shall discussed with those funding agencies during the appraisal mission study and other opportunities.

As for the JICA, JICA has prepared a “Monitoring Form” in the JBIC Environmental & social Consideration Guidelines. In the form, the principal environmental impact predicted by the EIA is social impacts caused by the land acquisitions and the compensations. Therefore, the monitoring items to be monitored shall focus on No.4 Social Environmental in the form which shall be discussed between KAWSA and JICA carefully.

Based on results of discussion(s) to be done with JICA, KWASA and/or the PMU (Project Management Unit) for the projects shall refer the monitoring form for the periodic submissions of the environmental monitoring reports to JICA during construction stage and/or after implementation stage of the projects.

10.8 JBIC Environmental & Social Consideration Guidelines and its Environmental Check List

10.8.1 Screening Form and Environmental Check Lists

Based on the JICA’s policy on the environmental and social consideration for Japanese loan projects, KWASA in cooperation with the JICA study team has prepared the following;

- “**Screening Form**” in the JBIC Environmental & Social Consideration Guideline (for loan projects by Japanese ODA) which was prepared by Managing Director at KWASA dated on 30th June 2010 as attached below.

- “**Sectoral Environmental Check lists of No.18 Water supply**” are attached as follows, which may be modified and filled by KWASA further more if any.

10.8.2 Monitoring Form

As for the implementation and reporting of the environmental monitoring, JICA has prepared a “Monitoring Form” (See next page) in the JBIC Environmental & Social Consideration Guidelines. KWASA and/or PMU (Project Management Unit) shall refer to the monitoring form for the periodic submissions of the environmental monitoring reports to JICA during the project construction stage and/or implementation stage.

JICA Environmental Monitoring Form attached in the Guidelines

-If environmental reviews indicate the need of monitoring by JICA, JICA undertakes monitoring for necessary items that are decided by environmental reviews. JICA undertakes monitoring based on regular reports including measured data submitted by the project proponent. When necessary, the project proponent should refer to the following monitoring form for submitting reports.
-When monitoring plans including monitoring items, frequencies and methods are decided, project phase or project life cycle (such as construction phase and operation phase or development, operation and mine closure) should be considered.

１． Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	**Monitoring Results during Report Period**
ex.) Responses/Actions to Comments and Guidance from Government Authorities	

２． Mitigation Measures

- Air Quality (Emission Gas / Ambient Air Quality）

Item	**Unit**	**Measured Value(Mean）**	**Measured Value(Max.）**	**Country's Standards**	**Standards for Contract**	**Referred International Standards**	**Remarks (Measurement Point, Frequency, Method, etc.)**
SO_2							
NO_2							
CO							
O_2							
Soot and dust							
SPM							
Dust							

- Water Quality (Effluent/Wastewater/Ambient Water Quality）

Item	Unit	**Measured Value(Mean)**	**Measured Value (Max.）**	**Country's Standards**	**Standards for Contract**	**Referred International Standards**	**Remarks (Measurement Point, Frequency, Method, etc.)**
pH							
SS (Suspended Solid）							
BOD/COD							
DO							
Total Nitrogen							
Total Phosphorus							
Heavy Metals							
Hydrocarbons / Mineral Oils							
Phenols							
Cyanide							
Temperature							

- Waste

Monitoring Item	**Monitoring Results during Report Period**

- Noise / Vibration

Item	**Unit**	**Measured Value (Mean）**	**Measured Value (Max.）**	**Country's Standards**	**Standards for Contract**	**Referred International Standards**	**Remarks (Measurement Point, Frequency, Method, etc.)**
Noise level							
Vibration level							

- Odor

Monitoring Item	**Monitoring Results during Report Period**

３． Natural Environment

- Ecosystem

Monitoring Item	**Monitoring Results during Report Period**
ex.) Negative effects/Actions to Valuable species	

４． Social Environment
- Resettlement

Monitoring Item	**Monitoring Results during Report Period**

- Living / Livelihood

Monitoring Item	**Monitoring Results during Report Period**

Screening Form

Name of Project : Khulna Water Supply Improvement Project

Name of Project Execution Organization : Khulna Water Supply and Sewerage Authority (KWASA)

Name of Borrower : Government of Bangladesh (GOB)

Please provide the name, department, job title, and contact details for the person who is responsible for filling out this form.

Name : Mr. Md. Abdullah

Department and title : Managing Director

Name of Company or Organization : Khulna Water Supply and Sewerage Authority (KWASA)

Telephone number : 041-2830557

Fax number : 041-720857

E-Mail address : mdkwasa@yahoo.com

Date : 30th June 2010

Signature : mabdullah

MD. ABDULLAH, PEng
Managing Director
Khulna WASA

(Matters to be noted)

1. Please note that JBIC may provide the information concerning the environmental assessment (including that in writing or orally; hereinafter referred to as the "Environmental Information") provided by the Borrower, etc. in considering the financing, investments or guarantee for a project as part of JBIC's international financial operations to the financial institutions in Japan, which also consider financing, investments or guarantee for the same project jointly or separately with JBIC (hereinafter referred to as the "Cofinancing Institutions"), whether or not any confidentiality agreement has been entered into by and between JBIC and the Borrower, etc. JBIC provides the Environmental Information to the Cofinancing Institutions for their conducting the confirmation of environmental and social consideration with respect to the project. In providing the Environmental Information, JBIC requires the Cofinancing Institutions (i) not to use the Environmental Information for any purpose other than the internal confirmation of environmental and social consideration with respect to the project, and (ii) not to disclose the Environmental Information to any third party.
2. Please note that this Screening Form or the contents thereof may be made public.

1

Questions

Q1. Please provide the address of the project site.

Address of the project site : Khulna Division (a water intake, a surface water treatment plant, an impounding reservoir, transmission and distribution facilities, distribution reservoirs and overhead tanks) (see Figure 1 and 2 attached).

Q2. Please provide brief explanation of the project.

Khulna, the third largest city in Bangladesh, is located in the southwest of the country and has a population of 1.5 million. The present water supply to Khulna is mainly from ground water sources drawn from both deep and shallow tube wells. To cope with current insufficient supply and increasing demand, the Khulna Water Supply and Sewerage Authority (KWASA) plans to construct a new water treatment plant and impounding reservoir for surface water with assistance from the Japan International Cooperation Agency (JICA).

Q3. Will JBIC loan be applied to a new project or an executing project? In case of executing project, please inform the presence of strong claims by local residents.

- ☑ New Project
- ☐ Executing Project (with Claim)
- ☐ Executing Project (without Claim)
- ☐ Others (Please specify)

Q4. In case of this project, is it necessary to execute Environmental Impact Assessment (EIA) based on the laws or regulations? If necessary, please inform the progress of EIA.

- ☐ Required (Completed)
- ☑ Required (Under execution or under planning)
- ☐ Not Required
- ☐ Others (Please specify)

Q5. In case that EIA is already completed, pleases inform whether EIA report is already approved based on the environmental assessment system or not. If EIA report is already approved, please provide the date and name of authorities of the approval.

- ☐ Approved (without condition)
- ☐ Approved (conditional)
- ☐ Under approval process
- ☐ Others (Please specify)

Date of Approval : Not Applicable
Name of Authorities : ____________

Q6. If environmental permit(s) other than EIA is required, please provide the name of required permit(s). Have you obtained required permit(s)?

- ☐ Obtained
- ☑ Required, but not obtained yet
- ☐ Not required
- ☐ Others (Please specify)

Name(s) of required permit(s) : Site Clearance Certificate, Environmental Clearance Certificate

Q7. Will the loan be used for the undertaking that cannot specify the project at this stage (e.g. export or lease of machinery that has no relation with specific project, or Two Step Loan that cannot specify the project at the time of loan agreement)?

(~~Yes~~ / No)

If you answered "Yes", it is not necessary to reply to the following questions.
If you answered "No", please reply to the following questions.

2

Q8. Are there any environmentally sensitive area shown below in and around project site?

(~~Yes~~ / No)

If you answered "Yes", please select applicable items by marking, and reply to following questions.
If you answered "No", please reply to questions 9 and after.

- ☐ (1) National parks, protected areas designated by government (coastal areas, wetlands, habitats of minorities or indigenous populations, heritage sites, etc.)
- ☐ (2) Primeval forests, tropical natural forests
- ☐ (3) Ecologically important habitats (coral reefs, mangrove, tidal flats, etc.)
- ☐ (4) Habitats of endangered species of which protection is required under local laws and international agreements.
- ☐ (5) Areas that have risks of large scale increase in soil salinity or soil erosion
- ☐ (6) Desertification areas
- ☐ (7) Areas with special values from archaeological, historical and/or cultural viewpoints
- ☐ (8) Habitats of minorities, indigenous populations, nomadic people with traditional life style, or areas with special social value

Q9. Does the project involve following elements?

