CHAPTER 6

DISTRIBUTION SYSTEM

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6.1 Planned Arrangements for Distribution Networks

The main objectives to be followed in the planning of the distribution network within the Karnaphuli Service Area are 'equitable distribution' and 'control of non-revenue water'.

In order to achieve these objectives, the distribution network within the Karnaphuli Service Area is subject to large-scale sectorization. This is expected to facilitate operation and maintenance of the system, and realize proactive and effective control of non-revenue water.

For the purpose of enhancing equitable distribution, the Karnaphuli Service Area shall be divided into hydraulically independent 'Sectors'. Each Sector will have only one inlet provided with a flow meter, a pressure gauge and a pressure regulating valve. Flow and pressure measurement data will be transmitted through the SCADA system to the Central Control Room located at the Karnaphuli water treatment plant, for monitoring and recording purposes on a 24/7 basis. Pressure regulating valves will automatically adjust the pressure at the outlets to match set points, which can be changed in the Central Control Room by operators. The set points for each Sector will initially be determined based on hydraulic analyses, but will be changed later by taking actual pressure conditions and measurements within each Sector into consideration.

For the effective control of non-revenue water, each Sector will be further divided into a number of small District Metered Areas (DMAs). On average, each DMA will be sized such that it includes approximately 2 to 4 km of distribution pipes. DMAs will be designed so that whenever it is necessary they can be hydraulically isolated from the rest of the distribution network by closing 2 to 4 valves in known locations. In principle, each DMA will have only one inlet provided with proper arrangements as shown in Figure 6.1.1 for the measurement of minimum night flow with the use of a vehicle-mounted electromagnetic flow meter. Figure 6.1.2 presents standard chamber for flow measurement.

The majority of the pipes that comprise the existing distribution network are made of asbestos cement and low quality polyvinyl chloride. They were installed more than 30 years ago, mostly on an ad-hoc basis without long-term planning, and are now severely deteriorated and undersized. Aside from such conditions, the extensive field investigations conducted by the PANI team (including excavation at various locations) demonstrated that the extent of the problems regarding the existing distribution network was much worse than had been previously anticipated. The investigation showed that the existing information on the distribution pipes with respect to their size, material, location and the state of interconnections with other parts of the network is either inadequate or inaccurate. The overall assessment of the investigation results suggested that establishing an entirely new distribution network is more effective than rehabilitating the existing network in order to create an equitable and controllable network with low levels of NRW.

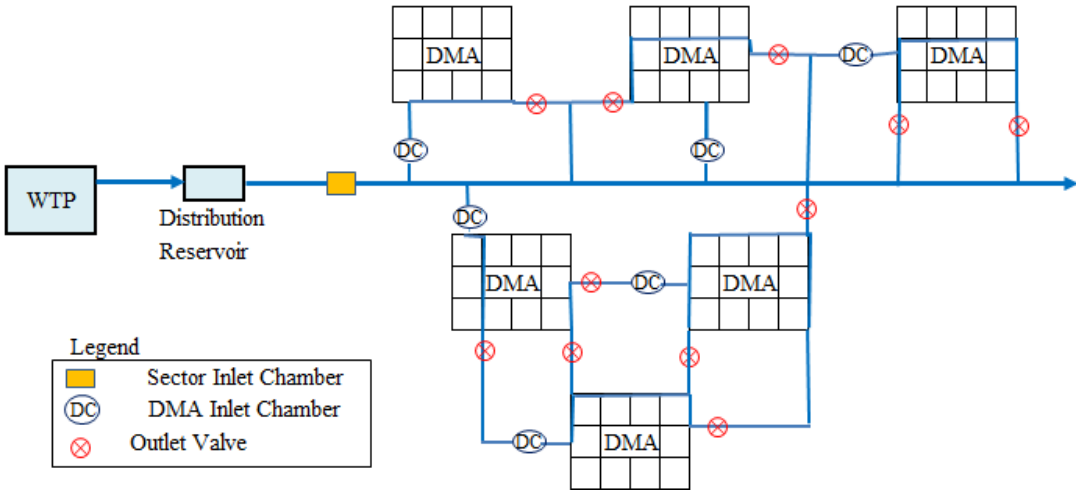


Figure 6.1.1 Standard Layout Plan of DMA

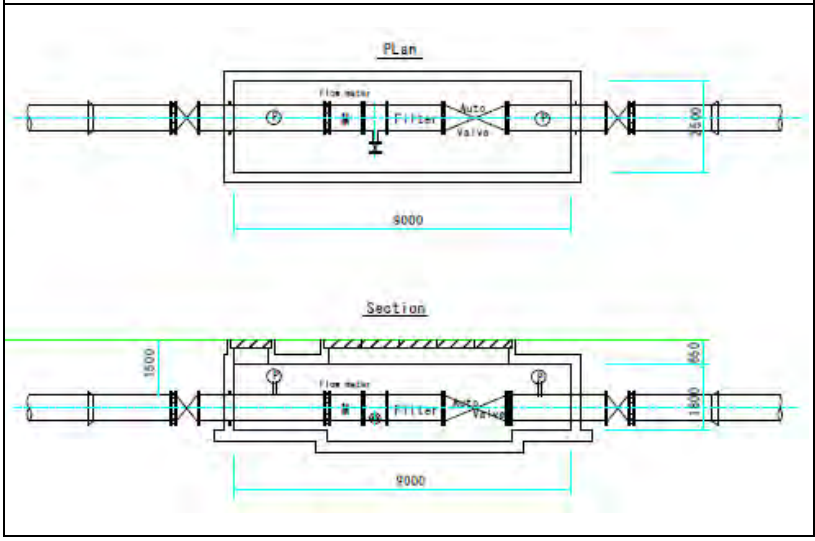
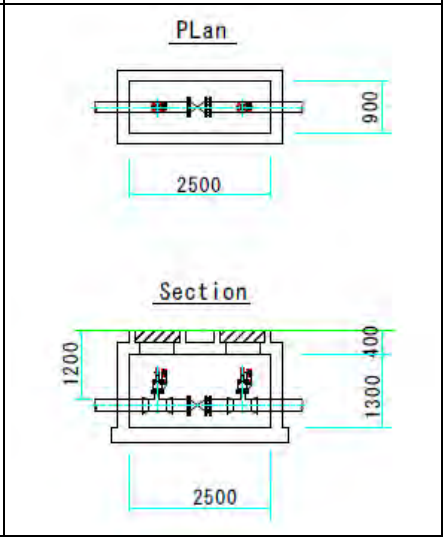
Sector Inlet Chamber	DMA Inlet Chamber
	

Figure 6.1.2 Standard Chamber of Sector Inlet and DMA Inlet

6.2 Configuration of Distribution System for Karnaphuli Service Area

6.2.1 Manner of Study for the Establishment of Distribution Networks in Karnaphuli Service Area

The area selected as the Karnaphuli Service Area is characterized for the planning of the distribution system as follows:

(1) The service area is located about 30 km from Karnaphuli WTP
(2) Available land in the CCC area is quite limited and it is difficult to obtain land for the construction of distribution reservoir/s in a location where the ground elevation allows gravity flow to the service area.

Under the above constraints, the Phase 1 Project planned to construct a ground reservoir at Nashirabad to transmit water to some distribution reservoirs/elevated tanks. Figure 6.2.1 shows the planned water supply system in the Phase 1 Project.

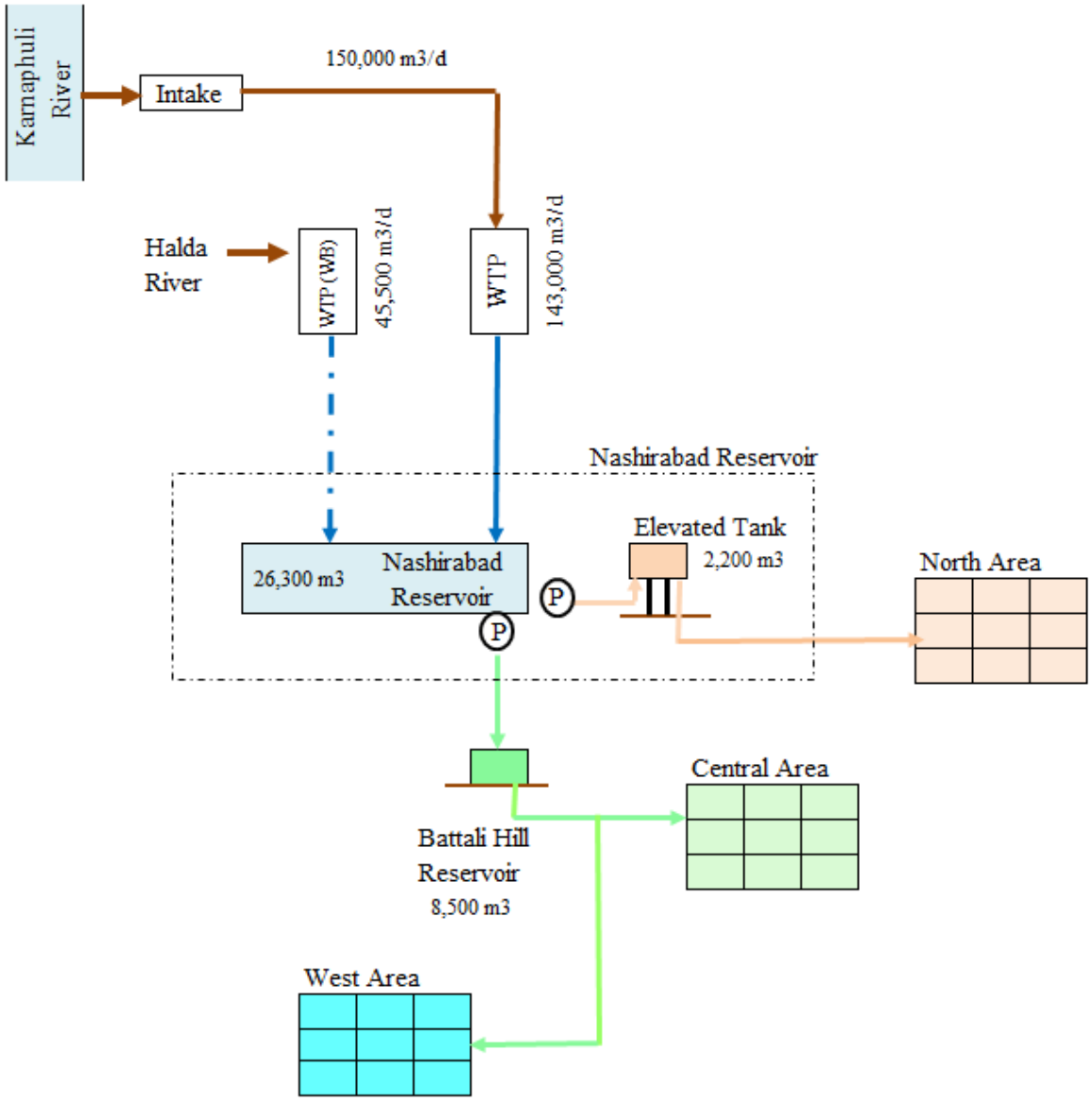


Figure 6.2.1 Water Supply System Planned in Phase 1 Project

There are three units of distribution reservoir/elevated tank in Phase-1 Project, Nashirabad Reservoir, Nashirabad Elevated Tank and Battali Hill Reservoir, all of which are under construction. Nashirabad Reservoir, planned to receive water from Karnaphuli WTP (143,000 m^3/d) and Madunaght WTP (45,500 m^3/d), has the function of providing a storage volume of 26,300 m^3 before transmitting water to Battali Hill distribution reservoir (V=8,500m^3) to supply the central and western areas, as well as pumping water to Nashirabad Elevated Tank to supply the northern area.

In the Phase-1 Project, yard pipes for the transmission pipeline from Madunaghat WTP to Nashirabad Reservoir (as planned under a WB project) were included in the reservoir site. However, the above pipeline will be cancelled in order to maintain a self-contained Karnaphuli water supply system.

6.2.2 Water Transmission Method from Nashirabad Reservoir to Distribution Reservoirs /Elevated Tanks

(1) Alternative water distribution methods

There are three options for planning of water distribution systems; (1) gravity distribution method, (2) direct pumping distribution method and (3) combination of the above two methods.

In the application of the gravity distribution method, the transmitted daily maximum volume from Nashirabad Reservoir to the distribution reservoirs/ elevated tanks is delivered to the service area as gravity flow throughout the day, provided that the low water level in the reservoir/ elevated tank is maintained. Under this arrangement, appropriate water pressure is maintained up to the end of the distribution pipeline, such that there is no risk of the inflow of polluted water occurring. In addition, the transmission pumps at Nashirabad Reservoir are arranged for the fixed water head and flow rate throughout the day for each reservoir/elevated tank. This arrangement facilitates economical and easy operation of the water supply system. In this connection, the gravity type distribution method is advantageous.

(2) Water transmission method from Nashirabad Reservoir to distribution reservoir/elevated tank under the conditions of limited capacity of distribution reservoir/elevated tank

The distribution reservoir has different functions including the following:

a) Adjustment of distribution volume to meet the hourly fluctuation in daily water demand
b) Adjustment of water pressure in the distribution system
c) Combination of the above two functions

Nashirabad Reservoir cannot be used for the adjustment of water pressure unless a distribution pump is provided for direct delivery of the hourly maximum water to the service area, as its ground elevation is not high enough to ensure gravity flow to the service areas. In this regard, the combined use of Nashirabad Reservoir and each distribution reservoir/elevated tank is necessary to achieve the function as a distribution reservoir to cater for the hourly peak demand in the service area, thus ensuring gravity delivery of water (coinciding with item c) in the above mentioned categories).

Treated water from Karnaphuli WTP is transmitted from the WTP to Nashirabad Reservoir at a constant hourly flow rate through the day, in order to meet the daily maximum water demand. Then, water is further transmitted to Battali Hill distribution reservoir, Nashirabad Elevated Tank and others, as required, to cater for the hourly peak demand, ensuring gravity delivery of water in the respective service areas.

If the capacity of the distribution reservoir/elevated tank is adequate to meet the standard design retention time (five hours at daily maximum demand in the subject service area), a constant flow to meet the daily maximum demand may be transmitted from Nashirabad Reservoir. However, the capacities of the distribution reservoir/ elevated tank (at least Nashirabad Elevated Tank and Battali Hill reservoir planned in Phase 1 Project) are not sufficient enough to meet the required retention time. In this connection, the retention time required for distribution of water to each service area shall be managed together with the capacity of Nashirabad Reservoir.

The “Design Criteria for Waterworks Facilities 2000 (Japan Water Works Association)” refers to the standards for the design of distribution reservoirs for different functional purposes as follows:

a) Adjustment to meet the hourly fluctuation in daily water demand: The capacity of the reservoir shall be more than 1-3 hours of the daily maximum water demand.
b) Adjustment of water pressure in the distribution system: The capacity of reservoir shall be

more than 30 minutes of the hourly maximum water demand.

Under the above conditions, the transmission pump facilities at Nashirabad Reservoir for the reservoir/elevated tank without the required capacity shall be planned for the hourly maximum demand. Planned elevated tank in this Project falls in this category due to the limited size of the tank and design demand (more than 20,000 m^3/d).

In case that the reservoir/ elevated tank satisfies the above conditions (refer to items a) and b), the following study may be made for reducing the cost of both the construction and O&M of the facilities. Namely, the hourly maximum demand for each service area shall be catered for by increasing the pumping rate to daily maximum flow rate from Nashirabad Reservoir to the distribution reservoir/Elevated tank, where necessary. The required transmission rate/hour is estimated using the following data/information and guideline.

1) Hourly fluctuation pattern of water use in the service area

There is no record of the diurnal variation in water consumption in Chittagong city. Therefore, the diurnal variation in water consumption for a big city in another Asian country is used for the purposes of this study. The daily maximum water demand by subject service area is distributed to each hour throughout a day using the hourly water consumption in Cirebon city, Indonesia (260,000 served population). The fluctuation in hourly water consumption in Cirebon is included, as a similar reference, in Supporting Report 6.2.1.

2) Daily maximum water demand for selected sectors by the territory of distribution reservoir/ elevated tank

The daily maximum water demand to be covered by the distribution reservoir/elevated tank is estimated by referring to the projected demand for each sector.

3) Fixed capacity of distribution reservoir/elevated tank

The possible/fixed capacity of the distribution reservoirs/elevated tank is used in the study to determine the hourly flow rate required for the transfer of water from Nashirabad Reservoir to the distribution reservoir/ elevated tank.

4) Calculation process to determine the required capacity of distribution reservoir/elevated tank in the case that the retention time for the reservoir can be provided as required: refer to Design Criteria for Water works Facilities, Japan Water works Association.

The above guideline is designed to calculate the required capacity of the distribution reservoir/ elevated tank, when the daily maximum flow is sent from the clear water reservoir at WTP. The manner of calculation in the guideline is used in this study.

In the case that the capacity of the distribution reservoir/ elevated tank is fixed and is less than the design capacity required, a trial calculation is made to determine the appropriate flow rate to transfer water from Nashirabad Reservoir, in order to cater for the hourly fluctuation in water demand throughout the day in the subject service area.

6.2.3 Distribution System in Karnaphuli Service Area

(1) Sectorization in Karnaphuli service area

The Karnaphuli service area (3,063 ha), with a projected population to be served in 2030 of 1,540,200, is divided into 10 sectors (A - J) in consideration of the following factors.

1) Locations of wards
2) Topographical conditions
3) Locations of major infrastructure; major roads, railway, canal, etc.
4) Distribution main pipeline routes planned in the Phase 1 Project
5) The daily maximum water demand per sector should be in the range from 20,000m^3/d to 50,000m^3/d

Figure 6.2.2 shows the locations of major roads and railways in the Karnaphuli service area, which are referred to in the sectorization of the entire service area.

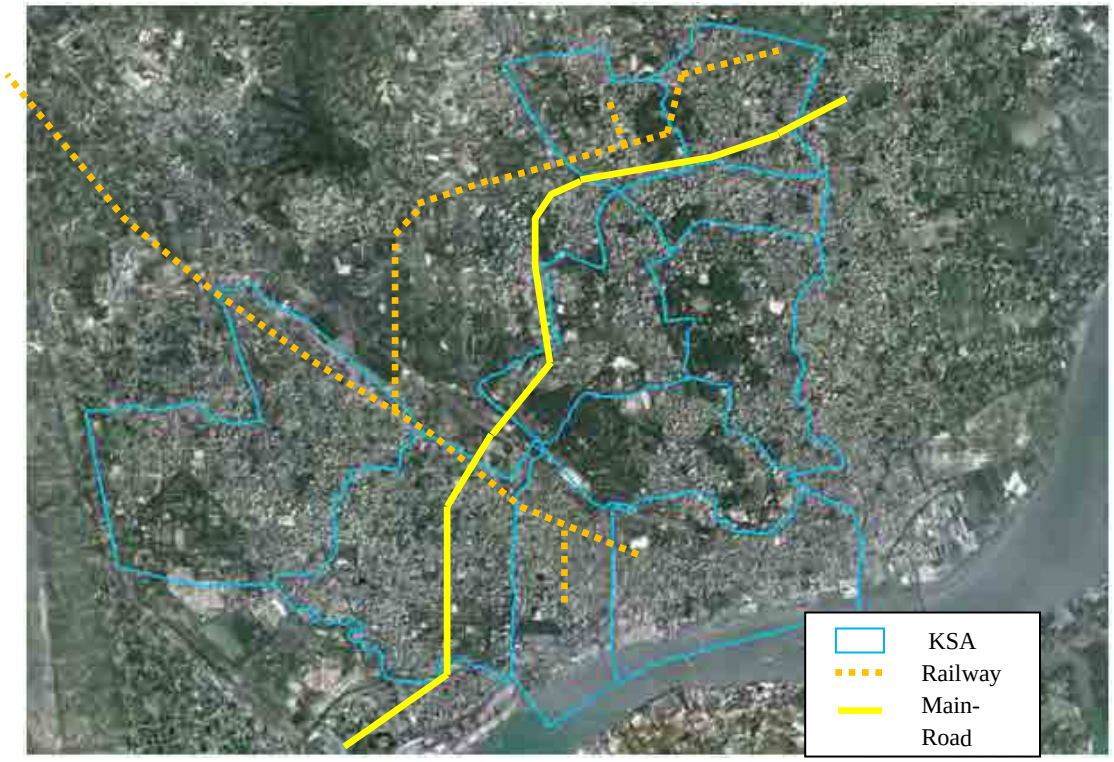


Figure 6.2.2 Locations of Major Roads and Railways in Karnaphuli Service Area

Figure 6.2.3 presents the locations of the proposed sectors, together with the water demand in each sector (daily maximum). Table 6.2.1 shows the water demand projection by ward up to the year 2030 in the CCC area. Table 6.2.2 presents the daily maximum water demand in 2030 by ward for each sector in the Karnaphuli service area.

(2) Alternative study of distribution systems

Following sectorization of the Karnaphuli service area, alternative distribution systems are studied in consideration of the following conditions.

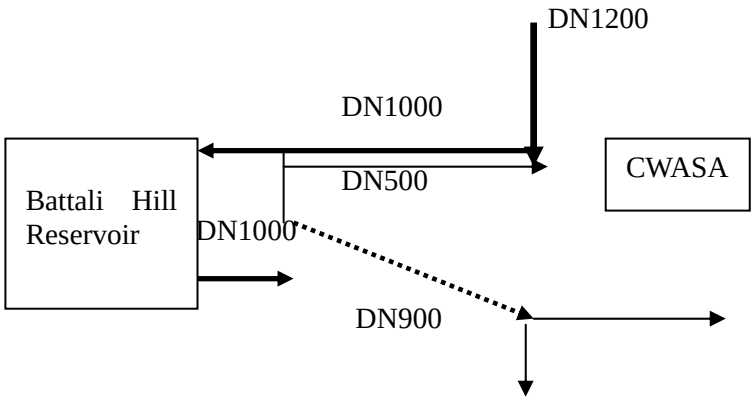
1) Effective use of distribution facilities planned in Phase 1 Project; reservoirs and pipelines

   - Nashirabad reservoir (26,300$m^{3)}$
   - Elevated Tank at Nashirabad reservoir site (2,200m^3)

- Transmission pipeline from Nashirabad Reservoir to Battali Hill Distribution Reservoir (DN 1,200mm)
- Battali Hill Distribution Reservoir (8,500m^3)

2) Limited space in the road for construction of pipelines from the premises of CWASA to Battali Hill Reservoir along the transmission route from Nashirabad Reservoir

Transmission and distribution pipelines in the section between the CWASA area and Battali Hill Reservoir site are planned in the Phase 1 Project, as shown in the figure below. Pipe diameters are limited due to narrow roads and there is no space to construct additional pipelines along this route. Using possible pipelines, the allowable capacity of the transmission pipeline from Nashirabad Reservoir to Battali Hill Reservoir may be in the range of 150,000m^3/d (v=1.5m/s)～195,000m^3/d (v =2.0m/s).



In addition, along the route of the distribution main pipes from Battali Hill Reservoir to the southern part of the central area and the western area, there is not sufficient space to install an additional pipeline with a capacity of 140,000 m^3/d-150,000 m^3/d in hourly maximum demand (in the case of service for Sectors D, E, F and G). In the Phase 1 Project it was decided to utilize existing pipes which have a diameter of 900mm, as there is space for the installation of new pipes. The above problems suggest the need for a sub-system for the western area and part of central area.

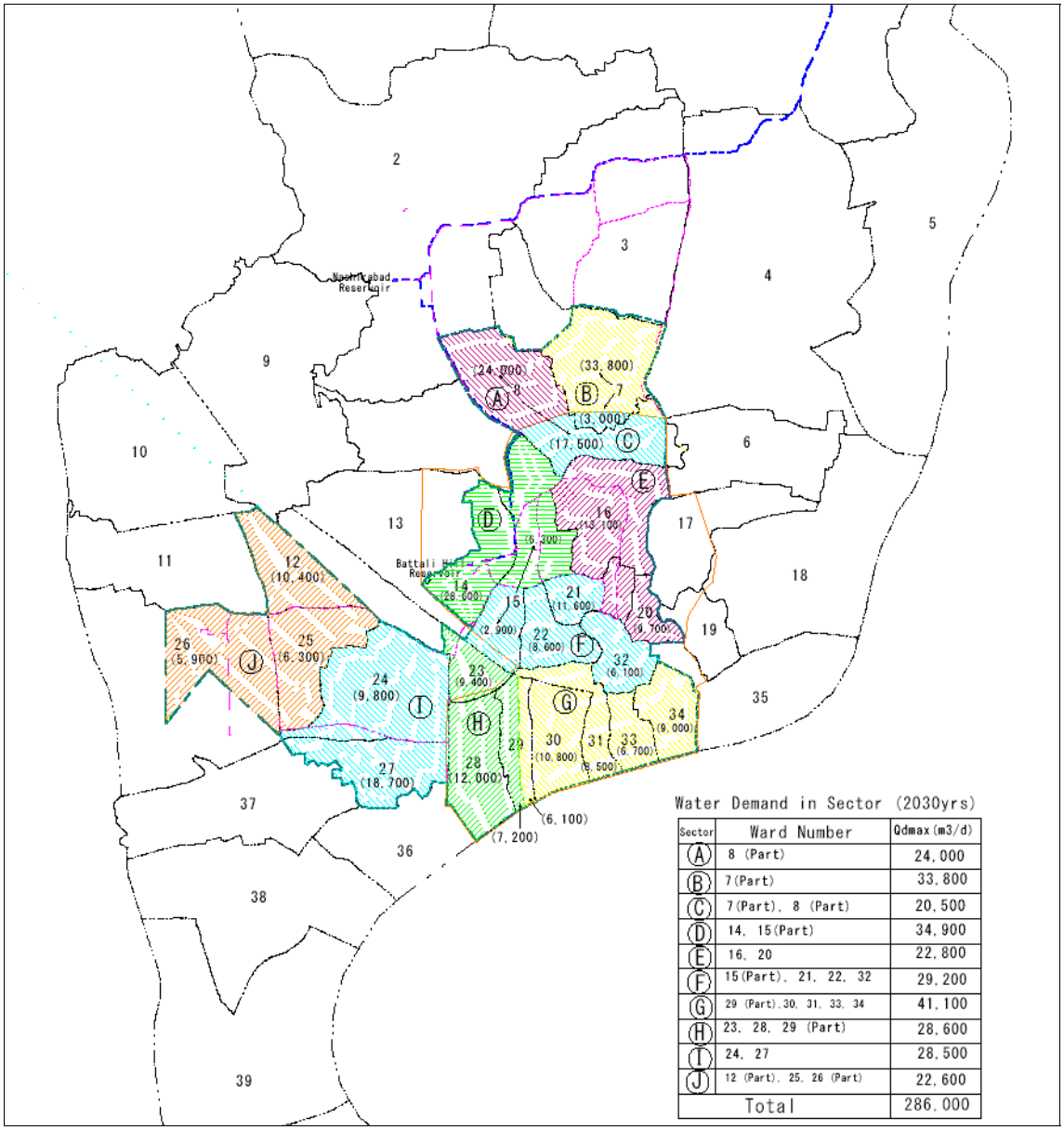


Figure 6.2.3 Locations of Sectors in Karnaphuli Service Area

Table 6.2.1 Water Demand Projection by Ward up to Year 2030

Ward			Year	2011		2015		2020		2025		2030	
		Per-capita water consumption Lpcd		105		108		110		115		120	
		1.15	= Qdmax/Qdave	Qdave	Qdmax	Qdave	Qdmax	Qdave	Qdmax	Qdave	Qdmax	Qdave	Qdmax
01	**16**	**Bayeijid Bostami Thana**		**37,400**	**43,100**	**48,500**	**55,800**	**53,600**	**61,700**	**62,000**	**71,200**	**79,900**	**91,900**
	01	Ward No.01	South Pahartali	11,100	12,800	14,300	16,400	15,700	18,100	18,200	20,900	23,300	26,800
	02	Ward No.02	Jalalabad	15,000	17,300	19,800	22,800	22,400	25,800	26,200	30,100	34,200	39,300
	03	Ward No.03	Panchlaish	11,300	13,000	14,400	16,600	15,500	17,800	17,600	20,200	22,400	25,800
02	**57**	**Panchlaish Thana**		**46,800**	**53,800**	**60,900**	**70,000**	**70,800**	**81,400**	**86,800**	**99,800**	**112,600**	**129,500**
	07	Ward No.07	West Sholakbawar	18,500	21,300	24,100	27,700	28,000	32,200	34,300	39,400	44,500	51,200
	08	Ward No.08(Part)	Shulokbahar	28,300	32,500	36,800	42,300	42,800	49,200	52,500	60,400	68,100	78,300
03	**19**	**Chandgaon Thana**		**42,100**	**48,400**	**55,600**	**63,900**	**65,300**	**75,000**	**81,100**	**93,300**	**106,200**	**122,100**
	04	Ward No.04	Chandgaon	17,300	19,900	22,800	26,200	26,800	30,800	33,300	38,300	43,600	50,100
	05	Ward No.05	Mohara	18,600	21,400	24,600	28,300	28,900	33,200	35,900	41,300	47,000	54,100
	06	Ward No.06	East Sholakbawar	6,200	7,100	8,200	9,400	9,600	11,000	11,900	13,700	15,600	17,900
04	**10**	**Bakalia**		**45,200**	**52,000**	**59,600**	**68,600**	**70,300**	**80,800**	**87,600**	**100,700**	**116,100**	**133,600**
	17	Ward No.17	West Bakalia	15,000	17,300	19,900	22,900	23,600	27,100	29,500	33,900	39,200	45,100
	18	Ward No.18	East Bakalia	9,600	11,000	12,700	14,600	15,100	17,400	18,900	21,700	25,000	28,800
	19	Ward No.19	South Bakalia	17,600	20,200	23,300	26,800	27,600	31,700	34,500	39,700	45,900	52,800
	35	Ward No.35(Part)	Boxirhat	3,000	3,500	3,700	4,300	4,000	4,600	4,700	5,400	6,000	6,900
05	**41**	**Kotwali Thana**		**44,700**	**51,400**	**52,400**	**60,200**	**54,600**	**62,900**	**61,300**	**70,500**	**71,700**	**82,500**
	15	Ward No.15	Bagmoniram	5,000	5,800	5,900	6,800	6,100	7,000	6,900	7,900	8,000	9,200
	16	Ward No.16	Chanik Bazar	7,100	8,200	8,300	9,500	8,700	10,000	9,700	11,200	11,400	13,100
	20	Ward No.20	Dewan Bazar	5,200	6,000	6,100	7,000	6,400	7,400	7,200	8,300	8,400	9,700
	21	Ward No.21	Jamalkhan	6,300	7,200	7,400	8,500	7,700	8,900	8,700	10,000	10,100	11,600
	22	Ward No.22	Enayet Bazar	4,700	5,400	5,500	6,300	5,700	6,600	6,400	7,400	7,500	8,600
	31	Ward No.31	Alkaran	4,600	5,300	5,400	6,200	5,600	6,400	6,300	7,200	7,400	8,500
	32	Ward No.32	Anderkilla	3,300	3,800	3,900	4,500	4,000	4,600	4,500	5,200	5,300	6,100
	33	Ward No.33	Finghee Bazar	3,600	4,100	4,200	4,800	4,400	5,100	4,900	5,600	5,800	6,700
	34	Ward No.34	Patharghata	4,900	5,600	5,700	6,600	6,000	6,900	6,700	7,700	7,800	9,000
	35	Ward No.35(Part)	Boxirhat					0		0		0	
06	**43**	**Khulshi Thana**		**35,500**	**40,900**	**46,500**	**53,500**	**54,300**	**62,400**	**67,000**	**77,000**	**87,500**	**100,600**
	08	Ward No.08(Part)	Sholakbahar					0					
	09	Ward No.09	North Pahartali	9,700	11,200	12,700	14,600	14,800	17,000	18,300	21,000	23,900	27,500
	13	Ward No.13	Pahartali	15,700	18,100	20,600	23,700	24,000	27,600	29,600	34,000	38,700	44,500
	14	Ward No.14	Lalkhan Bazar	10,100	11,600	13,200	15,200	15,500	17,800	19,100	22,000	24,900	28,600
07	**55**	**Pahartali**		**21,200**	**24,400**	**25,100**	**28,900**	**25,600**	**29,500**	**28,900**	**33,300**	**34,700**	**39,900**
	10	Ward No.10	North Kattali	4,900	5,600	5,800	6,700	5,900	6,800	6,700	7,700	8,100	9,300
	11	Ward No.11	South Kattali	5,300	6,100	6,300	7,200	6,400	7,400	7,200	8,300	8,600	9,900
	12	Ward No.12	Saraipara	11,000	12,700	13,000	15,000	13,300	15,300	15,000	17,300	18,000	20,700
08	**28**	**Double Mooring Thana**		**37,200**	**42,800**	**44,500**	**51,100**	**46,700**	**53,800**	**51,800**	**59,600**	**64,400**	**74,000**
	23	Ward No.23	North Pathantuli	4,400	5,100	5,300	6,100	5,700	6,600	6,700	7,700	8,200	9,400
	24	Ward No.24(Part)	North Agrabad	5,500	6,300	6,500	7,500	6,500	7,500	7,300	8,400	8,500	9,800
	27	Ward No.27	South Agrabad	10,500	12,100	12,300	14,100	12,500	14,400	13,900	16,000	16,300	18,700
	28	Ward No.28	Pathantuli	5,600	6,400	6,800	7,800	7,300	8,400	8,400	9,700	10,400	12,000
	29	Ward No.29	West Madarbari	6,200	7,100	7,500	8,600	8,100	9,300	9,400	10,800	11,600	13,300
	30	Ward No.30	East Madarbari	5,000	5,800	6,100	7,000	6,600	7,600	6,100	7,000	9,400	10,800
09	**35**	**Halishahar Thana**		**10,100**	**11,600**	**11,800**	**13,600**	**12,000**	**13,800**	**13,500**	**15,500**	**15,800**	**18,100**
	24	Ward No.24(Part)	North Agrabad										
	25	Ward No.25	Rampur	3,500	4,000	4,100	4,700	4,200	4,800	4,700	5,400	5,500	6,300
	26	Ward No.26	North Hallshahar	6,600	7,600	7,700	8,900	7,800	9,000	8,800	10,100	10,300	11,800
10	**20**	**Chittagong Port Thana**		**61,900**	**71,200**	**76,200**	**87,500**	**87,300**	**100,500**	**104,500**	**120,200**	**128,600**	**147,900**
	36	Ward No.36	Gosalldanga	7,200	8,300	8,200	9,400	8,400	9,700	9,300	10,700	10,600	12,200
	37	Ward No.37	Halishahar Munir Nagar	13,100	15,100	15,500	17,800	16,900	19,400	19,500	22,400	23,200	26,700
	38	Ward No.38	South Middle Halishahar	18,100	20,800	22,900	26,300	27,000	31,100	33,000	38,000	41,300	47,500
	39	Ward No.39	South Halishahar	23,500	27,000	29,600	34,000	35,000	40,300	42,700	49,100	53,500	61,500
11	**65**	**Patenga Thana**		**26,800**	**30,800**	**34,300**	**39,400**	**40,400**	**46,400**	**49,300**	**56,700**	**63,300**	**72,800**
	40	Ward No.40	North Patenga	14,700	16,900	18,800	21,600	22,100	25,400	27,000	31,100	34,700	39,900
	41	Ward No.41	SouthPatenga	12,100	13,900	15,500	17,800	18,300	21,000	22,300	25,600	28,600	32,900
						0							
Chittagong City Corporation Total				**408,900**	**470,400**	**515,400**	**592,500**	**580,900**	**668,200**	**693,800**	**797,800**	**880,800**	**1,012,900**

Table 6.2.2 Water Demand in 2030 by Sector

Table — Composition of Wards to be selected for Karnaphuli Service Area (120Lpcd)

Chittagong City Corporation				2030 Water Demand (WD)			Priority Ward				WD by Sector in Karnaphuli Service Area										rate of Area in partially covered Ward (%)
				WD by Ward	Area by Wrad	WD/ha	PANI	Phase-1 Project			Higher	A	B	C	D	E	F	G	H	I	J	
				Qdmax(m3/d)	ha	m3/d/ha	Project	North	Central	South	Demand	m3/d										
01	**16**	**Bayeijid Bostami Thana**		**91,900**	**3,015**	**30.5**																
	01	Ward No.01	South Pahartali	26,800	1,077	24.9																
	02	Ward No.02	Jalalabad	39,300	1,358	28.9		✓														
	03	Ward No.03	Panchlaish	25,800	580	44.5		✓														
02	**57**	**Panchlaish Thana**		**129,500**	**909**	**142.5**																
	07	Ward No.07	West Sholakbawar	51,200	407	125.8		✓			✓	24,000		17,500								72%
	08	Ward No.08(Part)	Shulokbahar	78,300	502	156.0	✓(part)	✓			✓		33,800	3,000								53%
03	**19**	**Chandgaon Thana**		**122,100**	**2,075**	**58.8**																
	04	Ward No.04	Chandgaon	50,100	927	54.0																
	05	Ward No.05	Mohara	54,100	904	59.8																
	06	Ward No.06	East Sholakbawar	17,900	244	73.4																
04	**10**	**Bakalia**		**133,600**	**1,323**	**101.0**																
	17	Ward No.17	West Bakalia	45,100	243	185.6	✓(part)				✓											
	18	Ward No.18	East Bakalia	28,800	655	44.0																
	19	Ward No.19	South Bakalia	52,800	127	415.7					✓											
	35	Ward No.35(Part)	Boxirhat	6,900	298	23.2																
05	**41**	**Kotwali Thana**		**82,500**	**931**	**88.6**																
	15	Ward No.15	Bagmoniram	9,200	180	51.1	✓		✓						6,300		2,900					
	16	Ward No.16	Chanik Bazar	13,100	177	74.0	✓		✓							13,100						
	20	Ward No.20	Dewan Bazar	9,700	39	248.7	✓				✓					9,700						
	21	Ward No.21	Jamalkhan	11,600	76	152.6	✓		✓		✓						11,600					
	22	Ward No.22	Enayet Bazar	8,600	86	100.0	✓										8,600					
	31	Ward No.31	Alkaran	8,500	92	92.4	✓											8,500				
	32	Ward No.32	Anderkilla	6,100	106	57.5	✓		✓								6,100					
	33	Ward No.33	Finghee Bazar	6,700	83	80.7	✓											6,700				
	34	Ward No.34	Patharghata	9,000	92	97.8	✓											9,000				
	35	Ward No.35(Part)	Boxirhat																			
06	**43**	**Khulshi Thana**		**100,600**	**903**	**111.4**																
	08	Ward No.08(Part)	Sholakbahar																			
	09	Ward No.09	North Pahartali	27,500	552	49.8																
	13	Ward No.13	Pahartali	44,500	227	196.0	✓(part)				✓											
	14	Ward No.14	Lalkhan Bazar	28,600	124	230.6	✓				✓				28,600							
07	**55**	**Pahartali**		**39,900**	**882**	**45.2**																
	10	Ward No.10	North Kattali	9,300	283	32.9																
	11	Ward No.11	South Kattali	9,900	331	29.9																
	12	Ward No.12	Saraipara	20,700	268	77.2				✓											10,400	50%
08	**28**	**Double Mooring Thana**		**74,000**	**771**	**96.0**																
	23	Ward No.23	North Pathantuli	9,400	77	122.1	✓			✓	✓								9,400			
	24	Ward No.24(Part)	North Agrabad	9,800	208	47.1				✓										9,800		
	27	Ward No.27	South Agrabad	18,700	148	126.4				✓	✓									18,700		
	28	Ward No.28	Pathantuli	12,000	122	98.4	✓			✓									12,000			
	29	Ward No.29	West Madarbari	13,300	107	124.3	✓				✓							6,100	7,200			54%, 46%
	30	Ward No.30	East Madarbari	10,800	109	99.1	✓											10,800				
09	**35**	**Halishahar Thana**		**18,100**	**881**	**20.5**																
	24	Ward No.24(Part)	North Agrabad																			
	25	Ward No.25	Rampur	6,300	193	32.6				✓											6,300	
	26	Ward No.26	North Hallshahar	11,800	688	17.2				✓											5,900	50%
10	**20**	**Chittagong Port Thana**		**147,900**	**1,896**	**78.0**																
	36	Ward No.36	Gosalldanga	12,200	136	89.7																
	37	Ward No.37	Halishahar Munir Nagar	26,700	378	70.6																
	38	Ward No.38	South Middle Halishahar	47,500	542	87.6																
	39	Ward No.39	South Halishahar	61,500	840	73.2																
11	**65**	**Patenga Thana**		**72,800**	**1,976**	**36.8**																
	40	Ward No.40	North Patenga	39,900	962	41.5																
	41	Ward No.41	SouthPatenga	32,900	1014	32.4																
Total				**1,012,900**	**15,562**	**65.1**						24,000	33,800	20,500	34,900	22,800	29,200	41,100	28,600	28,500	22,600	
Note) Higher water demand Area; Expansion ward area from PANI Project with higher water demand for water (more than 100m³/d/ha)												286,000										

3) Service areas to be covered for higher ground elevation areas under insufficient ground elevation of reservoir/ height of elevated tank

The service areas in Sector D and E cover comparatively higher elevation areas, with 20m to 30m GL, although other areas are less than 10m GL.

The sectors to be covered by each distribution reservoir/ elevated tank shall be selected in consideration of the higher areas, with consideration of the required hydraulic conditions for proper water distribution.

4) Alternative distribution systems

The Karnaphuli service area consists of the Northern, Central and Western areas geographically. Important considerations in planning are; No space to install pipes in the area surrounding Battali Hill Reservoir; and the location and elevation differences of the study areas compared to the planned distribution reservoir/elevated tank in the Phase 1 Project.

Under the above conditions, Nashirabad Elevated Tank may serve the Northern area and Battali Hill reservoir the Central area. An additional distribution reservoir/ elevated tank may be considered for the Western area considering its location, which is distant from Battali Hill reservoir, the presence of a railway (which divides the Central and Western areas) and the difficulty of installing additional pipes in the area surrounding Battali Hill Reservoir. The following are the capacities of the reservoir/ elevated tank considered for the study of the alternatives for the distribution system.

a) Nashirabad Elevated Tank: 2,200 m^3 (planned in Phase 1 Project)
b) Battali Hill Reservoir: 8,500 m^3 (planned in Phase 1 Project)
c) Halishahar Elevated Tank: 2,400 m^3 (assumed to serve the Western area by providing a similar capacity to the Nashirabad Elevated Tank, with the soil conditions at both tanks being similar)

The capacity of Nashirabad Reservoir shall be determined for each alternative to supplement the storage volume, due to the limited capacities of the respective reservoirs/ elevated tanks.

Two Alternative distribution systems are established for comparative study in full consideration of the Phase 1 Project and the restrictions mentioned above. Three sub-systems are considered covering the Northern, Central and Western areas.

a) Alternative 1: The Northern area is served by Nashirabad Elevated Tank and the Central area by Battali Hill Reservoir, with both sub-systems being served by gravity type distribution of water. The Western area is served by the direct pumping method from Nashirabad Reservoir.
b) Alternative 2: The three areas are served by respective reservoir/elevated tanks; the Northern area by Nashirabad Elevated Tank, the Central area by Battali Hill Reservoir and the Western area by Halishahar Elevated Tank

Table 6.2.3 Comparison of Alternative Distribution Systems

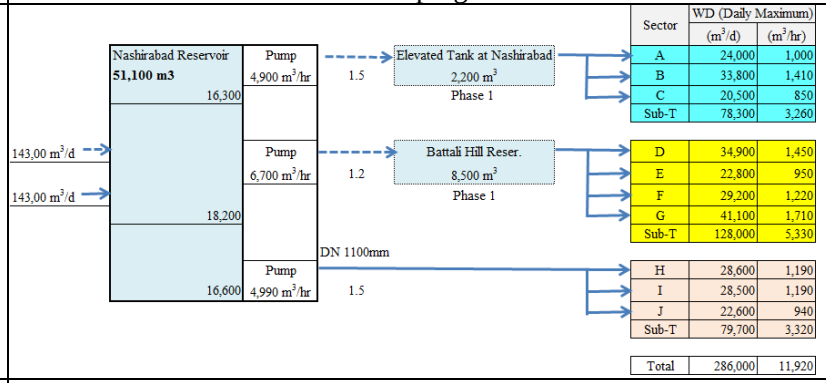
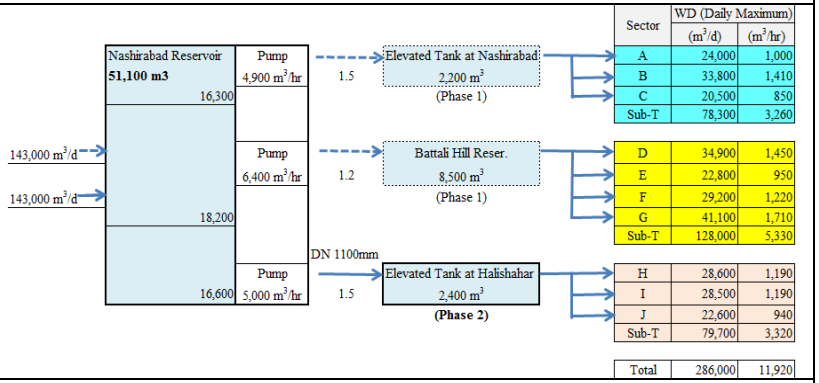
Alternatives	Alternative-1: Gravity Type for Northern & Central areas, but Direct Pumping method for Western area	Alternative-2: Gravity type for all three areas
Schematic plan of Distribution System Composition of Sectors by served reservoir/ E.T and water demand		
Composition of sectors by sub-system and demand (daily max & hourly max)	Sub-system / Sectors / Reservoir/E.T / Water Demand (Daily & Hourly Max; m^3/d) Northern A,B & C Nashirabad E.T 78,300 90,100 Central D, E, F & G Battali Hill Re. 128,000 147,200 Western H, I & J None 79,700 91,700	Sub-system / Sectors / Reservoir/E.T / Water Demand (Daily & Hourly Max; m^3/d) Northern A,B & C Nashirabad E.T 78,300 90,100 Central D, E, F & G Battali Hill Re. 128,000 147,200 Western H, I & J Halishahar E.T 79,700 91,700
Retention time in reservoir/E.T and transmission required from Nashirabad Re. to each reservoir/E.T at daily max demand	Sub-system / Reservoir/E.T / Retention Time / Transmission from Nashirabad: m^3/d Northern Nashirabad E.T 27 min 90,100 (1.5 x Dmax) Central Battali Hill Res. 1.6 hr 154,600 (1.2 x Dmax) Western None - 91,700 (1.5 x Dmax)	Sub-system / Reservoir/E.T / Retention Time / Transmission from Nashirabad: m^3/d Northern Nashirabad E.T 27min 90,100 (1.5 x Dmax) Central Battali Hill Re. 1.6 hr 154,600 (1.2 x Dmax) Western Halishahar E.T 29 min 91,700 (1.5 x Dmax)

Table 6.2.3 Comparison of Alternative Distribution Systems (cont'd)

Alternatives	Alternative-1: Gravity Type for Northern & Central areas, but Direct Pumping method for Western area	Alternative-2: Gravity type for all three areas
Expansion needs for Nashirabad Reservoir	Sub-system / Reservoir/E.T / Nashirabad Reservoir (m^3) Northern — Nashirabad E.T — 16,300 Central — Battali Hill Re. — 18,200 Western — None — 16,600 Total = 51,100 m^3 Additional 24,800 m^3	Sub-system / Reservoir/E.T / Nashirabad Reservoir (m^3) Northern — Nashirabad E.T — 16,300 Central — Battali Hill Re. — 18,200 Western — Halishahar E.T — 16,600 Total= 51,100m^3 Additional 24,800m^3
Required Additional Cost (Million Yen)	Sub-system / Transmission/Distribution pipes / E.T / Total Northern — 300 — - Central — 286 — - Western — 1,150 — 500 — - — 2,236	Sub-system / Transmission/Distribution pipes / E.T / Total Northern — 300 — - Central — 286 — - Western — 1,150 — 500 — - — 2,236
Issues & Problem and Advantages /disadvantage	1) The capital cost for this alternative is about 100 million yen lower than Alternative 2. 2) O&M cost is higher than for Alternative 2, due to application of direct pumping method for Western area. 3) O&M of facilities in Western area is difficult in terms of pump operation and water pressure near the pump station is higher than required to transmit water throughout the day, considering the water pressure and flow rate required at the farthest point in the service area.	1) The capital cost for this case is about 100 million yen higher than Alternative 1. 2) O&M cost for this alternative is lower than for Alternative 1, due to application of gravity type distribution for all sub- systems. 3) O&M of the facilities is much easier than Alternative 1 in use of three reservoir/elevated tanks. 4) In case of power failure, remaining water in the tanks will be used to provide continuous water supply until the start of operation of the generator sets.
Evaluation	Not Recommended due to the difficulty in O&M	Recommended

Table 6.2.3 summarizes the comparison of the two alternatives. In the case of the use of Battali Hill Reservoir, the required volume for transmission from Nashirabad Reservoir to Battali Hill Reservoir is calculated at 1.2 times of the daily maximum water demand in the Battali Hill sub-service area. Supporting Report 6.2.2 includes the calculation which uses the hourly fluctuation in water demand in the case of Cirebon city, Indonesia. On the other hand, the hourly maximum water demand is considered for the transmission pump facilities at Nashirabad Reservoir site, both for the Nashirabad and Halishahar Elevated Tanks, which both have a retention time of less than 30 minutes for adjustment of the water pressure.

As a result of comparison of the alternatives, Alternative 2 is recommended. The following which is a comparison of the two alternatives, explains the rational for this.

a) Common conditions for both:

- Sectors covered by sub-system and demand (daily max) by sub-system: Northern area 78,300 m^3/d, Central area 128,000m^3/d and Western area 79,700 m^3/d
- Transmission pump capacities and transmission/distribution pipeline from Nashirabad Reservoir to Elevated Tank/ inlet to sub-service area (western area)
- Expansion capacity of Nashirabad Reservoir (24,800 m^3)

b) Different conditions (advantages and disadvantages) of the two alternatives:

- The construction cost of Alternative 1 is about 100 million yen lower than Alternative 2, which requires an elevated tank in Halishahar. Land acquisition for construction of the elevated tank is not required.
- O&M cost for Alternative 1 is higher than for Alternative 2 and there are difficult in O&M for the direct pumping method to the Western area (Alternative 1)
- There are many advantages in the application of gravity distribution for all sub-systems, as in Alternative 2, as discussed previously.
- A continuous water supply from Halishahar Elevated Tank to the Western area can be provided in Alternative 2, in the case of power failure, before it is necessary to start a generator. The elevated tank provides for about 30 minutes storage at the daily maximum water demand of the service area.

c) Comprehensive evaluation

- Although the construction cost of Alternative 1 is about 100 million yen lower than Alternative 2, the O&M cost of this alternative will be higher.
- O&M of the Western area will be difficult in the case of Alternative 1.
- There are various advantages in application of gravity flow through the use of Halishahar Elevated Tank.
- The site on which Halishahar elevated tank will be constructed is owned by CWASA and there are no environmental impacts within the site and the surrounding area.

Figure 6.2.4 presents a schematic of Water Supply Flow, with an emphasis on the selected distribution system. The following is the definition of distribution pipes in accordance with the plan of the distribution network in the KSA.

a) Primary Distribution Main Pipe: Pipeline from Nashirabad Elevated Tank/ Battali Hill Reservor/ Halishahar Elevated Tank to the entrances to the respective sectors
b) Secondary Distribution Pipe: Pipeline installed in the DMAs to distribute water in each Sector maintaining the required water pressure. In principle, there should be no direct connec-

tion of service pipes to the Secondary Pipeline.

c) Tertiary Distribution Pipe: Distribution pipeline being branched from the Secondary Distribution Pipeline with diameters from 75mm to 150mm
d) Lateral Pipe: A ditch, pipe, or other conduit entering or leaving a water main from the side. A secondary conduit diverting water from a main conduit for delivery to service connections.
e) Service Connection: Water supply facilities being branched from the Tertiary Distribution Pipelines up to the water meter including saddle, valve, connection pipe and water meter

6.2.4 Configuration of Main Pipelines with Inlets to Respective Sectors

(1) Transmission pipeline from Nashirabad Reservoir to each reservoir/elevated tank

Transmission pipelines from Nashirabad Reservoir to Nashirabad Elevated Tank for Northern area and Battali Hill Reservoir for Central area are planned in the Phase 1 Project, while for the Western area an economical and realistic pipeline route shall be selected for the Phase 2 Project. The proposed pipeline route between Nashirabad Reservoir and Halishahar Elevated Tank is shown in Figure 6.2.5. The route will be finalized before the preliminary design of the facilities is carried out.

