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 Ⅰ
SUMMARY

MARCH 2011

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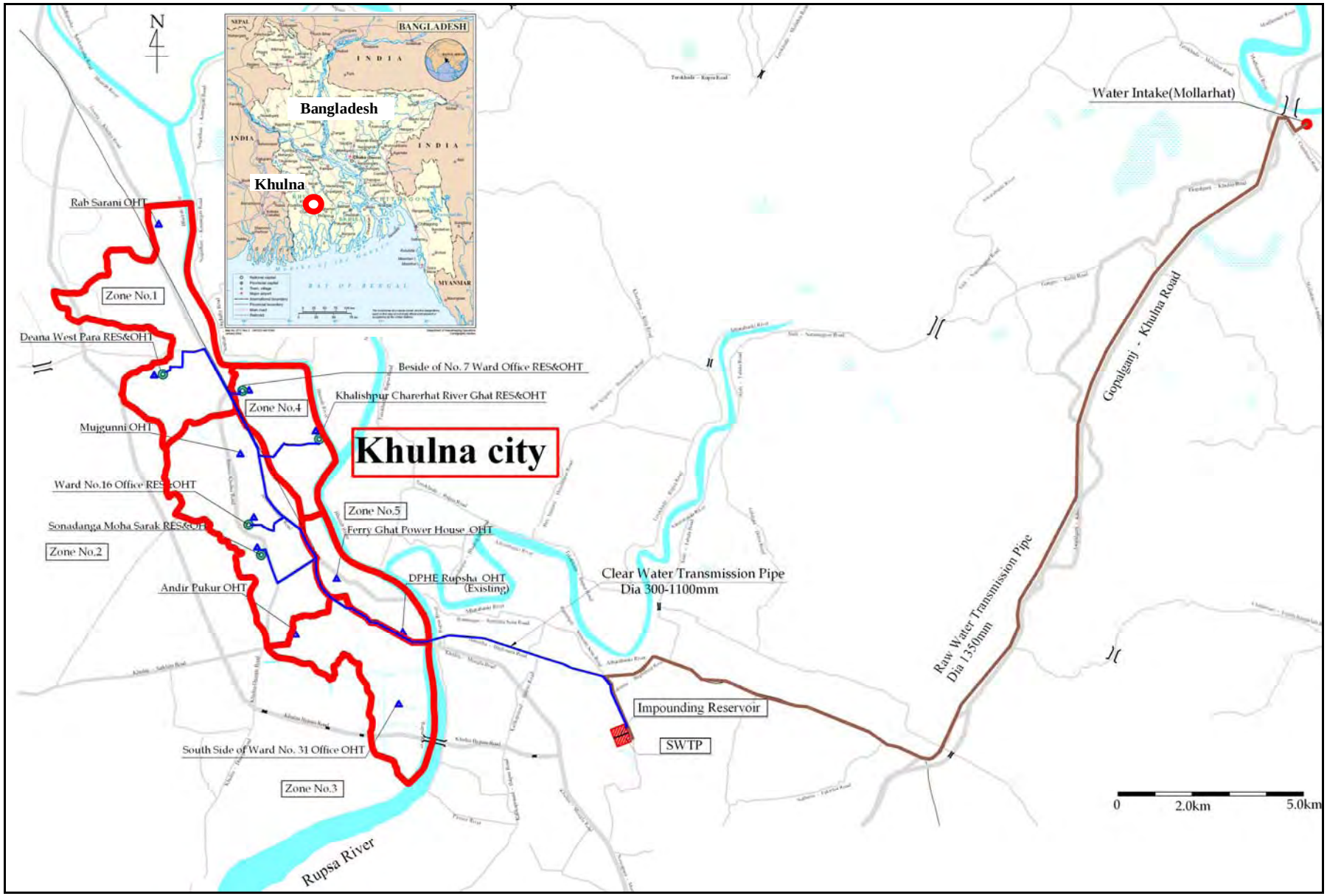
The cost estimate is based on the price level and exchange rate of November 2010.

The exchange rate is:

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



Location Map

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CHAPTER 12 RECOMMENDATIONS

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

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 the Study agreed upon between Ministry of Finance, MLGRD&C, KWASA and JICA, Dhaka on 31 March 2009; and Minutes of the Meeting on 2nd Preparatory Study on the Study agreed upon between Ministry of Finance, MLGRD&C, KWASA and JICA, Dhaka, signed on 12 August 2009. JICA had selected the Study Team and dispatched the Study Team. The Study commenced on 4 October 2009.

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.

CHAPTER 2 GENERAL DESCRIPTION OF THE KHULNA CITY

2.1 Natural Conditions

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 Bhairab 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. All of the rivers which flow surrounding Khulna City are tidal influenced. The tide for the estimate of saline water intrusion in the rivers surrounding Khulna City is one of the major issues discussed in the Study.

2.1.1 Meteorology

The average annual rainfall in Khulna is 1,946 mm during 2004 to 2009. The average annual evaporation is 953 mm.

2.1.2 Tidal Water Level

All of the rivers which flow surrounding Khulna City are tidal influenced.

2.1.3 Topography

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 Socio-Legislative Conditions

2.2.1 Water Sector Policies

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

- National Water Policy (1999)
  NWP was adopted in 1999 and it states 6 main objectives, (1) to develop groundwater and surface water in an efficient and equitable way, (2) to ensure the availability of water to all, (3) to accelerate the development of public and private water system, (4) to formulate institutional change encouraging decentralization and the role of women in water management, (5) to provide a legal and regulatory framework for encourages decentralization, environmental consideration and private sector investment, (6) to develop knowledge and capacity to facilitate future water management plan.
- National Water Management Plan (2004)
  The National Water Resources Council aims at implementing the NWMP including the improvement of water supply and sanitation.

- National Policy for Arsenic Mitigation (2004)
  The policy emphasizes public awareness, alternative safe water supply, proper diagnosis and management of patients.

Furthermore, the Environmental Conservation Act was established in 1995 and the Environment Conservation Rules were stipulates in 1997. In the rules the standers are specified as follows. In the Environment Conservation Rules, 1997, Standards for water are stipulated.

Table 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 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
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)

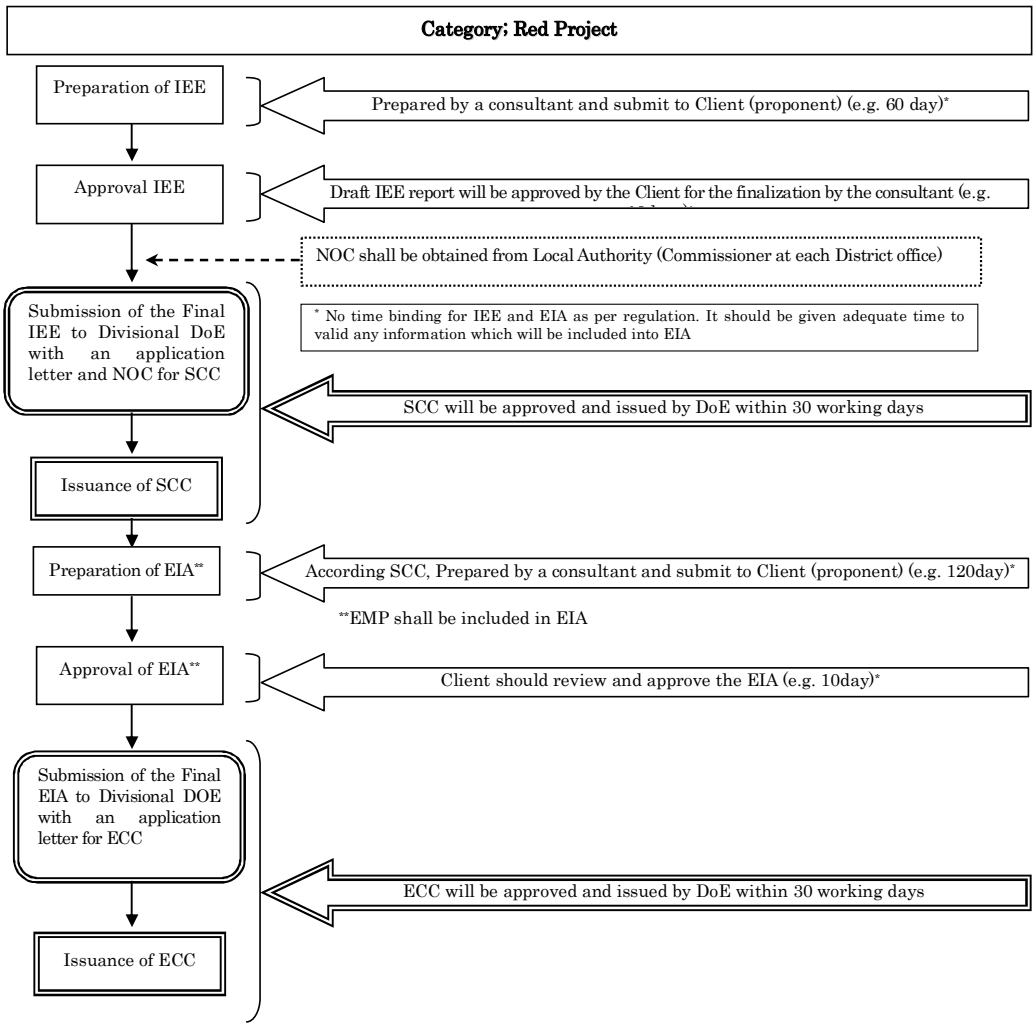
2.2.1. Environmental and Social Consideration

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

The Environmental Assessment (EA) system and its procedures are dealt with in the framework of the Environmental Clearance system. Projects to be planned are categorized into four categories and a project which requires constructing a new treatment plant is categorized into "Red", the most strictly justified category. The sequence between the "Environmental Clearance system" and "Environmental Assessment Procedures" in case of Red Projects is as shown in the **Figure 2.1**.

2.2.2. Land Acquisition and Compensation System



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

Figure 2.1 Environmental Clearance & Environmental Assessment in Red Category

2.2.3. Land Acquisition Flow

The process can be summarized as follows.

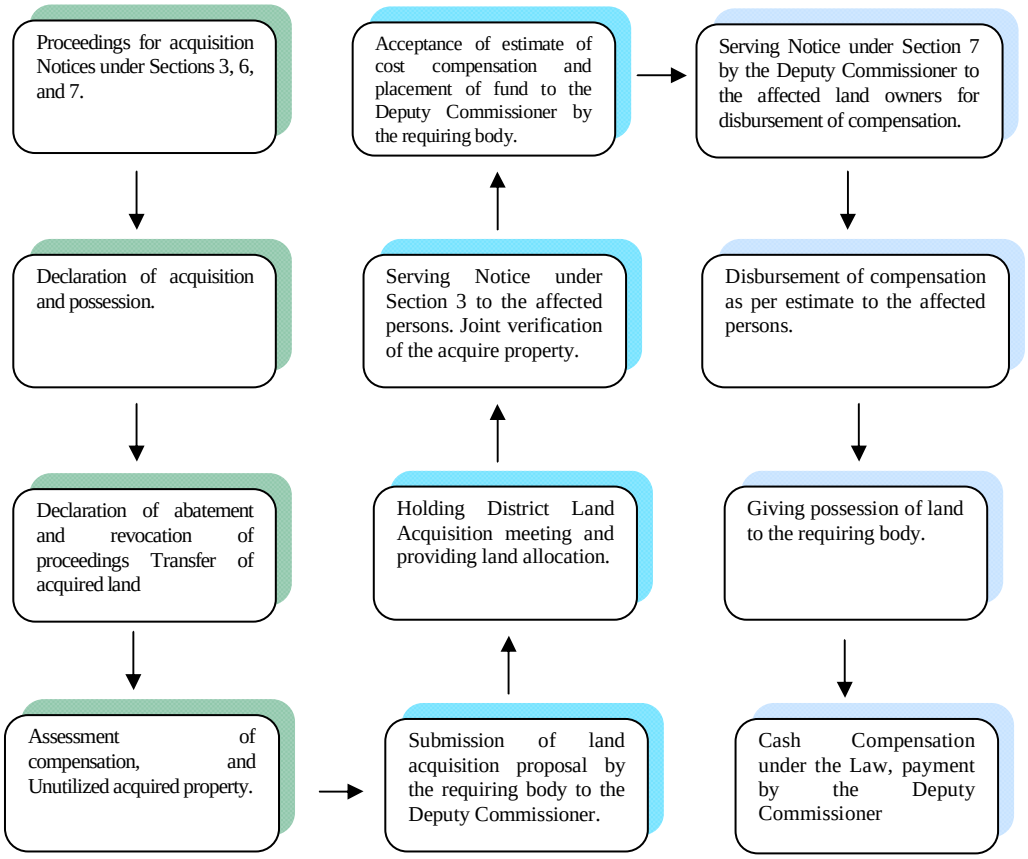


Figure 2.2 Land Acquisition Flow Chart

CHAPTER 3 EXISTING WATER SUPPLY SYSTEM IN KHULNA CITY

It was very difficult to accurately assess the actual water consumption in Khulna. For that reason the JICA Study Team conducted a water source-wise sample survey which covers entire Khulna City Corporation area and assumed the current water consumption as shown in the following table.