(Yes / ~~No~~)

If you answered "Yes", please describe the scale of applicable elements, and reply to the questions 10 and after.
If you answered "No", please reply to questions 11 and after.

- ☐ (1) Involuntary resettlement (Number of resettlers:)
- ☐ (2) Pumping of groundwater (Scale: ton/year)
- ☑ (3) Land reclamation and/or development (Scale: Minimum 20ha and Maximum 60 ha (Surface water treatment plant + Impounding reservoir)
- ☐ (4) Deforestation (Scale: ha)

Q10. Please reply to this question only in case that the project involves some of the above (1) to (4) elements. In the country where the project is planned, are there any regulations on a scale of the elements asked in question 9? If the country has such regulation, please answer whether the project satisfies the regulation or not.

☑ Regulation is applicable (☑ satisfied ☐ not satisfied) ☐ No regulation
☐ Others (Please specify)

Please reply to questions 11 and after.

Q11. Will JBIC share in the project be equal or less than 5% of the total project cost, or the total amount of JBIC loan equal or less than SDR 10 million?

(~~Yes~~ / No)

If you answered "Yes", it is not necessary to reply to the following questions.
If you answered "No", please reply to questions 12 and after.

Q12. Does the project belong to either of the sectors that impact on the environment is deemed immaterial or is not anticipated under normal conditions (e.g. maintenance of the existing facilities, non-expansionary renovation project, acquisition of rights or interest without additional plant investment)?

(~~Yes~~ / No)
If you answered "Yes", it is not necessary to reply to following questions.
If you answered "No", please reply to the questions 13 and after.

3

Q13. Does the project belong to the following sectors?

(Yes / ~~No~~)

If you answered "Yes", please specify the sector by marking, and reply to questions 14 and after.
If you answered "No", it is not necessary to reply to the following questions.

- ☑ (1) Hydro power plant, Dam or water reservoir
- ☐ (2) Thermal power plant
- ☐ (3) Mines
- ☐ (4) Development of oil and gas
- ☑ (5) Pipeline
- ☐ (6) Steel industry (with large scale furnace)
- ☐ (7) No-ferrous metal refining
- ☐ (8) Petrochemical (including manufacturing of raw materials and petrochemical complex)
- ☐ (9) Terminal of oil, gas and chemicals
- ☐ (10) Petroleum refining
- ☐ (11) Paper and pulp
- ☐ (12) Manufacturing and/or transportation of hazardous substances (specified by international agreement)
- ☐ (13) Road, railway or bride
- ☐ (14) Airport
- ☐ (15) Port
- ☐ (16) Waste material processing or treatment
- ☐ (17) Treatment of sewage and/or waste water that includes hazardous substances or executed at environmentally sensitive area
- ☐ (18) Power transmission and/or distribution lines (including large scale involuntary resettlement, large scale deforestation or submarine cable)
- ☐ (19) Tourism (Construction of hotel, etc.)
- ☐ (20) Forestry or tree planting
- ☐ (21) Agriculture (large scale project and/or project including irrigation)

Q14. Please provide information on the scale of the project (project area, area of plants and buildings, production capacity, amounts of power generation, etc.) Further, pleased explain whether an execution of EIA is required on account of the large scale of the project in the country where the project is implemented.

1. Proposed Project

Table 1 Summary of Proposed Water Supply Facilities

Project Components	Capacity	Quantity	Dimension (m)	Area	Location
Water Intake	110,000m^3/day	1 nos	75 x 125 + Access Road 120m	1.0ha (2.5acre)	Madhumati River at Mollarhat
Raw Water Transmission Pipe	-	φ1350mm, L=33km	See Figure.1		
Impounding Reservoir	775,200m^3	1 nos	Minimum 20 ha, Maximum 60ha		Samanto Sena
SWTP	110,000m^3/day	1 nos			Samanto Sena
Clear Water Transmission Pipe	-	Φ300mm-1100mm, L=25km	See Figure 2		
Distribution Reservoir & Overhead Tank (5 nos)	Reservoir (5,000m^3 - 18,000m^3 OHT (300m^3 - 500m^3)	Deana West Para Reservoir	100 x 70	0.7ha (1.7acre)	Paddy Land
		Ward No.16 Office Reservoir	100 x 70	0.7ha (1.7acre)	KCC Land
		Sonadanga Moha Sarak Reservoir	100 x 90	0.9ha (2.2acre)	Personal Land
		Beside of No.7 Ward Office Reservoir	100 x 70	0.7ha (1.7acre)	Pesonal Land
		Khalishpur Charerhat River Ghat Reservoir	100 x 90	0.9ha (2.2acre)	Government Land
Overhead Tank (6 nos)	300m^3	Rab Sarani OHT	45 x 30	0.14ha(0.4acre)	Personal land
	300m^3	Mujgunni OHT	45 x 30	0.14ha(0.4acre)	KCC land
	300m^3	Ferry Ghat Power House OHT	45 x 30	0.14ha(0.4acre)	KCC land
	500 m^3	Andir Pukur OHT	50 x 35	0.18ha(0.4acre)	Personal land
	500 m^3	South Side of Ward No.31 Office OHT	50 x 35	0.18ha(0.4acre)	Paddy land
	500 m^3	DPHE Rupsha OHT	50 x 35	0.18ha(0.4acre)	DPHE
Distribution Pipe Network	-	φ50mm-400mm, L=1000km	See Figure 2		

4

2. EIA

The following shows relevant rules, guidelines on EIA especially applied for water supply projects in Bangladesh.

- Environmental Conservation Rules 1997 (amended in 2000)
- EIA Guidelines for Industries 1997, DOE
- Guidelines for Environmental Assessment of Water Management (FCD/I) Projects 2005 WARPO

In accordance with the rules and guidelines noted above all water supply projects in Bangladesh are classified as "Red" category, which are required IEE and EIA studies for getting SCC and ECC from Khulna DOE office.