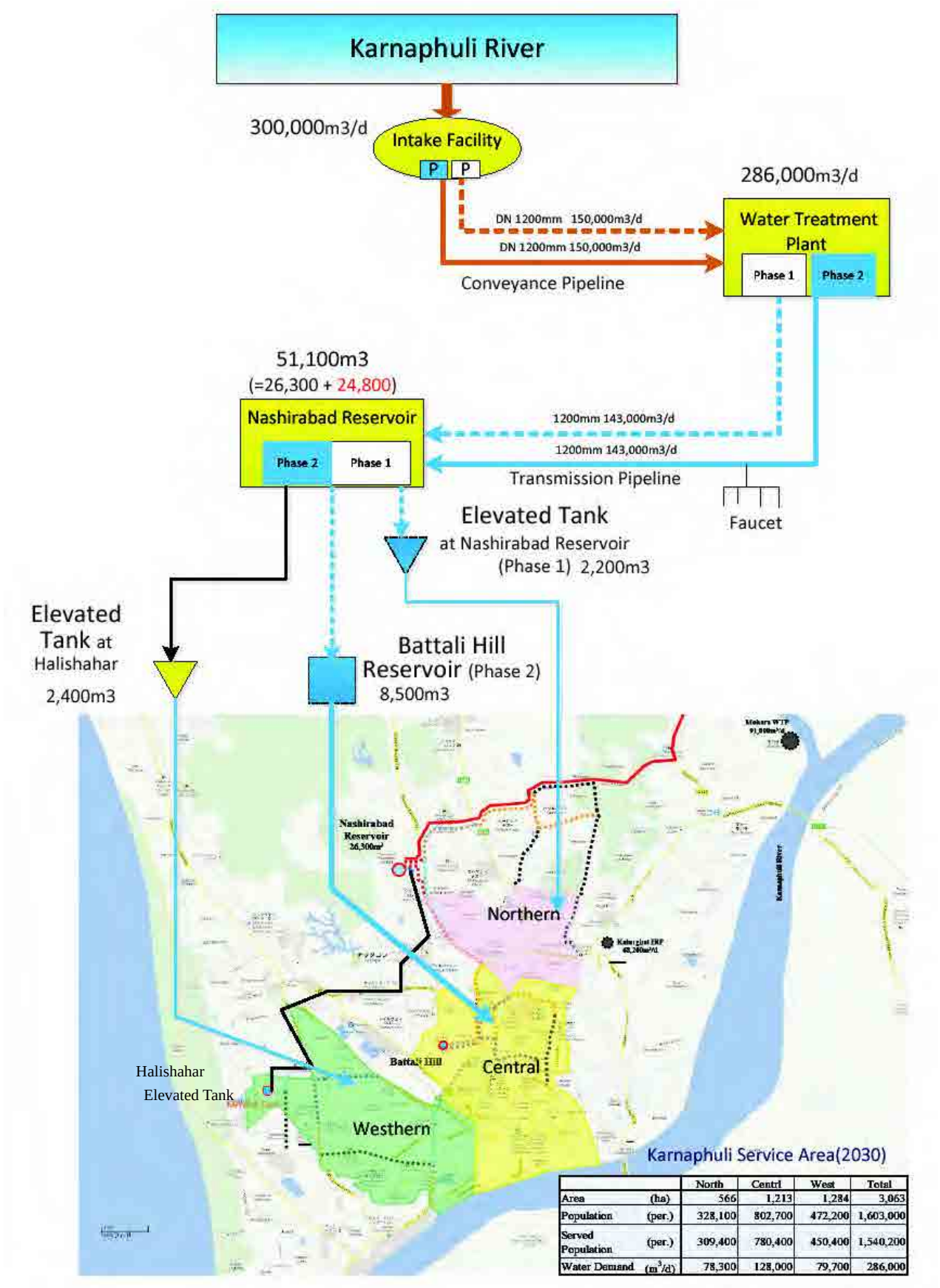
(2) Distribution main pipeline with inlets to each sector

The main pipeline routes with inlets to the respective sectors by sub-system are studied in view of economic and realistic pipe lying, considering the following conditions.

5) Main pipeline routes and pipeline capacities planned by Phase 1 Project
6) Geographical features of the component sectors in each sub-system
7) Hydraulic advantage for the selection of inlet points to the sectors with reference to the distance from the reservoir/ elevated tank to the subject sector
8) Availability of space in the roads for the installation of Phase 2 pipelines

Hydraulic calculations were made for the hourly maximum water demand, which is calculated by sector for the year 2030 in order to determine the pipe diameter and water head losses along the main pipelines. Figure 6.2.6, which presents a schematic of the main pipelines in the Karnaphuli service area, shows the pipe diameter and demand by sector. Figure 6.2.7 shows the results of the hydraulic calculations of the main distribution network (on the topographic map) and includes the ground elevation at major points, pipe diameter and flow velocity.

Figure 6.2.8 and 6.2.9 show the Distribution Pipelines by each Sector.



		North	Centri	West	Total
Area	(ha)	566	1,213	1,284	3,063
Population	(per.)	328,100	802,700	472,200	1,603,000
Served Population	(per.)	309,400	780,400	450,400	1,540,200
Water Demand	(m^3/d)	78,300	128,000	79,700	286,000

Figure 6.2.4 Schematic Water Supply Flow in Distribution System

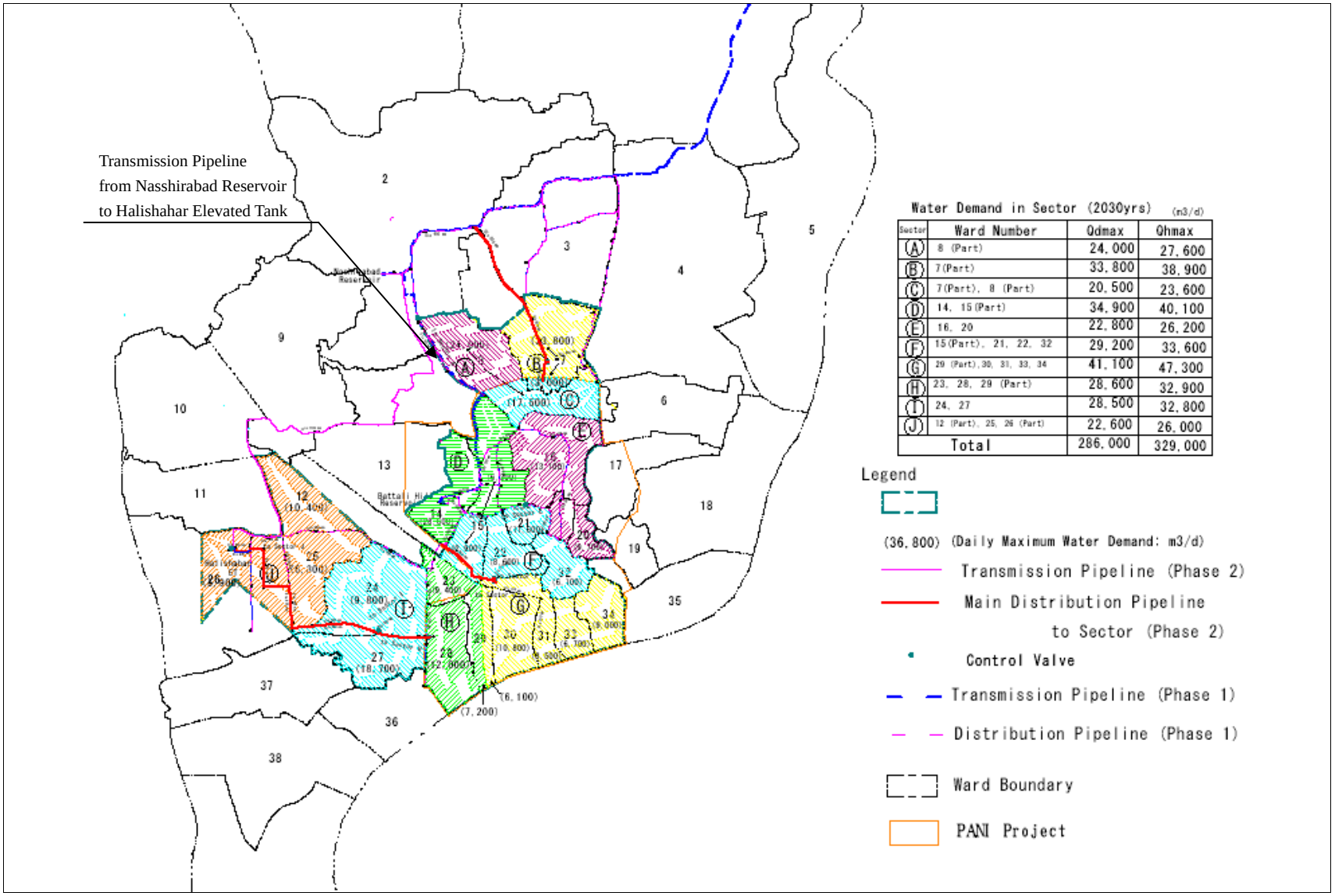


Figure 6.2.5 Transmission and Distribution Main Pipelines with Inlets to concerned Sectors

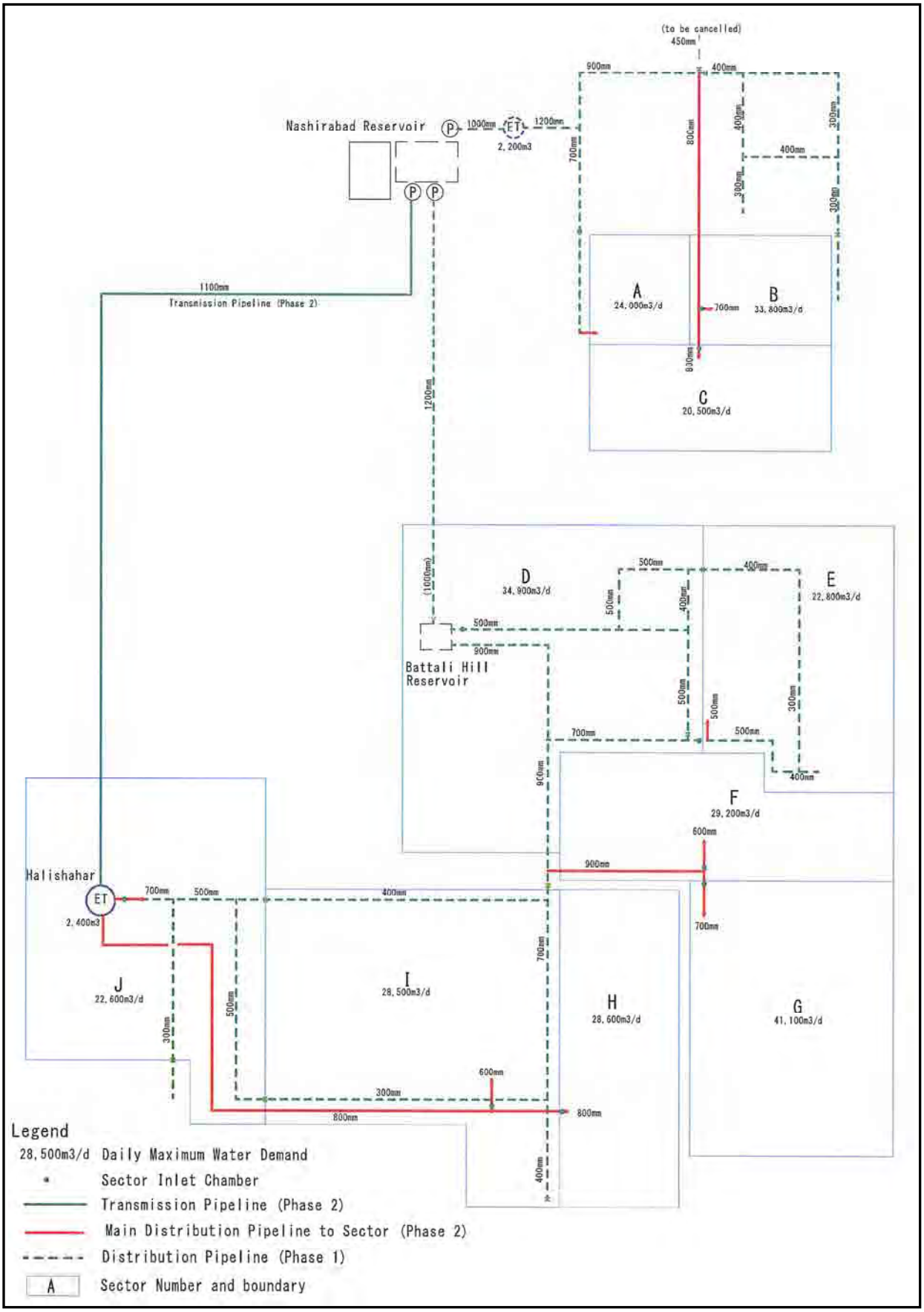


Figure 6.2.6 Schematic Configuration of Main Pipelines with Inlets to Sectors

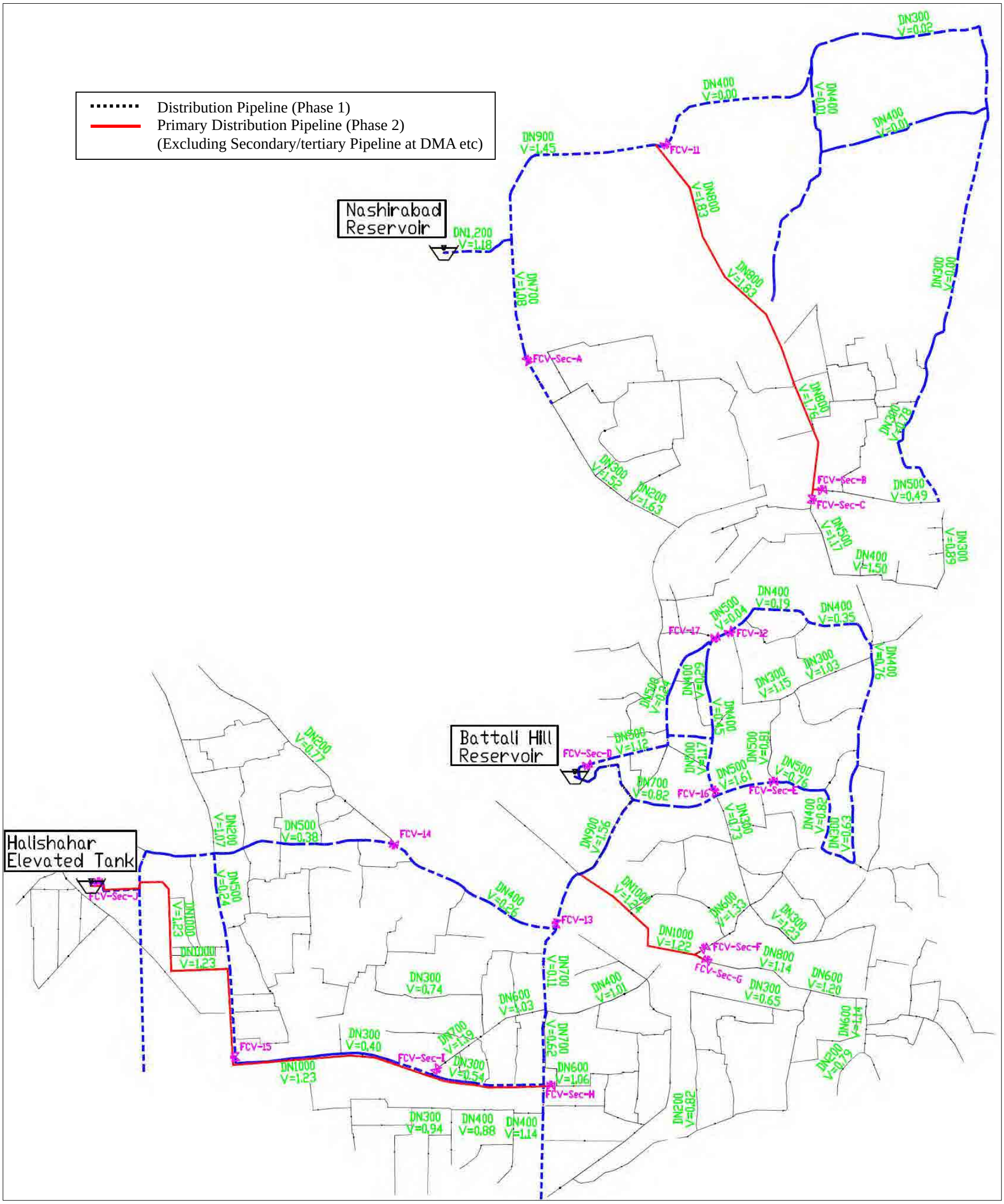


Figure 6.2.7 Hydraulic Calculation of Main Distribution Network

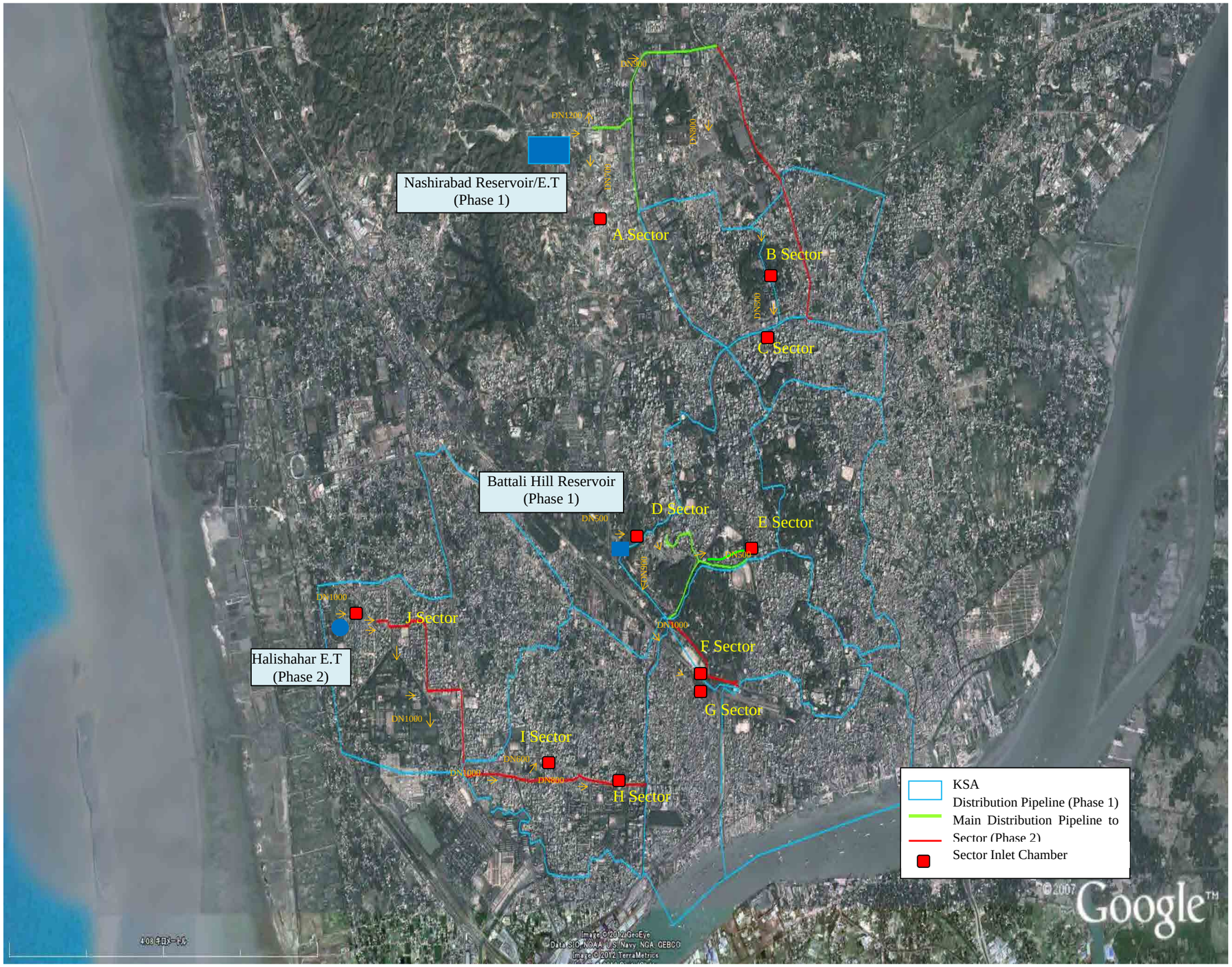


Figure 6.2.8 Configuration of Main Pipelines with Inlets to Sectors

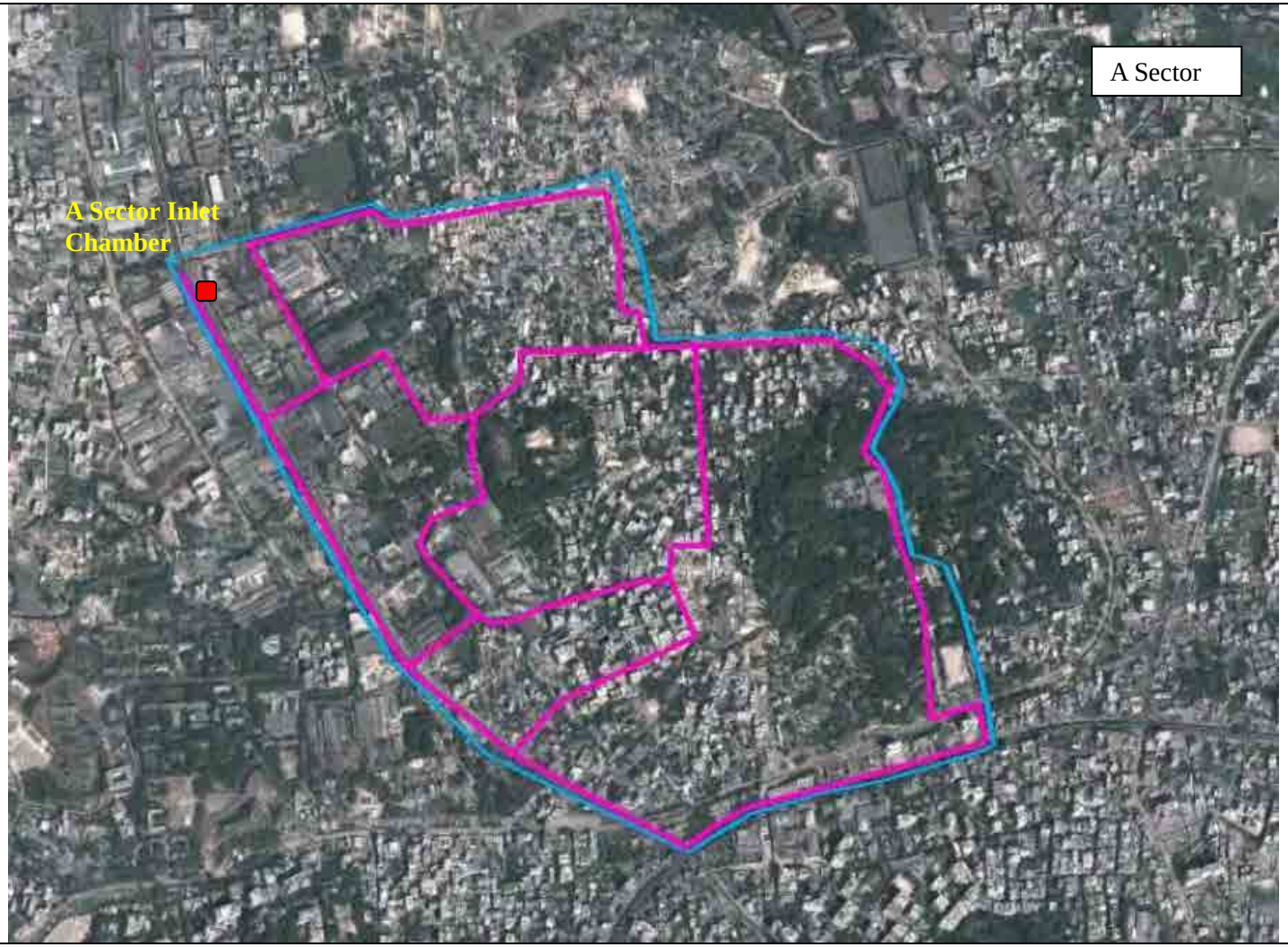


Figure 6.2.9 (1) Distribution Pipeline in Sector – A

Figure 6.2.9 (2) Distribution Pipeline in Sector –B

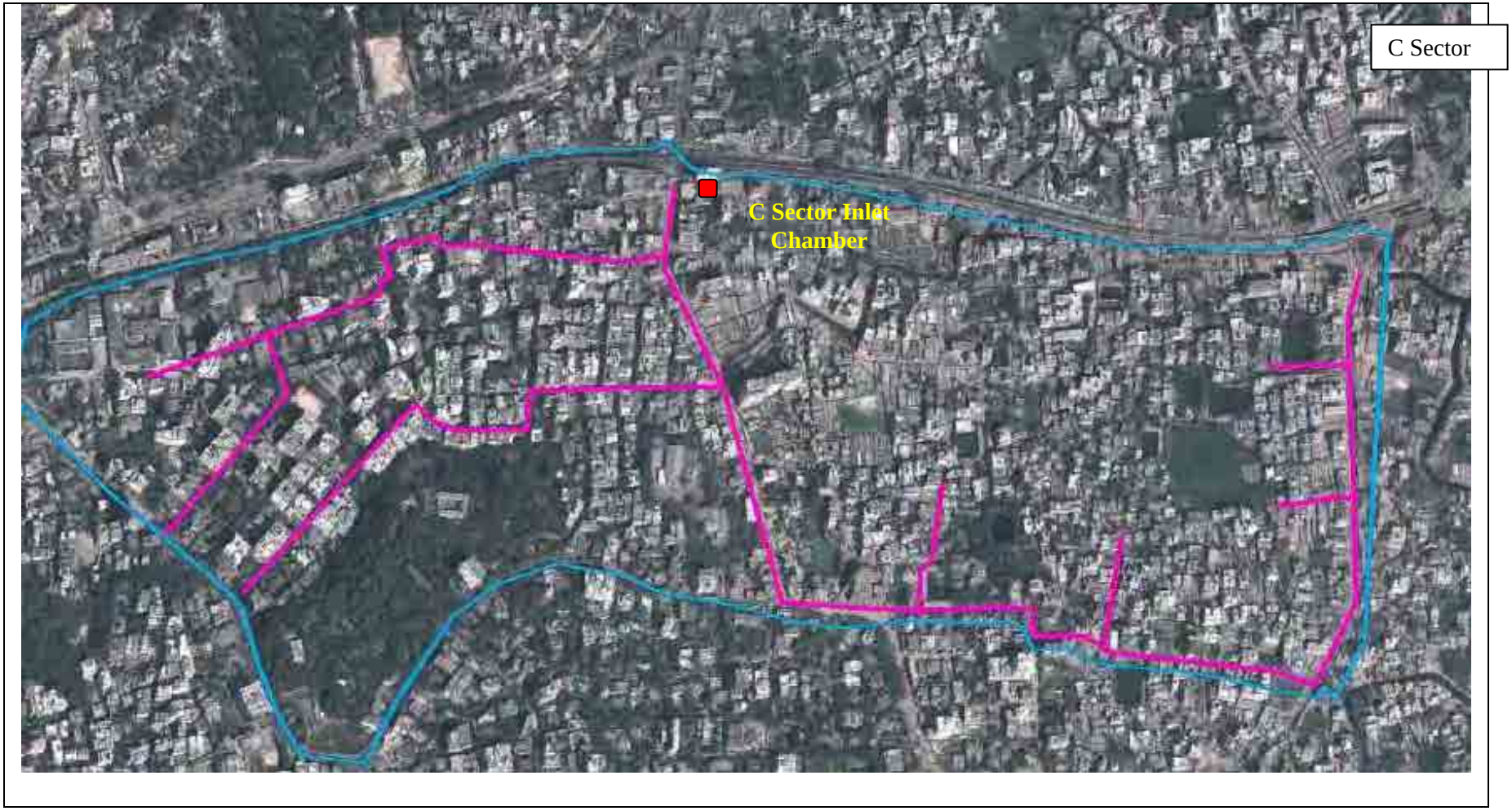


Figure 6.2.9 (3) Distribution Pipeline in Sector – C

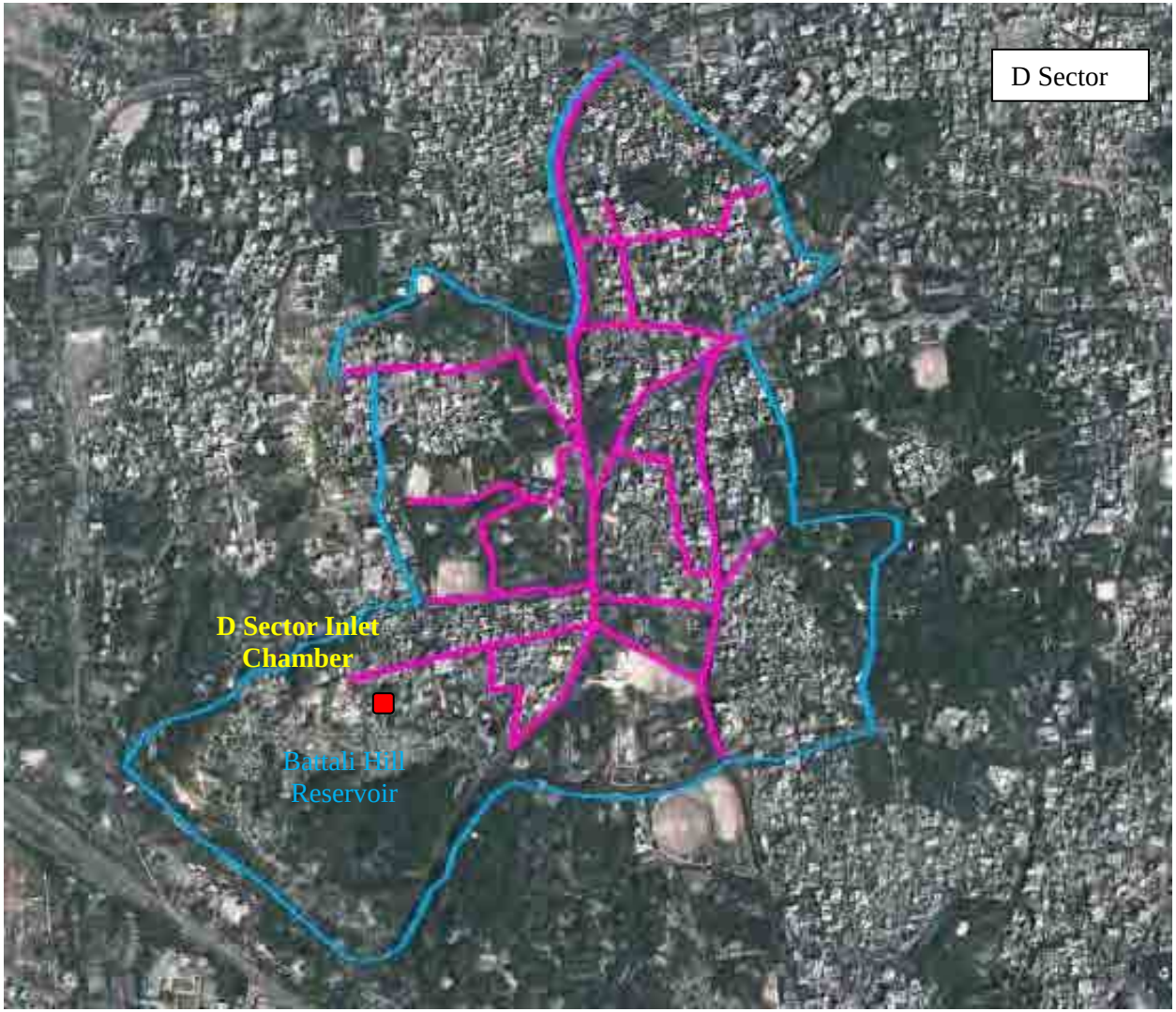


Figure 6.2.9 (4) Distribution Pipeline in Sector – D

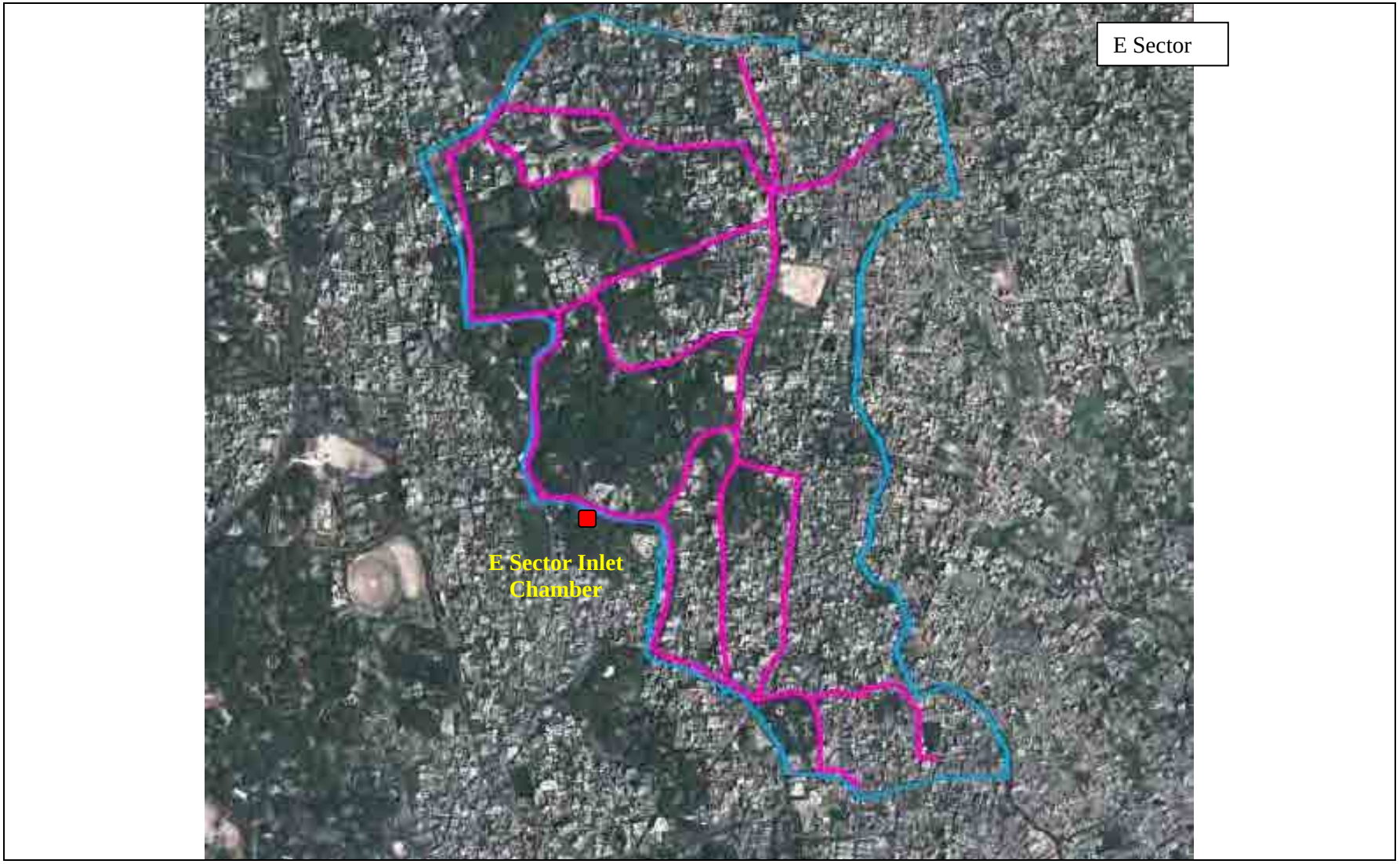


Figure 6.2.9 (5) Distribution Pipeline in Sector – E

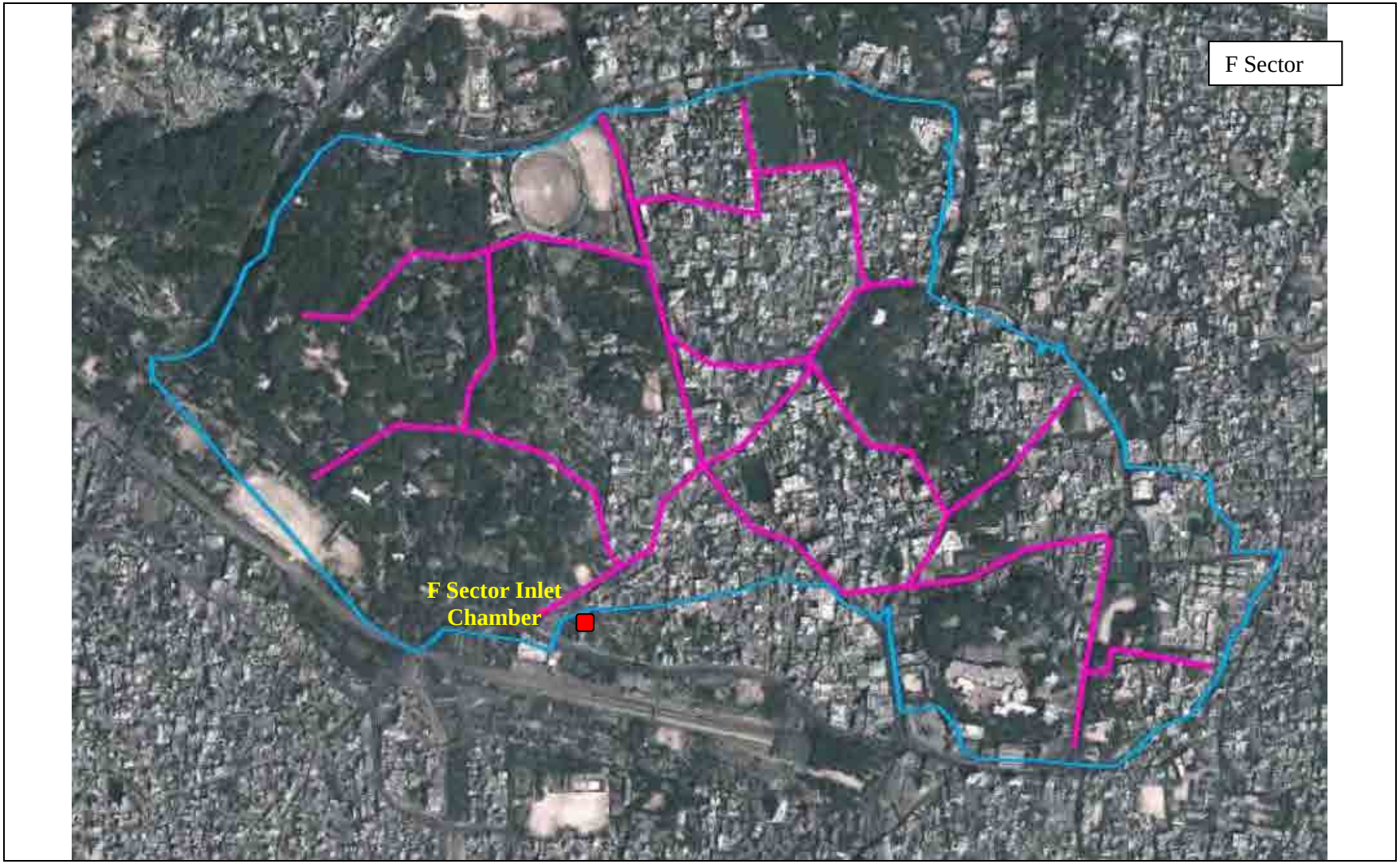


Figure 6.2.9 (6) Distribution Pipeline in Sector – F

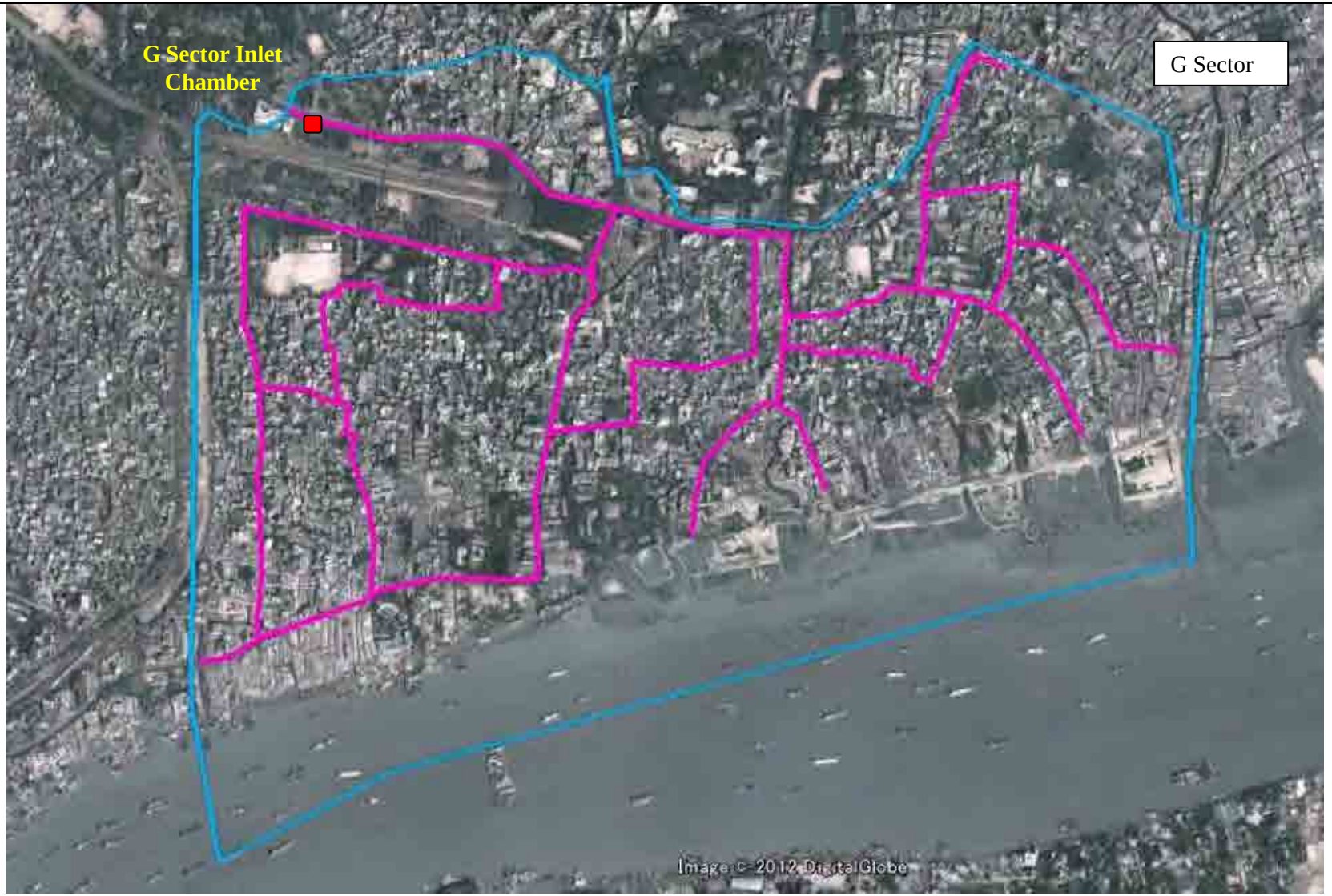


Figure 6.2.9 (7) Distribution Pipeline in Sector – G

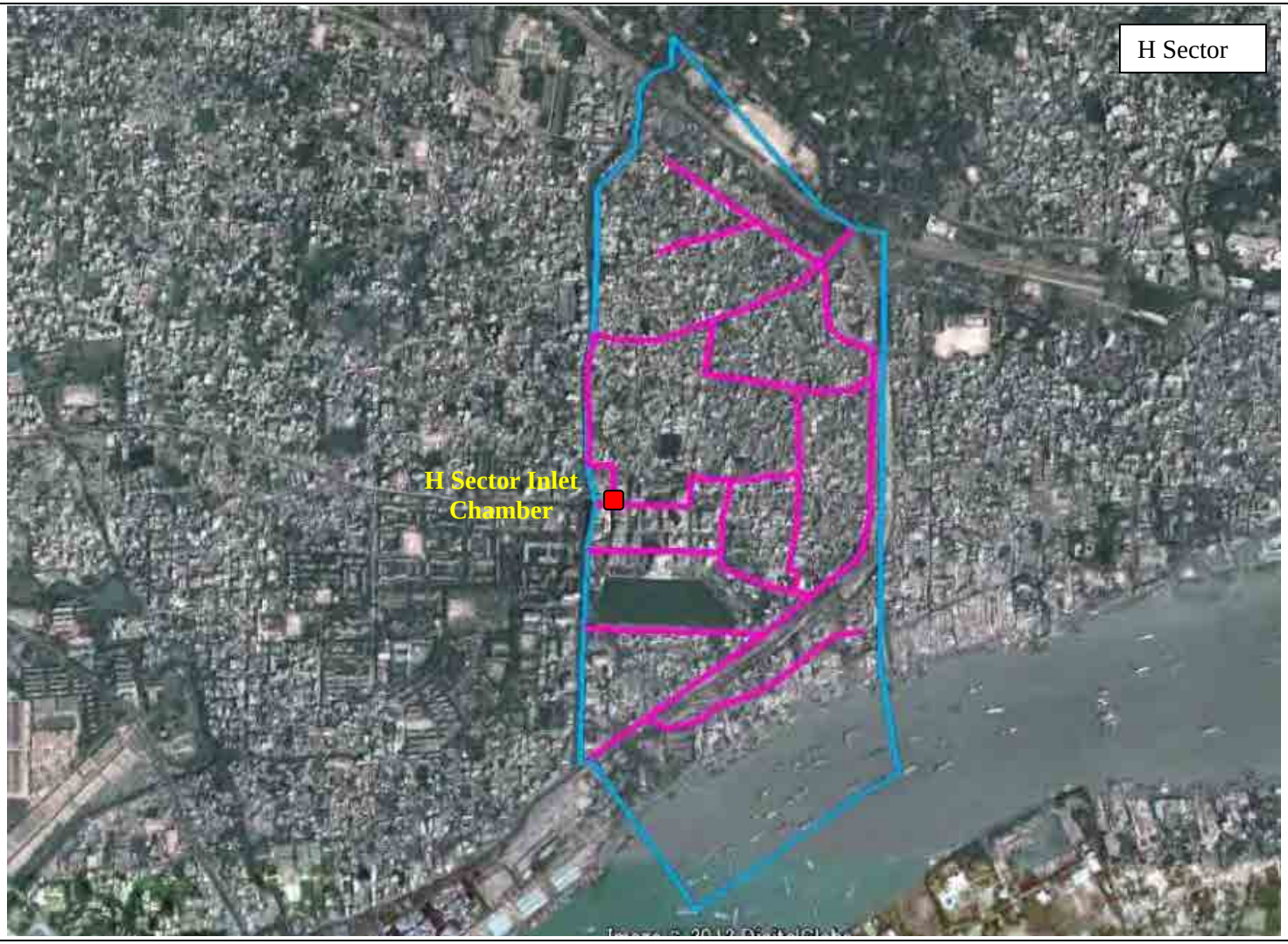


Figure 6.2.9 (8) Distribution Pipeline in Sector – H

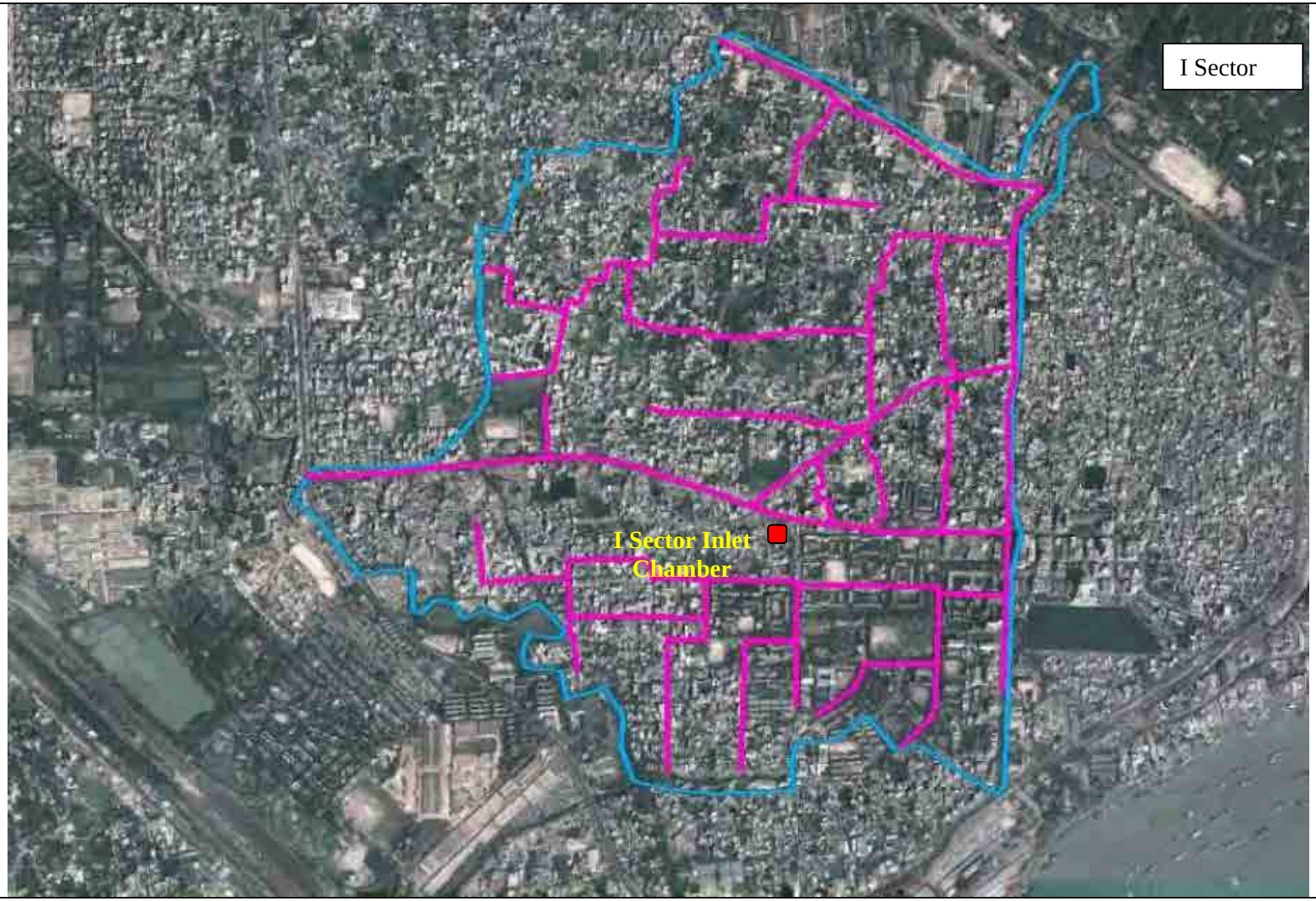


Figure 6.2.9 (9) Distribution Pipeline in Sector – I

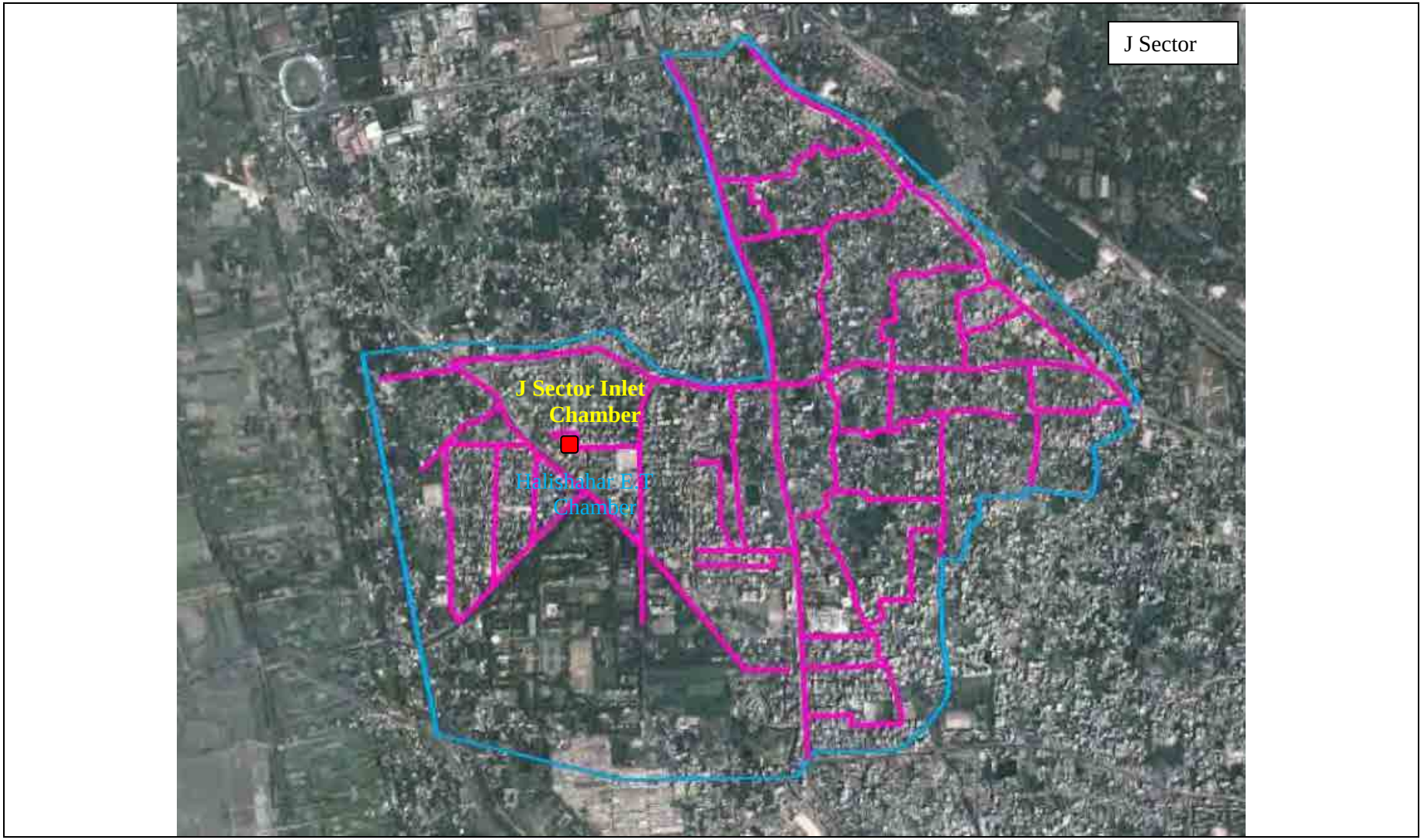


Figure 6.2.9 (10) Distribution Pipeline in Sector – J

CHAPTER 7

PRELIMINARY DESIGN OF THE WATER SUPPLY FACILITIES

CHAPTER 7 PRELIMINARY DESIGN OF THE WATER SUPPLY FACILITIES

7.1 Objectives of the Project

The objective of the Phase 2 Project is to increase sustainable access to safe water for the people in Chittagong city, by constructing water supply facilities and strengthening the capacity of CWASA, thereby contributing to the improvement of the living environment of the citizens. The scope of work for the Phase 2 Project is as follows:

(1) The expansion of Karnaphuli water treatment plant (production capacity 143,000m^3/day) and related facilities (intake, conveyance, transmission pipelines, reservoirs and distribution networks).