Table 3.1 Water Resource-wise Daily Water Consumption in Khulna

Water Source		Extraction per day
Ground water	KWASA's tubewells	30,100 m^3/d
	KWASA's hand pumps	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**

Current water source-wise served population in Khulna is assumed in the report of ADB TA, Supporting the Establishment of KWASA/November 2009).

Table 3.2 Water Source-wise Population in Khulna

Calculation of Served Population	Numbers	Remarks
KWASA's Tube Wells		
(1) Registered Connections	15,251	
(2) Inactive Connections	2,579	
(3) Active Connections	12,672	(1) – (2)
(4)Consumers per each	13.5	
(5) Served Population	171,100	(3) x (4)
Street Hydrant		
(6) Total Connections	503	
(7) Inactive Connections	403	
(8) Active Connections	100	(6) – (7)
(9) Consumers per each	100	
(10) Served Population	10,000	(8) x (9)
KWASA's Hand Pumps		
(11) Number of Deep Hand Pumps	3,748	
(12) Number of Shallow Hand Pumps	5,538	
(13) Consumers per each	30	
(14) Served Population	278,600	((11) + (12)) x (13)
Private wells		
(15) Number of Private Wells	13,733	
(16) Consumers per each	30	
(17) Served Population	412,000	(15) x (16)
(18) Uncategorized Population	85,300	
Total	957,000	

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

Table 3.3 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 Domestic=35,370 – 7,070 = 28,300 m^3/d Lpcd = 28,300x1,000/278,600 = 102 liter/day/person	Water loss: 10%
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	

CHAPTER 4 POPULATION AND WATER DEMAND PROJECTION

Prior to the JICA Study ADB conducted "Cities Development Initiative for Asia (CDIA) support to KCC: June 2009." In this study current and future forecasted populations in Khulna City are justified and forecasted as follows.

Table 4.1 Current and Future Populations in Khulna

	2009	2010	2015	2020	2025	2030
Total Population	957,000	976,000	1,078,000	1,190,000	1,314,000	1,450,000

The future water demand in Khulna is summarized as follows.

Table 4.2 Future Water Demand in Khulna

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

Summary of the Feasibility Study components (up to 2025) and Long-Term Development Plan's components (up to 2030) are as follows.

Table 4.3 Outlines of Khulna Water Supply Plans

	Feasibility Study Project	Long-Term Development Plan
Target year	2025*	2030
Population	1,314,000 persons	1,450,000 persons
Consumption/ capita/day	113 lpcd	120 lpcd
Water for non-domestic use:	10 %	10 %
Leakage after WTP	18 %	18 %
Domestic water demand	149,000 m^3/day	175,000 m^3/day
Non-domestic water demand	17,000 m^3/day	20,000 m^3/day
Water loss	37,000 m^3/day	43,000 m^3/day
Total water demand	203,000 m^3/day	238,000 m^3/day
Capacity of new system	110,000 m^3/day	220,000 m^3/day

* The target year has been decides as 10 years after the completion of the project Through discussion with Bangladesh C/P.

CHAPTER 5 KHULNA WATER SUPPLY WATER SOURCE

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. 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. The Department of Public Health Engineering under (MLGRD&C) is in charge of assisting municipalities and communities in building water supply infrastructure.

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.

5.3 Approach of Groundwater Source Development

5.3.1 LGED's Approach (MSP Study)

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)". 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 in the City centre. 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 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.

5.3.2 ADB's Approach

In the ADB's PPTA program, Supporting the Establishment of KWASA/November 2009,P, a groundwater assessment study had been conducted. It was found out that 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.

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.

In this study the policy of groundwater source development is specified as: to keep the level of current situation and do not propose extensive 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 Madhumati River and MBR": KWASA/2009

Water quality data conducted by above three organization are shown in "Main Report".

JICA Study Team has conducted water quality analysis in 2009 and 2010 at the point as shown in F**igure 5.1**.

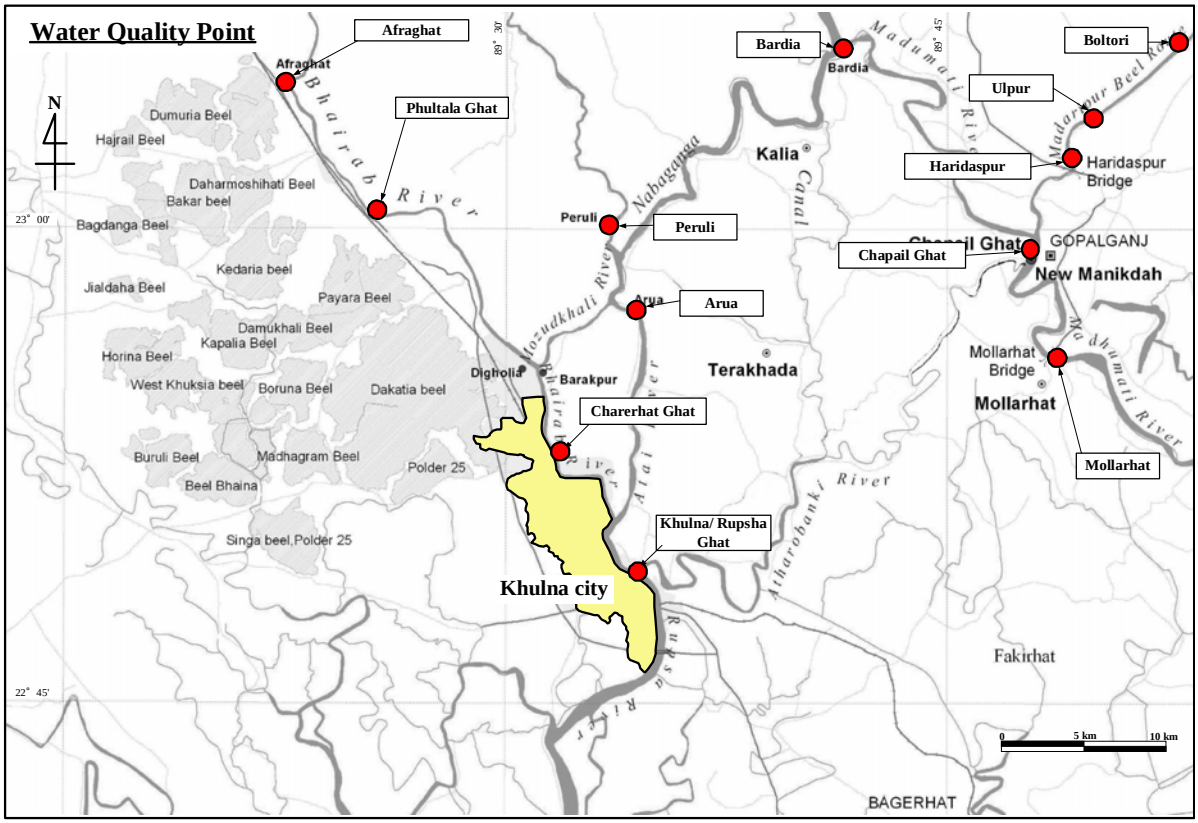


Figure 5.1 Locations of Water Quality Analysis by JICA Study Team 2009 - 2010

JICA Study Team conducted three times, in October 2009 at nine locations, in February 2010 at eleven locations and in March at three locations. The results of water quality analysis conducted by JICA Study are as shown in **Table 5.1, Table 5.2** and **Table 5.3.**

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.

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.

Table 5.1 Result of Water Quality Analysis done by JICA Study in October 2009

Parameters \ Locations		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.

Table 5.2 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

Table 5.3 Result of Water Quality Analysis done by JICA Study in March 2010

Parameters \ Locations	Unit	Standard	Mollarhat		Phultola		Khulna	
			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

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. TDS concentration is relatively high except Mollarhat, and this means the water at Mollarhat is the most suitable for the water resource.

5.4.2 Salinity Intrusion

(1) DOE Salinity Monitoring Result

The results of Chloride in river water monitoring conducted by DOE from 2005 to 2010 are as shown in the **Figure 5.2.** And it shows clearly the salinity intrusion gradually increasing into the river water surrounding Khulna City.

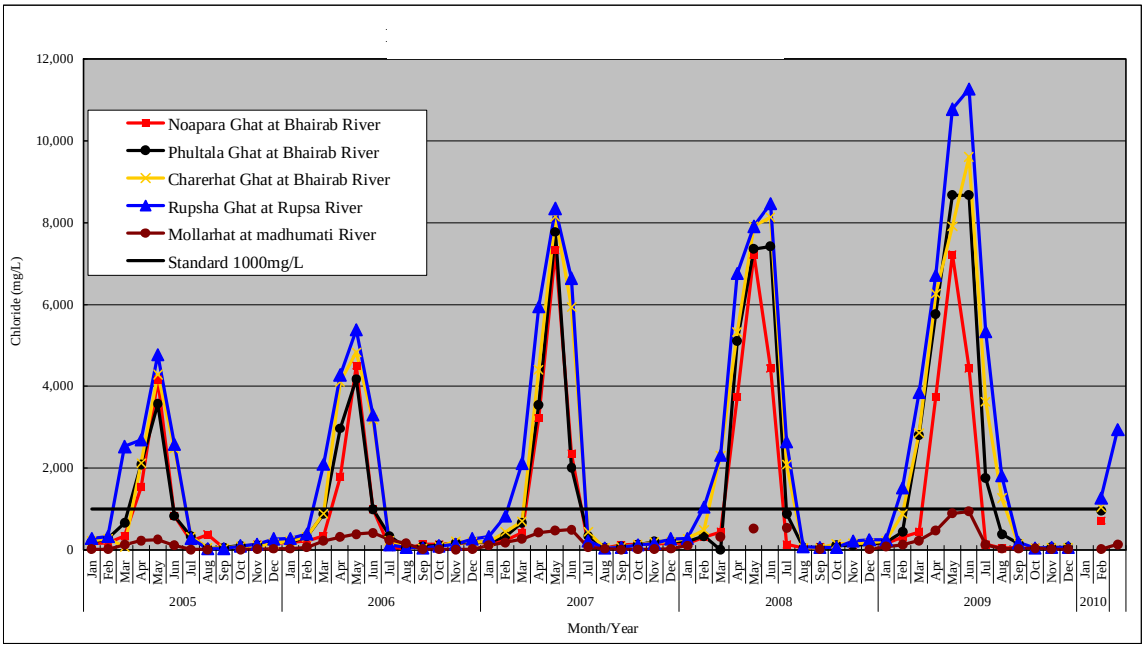


Figure 5.2 Monthly Chloride Data from 2005 to 2010(DOE)

(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 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, Peruli, 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

KWASA conducted a salinity mentoring survey from February to May in 2009 and 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.

(4) JICA Study Team's Chloride Monitoring Result in 2010

The Study Team has conducted **Chloride** monitoring in 2010 at the points as shown in **Figure 5.3**.