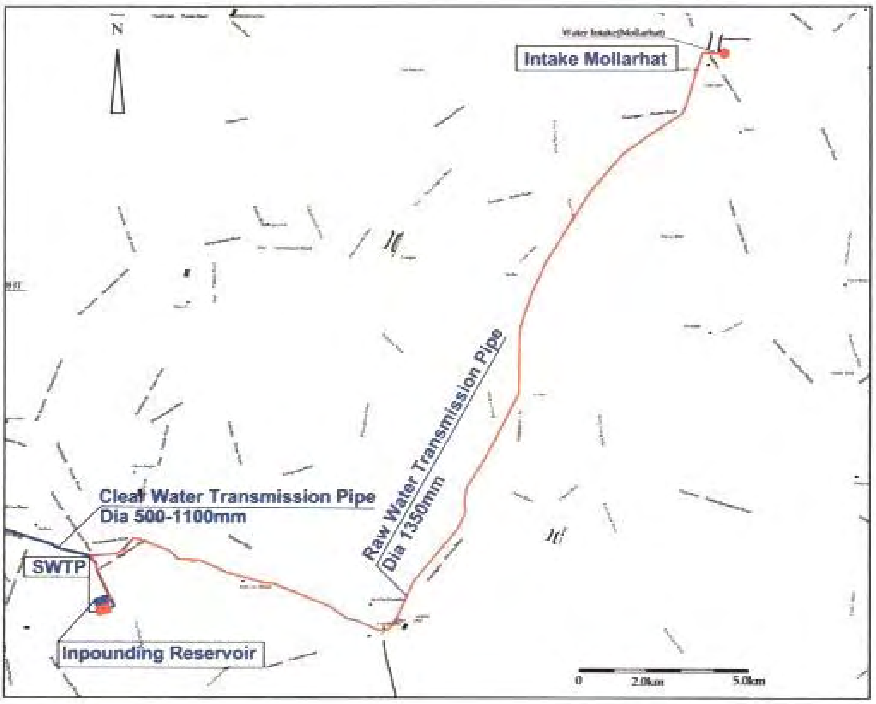


Figure1 Proposed Project Location from Intake to SWTP/IR

5

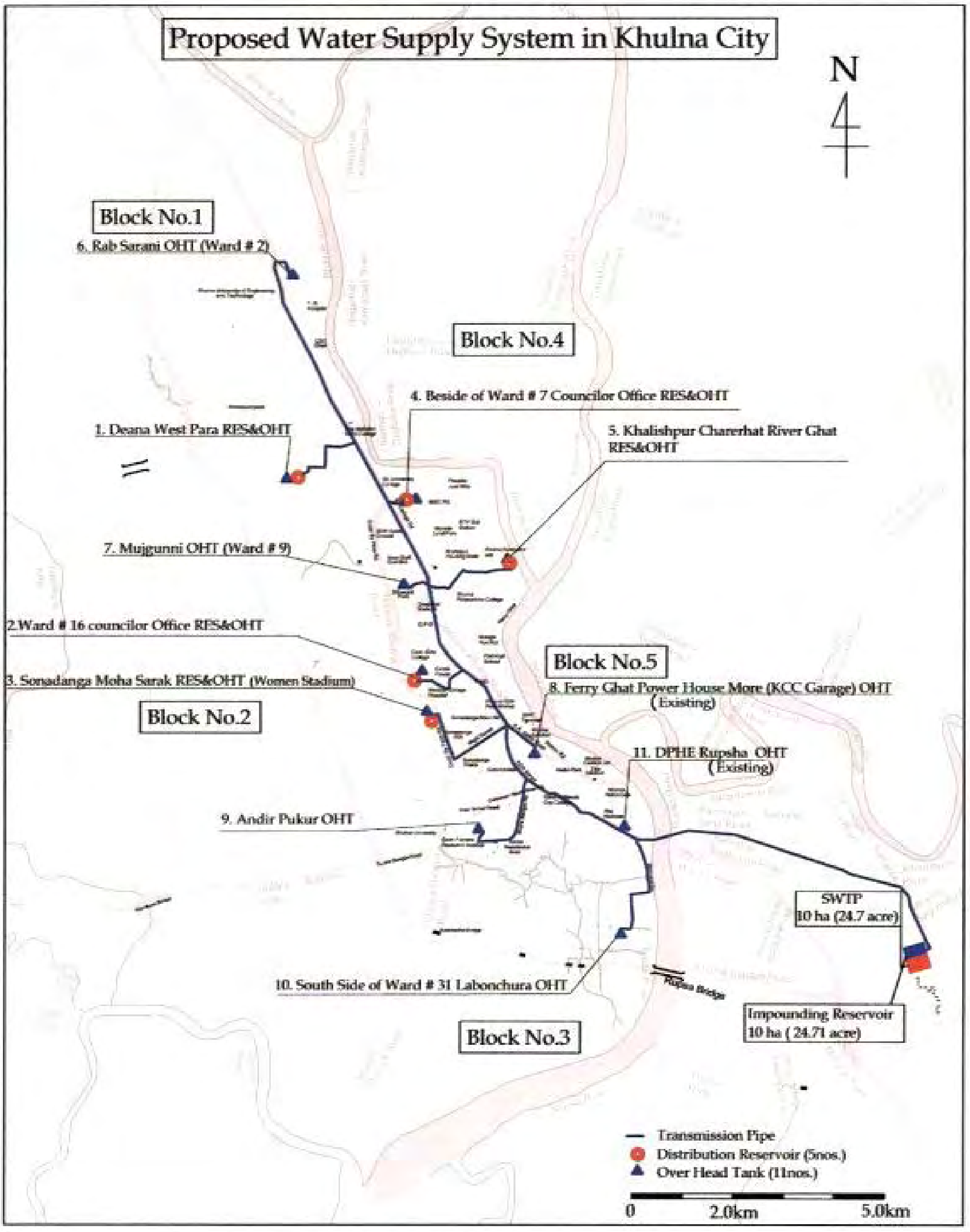


Figure 2 Proposed Project Location from SWTP/IR to OHT

6

Environmental Check List: 18. Water Supply (1) (Draft Final)

<table>
<tr><th>Category</th><th>Environmental Item</th><th>Main Check Items</th><th>Confirmation of Environmental Considerations</th></tr>
<tr><td rowspan="2">1 Permits and Explanation</td><td>(1) EIA and Environmental Permits</td><td>① Have EIA reports been officially completed?
② Have EIA reports been approved by authorities of the host country's government?
③ Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?
④ In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?</td><td>① An EIA study for the project was prepared and authorized by KWASA on November 2000 based on Environmental Conservation Rules (1997), DOE Environmental Guidelines for Industry(1997) and Guidelines for Environmental Assessment of Water Management (FCD/I) Projects 2005 WARPO.

②③DOE issued Site Clearance Certificate (SCC) for the project dated on 18th October 2010 to KWASA of which No. is DoE/Clearance/5021/2010/343 with terms and conditions by which the EIA has been elaborated.

All Environmental Clearance Certificate (ECC) application documents including the EIA reviewed by the DOE Khulna were transferred to DOE Head Office in Dhaka dated on 7th November 2010. On 24th November 2010, an Environmental Clearance Committee is scheduled to be convened at DOE HQ Office for evaluating the ECC application of KWASA in which a representative of KWASA will make a presentation on the project and environmental and social aspects to the committee member.

ECC will be issued with terms and conditions in which some recommendations will generally be discussed for the project implementation.

④ NOCs (No Objection Certificates) and Land use certificates for Mollalhat, Samanto Sena and KCC area were obtained from the District Commissioner's office, Bagerhat, District Commissioner's office, Khulna and KCC.</td></tr>
<tr><td>(2) Explanation to the Public</td><td>① Are contents of the project and the potential impacts adequately explained to the public based on appropriate procedures, including information disclosure? Is understanding obtained from the public?
② Are proper responses made to comments from the public and regulatory authorities?</td><td>① Stakeholders Meetings and Foucus Group Discussion were held at 5 different places of the 2 districts commencing from 21st August, 2010 during the field surveys. These public consultation meetings of the land owners, local elite and general members of the public were also attended on occasions by the City Mayor, ADC Revenue Bagerhat, Managing Director, KWASA, ADC (Land Acquisition) Khulna and the officials of JICA Study Team & KWASA including elected representatives, local leaders, women groups, representatives of professional groups like businessmen, farmers, teachers, religious leaders and public representatives as well as members and chairman of the Union and Upazila Councils and the consultant as shown in the following tables.

<table>
<tr><th>Date</th><th>Places</th><th>Local People</th><th>KWASA</th><th>JICA Team</th><th>Others</th><th>Total</th></tr>
<tr><td>12-08-2010</td><td>KWASA office</td><td>2</td><td>4</td><td>4</td><td>14</td><td>24</td></tr>
<tr><td>21-08-2010</td><td>Patharghata High School, Rupsha</td><td>150</td><td>3</td><td>3</td><td>3</td><td>159</td></tr>
</table>

<table>
<tr><th>Date</th><th>Places</th><th>Local People</th><th>KWASA</th><th>JICA Team</th><th>Others</th><th>Total</th></tr>
<tr><td>7-10-2010</td><td>Patharghata</td><td>7</td><td>1</td><td>1</td><td>-</td><td>9</td></tr>
<tr><td>9-10-2010</td><td>Samonto Sena Bazar</td><td>7</td><td>1</td><td>1</td><td>-</td><td>9</td></tr>
<tr><td>9-10-2010</td><td>Mollarhat Technical College</td><td>7</td><td>1</td><td>1</td><td>-</td><td>9</td></tr>
</table>
</td></tr>
</table>

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
			② Following shows KWAS respons for all comments from the stakeholders.

Focus Group Discussion at Patharghata

Profession	Issues Discussed/ Suggestion	KWASA Response
Farmer	Proper Compensation	Compensation
,,	Manage alternative land	Not beyond the Law
,,	Full compensation	Compensation
,,	Manage alternative land	Not beyond the Law
,,	Manage alternative land	Not beyond the Law
,	Manage alternative land	Not beyond the Law
Share cropper	Manage alternative land	Not beyond the Law

Focus Group Discussion at Samontosena Bazar

Profession	Issues Discussed/ Suggestion	KWASA Response
Ag/Shrimp	Proper compensation	Compensation
Up member	Under ground water extraction, rumor	Good response
Share cropper	Provide job	Under Consideration
Ag/Sharecropper	Livelihood damage	Under Consideration
Shrimp gher	They will be landless	Under Consideration
Shrimp gher	Proper compensation	Compensation
Farmer	Proper compensation	Compensation

Focus Group Discussion at Mollarhat Technical College

Profession	Issues Discussed/ Suggestion	KWASA Response
Chairman, Garfa UP	Land price should be at least upto market level, previous RHD rate was Tk.18,000 per decimal Demand of pure drinking water, the area is arsenic contaminated	Under Consideration
UP member	Proper compensation at market price	Compensation
College teacher	Full compensation and project for the community	Compensation
businessman	Timely and proper compensation	Compensation
Local elite	Public in getting payment shouldn't be harassed	Good idea
Service	Proper compensation	Compensation
Service	Proper compensation, road side land price is Tk.1,00,000	Under Consideration

It can be considered that these opinions from stakeholders concentrate mainly on the compensation for land acquisition and lives and livelihood (Noise, Air pollution during constructions and traffic management) which can be manageable as discussed in the EIA report.