(2) Consulting services (engineering; D/D, construction supervision, etc.)

7.2 Necessity and Priority of the Project

(1) Limited Service Coverage

Since the completion of the Mohara WTP, no major projects have been implemented to increase the production amount and expand the distribution networks. Currently, the production capacity is about 47% of the present demand and intermittent water supply or chronic shortages of water are common for those served by CWASA.

The people not yet served by CWASA use shallow wells located all over the city area. CWASA estimates the number of private shallow wells in Chittagong at 3,000 to 4,000. The shallow well water is usually saline and/or contains high iron, aside from the problem of unsanitary condition affected by polluted water. There is also some evidence of arsenic contamination of shallow wells in the city. Under such conditions people in the city are exposed to the danger of water borne/related diseases.

CWASA does not provide adequate services to the estimated forty percent of Chittagong's population who live in slum areas. As a result of CWASA inability to supply water to the whole city, CCC has developed deep wells in selected slums areas and has procured 14 tankers / bowsers. Several NGOs are also active in the provision of water supply services to slum areas. Some slum dwellers purchase water from water vendors.

The Railway Authority developed its own water scheme to serve their staff using treated water from Foy's Lake. Some industries and individuals have also developed their own tube wells (a license from CWASA is required to construct a tube well with a riser pipe with a diameter of more than 1.5 inches).

Presently only 47% of water demand is served by CWASA (supply amount of 219,000m^3/d against demand of 470,000m^3/d). Water demand will increase drastically through the future as projected from 2015 to 2030: 592,000m^3/d, 668,000m^3/d, 798,000m^3/d and 1,000,000m^3/d for the years 2015, 2020, 2025 and 2030, respectively. The gap between demand and supply amount will increase through the future without timely provision of water supply.

Although Phase 1Project is planned to provide services from year 2015, distribution facilities planned are limited to cope with increasing demand in KSA and a higher leakage will be arisen due to planned connection of main pipes to existing distribution network. Therefore, construction of distribution pipelines for entire KSA, which is included in Phase 2 Project, shall be started immediately.

(2) Dilapidated and Inadequate Distribution Networks

The distribution networks serve about 45,000 households out of an estimated number of households of more than 600,000 in the CCC area. However, within the current water supply networks water supply is not guaranteed on a regular basis. Significant parts of the existing networks include old and dilapidated pipes that are in need of rehabilitation or replacement. CWASA operates an emergency water supply system that uses a number of trucks to deliver water in emergency situations.

Furthermore it is difficult for CWASA to accurately calculate water consumption from the billing records, due to non-working meters, lack of updated information on installed meter, etc.

Under the present arrangements of water supply, CWASA have no option but to supply customers on a case by case basis, without effective control of water supply from the WTPs to and throughout the distribution system. The exact locations of the distribution pipes have not yet been determined, except for the main distribution pipelines from the WTPs. The quantity of and breakdown of NRW in the distribution network is not known, except to some extent in areas where work has been carried out under the PANI. Furthermore, based upon the investigation carried out in the PANI rehabilitation of existing pipes is not an appropriate solution, which means that pipe replacement is required. In application of the replacement, the capacity of the system to be increased can be considered in the design for future water demands and required water pressure.

The time required to address the above issues, as well as to develop a functional and realistic hydraulic model of the existing system, which could then be used to develop an optimized and efficient water supply and distribution system for the long term, is likely to be some years. On completion of the above works several years would be required to implement the first priority project, allowing for arranging finance, design, procurement, construction, etc.

The Phase 1 Project will be completed by the year 2014, which includes construction of main/ sub-main distribution pipelines. However, the Phase 1 Project does not include lateral pipe and service connections to deliver water to the consumers since main/sub-main pipeline are planned to connect to existing distribution pipeline. In this regard, Phase 2 Project, which includes lateral pipes and service connections for the service areas to be covered by both phases, is urgent to realize the augmentation of water supply services.

(3) Non-Revenue Water (NRW)

According to CWASA, the existing NRW is 33%. Results from the investigations carried out in the pilot areas under the PANI from 2011 to 2012 showed that NRW was more than 50%. The study in PANI identified issues related to a high level of NRW, as follows.

1) Human resource development: Absence of permanent training program for NRW reduction work by CWASA staff
2) Equipment and tools: Luck of survey instruments and tools for leakage detection and repair work
3) Budgetary support: No specific budget with action plan is arranged
4) Appropriate technology: Absence of technical standards for water supply works
5) Time frame: Absence of annual work plan/physical target for NRW reduction

7.3 Project Component

7.3.1 General

The objective of the Phase 2 Project is to increase sustainable access to safe water for the people in

Chittagong city, by constructing water supply facilities and strengthening the capacity of CWASA, thereby contributing to the improvement of the living environment of the citizens.

The Phase 2 Project is the expansion of the Phase 1 Project except for the arrangements of the distribution system, although the service area to be covered by the Phase 2 Project is almost the same as the Phase 1 Project. Likewise, the capacities, locations of major facilities and manner of design thereto for the Phase 2 Project are basically the same as the Phase 1 Project.

Nevertheless, some modifications, additions and/or reductions to the Phase 1 Project are studied for the major facilities covering the civil/architectural, mechanical and electrical aspects, taking into account the issues and problems encountered during the implementation of the Phase 1 Project.

The outlines of the facilities for the Phase 2 Project by major item are; intake, conveyance pipeline, water treatment, transmission and distribution facilities. The plan of facilities which is presented firstly in each major facility is the basis for the preliminary design of water supply facilities for the Phase 2 Project to achieve the following requirements, as well as the general conditions/criteria.

(1) Minimize the possibility for and consequences of delays;
(2) Minimize the possibility for and consequences of claims;
(3) Minimize the possibility for and consequences of increases in cost;
(4) Enhance public relations and minimize disruption to the public, businesses, etc.;

The facility planning is made adopting the following general conditions/ criteria on water supply services (refer to Table 7.3.1).

Table 7.3.1 General Conditions/Criteria

Item	Conditions/Criteria
Target Year	2030
Fluctuation of water demand	
Daily Maxi demand factor:	1.15 (Daily Average demand : Daily Maximum demand = 1.00 : 1.15)
Peak hour demand factor:	1.5 (Daily Maximum demand :Peak hour demand = 1.0 : 1.5)
Capacity of distribution reservoir	
Reservoir/ Elevated Tank:	5 hours of the maximum daily water demand
Raw water quality:	Turbidity 40 NTU
Treated water quality:	Turbidity 10 NTU
Water supply pressure:	The minimum distribution pressure shall be more than 1.5kg/cm^2.
Water supply hours:	Basically, 24 hours continuous water supply should be ensured.
Water supply area:	The water shall be equitably distributed in the entire service area.

Table 7.3.2 summarizes the outline of facilities for Karnaphuli Water Supply Improvement Project by Phase and Figure 7.3.1 shows the outline of Karnaphuli Water Supply Project (Phase 2).

Table 7.3.2 Outline of Karnaphuli Water Supply Improvement Project by Phase

No.	Facility Name	Quantity		Capacity/Diameter/Detail	
		Phase 1	**Phase 2**	**Phase 1**	**Phase 2**
1	Intake Facility	C/A and M/E works	Mainly M /E works	150,000 m^3/d	150,000 m^3/d
2	Conveyance Facilities (Intake – WTP)				
2.1	Conveyance Pipeline	L=3.6km	L=3.6km	DN1200mm	DN1200mm
2.2	Surge Tank 1	1 no.	1 no.	427m^3	427m^3
3	Water Treatment Plant	1 no.	1 no.	143,000 m^3/d	143,000 m^3/d
4	Transmission Facilities (WTP – Nashirabad Reservoir)				
4.1	Transmission Pipeline 1	L=24.4km	L=24.4km	DN1200mm	DN1200mm
4.2	Surge Tank 2	1 no.	1 no.	213m^3	213m^3
5	Nashirabad Reservoir Facilities				
5.1	Reservoir	1 no.	1 no.	26,300m^3	24,800m^3
5.2	Elevated Tank	1 no.	-	2,200m^3	-
6	Transmission Pipeline 2 (Nashirabad – Battali Hill)	L=5.5km	-	DN1200mm /1000mm	-
7	Transmission Pipeline 3 (Nashirabad – Halishahar)	-	L=10km	-	DN1100mm
8	Halishahar Elevated Tank	-	1 no.	-	2,400m^3
9	Primary /Secondary Distribution Pipeline				
9.1	Primary Distribution pipeline at Northern, Central, and Western Area	L=42.8km	-	DN300– 1200	-
9.2	Primary Distribution Pipeline in Karnaphuli Service Area				
	1) Nashirabad ET to Sector A, B and C	-	L=1.5km	-	DN700-800mm
	2) Battali Hill Reservoir to Sectors D, E, F and G	-	L=1.3km	-	DN600-1000mm
	3) Halishahar ET to Sectors H, I and J	-	L=5.1km	-	DN600-1000mm
10	Sector Inlet Chamber (Pressure/flow Control system)	-	10 No.	-	Sectors A- J
12	Optical fiber cable	L=37km	L=20km	-	-
13	Secondary/Tertiary Distribution Pipelines in DMAs by sector 3,063 ha, Total L=about 475km				
13.1	Sector A (A=192 ha), DMA=12 Nr	-	L=31.4km	-	DN100-500mm
13.2	Sector B (A=216 ha), DMA=13 Nr	-	L=33.1km	-	DN100-700mm
13.3	Sector C (A=158 ha), DMA=10Nr	-	L=23.8km	-	DN100-800mm
13.4	Sector D (A=352 ha), DMA=22Nr	-	L=51.8km	-	DN100-500mm
13.5	Sector E (A=216 ha), DMA=13Nr	-	L=33.8km	-	DN100-500mm
13.6	Sector F (A=220 ha), DMA=14Nr	-	L=35.4km	-	DN100-600mm
13.7	Sector G (A=425 ha), DMA=26Nr	-	L=63.3km	-	DN100-800mm
13.8	Sector H (A=257 ha), DMA=16Nr	-	L=40.6km	-	DN100-800mm
13.9	Sector I (A=356 ha), DMA=22Nr	-	L=57.5km	-	DN100-700mm
13.10	Sector J (A=671 ha), DMA=42Nr	-	L=104.2km	-	DN100-400mm
14	House Connections (Served Population:1,540,200)	-	51, 360 set	-	Saddle, Service pipe and water meter

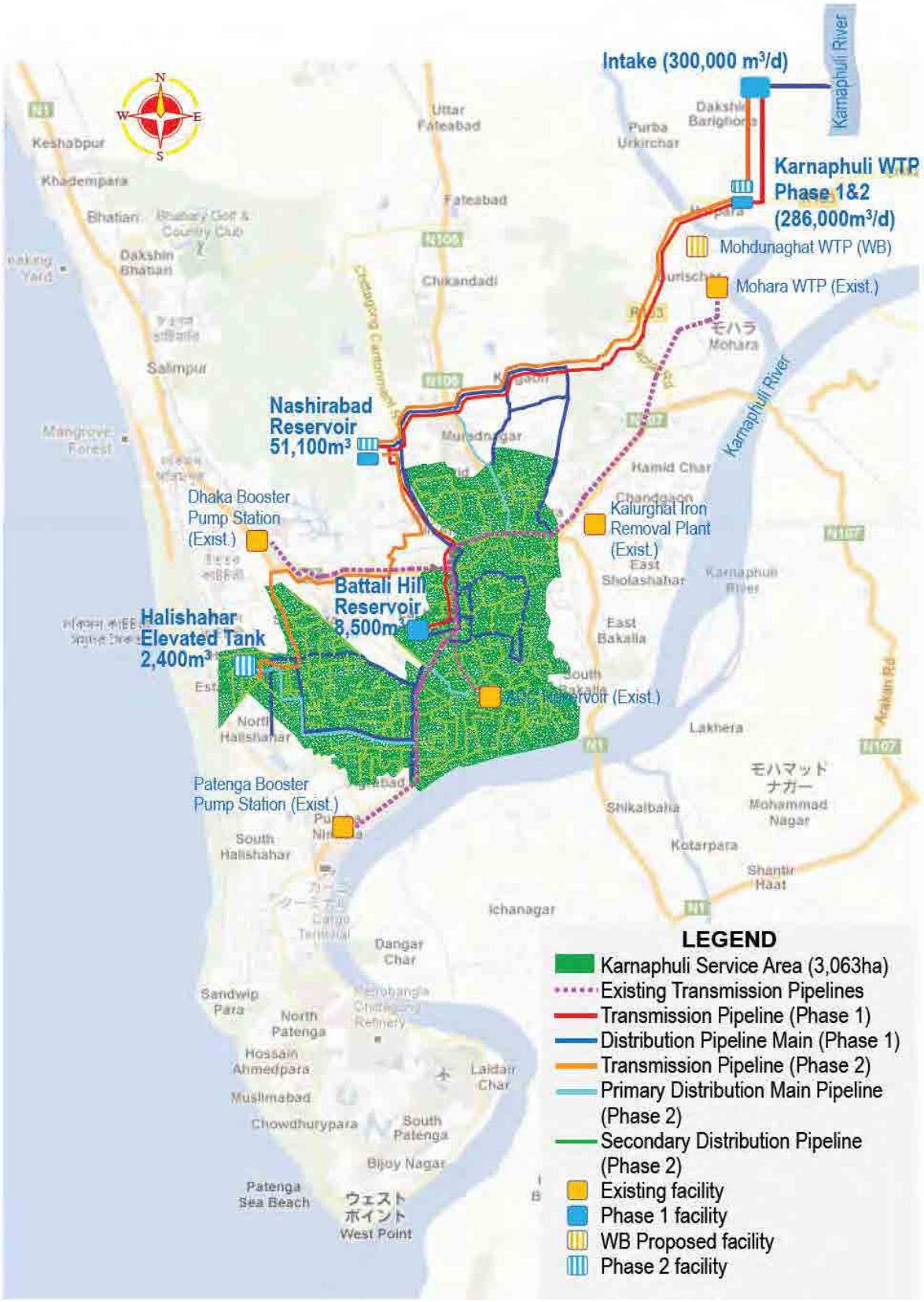


Figure 7.3.1 Location of Major Facilities for the Phase 1& 2 Project

7.4 Issues and Problems encountered by Phase 1 Project and Countermeasures

The plan of facilities for Phase 2 Project shall be prepared taking into account the lessons learned from the Phase 1 Project. There are two major issues/ problems in the Phase 1 Project, as enumerated below.

a) Land acquisition for the construction of facilities
b) Right of way for pipe laying

(1) Land acquisition

During the preparatory stage for the Phase 1 project, CWASA encountered problems on the land required for major facilities. Table 7.4.1 shows issues /problems, lessons learned and countermeasures for the implementation of Phase 2 project.

Table 7.4.1 Issues & Problems/Lessons learned and Countermeasures for Phase 2

Issues & Problems encountered by Phase 1 Project	Lessons learned from Phase 1 project	Status on land acquisition	Countermeasures for Phase 2 Project
1. Intake Facility	Boundary and shape of the land area were changed due to lack of an accurate map	Obtained for 2 Phases	Land area was confirmed and available
2. Conveyance Pipeline (surge tank)	Same problem as the site for Intake Facility	Obtained for 2 Phases	Need to confirm the boundary for Phase 2 surge tank site with CWASA
3. WTP	It took for a long time for negotiation with the land owner	Only site for Phase 1 WTP was obtained.	Due to the difficulty of obtaining additional land, the Phase 1 WTP site shall be utilized
4. Transmission Pipeline (surge tank)	Same problem as the site for Conveyance Pipeline	Obtained for 2 Phases	Need to confirm the boundary for Phase 2 surge tank site with CWASA
5. Distribution Facility (Nashirabad Reservoir)	None	Obtained for 2 Phases	Land area was confirmed and available

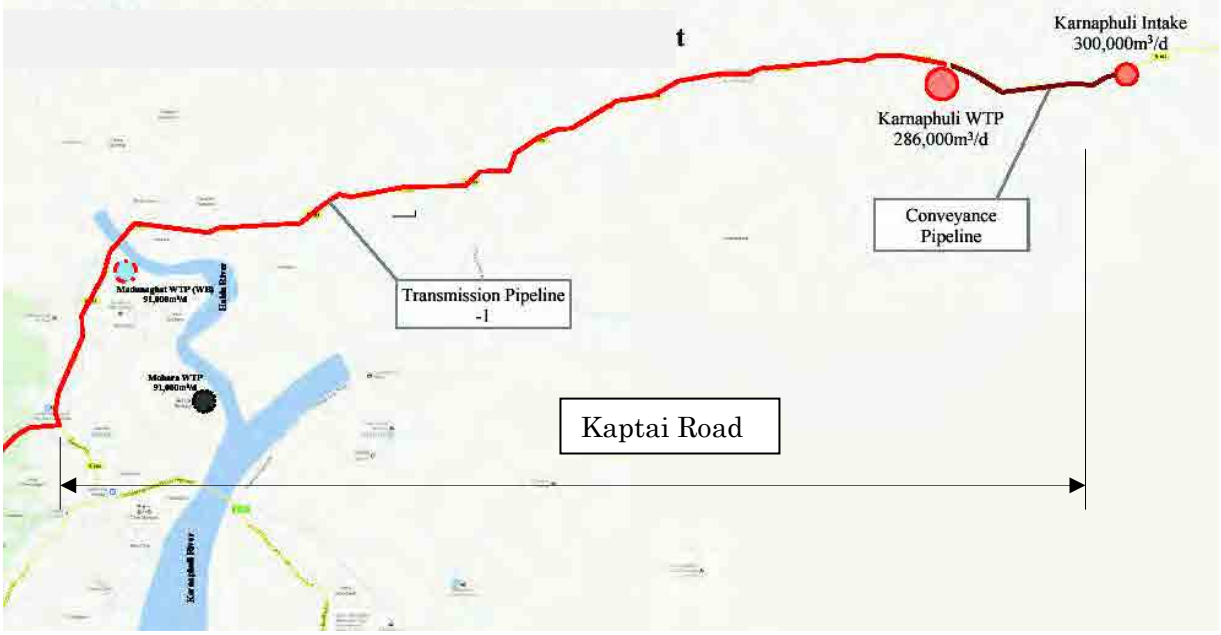


Figure 7.4.1 Location of Kaptai Road

(2) Right of way for the installation of pipelines

The permission from the Roads and Highways Department (RHD), Ministry of Communication was obtained in October, 2012 on the right of way for installation of conveyance and transmission lines along Kaptai road for the Phase 1 Project. There is a same problem for the Phase 2 Project in the construction of the same pipelines along Kaptai road. CWASA has been making all efforts to get approval from RHD for the Phase 2 before the end of January, 2013.

In order to mitigate possible problem before the determination of Phase 2 Project, the following are also requisites.

- Application of realistic construction methods
- Provision of countermeasures to mitigate traffic problems and to obtain social acceptance
- Establishment of cooperation system by concerned parties

In consideration of the above mentioned issues /problems, the plan of facilities is prepared to come up with the framework for respective facilities.

7.5 Intake Facility

The Phase 1 Project includes the majority of the civil/architectural works for both the Phase 1 and Phase 2 Projects. The scope of work includes inlet channel, pumping station, electrical building, and other buildings for a combined capacity of 300,000m^3/d. The requirements for the Phase 2 Project are mainly mechanical and electrical equipment for the intake for a capacity of 150,000m^3/d.

7.5.1 Civil Work

Yard pipes including a flow meter on the conveyance pipeline are planned.

7.5.2 Mechanical Equipment

(1) Pre-conditions for planning Phase 2

The intake facilities require various equipment including stop-logs, screens, water level gauge, conveyance pumps, flow meter and overhead crane to maintain pumps and valves. In the Phase 1 Project some equipment is provided for two phases, as summarized in Table 7.5.1.

Table 7.5.1 Mechanical Equipment at Inlet Channel

Item	Specification	Phase 1 & 2 (under Phase 1 Project)
Inflow Screen	Bar Screen W 2.0m x H 3.5 m x Opening 40mm	2 units
Sand Pump	Submersible Sand Pump 0.2m^3/min x 15m	2 units

(2) Intake Pump Facility

Four pumps (two duty and two standby) are planned for the inflow of 150,000m^3/d for the Phase 1 Project. For the Phase 2 project, two additional pumps are required, as shown in Table 7.5.2.

Table 7.5.2 Intake Pump Facilities

Item	Specification	Phase 1	Phase 2
Intake Pump	Vertical end suction volute pump $53m^3$/min x 27 m x 315kW (VVVF)	4 units Including 2 standby	2 units (duty)
Flow Control Valve	Motorized Butterfly D 1000mm x 0.75kW	1 unit	1 unit

(3) Intake Pump Control System

A variable speed control system is applied to cope with the fluctuation of water demand through the year. An additional one-way surge tank is planned to protect pipes and pump units against water hammer in the event of power failure.

7.5.3 Electrical Equipment

(1) Main Power Supply

In the Phase 1 Project it is planned to install an extension to the power supply from REB (single 33kV 50Hz) and a connecting transformer (33kV/3.3kV) at the intake facility site. The incoming power line is reliable, due it being a direct and dedicated supply from the nearest substation. However, the capacity of the transformer covers only the Phase 1 loads. Therefore, an additional transformer and connection breakers are required for the Phase 2 Project. The necessary area for the facility, including a concrete foundation, is considered and allowed for in the Phase 1 Project. The type of transformer shall be outdoor, oil immersed and natural cooling.

(2) Emergency Power Generation

One unit of standby diesel engine generator was planned for the intake pumps in the Phase 1 Project. An additional generator will be required for the Phase 2 Project and will be planned to be of the same type and with the same capacity as that provided in Phase 1.

Figure 7.5.1 shows the single line diagram to show the scope of the Phase 2 Project.

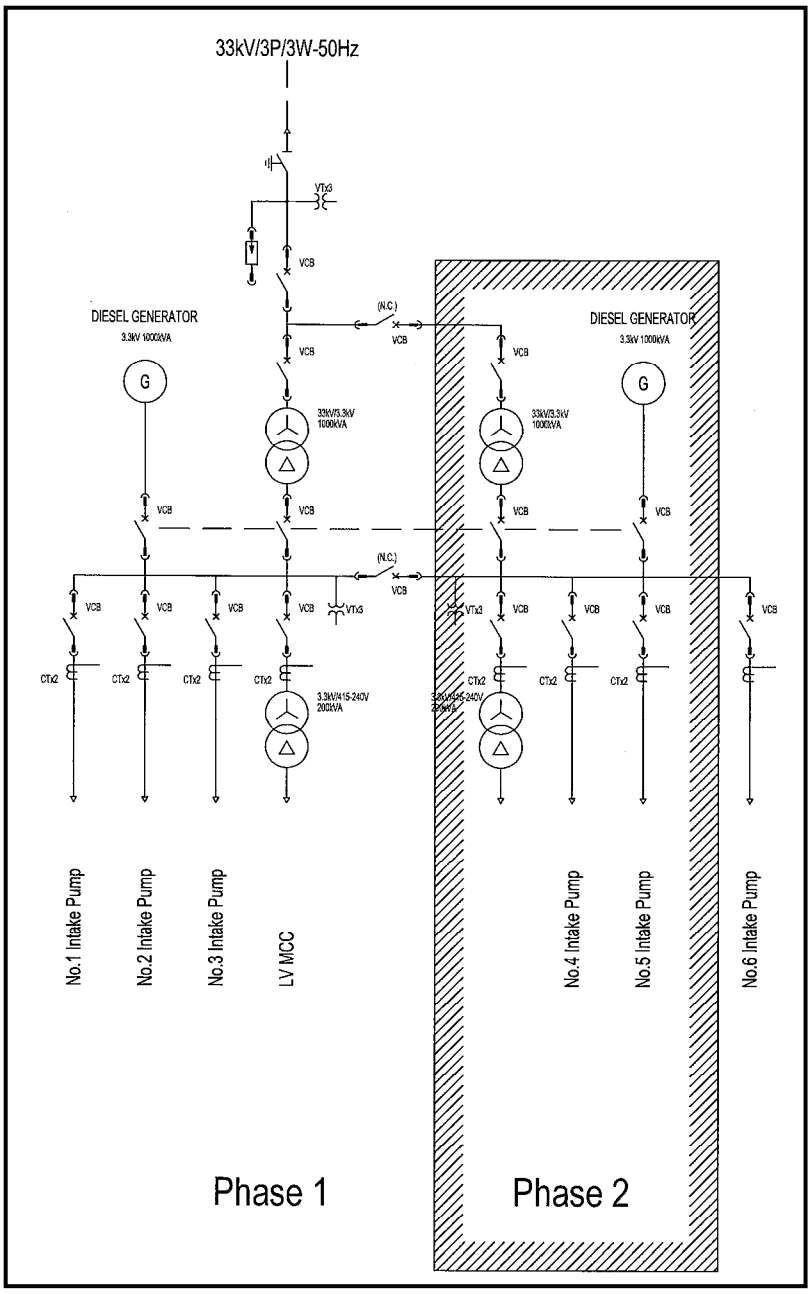


Figure 7.5.1 Single Line Diagram for Intake Pump Station

(3) Electrical Room

One electrical room was planned in the Phase 1 Project in each of the Electrical Building and Intake Pump Station. For the Phase 2 Project, 3.3kV switchgear and LV transformer, and LV distribution board shall be installed in the Electrical Building and pump starters and a motor control center shall be installed in the Pump Station. The electrical rooms planned in the Phase 1 Project will be able to accommodate additional equipment.

(4) SCADA and Instrument

A SCADA system was applied to the intake facilities in the Phase 1 Project. Under Phase 2 additional facilities shall be incorporated into the Phase 1 SCADA system using the same type of PLC. The software of the SCADA should be the same as that used in Phase 1.

Table 7.5.3 summarizes the main electrical equipment in Phase 2.

Table 7.5.3 Main Electrical Equipment in Phase 2

Equipment	Feature
33kV Switchgear	VCB
33/3.3kV Transformer	Oil type
3.3kV Switchgear	VCB
3.3kV pump starter	VFD drive
Intake MCC	400V Form 3b
Local Operation Panel	Stand type
Intake Flow Measurement	Electromagnetic
PLC/RTU	Open protocol (Profibus)
SCADA System	Modification and up-grading
Standby Generator	Diesel engine, radiator cooling

7.6 Conveyance Pipeline

A 4.5 km long conveyance pipeline from the Intake Pump Station to Pre-Sedimentation Basin in the WTP is necessary to connect the WTP with the intake facility (3.6 km between the contract boundaries of the intake facilities and WTP). It will be provided with a flow measurement device, isolation valves, air-relief valves for relief of accumulated air at high points in the pipeline, and surge-control devices for reducing transient pressure waves.

In the Phase 1 Project, three options for the design of the conveyance pipeline were considered, as shown in Table 7.6.1. Among them, Case-3 (150,000m^3/day, dia.1200mm x 1no.) was selected in the Phase 1 Project to reduce the construction cost. Figure 7.6.1 presents alignment of the pipeline.

Table 7.6.1 Section of Dia./No. of Conveyance Pipeline

		Case-1	Case-2	Case-3
Water Flow (m^3/day)		300,000	300,000	300,000
Conveyance Pipeline	Dia. (mm)	2000	1400	1200
	Length (m)	4,500	4,500	4,500
	Number of pipe	1	2	2
	Velocity (m/sec)	1.11	1.13	1.53
	Hydraulic loss (m)	19.0	21.50	27.0

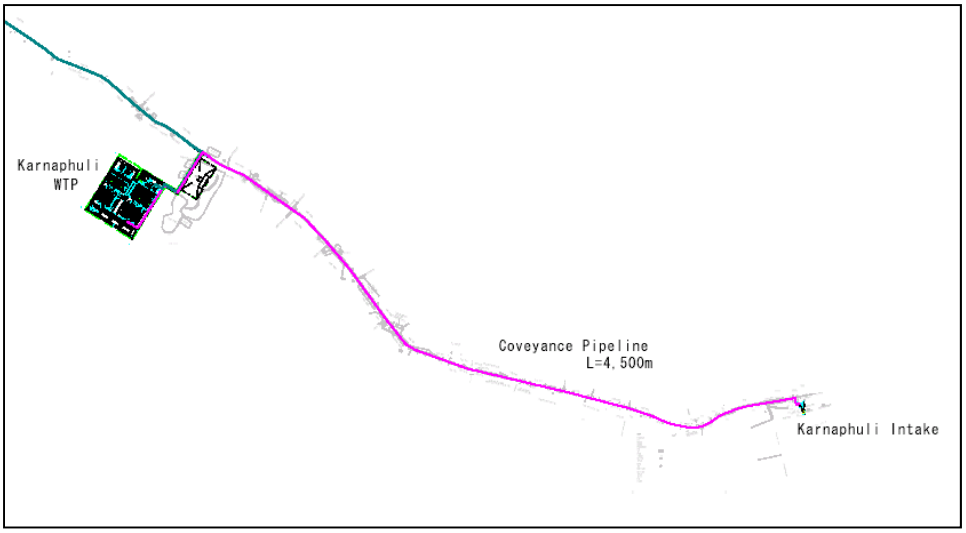


Figure 7.6.1 General Layout Plan of Conveyance Pipeline

In Phase 2, the same quantity of 150,000m^3/d as the Phase 1 Project is pumped to the WTP. On the way to the WTP, a one- way surge tank is installed to protect pipes and pump units in the event of a power failure, with the facilities being the same as in the Phase 1 Project.

The conveyance pipeline for the Phase 1 Project is arranged on the left side of the Kaptai road going towards the CCC area, with the pipeline for Phase 2 on the right side, as shown on Figure 7.6.2. The right of way for the pipelines for Phase 1 Project was approved on October 3, 2012 by RHD, Ministry of Communication. CWASA has been making efforts to get concurrence from RHD on the right of way for the Phase 2 Project by the end of November, 2012.

The location of the Surge tank for Phase 2 is arranged next to the Phase 1 tank, as also shown on Figure 7.6.2. However, the boundary of the site should be reconfirmed with the concerned agencies/persons.

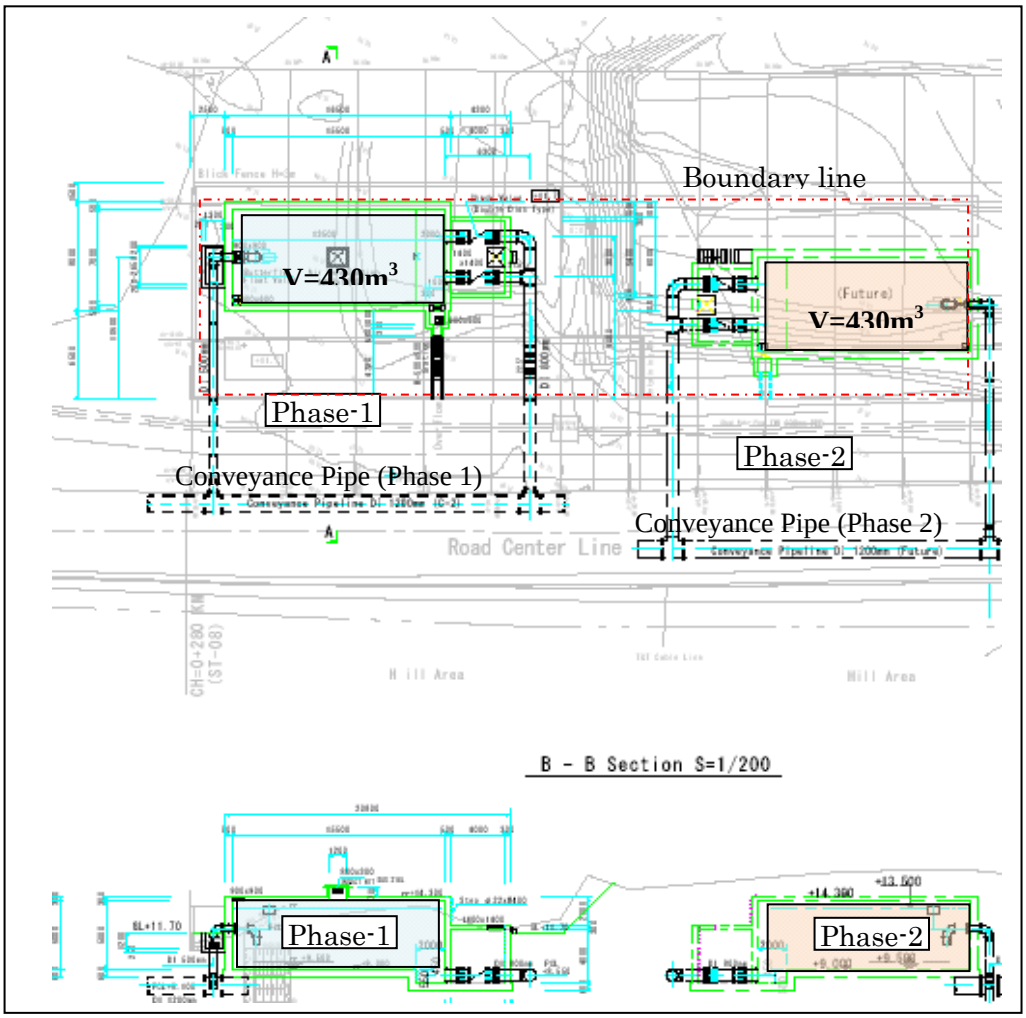


Figure 7.6.2 Installation of Surge Tanks and Alignment of Conveyance Pipelines for Two Phases

7.7 Water Treatment Plant

As experienced in Phase 1 Project, additional land acquisition for the construction of the Phase 2 WTP is very difficult. Therefore, a study was made on how to effectively utilize the area obtained for the Phase 1 Project, for both phases. The water treatment process for Phase 2 is basically the same as the process for Phase 1, which is flocculation, sedimentation, and rapid sand filtration process.

The layout of the Phase 2 works has been studied in order to facilitate construction of a parallel water treatment plant with the same capacity as Phase 1. In order to construct a parallel plant, adequate and appropriate sludge treatment has to be planned for both Phases 1 and 2, as the Phase 2 water treatment facilities have to be constructed on the site of part of the Phase 1 sludge lagoons. In addition, the capacity of the Phase 1 pre-sedimentation has to be reviewed, taking into account recent raw water quality data of Karnaphuli River.

The overall shape (rectangular) of the site is generally ideal; however between the pre-sedimentation basin and the northernmost sludge lagoon there is a cremation ground. The arrangement of yard pipes and cables will be installed outside of the site.

7.7.1 Water Treatment Process

(1) Pre-Sedimentation Basin

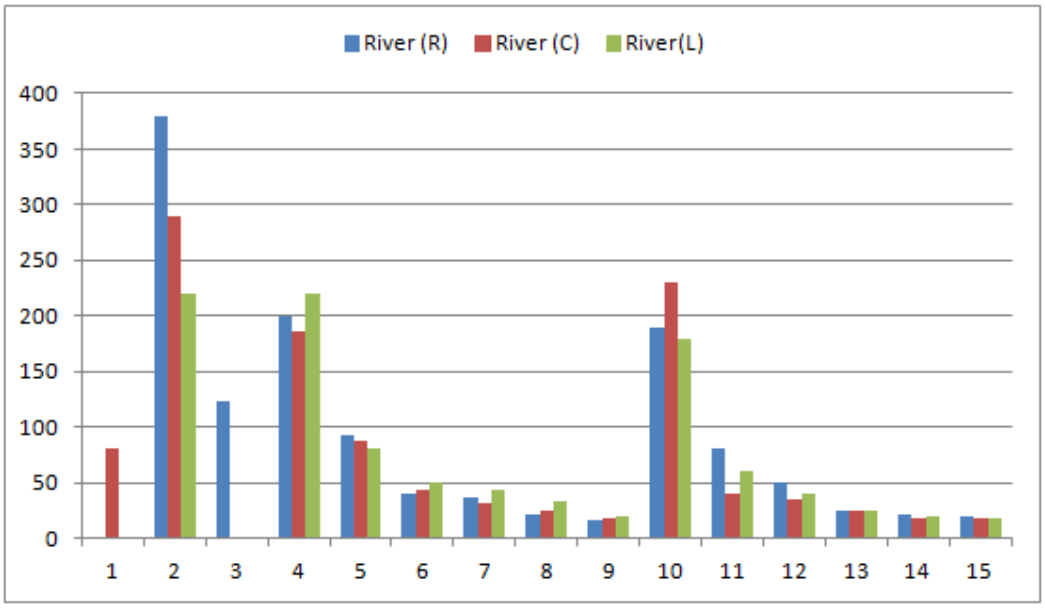
1) Design Turbidity for Karnaphuli WTP

The SAPROF study referred to the turbidity of the Halda River, which was used for the design of Mohara WTP. The design of the Phase 1 Project followed the same idea; however, the water quality (in terms of turbidity) in the Karnaphuli River is much better than in the Halda River. Table 7.7.1 shows a comparison of the water quality on the same day (13th July 2008).

Table 7.7.1 Comparison of Turbidity between Karnaphuli River and Halda River

Sampling Location	Water temperature (deg. C)	Turbidity (NTU)
Karnaphuli Intake point 20m away (surface)	23	25
Mohara Intake point (surface)	25	150

Examination of water quality at the intake point from the Karnaphuli River has been conducted from the June 17th, 2012 up to September 30th, 2012 (15 times during the rainy season) as shown in Figure 7.5.1. Turbidity in Halda River has exceeded 400NTU in the rainy season. However, turbidity in the Karnaphuli River is lower than in the Halda River and it was confirmed by the analysis in the above period that the water quality in the Karnaphuli River recovers within a few days of heavy rain. Thus, it is concluded that periods when high turbidity (more than 300 NTU) occurs are limited, even during the rainy season and that turbidity is less than 40 NTU (design turbidity for Phase 1 Project) in the majority of days in a year (refer to Supporting Report 7.7.1 for details).



Note: R: right bank of the River, C: centre of the River and L: left bank of the River;
Water sample from 6/17 to 9/30, 2012

Figure 7.7.1 Turbidity at Godown Bridge near Intake Site

2) Process flow

Considering that turbidity in the Karnaphuli River is comparatively low, except for during some times in the rainy season and that recovery from high turbidity is very fast, the need for a Pre-Sedimentation Basin may be considered for limited periods. In this connection, the Pre-Sedimentation basin planned in the Phase 1 project may be commonly used for both Phase 1 and 2 in the case where the inflow has a high turbidity.

The following process flow is planned, taking into account the need for economical and realistic treatment of sludge from Phases 1 and 2.

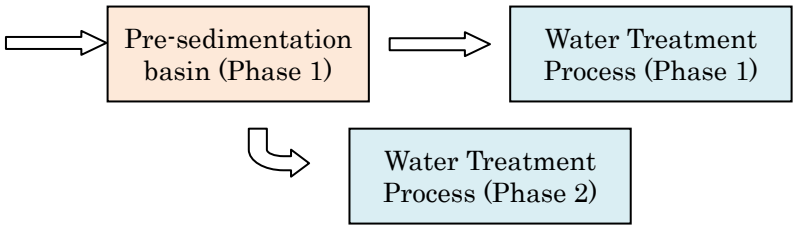


Figure 7.7.2 Water Treatment Flow Diagram

7.7.2 Sludge Treatment Process

(1) Generation of sludge in the water treatment process

Sludge is generated during the process of water treatment. Historically in Chittagong, sludge has been directly discharged into a water body. The major sources of sludge at the WTP are the pre-sedimentation basin, sedimentation basin and sand filter.

1) Sludge generated at pre-sedimentation basin

The sludge (mainly silt) is deposited by gravity in the pre-sedimentation basins. In case of Mohara WTP, the accumulated sludge is removed from the pre-sedimentation basin once a year in the dry season. The removed sludge is utilized for backfill/limited agriculture landfill.

2) Sludge generated at sedimentation basin

In the Phase 1 Project (Q=150,000m^3/d), lagoons were selected for the treatment of sludge generated in the sedimentation basins, as shown in Figure 7.7.3. Sludge flows into a lagoon by gravity and is accumulated for a few months. Upon filling of the lagoon with sludge, sludge from the sedimentation basin is transferred to the next lagoon.

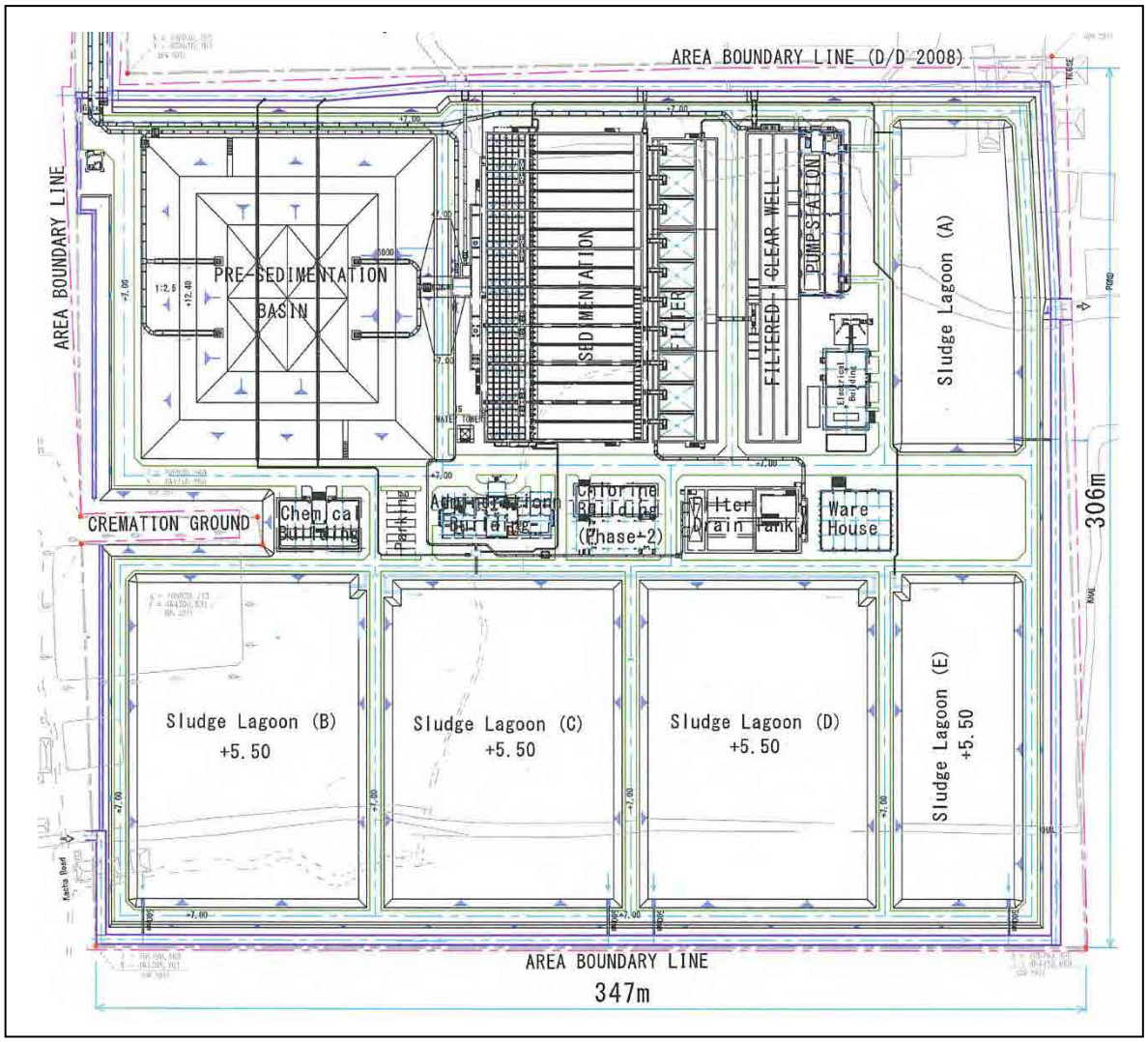


Figure 7.7.3 General Layout Plan of Phase 1

Alternation of feeding the sludge lagoon is planned to be carried out throughout the year. Then, thickened sludge in the lagoons is removed during the dry season. However, the area planned for the lagoons in Phase 1 has to be used for the water treatment facilities for Phase 2 because of the difficulty of additional land acquisition. In this regard, alternative sludge treatment processes are studied in order to accommodate the sludge treatment facilities for both phases within the area obtained in the Phase 1 Project.

Environmental considerations on the discharge of treated water are also another concern for the study of sludge treatment: Suspended Solids (SS) shall be less than 150mg/l in the case of discharge to inland surface waters, in accordance with the "Standards for of Schedule-10 (Discharge from industries/projects) of the Environmental Conservation Rules, 1997".

3) Wastewater generated in the process of backwashing Sand Filters

Wastewater generated from the backwashing process in the Sand Filters flows into the filter drain tank. The SS value is usually high when backwashing starts and decreases at the end of the cycle. The size of floc in the wastewater is small particles, which are wrapped and chemical jointed with Alum and suspended solids.

The wastewater, about 5% of the 300,000 m^3/d (the total amount of Phase 1 and 2), is returned by pumping to the sedimentation basin for recycling use.

(2) Alternative sludge treatment methods

The dried sludge shall be properly disposed of according to the prevailing laws and regulations in Bangladesh. However, there are no standards at present for the disposal of sludge generated at the WTP. In case of Mohara WTP, dried sludge from the pre-sedimentation basin is removed manually once a year in the dry season during 4 months from November to February, in which drying periods are 1 or 1.5 months, as stated above and as shown in the following photos (Figure 7.7.4).

Figure 7.7.4 Pictures on Removal of Sludge at Mohara WTP (18/1/ 2012)

The removed sludge is transported by residents living near to the WTP to fill in low land or is auctioned to sell to Brick factories at about 20 Taka/m^3, according to CWASA. These practices shall also be adopted for the reuse of the sludge from Karnaphuli WTP as well as disposal at the landfill site.

Alternative sludge treatment methods are studied for the total sludge to be generated from Phases 1 and 2, as follows:

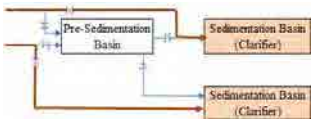
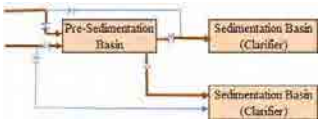
1) Projection of seasonal sludge volume

Due to the seasonal differences in the turbidity of inflow water from the Karnaphuli River, sludge volumes in the dry and rainy seasons are projected.

In days of heavy rain, turbidity of water to the Sedimentation Basin, after passing the Pre-Sedimentation Basin is assumed at about 100NTU, because Alum will be coagulated in the Pre-Sedimentation Basin when turbidity of the raw water is as high as 200NTU or 300NTU. Under

such assumptions, the sludge volume is 11.673 t DS/d (2,334m^3/d; turbidity in raw water = 40NTU, water content = 0.5%) in the dry season and 28.243 t DS/d (5,650m^3/d; turbidity in raw water = 100NTU, water content = 0.5%) in days of heavy rainy (refer to Table 7.7.2).

Table 7.7.2 Projection of Sludge Volume by Season

Items	Dry season	High Turbidity(Heavy rain)
Process Flow		
Capacity of WTP	Q= 300,000m^3/d	Q= 300,000m^3/d
Turbidity of inflow water to Sedimentation Basin (Clarifier)	T=40 NTU	T=100 NTU (after Pre-Sedimentation Basin)
Alum Dosing, $Al_2(SO_4)_3$ $16H_2O$	E=21 mg/l	E=30 mg/l
Sludge quantity	Q・(T+αx E) x 10^{-6} x 90% DS/d (α=0.154) =11.673 t DS/d =2,334 m^3/d (w=0.5%) =390m^3/d(w=3%) after thickener	Q・(T+αx E) x 10^{-6} x 90% DS/d, (α=0.154) =28.247 t DS/d =5,650 m^3/d (w=0.5%) = 470m^3/d (w=6%) after thickener (in case of 2 trains)

2) Study on Sludge Treatment Process and disposal

Under the above mentioned seasonal sludge generation, alternative sludge treatment processes are studied, as follows:

a) Alternative-1: Sedimentation Basin-Lagoon - Disposal
b) Alternative-2: Sedimentation Basin-Gravity type Sludge Thickener-Sludge Drying - Disposal
c) Alternative-3: Sedimentation Basin-Gravity type Sludge Thickener-Mechanical Dewatering-Disposal

In the case of the design of the sludge thickeners in Alternatives 2 and 3, the process flow diagrams shown in Figure 7.7.5 are recommended, taking into account the different estimated sludge volumes in the dry and rainy season (days of heavy rain).