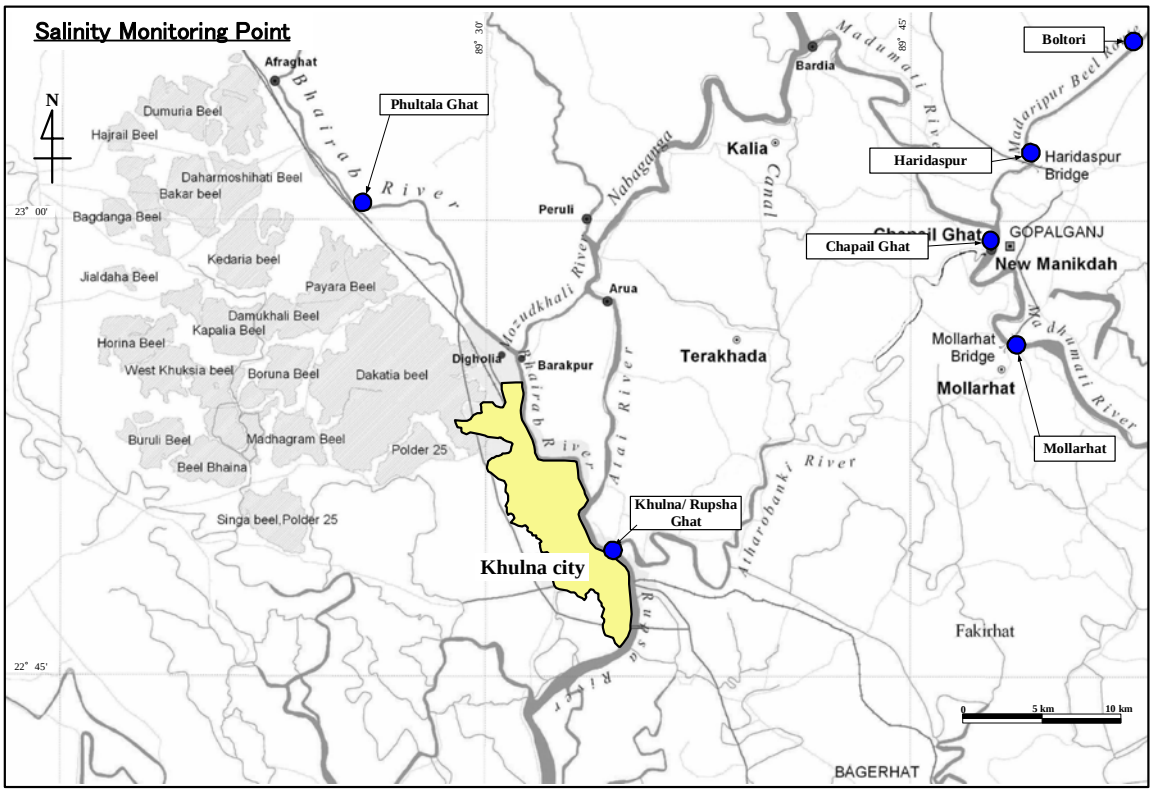


Figure 5.3 Locations of Chloride Monitoring Points by JICA Study Team in 2010

The results of Chloride monitoring at high tide and low tide conducted by JICA Study Team in 2010 are as shown in **Table 5.5**, **Table 5.6** and **Table 5.7**.

Table 5.5 Chloride Monitoring Results at Mollarhat, Phultala, Rupsha in March 2010

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
Average	411	410
Min.	320	240
Max.	500	640

Phultala	Chloride (mg/l)	
Date	High	Low
3/1	2,250	1,875
3/2	3,000	2,250
3/3	3,700	2,125
3/4	3,400	2,750
3/5	3,700	3,150
3/6	2,600	2,350
3/7	3,500	2,400
3/8	3,400	2,350
3/9	2,900	2,650
3/10	2,900	2,450
3/11	3,300	1,700
3/12	3,250	2,450
3/13	3,150	2,800
3/14	3,400	2,700
3/15	3,850	3,250
3/16	4,300	3,050
3/17	4,000	3,200
3/18	4,200	3,300
3/19	4,000	3,350
3/20	3,950	3,500
3/21	4,000	3,400
3/22	4,650	4,600
3/23	4,200	3,600
3/24	4,750	3,750
3/25	3,600	3,650
3/26	4,700	4,300
3/27	3,700	3,850
3/28	4,450	4,300
3/29	4,000	3,750
3/30	5,000	4,700
3/31	4,850	4,450
Average	3,763	3,161
Min.	2,250	1,700
Max.	5,000	4,700

Rupsha	Chloride (mg/l)	
Date	High	Low
3/1	3,600	3,400
3/2	4,100	3,050
3/3	4,650	3,750
3/4	4,900	3,500
3/5	4,950	3,750
3/6	4,200	4,100
3/7	4,050	3,650
3/8	3,950	3,450
3/9	3,750	3,550
3/10	3,200	3,050
3/11	4,100	3,950
3/12	4,450	4,050
3/13	4,200	4,300
3/14	4,150	4,350
3/15	4,550	4,450
3/16	4,800	4,450
3/17	4,900	4,150
3/18	4,950	4,750
3/19	5,000	4,700
3/20	5,000	4,800
3/21	4,700	5,000
3/22	6,600	5,000
3/23	8,100	7,400
3/24	7,400	5,700
3/25	7,800	6,800
3/26	7,700	7,100
3/27	5,100	4,500
3/28	5,100	5,900
3/29	8,900	6,600
3/30	8,300	6,000
3/31	9,700	9,100
Average	5,382	4,784
Min.	3,200	3,050
Max.	9,700	9,100

Table 5.6 Chloride Monitoring Results at Mollarhat, Phultala, Rupsha in April 2010

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
Average	1,065	1,003
Min.	360	360
Max.	3,500	3,000

Phultala	Chloride (mg/l)	
Date	High	Low
4/1	4,900	3,250
4/2	5,000	4,750
4/3	8,400	7,700
4/4	5,500	6,500
4/5	5,700	5,000
4/6	6,400	6,100
4/7	7,000	6,500
4/8	7,100	6,400
4/9	8,000	6,300
4/10	10,000	6,600
4/11	10,000	9,400
4/12	9,000	10,000
4/13	7,700	8,300
4/14	10,000	8,000
4/15	9,800	9,500
4/16	10,000	8,600
4/17	9,400	7,300
4/18	10,000	10,000
4/19	9,300	10,000
4/20	10,000	9,000
4/21	10,000	10,000
4/22	9,200	8,000
4/23	9,500	8,300
4/24	9,800	6,700
4/25	9,500	7,700
4/26	8,700	7,000
4/27	10,000	10,000
4/28	10,000	10,000
4/29	10,000	9,700
4/30	9,900	9,800
Average	8,660	7,880
Min.	4,900	3,250
Max.	10,000	10,000

Rupsha	Chloride (mg/l)	
Date	High	Low
4/1	9,600	9,900
4/2	8,900	8,900
4/3	6,200	5,500
4/4	9,500	8,700
4/5	7,800	6,100
4/6	8,200	7,100
4/7	7,800	5,900
4/8	7,600	4,300
4/9	7,300	6,500
4/10	8,100	6,500
4/11	7,500	6,200
4/12	8,400	8,900
4/13	7,800	5,900
4/14	6,600	5,700
4/15	6,700	5,500
4/16	7,500	6,100
4/17	7,200	6,500
4/18	6,800	5,900
4/19	6,400	5,600
4/20	7,200	6,700
4/21	8,900	6,500
4/22	8,200	5,700
4/23	6,500	5,200
4/24	6,900	6,100
4/25	6,800	5,600
4/26	7,200	6,100
4/27	6,900	5,800
4/28	7,100	5,700
4/29	7,500	5,900
4/30	7,600	5,600
Average	7,557	6,353
Min.	6,200	4,300
Max.	9,600	9,900

Table 5.7 Chloride Monitoring Results at Boltori, Haridaspur, Chapali Ghat in April 2010

Boltori	Chloride (mg/l)		Haridaspur	Chloride (mg/l)		Chapali Ghat	Chloride (mg/l)	
Date	High	Low	Date	High	Low	Date	High	Low
4/1	40	40	4/1	390	280	4/1	870	790
4/2	40	40	4/2	380	240	4/2	850	810
4/3	40	40	4/3	320	220	4/3	860	780
4/4	40	40	4/4	250	100	4/4	890	860
4/5	40	40	4/5	150	80	4/5	880	830
4/6	40	40	4/6	90	70	4/6	750	720
4/7	40	40	4/7	90	50	4/7	760	720
4/8	40	40	4/8	90	50	4/8	740	690
4/9	40	40	4/9	100	50	4/9	590	570
4/10	40	40	4/10	90	50	4/10	640	590
4/11	40	40	4/11	90	40	4/11	630	580
4/12	40	40	4/12	90	40	4/12	640	580
4/13	40	40	4/13	60	30	4/13	650	590
4/14	40	40	4/14	70	40	4/14	670	570
4/15	40	40	4/15	50	30	4/15	690	630
4/16			4/16			4/16		
4/17	40	40	4/17	50	30	4/17	790	720
4/18			4/18			4/18		
4/19	40	40	4/19	50	40	4/19	830	750
4/20			4/20			4/20		
4/21	40	40	4/21	50	40	4/21	560	510
4/22			4/22			4/22		
4/23	40	40	4/23	40	30	4/23	460	420
4/24			4/24			4/24		
4/25	40	40	4/25	40	30	4/25	340	310
4/26			4/26			4/26		
4/27	40	40	4/27	40	30	4/27	410	350
4/28			4/28			4/28		
4/29	40	40	4/29	40	30	4/29	320	300
4/30			4/30			4/30		
Average	40	40	Average	119	73	Average	674	621
Min.	40	40	Min.	40	30	Min.	320	300
Max.	40	40	Max.	390	280	Max.	890	860

(5) Things to Be Considered

According to these data confirmed through above-mentioned 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, Chapali Ghat 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. 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 very limited. Therefore, it is inevitable to develop surface water source to be developed to satisfy the future water demand increase in Khulna. 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, water source-wise development policies are to be summarised as follows;

Groundwater development policy

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

Surface water development policy

- 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 5.8 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							
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

ADB's technical assistant study, TA 7385-BAN "Preparing the Khulna Water Supply", has started in June 2010. The TA Study Team has been justified the water demand and production balance through discussion during the JICA and ADB joint appraisal mission period from November 19 2010 to

December 3 2010.

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.

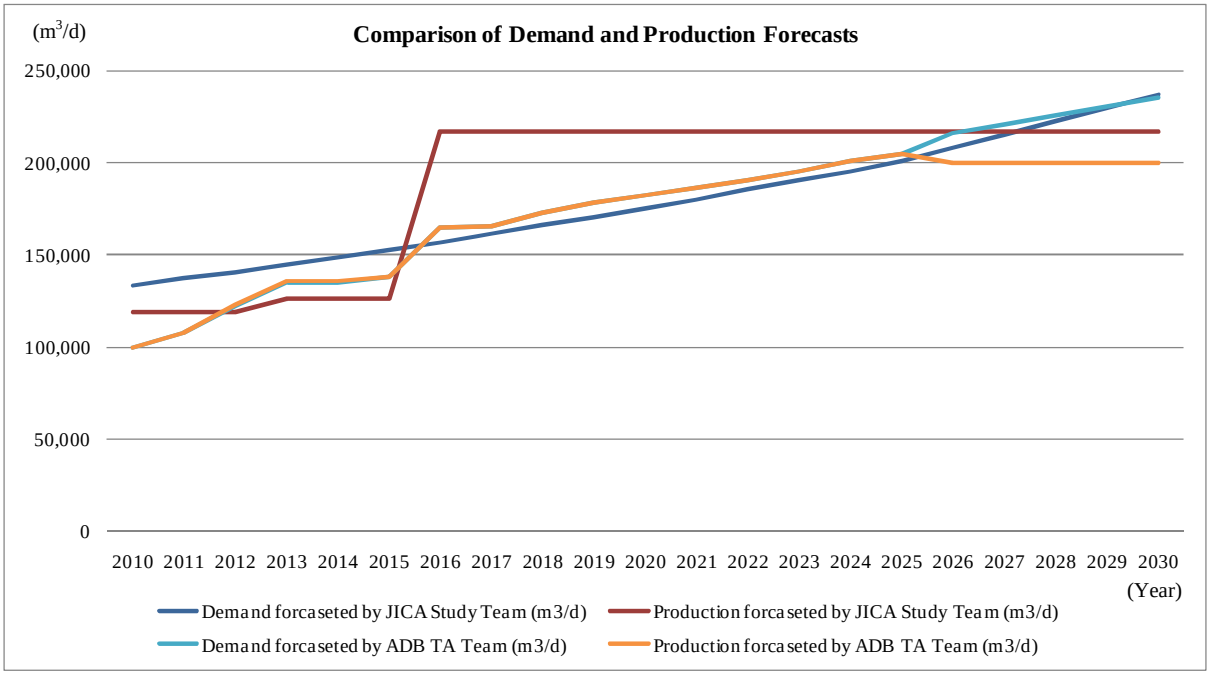


Figure 5.4 Comparison of Production and Demand Forecasted

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 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

6.2.2 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 110,000m^3/day and the one for 2030 will be 220,000m^3/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).