Environmental Check List: 18. Water Supply (2) (Draft Final)

2 Mitigation Measures	(1) Air Quality	① Is there a possibility that chlorine from chlorine storage facilities and chlorine injection facilities will cause air pollution? Do chlorine concentrations within the working environments comply with the country's occupational health and safety standards?	①Using HOCl (hypochlorous acid as liquid substance) is proposed to be used for disinfection of water at SWTP and OHTs.
	(2) Water Quality	① Do pollutants, such as SS, BOD, COD contained in effluents discharged by the facility operations comply with the country's effluent standards?	① Effluent after river water treatment is planed to be met the national standards.
	(3) Wastes	① Are wastes, such as sludges generated by the facility operations properly treated and disposed of in accordance with the country's standards?	① The treatment sludge is periodically cleaned up from SWTP, which is dry up under the sunshine at several sludge drying beds, and then to the transfer it to a solid waste landfill site located in KCC to be used as covering soil for the site
	(4) Noise and Vibration	① Do noise and vibrations generated from the facilities, such as pumping stations comply with the country's standards?	A pump to be used for the water intake is constructed and installed in the facility building which is a standard structure seen in Bangladesh. In addition, according to KWASA there has been no complaint on the noise and vibrations cased by existing relevant facilities from public at all so far. Therefore, negative impact is not predicted.
	(5) Subsidence	① In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	No groundwater is pumped up in this project. River (surface) water is used for the project.
3 Natural Environment	(1) Protected Areas	① Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	- Proposed Intake facility is constructed on the river bed where has basically been used as agriculture purposes - Proposed raw water transmission pipe is constructed under the existing roads - Proposed SWTP and Impounding Reservoir are constructed in the existing farming and fish pond firm areas - Proposed clear water transmission pipe is constructed under the existing roads - Proposed OHT and Distribution tanks are constructed in KCC private and public lands No such protected area is identified at all proposed sites.
	(2) Ecosystem	① Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? ② Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? ③ If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? ④ Is there a possibility that the amount of water (e.g., surface water, groundwater) used by the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	①②③No such ecosystem is identified. ④Necessary water is planed to be pumped up from Madhumati River at Mollarhat. Capacity of the water intake facility is 110,000m^3/day (approximately 1.27 m^3/sec) by which adversely affect in the rive environment (of which river flow rate is considerably huge of about 400 m^3/sec) is not predicted.

Environmental Check List: 18. Water Supply (3) (Draft Final)

4 Social Environment	(1) Resettlement	① Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? ② Is adequate explanation on relocation and compensation given to affected persons prior to resettlement? ③ Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? ④ Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? ⑤ Are agreements with the affected persons obtained prior to resettlement? ⑥ Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? ⑦ Is a plan developed to monitor the impacts of resettlement?	①No physical resettlement is occurred by the project. Necessary lands to be acquired are paddy, fish cultivation lands and public lands. No involuntary resettlement is expected by the project. ②③④Land Acquisition Plan/Resettlement Action Plan (LAP&RAP) has been prepared in accordance with relevant laws and regulations in Bangladesh. In the course of LAP&RAP as well as EIA study, stakeholders meetings have been held accordingly. ⑤NOCs (No Objection Certificates) were issued by Bagharhat DC, Khulna DC and KCC. NOCs are issued after the necessary agreements to be taken. ⑥⑦EIA and LAP&RAP repots discuses such a organizational framework based on relevant laws on land acquisition ⑦EIA and LAP&RAP repots discuses Environmental Monitoring Plan including social aspect.
	(2) Living and Livelihood	① Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? ② Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect the existing water uses and water area uses?	①No such impact is predicted. But during the construction stage some minor impacts (such as dust noise, vibration generation and traffic control management in especially narrow road and market areas with short period) are predicted in EIA report. Against the impacts, the EIA discuss several countermeasures which can be reduced by the required relevant construction norms in Bangladesh and public consultations and so on. ②Necessary water is planed to be pumped up from Madhumati River at Mollarhat. Capacity of the water intake facility is 110,000m^3/day (approximately 1.27 m^3/sec) by which adversely affect in the rive environment (of which river flow rate is considerably huge of about 400 m^3/sec) is not predicted.
	(3) Heritage	① Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage sites? Are adequate measures considered to protect these sites in accordance with the country's laws?	- Proposed Intake facility is constructed on the river bed where has basically been used as agriculture purposes - Proposed raw water transmission pipe is constructed under the existing roads - Proposed SWTP and Impounding Reservoir are constructed in the existing farming and fish pond firm areas - Proposed clear water transmission pipe is constructed under the existing roads - Proposed OHT and Distribution tanks are constructed in KCC private and public lands No such, archeological, historical, cultural, and religious heritage sites are identified at all proposed sites.
	(4) Landscape	① Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	- Proposed raw and clear transmission pipes are constructed under the existing roads - Proposed intake facility is constructed in a semi basement structure and all facility of pump and other equipment are set inside the structure. - Proposed SWTP and Impounding Reservoir are excavated the existing paddy and fish cultivating area in which some embankment and green plantation zone are planed to be constructed. - Proposed transmission reservoirs are constructed in a semi basement structure and covered - Proposed OHTs which are planed to be constructed in KCC area are general

			structure and common figure seen in most of the urban areas.

Environmental Check List: 18. Water Supply (4) (Draft Final)

4 Social Environment	(5) Ethnic Minorities and Indigenous Peoples	① Does the project comply with the country's laws for rights of ethnic minorities and indigenous peoples? ② Are considerations given to reduce the impacts on culture and lifestyle of ethnic minorities and indigenous peoples?	No such person is identified in the project sites.
5 Others	(1) Impacts during Construction	① Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? ② If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? ③ If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? ④ If necessary, is health and safety education (e.g., traffic safety, public health) provided for project personnel, including workers?	① Most of the noise and vibration are generated from vehicles and heavy equipment during construction stage. In Bangladesh there is an environmental standard of Noise and Vibration. The present situation in Noise level monitored in the EIA study in Rupsha River construction project shows that the noise levels monitored around the project site in KCC area were over the standard noise (See Chapter 4 of the EIA report). However, based on relevant laws and regulations reviewed in Chapter 2 of the EIA report, Chapter 6 in the EIA recommends on Noise and vibration as follows. - To avoid local traffic impact, time restriction for construction and diversion routes (if necessary) shall be considered. - Selecting 'quiet' working methods and use of low noise equipment must be specified in construction contract tender documents (See Chapter 2 of the EIA report) - Construction activities should not take place at night times due to noise (See Chapter 2 of the EIA report). If this is absolutely unavoidable, the contractor shall advise/ consult with local community leaders. - Local community should be consulted beforehand and reach an agreement over appropriate timing for noisy activities. - Working hour's duration is mention in Chapter2 of the EIA report; special cases can be done with consult with KWASA and local authorities and public consultation. Based on the law and regulations shown in and above measures discussed in Chapter 2 of the EIA, it is evaluated that noise and vibration impact can be managed accordingly. In addition, a pump to be used for the water intake is constructed and installed in the facility building which is a standard structure seen in Bangladesh. In addition, according to KWASA there has been no complaint on the noise and vibrations cased by existing relevant facilities from public at all so far. Same as Noise and Vibration above, the principal air quality impacts will arise from dust generation from excavation of soil, pipe laying and vehicle movement during construction stage. Heavy vehicles may cause exhaust gas emissions, but these impacts are temporary and for short duration in the construction stage most of which will diffuse into environment especially in the Intake Facility site, the Highway and roads for pipe laying and SWTP and Impounding reservoir where the location of relatively open air rural areas. Based on relevant laws and regulations reviewed in Chapter 2 of the EIA report, Chapter 6 in the EIA recommends on the Air pollution as follows.

Environmental Check List: 18. Water Supply (5) (Draft Final)

			- Excavated materials, stockpiles and haul roads shall be dampened with water spraying during dry ambient conditions; - Vehicle speed restrictions shall be imposed to reduce dust generation and dispersion; - Transport vehicles shall not be overloaded, - Transport vehicles shall be covered by triple/plastic - Periodical maintenance of the vehicle should be ensured. - Visual inspections of equipment and vehicles shall be conducted on a periodical basis to ensure no excessive emissions of black smoke (see Chapter 2 of the EIA report). - Education to the driver to keep traffic regulation and manner. Based on the law and regulations shown in and above measures discussed in Chapter 2 of the EIA, it is evaluated that air pollution caused by the construction can be managed accordingly. ② No large scale excavation such as dam construction for hydroelectric power generation is proposed, and there is no specifies ecosystem in the project area, therefore no impacts on ecosystem is predicted. ③Raw and Clear water Transmission Pipes are proposed to be constructed under the existing roads. During the construction, a traffic management plan and all the relevant information is shared with the relevant official entities such as BIWTA, BWDB RHD, LGED, KCC, KDA DPHE and so on. These entities shall react in order to maintain the traffic flow and collaborate with Traffic Police department in each Upazila and KCC. In this regard, the EIA report identifies the impacts and mitigation measures on the following critical points, which can be considered as the most appropriate manners for the possible impacts (See Chapter 6 of the EIA report). - River, Canal, Box Culvert, Bridge Crossing, Market Place (for raw water transmission pipe) - Narrow Road Section (for raw/clear water transmission pipes) - Water Canal Management (for especially Impounding reservoir and SWTP site) - Transportation / Traffic Management and Truck Use (for all project sites) - Interference with Navigation /Fisheries (for all project sites) - Transportation and Traffic Congestion (for project components in KCC) - Railway crossing (for project components in KCC) Therefore, KWASA shall follow the recommendations in the EIA regarding Traffic Management. As well, contractors to be selected shall be responsible for showing all the safety signs and other related information regarding traffic management.