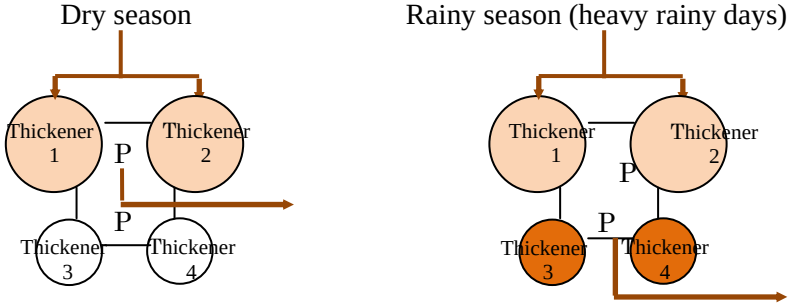


Figure 7.7.5 Sludge Thickening Process

Alternative plans of sludge treatment process after completion of Phase-2 Project are summarised as follows:

a) Alternative-1; Sedimentation Basin -Lagoon - Disposal

The sludge generated at Sedimentation Basin is pumped to a lagoon, but capacity of a lagoon is limited to storage for about 1.3 days (water content=0.5%) in the case of the dry season. Therefore, there is a high possibility that the supernatant from the lagoon has a high SS. To obtain SS in the supernatant of less than 150mg/l, sludge would need to be fed into the same lagoon for about one (1) month. During sludge drying in a lagoon, the sludge from Sedimentation Basin is pumped to another lagoon. Accumulation and drying of the sludge is practiced such that the lagoons are used on a cyclical basis. Dried sludge is utilized for land filling of low areas or recycling use for making bricks /construction materials.

b) Alternative-2; Sedimentation Basin – Gravity type Thickener - Sludge Drying - Disposal

The sludge from Sedimentation Basin flows into a sludge receiving tank and is pumped to the sludge thickeners. The thickened sludge (water content = from 99.5% to 94% (or 97%) depending upon the season, as shown in Table 7.5.3 and is pumped to a sludge drying bed until the sludge accumulates up to a certain depth, following which the next bed is fed with sludge. Dried sludge from the drying bed is managed in the same manner as alternative-1.

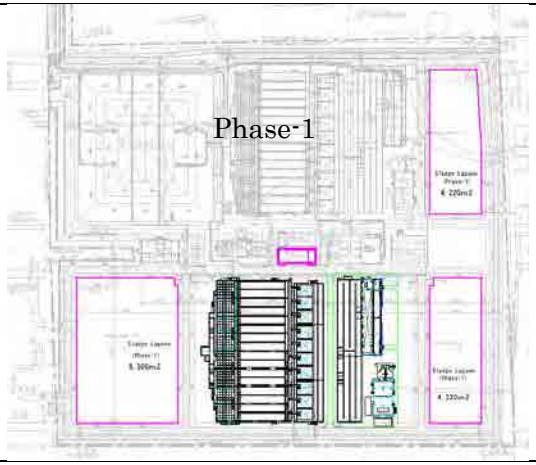
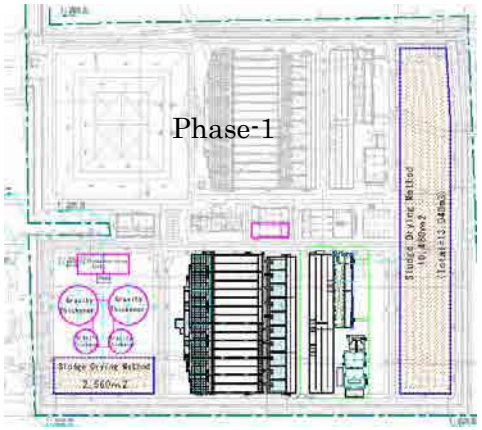
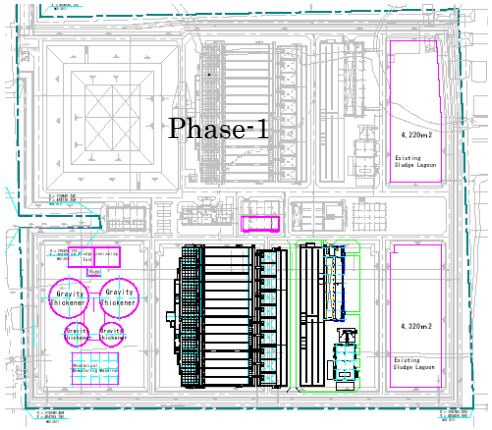
c) Alternative-3; Sedimentation Basin – Gravity type Thickener - Mechanical Dewatering - Disposal

The sludge treatment process is same as for alternative-2 up to and including sludge thickening. The thickened sludge is pumped to a mechanical dewatering process and the water content of dewatered sludge is planned to be about 75%. Sludge cake is managed in the same manner as alterneative-1.

Table 7.7.3 shows the summary of the comparison on the alternative sludge treatment processes. Alternative 2 is recommended because of the following reasons.

a) In Alternative 1 it is difficult to maintain a SS concentration of less than 150 mg/l in the supernatant without acquiring additional land to provide an increased sludge lagoon volume.
b) Alternatives 2 and 3 both meet the condition that the SS of supernatant from sludge treatment process should be less than 150mg/l according to the discharge regulation (Standard for Schedule-10).
c) The construction and operation and maintenance costs of Alternative 2 are considerably lower than those of Alternative 3.

Table 7.7.3 Summary of Comparison on Alternative Sludge Treatment Process

Item	Alternative-1 Lagoon		Alternative-2 Gravity Thickener + Sludge Drying		Alternative-3 Gravity Thickener + Mechanical Dewatering	
General Layout Plan						
Outline of Major Facilities	1) Lagoon (Phase-1); A:4,220m^2, B:8,500m^2, E:4,320m^2 Total=17,040m^2 2)Lagoon Capacity; (in case of a Lagoon) 4,220m^{2}x0.7m/2,334m^3/d=1.3day 11,673kg/d x 60d/4,220m^2 =166kg/m^2 (Dry season)		1) Gravity Thickener with sludge recieving tank Normal NTU;11,673kg/d / 15kg/m^2/d =780m^2 High NTU ;28,247kg/d /15kg/m^2/d =1,900m^2 →Dia.30&18m x 2no. (standby-1no in case of normal NTU) 2) In case of high turbidity, 2-stage thickening is used (water content: 94%) 3) Sludge Drying Method 11,673kg/dx 60day/60kg/m^2/d =11,673m^2		1) Gravity Thickener with sludge recieving tank Normal NTU;11,673kg/d / 15kg/m^2/d =780m^2 High NTU ;28,247kg/d /15kg/m^2/d =1,900m^2 →Dia.30&18m x 2no. (stanby-1no in case of normal NTU) 2) Mechanical Dewatering in case of centrifugal type 30kW x 3 units 4) Lagoon;(for emergency) A:4,220m^2, E:4,320m^2	
Discharge of SS to public water body (agricultural channel)	There is a possibilty to discharge SS with more than 150mg/l due to limited retension time (1.3 day) and high sludge load to Lagoon, specially in case of high tubidity in days of heavy rainy.	×	Easy control in discharging SS from WTP.	○	Easy control in discharging SS from WTP and also there are sludge lagoons for emergency use.	◎

Item	Alternative-1 Lagoon		Alternative-2 Gravity Thickener + Sludge Drying		Alternative-3 Gravity Thickener + Mechanical Dewatering	
Sludge treatment for Phase 1 WTP during construction of Phase-2 WTP	Existing Lagoon can be operated as temporary sludge treatment for Phase-1	○	At least, half size facility of Sludge Drying Method should be constructed in first stage of Phase-2 Project	Δ	Existing Lagoon will be operated for temporary sludge treatment for Phase-1 treatment	○
Operation & maintenance	Very easy but frequent overflow of supernant from Lagoon to nearby canal	×	Need frequent O&M	○	Difficult	×
Construction Cost	Constructed by Phase-1	◎	1) Sludge receiving tank; 920,000 US$ 2) Gravity thickener ; 3,623,000 US$ 3) Sludge drying Method 11,550m^2 x 400US$/m^2 = 4,600,000US$ **Total 9,143,000 US$** **(100)**	Δ	1) Sludge receiving tank; 920,000 US$ 2) Gravity thickener; 3,623,000 US$ 3) Mechanical Dewatering C&A: 35m x 24m x 3,000US$/m^2 = 2,520,000 US$ M&E = 7,000,000 US$ **Total 14,063,000 US$** **(154)**	×
O & M Cost for sludge treatment	1) Sludge removal ; 4 times/year 2) 10 persons/time/month 3) 4 x 10 x 150 US$/M = 6,000 US$ **Total 6,000 US$ /year** **(100)**	◎	**65,000 US$/year** **(1080)**	Δ	**200,000 US$/year** **(3,300)**	×
Recommendation	Not recommended due to a high possibility of supernatant with SS more than 150mg/l due to high sludge load to the lagoon	×	Recommended as lower construction and O&M costs than Alternative-3	○	Not recommended due to high construction and O &M Cost	Δ

Note) ◎;fairly good, ○;good, Δ;not bad, ×;bad

7.7.3 Civil/Architectural design

(1) Buildings & facilities

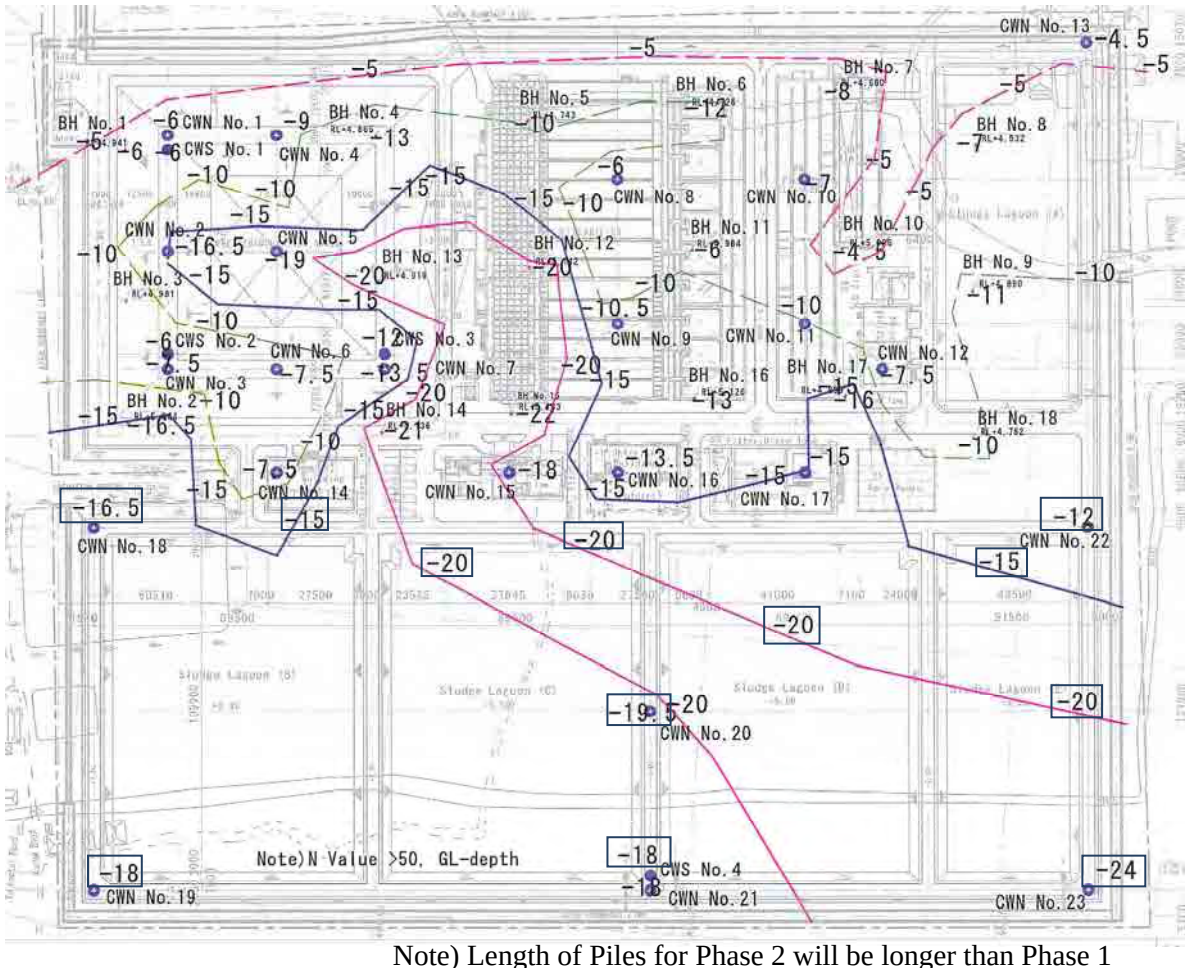
Table 7.7.4 shows the outline of the facilities in Phase 1 and Phase 2. The Phase 2 Project includes sludge receiving tank, thickeners and sludge drying beds for sludge treatment.

Table 7.7.4 Outline of the Facilities in Phase 1 and Phase 2 Projects

Facilities	Phase 1	Phase 2	Notes
Pre-Sedimentation Basin	For 150,000m^3/d	-	Common to Phases 1 & 2
Clarifier (Sedimentation Basin)	1) Mixing Chamber; W3.0m x L13.6m x D4.7m x 2 tanks 2) Flocculation Tank; W1.9m x L 63.1m x D4.0m x 8 channels 3) Sedimentation; W12.8m x L39.0m x D4.0m x 8 tanks	1) Mixing Chamber; W3.0m x L13.6m x D4.7m x 2 tanks 2) Flocculation Tank; W1.9m x L63.1m x D4.0m x 8 channels 3) Sedimentation; W12.8m x L39.0m x D4.0m x 8 tanks	
Filter	W7.6m x L12.2m x 10 tanks	W7.6m x L12.2m x 10 tanks	
Filter Drain Tank	W10.0m x L39.0m x D3m x 2 tanks	-	
Clear Well Reservoir	W4.0m x D4.0m x Total L413.7m	W4.0m x D4.0m x Total-L 413.7m	
Sludge Lagoon	A:V=3,669m3, H=0.7m B:V=5,384m3, H=0.7m C:V=5,492m3, H=0.7m D:V=5,492m3, H=0.7m E:V=5,384m3, H=0.7m	-	
Sludge Treatment	-	- Sludge receiving Tank; W15.0m x L20.0m x D4.0m x 2no. - Thickening Tank; Dia. 30m x D4.0m x 2 No. Dia. 18m x D4.0m x 2No. - Sludge drying bed; about 11,000m^2	
Sub-Station	W10.8m x L11.7m	-	
Electrical Building	W14m x L26m	-	
Generator Building	-	New building required.	
Chemical Building	W16.5m x L27.5m	-	
Chlorine Building	W9.5m x L27.5m	W9.5m x L27.5m	
Administration Building	W11.8m x L38m	-	
Warehouse	W20.5m x L24m	-	
Guard House	W5.0m x L5.0m	-	
Water Tower	W2.9m x L2.9m x D3.0m	-	
Yard piping	Conveyance Pipe: DN1200mm Transmission Pipe: DN1200mm Connecting pipe between facilities	Conveyance Pipe: DN1200mm Transmission Pipe: DN1200mm Connecting pipe between facilities	
Site works	Fence, road, earth filling, drainage etc.	Road	

(2) Soil Conditions

Soil investigation was conducted at the WTP site in 2012 and the information on the bearing layer for planning the pile foundation was collected. The bearing layer for the construction of WTP in Phase 2 is shown in Figure 7.7.6. About 20m long concrete piles will be required in the sedimentation basin area.



Note) Length of Piles for Phase 2 will be longer than Phase 1

Figure 7.7.6 Soil Investigation Results in 2012

7.7.4 Mechanical Equipment

(1) Design Conditions

Table 7.7.5 shows the major mechanical design conditions for the water treatment and sludge treatment processes.

Table 7.7.5 Mechanical Design Condition for Phase 2 Project

Facility Name	Design Condition of Phase 2		Reference
Water Treatment Plant (WTP) 1) Receiving Well/ Mixing Chamber/ Flocculation Facility 2) Sedimentation Basin Facility 3) Filter Facility	150,000 m^3/ day Design average turbidity 40 NTU Design maximum turbidity 100 NTU		Phase 1 is 150,000 m^3/day
4) Clear Well /Transmission Pump Facility	143,000 m^3/ day		Phase 1 is 143,000 m^3/day
5) Filter Drain Tank Facility			All work including phase 2 is under construction.
6) Chemical Facility	150,000 m^3/ day		Civil work including phase 2 is under construction.
	Alum	Average dosage rate 21 mg/l Maximum dosage rate 30 mg/l	
	Lime	Average dosage rate 5 mg/l Maximum dosage rate 15 mg/l	
7) Chlorine Facility	150,000 m^3/ day		Phase 1 is 150,000 m^3/day
	Pre chlorine	Average dosage rate 3 mg/l Maximum dosage rate 5 mg/l	
	Post chlorine	Average dosage rate 1 mg/l Maximum dosage rate 1.5 mg/l	
8) Sludge Treatment Facility	300,000 m^3/ day		
	Inlet sludge concentration and volume	approx. 0.5 % dry season 2,334m^3/d Rainy season 5,650m^3/d	
	Thickened sludge concentration and volume	approx. 3.0 % dry season 390m^3/d Heavy rainy day 950m^3/d	Total two thickeners, including each one stage thickener during dry season
	Thickened sludge concentration and volume	approx. 6.0 % Heavy rainy day 470m^3/d	Total four thickeners, including two sets of two thickeners connected in series during rainy season

Note: The number and specification of mechanical equipment for Phase 2 WTP is basically the same as for the Phase 1 WTP.

(2) Major Equipment

Table 7.7.6 shows the major Mechanical Equipment for the Phase 2 Project, as well as equipment provided in Phase 1.

Table 7.7.6 Major Mechanical Equipment for Phase 2 Project

Item	Specification	Phase 1 (under construction)	Phase 2
a. Receiving Well/ Mixing Chamber/ Flocculation facility			
Flash Mixer:	Turbine Mixer D 1.0m x 8 blades x 11kW	2 units	2 units
Inlet Gate	Manual Sluice W 0.6m x H 0.6m	8 units	8 units
b. Sedimentation Basin			
Sludge Collector	Submerged Car-scraper (rope pulling) W5.75m x L36.3m x 0.75kW	8 units	8 units
De-sludge Valve	Motorized Eccentric D-200 x 0.4kW	32 units	32 units
c. Filter Facility			
Inflow Valve	Motorized Butterfly D-600 x 0.2kW	10 units	10 units
Filtrated & Backwash Valve	Manual Butterfly D-600	10 units	10 units
Surface Wash Valve	Motorized Butterfly D-300 x 0.2kW	10 units	10 units
Wash Waste Gate	Motorized Rectangular Butterfly W0.9m x H0.9m x 0.75kW	10 units	10 units
d. Filter Drain Tank			
Wash Waste Pump:	Submersible Sewage 14m3/min x 16 m x 55kW	4 units including 2 standby	-
e. Clear Well/ Transmission Pump Facility			
Transmission Pump	Horizontal double suction volute 34m3/min x 81 m x 630kW (two are VVVF/ each phase)	5 units including 2 standby	5 units including 2 standby
f. Chemical and Chlorine Facility			
Alum Facility			
Alum Mixer	Double Impeller Turbine Mixer 3.7 kW	2 units	2 units
Alum Pump	Diaphragm 280-850 L/ hr x 0.75kW	4 units including 2 standby	4 units including 2 standby
Lime Facility			
Lime Mixer	Double Impeller Turbine Mixer 3.7 kW	2 units	2 units
Lime Pump	Diaphragm 170-860 L/ hr x 0.75kW	3 units including 2 standby	3 units including 2 standby
g. Chlorination Facility			
Chlorine cylinder	Cylindrical Convexed Container 1000 kg	18 units	18 units
Chlorinator	Self-Stand Vacuum 40kg/ hr	3 units including 1 standby	3 units including 1 standby
h. Sludge Treatment Facility			
Sludge Receiving Tank			
Sludge Mixer	Submersible Mixer 5.5kW	-	6 units including 2 in stock
De-sludge Pump	2.0 m^3/min x 15kW	-	4 units including 2 standby
Sludge Thickener			
Thickener 1	Gravity Thickener Dia. 30m x 1.5kW	-	2 units
Thickener 2	Gravity Thickener Dia. 18m x 1.5kW	-	2 units
Thickened Sludge Pump 1 group	Non-clog centrifugal 0.41 m^3/min x 7.5 kW	-	4 units including 2 standby
Thickened Sludge Pump 2 group	Non-clog centrifugal 1.0 m^3/min x 11kW	-	3 units including 2 standby
i. Supernatant Tank Facility			
Supernatant Pump	Non-Clog Submersible 1.8 m^3/min x 15kW	-	4 units including 2 standby

(3) Sludge Treatment Facility

The sludge treatment facilities require various equipment including sludge mixers, gates, de-sludge pumps, thickened sludge pumps, thickeners, and other necessary items. Sludge from the sedimentation basin, which is used for both phase 1 and 2, is transferred to the sludge receiving tank by gravity. Four sludge mixers (with an additional two in stock) will be provided in the tanks to prevent the inlet sludge from settling and sludge is transferred to the sludge thickeners by de-sludge pumps. It is planned that one duty pump out of the total of four pumps will be operated during the dry season and two duty pumps during the rainy season.

A total of four thickeners (D30m x2, D18 x 2) are planned. Two thickeners will be operated during the dry season. During days with heavy rain/rainy season, a total of four thickeners, two systems each with two thickeners connected in series will be operated. During the dry season, sludge with about 0.5 % concentration from sludge receiving tanks is thickened up to about 3 % concentration in the gravity thickener, and thickened sludge is transferred to the sludge drying bed by a thickened sludge pump. During days with heavy rain/rainy season, the thickened sludge concentration is increased up to about 6% due to two stage thickeners being connected in series. Thickened sludge is transferred to the sludge drying bed using a thickened sludge pump (refer to Figure 7.7.7 for schematic operation flow of sludge treatment).

7.7.5 Electrical Equipment

(1) Main Power Supply

In the Phase 1 Project expansion of the main power supply with a single 33kV 50Hz by REB and connecting to 33kV/3.3kV transformer is planned. The incoming line is reliable due to it being a direct and dedicated supply from the nearest substation. However, the capacity of transformer allows for only the Phase 1 needs.

An additional transformer and connection breakers are required for Phase 2. The necessary space, including concrete foundation is considered and allowed for in the Phase 1 Project. The transformer shall be of the outdoor, oil immersed, and natural cooling type.

(2) Emergency Power Generation

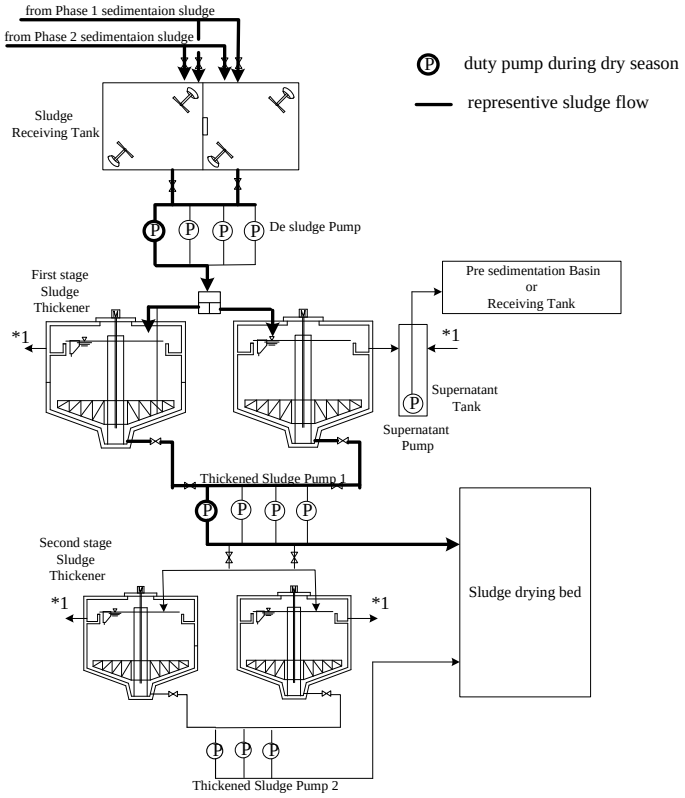
An additional generator will be required for the Phase 2 WTP. The capacity and type of generator will be the same as that in Phase 1. A new generator building will be required for the additional generator.

Figure 7.7.8 shows the single line diagram to show the scope of the Phase 2 Project.

(3) Electrical Room

Four electrical rooms will be required for the Phase 2 project, located in the Substation, Filter, Transmission Pump Station and Chemical Building. In the Phase 2 project, 3.3kV switchgear, LV transformer and LV distribution board shall be installed in the Substation; and pump starters and motor control centres shall be installed in the other electrical rooms. It is possible to accommodate additional equipment in the Phase 1 Substation and Chemical Building. However, for the Filter and Pump Station, new electrical rooms, which are similar to the Phase 1 works, will be required.

Dry Season



Rainy season (heavy rain day)

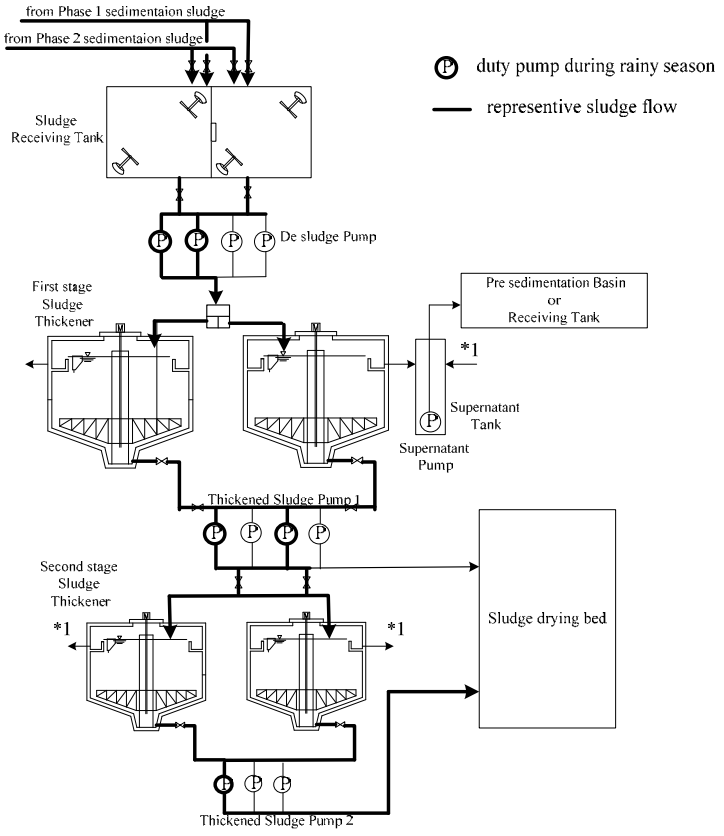


Figure 7.7.7 Schematic Operation Flow of Sludge Treatment

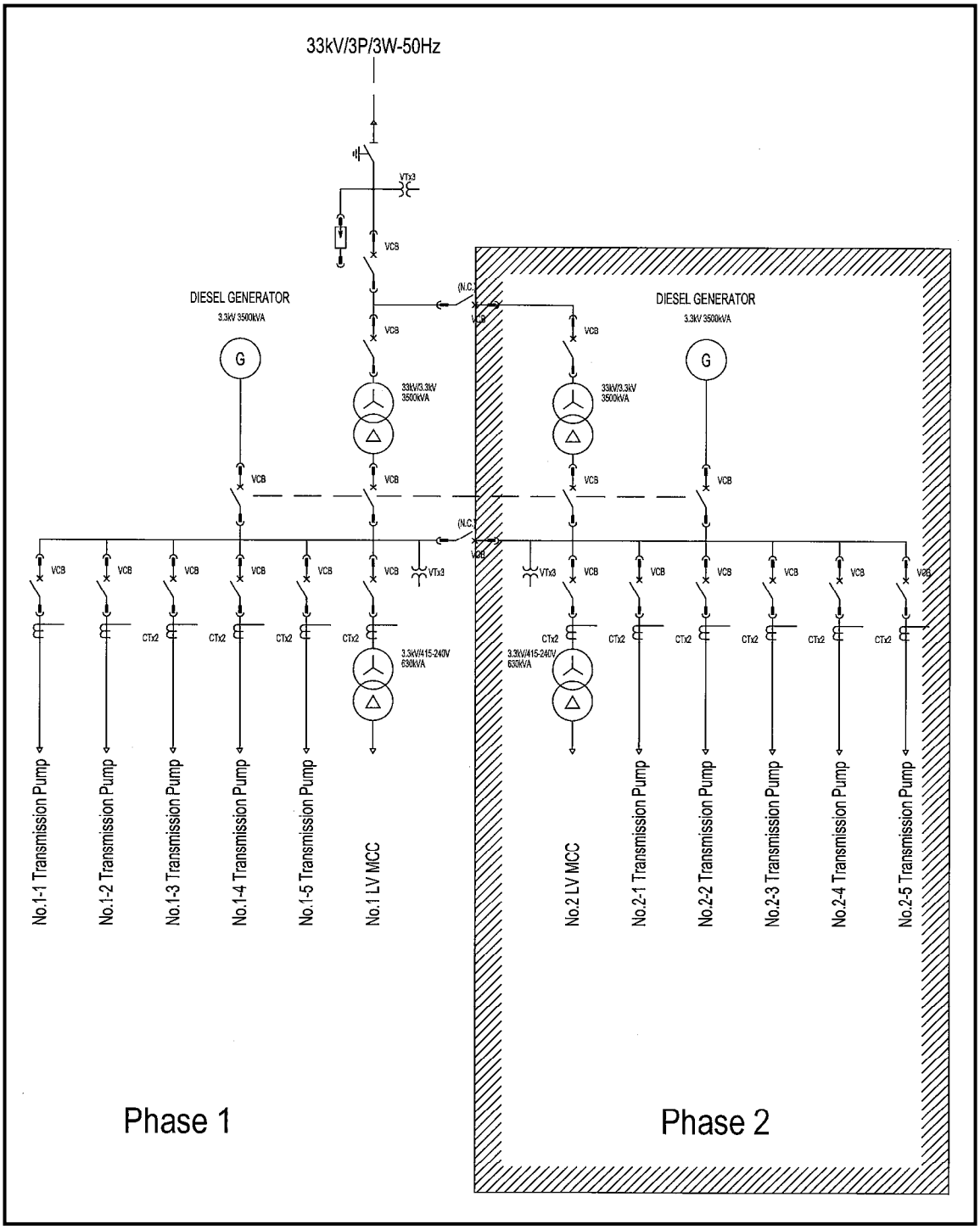


Figure 7.7.8 Single Line Diagram for Karnaphuli WTP

(4) SCADA and Instrumentation

A SCADA system for the WTP facilities is included in Phase 1. Additional facilities should be provided in Phase 2 and these should be compatible with and incorporated into the Phase 1 SCADA system, using the same type of PLC as Phase 1 (Profibus protocol). The software of the SCADA should be same as that of the Phase 1 Project.

Table 7.7.7 shows the main electrical equipment required for Phase 2 Project.

Table 7.7.7 Major Electrical Equipment required for Phase 2 Project

Equipment	Features
33kV Switchgear	VCB
33/3.3kV Transformer	Oil type
3.3kV Switchgear	VCB
3.3kV pump starter	VFD drive
WTP MCC	400V Form 3b
Chemical MCC	400V Form 3b
Local Operation Panel	Stand type
Intake Flow Measurement	Electromagnetic type
Filter Level Measurement	Ultrasonic type
Residual Chlorine Measurement	Polarograph Type
Clear Water Level Measurement	Submersible type
Transmission Flow Measurement	Electromagnetic type
PLC/RTU	Open protocol (Profibus)
SCADA System	Modification and up-grading
Standby Generator	Diesel engine, radiator cooling

Figure 7.7.9 shows the Instrumentation Flow Diagram in the WTP.

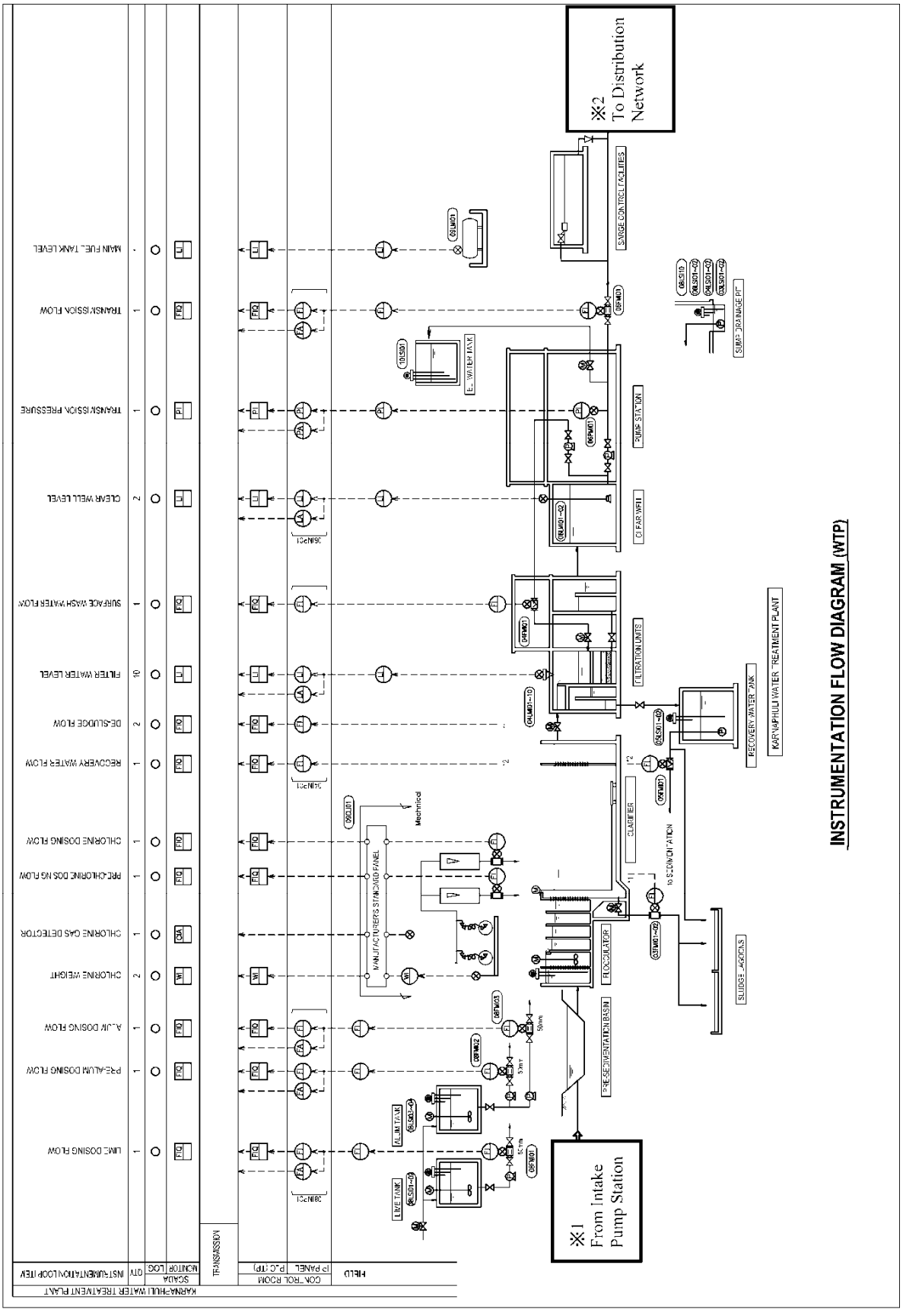


Figure 7.7.9 Instrumentation Flow Diagram in Karnaphuli WTP

7.8 Transmission Pipeline

(1) Outline of Transmission Pipeline

Transmission pipelines are planned for the two phases, as shown in Table 7.8.1.

Table 7.8.1 Outline of Transmission Pipeline

Pipeline Route		Diameter (mm)	Length (m)	Project	
Starting point	**End point**			**Phase 1**	**Phase 2**
Karnaphuli WTP	Nashirabad Reservoir	1200	24,400	x	x
Nashirabad Reservoir	Nashirabad Elevated Tank	1000	100	x	-
	Battali Hill Reservoir	1200 1000	5,000	x	-
	Halishahar Elevated Tank	1100	10,000	-	x

Note: x- included

(2) Transmission Pipeline from WTP to Nashirabad Reservoir

The road section from the WTP to Halda River (Madunaghat bridge) is out of Chittagong City Cooperation or CWASA's jurisdiction area. In this section the transmission pipeline from the WTP to Nashirabad Reservoir is planned along Kaptai road for both the Phase 1 and Phase 2 Projects, as shown in Figure 7.8.1.

The right of way for the Phase 1 pipelines was approved on October 3, 2012 by RHD, Ministry of Communication. The following are issues and problems in case of "off the road" construction being required, in the case that concurrence from RHD to construct the pipeline in the road is not obtained for the Phase 2 Project.

1) Social issues/problems: To work off the roadway will require the removal of Mosques, Graveyards, big houses, hundreds of trees, demolition of stores, filling in of ponds, removal of power poles, etc.
2) Technical issues/problems: The contractor would have to restrict his working periods to the dry season, which will be costly and extend the period of execution. The excavation will require sheet piling to prevent the soft soil from caving in. Additional restraining joints for the pipe are necessary due to the soft soil conditions. Dewatering of the trench will be required, as the water table is high.
3) Government sector targets and policy response: The Government sector objective in the National Strategy of supplying drinking water to the entire population by 2011 will be adversely affected in terms of service coverage and will result in sanitation problems and complaints from people.

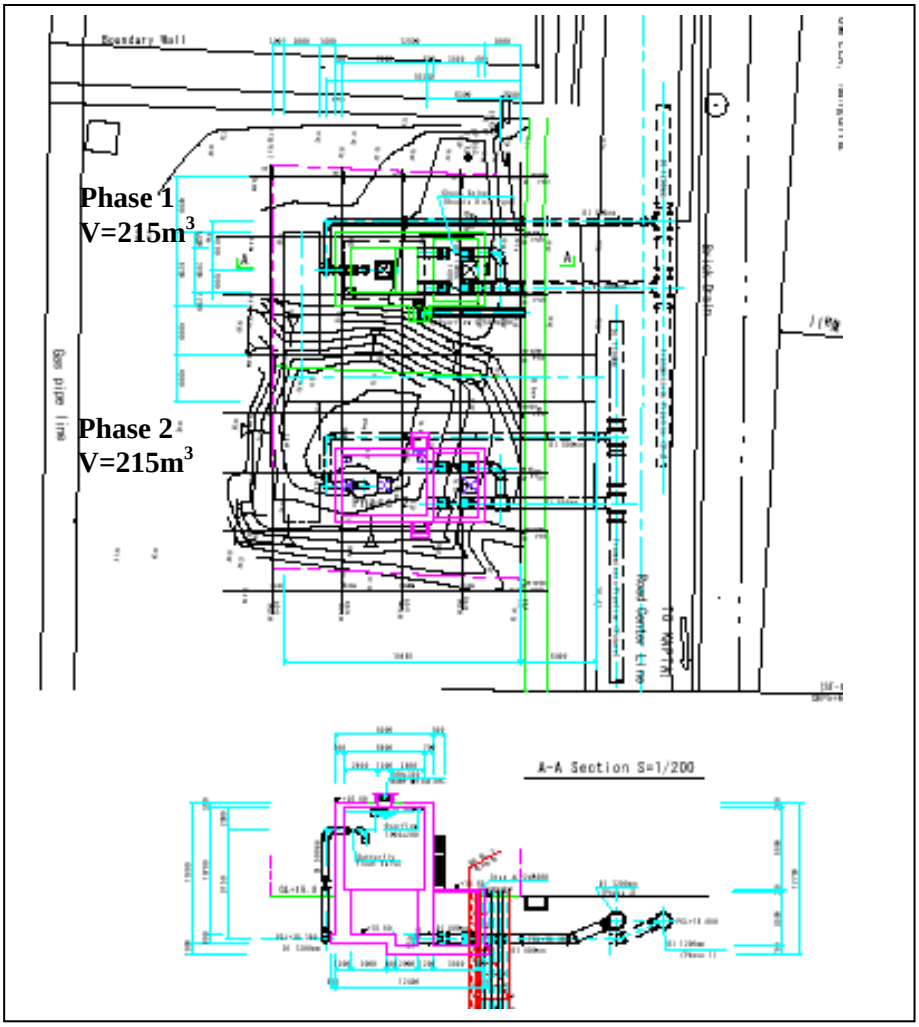


Figure 7.8.1 Location of Surge Tank and Transmission Pipelines

Concurrence from RHD on the right of way for the Phase 2 is urgent and the construction plan shall consider realistic and acceptable construction methods, adequate traffic control and public communication. Some faucet systems along the transmission pipeline shall be provided for the residents to mitigate complaints, as shown in Figure 7.8.2 and it is proposed that systems are provided at five locations, as shown in Figure 7.8.3. The faucets will be used by the people including not only the residents near the faucet systems, but also travelers. However, associations consisting of the residents near the faucet systems shall be established for the adequate use and O&M of the facilities under the leadership of CWASA. CWASA shall have a continuous talk with the associations before construction of the facilities.

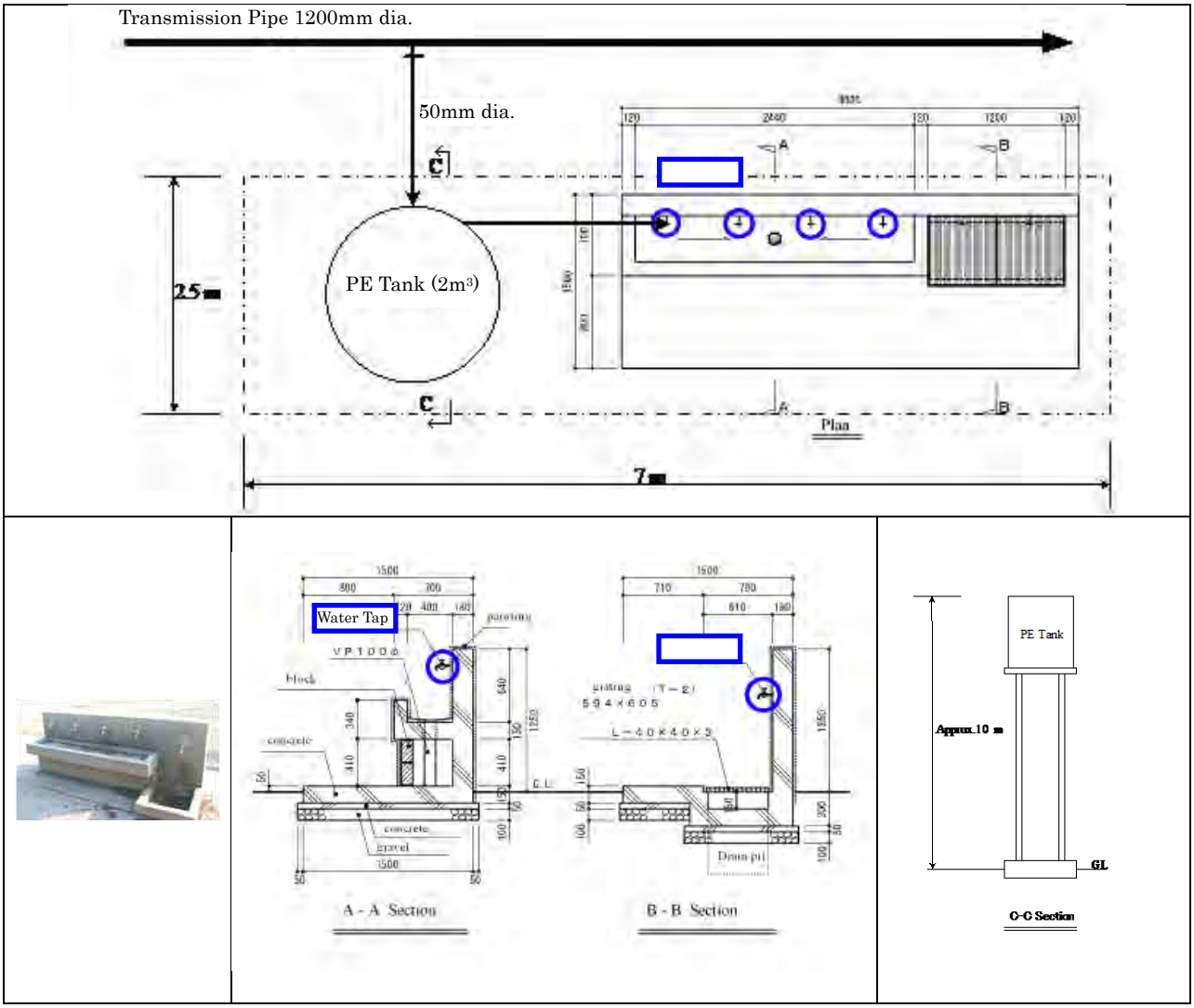


Figure 7.8.2 Faucet for Residents

Figure 7.8.3 Proposed Location of Faucet Systems

Regarding the Halda River crossing, the supports for the water bridge are provided in the Phase 1 Project, as shown in Figure 7.8.4. Only steel pipes will be required for the Phase 2 Project.

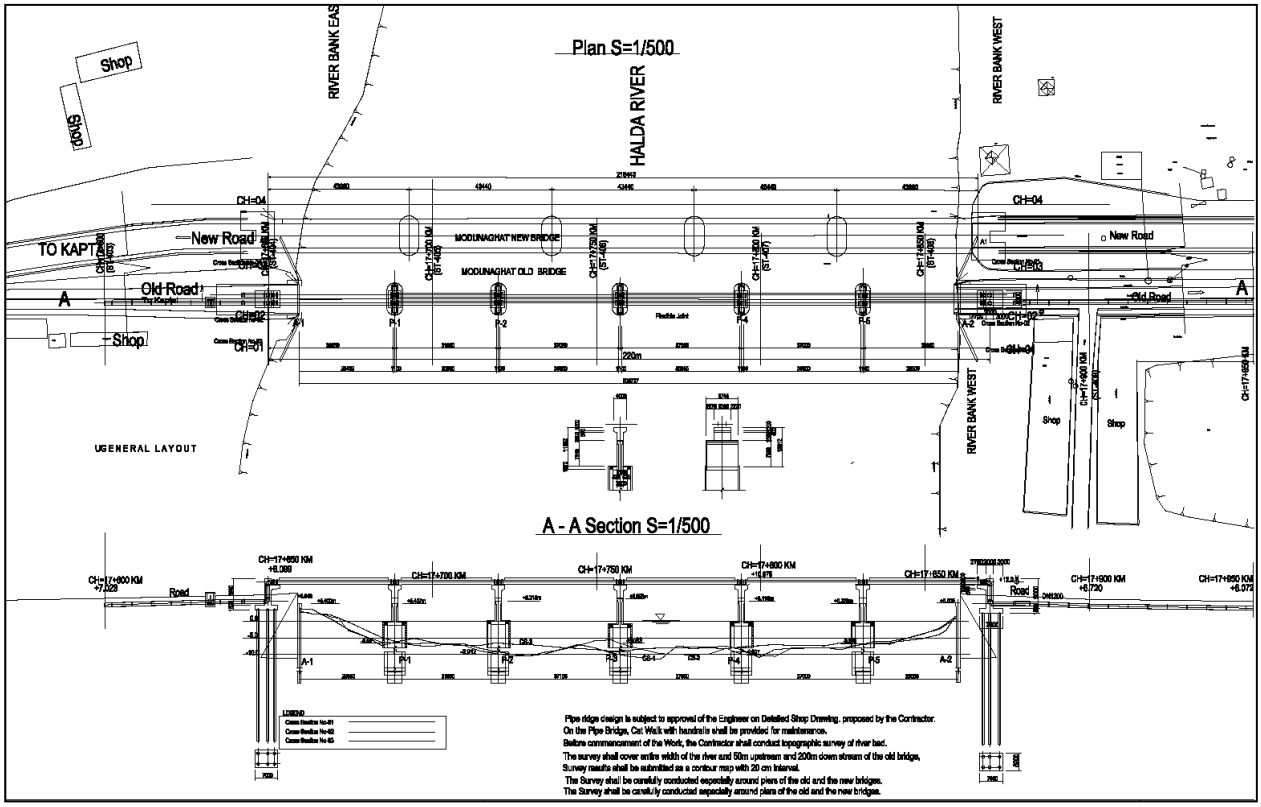


Figure 7.8.4 Water Bridge at Halda River Crossing

(3) Transmission Pipeline from Nashirabad Reservoir to Elevated Tank/Reservoir

As shown in Table 7.8.1 there are two transmission pipelines from Nashirabad Reservoir in Phase 1. These are to:

- Elevated Tank at Nashirabad Site
- Battali Hill Reservoir

A pipeline from the Nashirabad Reservoir to Halishahar Elevated Tank is proposed for the Phase 2 Project to supply the western area of the Karnaphuli service area. Figure 7.8.5 shows the transmission pipeline route and site conditions of this route are included in Supporting Report 7.8.1.

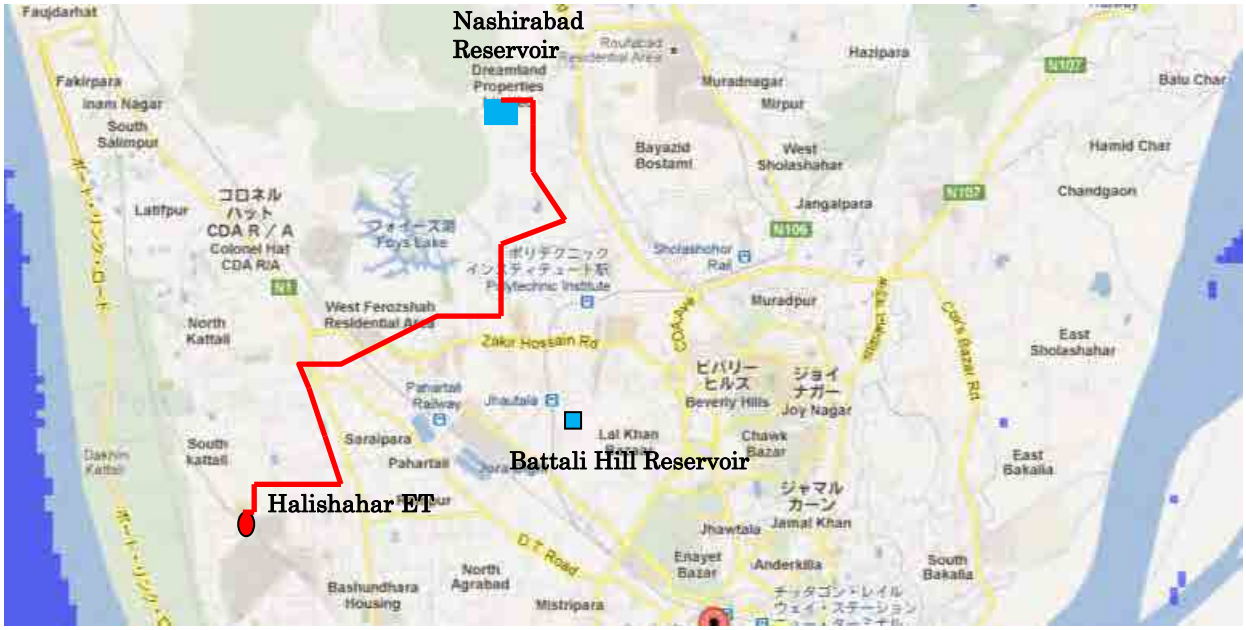


Figure 7.8.5 Transmission Pipeline Route from Nashirabad to Halishahar

7.9 Distribution Facilities

(1) Outline of Distribution System

The distribution system covers ten (10) Sectors and is divided into three (3) sub-systems, the northern, central and western areas. These areas are served by the Elevated Tank at Nashirabad site, Battali Hill Reservoir, and Halishahar Elevated Tank respectively, as shown in Figure 7.9.1.