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

6.2.3 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 Alternative Approach for Water Supply System for 2025 Water Demand

6.3.1 Water Intake

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 shown in **Table 6.1**.

Table 6.1 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	30 km	30 days	Not Necessary	1
	Option -5	Mollarhat	River	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

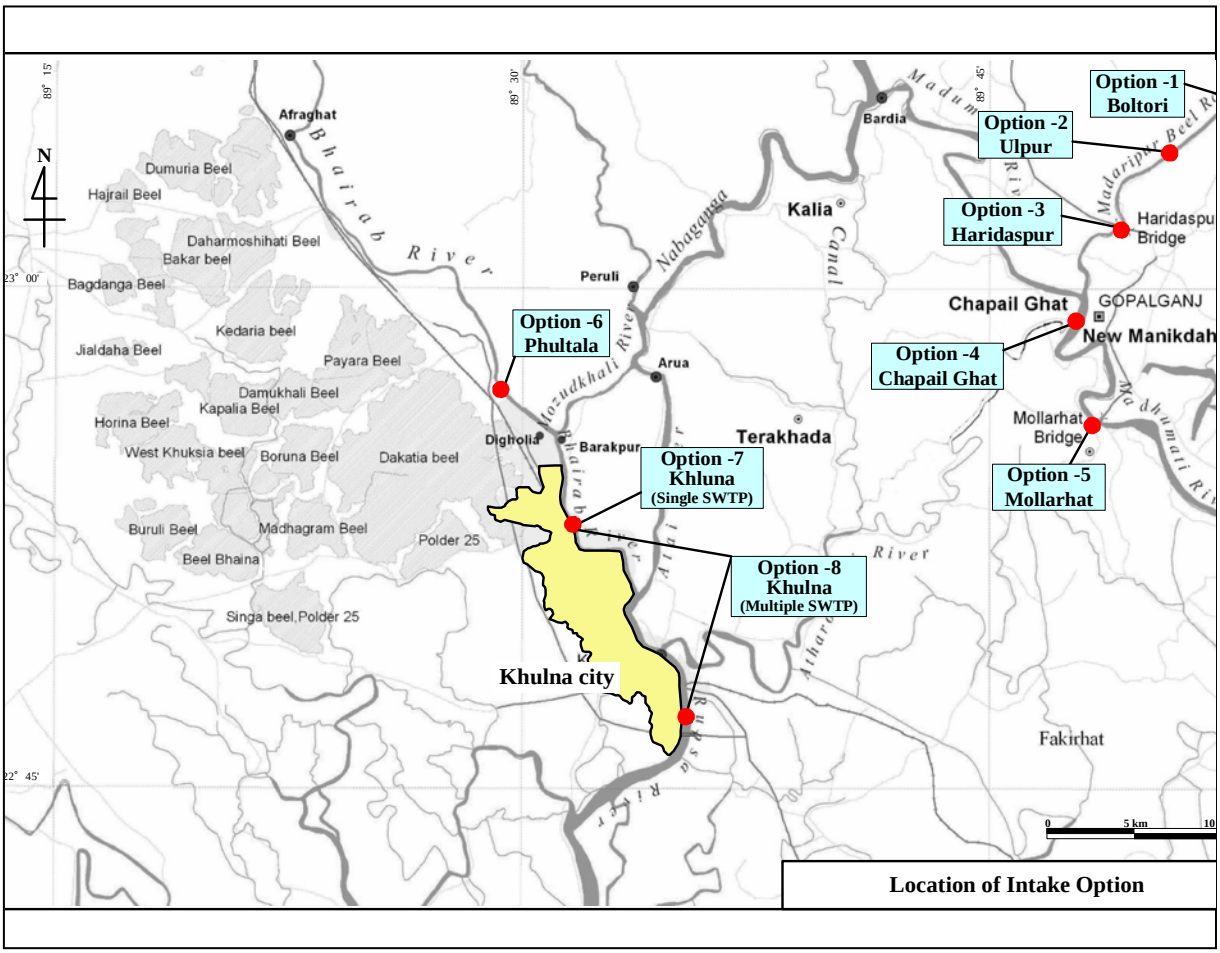


Figure 6.1 Locations of Water Intake Options

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.

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

According to the comparison result shown in **Table 6.2**, CASE –A is evaluated as the most appropriated. Option 5, to take water from Madhumati River at Mollarhat was selected as optimum option since this is the lowest construction cost in CASE -A.

Table 6.2 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

6.3.2 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.

Water supply service area is divided into 3 to 10 distribution zone by each alternative. 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

The result of comparison study the Alternative-C is selected as the optimum alternative.

- 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.

6.3.3 Size of Impounding Reservoir

(1) Necessity of Consideration

Based on the existing chloride concentration monitoring record, proposed impounding reservoir site is found considering chloride concentration in the river water at Mollarhat intake point will be beyond the EQS standard (1000mg/L) during 45 days for dry season. The result of site investigation, Samanto Sena opposite side of the Rupsha River is selected as a SWTP and impounding reservoir construction site.

(2) 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 6.2**.

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

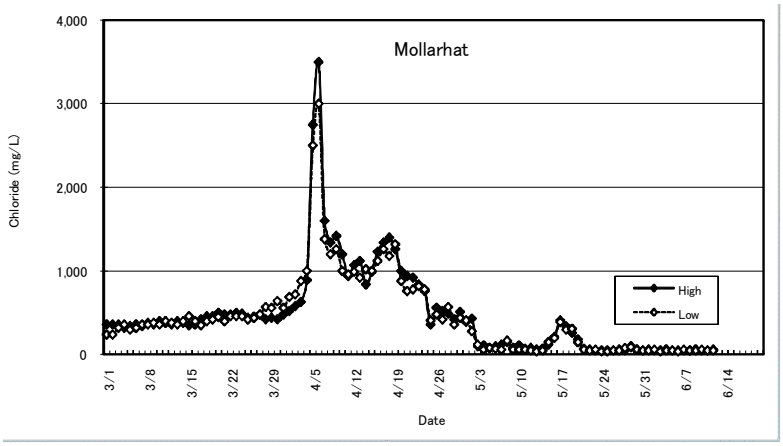


Figure 6.2 Monitoring Result of Chloride Concentration at Mollarhat

(3) Things to be considered to decide Impounding Reservoir Capacity at Detail Design Stage

1) To justify the necessary capacity of the impounding reservoir based on the next two years (2011 and 2012) consecutive chloride concentration monitoring result conducted by KWASA.

2) To minimize the impounding reservoir that only can be confirm a steady control for raw water quality troubled days mainly due to high chloride concentration.

(4) Approach to Minimize Impounding Reservoir Size in this Study

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.

Case-1: Assumed that chloride concentration will be beyond the EOQ standards about 45 days

- Land for SWTP = 10 ha
- Land for Impounding Reservoir = 60 ha (2 ponds are examined considering land shape)
- Necessary Land = 70 ha

Case-2: Assumed that chloride concentration will be beyond the EOQ standards about 30 days

- Land for SWTP = 10 ha
- Land for Impounding Reservoir = 38 ha (2 ponds are examined considering land shape)
- Necessary Land = 48 ha

Case-3: Assumed that chloride concentration will be beyond the EOQ standards about 15 days

- Land for SWTP = 10 ha
- Land for Impounding Reservoir = 16 ha
- Necessary Land = 26ha

Case-4: Assumed that chloride concentration will be beyond the EOQ standards about 10 days

- Land for SWTP = 10 ha
- Land for Impounding Reservoir = 10 ha
- Necessary Land = 20ha

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.

6.3.4 Summary of Proposed Water Supply Facilities

(1) Proposed Water Supply System

Table 6.3 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
9	Service Pipe Connection	-	90,000

(2) Proposed Site for Water Supply Facilities

Table 6.4 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
Reservoir and Overhead Tank	Deana West Para	100 x 70	0.7ha	Paddy land
	Ward No.16 office	100 x 70	0.7ha	KCC land
	Sonadanga Moha Sarak	100 x 90	0.9ha	Personal land
	Beside of No.7 Ward office	100 x 70	0.7ha	Personal land
	Khalishpur Charerhat River Ghat	100 x 90	0.9ha	Government land (KASS)
Overhead Tank	Rab Sarani	45 x 30	0.14ha	Personal land
	Mujgunni	45 x 30	0.14ha	KCC land
	Ferry Ghat Power House	45 x 30	0.14ha	KCC land
	Andir Pukur	50 x 35	0.18ha	Personal land
	South Side of Ward No. 31 Office	50 x 35	0.18ha	Paddy land
	DPHE Rupsha	50 x 35	0.18ha	DPHE

6.4 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 2025)

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

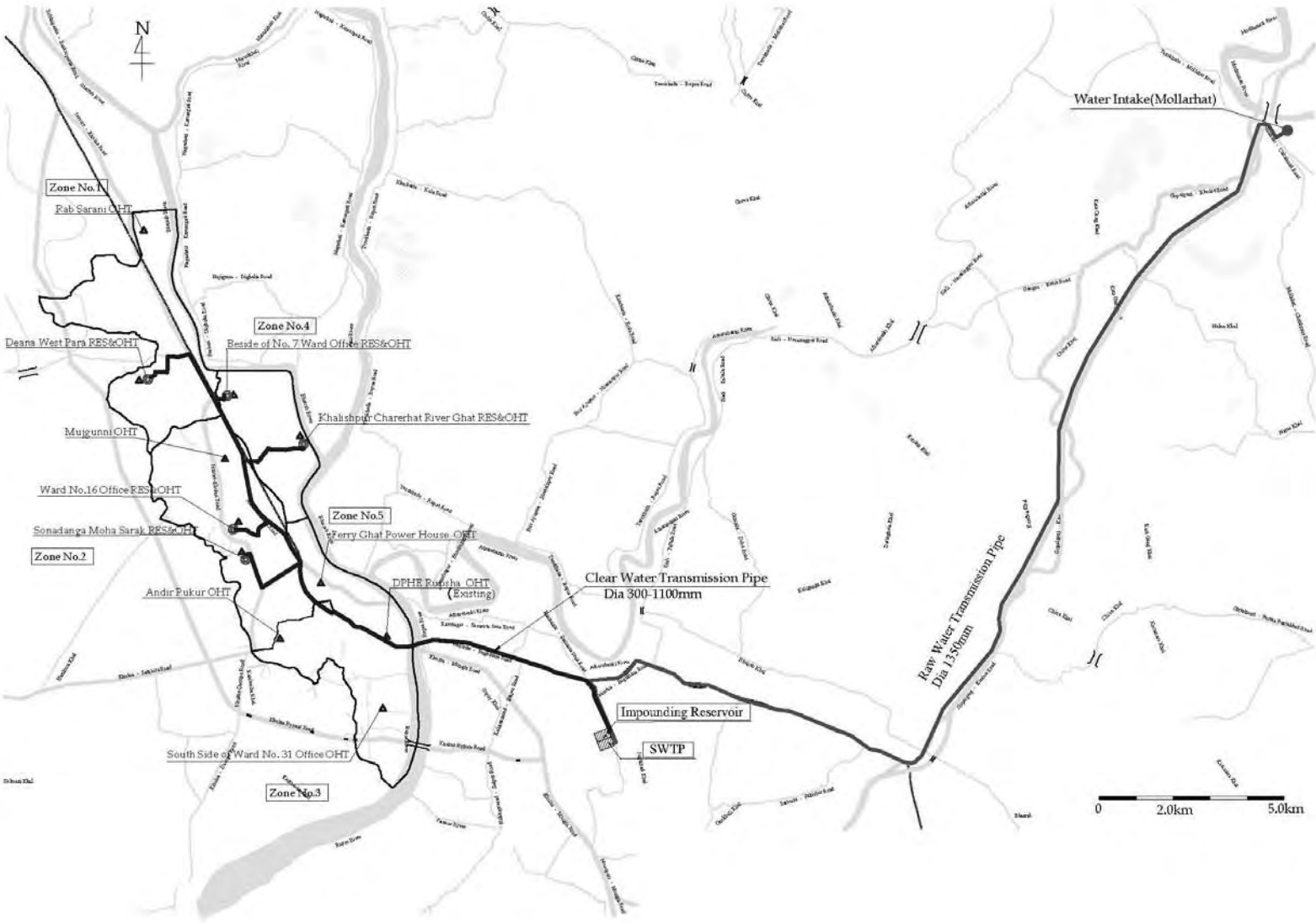


Figure 6.3 Proposed Water Supply System in Khulna City

CHAPTER 7 PROJECT SCOPE AND FACILITIES

7.1 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) considering river flow/velocity, water flow amount and distance of raw water transmission pipe.