Environmental Check List: 18. Water Supply (6) (Draft Final)

			④As reviewed in Chapter 2 of the EIA report, Bangladesh Labour Law 2006 stipulates working environment, work place conditions and sanitary facilities for the workers. Based on the law and relevant regulation reviewed in Chapter 2 of the EIA, Chapter 6 in the EIA recommends the followings. - Protective clothing, earplug, hamlets, shoes and accessories (PPE) should be provided to the workers, who would be subjected to adverse safety situation. - Adverse impact on worker's safety would be minimized by implementing an occupational health and safety training program (see Chapter 2 of the EIA report). - Periodically medical check-up would be done to ensure the soundness of health of employees and workers (see Chapter 2 of the EIA report). - Periodically health education to labours, drivers shall be done especially HIV/AIDS issues. Based on the law and regulations shown in and above measures discussed in Chapter 2 of the EIA, it is evaluated that workers are protected and educated accordingly.
	(2) Monitoring	① Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? ② Are the items, methods and frequencies included in the monitoring program judged to be appropriate? ③ Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? ④ Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	① Environmental and social monitoring systems are discussed in EIA and LAP&RAP. KWASA authorized the EIA and shall follow the relevant recommendations in EIA and LAP&RAP in accordance with relevant laws and regulations in Bangladesh. ②The EIA report recommends an monitoring framework in consideration of a PIU and a new KWASA organization chart discussed in the JICA F/S Study report. ③④ With an ECC to be issued by DOE, there will be terms and conditions in which monitoring items and frequency may generally be recommended by Environmental Conservation Rules as well as based on the evaluation of the EIA report and proposed project nature by an Environmental Evaluation Committee to be held in DOE Head Office.
6 Note	Note on Using Environmental Checklist	① If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	Not Applicable

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are made, if necessary.

In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan' experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

CHAPTER 11 IMPLEMENTATION PLAN

11.1 Project Summary

This section presents project implementation plan and schedule for Khulna Water Supply Improvement Project in the People's Republic of Bangladesh. Components of the Project are shown in **Table 11.1.1**.

Table 11.1.1 Project Components

No.	Facility Name	Capacity	Quantity	Remarks
1	Water Intake	110,000 m^3/d	1 nos.	
2	Raw Water Transmission Pipe	-	ϕ 1350mm, L=33km	
3	Impounding Reservoir	775,200 m^3	1 nos.	
4	SWTP	110,000 m^3	1 nos.	
5	Clear Water Transmission Pipe	-	ϕ 300-1100mm, L=25km	
6	Distribution Reservoir		Total 5 nos.	
6.1	Deana West Para Reservoir	8,000 m^3		
6.2	Ward No.16 Office Reservoir	9,000 m^3		
6.3	Sonadanga Moha Sarak Reservoir	18,000 m^3		
6.4	Beside of No.7 Ward Office Reservoir	5,000 m^3		
6.5	Khalishpur Charehat River Ghat Reservoir	15,000 m^3		
7	Overhead Tank (OHT)		Total 11 nos.	
7.1	Deana West Para OHT	300 m^3		
7.2	Ward No.16 Office OHT	300 m^3		
7.3	Sonadanga Moha Sarak OHT	500 m^3		
7.4	Beside of No.7 Ward Office OHT	500 m^3		
7.5	Khalishpur Charehat River Ghat OHT	500 m^3		
7.6	Rab Sarani OHT	300 m^3		
7.7	Mujgunni OHT	300 m^3		
7.8	Ferry Ghat Power House OHT	300 m^3		
7.9	Andir Pukur OHT	500 m^3		
7.10	South Side of Ward No.31 Office OHT	500 m^3		
7.11	DPHE Rupsha OHT	500 m^3		
9	Distribution Pipe Network	-	ϕ 50-400mm, L=700km	
10	Service Pipe	-	90,000 nos.	

11.2 Project Implementation Schedule

The expected overall schedule is shown in **Figure 11.2.1**. In preparation of the overall schedule, following schedule is considered for pre-construction and construction stage.

Pledge of JICA Loan	February 2011
Exchange of Note between GOB and GOJ	March 2011
Signing of Loan Agreement	March 2011
Selection of consultant for Designing and PMC[1]	9 months
Detailed Engineering Design, Preparation of specifications	9 months
Contractor Prequalification (P/Q), evaluation and JICA concurrence	3 months
Tender documents for individual project components, JICA concurrence on tender documents	3 months
Project Tender period	2 months
Evaluation of contractor proposals	2 months
JICA concurrence on tender evaluation (Contractor proposals)	1 month
Contract negotiation	1.5 months
JICA concurrence on contract award	0.5 month
L/C Issuance for project	1 month
Total period of Construction Work	36 months
Completion of the Project and Plant trails	June 2016
O&M Training	12 month (July 2016 to June 2017)

The construction periods of major sub-projects are assumed and summarised as follows considering the size of the project and work volume and workability.

JICA Loan	Package 1	Water Intake Facility	24 months
		Raw Water Transmission Pipe	12 months
	Package 2	SWTP	36 months
		Impounding Reservoir	12 months
ADB Loan	Package 3	Clear Water Transmission Pipe	36 months
		Distribution Reservoir	24 months
	Package 4	Overhead Tank	24 months
		Distribution Pipe and Service Pipe	36 months

1 PMC: Project Management Consultant

Implementation Schedule

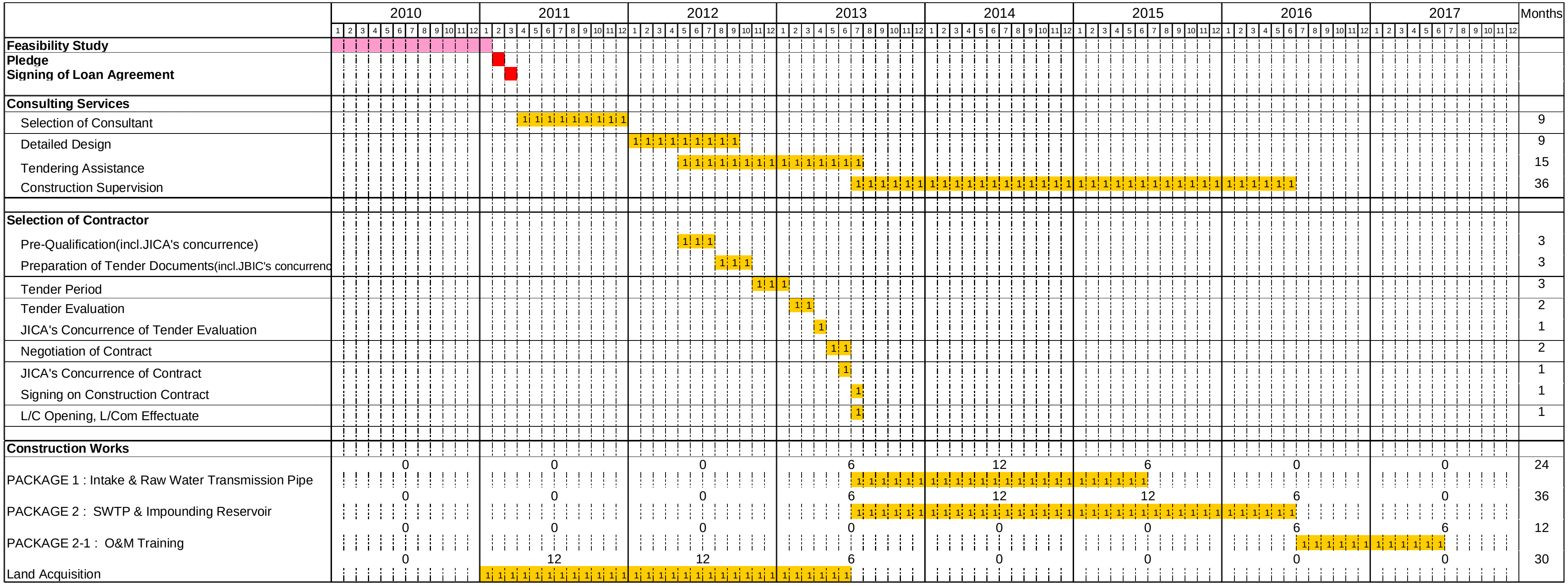


Figure 11.2.1 Implementation Schedule (Package 1 & 2)

11.3 Implementation Method

11.3.1 Packaging for the Project Components

Construction packaging for the Project is one of the most important factors for smooth implementation of all the components.