(2) Nashirabad Reservoir

1) Civil Works

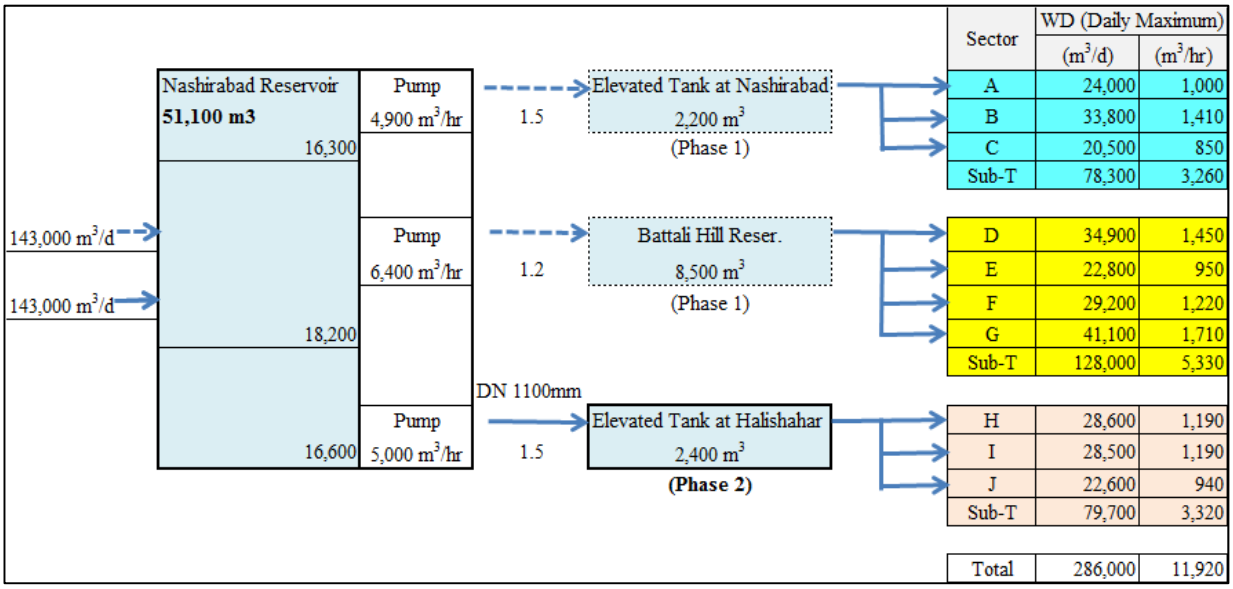
Nashirabad Reservoir with a capacity of 26,300m^3 is planned for the Phase 1 Project to achieve the function of storage of water to cater for the peak hour demand in the Karnaphuli service area. In the Phase 2 Project, augmentation of the reservoir up to a capacity of 51,100m^3 is needed, in accordance with the distribution plan in Chapter 6. Thus, a reservoir with a capacity of 24,800m^3 (= 51,100 – 26,300) is required in Phase 2, the location of which is shown in Figure 7.9.2. Figure 7.9.3 shows the Hydraulic Profile from Nashirabad Reservoir to the other Reservoir/Elevated Tank.

2) Mechanical Equipment

Table 7.9.1 shows the outline of mechanical equipment at the Pump Station at Nashirabad Reservoir.

Table 7.9.1 Distribution Reservoir Facility (Nashirabad Pump Station)

Facility Name	Design condition of Phase 2
For Nashirabad Elevated Tank	117,450 m^3/day (78,300m^3/day x 1.5)
For Battali Hill Reservoir	153,600 m^3/day (128,000m^3/day x 1.2)
For Halishahar Elevated Tank	119,550 m^3/day (79,700m^3/day x 1.5)



Sector	WD (Daily Maximum) (m^3/d)	(m^3/hr)
A	24,000	1,000
B	33,800	1,410
C	20,500	850
Sub-T	78,300	3,260
D	34,900	1,450
E	22,800	950
F	29,200	1,220
G	41,100	1,710
Sub-T	128,000	5,330
H	28,600	1,190
I	28,500	1,190
J	22,600	940
Sub-T	79,700	3,320
Total	286,000	11,920

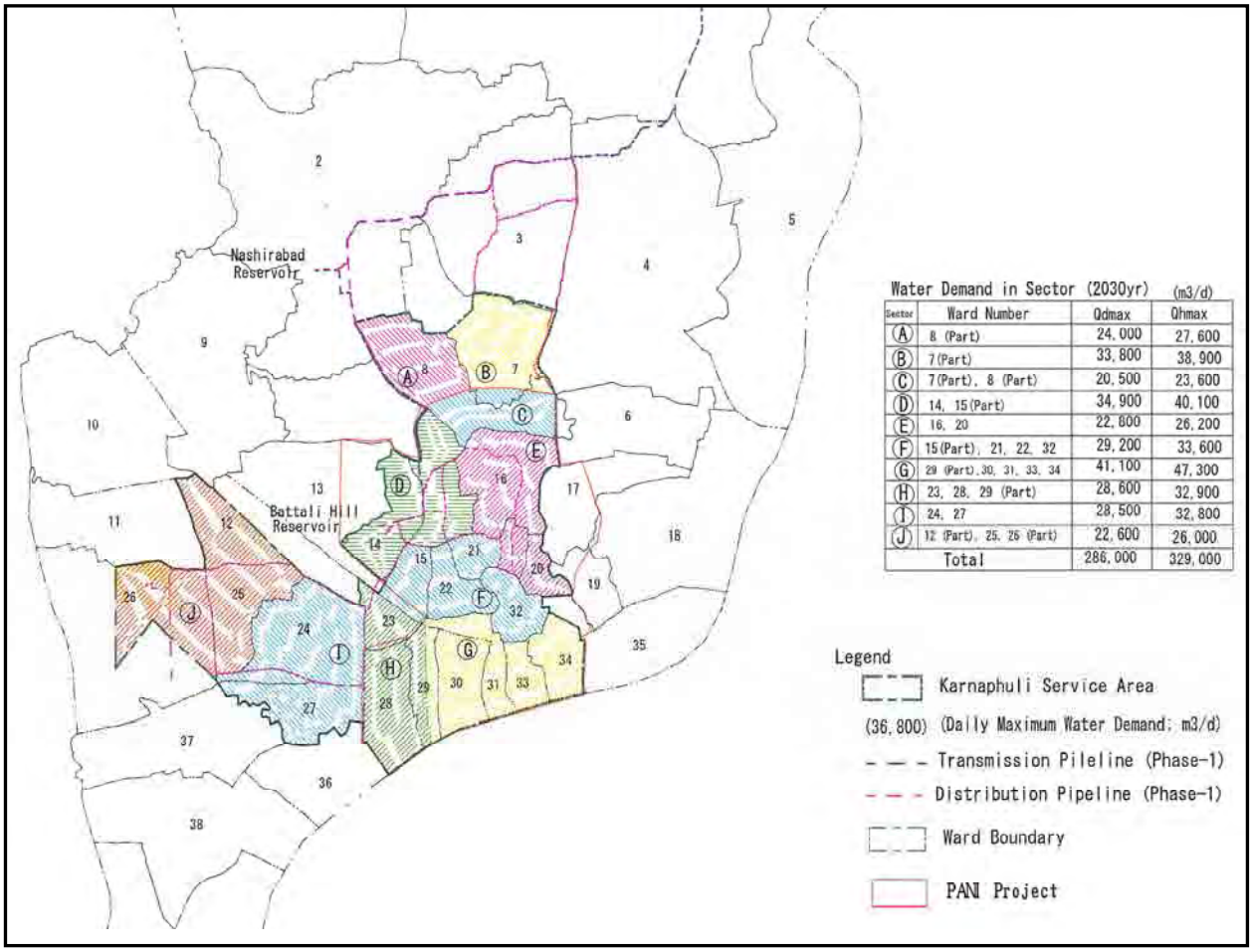


Figure 7.9.1 Schematic Plan of Distribution System and Locations of Sectors

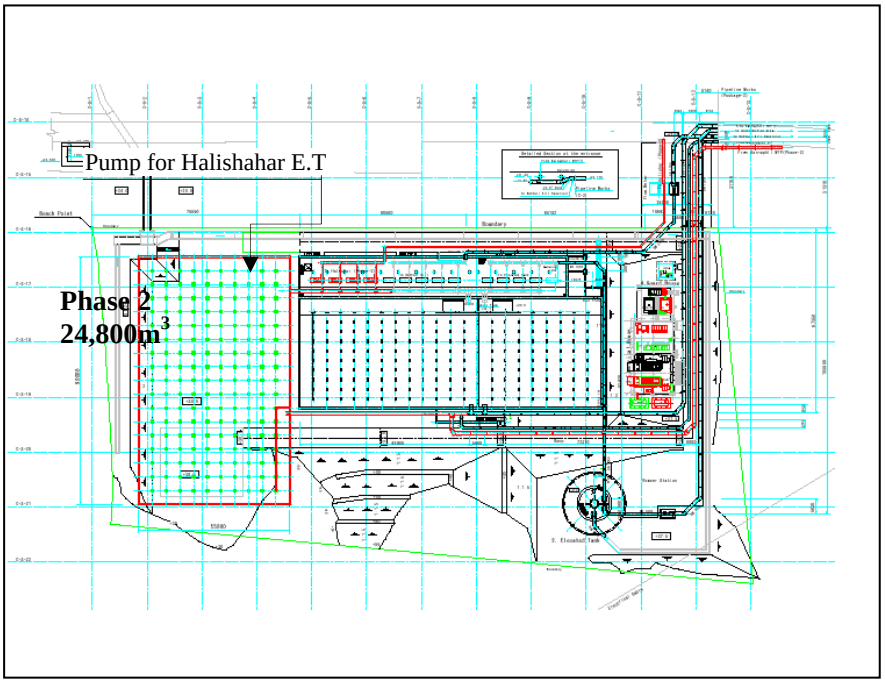


Figure 7.9.2 General Layout Plan of Nashirabad Reservoir for Phase 2 Project

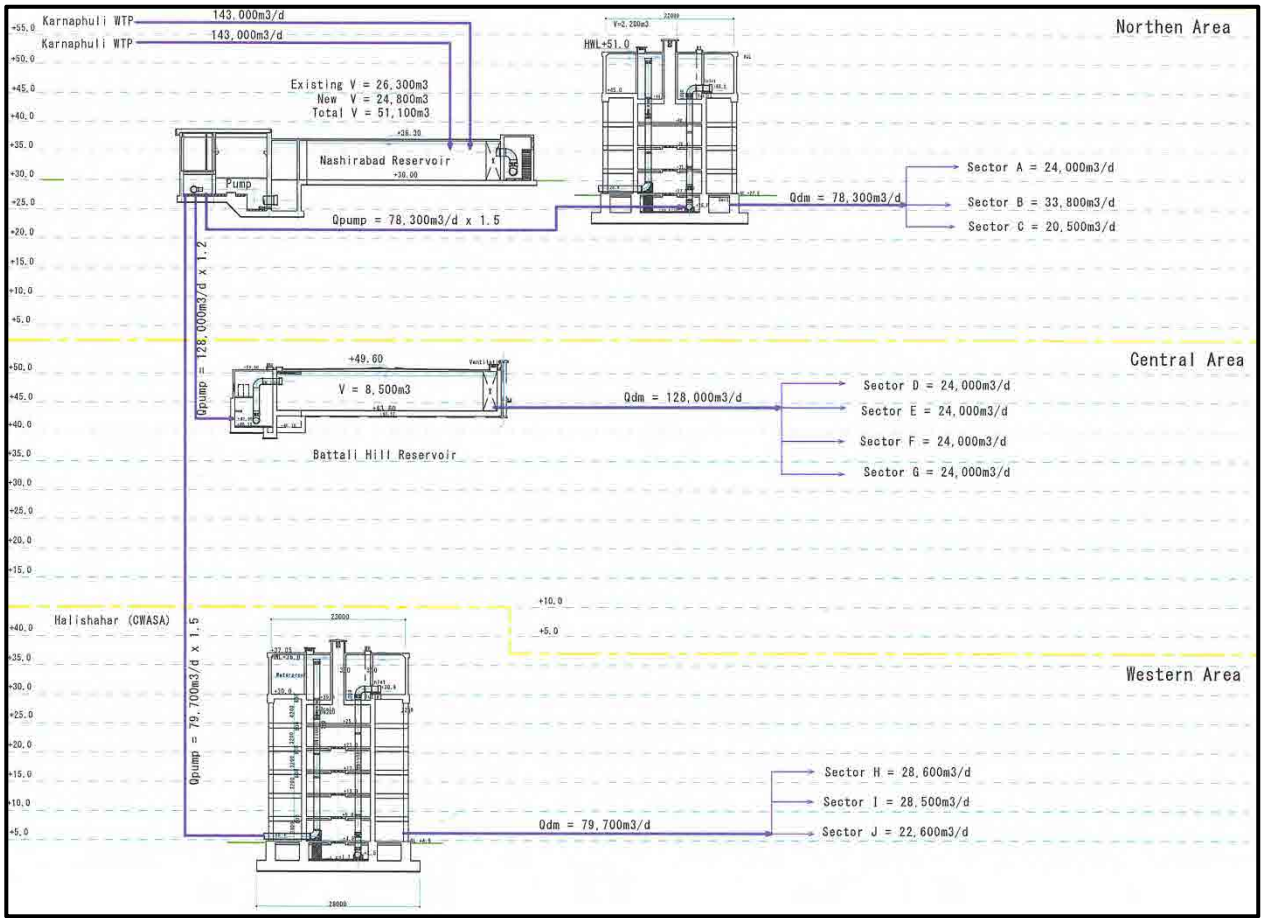


Figure 7.9.3 Hydraulic Profile from Nashirabad Reservoir to Other Reservoir/Elevated Tank

Additional mechanical equipment for Phase 2 at Nashirabad Elevated Tank is not necessary, since it will be equipped under the Phase 1 Project. Regarding the transmission pumps to Battali Hill Reservoir, the five pumps which are planned in phase 1 cannot be used in Phase 2 because both the pump flow capacity and hydraulic head are to be increased in accordance with the planned distribution area in Phase 2. Thus, five new pumps shall be installed to meet the planned capacity for Phase 2. Fortunately, all pumps planned for Battali Hill in Phase 1 will be able to be used as the pumps for transmission of water to Halishahar Elevated Tank. The five transmission pumps planned for Battali Hill in Phase 1, which include one standby and one in stock, are arranged as transmission pumps to Halishahar Elevated Tank. The required equipment at Nashirabad Pump station is summarized in Table 7.9.2.

Table 7.9.2 Transmission Pumps to be installed at Nashirabad Pump Station

Item	Specification	Phase 1	Phase 2
Transmission Pump to Nashirabad ET	Horizontal double suction volute 54m^3/min x 26 m x 315kW	4 units including 2 standby	-
Transmission Pump to Battali Hill	Horizontal double suction volute 29m^3/min x 33 m x 220kW	5 units including 2 standby	(all pumps will be relocated to supply Halishahar Elevated Tank)
Transmission Pump to Battali Hill	Horizontal double suction volute 36m^3/min x 38 m x 320kW	-	5 units including 2 standby (proposed)
Transmission Pump to Halishahar	Horizontal double suction volute 28m^3/min x 28 m x 220kW	-	5 units including 1 standby and 1 stock (re-installed Battali Hill pumps of phase 1)

3) Electrical Equipment

a) Main Power Supply

The main power supply for Phase 1 is double (duty-standby), 11kV, 50Hz, supplied by PDB connecting to a 11kV/3.3kV transformer. The incoming line is reliable due to the dual incoming power supply. However, the capacity of the transformer only covers the Phase 1 needs.

An additional transformer and connection breakers are required for the Phase 2 project. The necessary space including concrete foundation work is considered and allowed for in the Phase 1 Project. The transformer shall be of the outdoor, oil immersed, and natural cooling type.

b) Emergency Power Generation

Standby diesel engine generator capacity to operate all of the duty transmission pumps is provided in the Phase 1 Project. An additional generator set is required for the additional transmission pumps. The capacity and type of generator shall be the same as for Phase 1. The additional generator sets can be accommodated in the building provided in the Phase 1 Project. Figure 7.7.4 shows the single line diagram to show the scope of the Phase 2 Project.

c) Electrical Room

Two electrical rooms were planned in the Phase 1 project, one in the Electrical Building and other in the Transmission Pump Station. In the Phase 2 project, 3.3kV switchgear and LV transformer and LV distribution board shall be installed in the Electrical Building, and pump starters and

motor control centre shall be installed in the Pump Station. Both electrical rooms are able to accommodate additional equipment without expansion work.

d) SCADA and Instrumentation

A SCADA system at Nashirabad Reservoir is included in Phase 1. The system is connecting to the SCADA system at the WTP by optical cable and it is possible to conduct comprehensive monitoring from the intake to distribution system. Additional facilities in Phase 2 should be incorporated into the Phase 1 SCADA system using same type of PLC. The software of the SCADA system should also be the same as that of Phase 1.

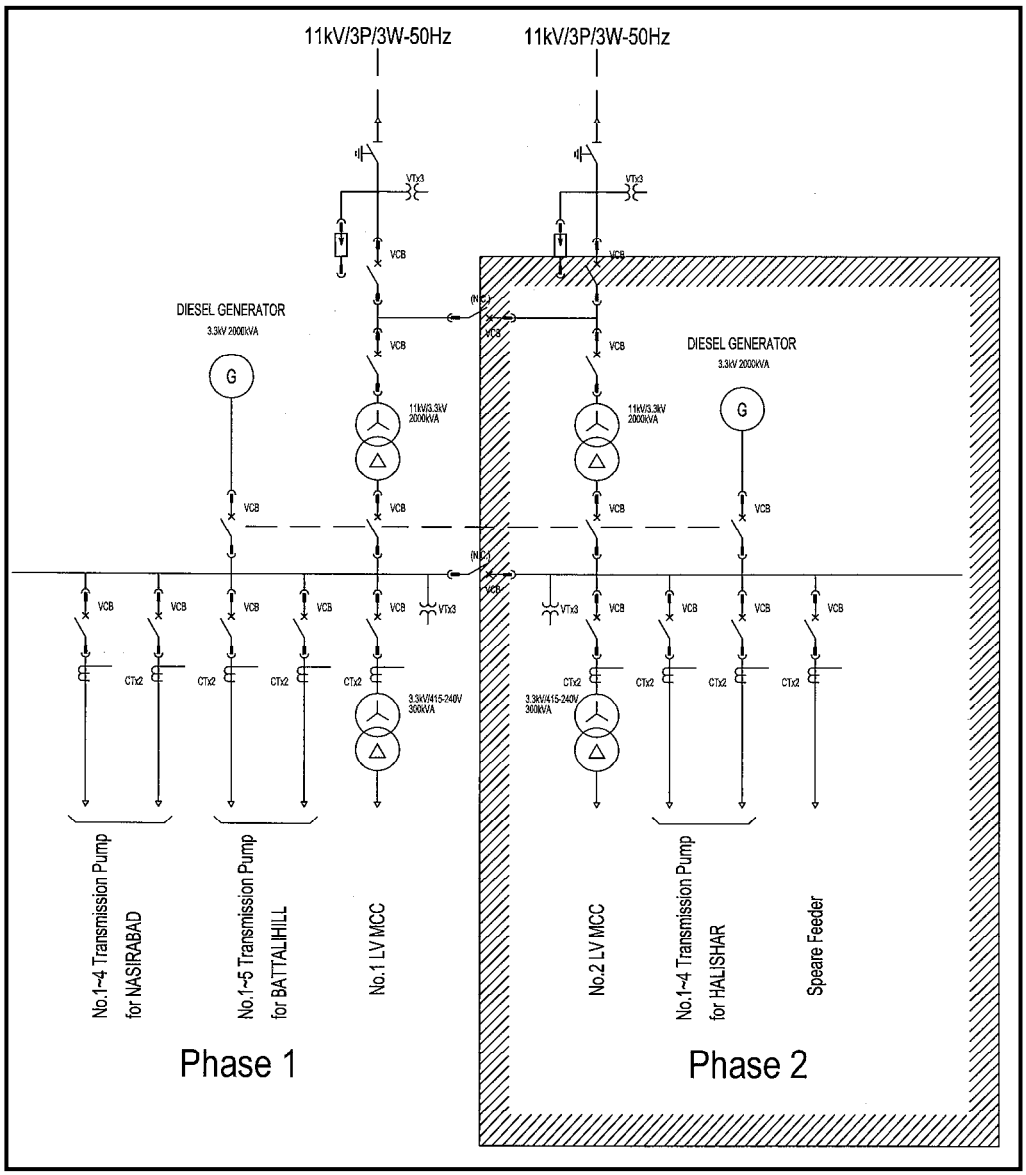


Figure 7.9.4 Single Line Diagram for Nashirabad Reservoir

Table 7.9.3 summarizes the major electrical equipment for Phase 2 Project.

Table 7.9.3 Summary of Major Electrical Equipment

Equipment	Feature
33/3.3kV Transformer	Oil
3.3kV Switchgear	VCB
3.3kV pump starter	VFD drive
Transmission MCC	400V Form 3b
Local Operation Panel	Stand type
Reservoir Level Measurement	Submersible type
Distribution Flow Measurement	Electromagnetic
PLC/RTU	Open protocol (Profibus)
SCADA System	Modification and up-grading
Standby Generator	Diesel engine, radiator cooling

(3) Battali Hill Reservoir

Battali Hill Reservoir with a capacity of 8,500m^3 is constructed in the Phase 1 Project (Refer to General Layout of the Reservoir in Figure 7.9.5). The inlet pipe diameter to the reservoir is from DN1000mm to DN1200mm because of the very narrow access road to the reservoir. Two distribution pipelines are connected to the reservoir in Phase 1 (DN 500mm and the exiting DN900mm). The water levels in the reservoir are LWL +43.6 m and HWL +49.6m. The Inlet Chamber for Sector D will be constructed at DN500mm in Phase 1.

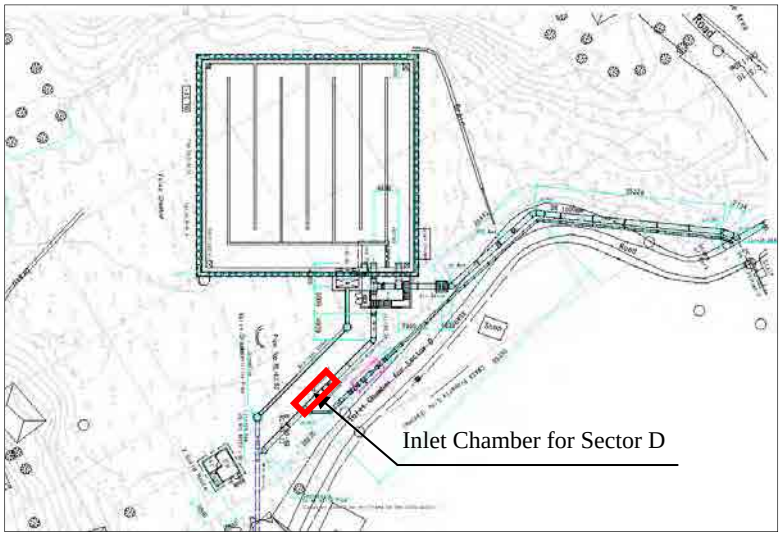


Figure 7.9.5 General Layout Plan of Battali Hill Reservoir

(4) Elevated tank at Nashirabad site

An Elevated Tank at Nashirabad site with a capacity of 2,200m^3 is constructed in the Phase 1 Project. The planned water levels in the tanks are LWL +45.0m and HWL +51.0m. Figure 7.9.6 shows the general layout of the Elevated Tank.

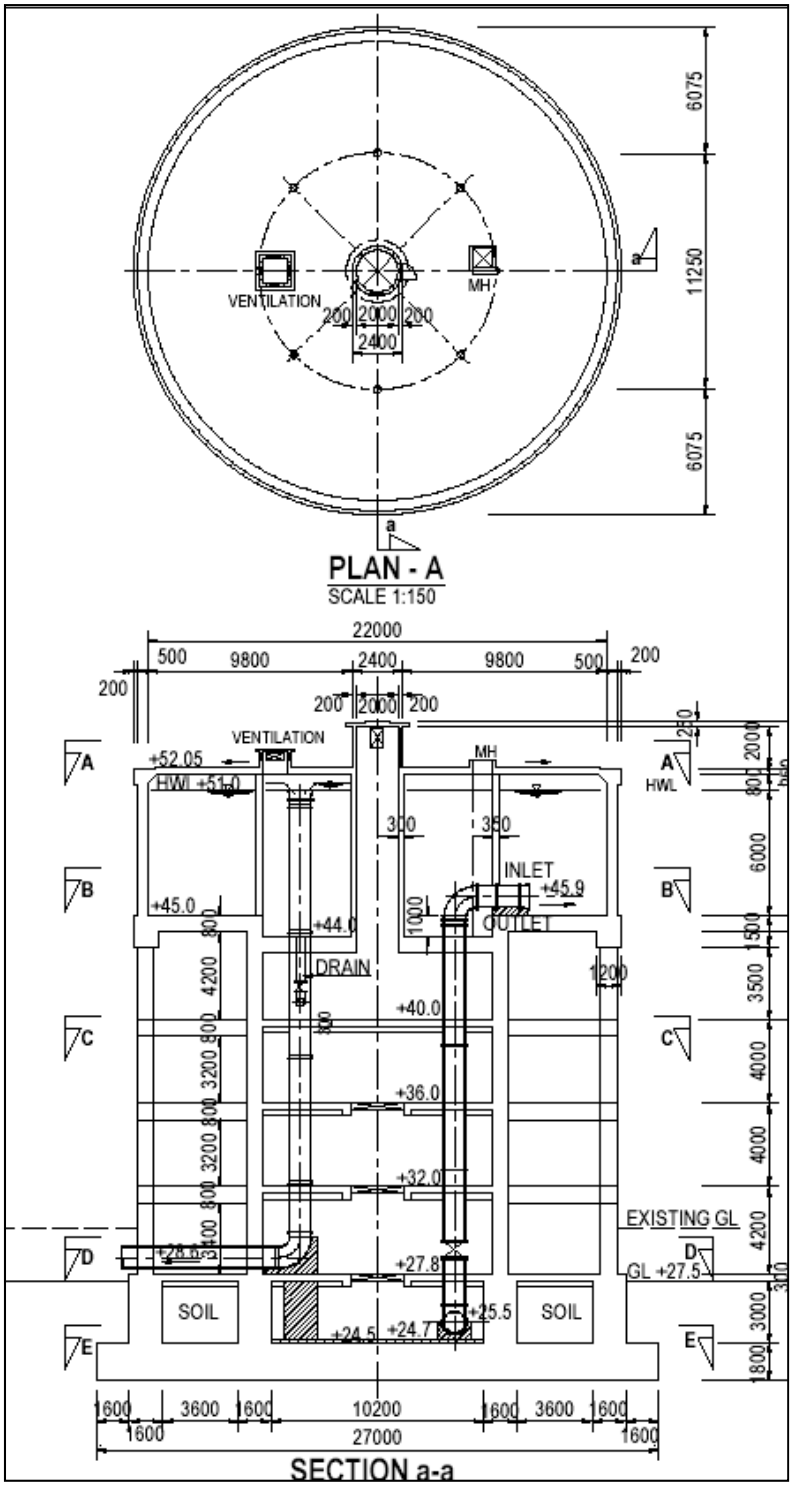


Figure 7.9.6 General Layout of Nashirabad E.T.

(5) Elevated tank in Halishahar

Halishahar Elevated Tank (capacity 2,400m^3) will be constructed in the Phase 2 Project and it will be located on CWASA owned property, as shown in Figure 7.9.7.

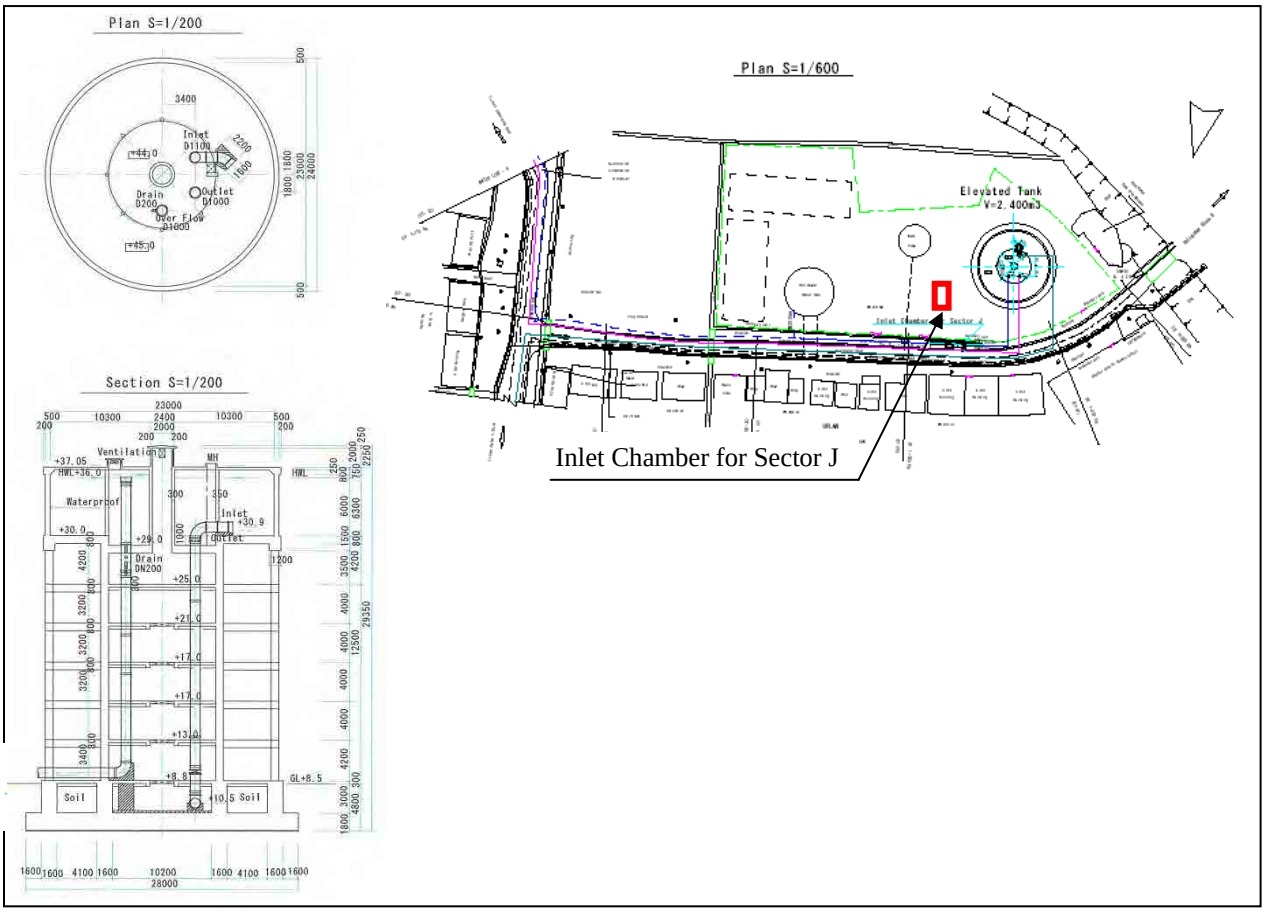


Figure 7.9.7 General Layout Plan of Halishahar Elevated Tank

7.10 Distribution Pipeline

(1) Distribution pipelines in Phase 1

Water (143,000m^3/d) produced from Karnaphuli WTP is planned to be distributed mainly to the Fatehabad, Nashirabad, Agrabad, Madarbari, Kotowari, and Halishahar areas via Nashirabad Elevated Tank and Battali Hill Reservoir by connecting with the existing pipes to meet the water demands in 2010, as shown in Figure 7.10.1.

(2) Distribution pipelines in Phase 2

Water from the three (3) main distribution facilities, namely the Elevated Tank at Nashirabad site, Battali Hill Reservoir and Halishahar Elevated Tank, is distributed to ten (10) sectors (A to J), as shown in Figures 6.2.6 and 6.2.7. Furthermore, water is supplied to District Metered Areas (DMAs), as described in Chapter 6.

Table 7.10.1 shows the approximate length of distribution pipelines for the Phase 2 Project, from the distribution reservoir/elevated tank to the sector inlet valve, from the sector valve to the DMAs, and within the DMAs in the Karnaphuli Service Area.

Water delivery to the slum areas in KSA will be arranged through discussions between CWASA and communities established by the people in each slum area (about 50 groups exist in CCC area). Depending on the request from communities, service connections or faucets will be installed for them, extending from the main pipes to be constructed in the Phase 2 Project.

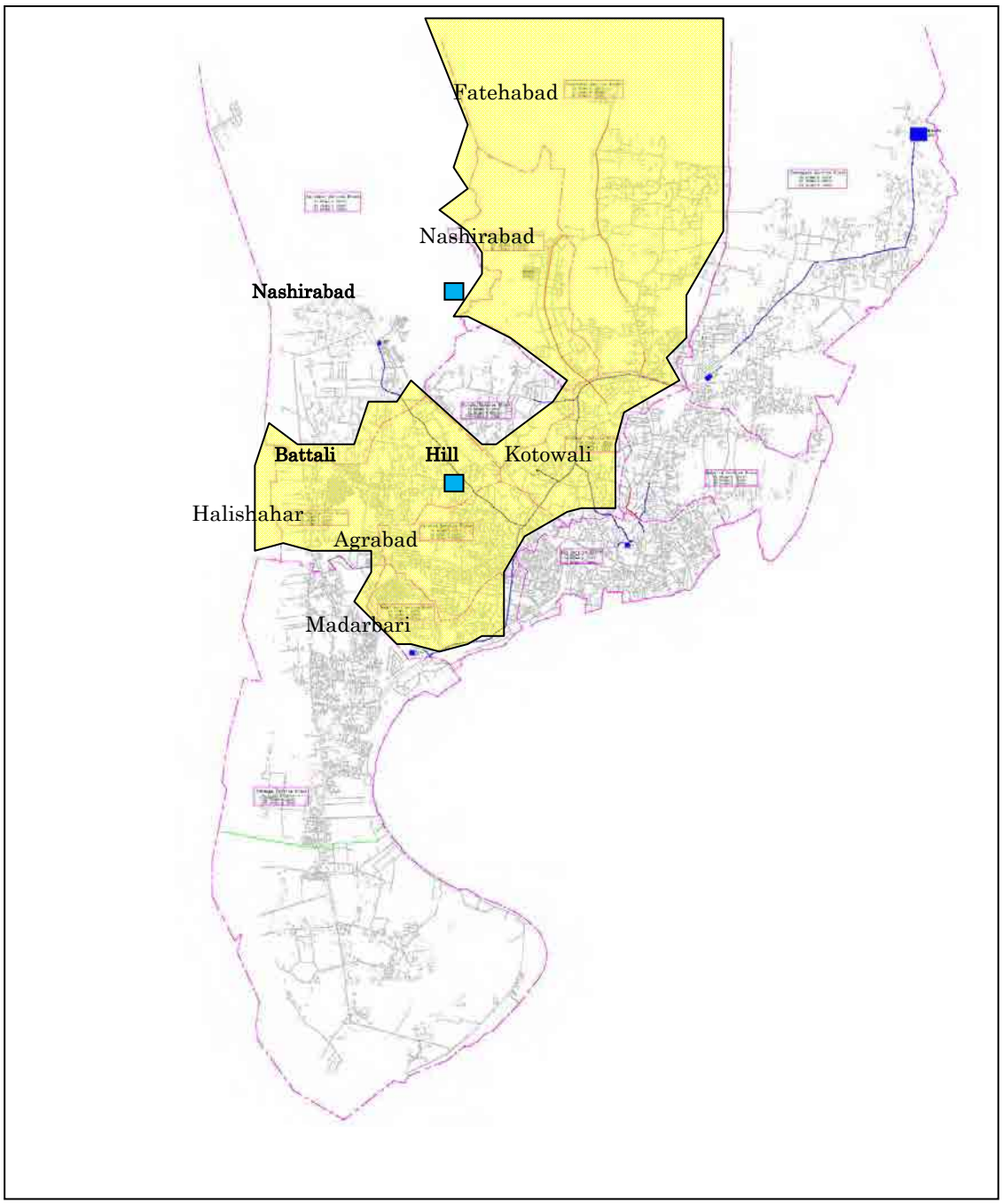


Figure 7.10.1 Water Supply Area in Phase 1

Table 7.10.1 Length of Distribution Pipeline in KSA

Unit: m

	Upstream to Sector Valve					Downstream of Sector Valve to DMA							DMA
Dia. (mm)	1000	900	800	700	600	800	700	600	500	400	300	200	150/100
Length	5,367	2	2,428	91	44	1,058	668	4,776	2,968	5,056	18,05	74,883	367,560
Breakdown													
A Sector	0	0	1,417	74	0	0	0	0	167	0	2,161	5,989	23,040
B Sector						0	161	867	816	385	918	4,065	25,920
C Sector						105	0	0	216	1,472	1,094	2,001	18,960
D Sector	1,185	2	86	0	44	0	0	0	833	167	2,662	5,866	42,240
E Sector						0	0	0	692	127	660	6,444	25,920
F Sector						0	0	559	0	0	3,007	5,468	26,400
G Sector						893	0	1,240	244	427	3,211	6,305	51,000
H Sector	4,182	0	925	17	0	60	0	1,581	0	1,162	1,798	5,168	30,840
I Sector						0	507	529	0	1,046	1,354	11,382	42,720
J Sector						0	0	0	0	270	1,189	22,194	80,520
Sub -total	7,932					107,464							367,560
Total	482,956 →483km												

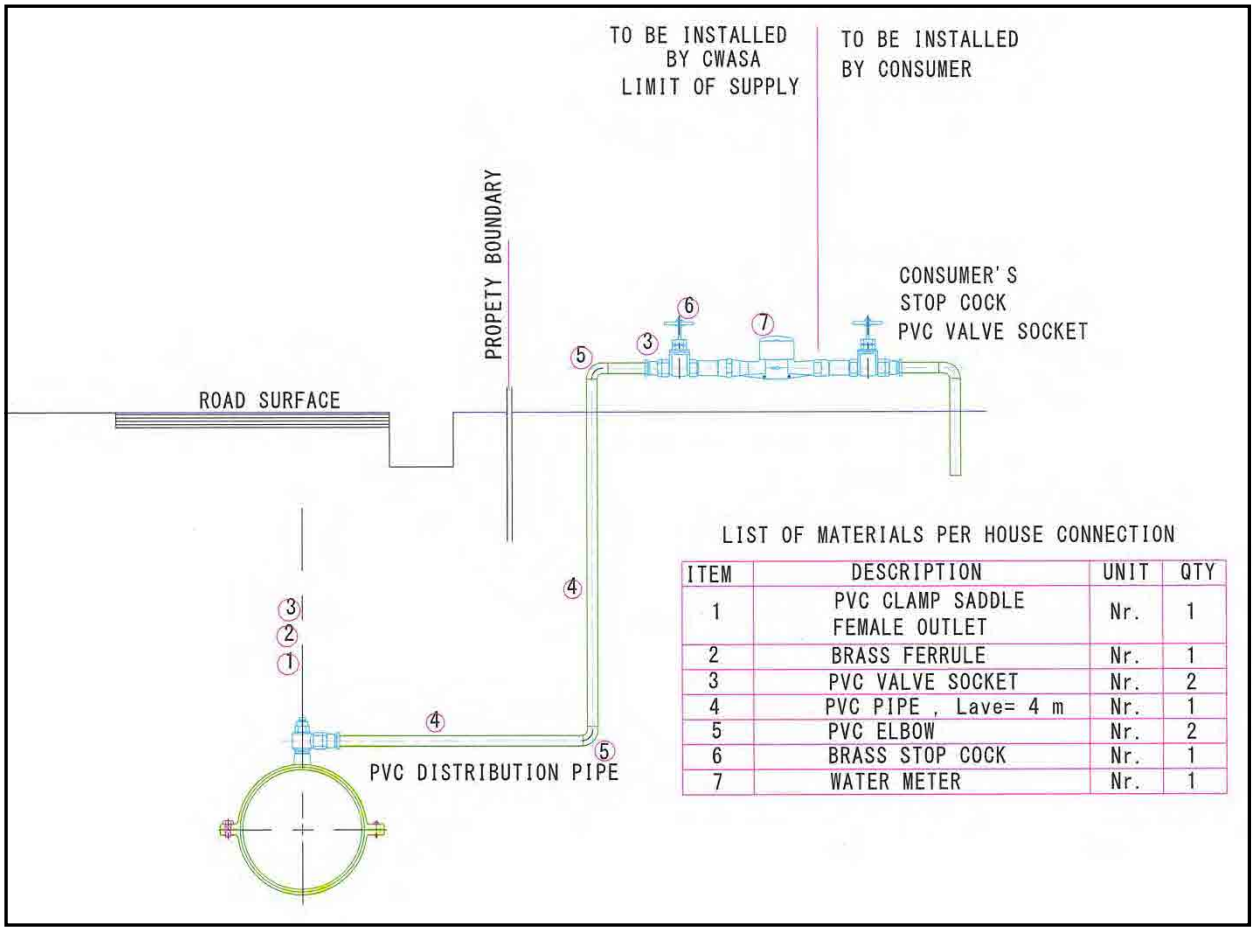
Note: Pipe length in DMA is calculated in assumption of 120m/ha,
The total amount may not be the same as the sum, due to the round off.

(3) Service Connections

In the present situation, service pipes are sometimes laid in U shape drainage channels, as shown in the following Photo, which may result in supplied water being polluted and also reduce the capacity of the drainage channels. Therefore, new distribution pipes in the DMAs should be laid in the road near to housing, businesses, etc. and the length of the service connection pipes should be minimized, as shown in Figure 7.10.2.

Location of Photo	Example of Present Service Connection Pipe
	

Photograph on Existing Service Connections, where is without distribution pipeline



ITEM	DESCRIPTION	UNIT	QTY
1	PVC CLAMP SADDLE FEMALE OUTLET	Nr.	1
2	BRASS FERRULE	Nr.	1
3	PVC VALVE SOCKET	Nr.	2
4	PVC PIPE , Lave= 4 m	Nr.	1
5	PVC ELBOW	Nr.	2
6	BRASS STOP COCK	Nr.	1
7	WATER METER	Nr.	1

Figure 7.10.2 Proposed Service Connection

7.11 Water Distribution Control System

(1) General

For the purpose of enhancing equitable distribution, the Karnaphuli Service Area is divided into at 10 numbers of hydraulically independent 'Sectors'. Each Sector will have only one inlet which is provided with a flow meter, a pressure gauge and a pressure regulating valve. Flow and pressure measurement data will be transmitted through the SCADA system to the Central Control Room, which is located at the Karnaphuli WTP for monitoring and recording purposes on a 24/7 basis. Pressure regulating valves will automatically adjust the pressure at the outlet to match a set point, which can be changed by operators in the Central Control Room. The set points for each Sector will be initially determined based on hydraulic analyses, but will be changed later by taking actual pressure conditions within each Sector into consideration.

For the effective control of non-revenue water, each Sector will be further divided into a number of small District Metered Areas (DMAs). On average, each DMA will be sized to accommodate approximately 2 to 3 kilometers of distribution pipes. DMAs will be so designed that whenever it is necessary they can be hydraulically isolated from the rest of the distribution network by closing 3 to 4 valves at known locations. In principle, each DMA will have only one inlet which is provided with proper arrangements for the measurement of minimum night flows.

(2) Control/monitoring of Sector

1) Monitoring and flow/pressure control

a) Control and monitoring of each distribution sector

A flow meter, pressure gages (primary and secondary) and a pressure regulating valve will be installed in each distribution sector and they will be monitored and controlled at the Karnaphuli WTP utilizing the SCADA System which was adopted in Phase 1 project.

b) Method of monitoring and control

Auto Monitor and Auto Control will be adopted.

Monitor: Flow and pressure data will be transmitted to the Control Room of the Karnaphuli WTP through dedicated fiber-optic cables.

Control: A pressure regulating valve is controlled automatically by PLC to keep certain pressure.

c) Distribution system

Treated water at Karnaphuli WTP is transmitted to Nashirabad Reservoir at first and then reserved at Nashirabad Reservoir, then transmitted to the service reservoirs by transmission pumps. Water in the service reservoir is distributed to each distribution sector by gravity. The number of sectors is ten and the pipe size ranges from 500mm to 800mm, so the valve chamber will be relatively large due to the requirement to install an electromagnetic flow meter and a pressure regulating valve. A valve chamber shall be newly constructed under the road.

Figure 7.11.1 shows the schematic flow for Monitoring and Control of the water supply system. Monitoring of entire water supply system will be made and required control will be provided from the intake to the distribution system. The Instrumentation Flow Diagram for the entire water supply system is shown in Figure 7.11.2.

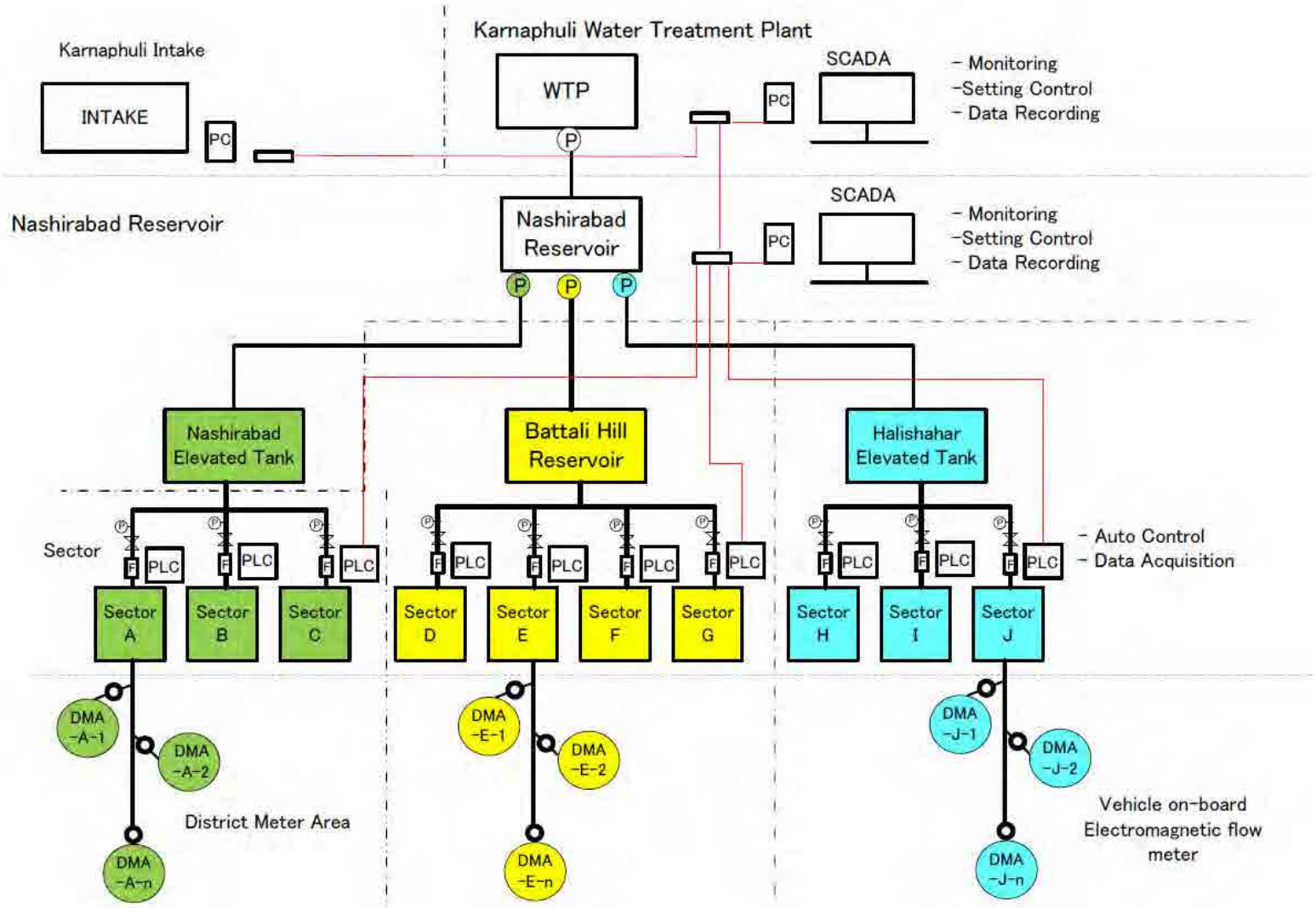


Figure 7.11.1 Schematic Flow of Water Supply and Distribution Control System

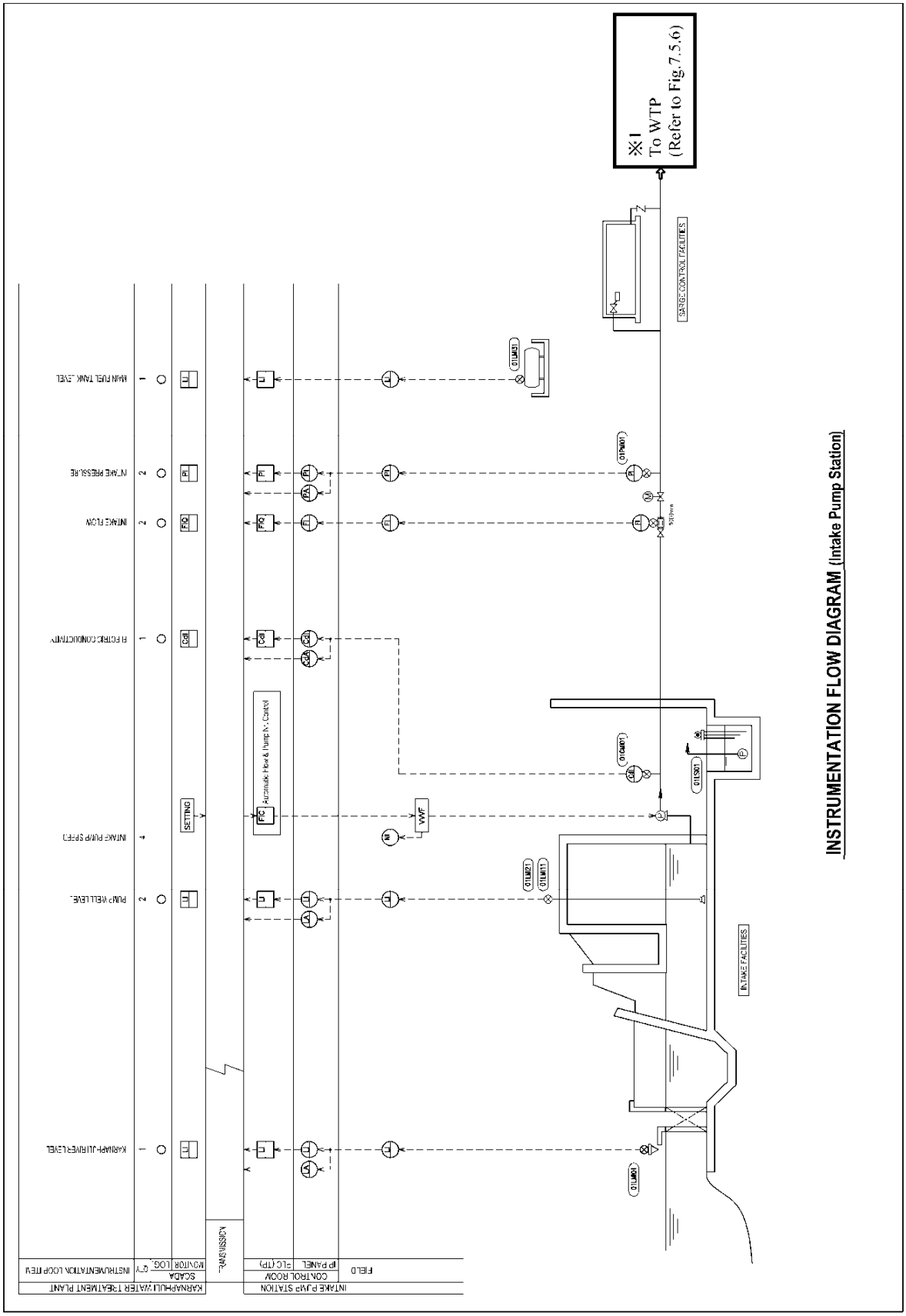


Figure 7.11.2 (1) Instrumentation Flow Diagram for Water Supply System

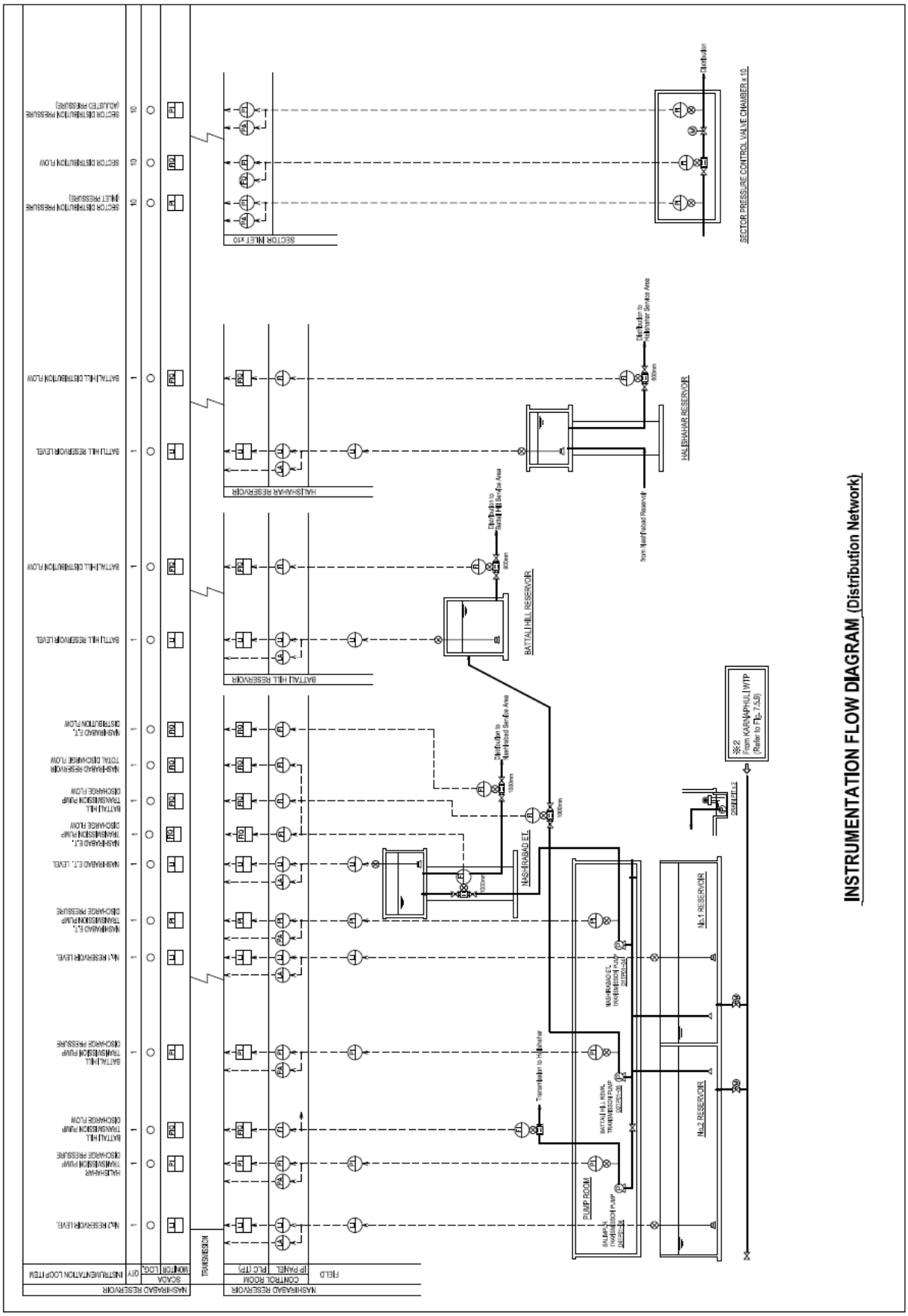


Figure 7.11.2 (2) Instrumentation Flow Diagram for Water Supply System

(3) Measurement point at the inlet of sector and the district metered area

The required size of a valve chamber at the inlet to a sector will be 2m x 6.2m x 2.5m depth and all chambers shall be located in/adjacent to a main road. In addition, an area of 1m x 2.5m for a control panel will be required on the ground near each valve chamber.