(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 considering river water depth, difficulty of construction, blocking water flow during construction period and construction cost.

(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 7.1**.

(5) Mechanical Equipment

Intake pumps are Vertical double suction volute pump with dry sump selected by safety against flood, high efficiency, superior cavitations characteristic, O&M, etc. 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.

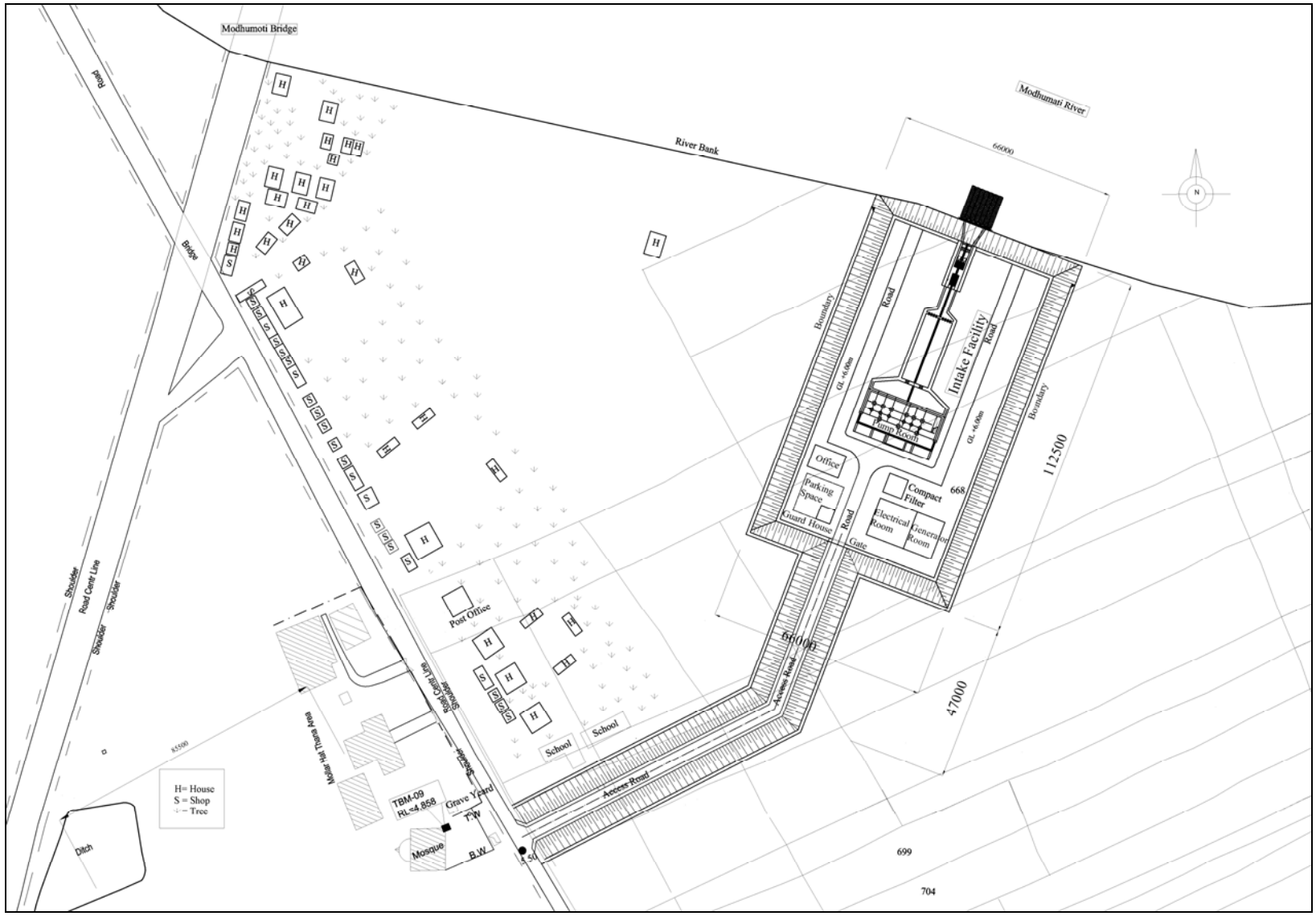


Figure 7.1 Layout of Water Intake

(6) Electrical Equipment

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. One set of diesel engine generator will be applied for standby power generator. 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.

7.2 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. Steel pipe is applied for the channel crossing point.

(2) Route of Raw Water Transmission Pipe

Proposed raw water transmission pipe route is shown in **Figure 7.2.**

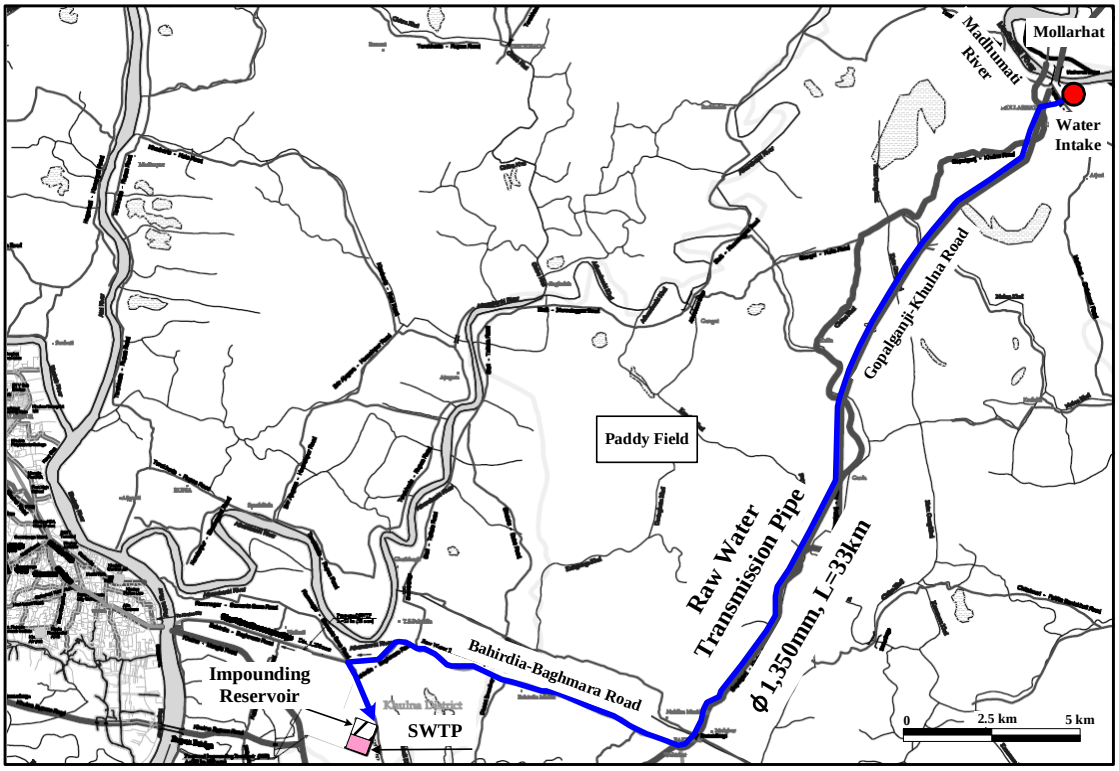


Figure 7.2 Selected Route of Raw Water Transmission Pipe

(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.

7.3 Impounding Reservoir

(1) Raw Water Allocation Plan

Surface water of the Madhumati River is the proposed water source for this study. To deal with salinity intrusion issue, following "Raw Water Allocation Plan" can be proposed:

- During rainy season, surface water with lower Chloride is stored in impounding reservoir
- Mixing the raw water with high Chloride and the reserved water with low Chloride during salinity influenced period to lessen the concentration within the standard

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.

CASE -1: River water amount of 110,000m^3/day is sent to SWTP directly and used as raw water during Non Salinity Period (Chloride: less than 1000 mg/L).

CASE -2: River water is sent to SWTP directly and used as raw water during Non Salinity Period (Chloride: less than 1000 mg/L). While, river water whose Chloride is low will be stored and supplied in the Impounding Reservoir about 3 months/year..

CASE -3: Stored water in the Impounding Reservoir is sent to SWTP and used as raw water during Salinity Period (Chloride: more than 1000 mg/L). River water whose Chloride is high will not be used as raw water.

(2) Design Condition of Impounding Reservoir

Impounding reservoir is will be constructed at Samanto Sena near Bahirdia-Baghmara Road southern of Khulna city, adjacent SWTP 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 m3/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

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. One set of diesel engine generator will be applied for standby power generator. 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.

7.4 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.

(2) Outline of SWTP

Location of proposed SWTP is at Samanto Sena near Bahirdia-Baghmara Road southern of Khulna city. Required land for SWTP is 10ha (250 m × 400 m).

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. Proposed SWTP layout is shown in **Figure 7.3**.

(3) Mechanical Equipment

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.

Chemical dosing facilities for alum, lime and chlorination will be installed in the proposed SWTP.

(4) Electrical Equipment

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. Diesel engine generator will be applied for standby power generator. 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. 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.