Construction works of the surface water treatment Plant will need several kind of expertise such as civil, structural, mechanical, electrical and instrumental works. Coordination management among these works will be inevitable. Time for such coordination management will influence the time of completion. Mechanical and electrical works will be carried out after the most of the structures have been completed. Careful arrangement in corporate with civil and architectural works will be required for installation of mechanical and electrical equipment.

From the aspect of construction supervision and management, a project management consultant (PMC) will be required for review of contractors' substantial, organize progress meetings, schedule factory inspection, certification of accomplishment, maintain quality control, and preparation of documents for payment.

Under the JICA ODA loan procedures, the contract package shall be concurred by JICA for each stage of prequalification evaluation, tender evaluation, and contract. In principle, under the JICA ODA loan procedure, tendering shall be done as International Competitive Bidding (ICB).

Proposed contract packages, 2 packages for the JICA ODA loan, in the Project are shown in **Table 11.3.1**.

Table 11.3.1 Proposed Contract Packages for the Project Components

No	Work	Contents	Construction Cost	Remarks
Package -1	(a) Water Intake Facility	1 intake facility	6,968 million yen = 5,665 million TK = 81.50 million US$	ICB
	(b) Raw water Transmission Pipe	Pipe Diameter: 1,350mm Length: 33 km		
Package -2	(a) SWTP	110,000m^3/d	5,504 million yen = 4,474 million TK = 64.37 million US$	ICB
	(b) Impounding Reservoir	Reservoir volume: 775,200 m^3		

Packages which conducted by ADB loan will be done following ADB guideline hence the schedules and approval procedures will be different.

11.3.2 Process of Project Implementation

Implementation of the Project will consist of the six major processes:

1) Preparation of finances
2) Selection of consultants for detailed design and PMC

3) Preparation of tender documents and detailed design
4) Tender of build-operate contractors/consortiums
5) Construction and commissioning
6) Supervision of O&M activities for the initial year by consultant (advisory role)

Selection of the consultants will need to be conducted by KWASA in accordance with the JICA/ADB Guidelines and PPR-2008[2]. Selection process of the consultant will have to be initiated as soon as possible after the commitment for the finance is made by the Japanese side. Preparation of tender documents and detailed design will be carried out by the consultants to be selected and employed by KWASA. Conditions applied in the tender documents will have to meet the requirements in the JICA/ADB Guidelines and PPR-2008. JICA/ADB normally requires that the procurement of goods and services will be obtained through ICB. Construction will therefore be carried out by the contractor/s awarded the contract through the ICB method.

The construction works of the contractor/s will need to be regularly inspected and supervised, normally by the consultants employed by KWASA.

11.3.3 Method of Detailed Design for Major Facilities

Major differences in these two methods are described as follows:

(1) Construction as designed

Contractors are issued for the detailed drawings to construct the facilities designed by the Employer and/or consultants. Construction will follow the detailed dimensions and specifications which are stipulated in the tender documents. Liability of the contractor will be limited to quality of the construction work as long as the facilities are built as designed. Preparation of design drawings will take a longer time compared with the design-build method.

(2) Design-build concept

Tender documents and drawings stipulate the minimum requirements for construction. Contractors will have flexibility in construction details. However, they are subject to approval by the client and its consultant. As the structural design is normally carried out by the Contractor, time for the preparation of the tender document will be shortened. The Contractor should be should be liable his design. Duration of the detailed design will solely depend on the grade of design. Preparation of the tender drawings in full details will take longer time while introduction of the "design-build (turn-key) concept" will shorten the time for the design stage.

However, with the advantages of the design-build (turn-key) concept, there are several issues need to be considered in the design-build concept. These issues are important for mitigation of the unnecessary time wastage during the construction period to be spent for review and revision of the design submitted

[2] PPR-2008: Public Procurement Rules in Bangladesh 2008

by the Contractor.

11.3.4 Subjects to be considered in the Detail Design Stage

The conceptual design for the proposed components presented in this report are prepared with design concepts as described in **Chapter 7**. Details of the conceptual design were prepared to the extent possible for budgetary purposes.

In the detailed design of each component, flexibility should be allowed to reduce, to the extent possible, civil construction, electrical and mechanical costs, and O&M costs and encourage the usage of suitable materials and input consistent with local conditions as long as the water supply systems conform to the basic requirements of design, treatment capacity and supply standards.

There are several issues to be considered in the design stage from both technical and economical points of view as described below:

(1) Participation of local consultants

Participation of local consultants is necessary for technology transfer from the foreign consultants. Local consultants will also be able to contribute to make economical design since they are familiar with local practices for construction works and locally available materials and equipment in Bangladesh.

(2) Approval of detailed design

During the design stage, engineering consultants appointed for the Project should be required to submit sufficient details for their design prior to the preparation of the final design and specifications.

(3) Process design

Process design will have to be determined considering not only technical aspects of operation but also cost-effective aspects. In the conceptual design by the JICA Study Team, intake facility, raw water transmission pipes, SWTP, impounding reservoir, treated water transmission pipes, reservoirs, and overhead tanks are planed in generally accepted shapes. The detailed alignment and each treatment unit, etc. will have to be determined considering the total costs for pipelines, structures and equipment.

(4) Specifications

Specifications are to be developed by the design/PMC consultants to make contractors develop adequate confidence in preparing; costs for construction, equipment and O&M; ease of O&M; availability of services; etc. in the design stage to select the best fit the conditions of the Project. Any equipment and machinery as well as material required for construction that is available and best fit condition.

11.3.5 Procurement Method

The construction materials for civil works such as concrete, RC pile, sand, gravel, brick, reinforcement bar, sheet pile can be procured in Bangladesh by the Contractor as per specifications in tender document..

Pipe material such as DIP is imported from suitable countries through ICB. Construction machinery such as excavator, pile driver, dump truck and bulldozer except a pipe jacking machine can be leased in Bangladesh. Major mechanical equipment such as pumps, chemical dosing equipment and valves can be imported from suitable countries. Electrical equipment such as control panels, transformer and generator can be imported from suitable countries. While minor items such as cables can be procured in Bangladesh if the specification is fulfilled.

11.3.6 Implementing Organization

KWASA will be the primary agency responsible for executing and supervising the Project. Proposed project management unit (PMU) in KWASA is shown in **Figure 11.3.1**.

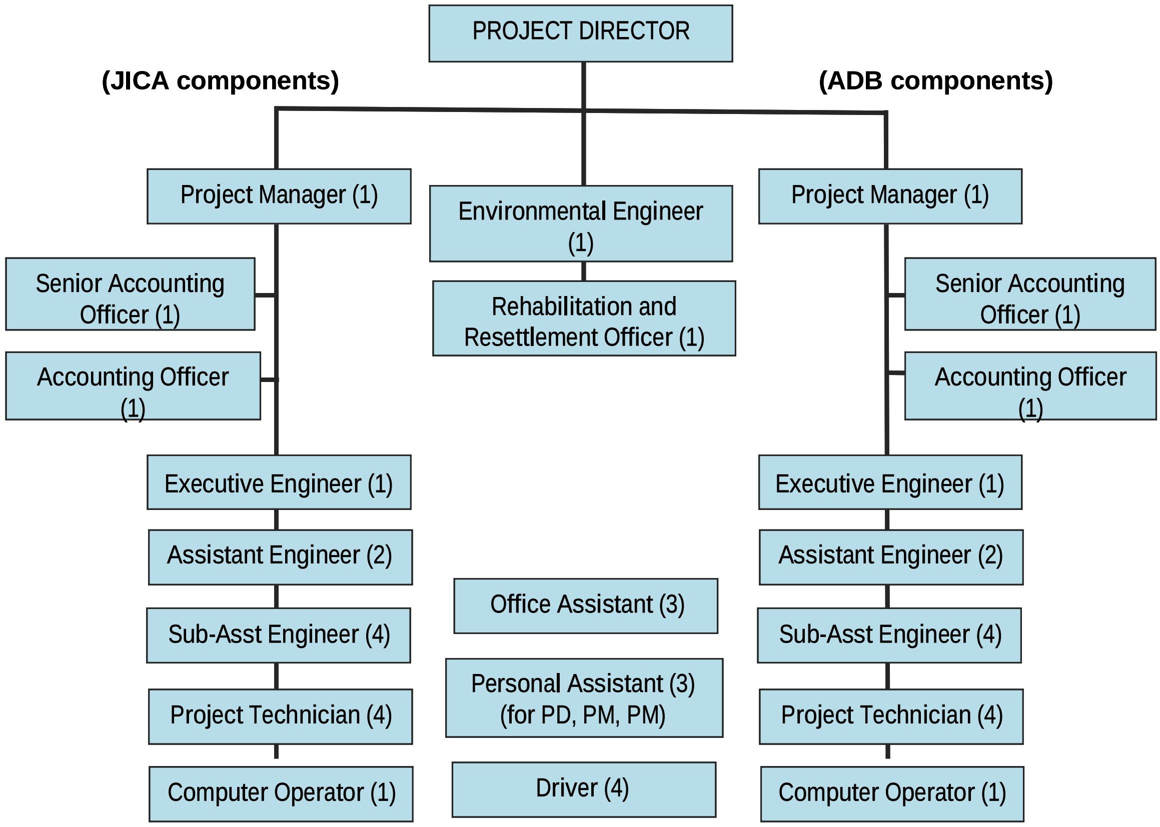


Figure 11.3.1 Proposed Management Unit in the KWASA Organization

11.4 Consulting Services

11.4.1 Terms of Reference

(1) Consulting Service for Detail Design and Project Management

KWASA shall procure consultant services for design of detail of Khulna water supply project and consultant shall consist of both international and local consultants.