In Chittagong city, main roads in low lying areas are always inundated in heavy rain, which might cause problems for equipment such as the flow meter and pressure gauge inside the sector inlet chamber. In this connection, design of sector inlet chamber should be carefully prepared by considering the following:

- To prevent the rain water inflow to the chamber
  For example, Level of manhole slab shall be higher than ground level or to use the sealed manhole cover.
- To select waterproof equipment etc.
- To prepare the ventilation

Table 7.11.1 shows a summary of the Sector Inlet Chamber at each Sector regarding the possibility of inundation and necessity for special countermeasures such as the provision of water sealed manhole/water proof equipment, etc.

Table 7.11.1 Summary of Sector Inlet Chamber to each Sector

	Location	Pipe (mm)	G.L (m)	Possibility of inundation	Necessity for Special Countermeasures
Sector A	Baizid Bostami Road	DN700	+15.0	No	No
Sector B	CDA Avenue	DN800	+4.5	Yes	Yes
Sector C	Ditto	DN700	+4.5	Yes	Yes
Sector D	Battali Hill Reservoir Site	DN500	+45.0	No	No
Sector E	S.S Khaled RD	DN500	+17.0	No	No
Sector F	Tigerpass RD	DN600	+15.0	No	No
Sector G	Ditto	DN800	+13.0	No	No
Sector H	Agrabad	DN800	+7.0	Yes	Yes
Sector I	Halishahar RD	DN700	+3.0	Yes	Yes
Sector J	Halishahar Elevated Tank Site	DN700	+3.0	Yes	Yes (Manhole level of Chamber should be higher than G.L)

Figure 7.11.3 shows the location of a sector inlet chamber and DMA inlet chamber in one sector, as well as typical details of the chambers.

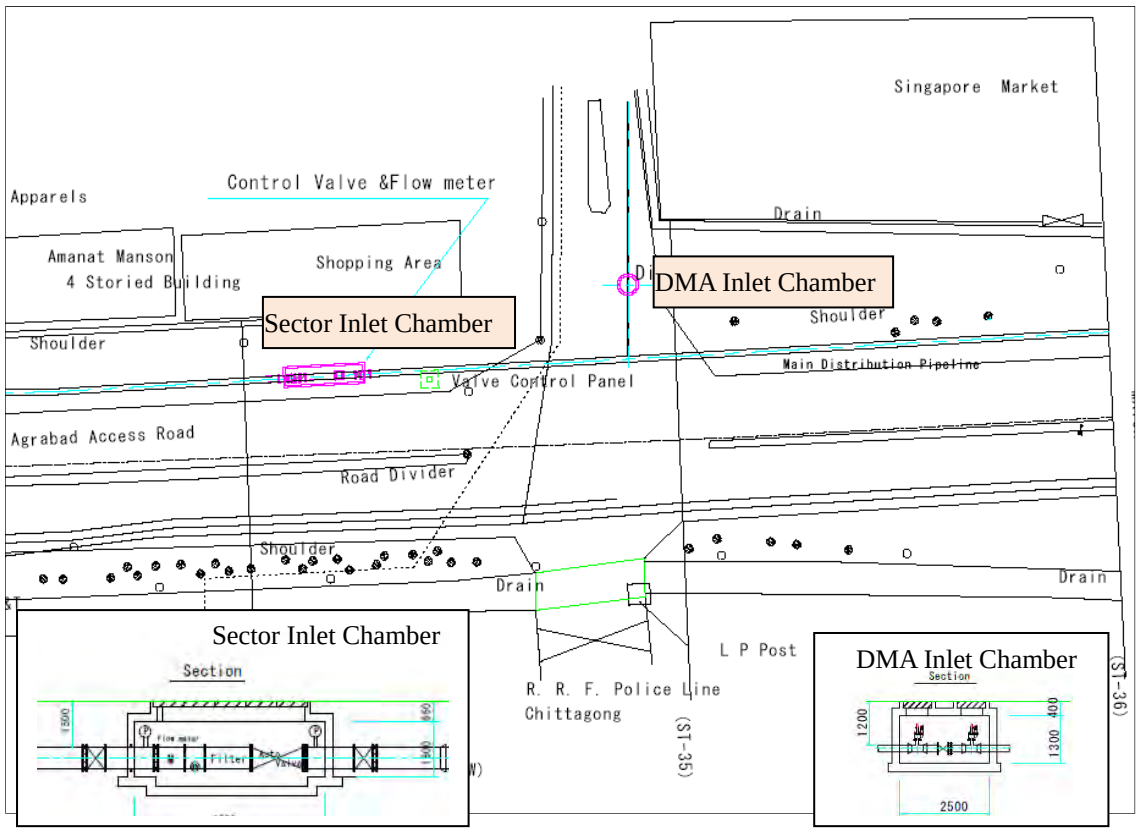


Figure 7.11.3 Location of the Manholes at Sector Inlet and the District Metered Area

To measure the flow to each DMA, measuring man-hole will be installed as shown in the above figure. The most suitable measurement method(s) will be determined when the distribution pipelines are designed. At the moment, the number of DMA is estimated at about 190 assuming that one DMA covers about 3-4km of distribution pipeline or about 16 ha. The flow meter shall be a vehicle on-board electromagnetic flow meter type considering high accuracy and easy measuring.

Figure 7.11.4 shows the location of Sector Inlet Chambers for Sectors A to Sector J.

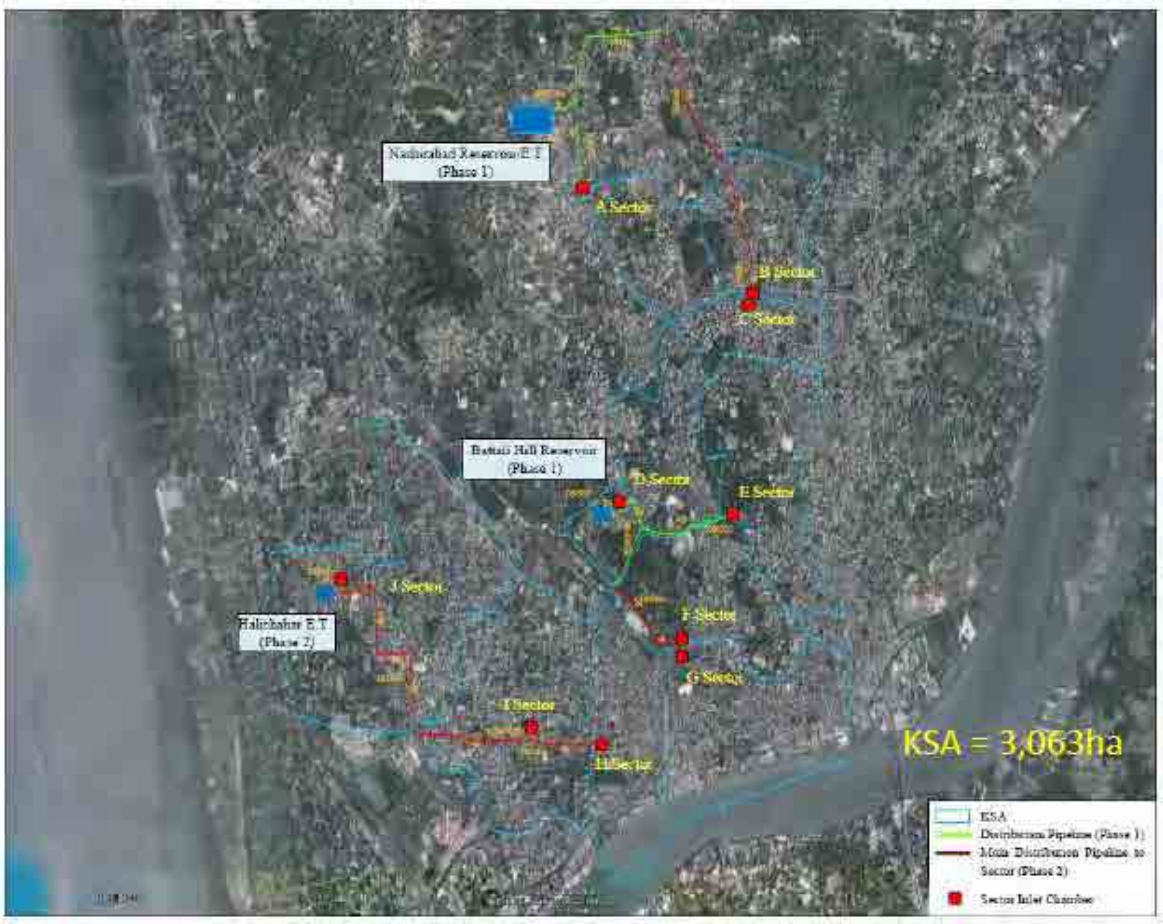


Figure 7.11.4 Location of Sector Inlet Chamber

CHAPTER 8

CONSTRUCTION PLAN OF WATER SUPPLY FACILITIES

CHAPTER 8 CONSTRUCTION PLAN OF WATER SUPPLY FACILITIES

8.1 General

The construction plan for the Phase 2 Project is planned considering environmental and social impacts and security problems during the construction work. Major problems are construction boundary, access road, stock yard, safety/security countermeasures. The required arrangements for construction methods are also included for important items of work. However, those items common to the Phase 1 Project are basically omitted.

The following sub-sections present the plan for the construction of the major water supply facilities.

8.2 Intake/Conveyance Facilities

8.2.1 Intake Facility

The access road which is connected from the existing road to the construction site shall be maintained for CWASA staff and the contractor for the Phase 2 Project, as shown in Figure 8.2.1.

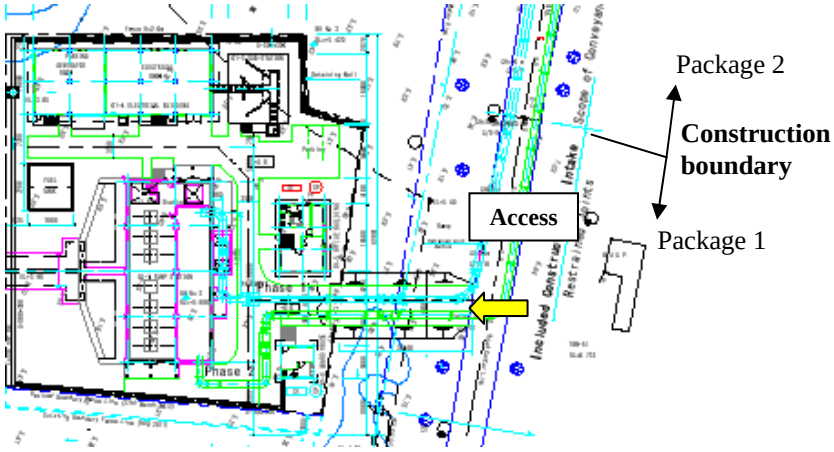


Figure 8.2.1 Access Road to Intake Site from Existing road

(Refer to Package in Chapter 11)

Civil and Architectural facilities with a capacity of 300,000m^3/d are constructed in Phase 1; therefore, only two units of intake pumps with a total capacity of 150,000m^3/d and related electrical equipment will be installed in this phase. The construction boundary of the yard piping as well as the conveyance pipe will be clearly demarcated, as shown in Figure 8.2.1.

Connections to the Phase 1 facilities (for example electrical works) shall be carried out such that the facilities operate continuously (except for short term interruptions to the power supply). In case that the power supply has to be interrupted, the standby generator provided under Phase 1 shall be utilized. It is considered that interruptions would be approximately 1 hour duration and that the works could be undertaken with one interruption to the supply.

8.2.2 Conveyance Pipeline

The conveyance pipeline from the Intake to the WTP (DN1200mm and 3.6km in length) will be installed in the Kaptai Road using open-cut method of construction. The pipeline will be laid in the opposite side of the road to the Phase 1 pipeline with appropriate traffic control during pipe laying. Sheet piles are recommended to support the trench and minimise the working width. Figure 8.2.2 shows the manner of traffic control where the opposite half side of the road to that for the construction works is used for two-way traffic, carefully observing the traffic conditions.

Figure 8.2.2 Traffic Control on Kaptai Road

8.2.3 Surge Tank 1

Surge Tank 1 will be constructed next to the Phase 1 Surge Tank within the land obtained in Phase 1. The facility level of the surge tank for Phase 2 shall be reviewed in the detailed design stage in order to reduce the construction cost for excavation and provision of retaining walls, as shown in Figure 8.2.3.

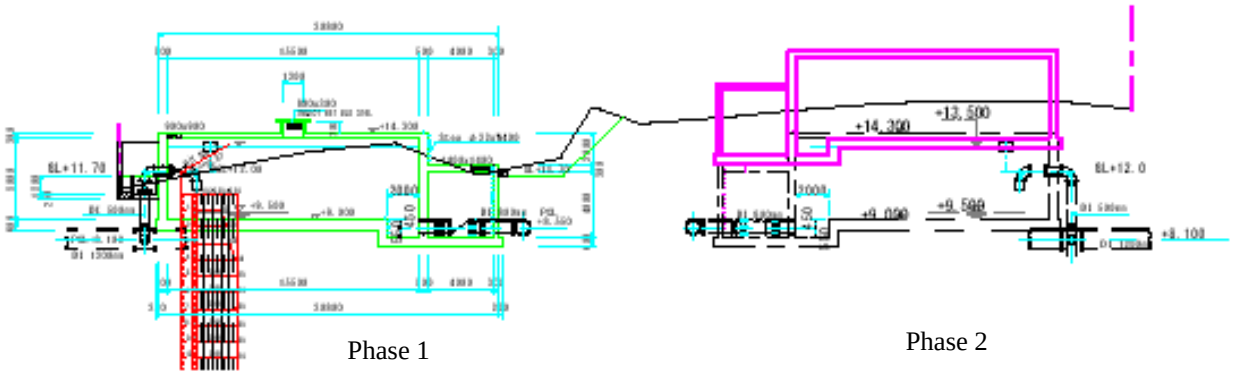


Figure 8.2.3 Surge Tank

8.3 Water Treatment Facilities

8.3.1 General

The access road from the existing road and the construction yard for the construction of the Phase 2 WTP are assured in Phase 1, as shown in figure 8.3.1. This access road shall be maintained for CWASA staff and the contractor. Due to limited open space in the WTP Site, especially taking into account of the need of the area for sludge treatment facilities for Phase 1 during construction of Phase 2 WTP, the Construction Yard shall include the area allocated for CWASA staff quarters, as shown in Figure 8.3.1. The Contractor shall also be allowed to use the site where the Phase 2 WTP is to be constructed including for offices and storage of materials subject to access being provided to CWASA staff for operation and maintenance of the sludge lagoons and other facilities.

The construction boundary of Conveyance/Transmission pipelines as well as yard pipes shall be clearly demarcated before construction.

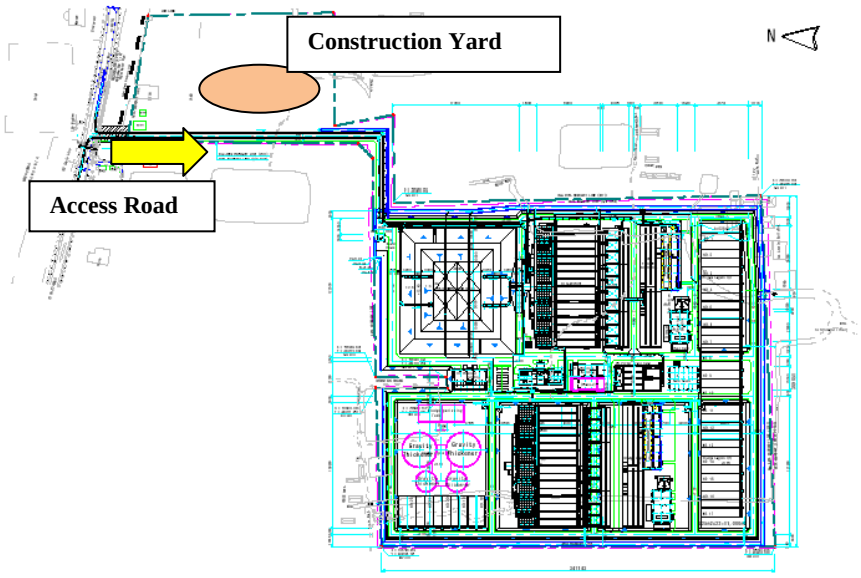


Figure 8.3.1 Access Road to WTP Site

The construction of water and sludge treatment facilities shall be made under the following conditions.

1) The Phase 2 facilities have to be constructed on the location of the sludge lagoons constructed in Phase 1 without interrupting sludge treatment.
2) The sludge treatment process will be changed from sludge lagoons to gravity thickeners and drying beds.

Excavated soil at the WTP construction site should be kept properly on site to prevent pollution of the Karnaphuli River. Provision of temporary sedimentation basins is one of the countermeasures to be used, as also discussed in 8.3.3. The EMP refers to the need for protection of inland waters.

Connections to the Phase 1 facilities (for example pre-sedimentation basin, sludge treatment, electrical works), shall be carried out such that the Phase 1 WTP operates continuously (except for short term interruptions to the power supply) and without adversely affecting the treated water quality. In the case when the power supply has to be interrupted the standby generator which is provided under Phase 1 shall be utilized, such that interruptions are short. It is considered that interruptions would be approximately 1 hour duration and that the works could be undertaken with one interruption to the supply.

8.3.2 Construction of Phase 2 Facilities considering Treatment of Phase 1 sludge

Due to the restriction of land area for WTP, Phase 2 facilities are planned on the site of sludge lagoon to be constructed in Phase 1 project. To secure treatment capacity for Phase 1 sludge, a staged construction plan of the Phase 2 facilities has to be considered.

Phase 2 water treatment facilities with capacity of 150,000m^3/d and sludge treatment facilities with capacity of 300,000m^3/d, that is total capacity of Phase 1 and Phase 2, are constructed as follows:

Construction of phase 2 facilities is planned in three stages as follows:

(1) First Stage

4 Sludge Thickener tanks and 5 units of Sludge Drying Bed will be constructed in the open space next to pre-sedimentation basin. This open space can be assured to be available at the commencement of the

contract period by not constructing one stand-by sludge lagoon (called as B lagoon in Phase 1), which is originally designed in this location. After the first stage, sludge from Phase 1 will be treated by the above facilities and one lagoon (called as A lagoon in Phase 1). Other lagoons will be abandoned in order to provide space for the construction area for next stage of the work.

(2) Second Stage

All of Phase 2 water treatment facilities and 9 units of Sludge drying bed are constructed in the area as shown in Figure 8.3.2. After the completion of this stage, sludge is treated by 4 sludge thickeners and 14 units of Sludge drying bed.

(3) Third Stage

8 units of Sludge Drying Bed will be constructed in this stage. With completion of this stage, the capacity of the WTP is the proposed capacity of 300,000m^3/d, corresponding to the total capacity of Phase 1 and Phase 2. Sludge is treated by thickeners and sludge drying beds.

The construction plan of the Phase 2 facilities in each stage is summarized in Figure 8.3.2.

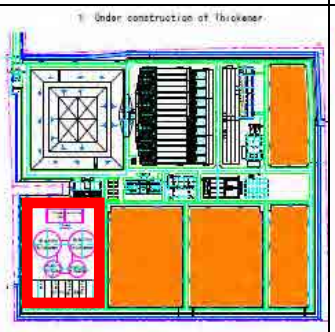
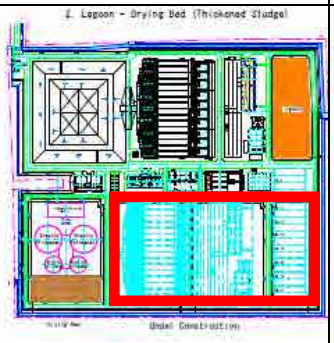
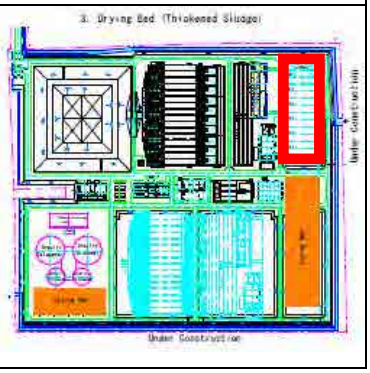
Stage	First Stage	Second Stage	Third Stage
Facility to be constructed	4 Sludge Thickener tanks 5 unit of Sludge Drying Bed	Water Treatment Facilities 9 unit of Sludge Drying Bed	8 unit of Sludge Drying Bed
Alignment of facilities **Construction area**			

Figure 8.3.2 Staged Construction of Phase 2 Facilities

Water treatment facilities and sludge thickeners will be constructed with foundation piles, the same as for the Phase 1 facilities. The sludge drying bed walls be constructed above the lagoon bottom, without breaking the bottom bricks of the Phase 1 lagoons. Low-noise and low-vibration piling machines shall be used to minimize complaints from residents living in the vicinity of the WTP site. Dirty water which is generated from excavation, piling and other works shall be properly treated so as not to pollute public water bodies, including the stream adjacent to the site and the Karnaphuli River.

Supernatant from the lagoons and leachate from the sludge drying beds shall be carefully discharged to the above stream (as is planned in Phase 1), such that discharge from the site meets the prevailing standard, including that for Suspended Solids of 150mg/L.

8.3.3 Countermeasures to Protect Soil Runoff from Construction Site during Heavy Rain

During the construction period, surface soil at the construction site may be washed away by heavy rain, causing pollution of the Karnaphuli River. To prevent soil runoff during heavy rain, a sedimentation tank/pit shall be constructed at the lowest corner of construction site. It is desirable to install floating

curtain in the tank in order to quicken deposition of soil and also to reduce soil run off to the river.

8.4 Transmission Facilities

8.4.1 Transmission Pipeline

(1) From WTP to Nashirabad Reservoir

The transmission pipeline with DN1200mm and 24.4km in length will be installed in the Kaptai road in the opposite side of the Phase 1 pipeline. The profile of the Phase 2 pipeline is almost the same as that of Phase 1. In case open cut method is inapplicable at obstacles such as crossing drainage/waterway, special crossing method shall be adopted as shown in Figure 8.4.1.

(2) From Nashirabad reservoir to Halishahar Elevated Tank

The transmission pipeline with DN1100mm and 10km in length will be installed from Nashirabad Reservoir to Halishahar Elevated Tank. Traffic control including detour plan and resident's cooperation are required due to existing narrow roads. A new optical fiber cable is also planned along this pipeline route.

8.4.2 Halda River Crossing

Pipe supporting platforms have been already prepared both for Phase 1 and 2 as described in Chapter 7.

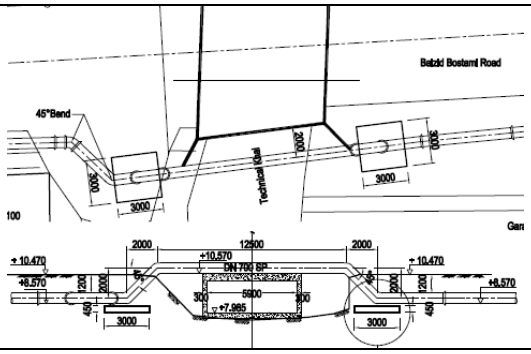
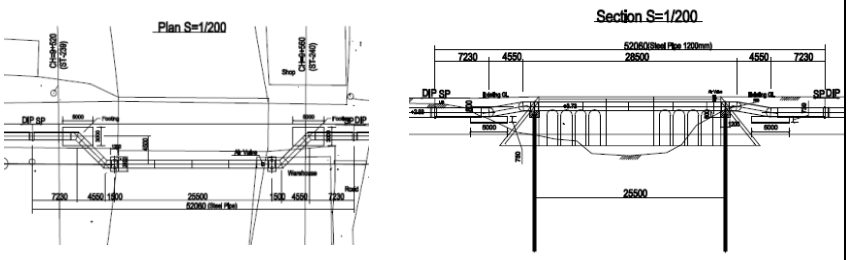
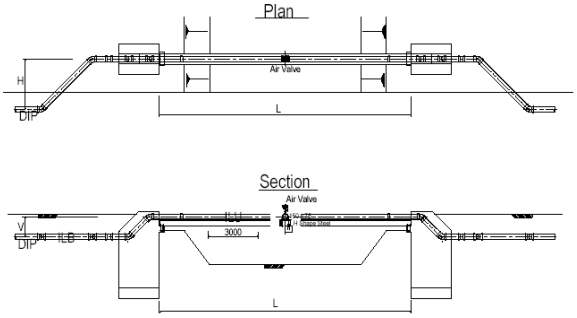
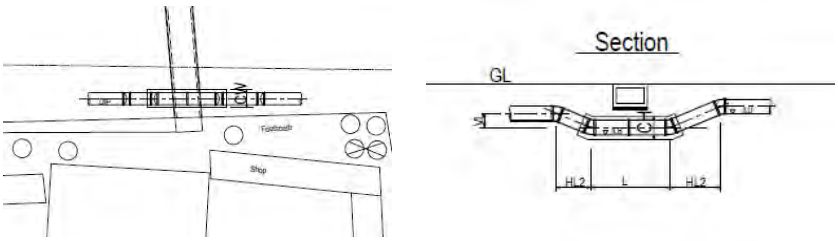
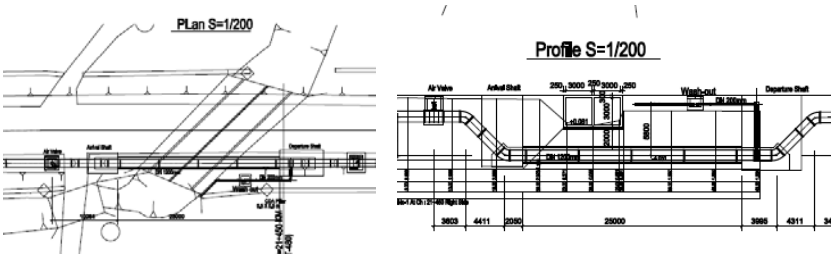
Over Passing	Without pile	
	With pile	
	With H shape Steel	
Under Passing	Open Cut Method	
	Pipe Jacking Method	

Figure 8.4.1 Special Crossing Method to the Obstacles

8.5 Distribution Facilities

8.5.1 Reservoir/ Elevated Tank

(1) Nashirabad Reservoir

The construction boundary between yard piping and the transmission pipeline is clearly demarcated. Expansion of the Nashirabad reservoir with a capacity of 24,800m^3 in Phase 2 project augments the capacity up to 51,100 m^3. Pile foundations will be required for the reservoir due to it being located in the filling area next to the Phase 1 Reservoir (refer to Supporting Report 8.5.1 Results of Boring Test). In this regard, low-noise and low-vibration type of piling machine will be required to minimize complaints from residents living in the vicinity of the site. The access road to this construction site is ensured in Phase 1, as shown in Figure 8.5.1.

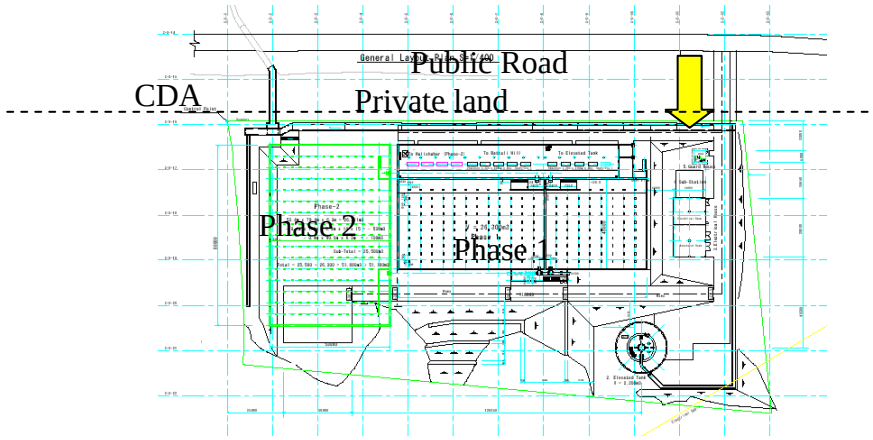


Figure 8.5.1 Access Road to Nashirabad Reservoir

(2) Battali Hill Reservoir

This reservoir with a capacity of 8,500m^3 is constructed in Phase 1. A Sector Inlet Chamber for Sector D will be constructed at the outlet of distribution main pipe to be constructed in Phase 1 in the Battali Hill Reservoir site (refer to Figure 8.5.2). The pipe will be used for the distribution of water after Phase 1 of the Project is complete. Therefore, the inlet chamber must be constructed in the nighttime in order to ensure a continuous water supply to residents in the daytime.

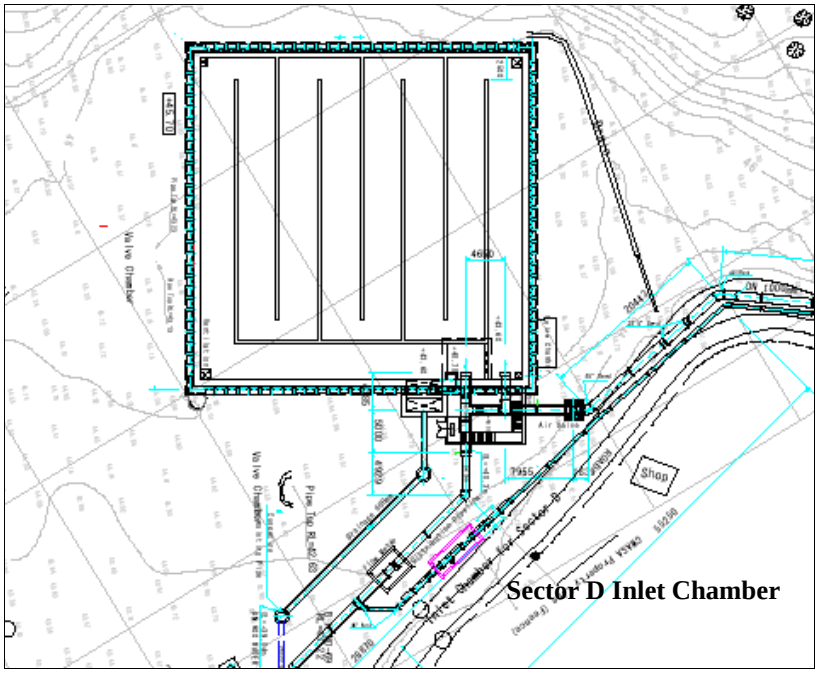


Figure 8.5.2 Location of Sector D Inlet Chamber

(3) Halishahar Elevated Tank

The access road to this elevated tank with a capacity of 2,400m^3 is ensured, as shown in Figure 8.5.3. Pile foundations to the tank will be required based on the soil investigations. (Boring test results are included in Supporting Report 8.5.1). Countermeasures to prevent public nuisance, with regard to noise and vibration, shall be taken as for other sites during the construction period. As the elevated tank is high at about 30m above ground level, a safe temporary work plan such as that used for the construction of Nashirabad Elevated Tank shall be prepared.

Figure 8.5.3 Access Road to Halishahar Elevated Tank

8.5.2 Distribution Pipeline

(1) Stock yard for pipe materials

Nearly 9,000m^2 of stock yard for pipe materials are assured in the CWASA property near Bayazid Bostami Road, as shown in Figure 8.5.4.

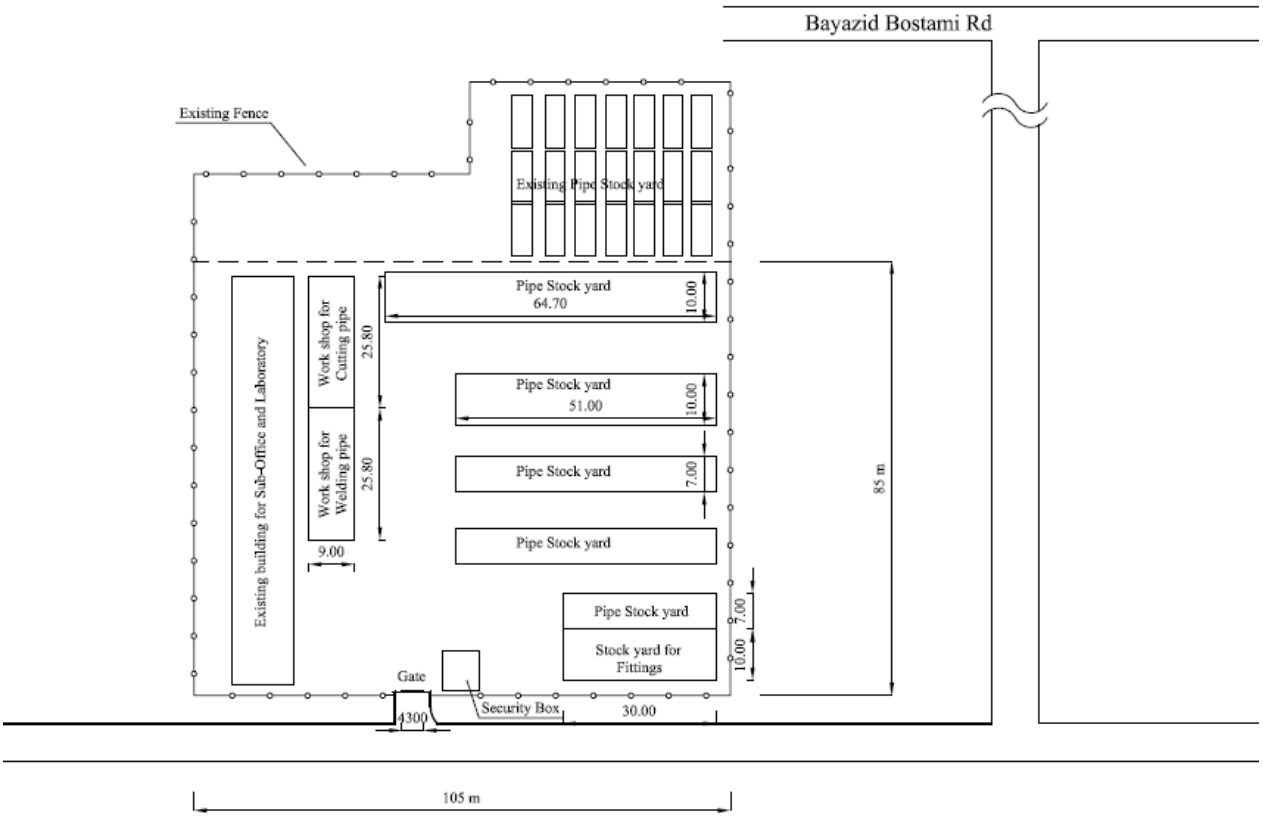


Figure 8.5.4 Stock Yard for Pipe Materials

(2) Removal and disposal of Asbestos Cement pipe (AC pipe)

During construction, the contractor may encounter AC pipes, for which removal and disposal shall be properly and safely carried out. There is a high probability of breaking buried AC pipe during construction, as detailed information on the location of existing AC pipes is not available. If construction machine break AC pipes, broken pieces shall be treated carefully so that direct contact with the pipes does not occur and exposure to airborne asbestos fibers is in accordance with the prevailing standards and legislation with regard to Permissible Exposure Levels. Broken pieces of pipe shall be packed safely and collected to storage areas, prior to final disposal from the site. Workers shall be equipped with eye-protection glasses, masks and rubber/leather gloves. In case broken pipe is an operational pipe, repair/replacement of the pipe is the responsibility of the contractor. An operations manual for removal, replacement and disposal shall be prepared prior to construction.

Regarding the right of way of the road, in the city where distribution networks will be installed, this is under the control of CCC, which is not the case for Kaptai Road. CWASA will be responsible for obtaining approval from CCC for the construction of distribution pipes after completion of D/D of the facilities.

(3) Primary distribution pipeline from distribution reservoir to Sector Inlet Chamber

Primary distribution pipelines are from distribution reservoirs to Sector Inlet Chambers and the total length of these pipelines is 7.9km. The secondary distribution pipeline, which is connected at the inlet chamber, is the main pipeline in the respective sectors.

An optical fiber cable is planned along primary distribution pipeline route to monitor and control each sector.

Traffic control or traffic diversions shall be considered during the construction period. Generation of noise, vibration by excavation machine should be minimized by appropriate countermeasures, and also subsidence or collapse of land should be prevented during installation works.

(4) Secondary Pipe from Sector Inlet Chamber to DMA Inlet Chamber

Secondary distribution pipeline is from the Sector Inlet Chamber to DMA Inlet Chambers. The same countermeasures as for primary distribution pipelines shall be taken for safety of construction and mitigation of environmental impacts such as noise and vibration. Service connections are not connected to this pipeline in principle.

(5) Tertiary Distribution Pipeline

The construction method for pipe laying with the diameter less than 400mm may be determined in consideration of alternatives; open-cut or trench less methods, during detailed design stage.

Customers shall be informed in advance of the timing and duration of the works, such that they can make arrangements to store water and informed of progress and delays to the works (if any, for example due to unforeseen conditions). Works shall be coordinated with replacement of meters, if the existing meter is used.

In the case where existing AC pipes are to be abandoned, the detailed design shall consider alternative methods for abandoning the pipes (e.g. leaving the pipes in the ground, removal and safe disposal, etc). The preferred solution is to leave existing AC pipes in the ground.

The Bidding Documents shall include (i) clear responsibilities for locating existing pipes, which are to be abandoned, (ii) safe working procedures for demolition/disposal of AC pipes, and (iii) provisions for unforeseen conditions, such that delays (including disruptions to the water supply) and additional costs are minimized.

These tertiary pipes are to be installed in narrow roads, where excavation machine such as backhoes may not access the construction site. In such cases, manual excavation should be adopted. The traffic control plan including diversions during the construction work should be carefully prepared.

8.5.3 Service Connection with Water Meter

For the construction of service connections, the following work shall be undertaken by different parties.

a) Procurement of equipment

   The contractor to be selected for the construction of distribution pipelines will procure required equipment for the service connection before installation of distribution pipelines.

b) Collection of information on customers including mapping on the location of water meter to be installed

   CWASA staff trained by PANI will undertake the required work in the field as early as possible after loan agreement.

c) Preparation of installation plan for service connections

   The contractor to be selected for the construction of distribution pipelines will prepare plan using

information collected by CWASA staff.

d) Construction of distribution pipeline up to water meter for each service connection

The contractor install tertiary main pipe/lateral pipe and conduct leakage test. After confirmation of no leakage in the pipe, service connections will be installed from the pipe to each water meter near the boundary of public and private land.

e) Connection work from CWASA pipeline to each customer connection pipe in the premises of each house/building

The customers will make contract with private company for the connection of pipes between newly constructed CWASA pipe and existing private pipe.

All customers should be informed sufficiently in advance of the timing of works to change the connection pipe, such that they can make arrangements for the storage of water and for the works required to be undertaken by the customer. Works should be carried out timely such that disturbance to customers is minimized (for example by carrying out works when commercial establishments are closed) and the duration of the cut off in supply is also minimized.

About 52,000 connections are planned in the Phase 2 project. After water pressure test of tertiary distribution main pipe, service connections (from saddle installed at tertiary main pipe up to water meter box) will be installed as the last work in the series of pipe laying process before backfilling. “Spaghetti Connections” shall be strictly prohibited.

When new connections are installed, some problems may occur. Joint planning and work among concerned parties, including CWASA staff is indispensable. Before the installation of service connections, CWASA staff shall prepare a map showing the exact location of the water meter for each consumer. The contractor (for package 3: construction of distribution pipelines) will install the service connection up to the construction boundary, as shown in Supporting Report 8.5.2 (i.e. up to a short distance inside the private land from the boundary between public and private land).

The project cost includes installation cost of service connections; however, connection fee to be collected from customers later will be utilized for the maintenance of service connections by CWASA.

Water meter management center is planned to be accommodated in the building which is planned to be completed in 2013 financed by GOB.

CHAPTER 9

OPERATION AND MAINTENANCE OF WATER SUPPLY FACILITIES

CHAPTER 9 OPERATION AND MAINTENANCE OF WATER SUPPLY FACILITIES

9.1 General

The Operation and Maintenance (O&M) of water supply facilities after completion of the Phase 2 Project is discussed in this Chapter considering the planned sectorization of the distribution system with the provision of DMAs.

The planned requirements for O&M of the Phase 1 facilities are firstly studied, such that they are utilized fully in this study, following which the additional requirements to meet the Phase 2 requirements are proposed. There are six additional major items, as enumerated below, which have to be considered in planning of operation and maintenance.

(1) Monitoring and control of overall water supply system in use of SCADA System

SCADA system is included in the Phase 1 Project, but limited to the major facilities: intake facility, WTP and Nashirabad Reservoir. In the Phase 2 project, the SCADA system will be expanded up to the entrance to each Sector in the distribution system.

(2) Sludge Treatment at WTP both for Phase 1 and 2

Sludge generated in the water treatment process from both Phases 1 and 2 will be treated at the WTP site. The arrangement for the sludge treatment in the transition period during the construction of the Phase 2 WTP after completion of Phase 1 WTP shall be established such that the construction work for Phase 2, as well operation of the Phase 1 facilities can be managed within the limited land area.

(3) Manner of operation of transmission pump facilities at Nashirabad Reservoir to service reservoir/elevated tanks (total 3 in number)

The water which is stored at Nashirabad Reservoir is transmitted to the reservoir/elevated tanks for pressure adjustment. Transmission of water shall be carried out to meet the water demand from years 2020 to 2030 by using an appropriate number of the duty pumps which are planned to meet the demand in the year 2030 and such that energy consumption and cost are minimized.

(4) O&M of communal faucet systems planned to be constructed along the transmission pipeline in the Phase 2 Project

Several faucet systems are planned along the transmission pipeline in Phase 2, in order to mitigate complaints from the residents, who live outside the KSA and CWASA service area. Periodic technical supervision by CWASA entailing communications with the users is a requisite to maintain the facilities properly.

(5) Leakage monitoring and control in each DMA

DMAs are planned in each Sector in the distribution system. Survey teams will conduct surveys in the night time to detect leakage, with leak investigation/repair teams using information from the surveys to develop and implement countermeasures accordingly.

(6) Calibration, repair and replacement of water meter

One of the major causes of NRW is inadequate water meters. CWASA shall maintain all water meters in a satisfactory condition providing various kinds of countermeasures.

The above mentioned points are discussed in detail in the following sub-sections.

9.2 O&M Plan prepared in Phase 1

The O&M plan, which was prepared in the SAPROF for Karnaphuli Water Supply Project in 2005, focused on O&M of Karnaphuli WTP, as well as leak detection and the reduction of errors included in NRW in the existing distribution network.

In the plan the organizational arrangement is discussed and the number of staff required for O&M work for water supply facilities including the intake, WTP and distribution reservoirs is recommended to be 81 persons in total. In the O&M work for the WTP, setting up an operation plan for the WTP to meet the annual increase in water demand, adjustment of chemical dosing rate using jar-tests and scheduled replacement of filter media are emphasized. Table 9.2.1 presents routine maintenance work including inspection and examination items, repair and maintenance, and data recording, as proposed in the SAPROF.

Regarding leak detection and error reduction, the following actions are recommended referring to the previous studies and field observations. In the Phase 1 project, treated water was planned to be distributed to the existing network. Under such an arrangement, error reduction related to NRW was a major concern. In this regard, the following are recommended by the ongoing PANI, which commenced after completion of the SAPROF study.

- Set up Task Force for leak detection
- Introduction of special contractor license issued by CWASA for minor water works, especially for service connections and repair works
- Introduction of aggressive index (AI) to compare the performance of pipes
- Supervisory service for leak detection by hired engineers

With reference to the above mentioned requirements, two teams have been established in CWASA as follows:

- NRW Reduction Management Team, which is responsible for the preparation of a NRW Reduction plan.
- NRW Reduction Action Team which is dedicated to NRW Reduction field management and operation.

The above mentioned teams have been trained by PANI team and actions by themselves are planned to start from year 2012.

Table 9.2.1 List of Routine Maintenance Works at WTP

Frequency	Inspection and examination Items	Repair and maintenance	Data Recording
1) Daily Inspection (3 times a day)	・ Water Pressure ・ Water Quality ・ Noise ・ Heat ・ Smell ・ Vibration ・ Lamp test on electrical-monitoring panel ・ Leakage ・ Others	・ Cleaning ・ Check of oil and grease ・ Drain ・ Others	・ Quantity of Intake/Supply ・ Pressure gauge and water level ・ Quality of raw water and treated water ・ Amount of chemicals added and stock volume ・ Status of noise ・ Heat ・ Temperature ・ Smell ・ Vibration of equipment ・ Particular comments on failure ・ Attendance and performance of staff members ・ Others
2) Periodical Inspection (Once a week, a month, 3 months and 6 month)	・ Electrical lamp ・ Mixer ・ Pump ・ Leakage ・ Others	・ Check and repair of pressure gauge ・ Level meter ・ Sensor of water quality monitoring devices ・ Confirmation of performance of all devices ・ Refilling of oil and gauge ・ Screw up loose bolts and nuts ・ Repair of leakage ・ Clean-up of premises ・ Others	・ Quantity of Intake/Supply ・ Water quality ・ Water Level ・ Weekly average water production/transmission ・ Consumed Chemicals and power ・ Staff attendance and performance evaluation ・ Expense ・ Production Cost ・ Preparation of weekly/monthly report ・ Others
3) Medium Term Inspection (Once a year)	・ Performance test of equipment ・ Condition of Paint work ・ Condition of sludge accumulation ・ Calibration of all measurement equipment ・ Others	・ Drain work ・ Sludge removal ・ Touch up painting ・ Calibration of instruments ・ others	・ Preparation of annual report
4) Long Term Inspection (Over 3 years or longer interval)	・ Overhaul check Integrated functional diagnosis of the plant	・ Overhaul Repair ・ Others	
5) Emergency Inspection (as needed)	・ Investigation on major defects and accidents ・ Others	・ Repair of major defects and accidents ・ Others	

9.3 Monitoring and Control of Overall Water Supply System in Use of SCADA System

As mentioned in Section 7, data and information on water flow, water pressure, water level and operational conditions at the major water supply facilities are collected through the SCADA system in the control center at the WTP. Based on the analysis on the data collected, system operators will manage the system on a 24 /7 basis, such that for example pressure is maintained in the system at pre-set levels. The SCADA system will also provide details of the operation status of machinery/equipment, including showing abnormal values and failure signals, in order to facilitate rapid checks and repairs. Data on the water production/Supply amount during a certain period can be compared with the billed volume to assess NRW, which is one of the performance indicators of the water supply system. Sector meter data in the distribution system will be used both for (1) the equitable distribution of water to all sectors and (2) NRW control. Further details on these matters are discussed below.

(1) Equitable distribution of water to each sector concerned is essential and inequitable conditions among sectors have to be adjusted immediately. Irregularities in the trend of distribution to the sectors can be attributed to leakage, illegal connections or a large amount of water consumption by some specific individuals/enterprises. Through the study by leakage monitoring team of CWASA on billed water volume and DMA survey, the reasons for irregularities in the trend of distribution shall be identified and appropriate countermeasure shall be taken.
(2) Records of flow data from the meters to each sector are also useful for leakage control. The NRW percentage in each sector can be easily calculated by comparing the inflow water volume with the billed water volume. Priority sector/s for leakage detection will be determined based on this study followed by DMA survey by the team of CWASA.

9.4 Intake/Conveyance Facilities

(1) Intake Facilities

The operation of the intake pumps is adjusted to meet the planned treatment volume of the WTP in accordance with annual increase in water demand. Removal of screened debris and sedimentation from the inlet point and O&M of mechanical/electrical equipment are the major work, which is required to be undertaken. Sampling and analysis of raw water is also an important daily task.

(2) Conveyance Facilities

A surge tank is installed on the line of the conveyance pipeline as a protection facility for the pumps and pipeline from water hammer in case of abrupt interruptions of the power supply. The water level in the tank shall be maintained, such that it can operate as designed at any time.

9.5 Water Treatment Plant

The Phase 1 and 2 Water Treatment Plants are arranged to be accommodated in the land area, which was acquired during Phase 1. Under such an arrangement, the sludge treatment method for both phases is modified from that planned for Phase 1 only. In Phase 1, “Sedimentation Basin-Lagoon- Disposal process” was planned, however, the process of “Sedimentation basin- Gravity type Sludge Thickener- Sludge Drying Bed-Disposal” is selected in this survey, as presented in section 7. The water treatment process in the Phase 2 Project is same as that of Phase 1 Project, with the Phase 1 pre-sedimentation basin being used for both phases. Therefore, this sub-section focuses on the O&M work for the sludge treatment processes.

The pre-sedimentation basin will normally be used during the rainy season, from May to October, when the turbidity of the river water becomes high (more than 100 NTU).

The sludge lagoons, which will be temporarily used for the Phase 1 WTP shall be converted to sludge drying beds (together with sludge thickeners) during the Phase 2 construction stage. Appropriate countermeasures shall be developed for the smooth change from the sludge lagoon process to the sludge drying bed process without disturbing treatment of sludge from the Phase 1 WTP.