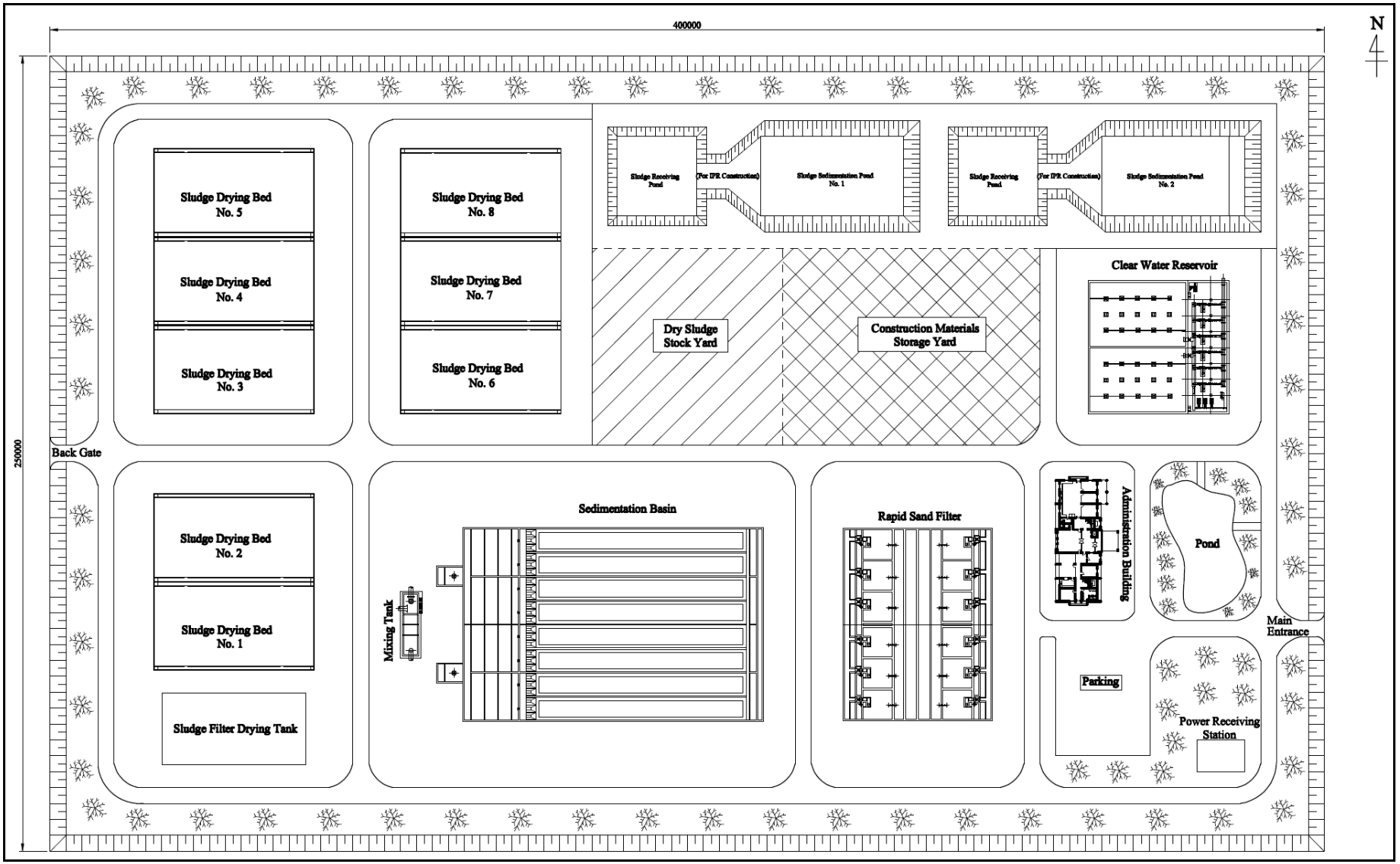


Figure 7.3 Layout Plan of SWTP

7.5 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

Dry well horizontal end suction volute pumps are recommended for the clear water transmission.

The chlorination facilities shall be installed in five distribution reservoirs because underground water is also transferred to the distribution reservoir from existing tube well.

(5) Electrical Equipment

One transformer will be installed because of the small scale facility and also damage scale is comparatively small when the accident will occur. One set of diesel engine generator will be applied for standby power generator. 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 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.

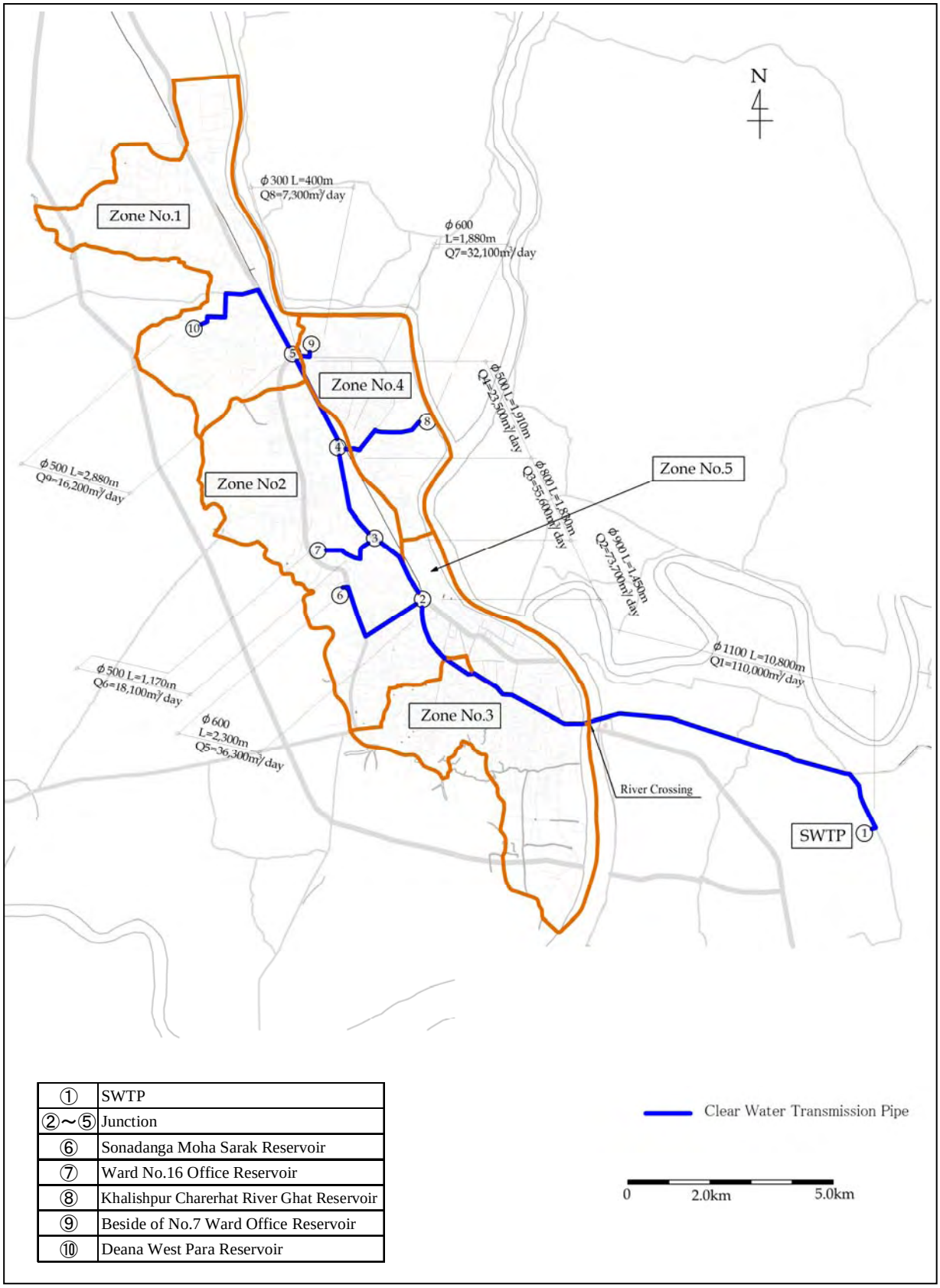


Figure 7.4 Clear Water Transmission Pipe

7.6 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

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

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.

Location of distribution reservoir and overhead tank is shown in **Figure 7.5**.

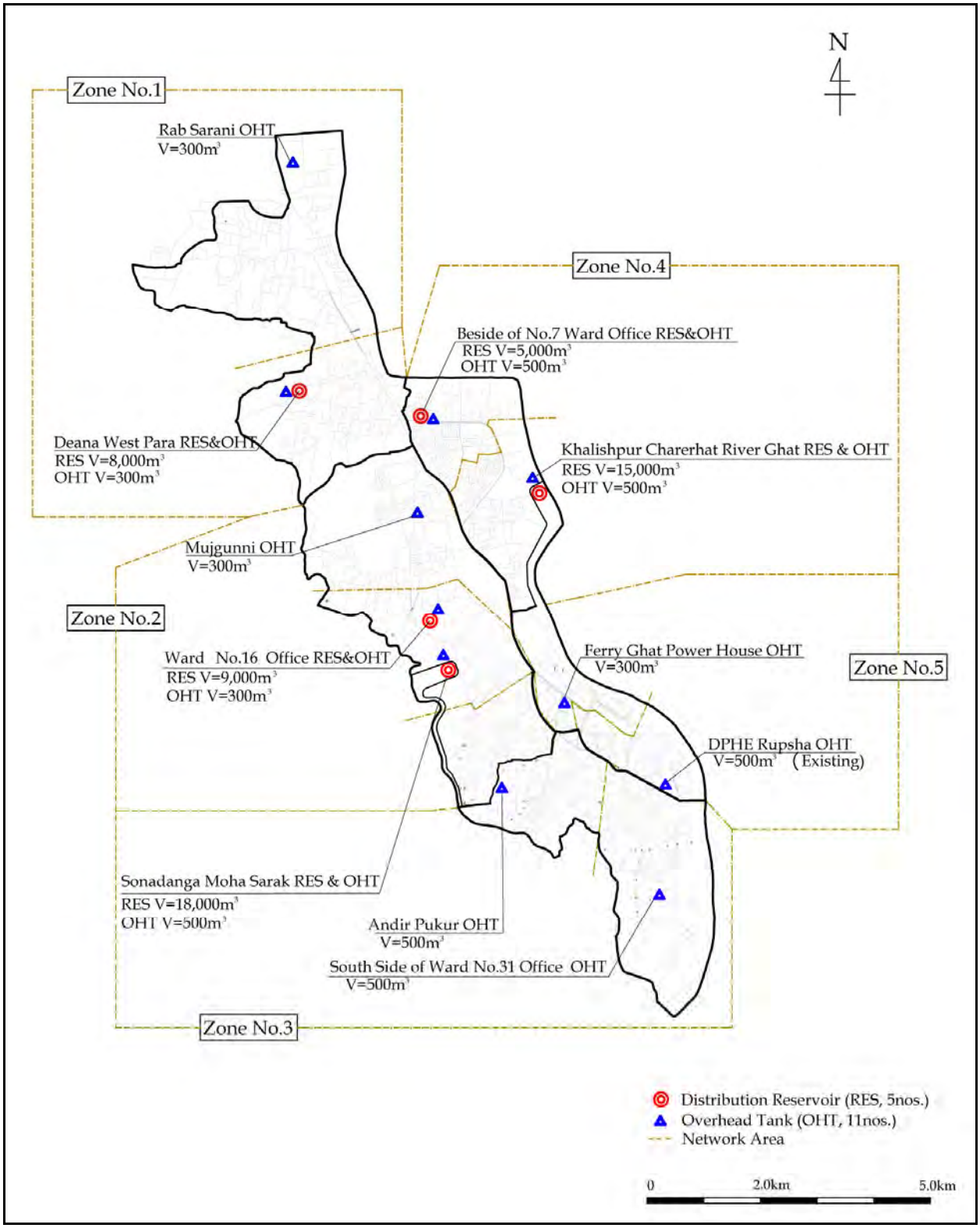


Figure 7.5 Distribution Reservoir & Over Head Tank

(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 Overhead Tank

Distribution reservoir is constructed by reinforced concrete. Volume of distribution reservoir is calculated following formula.

$$V = \text{Daily Maximum} \times (12 / 24)$$

Table 7.1 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

Water levels of distribution reservoir are HWL +2.40 m, and LWL -2.60 m. Water levels of overhead are; HWL +27.4 m and LWL +23.4 m.

(6) Distribution Network

Distribution pipeline is classified four types; distribution trunk pipe, distribution main pipe, distribution branch pipe and small distribution pipe.

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 CONSIDERATION

Institutional development at KWASA is an internal process that involves having the appropriate organization structure, policies and systems, and the right number of qualified people, whose capacities are developed over time, to enable them to fulfill the Authority's legal mandate, institutional mission, and corporate objectives effectively and efficiently.

8.1 Current Institutional Set-up

Khulna Water Supply and Sewerage Authority (KWASA) were established in February 2008 through 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." The highest policy-making body of the Authority is 13-member KWASA Board vested with the broad-spectrum powers to set its general direction and administration of the affairs and functions. The Board's powers encompass policy formulation, the appointment of key officers, setting of strategic corporate directions, approval of corporate financial and business plans, and reporting to and getting approval from Government.

KWASA's management is composed of the Managing Director (MD), who will be assisted by two Deputy Managing Directors (DMD). The responsibilities, powers and functions of the MD are in general management and supervision of the affairs and business of the Authority in a financially and administratively sound manner, the formulation of operational policies and internal work systems as well as corporate plans and performance targets, and the appointment of all officers and employees.

The initial organization structure of KWASA should 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). The latter provides for two divisions – Technical Division and Finance and Administration Division – with both divisions having two departments and four sections each.

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. 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 2010.

8.2 Proposed KWASA Institutional Set-up (2017)

The Implementation Time Frame for the organization structure(s) of KWASA is shown 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 (2012-2016)[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.