It consists of detailed engineering design of the water intake, raw water transmission pipe line, SWTP, impounding reservoir, all other related works including road and pipe water bridges. It will include preparation of detail technical specification and tender document for the (1) water intake & raw water transmission pipe, (2) SWTP & impounding reservoir, leading to project implementation.

KWASA shall procure services of Project Management Consultants (PMC) for the management of Khulna water supply project and PMC shall consist of both international and local consultants.

Details of Terms of Reference for Consulting Service for Detail Design and Project Management are shown in **Appendix 11.4**.

11.4.2 Cost Estimates for Consulting Services

Total cost estimates for consulting services of the Detail Design and Project Management Service for the Package 1&2 project is approximately 929 million yen (Foreign portion: 495 million yen, Local portion: 353 million Taka). This total cost of Detail Design and Project Management Service includes total of 573 man-months of foreign and local engineers and 328 man-months of additional supporting staffs. The expected cost breakdown of the consulting services is shown in **Table 11.4.1** for the Detailed Design Consultant Services and Project Management Services.

Table 11.4.1 Expected Cost Breakdown of Consulting Services

US$ = 85.5 Yen, TK = 1.23 Yen

	Unit	Q'ty	Foreign Portion (Yen)		Local Portion (TK)		Combined Total (Yen)	Combined Total (TK)
			Ave. Rate	Amount	Ave. Rate	Amount		
A Remuneration								
1) Foreign Professional	M/M	174	2,632,759	458,100,000			458,100,000	372,439,024
2) Local Professional	M/M	399			330,702	131,950,000	162,298,500	131,950,000
3) Supporting Stuff	M/M	328			138,796	45,525,000	55,995,750	45,525,000
Sub-Total of A		901		458,100,000		177,475,000	676,394,250	549,914,024
B Direct Cost								
1) International Airfare	times	74	500,000	37,000,000			37,000,000	30,081,301
2) Domestic Airfare	times	100			7,000	700,000	861,000	700,000
3) Accommodation Allowance							0	0
Foreign Professional	M	174			350,000	60,900,000	74,907,000	60,900,000
Local Professional	M	399			100,000	39,900,000	49,077,000	39,900,000
Supporting Stuff	M	328			50,000	16,400,000	20,172,000	16,400,000
4) Topographic & Soil Survey	Ls	1				9,000,000	11,070,000	9,000,000
5) Vehicle Rental	M	156			160,000	25,013,333	30,766,400	25,013,333
6) Office Rental	M	51			150,000	7,650,000	9,409,500	7,650,000
7) International Communications	M	51			150,000	7,650,000	9,409,500	7,650,000
8) Domestic Communications	M	51			50,000	2,550,000	3,136,500	2,550,000
9) Office Supply	M	51			50,000	2,550,000	3,136,500	2,550,000
10) Office Furniture and Equipment	Ls	1				2,000,000	2,460,000	2,000,000
11) Report Preparation	nos	1340			1,000	1,340,000	1,648,200	1,340,000
Sub-Total of B				37,000,000		175,653,333	253,053,600	205,734,634
Total				**495,100,000**		**353,128,333**	**929,447,850**	**755,648,658**

11.5 Cost Estimates

11.5.1 Condition and Assumptions for Cost Estimates

Following conditions were assumed for cost estimates:

(1) Cost for Construction

1)	Base Year	November, 2010
2)	Exchange Rate	1 Taka = 1.23 Japanese Yen 1 USD = 69.4 Taka 1 USD = 85.5 Japanese Yen
3)	Price Escalation Rate per annum	Foreign Currency = 1.8%, Local Currency = 4.8%
4)	Physical Contingency	5%

(2) Administration Cost and Service Tax

1)	Administration Cost	Appropriated for ADB loan and GOB
2)	VAT for local currency	15% (of the expenditure in local currency of the eligible portion)
3)	VAT for foreign currency	15% (of the expenditure in foreign currency of the eligible portion for Consulting Service)
4)	Import tax	30% (of the expenditure in foreign currency of the eligible portion for Procurement/Construction)

11.5.2 Capital Costs

A summary of capital cost is tabulated in as follows in **Table 11.5.1** and annual fund requirement for Package-1&2 (JICA Project) are tabulated in **Table 11.5.2**. Breakdown of construction cost is shown in **Appendix 11.5**.

Table 11.5.1 Summary of Capital Cost

Item		Total FC	Total LC	Total
A. ELIGIBLE PORTION				
I)	Procurement / Construction	10,296	3,526	14,634
	PACKAGE 1 : Intake & Raw Water Transmission Pipe	5,525	1,173	6,968
	PACKAGE 2 : SWTP & Impounding Reservoir	3,521	1,571	5,454
	PACKAGE 2-1 : O&M Training	50	0	50
		0	0	0
	Base cost for JICA financing	9,096	2,745	12,472
	for Construction	9,096	2,745	12,472
	for Procurement	0	0	0
	Price escalation	710	614	1,465
	for Construction	710	614	1,465
	for Procurement	0	0	0
	Physical contingency	490	168	697
	for Construction	490	168	697
	for Procurement	0	0	0
II)	Consulting services	552	441	1,095
	Base cost	495	353	929
	Price escalation	31	67	114
	Physical contingency	26	21	52
Total (I +II)		10,849	3,968	15,729
B. NON ELIGIBLE PORTION				
a	Land Acquisition	0	268	330
	Base cost	0	234	288
	Price escalation	0	21	26
	Physical contingency	0	13	16
b	Administration cost	0	0	0
c	VAT (1)	0	595	732
e	VAT (2)	0	67	83
d	Import Tax	0	2,511	3,089
Total (a+b+c+d+e)		0	3,442	4,233
TOTAL (A+B)		10,849	7,410	19,963
C. Interest during Construction		5	0	5
GRAND TOTAL (A+B+C)		10,854	7,410	19,968

Table 11.5.2 Annual Fund Requirement for Package-1&2 (JICA Project)

Base Year For Cost Estimation:		October, 2010			FC & Total:	million JPY
Exchange Rates	Tk	= yen 1.23			LC :	million Tk
Price Escalation:	FC:	1.8%	LC:	4.8%		
Physical Contingency	5%					
Physical Contingency for Consultant	5%					