9.5.1 O&M of Sludge Treatment Facility After Completion of Phase 2 WTP

(1) Sludge Thickener

For the sludge treatment, four units of sludge thickener (two pairs of sludge thickener, primary and secondary) are planned to cope with inflow of higher turbid raw water during rainy season. For the design of the facilities, the design conditions and criteria are established, as shown in Table 9.5.1.

Table 9.5.1 Design Conditions & Criteria for Sludge Treatment

Season	Design Conditions	Inflow Sludge to thickener		Sludge inflow to SDB	Removed Sludge
		Primary	Secondary		
Dry	Q_{in}300,000m^3/d Turbidity 40NTU Removal Ratio 90%	C=99.5 % V=2,340 m^3/d Ds=11.6 t/d	-	C=97 % V= 390m^3/d Ds=11.6 t/d	C≦65%
Rainy	Q_{in}300,000m^3/d Turbidity 100NTU Removal Ratio 90%	C=99.5 % V=5,680 m^3/d Ds=28.6 t/d	C=97 % V= 950m^3/d Ds=28.6 t/d	C=94 % V=470 m^3/d Ds=28.6 t/d	

Note: C; content of water %, V; volume, Ds; dry solids per day, SDB; sludge drying bed

Primary thickeners are operated all year round, while secondary thickeners are used only during days when raw water has a high turbidity during the rainy season. Cleaning of thickener equipment and the connection pipes shall be carried out in dry days.

(2) Sludge Drying Bed

1) Control of supernatant from sludge drying bed

Discharge of supernatant after the initial filtration of water through sub-layer of sand/gravel shall be carefully managed by manual operation of stop-logs.

2) Disposal of dried sludge

As dried sludge does not contain toxic substances, it can be supplied to local manufacturers/residents for the production of bricks or use as soil conditioner.

3) Replacement of sub-layer sand and gravel

Part of the sand filtration media on the top of the sludge drying beds shall be refilled every time after dried sludge is removed and all filtration media shall be replaced at least every 3 years to prevent clogging of the media.

(3) Vehicle/Equipment required for sludge disposal

Dried sludge is collected manually and loaded to a dump truck using a backhoe, following which surplus sludge (which has not been sold or supplied as discussed above) is transported to a land reclamation or landfill site. The required number and type of vehicles in Phase 2 is summarized in Table.9.5.2, which also shows the planned number and type of vehicles in the Phase 1 Project.

Table 9.5.2 Required Vehicles for Sludge Disposal

Vehicle	Quantity in Phase 1	Additional Quantity in Phase 2	Total
Dump-truck	2	-	2
Backhoe	-	2	2

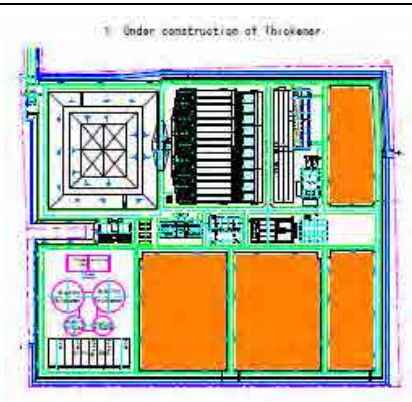
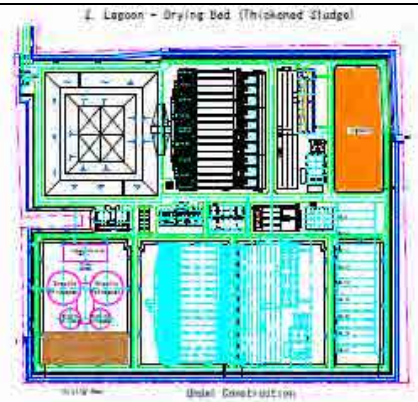
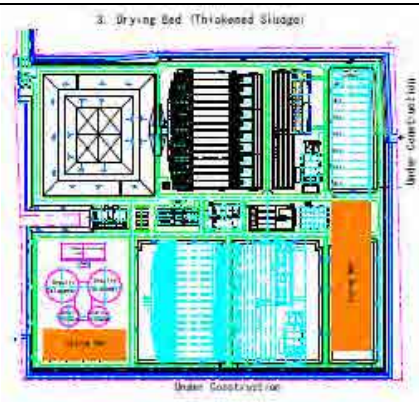
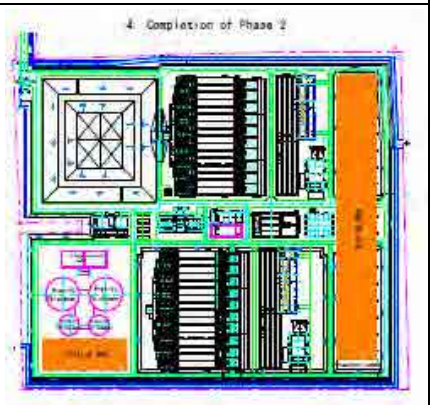
9.5.2 Arrangements for the Treatment of Sludge in the Transition Period from Completion of Phase 1 to the Completion of Phase 2 Work

Before completion of the Phase 2 construction work, appropriate arrangements shall be made so as not to disturb the sludge treatment process for the Phase 1 WTP, which uses sludge lagoons located in the area where the Phase 2 water treatment facilities are planned to be constructed. Table 9.5.3 and Table 9.5.4 show the sludge treatment facility arrangements and operation method in four stages; (1) during construction of thickener units and Sludge Drying Bed in the open space, (2) during construction of Phase 2 water treatment facility and a part of Sludge Drying Bed, (3) during construction of the rest of Sludge Drying Bed and finally (4) completion of Phase 2.

Table 9.5.3 Arrangements for Sludge Treatment in the Transition Period

Stage		Sludge Generation Volume	Sludge Treatment Facility	O&M of Sludge Treatment
1	During Construction of 4 units of Thickener and 5 units of Sludge Drying Bed (treatment of Phase 1 sludge)	(Q_{in}=150,000 m^3/d) Dry season 5.9 Dt/d 1,180 m^3/d Rainy season 14.2Dt/d 2,840m^3/d	4 Sludge Lagoon A:3,669m^3 x 0.7m B:5,492m^3x0.7m C:5,492m^3x0.7m D:3,669m^3x0.7m	5 month/unit in 1 cycle use: Inflow 2.5 months Drying 2.0 months Removal 0.5 month 4 Lagoon are used in turn
2	During Construction of Phase 2 Water Treatment Facility and 9 units of Sludge Drying Bed (treatment of Phase 1 sludge)	Ditto	4 Sludge thickener D=30m x 2 tank D=18m x 2 tank 5 Sludge Drying Bed 500m^2x5=2,500m^2 1 Sludge Lagoon 3,669m^3, H: 0.7m (A=5,241 m^2)	Thickened Sludge volume Dry Season 5.9/(1-0.97)= 200 m^3/d Rainy season 14.2/(1-0.94)= 240 m^3/d 1 Lagoon and 5 Drying Beds are used for the drying of Phase 1 Sludge.
3	During Construction of 8 units of Sludge Drying Bed (treatment of Phase 1 sludge)	Ditto	4 Sludge thickener D=30m x 2 tank D=18m x 2 tank 14 Sludge Drying Bed 500m^2x14=7,000m^2	Thickened Sludge volume Dry Season 5.9/(1-0.97)= 200 m^3/d Rainy season 14.2/(1-0.94)= 240 m^3/d Total 14 Sludge Drying Beds are used.
4	After Completion of Phase 2 with additional 8 units of Sludge Drying Bed (treatment of Phase 1 & 2 sludge)	(Q_{in}=300,000 m^3/d) Dry season 11.7 Dt/d 2,330 m^3/d Rainy season 28.2 Dt/d 5,630 m^3/d	4 Sludge thickener D=30m x 2 tank D=18m x 2 tank 22 Sludge Drying Bed 500m^2x22=11,000m^2	Thickened Sludge volume Dry Season 11.7/(1-0.97)= 390 m^3/d Rainy season 28.2/(1-0.94)= 470 m^3/d Total 22 Sludge Drying Beds are used.

Table 9.5.4 Staged Arrangements for Sludge Treatment during Transition Period

Stage	1	2	3	4
Layout Plan of Sludge Treatment Facility				
	Common conditions 1 Lagoon can receive 2.5 months of sludge in an average as planned in Phase 1. Sludge inflow load to Drying Bed is assumed to be around 60 kg-Ds/m^2 /day in dry season In case of 500m^2 Drying Bed, sludge weight is 5,900kg in Phase 1 and inflow day is 500 /(5,900/60)=5.08 days → 5 days Target drying period is assumed to be 2.0 months (=60 days) for lagoon system and 45 days for Sludge Drying Bed system considering filtration function of the bed. 2days for sludge removal is required in case thickened sludge is fed into drying beds. 0.5 month is required for lagoon system fed with un-thickened sludge. In case thickened sludge is fed into lagoon, 45 days for drying and 15 days (0.5 month) for removal shall be assured.			
	4 units of sludge lagoon are constructed in Phase 1 and operated during this stage (1 cycle; 5.0 months/unit) 2.5 month; sludge inflow 2.0 month ; Drying 0.5 month; scraping and removing dried sludge	Lagoon is divided into 2 units and each receive 1.25 month=37days of sludge inflow (1 cycle of Lagoon) 37 days of sludge inflow 45 days of drying and 15 days of scraping and removing of dried sludge Total 97 days (1 cycle of Sludge Drying Bed) 5 days of sludge inflow 45 days of drying and 2 days of scraping and removing of dried sludge Total 52 days	Thickened sludge is dried in 14 units of Sludge Drying Bed with total area of 7,000m^2. (1 cycle) 5 days of sludge inflow 45 days of drying and 2 days of scraping and removing of dried sludge Total 52 days	Thickened sludge is dried in 22 units of Sludge Drying Bed with total area of 11,000m^2. (1 cycle) 3 days of sludge inflow 45 days of drying and 2 days of scraping and removing of dried sludge Total 50 days In this case, inflow days are; 500/(11,700/60)=2.56→3.0 day

Average capacity of four lagoons in first stage is 4,580m^3 and each lagoon can accept 442.5t of sludge, which is generated during 2.5 months (5.9t x 2.5 x 30=442.5t) in the first stage.

In case a lagoon receives thickened sludge in second stage, a lagoon can receive the same weight of sludge. The lagoon is divided into 2 units and thickened sludge will inflow to each unit, the amount of which is equivalent to 1.25 month (2.5months/2=1.25month=37 days). 5 units of Sludge Drying Bed are used, together with the lagoon in the second stage and each unit is fed with sludge for 5 days based upon the standard inflow load. Both facilities are operated in accordance with the cycle times in Table 9.5.4.

During the third stage, 14 units of Sludge Drying Bed are operated to treat 5.9t/d of sludge in Phase 1. Each unit is fed with sludge for 5 days. It takes 70 days (5 days x 14 =70 days) before the first bed is fed again, which means that the 45 days of drying time and 2 days of removal time for one bed are ensured.

The final stage is the Phase 2 stage and a total 22 units of Sludge Drying Bed are operated. Due to the volume of sludge to be fed to the Sludge Drying Beds being double that in Phase 1 stage, the inflow time is shortened to 3 days. In this case, also 45 days of drying time and 2 days of removal time are ensured by feeding the Sludge Drying Beds sequentially. It takes 66 days (3 days x 22 =66 days) before the first bed is fed again.

9.6 Transmission Facilities

Transmission facilities in this project include;

- Transmission pipeline from WTP to Nashirabad Reservoir and another 3 transmission pipelines from Nashirabad Reservoir to each distribution reservoir/elevated tank, and
- Transmission pump facilities at WTP and at Nashirabad Reservoir

Nashirabad Reservoir is planned for storage of the required volume of water for the adjustment of peak hour demand in the entire Karnaphuli service area.

For the economical operation of pump facilities at Nashirabad Reservoir according to the increase in the annual water demand, a combination of some pump units with different capacities shall be studied considering intermediate year 2025, from year 2020 (Phase 2 completion year) to year 2030 (design target year). For Nashirabad E.T and Halishahar E.T, 1.5 times the daily maximum demand (equivalent to hourly maximum flow) shall be sent from Nashirabad Reservoir, whereas for Battali Hill Reservoir, 1.2 times the daily maximum water demand shall be pumped.

Communal faucet systems are planned to provide water for the residents living along part of the route of the transmission pipeline from the WTP to Nashirabad Reservoir. These systems and surge tank, as well as air release valve and drain pipe of the transmission pipeline shall be inspected as routine work.

9.6.1 Operation of Transmission Pump Facilities from Nashirabad Reservoir to 3 Distribution Reservoir/Elevated Tanks

(1) Water Demand and Retention time at E.T tank/ Reservoir by target year

The projected water demand for each reservoir/ E.T service area; northern, central and western areas, is shown in Table 9.6.1.

Table 9.6.1 Staged Water Demand by Sub-service Area

Year		2020		2025		2030	
Unit		m^3/d	m^3/min	m^3/d	m^3/min	m^3/d	m^3/min
North	Q_{dmax}	50,000	34.7	61,000	42.4	78,400	54.4
	Q_{hmax} ($=1.5xQ_{dmax}$)	75,000	52.1	91,500	63.5	117,600	81.7
Central	Q_{dmax}	93,000	64.6	104,000	72.2	128,000	88.9
	Q_{hmax} ($=1.5xQ_{dmax}$)	139,500	96.9	156,000	108.3	192,000	133.3
	$1.2xQ_{dmax}$	111,600	77.5	124,800	86.7	153,600	106.7
West	Q_{dmax}	58,000	40.3	66,000	45.8	79,600	55.3
	Q_{hmax} ($=1.5xQ_{dmax}$)	87,000	60.4	99,000	68.8	119,400	82.9
Total	Q_{dmax}	201,000	139.6	231,000	160.4	286,000	198.6
	Q_{hmax} ($=1.5xQ_{dmax}$)	301,500	209.4	346,500	240.6	429,000	297.9

Table 9.6.2 shows the retention time at each reservoir against the daily maximum water demand.

Table 9.6.2 Retention time to Daily Maximum Water Demand by Target Year

Reservoir/E.T	Capacity (m^3)	Retention Time (hour)		
		2020	2025	2030
Nashirabad Reservoir	51,100	6.1	5.3	4.3
Nashirabad E.T	2,200	1.1	0.9	0.7
Battali Hill Reservoir	8,500	2.2	2.0	1.6
Halishahar E.T	2,400	1.0	0.9	0.7

(2) Operation Plan of transmission pump by target year at Nashirabad Reservoir for service reservoir/ elevated tank

All pump facilities required in 2030 are planned to be installed in Phase 2 Project. Before year 2030 less on-off operation of the pump facilities occurs, as the water demand in 2020 and 2025 is less than that in 2030. Careful inspection of the condition of the pumps is necessary to provide immediate countermeasures in case of a problem. On the other hand, pump operation will be made by using a combination of some pump units to meet the fluctuation in water demand in the day.

9.6.2 O&M of Communal Faucets

Several faucet systems to be installed along the transmission pipe from WTP to Nashirabad reservoir shall be technically maintained by CWASA. However, the association shall be organized by the beneficiaries. Monitoring and maintenance of the facilities shall be made as a joint effort of CWASA and the association.

9.7 Distribution Facilities

Distribution Facilities comprise distribution reservoir/elevated tank, distribution pipeline (including lateral pipes) and service connections with water meters. Ancillary equipment of the distribution pipeline includes air release valve, drain pipe and fire hydrant, which are inspected in routine work and are repaired/ replaced, as required.

Distribution reservoir/elevated tanks including Nashirabad Reservoir are filled by transmission pumps so that the water level in each is maintained at the planned level shown in Table 9.7.1.

Table 9.7.1 Water Level of Reservoir

Reservoir	HWL	LWL	Remarks
Nashirabad Reservoir	+36.3m	+30.0m	
Battali Hill Reservoir	+49.6m	+43.6m	
Nashirabad Elevated Tank	+51.0m	+45.0m	
Halishahar Elevated Tank	+36.0m	+30.0m	

The distribution system is divided into 10 Sectors and flow volume and water pressure is monitored and controlled by the pressure regulating valve, sector by sector. The NRW percentage is estimated by sector. In order to assess the leakage in a DMA, night time flow is measured at the DMA inlet chambers provided with fire hydrant outlets.

Water quality examination at the service connections shall be made taking samples of tap water periodically to confirm the water quality compared to the national drinking water standard. Important water quality indices, frequency and sampling number for water quality examination are listed in Table 9.7.2. CWASA shall publicize officially the result of water quality test every month.

Table 9.7.2 Water Quality Test for Drinking Water

Water Quality Indices	Frequency	Remarks
Coliform Bacteria	Once a month	Sampling: one in 1,000 connections
Residual chlorine		
Nitrate		

9.7.1 DMA

DMAs are utilized as a primary diagnostic tool to reduce the volume of leakage. The night time flow at the entrance to a DMA (inlet chamber) is measured to analyze the existence of leakage in the DMA. The work flow for leakage detection, which is used in the development of countermeasures, is shown in Figure 9.7.1.

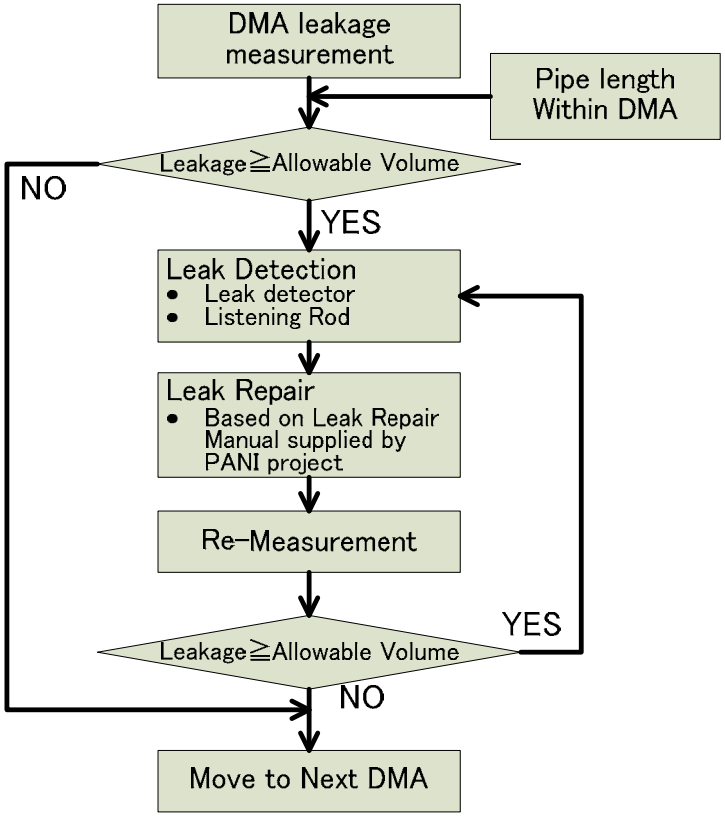


Figure 9.7.1 Work Flow of Leakage Reduction in DMA

An image of night time minimum flow is illustrated in Figure 9.7.2.

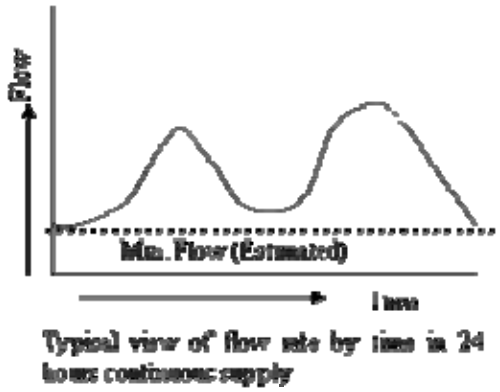


Figure 9.7.2 Image of Night time Minimum Flow

The allowable volume of night time flow is about 10-20 liters / min / km of Pipe based on the experiences in Japan.

Three teams of monitoring team shall be organized to cover the three sub-service areas; Northern, Central and Western areas. These teams shall survey all DMAs in a year (3teams x 7 DMAs x12 month = 252 points). Each team shall be equipped with vehicle mounted electro-magnetic flow meter. Two sets of ultrasonic flow meter shall also be procured to use in narrow roads where vehicles cannot access the DMA inlet chamber.

Leak investigation/repair team will get information on the monitoring results from the monitoring team and if there is evidence of leakage, they will try to identify points of leakage point/s in the DMA using detectors, listening rods, following which repair works will be carried out. In case repair work is large, it shall be contracted out to a Contractor.

Data management and analysis shall be used by the staff to prepare a leakage reduction manual. An annual plan for the work shall be prepared at the beginning of a year. A Leak repair manual will be prepared by PANI team and it shall be updated based on the experience and lessons learned of the teams.

Data management staff members are expected to conduct the following work.

(1) Analysis on the causes of leakage

Following repair data is statistically necessary to determine the causes of leakage.

- Location of leaking point/s (GIS information, distribution block, DMA, etc.)
- Pipe info. (diameter, material, laying depth, backfill materials, completion year, etc.)
- Leak condition (estimated leak amount, leaking portion, etc.)
- Repairing condition (method, used material, backfill materials, etc.)

(2) Analysis of Flow Balance of subject DMA and comparison at each DMA

Water balance data including night time flow shall be collected. These data categories of DMA shall be included for improvement of analytical precision. It is desirable to collect water meter reading data within the DMA. Such analysis enables more effective NRW countermeasures. Comparison of each DMA data also assists in clarifying the l characteristics of leakage within the Sectors

(3) Review of Leak Reduction Manual

It involves criteria for the judgment of leakage-prone DMA. Repair work must be performed properly, in order to prevent the recurrence of the leakage. This manual must be prepared covering clear topics such as external construction standards of road excavation and restoration in consultation with the concerned authorities.

9.7.2 Water Meters

Water tariff collection based on accurate reading of water meters contributes significantly to the sound operation of the CWASA and also improves the water-saving consciousness of the customers. It is fair for all customers to charge them in proportion to the water they use.

As a large number of nonfunctional water meters have not been replaced and many water meters are reserved in the stock yard un-checked for accuracy, appropriate and improved management of water meters is indeed necessary.

(1) Organization and Equipment Needed

A water meter management center shall be established for common use for all water supply systems in the city through the future. The center should undertake accuracy test of all new meters, collection of expired meters, repair and recycling of the collected meters and on-site accuracy test of existing water meters. A new test yard equipped with accuracy test tools shall be constructed in CWASA compound in Halishahar.

1) New Meter Accuracy Test

- A meter error is examined in the meter test shop through authorized measuring method.
- Tolerant range of water meter is set up at ±4% in practical use, that of examination value is set at ±3% in case of new meter examined in test yard.
- All meters procured are subjected to the accuracy test.

2) Replacement Schedule

Replacement term is set up as follows:

- 1/2 inch – 8 years
- 2～3/4 inch – 5years
- Over 3 inch – 3 years

Based on the replacement term, expired meters should be replaced. In case collected meters are in good condition, they should be recycled after repairing. The target number of replacement and recycle is as follows:

- 1,000 meters per month (12,000 meters per year)
- While 500 meters, half of collected meters, are scrapped and disposed, 500 meters are repaired and reused.

Sample equipment for accuracy test is shown in Figure 9.7.3 and on-site test (calibration) is shown in Figure 9.7.4

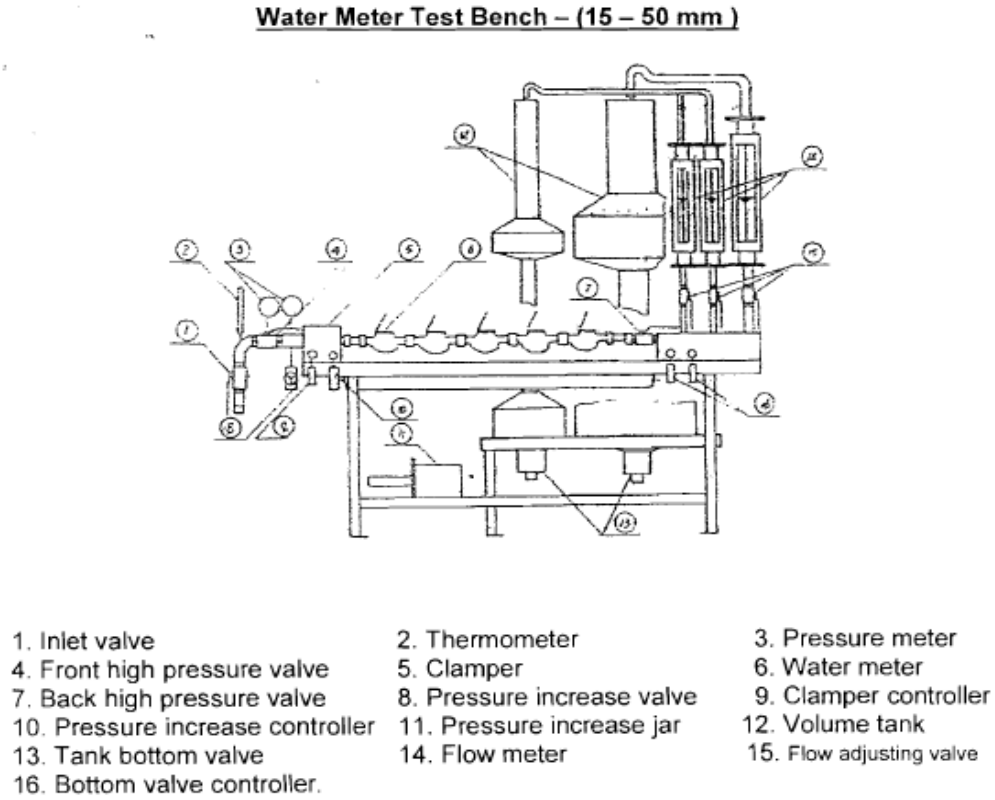


Figure 9.7.3 Meter Accuracy Test Bench

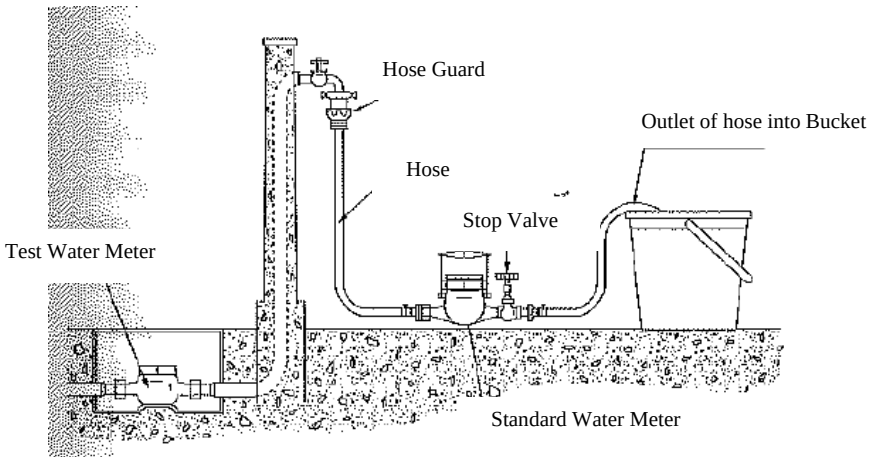


Figure 9.7.4 On-site Calibration Test

9.8 Countermeasures to Reduce O&M Cost

(1) Personnel Cost

As to the personnel cost, introduction of SCADA system can reduce the O&M cost, especially the personnel cost for data collection and on-site control. Other IT related equipment also contributes to the cost reduction. Another countermeasure for reducing personnel cost is done mainly by outsourcing of O&M work. Potential works to be subcontracted are as follows;

- Disposal of dried sludge
- Water meter reading and tariff collection work
- Water quality test

(2) Power/Fuel Cost

To save the pump operation cost, which accounts for major part of power cost, introduction of higher efficiency motor is recommended. Cost saving lightning equipment, such as LED illumination equipment shall also be considered. Ventilation facilities and air conditioners are to be operated adequately.

(3) Chemical Cost

Karnaphuli WTP consumes a lot of chemicals, Alum, Lime and Chlorine. Chemicals which can be stored on site for periods can be procured more cheaply as the quantity of one order increases. A scheduled procurement plan, based on procurement in large (as opposed to small) quantities is helpful to reduce the cost of chemicals.

9.9 Institutional Structure and Technical Capacity Needs for CWAS to Manage Phase 2 Facilities

(1) Required Organization for O&M work for Karnaphuli Water Supply System

The organization for O&M of Karnaphuli Water Supply System is recommended from functional view point as a total system of Phase 1 and Phase 2. The requirements for administrative, engineering (planning and design), commercial/ marketing and public relations are regarded to be managed by CWASA head office, as common services to all water supply systems in Chittagong city. Therefore, the Karnaphuli Water Supply System Office has an independent function for O&M of the facilities. Figure

9.9.1 shows the organization for O&M of the Karnaphuli Water Supply System (covering Phase 1 and Phase 2).

The organization for O&M of Karnaphuli Water Supply System consists of the two divisions (broken down into two groups among the major facility components) as shown below. System management from Intake to the entrances to the sectors of the distribution main pipelines will be undertaken by monitoring and control staff under the Assistant KWS System Manager.

1) O&M for Intake- Transmission Pipeline
2) O&M of Distribution Facilities

The following are the functions of water supply system management and the two divisions.

a) Water Supply System Management

This work is directly supervised by Assistant KWS System Manager. Overall monitoring and control of water supply system shall be undertaken by the staff and coordinated with the two O&M divisions. There are three groups; monitoring and control of the entire system using the SCADA system, data collection/processing and analysis in order to develop an improved operation plan for/manual of the entire water supply system, and environmental monitoring and countermeasures .

b) O&M for Intake- Transmission Pipeline

Under the Department Manager of O&M for Intake to Transmission Pipeline, Process, Mechanical, Electrical and Instrumentation Engineers will be engaged in the required O&M work related to the intake, water treatment (water and sludge treatment processes) and pipe line. The laboratory for water quality examination operated by the section manager (Chemist) is also in this division. This section will analyze and monitor the raw water, process water and service water.

Operators/ technicians shall be assigned under the sections of Intake, Water Treatment, Sludge Treatment, Pipeline maintenance and laboratory.

c) O&M for Distribution Facilities

The Department Manager of O&M for the Distribution Facilities will manage concerned sections consisting of (1) reservoir/elevated tank, and (2) main & sub-main Pipelines with Sector Inlet chambers, DMA networks with DMA chambers.

Main pipe/Section Inlet chamber & DMA Section includes (1) 10 Sector offices, (2) Leakage Detection Teams for the three sub- distribution systems which cover 10 sectors, and (3) Water Meter Maintenance Center, which will be commonly used for all established Water Supply System in Chittagong City. The Water Meter Center is engaged in the water meter accuracy test, periodical on-site meter calibration and replacement of broken meters.

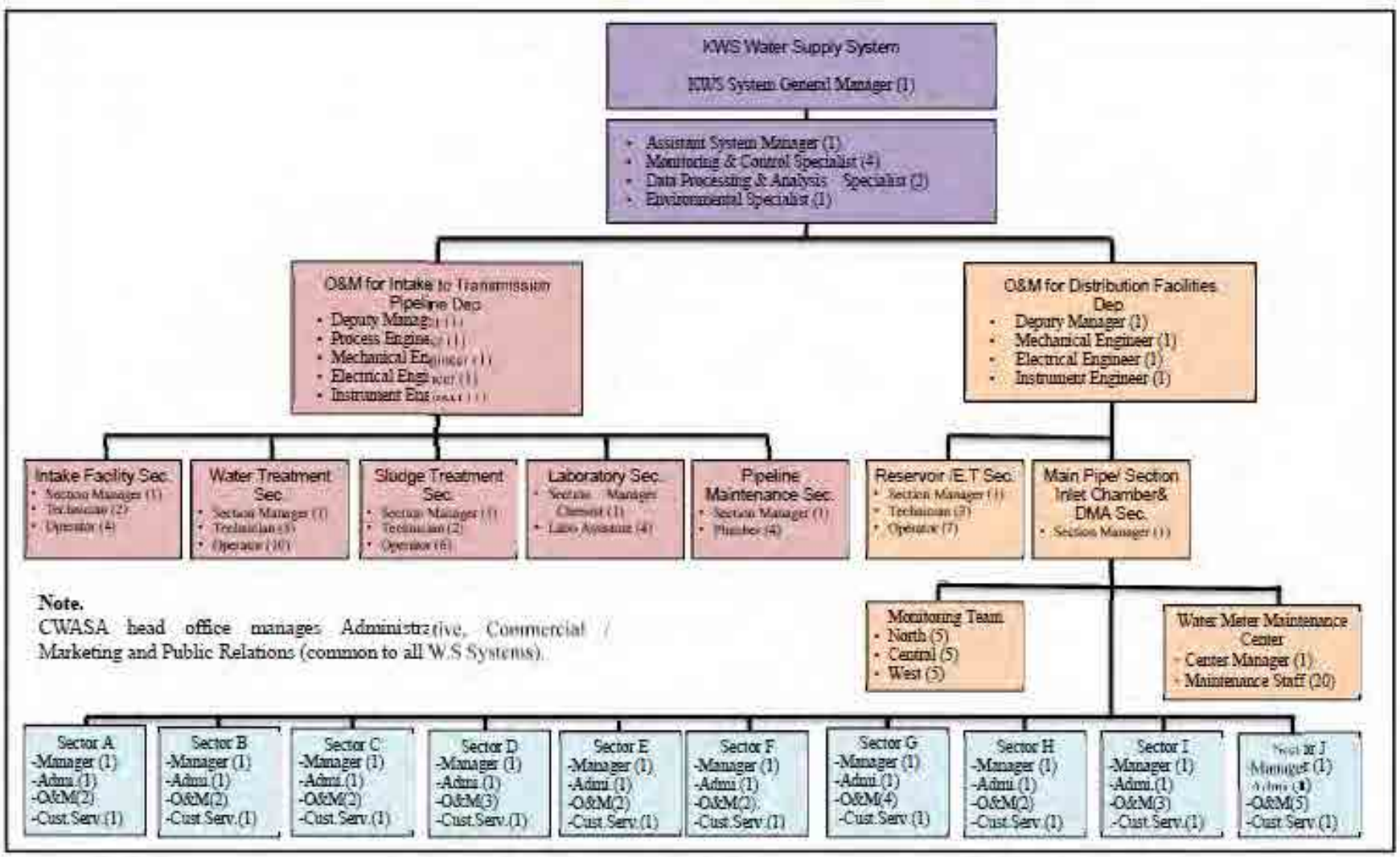


Figure 9.9.1 Organization for O&M of Karnaphuli Water Supply System

The field office of each sector shall be established before completion of respective DMAs to manage the water supply business in their territories including marketing, water tariff collection, and monitoring/control of water use and repair of facilities (leakages). For the establishment of comprehensive management for the water supply in the KSA, incentives to staff members and appropriate compensation shall be provided through the competition on the performance of the sectors.

(2) Staff Members required for O&M of Karnaphuli Water Supply System

Table 9.9.1 presents required number of staff members with job descriptions (refer to Figure 9.1.1).

Table 9.9.1 Staff Numbers required for O&M of Karnaphuli Water Supply System

Department	Section	Number of Staff	Job Description
KWS System Manager		1	Overall management for KWS system operation and coordination with CWASA head office
KWS Assist. Manager		1	Assist System Manager and responsible for overall system monitoring & control
	Monitoring & Control	4	Monitoring and control of the system using SCADA system coordinating sections of major facilities
	Data Processing & Analysis	2	Data collected from major facilities will be managed with analysis for improvement and stable operation of the facilities through the future
O&M for Intake to Transmission Pipeline			Physical O&M of the facilities from Intake to Transmission Pipelines
	Department Manager	1	Management of the Department (organizational & personnel, budget and technology)
	Process Eng	1	Water and sludge treatment processes are managed
	Mechanical Eng	1	Inspect, study and find countermeasures on mechanical equipment for concerned facilities.
	Electrical Eng	1	Inspect, study and find countermeasures on electrical equipment for concerned facilities.
	Instrumentation Eng	1	Inspect, study and find countermeasures on instrumentation equipment for concerned facilities.
	1.Intake Facility Sec.		O&M of Intake Facilities
	Section manager	1	Management of the Section
	Technician	2	Maintenance of Intake facility
	Operator	4	Intake pump operation
	2.Water Treatment Sec.		O&M of water treatment facilities
	Section manager	1	Management of the Section
	Technician	5	Maintenance of water treatment facilities
	Operator	10	Monitor and Operate water treatment facilities
	3.Sludge Treatment Sec.		O&M of sludge treatment
	Section Manager	1	Management of the Section
	Technician	2	Maintenance of sludge treatment facilities
	Operator	6	Monitor and Operate sludge treatment facilities
	4.Laboratory		Water quality examination
	Section manager (Chemist)	1	Management of the Section with quality control in the examination
	Labo. Assistant	4	Conduct water quality examination
	5.Pipeline maintenance Sec.		O&M of conveyance and transmission pipelines with accessories (including serge tank & communal faucet systems)
	Section Manager	1	Management of the Section

De-partment	Section	Number of Staff	Job Description
	Plumber	4	Survey and repair of pipes
O&M for Distribution Facilities			Physical O&M of the distribution facilities
	Department manager	1	Management of the Department
	Mechanical Eng.	1	Inspect, study and find countermeasures on mechanical equipment for concerned facilities.
	Electrical Eng.	1	Inspect, study and find countermeasures on electrical equipment for concerned facilities.
	Instrumentation Eng.	1	Inspect, study and find countermeasures on instrumentation equipment for concerned facilities.
	1.Reservoir/ E.T Sec		O&M of Reservoir/ E.T
	Section manager	1	Management of the Section
	Technician	3	Maintenance of reservoir/ E.T
	Operator	7	Operate transmission pump
	2.Main Pipe/Sector Chamber & DMA Sec.		O&M of main pipeline, Sector chambers and DMA
	Section Manager	1	Management of the Section
	Leakage Monitoring Team	15	Conduct monitoring of leakage by DMA for three sub-service areas
	Sector Manager	10	Management of Water supply business
	Administrative staff	10	Administrative work
	IO&M of facilities(including investigation & repair)	27	Conduct investigation on leakage receiving information from monitoring team and repair pipes as required
	Customer service	10	
	3.Water Meter maintenance Center		Meter calibration and replacement of broken meters and promotion of willingness to pay by customers
	Center manager	1	Management of the Section and conduct public education on water meter use
	Water Meter Maintenance staff	20	Meter calibration and replacement of broken meters
Total No.		164	

Under Customer Services at the ten Sector Field Office, a total of 290 staff is required for meter reading and public relation works as summarized in Table 9.9.2 (150 connections/person are assumed to estimate required number of staff in Customer Services).

Table 9.9.2 Number of Customer Services in Each Sector

Sector	Number of Staff	Sector	Number of Staff	Sector	Number of Staff
Sector A	18	Sector D	47	Sector H	33
Sector B	25	Sector E	26	Sector I	33
Sector C	15	Sector F	27	Sector J	10
		Sector G	47		
Sub-Total	58	Sub-Total	147	Sub-Total	85
Total 290					

CHAPTER 10

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

CHAPTER 10 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

10.1 Project Requirements for Environmental Procedures in Bangladesh

10.1.1 Environmental Clearance Required for Water Supply Project

(1) Environmental Clearance Requirements

As discussed in Chapter 2.2.3, in accordance with Clause 7 of the Environmental Conservation Rules, 1997 (ECR), all new industries and projects must apply for a Site Clearance Certificate (SCC, or Environmental Site Clearance (ESC)) and/or an Environmental Clearance Certificate (ECC) to obtain necessary environmental clearance from the DOE.

As specified also in Clause 7 (1) of the ECR, for the purpose of the issuance of ECC, the industrial units and projects shall, in consideration of their sites and potential environmental impacts, be classified into four categories i.e. (a) Green, (b) Orange – A, (c) Orange – B and (d) Red.

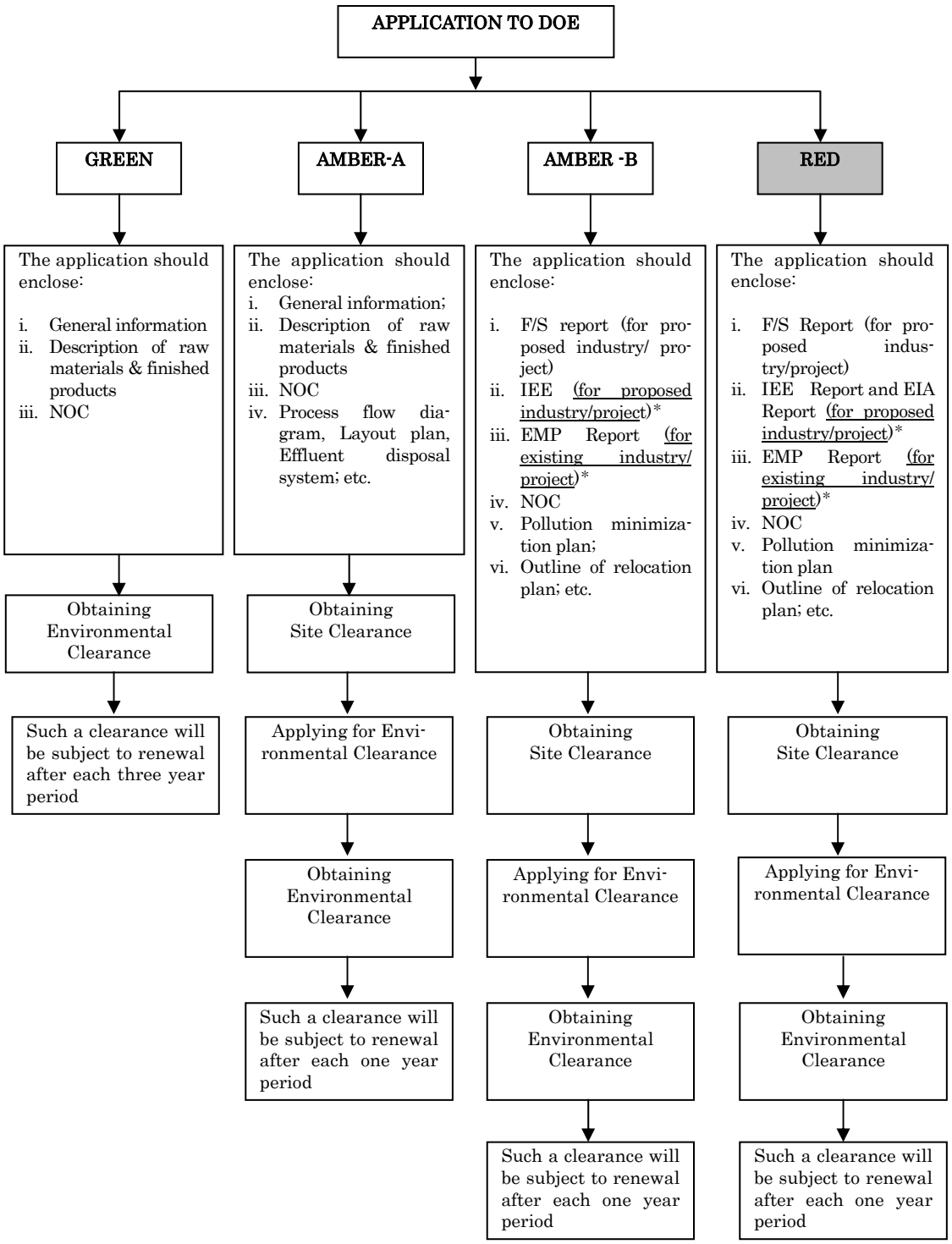
(2) Categorization of the Karnaphuli Water Supply Project

Schedule 1 of the ECR is the category classification of the most common industries and projects, with the "Red" category including "No.62 Water treatment plant" and "No.64 Water, power and gas distribution line laying/relaying/extension". Thus, the Karnaphuli Water Supply Project was previously (during Phase 1) classified as a "Red" category project and this is still the case in accordance with the prevailing legislation.

Consequently the project proponent (CWASA) was required to prepare IEE and EIA reports according to the relevant laws and guidelines, which are discussed in Chapter 2.2.3. The above reports were prepared as part of Phase 1 of the project, as discussed in Chapter 10.2.

(3) Application for Environmental Clearance

As specified in Clause 7 (5) of the ECR, a project proponent shall apply to the concerned Divisional Officer of DOE in Form-3 along with the appropriate fees and necessary documents for environmental clearance. These procedures are shown in Figure 10.1.1.



NOC ; No Objection Certificate, usually obtained from local government, F/S; Feasibility Study, IEE; Initial Environmental Examination, TOR; Terms of Reference, EIA; Environmental Impact Assessment, EMP; Environmental Management Plan,
** ; See 3) Environmental Assessment Process in WARPO Guidelines*
Source; EIA Guidelines for Industry 1997, DoE, MoEF,

Figure 10.1.1 Flow Chart of Environmental Clearance Procedure

10.1.2 Summary of Phase 2 Project Components

The Phase 2 Project is the expansion of the Phase 1 Project, as discussed in Chapter 7, with the main project components of Phase 2 shown in Table 10.1.1 and the location of the project area and the main facilities shown in Figure 10.1.2.

Table 10.1.1 Project Components of Phase 2

		Major Works	
1	Intake Facilities	1) Mechanical Works	Pumps for 150,000m^3/d
		2) Electrical Works	Additional transformer and generator
		3) Civil Works	Yard piping
2	Conveyance Pipeline	DN 1200mm in road	From Intake to WTP including surge tank
3	Water Treatment Plant	Production capacity 143,000 m^3/d	Civil, Mechanical, Electrical works.
4	Transmission Pipeline	DN 1200 mm in road	From WTP to Nashirabad Reservoir including surge tank
5	Nashirabad Reservoir	Reservoir with a capacity of about 24,800 m^3/d and associated works	Civil, Mechanical, Electrical works.
6	Transmission Pipeline	DN 1,100 mm in road	From Nashirabad Reservoir to Halishahar Elevated Tank
7	Halishahar Elevated Tank	Volume 2,400 m^3	Located on land owned by CWASA
8	Distribution Pipelines	1) Northern service area	Area 566 ha, L=89.8km
		2) Central service area	Area 1,213 ha, L=185.6km
		3) Western service area	Area 1,284 ha, L=207.4km
9	Lateral Pipelines		In above sub-service areas, covering an area of 3,063 ha
10	Service Connections		About 51,360 nr

Figure 10.1.2 Location of the Phase 2 Project Area

10.1.3 Environmental Laws and Regulations to be considered for Design of Project Facilities

(1) General

As discussed in Chapter 2.2 the most important environmental rules and regulations are as follows:

- Environmental Conservation Act 1995 (ECA)
- Environmental Conservation Rules 1997 (ECR)

(2) Environmental Conservation Act 1995

The ECA is the basic law on the environment and mainly contains the following items:

- Environmental conservation
- Authority to control development and pollution
- Preparation of environmental standards including effluent standards
- Review and approval of environmental impact assessment (EIA)
- Authority of entry for inspection
- Regulation of fine to violation

Section 12 of the Act stipulates "No industrial unit or project shall be established or undertaken without obtaining environmental clearance from the Director General of DOE in the manner prescribed by the Rules".

(3) Environment Conservation Rules (ECR), 1997

The ECR has been promulgated, under the ECA, to evaluate and review the environmental impact of various projects and activities. The necessary procedures for environmental approval are also established in the ECR as mentioned in Chapter 10.1.1.

In addition, the Environmental Quality Standards for Bangladesh (EQS), which are included in the ECR have been set to control the ambient environmental quality. The specified limits, which may have adverse impacts on the environment, are shown in the respective standards for the following fields (Standards are shown in Supporting Report 10.1.1 to Supporting Report 10.1.10):

- Air quality standards
- Water quality standards (Inland surface water and Potable water)
- Noise quality standards (General)
- Noise quality standards (For Motor vehicle or mechanical vessel)
- Motor vehicle exhaust quality standards
- Quality standards for mechanized vessel exhaust
- Quality standards for Odour
- Sewer discharge quality standards
- Waste discharge quality standards for industrial units and projects
- Gaseous discharge quality standards for industrial units and projects
- Waste emission or discharge quality standards for classified industries (Fertilizer, Integrated textile mill & large processing unit)

Most of the above environmental standards are included in Appendices 10.1.1 to 10.1.10.

(4) Other Laws /Regulations/Plans Related to the Environment

There are a considerable number of other laws, regulations and standards related to the environment, such as the Factories Act, Factory Rules, Acquisition and Requisition of Immovable Property Ordinance, Building Construction Act, Forest Act and the Bangladesh National Environment Action Plan.

The Government of Bangladesh has already ratified (or signed on) the major international conventions/legislation for environmental conservation, such as the UN Framework Convention on Climate Change, Convention of Biological Diversity, World Heritage Convention, and RAMSAR Convention.

The major laws, regulations and standards, which are to be considered relevant to the project, are shown in Table 10.1.2. This table also includes details of which stage of the project they are relevant.

Table 10.1.2 Major Laws/Regulations and Standards to be considered in the Project

Title	Environmental Clearance	Planning Stage	Construction Stage	Operation Stage	Project as a whole
I. Environmental Clearance					
Bangladesh Environmental Conservation Act 1995	x	x	x	x	x
Environmental Conservation Rules 1997 as a whole	x	x	x	x	x
-Form-1 Application for remedy					x
-Form-2 Notice of intention for collection of sample			x	x	x
-Form-3 Application for Environmental Clearance Certificate	x	x	x	x	x
-Form-4 Pollution under Control Certificate			x	x	
-Schedule-1 Classification of industrial units or projects based on its location and impact on environment	x				
-Schedule-2 Standards for Air			x	x	
-Schedule-3 Standard for Water			x	x	
-Schedule-4 Standard for Sound			x	x	
-Schedule-5 Standards for Sound originating from Motor Vehicles or Mechanized Vessels			x	x	
-Schedule-6 Standards for Emission from Motor Vehicles			x	x	
-Schedule-7 Standards for Emission from Mechanized Vessels			x	x	
-Schedule-8 Standards for Emission from Mechanized Vessels			x	x	
-Schedule-9 Standards for Sewage Discharge			x	x	
-Schedule-10 Standards for Waste from Industrial Units or Projects waste			x	x	
-Schedule-11 Standards for Gaseous Emission from Industries or Projects			x	x	
-Schedule 12 Standards for Sector-wise Industrial Effluent or Emission					
-Schedule-13 Fees for Environmental Clearance Certificate or Renewal	x				x
-Schedule-14 Fees to be realized by the Department of Environment for supplying various analytical information or data or test results of samples of water, effluent, air and sound.					x

Title	Environmental Clearance	Planning Stage	Construction Stage	Operation Stage	Project as a whole
Bangladesh Environment Conservation Act (Amendment 2000)			x	x	
Bangladesh Environment Conservation Act (Amendment 2002)			x	x	
II. Planning Stage (Land Acquisition and Resettlement)					
Acquisition and Requisition of Immovable Property Ordinance 1982		x			x
The Acquisition of Immovable Property Rules 1982		x			x
Land Reform Ordinance		x			x
he Movable Property Requisition (Compensation) Rules, 1990		x			x
Acquisition and Requisition Act, 1994		x			x
III. Construction Work and Operation of Water Supply Facilities					
East Bengal protection and conservation of fish Act 1950			x	x	
The Protection and Conservation of Fish Rules 1958			x	x	
Antiquities Act 1958			x	x	
Port Rules, Shipping Operation (1960,1966)			x	x	
Factories Act 1965			x	x	
Pesticide Ordinance 1971					
Antiquates (Amendment) Ordinance 1976					
Municipal Ordinance 1977					x
Factory Rules 1979					x
Agricultural pesticide (amendment) act					
Agricultural pesticides (Amendment) ordinance 1983					
The Pesticide Rule 1985					
Bangladesh standard specification for drinking water 1990			x	x	
The Penal Code 1996			x	x	x
Building Construction (Amendment) Act and Building Construction Rules 1996			x		x
Inspection and Enforcement Manual 2008			x	x	x
Labor Act 2006			x	x	x
Public Health Ordinance 1994			x	x	x

10.2 Present Status on Environmental Clearance for Karnaphuli Water Supply Project (Phase 1and 2 Projects)

10.2.1 Progress in Obtaining Environmental Clearance

An IEE report (dated December 2005) and an EIA report (dated June 2007) were prepared for the Karnaphuli Water Supply Project and both were submitted to the Department of Environment (DOE) to obtain the necessary approvals. The descriptions in both reports cover Phases 1 and 2 of the Project.

CWASA received approvals with conditions from the DOE as follows:

(1) Environmental Site Clearance, issued on January 9, 2006 (Memo No. DoE /Clearance /2225 /2005/75).