The Proposed KWASA Organogram (2017), shown in the figure below, reflects the main functions of a modern water utility. Its organization design allows six hierarchical levels, from which authority, decision-making, responsibility, accountability and communication structures will flow. The organogram also takes cognizance of the establishment of zonal offices to match the distribution zones as per network design, and the creation of a strategic management group to ensure the accomplishment of corporate and unit vision, mission and objectives.

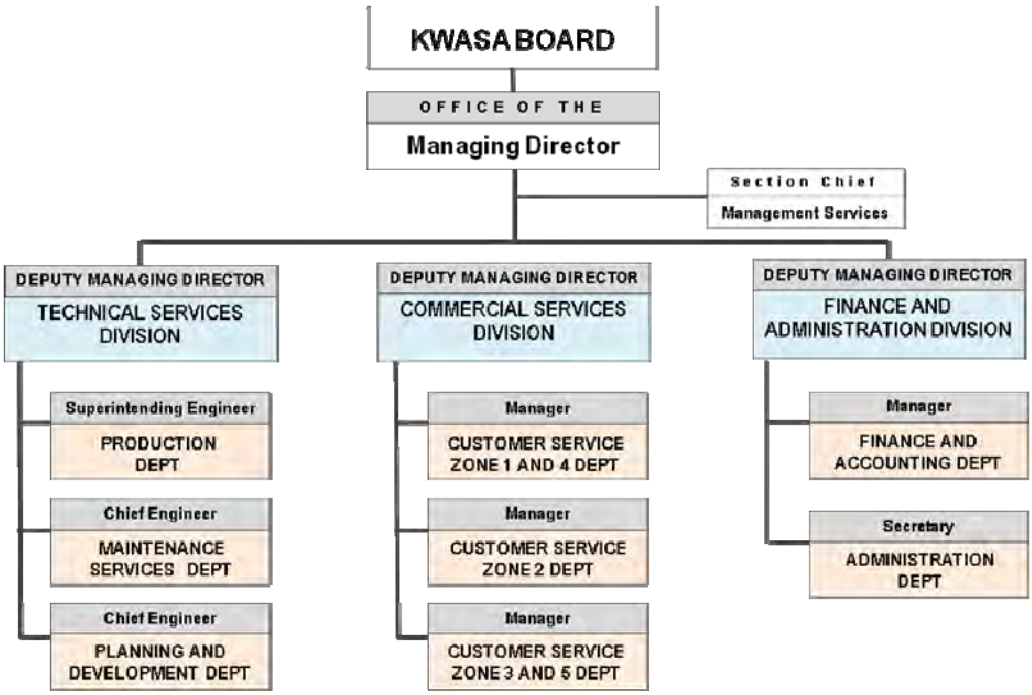


Figure 8.1 Proposed KWASA Organogram (2017)

The Human Resources Plan for 2017, shown in the table below, 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 new metered service connections given increased

water production.

Table 8.1 KWASA Human Resources Plan (2017)

ORGANIZATIONAL UNIT	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 DMD	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 DMD	3	0	3
Finance and Accounting Department	8	10	18
Administration Department	32	18	50
COMMERCIAL SERVICES DIVISION			
Office of the DMD	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*

8.3 The Project Implementation System

Project implementation responsibilities have been divided into project coordination, through the Project Steering Committee (SC), and project implementation, through the Project Management Unit (PMU) and the Project Consultants' Teams (PCT), as shown below:

Table 8.2 Role of Project Organizations in Project Implementation

	PROJECT ORGANIZATION	ROLE IN PROJECT IMPLEMENTATION	RESPONSIBILITY AREA
1.	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	Provision of policy guidelines for **strategic inter-agency coordination** for Project implementation	General Financial Implementation Legal

	(Advisors: JICA and ADB)		
2.	Project Management Unit (PMU) KWASA	Directly responsible for **undertaking actual field supervision and management** of Project implementation	General Disbursement Implementation
	Project Consultants' Teams (PCT)	Provides KWASA with services in **detailed design and construction management** during project implementation per Contract of Consulting Services	

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 together with the PMU Project Director. 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, which include the PMU Project Director. The proposed structure of the PMU is shown in the figure below:

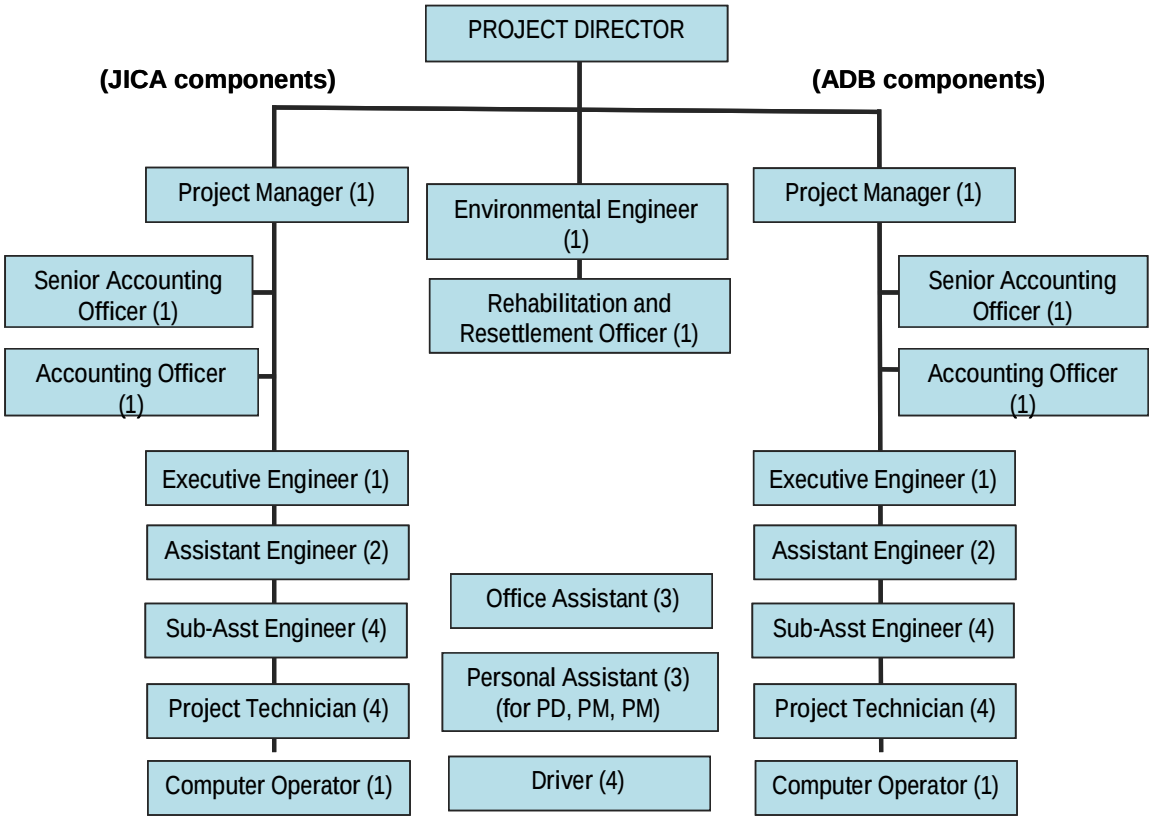


Figure 8.2 Proposed Organization Structure of PMU

As for the Project Consultants' Team (PCT), reporting will be directly to the PMU Project Director. The PCT 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, pre-operation and maintenance, and the development of appropriate implementation strategies, work processes and procedures consistent with the fundamental principles espoused by the Project.

8.4 Capacity Building

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 functions. Fortunately, by this same time, the proposed ADB Corporate Management Consultancy for KWASA would have been completed, guaranteeing KWASA staff readiness in assuming the tasks that will accompany the completion of the project in 2017.

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. 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 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 to ensure that training has the desired long lasting effects on behavioral change that positively impacts on how KWASA personnel should do their jobs.

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.

CHAPTER 9 FINANCIAL AND ECONOMICAL CONSIDERATION

9.1 Financing Possibility of the Project

The analysis of KWASA's current financial situation and its potential indicates KWASA's obvious incapability of self-financing the Project. If KWASA implements the Project, with a financial condition that the tariff should be set at an O&M cost recovery level, KWASA will inevitably need to find outside financing sources to pay the project capital cost.

The current financial market and donor's lending situations suggest that JICA and ADB will extend loans to GOB in relation with the Project. GOB will on-lend the loans to KWASA as subsidiary loans. Despite the terms of loan suggested in the GOB subsidiary loan guideline, actual application could be softer depending on borrower's financial situation and type of industry in which the borrower will operate. KWASA should appeal to GOB for application of softer loan conditions such as lower interest rate and longer repayment period.

It should be also noted that these foreign loans will not cover the whole project cost. KWASA may be able to ask government grants to pay such uncovered cost through capital budget allocation. KWASA should appeal to GOB not only for the softer subsidiary loan, but also for more generous financing mix of grants and subsidiary loans than what will be determined by the foreign loans. KWASA should also aim at reduction of debts through grant receipt and debt restructuring and equalization.

9.2 Financial Evaluation

Financial viability of the Project was evaluated using FIRR, FNPV and 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. Key parameters and assumptions used in the financial evaluation are as follows:

- Project analysis period: 2010 to 2046
- Initial capital costs: Tk. 23,244 million in 2010 price, excluding price escalation
- New O&M costs: Tk. 214 million in 2010 price at the peak years commencing from 2025
- Existing tube well O&M costs: Tk. 31 million in 2010 price
- Replacement costs of mechanical and electric works in 2032: 24% of the initial capital costs
- Residual value of capital assets at the end of project analysis period: based on 50 year usable life for civil structures and pipes, 15 year life for mechanical and electrical works, and full market value at acquisition timing for land
- Use of water: 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
- Tariff in base case scenario: O&M cost recovery tariffs: Tk. 5/m^3 for domestic connection and Tk. 10/m^3 for non-domestic connection in 2010 price

- Incremental revenue from tube well water: difference between the existing effective tariff and base case tariff: Tk. 3.8/m^3 for domestic connection and Tk. 9/m^3 for non-domestic connection in 2010 price
- Connection fee: actual cost will be charged
- User charge collection efficiency: 100%

The FIRR in real terms resulted in minus 6.09% and was inferior to the FOCC of 0.23%, meaning that the Project is not financially viable under the above assumptions.

Main contributor of this financial inviability is the O&M cost recovery tariff. The O&M cost recovery target is the most realistic and feasible tariff setting for KWASA. However the project FIRR becomes hardly 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. The FIRR will rise to 0.37% and become a satisfactory level when the full cost recovery tariffs (Tk. 27/m^3 for domestic and Tk. 54/m3 for non-domestic) are adopted.

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 of Tk. 48/m^3. The non-domestic tariff is the same level as the ATP price (Tk. 54/m^3).

9.3 Financial Projection under Base Case Scenario

Financial projection was attempted, highlighting financial activity and outputs attributable only to the Project, due to lack of reliable KWASA financial data (externally audited data). Key assumptions are:

- Time horizon of 2046, which will cover 20 years of post implementation period
- Annual inflation rate of 4.8% during the project implementation period (2011 to 2016), which will be halved from 2017
- Cash shortage of KWASA will be financed by GOB through contribution of capital grants
- KWASA has to maintain the O&M cost recovery tariffs, which should be Tk. 5/m^3 for domestic and Tk. 10/m^3 for non-domestic connection in 2010 prices. These prices should increase in accordance with the inflation rate above, becoming Tk. 6.6/m^3 for domestic and Tk. 13.2/m^3 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 and the grant equity to finance the cumulative loss will also increase. However as a result of the equity capital injection by GOB, the KWASA' cash position will balance.

9.4 Economic Evaluation

Economic viability of the Project was evaluated using EIRR, ENPV and EOCC. If the EIRR exceeds

the EOCC, the Project is regarded economically viable. ENPV computed by using a discount rate equal to the EOCC will be positive when the Project is economically viable. Key parameters and assumptions used in the economic evaluation are as follows:

- Project analysis period: 2016 to 2046
- EOCC: 12%
- Financial costs can be apportioned into tradable, nontradable, skilled labor, unskilled labor, land, and other costs. They are converted to economic costs in 2010 constant prices by applying conversion factors.
- Financial prices of tradable components as reduced by duties and taxes are converted to economic prices by a shadow exchange rate factor (SERF), which is estimated at 1.07.