Item	Total			2011			2012			2013			2014			2015			2016			2017		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION																								
I) Procurement / Construction	10,296	3,526	14,634	0	0	0	0	0	0	2,180	671	3,005	4,439	1,407	6,169	2,933	1,085	4,267	715	364	1,163	30	0	30
PACKAGE 1 : Intake & Raw Water Transmission Pipe	5,525	1,173	6,968	0	0	0	0	0	0	1,381	293	1,742	2,763	587	3,484	1,381	293	1,742	0	0	0	0	0	0
PACKAGE 2 : SWTP & Impounding Reservoir	3,521	1,571	5,454	0	0	0	0	0	0	587	262	909	1,174	524	1,818	1,174	524	1,818	587	262	909	0	0	0
PACKAGE 2-1 : O&M Training	50	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	25	25	0	25
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Base cost for JICA financing	9,096	2,745	12,472	0	0	0	0	0	0	1,968	555	2,651	3,936	1,110	5,302	2,555	817	3,560	612	262	934	25	0	25
for Construction	9,096	2,745	12,472	0	0	0	0	0	0	1,968	555	2,651	3,936	1,110	5,302	2,555	817	3,560	612	262	934	25	0	25
for Procurement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Price escalation	710	614	1,465	0	0	0	0	0	0	108	84	211	291	229	573	238	216	504	69	85	174	3	0	3
for Construction	710	614	1,465	0	0	0	0	0	0	108	84	211	291	229	573	238	216	504	69	85	174	3	0	3
for Procurement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical contingency	490	168	697	0	0	0	0	0	0	104	32	143	211	67	294	140	52	203	34	17	55	1	0	1
for Construction	490	168	697	0	0	0	0	0	0	104	32	143	211	67	294	140	52	203	34	17	55	1	0	1
for Procurement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
II) Consulting services	552	441	1,095	0	0	0	237	136	405	62	47	120	90	98	211	112	106	243	50	54	117	0	0	0
Base cost	495	353	929	0	0	0	218	118	363	56	39	104	80	77	175	98	80	196	43	39	91	0	0	0
Price escalation	31	67	114	0	0	0	8	12	22	3	6	10	6	16	25	9	21	35	5	13	20	0	0	0
Physical contingency	26	21	52	0	0	0	11	6	19	3	2	6	4	5	10	5	5	12	2	3	6	0	0	0
Total (I +II)	10,849	3,968	15,729	0	0	0	237	136	405	2,242	719	3,126	4,529	1,504	6,379	3,045	1,191	4,510	765	418	1,280	30	0	30
B. NON ELIGIBLE PORTION																								
a Land Acquisition	0	268	330	0	103	127	0	108	133	0	57	70	0	0	0	0	0	0	0	0	0	0	0	0
Base cost	0	234	288	0	94	115	0	94	115	0	47	58	0	0	0	0	0	0	0	0	0	0	0	0
Price escalation	0	21	26	0	5	6	0	9	11	0	7	9	0	0	0	0	0	0	0	0	0	0	0	0
Physical contingency	0	13	16	0	5	6	0	5	6	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0
b Administration cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c VAT (1)	0	595	732	0	0	0	0	20	25	0	108	133	0	226	278	0	179	220	0	63	77	0	0	0
e VAT (2)	0	67	83	0	0	0	0	29	36	0	8	9	0	11	14	0	14	17	0	6	8	0	0	0
d Import Tax	0	2,511	3,089	0	0	0	0	0	0	0	532	654	0	1,083	1,332	0	715	880	0	174	215	0	7	9
Total (a+b+c+d+e)	0	3,442	4,233	0	103	127	0	157	194	0	704	866	0	1,319	1,623	0	908	1,116	0	243	299	0	7	9
TOTAL (A+B)	10,849	7,410	19,963	0	103	127	237	293	598	2,242	1,422	3,991	4,529	2,823	8,002	3,045	2,098	5,626	765	662	1,579	30	7	39
C. Interest during Construction	5	0	5	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	0	1	1	0	1
GRAND TOTAL (A+B+C)	10,854	7,410	19,968	0	103	127	237	293	598	2,242	1,422	3,991	4,530	2,823	8,003	3,047	2,098	5,628	767	662	1,581	31	7	40

Administration Cost = 0.0% of the Eligible portion
VAT (1) = 15% of the expenditure in local currency of the eligible portion
VAT (2) = 15% of the expenditure in foreign currency of the eligible portion for Consulting Service
Import Tax= 30% of the expenditure in foreign currency of the eligible portion for Procurement / Construction

Price Escalation

	2011 FC	2011 LC	2012 FC	2012 LC	2013 FC	2013 LC	2014 FC	2014 LC	2015 FC	2015 LC	2016 FC	2016 LC	2017 FC	2017 LC
Price Escale	1.018	1.048	1.036324	1.098304	1.054978	1.151023	1.073967	1.206272	1.0932988	1.2641727	1.1129782	1.324853	1.133012	1.388446
d Price Escal	0.018	0.048	0.036324	0.098304	0.054978	0.151023	0.073967	0.206272	0.0932988	0.2641727	0.1129782	0.324853	0.133012	0.388446

Loan interest during const.
Financing rate 100.0%
Interest rate for YEN loan 0.01%

	Total	2011 FC	2011 Total	2012 FC	2012 Total	2013 FC	2013 Total	2014 FC	2014 Total	2015 FC	2015 Total	2016 FC	2016 Total	2017 FC	2017 Total
Temporally allocation	19,963	0	0	0	0	3,005	3,005	6,169	6,169	4,267	4,267	1,163	1,163	30	30
Debt at the end of term		0		0		3,005		9,175		13,442		14,607		14,638	
Interest during const		0		0		0		1		1		1		1	

11.5.3 O&M Costs

These costs will be represented anticipated yearly expenditures for Personnel Expense, Power Cost, Chemical Cost and Maintenance & Others.

Annual operation and maintenance cost is estimated 3,080 thousand US$. Breakdown of O&M cost is shown in **Table 11.5.4**.

Table 11.5.4 Breakdown of Annual O&M Costs

O&M Cost Items	O&M Cost (US$/year)
- Personnel Expense	357,000
- Power Cost	1,748,000
- Chemical Cost	695,000
- Maintenance & Others (10% of above)	280,000
Total	**3,080,000**

11.6 Performance Indicators

Performance indicators or performance monitoring indicators are measures for monitoring of inputs, outputs, outcomes, and impacts of a project. They are monitored during project implementation to assess project progress toward project objectives, and for evaluation of project accomplishments after project implementation. KWASA, the JICA Study Team and ADB TA Study Team (TA 738-BAN Preparing the Khulna Water Supply) discussed how to monitor the performance of KWASA, and the agreed indicators will be included in the KWASA Business Plan 2011 to 2017 prepared by KWASA and ADB's TA Study Team.

According to the identified and agreed indicators up to 2016, in 2018 i.e. two years after the completion of the project implementation and in 2025 i.e. the project target year, the indicators are assumed as shown in the following table (Some figures in the table are different from what described former chapters; however, those will not affects anything to the project components).

Table 11.6.1 Performance Indicators

Indicator	2010	2016	2018	2025	Remarks
Water coverage (%)	24.1	57.0	62.3	73.5	
Population served	273,555	633,778	766,667	977,089	
NRW ratio (%)	36	25	20	20	
Water produced (m^3/day)	30,100	68,320	121,070	167,950	
Water sold (m^3/day)	29,640	68,110	105,440	167,500	
Meter coverage (%)	0	0	100	100	
Billing ratio (%)	84	100	100	100	
Rate of facility utilization (daily average, %)	0	51	59	100	Surface water

CHAPTER 12 RECOMMENDATIONS

KWASA, the JICA Study Team and ADB TA Study Team discussed about the issues to be clarified to confirm the sustainable management of KWASA in future. In this context, the recommendations of the JICA Study and ADB Study have become almost same. Following proposed programs are agreed to be conducted, in addition to the new project, from which investment will come from both JICA and ADB based on this Study.

12.1 Sustainable Groundwater Extraction Plan

All groundwater production development entails digging of new tube wells, which KWASA plans to implement with funding from GOB. This tube well development program needs to be well planned and systematically implemented, considering that supply from these wells will be connected to the ground reservoirs. To ensure an organized installation of production tube wells, a special technical enforcement programme will be necessary to support KWASA, if required.

As to the water quality of groundwater, the result JICA Study Team survey suggests that some groundwater samples extracted from existing tube wells contain iron and manganese that exceed slightly the allowable limit. To plan and design the additional tube wells, this water quality situation shall also be taken into consideration.

There is a need to support KWASA, through a technical assistance program, to design and implement a sustainable groundwater extraction plan. Towards this end, three specialists shall be assigned: Water Supply Specialist, a Groundwater Specialist and a Water Quality Specialist periodically within three years as follows.

	2011		2012		2013		Remarks
Water Supply Specialist	■				■		12 MM
Groundwater Specialist	■		■		■		18 MM
Water Quality Specialist	■				■		12 MM

12.2 Poverty Reduction Plan

KWASA intends to incorporate measures for inclusive service coverage of the poor and vulnerable households in low income and slum communities. This will include the implementation of a Gender Action Plan (GAP) and Poverty Reduction Strategy (PRS) as an integrated component of KWASA operating plan. The Poverty Reduction Strategy and Gender Action Plan will institutionalize the beneficiary-driven approach for sustainable social development interventions particularly for the women members of households, poor households and low income households in slum areas.

Based on the ADB TA's assumption, the extraction of water from hand tube wells will be reduced. But the GAP and PRS shall be conducted very carefully taking into consideration to the aspects of poverty reduction and gender issues.

An assumed TA program to support KWASA to formulate a Gender Policy and Poverty Reduction Strategy, and to establish gender focal points and poverty reduction measurements is to assign four (4) specialists, a Sociologist (International), a Sociologist (National), a Gender Specialist (International) and a Gender Specialist (National) periodically within three years as follows.

	2011		2012		2013		Remarks
Sociologist (International)							12 MM
Sociologist (National)							18 MM
Gender Specialist (International)							12 MM
Gender Specialist (National)							18 MM

12.3 Comprehensive Master Plan

As mentioned in the Chapter 6, a Comprehensive Master Plan shall be developed in order to insure the adequate water supply to support the future growth of Khulna City and its surrounding area.

The Comprehensive Master Plan will consist of three parts – Master Plan of Water Supply System, Master Plan of Sewerage System and a Master Plan of Storm Water Drainage System.

An assumed TA program to support KWASA to formulate a Comprehensive Master Plan, inclusive feasibility study for future projects, is to assign three consultants. These consultants will develop the Master Plan of Water Supply System, the Master Plan of Sewerage System and the Master Plan of Storm Water Drainage System respectively after the implementation of the Project, as proposed in this Feasibility Study.

	2016		2017		2018		Remarks
Baseline Study							3 Consultants
Development of Master Plan							
Feasibility Study							