Economic benefits identified are as follows:

- Value of nonincremental water is resource cost savings as a result of switching from hand pump tube wells to new water of SWTP. Based on current water fetching cost, the nonincremental water value for domestic user was estimated at Tk. 68.3/m^3.
- Nonincremental water for non-domestic users can be valued at supply price by private vendor. The economic value was estimated at Tk. 2,000/m^3.
- Incremental water is valued in terms of willingness to pay (WTP), which is regarded as proxy for demand price of new water of SWTP. Newly connected domestic user's WTP was estimated at Tk. 22.2/m^3, assuming the average connection costs of Tk. 3,000.
- Value of incremental water for non-domestic users was estimated at Tk. 54/m^3, deduced from ability to pay price as a proxy of WTP
- Value added to tube well water by starting the new distribution system was estimated at Tk. 29.7/m^3, using the WTP estimate from the domestic consumer survey.
- Administrative water loss (e.g., water theft, metering result alteration and low billing) is actually used by someone who do not pay but enjoy economic value of the water. Such benefits are valued at WTP prices. The percentage of administrative loss within total KWASA water loss is assumed at 50%.
- KWASA's financial benefit of the O&M cost resource saving by starting the new system was converted to the economic value. The O&M cost conversion factor of 0.85 was used for the conversion.
- Financial residual values of civil structures, pipes and mechanical and electrical equipment were converted to the economic values, by using a conversion factor of 1.05.

The EIRR in real terms resulted in 14.41% and exceeded the FOCC of 12%, meaning that the Project is economically viable under the above assumptions.

CHAPTER 10 ENVIRONMENTAL AND SOCIAL CONSECRATION

10.1 Obtaining Environmental Clearance Certificate

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", the most significant, stipulated in relevant laws, regulations and guidelines of Bangladesh. Consequently the project proponent (KWASA) shall prepare IEE and EIA reports for getting Site Clearance Certificate (SCC) and Environmental Clearance Certificate (ECC) from DOE (Department of Environment)

10.2 IEE Preparation and SCC Issuance

An IEE report for the project was prepared and submitted to DOE by KWASA. And DOE approved and issued ECC with terms and conditions to be clarified during the project implementation. The IEE report is attached in the Supporting Report of the Study.

10.3 EIA Preparation /ECC Issuance

KWASA prepared and submitted the EIA report for the project to DOE in November 2010. And on February 1 2011 DOE issued ECC for the project. The EIA report is attached in the Supporting Report of the Study.

10.4 LAP & RAP

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. KWASA prepared the LAP/RAP report and in November 2010. And KWASA discussed with ADB and JICA appraisal missions about land issues for the project based on the report. The LAP/RAP report is attached in the Supporting Report of the Study

10.5 Specific Environmental and Social Aspects in the Projects Sites

10.5.1 Social Aspects

(1) Necessary Land Acquisition

Lands for the project components to be acquired are as summarized in **Table 10.1**.

Table 10.1 Summary of Project Components and Land Issue

Facility & Location		Land Type	Ownership	Land Issue
1. WI	Mollarhat	Paddy + River bank	Private Land	To be acquired
2. RWT P	Mollarhat to Samanto Sena	National Highway	RHD	Not necessary for Land Acquisition
		Local Government Roads	LGED	
3.SWTP	Samanto Sena	Paddy + Fish Pond	Private & Govt. Lands	To be acquired
4.IR				
5.CWTP	KCC area	Under the existing roads	KCC/ others	Not necessary for Land

					Acquisition
6. DR & OHT	1	Deana West Para Reservoir and Over Head Tank	Paddy+ Fish Land (Low Land)	Private Land	To be acquired
	2	Ward # 16 Councilor office Reservoir and Over Head Tank	Plain Land	Govt. Land	To be acquired
	3	Sonadanga Moha Sarak Reservoir and Over Head Tank (Women Stadium)	Paddy+ Fish Land (Low Land)	Private Land	To be acquired
	4	Beside of 7 No. Wrd Councilor Office Reservoir and Over Head Tank	Marshy Land	Private Land	To be acquired
	5	Khalishpur Chorerhat River Ghat Reservoir and Over Head Tank	Plain Land	Govt. Land	To be acquired
7. OHT	1	Rab Sarani Over Head Tank (Word # 2)	Cultivable Land Plain Land	Private Land	To be acquired
	2	Mujgunni Over Head Tank (Word # 9)	Plain Land	Govt. Land	To be acquired
	3	Ferry Ghat Power House More (KCC Garage) Over Head Tank	Plain Land	Govt. Land	To be acquired
	4	Andir Pukur Over Head Tank	Plain Land	Private Land	To be acquired
	5	South side of Word # 31office Labonchura Over Head Tank	Paddy Land (Low Land)	Private Land	To be acquired
	6	DPHE Rupsha Over Head Tank	Plain Land	Govt. Land	To be acquired

Note; 1. WI: Water Intake Facility 2. RWTP: Raw water Transition Pipe 3. SWTP: Surface Water Treatment Plant
4. IR: Impounding Reservoir 5. CWTP: Clear water Transition Pipe 6. DR: Distribution Reservoir
7. OHT: Over Head Tank 8. RHD: Road & Highway Dept. LGDE: 9. Local Government Engineering Dept.
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(2) Local People Affected by the Land Acquisitions

- 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

(3) Other Social Environment in the Project Sites

As a result of the EIA surveys, illegal settlement, socially and culturally important sites in and around the project sites and the existing roads are not identified at all.

10.5.2 Physical Environmental Aspects

- The Khulna division is prominent to the world for the largest mangroves forest called "Sundarban" However, 85 km from the Intake Facility 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 al
- 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. Namely, rare and endangers flora / fauna species are not identified in the project area at all.

10.6 Identification of Possible Impacts by the Projects

Table10.2 summarizes possible social impacts caused by the project. As the result, critical social impacts have not initially been identified excluding necessary land acquisitions for the project sites.

Table 10.2 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

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Table10.3 summarizes possible environmental impacts caused by the project. As the result, critical environmental impacts have not initially been identified excluding some impacts during construction period.

Table 10.3 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

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10.7 Environmental and Social Considerations for the Projects

Stakeholders Meeting and Focus Group Discussions were held as shown in **Table 10.4**.

Table 10.4 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 10.5 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 shows major issues among others were raised in the Focus Group Discussion for three sites.

Table 10.6 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** 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.

10.7.1 Environmental Monitoring

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 LAP/RAP. 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 ECC, there may be certain terms and condition to full fill by the KWASA on environmental monitoring plan (EMP).

(1) Environmental Monitoring Function for the Project

The EIA report has recommended the proposed Environmental Monitoring Organization as follows.

Table 10.7 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

(2) Reporting

In the terms and conditions to be written in the ECC, there may generally be 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.

As for the JICA, JICA has prepared a "Monitoring Form" in the JBIC Environmental & social Consideration Guidelines. Based on results of discussion(s) to be done with JICA, KWASA and/or the PMU 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.

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**.

Table 11.1 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 11.1**. 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 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 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 summarized 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

11.3 Implementation Method

11.3.1 Packaging for the Project Components

Proposed contract packages, 2 packages for the JICA ODA loan, in the Project are shown in **Table 11.2**.

Table 11.2 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		

Implementation Schedule

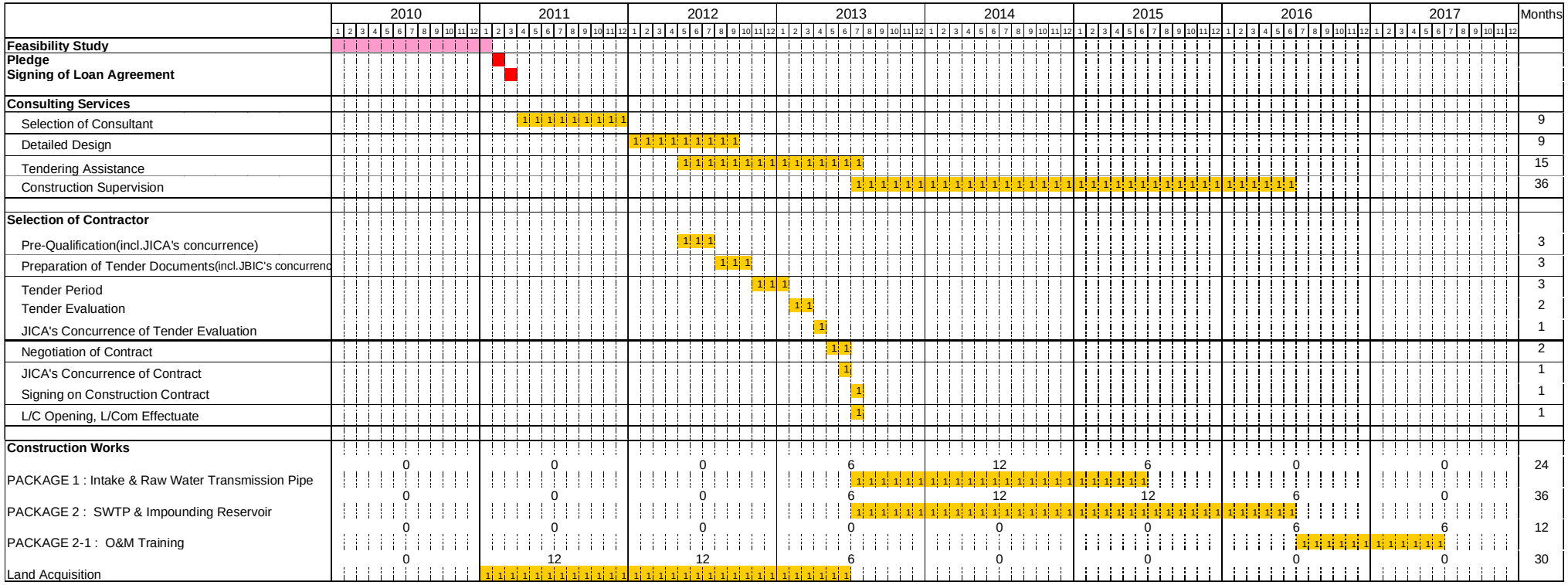

Figure 11.1 Implementation Schedule (Package 1 & 2)

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 Project Management Consultant
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)

11.3.3 Implementing Organization (PMU)

KWASA will be the primary agency responsible for executing and supervising the Project. Proposed project management unit (PMU) in KWASA is shown in **Figure 8.2**.

11.4 Consulting Services

11.4.1 Terms of Reference

KWASA shall procure consultant services for detailed design and project management for Khulna water supply project and consultant shall consist of both international and local consultants.

11.4.2 Cost Estimates for Consulting Services

The expected cost breakdown of the consulting services is shown in **Table 11.3** for the Detailed Design Consultant Services and Project Management Services.

Table 11.3 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 for JICA Project is tabulated in as follows in **Table 11.4** and annual fund requirement for Package-1&2 (JICA Project) are tabulated in **Table 11.5**.

Table 11.4 Summary of Capital Cost

Item		Total		
		FC	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 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																								
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%																							
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

Annual operation and maintenance cost is estimated 3,080 thousand US$. Breakdown of O&M cost is shown in **Table 11.6**.

Table 11.6 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 11.7 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

There is a need to support KWASA, through a technical assistance program, to design and implement a sustainable groundwater extraction plan. For this purpose, 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	[redacted]				[redacted]		12 MM
Groundwater Specialist	[redacted]		[redacted]		[redacted]		18 MM
Water Quality Specialist	[redacted]				[redacted]		12 MM

12.2 Poverty Reduction Plan

An assumed TA program to support KWASA to formulate Poverty Reduction Strategy including gender issue measurements, 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)	[redacted]				[redacted]		12 MM
Sociologist (National)	[redacted]		[redacted]		[redacted]		18 MM
Gender Specialist (International)	[redacted]				[redacted]		12 MM
Gender Specialist (National)	[redacted]		[redacted]		[redacted]		18 MM

12.3 Comprehensive Master Plan

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							