In accordance with Item No.11 of the Terms of Conditions, "The Clearance is valid for one year from the date of issuance and CWASA shall apply to the Chittagong Divisional Office of DOE at Chittagong with a copy to Head Office at least 30 days ahead of expiry." The terms and conditions of the ESC are shown in Supporting Report 10.2.1, which is rewritten from the original version.

(2) Approval of Environmental Impact Assessment (EIA) Report, issued on September 13, 2007 (Memo No. DoE/Clearance/2225/2005/2416).

Approval of the EIA Report allows CWASA to undertake activities for land and infrastructural developments including construction work. These activities are in progress at present.

The approval includes various conditions, such as requirements for proper mitigation countermeasures and monitoring for the site preparation, construction and operation stages and for the resettlement plan. It is also stated in Clause 10 that "the Project Proponent (CWASA) shall, after installation of the plant as well as other pollution control facilities and equipment, apply for Environmental Clearance Certificate". Supporting Report 10.2.2 is a copy of the approval, which is rewritten from the original version.

Table 10.2.1 summarises the status of the steps leading to the current status of Environmental Clearance for the project (both Phases 1 and 2), as well as future steps, based upon the above approvals and relevant legislation.

Table 10.2.1 Progress in Obtaining Environmental Clearance for Karnaphuli Water Supply Project (Phases 1 and 2)

Subject	Action/Process	Record and Status of Progress		
I. Procedure of Environmental Clearance (Obtaining SCC* and ECC)				
(1) Preparation of Project Plan	Prepared by the proponent	Done		
(2) Preparation of IEE Report	Prepared by a certificated consultant (sub-contract) and submit to the project proponent	Done	by House of Consultants Ltd.	Dec. 10th, 2005
(3) Acceptance of IEE Report	Draft IEE report shall be accepted by the proponent and finalized.	Done	by CWASA	
(4) Obtain NOC from District Commissioner	On the other hand, NOC (No Objection Certificate) will be obtained from Local Authority (Commissioner at each District office) separately	No Need	by CWASA (Chittagong District Commissioner)	
(5) Submit necessary documents to obtain SCC (Site Clearance Certificate) from DOE	Proponent should submit the Final IEE Report to Divisional DOE with an application letter (Form 3 Application for Environmental Clearance) and NOC	Done	by CWASA	Dec. 4th, 2005
(6) Issuance of SCC	IEE report and the Application Form will be reviewed and ESC will be issued without/with terms and conditions by DOE	Done	by DOE	Jan. 9th, 2006
(7) EIA study and EIA report preparation	After obtaining SCC, EIA study will be conducted and EIA report including Environmental Management Plan will be prepared by a consultant and submitted to proponent.	Done	by House of Consultants Ltd.	Nov. 3rd, 2007
	In case that the terms and conditions are accompanied with SCC, EIA report should satisfy them.	Done	by CWASA	
(8) Acceptance of EIA report	Proponent should review and accept the EIA report for finalization	Done	by DOE	
(9) Submit necessary	Proponent should submit the Final EIA Report to Divi-	Done	by CWASA	Mar.

Subject	Action/Process	Record and Status of Progress		
documents to DOE to obtain ECC	sional DOE with an application letter (Form 3 Application for Environmental Clearance) for obtaining ECC.			14th, 2006
(10) Approval of EIA Report	The EIA Report and the Application Form will be reviewed and ECC will be issued without/with terms and conditions by DOE. Without obtaining approval of EIA Report, proponent shall not be able to start the physical activity of the project and also not be able to open L/C.	Done	by DOE	Sep. 17th, 2007
	If the EIA Report and the Application Form are not satisfied with requirement by DOE, Approval of EIA Report, instead of ECC, will be only issued by DoE with terms and conditions. Thus proponent should fulfil them in revised EIA Report or in additional documents to obtain ECC.	Done	by DOE	
(11) Submit further necessary documents to DOE to obtain ECC	Upon completion of activities for land and infrastructure development including construction work, proponent should submit further necessary documents to Divisional DOE with an application letter for obtaining ECC.	Not yet	by CWASA	
(12) Issuance of ECC	The documents will be reviewed and ECC will be issued without/with terms and conditions by DOE.	Not yet	by DOE	
(13) Start Operation of the Project	After issuance of ECC the proponent can start operation of the project.	Not yet	by CWASA	
II. Renewal of Environmental Clearance				
(1) Submit necessary document to renew SCC from DOE	Renewal of SCC should be done after each one-year period	done	by CWASA	Jul. 5, 2012
(2) Issuance for Renewal of SCC	The documents were reviewed and renewal of SCC was issued /with terms and conditions by DOE.	done	by DOE	Jul. 31, 2012
(3) Submit necessary document to obtain SCC for Phase 2 Project from DOE	Renewal of SCC should be done after each one-year period	done	by CWASA	Sep. 20, 2012
(4) Issuance of SCC of Phase 2 Project	Expected to receive from DOE Chittagong by the end of November, 2012	Not yet	by DOE	

10.2.2 Issues, Problems and Countermeasures

Table 10.2.2 summarises the terms and conditions of the DOE, together with the countermeasures/actions taken by CWASA to address them during the preparation of the detailed design and bidding documents (and subsequent Contract Documents) and during construction supervision, together with future actions.

Table 10.2.2 Terms and Conditions of DOE Relating to ESC and Approval of EIA Report on Karnaphuli Water Supply Project and Action to be taken

Issue/Item	Terms and Conditions	Countermeasures/Action Taken
	1. Project Proponent may undertake activities for land development and infrastructural development of the project subject to conditions laid out in the Site Clearance issued from the DOE on 09 January 2006 as well as the following:	
I. Pre-Construction (Planning) Stage		
(1) Land acquisition/resettlement	1.11 Resettlement plan should be properly implemented and people should be adequately compensated, where necessary.	Resettlement plan was implemented by CWASA.
(2) Updating water quality data before the design of WTP	8. Before finalizing of the design of Karnaphuli Water Treatment Plant following water quality data should be updated: (1) Spatial variability of water quality along the rivers Karnaphuli and Halda. (2) Variables to be chosen for water quality analysis should include: temperature, TSS, TDS, turbidity, conductivity, pH, DO, hardness, nutrients (NH4-N, NO3-N), Phosphorus), organic matter (COD, BOD), major	Further sampling and analysis of water quality was carried out during the detailed design and the results of this were taken account of in the preparation of the detailed design.

Issue/Item	Terms and Conditions	Countermeasures/Action Taken
	ions (Sodium, Potassium, Calcium, manganese, Chloride, Sulphate, other inorganic variables (Fluoride, Boron, Cyanide), trace elements, heavy metals, Arsenic, Organic contaminants (oil and petroleum products, pesticides), faecal coliform and total coliform. (3) Hydrodynamic and water quality models should be used by constructing different scenarios for production and quantification of the potential impacts on water quality.	
	9. Based on up-to-date water quality data, model out-put as well as other scientific study WTP should be designed, installed and operated.	Design and specification of WTP takes account of up-to-date water quality. Operation of the WTP will be adjusted as necessary depending upon the raw water quality, in order to ensure that treated water quality meets the National Standard and such that water discharged from the site and sludge meet the prevailing regulations.
II. Countermeasures against construction work		
(1) Top soil restoration and soil erosion	1.1 During site preparation, top soil shall be kept aside and be restored after completion of the said activities	Construction practices are required to be in accordance with this requirement.
	1.3 Soil erosion caused by removal of vegetation cover and excavated loose soil shall be checked through repopulation with local vegetation as soon as possible; loose soil shall be covered and stored away from the edge of the hoar/river.	Construction practices are required to be in accordance with this requirement.
(2) Protection habitats and fish breeding sites	1.4 Proper construction practices shall be followed that minimize loss of habitats and fish breeding, feeding & nursery sites.	Construction practices are required to be in accordance with this requirement.
	1.8 Proper and adequate on-site precautionary measures and safety measures shall be ensured so that no habitat of any flora and fauna would be demolished or destructed.	Construction practices are required to be in accordance with this requirement.
(3) Solid waste management	1.12 Construction material should be properly disposed of after the construction work is over.	Construction practices are required to be in accordance with this requirement.
	1.2 The open areas that are grasslands can be used for construction but with appropriate safeguards to maintain materials and dump sites from contaminating hoar/river waters.	Construction practices are required to be in accordance with this requirement.
(4) Air pollution	1.10 To control dust vehicles and equipment to be used for this project shall be maintained properly, water trucks shall be used, stockpiles to be located away from sensitive receptors and vehicle speed limits shall be enforced.	Construction practices are required to be in accordance with this requirement.
(5) Noise pollution	1.6 In order to control noise pollution, vehicles & equipment shall be maintained regularly; working during sensitive hours and locating machinery close to sensitive receptors shall be avoided.	Construction practices are required to be in accordance with this requirement.
(6) Sanitation in labour camps	1.5 Proper and adequate sanitation facilities shall be ensured in labour camps throughout the proposed project period.	Construction practices are required to be in accordance with this requirement.
(7) Permission from concerned authority (trees, hilly land)	< ESC incidental Conditions 7. > No activity of cutting/razing/dressing of hill or hilly land is endorsed without permission/clearance of the concerned authority of the government.	Permission to be obtained, if required.
	< ESC incidental Conditions 8..> Appropriate permission would be required to obtain from the forest department in favor of cutting/felling of any plant/sapling forested by individual or government before doing such type of activity.	Permission to be obtained, if required.
III. All Stages (Pre-construction, Construction, Operation)		
(8) Comply with air and water standards	2. Limit Condition for Discharges to Air and Water: The Site Clearance Certificate must comply with schedule 2 and 10, rule 12 of the Environment Conservation Rules, 1997.	Design complies with schedules 2 and 10. Construction practices are required to meet the schedule.

Issue/Item	Terms and Conditions	Countermeasures/Action Taken
(9) Comply with noise standard	3. Noise Limit: The Site Clearance Certificate must be comply with schedule 4, rule 5(2) of the Noise Pollution (Control) Rules, 2006.	Design complies with this requirement. Construction practices are required to meet the schedule.
(10) Environmental Management Plan	1.13 The Environmental Management Plan included in the IEE and EIA reports shall be implemented and kept functioning on a continuous basis.	The EMP is being implemented during the construction contracts.
	1.9 All the required mitigation measures suggested in the IEE and EIA reports along with the emergency response plan are to be strictly implemented and kept operative/functioning on a continuous basis.	The mitigation measures are included in the design and contract documents, where appropriate. During construction mitigation measures are being taken.
IV. Obtaining Environmental Clearance Certificate		
(1) Without ECC Operation cannot start	10. Project Proponent shall, after installation of the plant as well as other pollution control facilities and equipment apply for Environmental Clearance Certificate without which, proponent shall not start operation of the project.	To be actioned by CWASA in the future.
(2) Renewal of ESC after 6 years absence	< ESC incidental Conditions 11.> Environmental Site Clearance (ESC) is valid for one year from the date of issuance (January 9, 2006) and CWASA shall apply for renewal to the Chittagong Divisional Office of DOE at Chittagong with a copy to Head Office at least 30 days ahead of expiry.	Renewed
V. Environmental Monitoring		
(1) Record of monitoring	4. Monitoring and Recording conditions:	
	M1.1 The results of any monitoring required to be conducted by this Clearance Certificate must be recorded.	To be actioned by CWASA
	M1.2 The following records must be kept in respect of any samples required to be collected for the purpose of this Clearance certificate:	
	(a) The date(s) on which the sample was taken;	
	(b) The time(s) at which the sample was collected;	
	(c) The point at which the sample was taken; and	
	(d) The name of the person who collected the sample.	
(2) Monitoring items and timing	M2. Requirement to monitor concentration of pollutants discharged	To be actioned by CWASA
	M2.1 For each monitoring, the Clearance Certificate holder must monitor (by sampling and obtaining results by analysis) the following parameter; (1) water flow, water quality, air quality (SPM), the surrounding areas for spread of invasive species, the changes in aquatic habitats before, during and after construction, (2) fish catching during and after construction.	
(3) Reporting	5. Reporting Conditions: Environmental Monitoring Reports shall be made available simultaneously to Head Quarters and respective Divisional offices of the Department of Environment on a quarterly basis during the whole period of the project.	To be prepared by CWASWA and concerned parties
(4) Notification of Environmental Harm	6. Notification of Environmental Harm: The Clearance Certificate holder or its employees must notify the Department of Environment of incidents causing or threatening material harm to the environment as soon as practicable after the person becomes aware of the incident.	To be actioned as necessary by CWASA.
(5) Open L/C	7. Project Proponent may open L/C (Letter of Credit) for importing machineries for the project which shall also include machineries relating to pollution devices;	Actioned by CWASA

With regard to obtaining the issuance of ESC for Phase 2 Project, CWASA sent a letter to the DOE Chittagong on July 5th, 2012 requesting the DOE to advise on what needs to be done to address the fact that the ESC has not been renewed and on other issues related to the environment, taking into account the

status of the Phase 2 project (refer to Supporting Report 10.2.3). DOE Chittagong responded on July 9th, 2012 stating that a fee of 875,000 BDT should be paid.

After the renewal of the ESC by CWASA, the DOE issued the letter on July 31, 2012 on the acceptance of the renewal with four conditions (refer to the letter in Supporting Report 10.2.4). These conditions and a further requirement, as abstracted from the letter are as follows:

> Renewal of the site clearance certificate will be valid for a period of 1 (one) year with effect from 17th January 2012 to 16th January 2013.
>
> 1) No activity of cutting/razing/dressing of hill, helloes is favoured with this renewal.
> 2) Must submit Environmental Monitoring reports as mentioned in the article 5 of the approved EIA
> 3) Application along with renewal fees must be submitted to this office prior to 30 days of the expiry of the certificate.

Beside this you will also abide by terms and conditions mentioned in the original Site Clearance Certificate and approved EIA (refer to the letter attached in Supporting Report 10.2 in this report).

As mentioned in the conditions, "Environmental Monitoring Report" on a quarterly basis, shall be submitted by CWASA with reference to the implementation of the Phase 1 Project.

With reference to the Phase 2 Project, CWASA sent a letter to DOE Chittagong to obtain "Environmental Site Clearance" on September 20, 2012. DOE Chittagong replied to CWASA on September 20, 2012 about the need for the site clearance certificate for Phase 2 of KWSP with requisite fees (refer to Supporting Report 10. 2.5).

According to the request from DOE Chittagong, CWASA submitted the requisites to obtain the ESC for the Phase 2 Project (refer to Supporting Report 10.2.6), following which DOE Chittagong will issue the ESC in November, 2012.

10.3 Specific Environmental and Social Aspects in the Project Sites

10.3.1 Social Aspect

This sub-section refers to social problems which are related to people's participation in the Project and social problems caused by the implementation of the Project. Individual environmental problems and their mitigation measures are described in sub-section 10.3.2 and 10.4.

(1) Land acquisition and Resettlement

There is no need for additional land and resettlement for the construction of water supply facilities for Phase 2 project. The land required for Phase 2 will be managed within the area obtained during the project preparation stage for Phase 1 and/or owned by CWASA. However, before commencement of the Phase 1 Project, six households (about 40 persons) resided at the south-eastern edge of the WTP site, were relocated.

The route for the conveyance and transmission pipelines along Kaptai road shall be ensured, as negotiated with RHD both for Phase 1 and 2 Projects. Figure 10.3.1 shows the land area to be used for the expansion of facilities for Phase 2 within the area obtained for Phase 1. There is therefore no need for resettlement of people or compensation. The land where Halishahar Elevated Tank is located is owned by CWASA (as shown in Figure 10.3.1) and there is no need for resettlement of people.

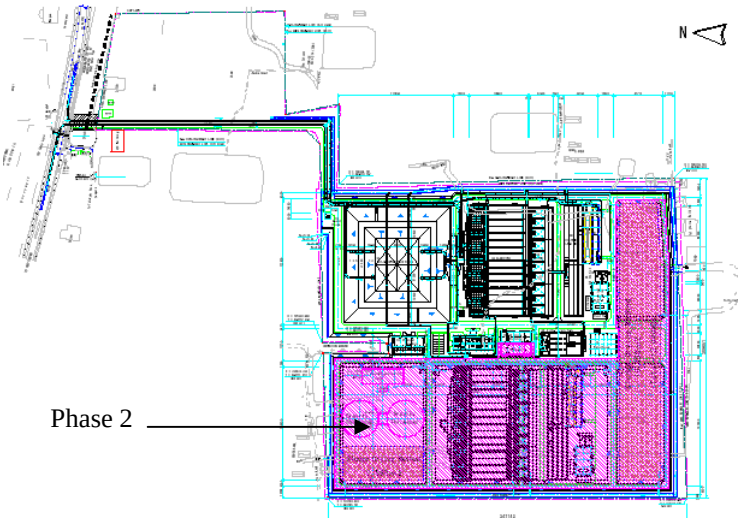
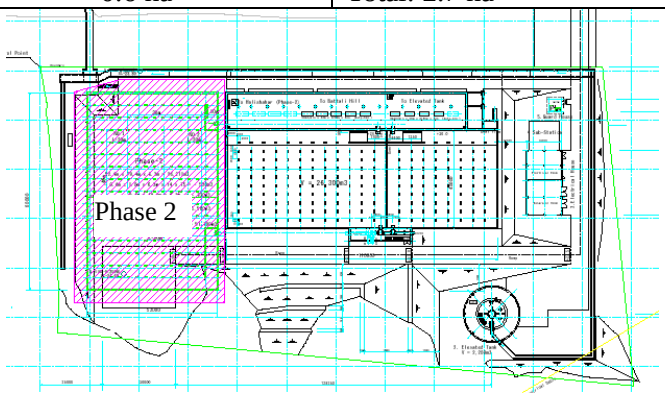
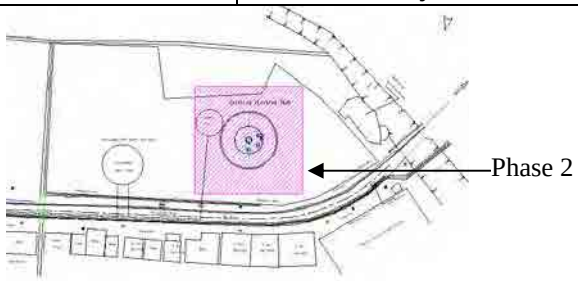
Facility	Required Area for Phase 2	Remarks
Karnaphuli WTP	5.0 ha	Total: 12.7 ha
		
Nashirabad Reservoir	0.6 ha	Total: 2.7 ha
		
Halishahar E.T	1,400 m^2	Land owned by CWASA
		

Figure 10.3.1 Land Area required for Expansion of Phase 2 Facilities within the Area obtained in Phase 1 and Additional Area

(2) People's Participation in the Project

1) Public's Response to the Project

Public consultation as a means of integration of local people's concerns into the Environmental Assessment process was conducted during the preparation stage of Phase 1 Project. The date and place of the meetings including the number of participants are shown below.

No	Date	Place	No. of Participants
1	12.09.05	Shantir Hat of Rangunia	20
2	12.09.05	Godown of Rangunia	24
3	13.09.05	Ward No.14 of Double Mooring thana	18
4	13.09.05	Ward No. 8 of Khulshi thana	20

Participants of public consultation meetings were local leaders, women's groups, representatives of professional groups such as farmers, businessmen, teachers, local elected representatives, etc. Both social and environmental consultants conducted the meetings together, which enabled them to collect/record opinions and views from their own perspectives. They explained all relevant points and issues in order to enable participants to comprehend the proposed project properly and to respond, accordingly.

The people also looked forward to participating indirectly in various economic activities and support activities associated with the project. Most of the people interviewed were not aware of any pollution hazard and also did not feel that the project would be a source of any hazard to them, except with regard to land acquisition for the project.

In general, the local people's response to the Karnaphuli Water Supply Project was positive and they were interested to receive the benefits of the project. Most of the people who live close to the treatment plant had no objection towards the implementation of the project, but they expressed concern about the loss of agricultural and productive land. The people along the pipeline did not feel concerned as the pipeline will go along an existing road. The people in the city area welcomed the project with great interest as it is likely to alleviate the problems of acute shortage of water from which they are suffering.

2) Willingness to Pay

People's "willingness to pay" for the water tariff is one of the criteria, which can be used in assessing residents' interest and understanding of the water supply service. The socio-economic survey which was conducted in July 2012 included the item "willingness to pay", as well as questions relating to various other issues, including water supply condition, sanitation and wastewater disposal. The survey was carried out in eight *Thana*s, which are part of the KSA, and answers from 1,047 properties of various types were collected. Ninety per cent of answers (939) were collected from households, and 10 per cent (107) from non-households, such as offices, hotels and schools. The results of the social survey are attached in Supporting Report 10.3.1.

(3) People's Participation in the Project

1) Public's Response to the Project

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The survey covered three types of house/ building under the category of household and samples were collected from Pucca (41%), Semi-Pucca (33%) and Kutcha (26%), with the sampling of households being equitably distributed among different income groups. The percentage of households with a water supply connection was 98% in Pucca (high income group), 84% in Semi-Pucca (middle income group) and 24% in Kutcha (low income group). The connection percentage is higher in the higher income level households than in the low income level households. Therefore, service coverage at present (47%) is mainly contributed by Pucca and Semi-Pucca in household category. The average monthly income by type of house/building is 63,182 Taka in Pucca, 25,186 Taka in Semi-Pucca and 14,716 Taka in Kutcha. The average number of people per household is 5.80 persons and the overall average monthly income is 38,051 Taka/household affected by high income level households. In Pucca households the average monthly income is about 4 times higher than in Kutcha, whereas there is not such a big difference between incomes in Semi-Pucca and Kutcha households.

The present water supply provided by CWASA is not on a 24/7 basis for the majority of the service area, with service being limited to several hours per day and not every day of the week. In the sur-

vey the overall average of water supply service hours (hrs) in a day is 3.84 hours ranging from 3.78 hrs in Pucca to 4.27 hrs in Kutcha. Regarding the relationship between service hours of water supply in a day and willingness to pay, the respondents in the group of "1-3 hour of water supply" is the most positive (78% of respondents) to paying a higher water tariff.

According to the answers from households, 74% (696) of respondents have water supply connections from CWASA with the range being from 24% to 98% in the different house/building types, as mentioned above. Residents' opinion regarding willingness to pay for an improved water supply service is relatively positive and overall an average of 76% (512) of respondents served by CWASA (ranging from 43% in Kutcha to 82% in Pucca) are willing to pay a higher water tariff for provision of an improved services. The overall average amount that respondents are willing to pay is 353 Taka/month/household (0.9% of monthly income), with the monthly amount by income level as follows:

- Pucca: 442 Taka (0.7% of monthly income)
- Semi-Pucca: 246 Taka (1% of monthly income)
- Kutcha: 198 Taka (1.3% of monthly income)

With reference to willingness to pay, respondents are willing to pay about 1% of their monthly income, which is well below 5% that is usually applied in developing countries with reference to affordability by low income households.

3) Improvement in People's Consciousness on the Importance of Water Supply

In the recent survey all of the respondents requested CWASA to provide improved water supply services in terms of 24/7 service, sufficient water pressure and water quality for drinking purposes. On the other hand, the results of the previous social survey, which was conducted in 2000, showed that 85% of respondents requested a continuous supply, 48% sufficient water pressure, 45% water quality for drinking purpose. Although the number of samples was limited to only 60 in the survey of 2000, the results imply that the residents' expectation of the water supply service was not so high, except for 24/7 service. After 12 years, people's concerns and expectations on the need for an improved water supply in all respects has drastically increased.

(3) Social Problems Caused by Construction Work and Mitigation Measures Required

During construction work for the Project inconvenience to the people's lives may occur. In this regard, topics about how to deal with residents' complaints and concerns on the construction work is discussed. On the other hand, environmental problems including social related matters and mitigation countermeasures thereto are summarized in sub-section 10.3.5, Environmental Management Plan.

1) Complaints from Residents to Construction Work

Disruption to traffic and congestion, mainly caused by pipe laying in and beside roads is potentially the reason for the highest number of complaints. In order to minimize complaints traffic management measures in major roads, such as Kaptai Road will be provided, with working areas limited to 100 meters long in order to minimize disturbance to traffic flow (refer to Chapter 8). Inconvenience to residents may also occur during the construction of the distribution network in built up areas.

To mitigate inconvenience, residents' complaints and opinions should be collected at timely public meetings in the concerned areas. Public meetings can be opportunities for building mutual understanding between residents and the Contractor/ CWASA, and people's participation in the project as well.

Residents along the conveyance and transmission pipelines (outside the CWASA service area) are not served by this Project, although they may be inconvenienced by construction work along Kaptai Road. For their benefit, community faucet systems are planned to be installed along the transmission pipeline route, as discussed in Chapter 7.

2) Residents Concern on the Migration of Large Number of Labor to the Construction Area.

According to the public consultation, residents were concerned that assembly of people during project activities may adversely influence the local environment. The problem can be negligible in the case where local residents are employed in the Project. In the case where non-local labor forces are employed, they need to be trained regarding hygienic habits and behavior. However, the influence of migration may be minimal because the increase in the number of workers is limited to the construction period.

Public meetings shall be timely conducted before and during construction work to concerned people. Further details on impacts and mitigation countermeasures are described in the following sub-sections from 10.3.3 to 10.3.5.

10.3.2 Physical Environmental Aspect

In general the following items/issues should be carefully considered to avoid, minimize and/or mitigate possible negative impacts due to the project in terms of physical environment (natural environment and items related to environmental pollution).

(1) Location of Project Sites in and Vicinity of the Protected Areas and Environmentally Sensitive Areas

1) Protected Areas

No protected area and national park/reserve are located in and around the project area. There are two wildlife sanctuaries (Pablakhali and Rampahar Sitaphar) which are located in Chittagong Zila/District, but these are not in or in the vicinity of the project area.

2) Areas with Unique Archeological, Historical or Cultural Value

Chittagong City and the neighboring areas have some historical/cultural/tourism locations such as the Tomb of Sultan Bayazid Bostami, World War II Cemetery, Shrine of Shah Amanat, etc. However, none of the locations are located in or in the vicinity of the construction sites.

3) Areas with Specific Topographical and Geological Features

Existing topographic and geological conditions are described in Chapter 2. There are no areas with specific topographical or geological feature in the project area.

(2) Vegetation, Animals and Valuable and Endangered Species

As it is located in a tropical climate zone with much rainfall, there are many trees and grass lands in Bangladesh. The Chittagong District/Zila is known for its timber-yielding plants such as teak, chambal, gurfan. Besides, there are also many medicinal plants grown in the forests. However, the vegetation areas are scattered in the urban area. Trees are mostly seen on slopes of hills, along roadsides or in the yards of houses. Trees commonly seen are Sisoo, Mahogonj, Babla, Neem, *Eucalptus sp.*, etc. In addition, fruits and horticultural crops are grown in farmlands or homesteads. These includes mango, jack fruit, coconut, etc.

There is no remarkable wildlife in the project area, except some common lizards, as human activities covering the whole area. In Chittagong District/Zila, there are some endangered species of terrestrial fauna and flora, which are recorded in an environmental data book. However, it may be unlikely to find such species in the project area.

(3) Rich Fish Resources and Fishery Activity

Both Karnaphuli River and Halda River are located upstream of the estuary of the Bay of Bengal, and are tidal rivers. Therefore, the rivers are rich in freshwater and marine fish resources having habitat of breeding and hatchery and river fishery is active. There are 76 species and 35 families of fish in the area, of which 49 species are either endangered or threatened.

(4) Specific Hydrological Conditions of Karnaphuli River and its Tributaries due to Coastal and tidal Effect

The most important hydrological characteristic of the Karnaphuli River is that it is a tidal river the river flow is influenced by the tide, with the tide reversing the direction of the river flow. Saltwater intrusion is one of the significant environmental factors for the river. The tidal flow generally reaches to a location about 10 km upstream from the confluence of the Karnaphuli and Halda Rivers. Saltwater intrusion depends on conditions such as the tide water level, discharge of the Halda and Karnaphuli Rivers.

(5) Air Pollution

In Chittagong, many old vehicles run without control of exhaust emissions and large industries are located in and around the city. Accordingly, gases (SO_X, NO_X, etc.) and suspended particles (smoke, dust, fumes and etc.) are a serious concern. However, there is no site specific air quality data. At present, the only reliable means to assess the air quality in the project area is the clear visibility of the surrounding area. The project area is located beside a number of rivers. Clean air flowing over the rivers spreads on and around the project area. From visual inspection air is clean and there is no sign of air pollution except at the roadside in populated urban areas.

(6) Surface Water Quality

Regarding point sources and non-point sources of wastewater discharge to the Karnaphuli River, the point sources such as factories are mostly located in the city except for Karnaphuli Paper mill, which is located at Chandraghona nearly 12 km upstream of the intake point. Major non-point sources of wastewater are drainage from built-up areas and agricultural fields along the Karnaphuli and Halda Rivers.

Based on the survey in the EIA study in Phase 1, water quality in the Karnaphuli River is not polluted and relatively good in comparison with that in other major rivers in the country.

(7) Ambient Noise

Chittagong is a noisy city because of many kinds of sound, especially from old vehicles. It seems that most people do not care about noise at present and the requirement for an environment without noise is much lower than in other development countries, although it may be better for the people if the environment was quieter.

(8) Solid Waste Disposal

In general, solid waste which is generated from construction work will be earth material and other materials used for concrete structures, mechanical facilities and pipes. No toxic and hazardous wastes will

be generated. However, there is a significant length of existing asbestos cement pipes in the project area. It is planned that all asbestos cement pipes will be replaced, although the pipes may remain in the ground and be abandoned. In the replacement work (including disposal of the pipes, if they are removed) such pipes should be treated carefully taking into consideration the possible health effect to workers due to inhalable fine fibers.

10.4 Identification of Possible Environmental Impacts and Necessary Measures

10.4.1 Manner of Impacts Identification and Examination

According to the procedure shown in Figure 10.4.1 the following are summarized in this sub-section.

- Identify possible negative and positive impacts caused by the project
- Study possible mitigation methods and prepare Environmental Management Plan (EMP) and environmental monitoring plan.

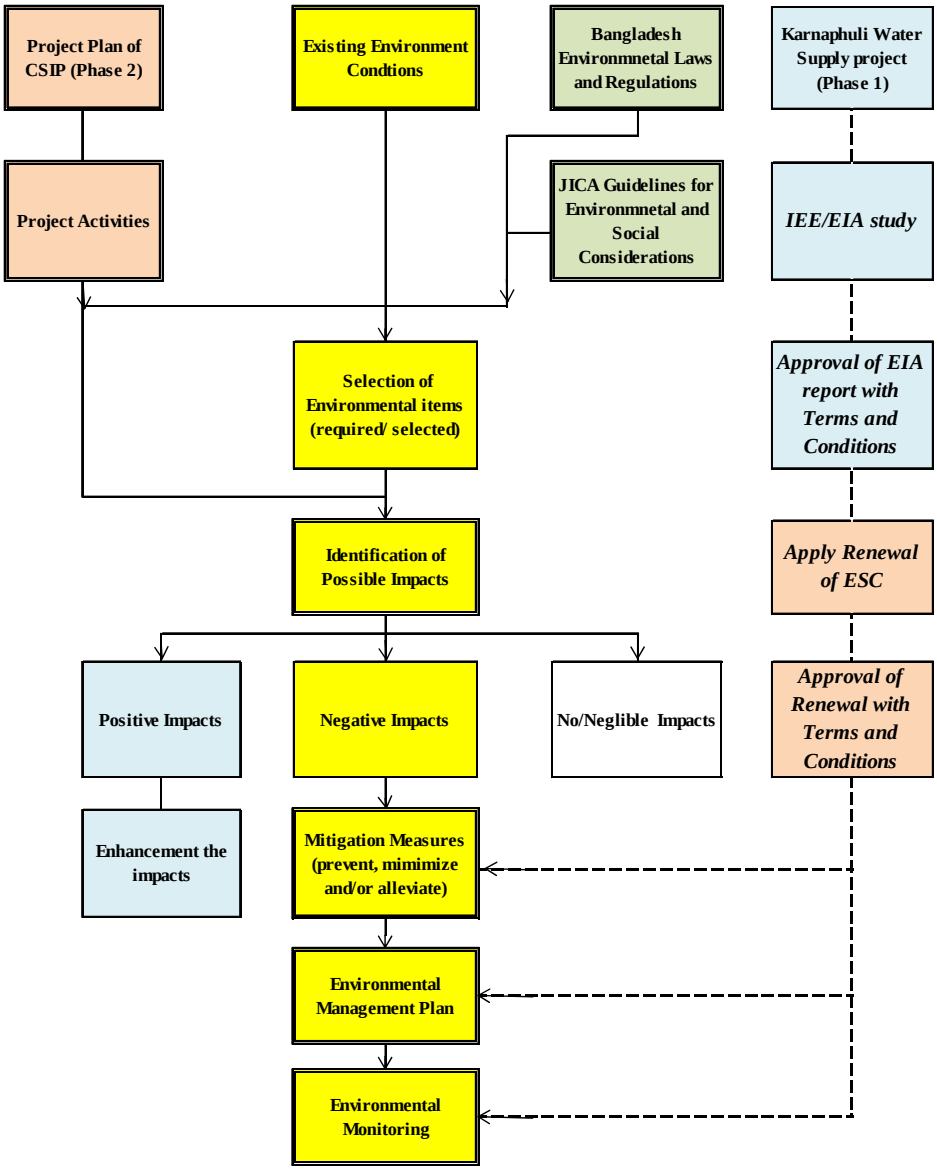

Figure 10.4.1 Flow of Identification of Possible Environmental Impacts

10.4.2 Setting of Environmental Components and Items

According to the JICA Guidelines for Environmental and Social Considerations, anticipated impacts to be assessed include those on human health and safety, as well as on the natural environment, which are transmitted through air, water, soil, waste, accidents, water usage, climate change, ecosystems, fauna and flora, including trans-boundary or global scale impacts. These also include social impacts, including migration of population and involuntary resettlement, local economy such as employment and livelihood, utilization of land and local resources, social institutions such as social capital and local decision-making institutions, existing social infrastructures and services, vulnerable social groups such as poor and indigenous peoples, equality of benefits and losses and equality in the development process, gender, children's rights, cultural heritage, local conflicts of interest, infectious diseases such as HIV/AIDS, and working conditions including occupational safety.

In addition to the direct and immediate impacts of projects, the derivative, secondary, and cumulative impacts as well as impacts associated with indivisible projects will also be assessed with regard to environmental and social considerations, so far as it is rational to do so.

In this examination by taking into consideration the above and laws and relevant guidelines of the GOB, as well as the features of the project and the location of the project area, as indicators expressing environmental and social conditions following the three environmental components, as shown below, are chosen and the components are sub-divided into a total of 35 environmental items, as shown in Table 10.4.1.

(A) Social Environment (Socio-economic Environment)
(B) Natural Environment (Physical and Biological Environment)
(C) Environmental Pollution (Physical Environment related to Pollution)

Table 10.4.1 Environmental Components/Items

Environmental Components/Items
(A) Social Environment (Socio-economic Environment)
(1) Involuntary Resettlement (Land Acquisition and Resettlement)
(2) Local economy
(3) Change in land use and utilization of local resources
(4) Social institutions such as social capital and local decision-making institutions,
(5) Existing social infrastructure and services -1 Water supply
(6) Existing social infrastructure and services -2 Others such as transport
(7) The poor, indigenous or ethnic people
(8) Misdistribution of benefit and damage
(9) Local conflict of interests
(10) Cultural property and heritage
(11) Water Rights, Fishing Rights, and Rights of Commons
(12) Public health and Sanitation
(13) Infectious diseases such as HIV/AIDS
(14) Working condition (occupational safety)
(15) Hazard/risk (disaster, security)
(16) Accidents
(B) Natural Environment (Physical and Biological Environment)
(17) Topography and Geology
(18) Soil erosion
(19) Groundwater
(20) Hydrological situation/Drainage pattern
(21) Coastal area

Environmental Components/Items
(22) Terrestrial flora, fauna and ecosystem
(23) Fishes and aquatic ecosystem
(24) Protected zone
(25) Landscape and visual amenity
(26) Local Climate
(27) Global Warming/Climate change
(C) Environmental Pollution (Physical Environment related to Pollution)
(28) Air pollution
(29) Water pollution
(30) Soil contamination
(31) Bottom sediment
(32) Waste
(33) Noise and Vibration
(34) Ground Subsidence
(35) Offensive odor

10.4.3 Anticipated Activities due to the Project

Activities related to the Project, which might affect the environment are discussed for each of the three stages of project implementation, i.e. pre-construction (planning), construction and operation stages as shown in Table 10.4.2.

Table 10.4.2 Anticipated Activities due to the Chittagong Water Supply Improvement Project (Phase 2)

Stage	Expected activities due to the project
Planning Stage (I)	Securing land/space (land acquisition. easement, resettlement etc.)
	Change in use of land and local resources
Construction Stage (II)	Construction work (earth moving and engineering works)
	Operation of plant, machines, vehicles etc.
	Installation of warehouse, plants and worker's camp
	Construction of water supply related facilities such as WTP
	Construction of pipelines for conveyance, transmission and distribution lines
Operation Stage (III)	Operation of water supply related facilities
	Spatial occupancy of the facilities

10.4.4 Identification of Anticipated Environmental Impacts

For each activity by stage shown in Table 10.4.2, the extent of the anticipated environmental impacts are evaluated one by one with rating against the 35 environmental items (social environment, natural environment and environmental pollution) which are tabulated in Table 10.4.1. In the evaluation, the following rating criteria are adopted depending on the extent of impacts.

A (+/-) – Significant positive/negative impact is expected,
B (+/-) – Positive/negative impact is expected to some extent but not significant,
C (+/-) - Extent of positive/negative impact is little but not negligible
D or Blank - Negligible or no impact is expected.

The results of the identification are shown in Table 10.4.3.

Table 10.4.3 Identification of Possible Impacts

Environmental Item	Stage			Reasons
	I	II	III	
(A) Social Environment				
(1) Involuntary Resettlement (Land Acquisition and Resettlement)	D	D	D	(I) All the necessary land and space for the project related facilities have been secured by land acquisition and relocation of people during Phase 1. Therefore, involuntary resettlement is not expected.
(2) Local economy	B+	B+	B+	(III) Beneficial impacts are expected on the local economy, such as creation of employment opportunity for public works during construction and easier access to drinking water will contribute to the reduction of the burden on women and children to collect water and improvement, thus improving living conditions.
(3) Land use and utilization of local resources	D	C-	D	(II) 1) Temporary occupancy of space for construction related facilities (office, worker's camp, material storage, waste disposal) may cause nuisance to the community and people. 2) Groundwater will be used for some construction works. (III) Amount of water used for the proposed water treatment plant is manageable, taking into account lowest flow in the Karnaphuli river
(4) Social institutions such as social capital and local decision-making institutions	B-	B-	B-	(I, II, III) If information disclosure of the project plan and procedure and public participation are not properly conducted, anxieties and complaints may spread amongst the people and communities, resulting in difficulties in obtaining a thorough understanding of the project and obtaining a consensus with them.
(5) Existing social infrastructure and services -1 Water supply	D	D	A+	(III) The project may contribute to easier access of safe drinking water and improvement in sanitary conditions, as well as a decrease in the number of cases of water-borne diseases.
(6) Existing social infrastructure and services - such as transport	D	B-	D	(II) Construction works, especially laying pipelines in existing roads may cause traffic congestion and nuisance to business activities and living conditions.
(7) The poor, indigenous or ethnic people	D	D	C+	(III) It is expected that improvement in the water supply system will contribute to a reduction in the daily workload of women and children. However, there is some concern that the load may not change, if the water tariff is higher than their willingness to pay and the site selection of public water taps is not appropriate.
(8) Misdistribution of benefit and damage	B-	B-	B-	(I, II, III) There is some possibility of misdistribution of benefit and damage, if the project plan for the water service areas and implementation plan for the construction work are not properly disseminated and consultation with residents, communities and other stakeholders is not carried out at an early stage.
(9) Local conflict of interests	B-	B-	B-	(I, II, III) There is some possibility of local conflict of interests, if the project plan for the water service areas and implementation plan for the construction work are not properly disseminated and consultation with residents, communities and other stakeholders is not carried out at an early stage.
(10) Cultural property and heritage	D	D	D	(I, II, III) There is no evidence of archaeological, historical and cultural landmarks located in and in the vicinity of the proposed project area.
(11) Water Rights, Fishing Rights, and Rights of Commons	D	D	D	(III) There no official water rights, fishery rights and rights of commons in Bangladesh. However, the Government reserves the right to allocate water to ensure equitable distribution, efficient development and use and to address poverty. Water supply for domestic and municipal use generally has priority over other uses. Therefore, infringements relating to water use and related rights are not expected in the Karnaphuli River and the project area.

Environmental Item	Stage			Reasons
	I	II	III	
(12) Public health and Sanitation	D	B-	A+	(II) Construction work may have an adverse effect on the health condition of residents and workers due to pollution and nuisance such as dust, noise and traffic congestion. (III) The supply of safe drinking water will contribute to an improvement in the health and sanitation situation, resulting in a reduction in the number of cases of water-borne diseases.
(13) Infectious diseases such as HIV/AIDS	D	B-	D	(II) In other developing countries construction workers and construction vehicle drivers are considered as having a high potential for the spread of sexually transmitted diseases (STDs) and HIV/AIDS virus due to their mobility. Infection with HIV/AIDS and venereal disease has often been reported at worker's camps in other countries.
(14) Working condition (occupational safety)	D	B-	D	(II) Many workers will be engaged in construction work and stay at worker's camps under poor living conditions. Thus, the health and safety of the workers may be jeopardized, especially due to the physical work required in construction.
(15)Hazard/risk (disaster, security)	D	B-	D	(II) Risk of security and crime are somewhat expected due to construction workers who move into and stay in the project area.
(16) Accidents	D	B-	C-	(II) An increase in the number of traffic accidents could occur due to traffic congestion and disturbance laying pipelines along roads. (III) Accidental leakage of chlorine gas for disinfection of treated water may happen.
(B) Natural Environment				
(17) Topography and Geology	D	D	D	(II) No large scale alteration of ground, which may give rise to a change in topography and geology, is expected.
(18) Soil erosion	D	B-	D	(II) Soil erosion is somewhat expected due to excavation, cutting and filling of earth and removal of vegetation cover.
(19) Groundwater	D	C-	A+	(II) Groundwater will be used for some construction work, subject to permission being received from the concerned authorities. (III) Water supply in terms of both quality and quantity will be improved by the project. Thus the present dependence on the use of groundwater will be reduced.
(20) Hydrological situation/Drainage pattern	D	C-	C-	(III) 1) Karnaphuli River discharges into the Bay of Bengal. It is a tidal river and the tidal flow generally reaches to a location about 10 km upstream from the confluence of the Karnaphuli and Halda Rivers, which is downstream of the intake point and no salinity problem has been reported, due to salt intrusion from the rising tide. 2) The impact on the river regime is expected to be negligible considering the size of the rivers and the flow discharge.
(21) Coastal area	D	D	D	(III) River mouth of Karnaphuli river is located in coastal zone of the Bay of Bengal. However, the project sites including the water intake are more than about 40 km upstream from the river mouth. Therefore, effects related to coastal erosion and sedimentation of sand are not expected.
(22) Terrestrial flora, fauna and ecosystem	D	C-	C-	(II, III) No rare, endangered or endemic terrestrial plant or animal species are expected in the project area. However, planted trees along the road contribute to the greenery and visual amenity providing relaxation and recreation area to local residents.
(23) Fishes and aquatic ecosystem	D	C-	C-	(II, III) The project area being estuarine is rich in fish resources as both marine and freshwater fish roam the area. There are 76 species and 35 families of fishes in the project area. Out of the 76 species 49 are either endangered or threatened. Both the Karnaphuli and Halda rivers are rich in fish and good locations for hatcheries. River

Environmental Item	Stage			Reasons
	I	II	III	
				fishing is active in both rivers. However, the project would not involve any direct interference with water bodies and water resources. Thus, effect on fishery resources activity is not expected.
(24) Protected zone	D	D	D	(I, II, III) There are no sites of protected areas such as National Parks, Wildlife Sanctuaries and Game reserves in the project area.
(25) Landscape and visual amenity	D	D	D	(III) No negative impact on the landscape is expected in view of the location, scale and design of water supply facilities.
(26) Local Climate	D	D	D	(III) No major infrastructure development and reclamation, which may give rise to a change in the micro-climate is expected.
(27) Global Warming/Climate change	D	D	D	(II) The amount of greenhouse gases such as CO_2, which are generated due to construction vehicles and machines, is expected to be negligible. (III) The amount of greenhouse gas emissions from diesel generators is expected to be negligible.
(C) Environmental Pollution				
(28) Air pollution	D	B-	C-	(II) Emission of air pollutants (dust, NOx, etc.) from vehicles and equipment during construction works is expected. (III) 1) Emission of air pollutants from diesel generators at the water treatment plant and other facilities is expected to be negligible. 2) In ordinary handling, chlorine gas emission is hardly expected from stored utilities and automatic injection equipment of chlorination.
(29) Water pollution	D	B-	C-	(II) 1) Discharge of wastewater from construction work and worker's camps is expected. 2) Water contamination is expected, if spillage of lubricating oil and asphalt emulsifier occurs. (III) The increase in the quantity of water supply will result in an increase in the quantity of wastewater and sludge. However, only supernatant water from the WTP will be discharged and sludge will be dried and utilized.
(30) Soil contamination	D	B-	C-	(II, III) Toxic materials such as lubricant oil and asphalt emulsifiers for construction works may give rise to soil contamination.
(31) Bottom sediment	D	D	D	Wastewater, which is discharged indirectly to the Karnaphuli River is supernatant water from the water treatment process. Thus pollution of bottom sediment is not expected.
(32) Waste	D	C-	C-	(II) 1) Generation of construction waste and garbage from worker's camps is expected. 2) Asbestos cement pipes, which are hazardous, are used in the existing distribution network. (III) Generation of sludge from water treatment plants – sludge will be dried and utilized.
(33) Noise and Vibration	D	B-	C-	(II) Generation of noise and vibration from construction vehicles, machines and plants is expected. (III) Generation of noise and vibration from water supply facilities (pumps, generator, etc.) is expected.
(34) Ground Subsidence	D	D	D	(II) Groundwater will be used for some construction works. However, the amount of groundwater will be small and not cause ground subsidence.
(35) Offensive odor	D	D	C-	(III) 1) Mal odor from water treatment sludge is hardly expected. 2) Offensive odor of chlorine gas is expected if accidental leakage may happen.

10.5 Environmental Management Plan

10.5.1 Mitigation Measures against Possible Negative Impacts

Regarding the impacts anticipated through the scoping, it is required to examine the possible mitigation measures and monitoring against negative impacts as much as possible.

Mitigation measures will minimize the negative impact to an acceptable level through the planning, construction and operation phases. Monitoring is required to ensure that the specified mitigation measures are properly carried out throughout the construction and operation stages.

As a result of identification of possible impacts shown in Table 10.5.1, the major possible negative impacts are as follows:

- Pre-Construction Stage
  (a) Change in land use and utilization of local resources

- Construction Stage
  (a) Nuisance and/or disturbance of business activities and living conditions affected by the construction work. In particular work for laying pipelines along existing roads may cause traffic congestion, resulting in nuisance and/or disturbance to business activities and living conditions in the project area.
  (b) Public health condition
  (c) Working condition
  (d) Accidents
  (e) Surface soil erosion
  (f) Hydrological condition
  (g) Air pollution
  (h) Water pollution
  (i) Noise and vibration
  (j) Solid waste disposal

- Operation Stage
  (a) Air pollution
  (b) Water pollution caused by sludge treatment at WTP
  (c) Noise and vibration caused by pump operation
  (d) Chlorine leakage from chlorine storage and injection facilities
  (e) Sewage volume increase according to the increase of water uses

- All Stages
  (a) Acceptability by people and local communities
  (b) Occurrence of conflict and discord within community due to worker's staying in the area and unfairness of benefits
  (c) Impact to Habitat of flora, fauna and endangered species
  (d) Impact to fishery resources

The proposed mitigation measures for the main negative impacts are shown in Table 10.5.1.

Table 10.5.1 Mitigation Measures against Possible Negative Impacts

Environmental Item	Stage			Mitigation Measures
	I	II	III	
(A) Social Environment				
(3) Land use and utilization of local resources	D	C-	D	(II) Plan to avoid or minimize nuisance to residents and local communities and disturbance to road transport.
(4) Social institutions such as social capital and local decision-making institutions	B-	B-	B-	(I, II, III) Information disclosure and public participation should be fully considered for all the stakeholders from the early stage of planning in order to obtain a thorough understanding of the project and consensus of the people and communities.
(6) Existing social infrastructures and services - such as transport	D	B-	D	(II) 1) In case of pipe laying work along roads, permission from concerned authorities should be obtained before start of construction works (and in the case of construction along Kaptai Road in the planning stage), by submission of drawings of pipe laying works in the roads, schedules, safety traffic control plan, etc. 2) To avoid or minimize traffic disturbance and nuisance to local people and communities, consideration should be given to pipelaying in one lane of a two way road (to allow vehicular access to be maintained), as well as providing construction signs and post with color taping, temporary fences and using watchmen. 3) In addition, at night time, the Contractor shall provide electric lighting/signal equipment indicating the location of the construction site to ensure safe traffic control and management.
(8) Misdistribution of benefit and damage	B-	B-	B-	(I, II, III) Consultation with stakeholders including residents and community organizations, should be planned from an early stage to obtain understanding and consent amongst the stakeholders in order to provide equitable benefits and damages.
(9) Local conflict of interests	B-	B-	B-	Consultation with stakeholders including residents and community organizations should be planned from an early stage to obtain understanding and consent among the stakeholders in order to avoid or minimize local conflict(s) of interests.
(12) Public health and Sanitation	D	B-	A+	(II) Proper and adequate sanitation facilities shall be ensured in labor camps throughout the proposed project period. Measures to minimize dust, noise and traffic congestion shall be taken, as mentioned in other items.
(13) Infectious diseases such as HIV/AIDS	D	B-	D	(II) 1) Education of and campaign of prevention and cure of HIV/AIDS to residents and construction workers. 2) Monitoring of cases of HIV/AIDS before, during and after the construction stage.
(14) Working condition (occupational safety)	D	B-	D	(II) 1) Proper and adequate sanitation facilities shall be ensured in labor camps throughout the proposed project period. 2) Medical check for workers, as required.
(15)Hazard/risk (disaster, security)	D	B-	D-	(II) 1) Consult with police and local government and establish vigilantes composed of CBOs and residents, if necessary. 2) Education of workers to keep manners and obey community rules. 3) Monitoring of cases and causes of hazard risks.
(16) Accidents	D	B-	C-	(II) 1) Suitable planning and management over construction work to prevent and minimize the number and consequences of accidents. 2) Monitoring cases and causes of accidents.
(B) Natural Environment				
(18) Soil erosion	D	B-	D	(II) 1) Soil erosion caused by removal of vegetation cover and excavated loose soil shall be checked and replantation with local vegetation carried out as soon as possible, as necessary. 2) Loose soil shall be covered and stored away from the edge of the hoar/rivers.
(19) Groundwater	D	C-	A+	Measures to prevent infiltration of polluted water to the ground and groundwater shall be implemented.
(20) Hydrological situation/Drainage pattern	D	C-	C-	(II, III) 1) Monitoring hydrological situation of Karnaphuli River as relevant to the river regime ,such as water level, discharge from Kaptai Lake, tid-

Environmental Item	Stage			Mitigation Measures
	I	II	III	
				al/saline water intrusion, etc. by collecting data from meteorological and hydrological observatories in the Karnaphuli River Basin and by visual inspection.
(22) Terrestrial flora, fauna and ecosystem	D	C-	C-	(II, III) 1) Proper and adequate on-site precautionary measures and safety measures shall be ensured so that no habitat of any flora and fauna would be demolished or destroyed. 2) No activity of cutting/razing/dressing of hills or hilly land shall be carried out without permission/clearance of the concerned authority of the government.3) Monitoring by visual inspection, as required.
(23) Fishes and aquatic ecosystem	D	C-	C-	(II, III) Proper and adequate on-site precautionary measures shall be ensured so that discharge of water (that does not meet the prevailing legislation), fuel, chemicals, etc. to rivers, watercourses does not occur (refer also to item 29).
(C) Environmental Pollution				
(28) Air pollution	D	B-	C-	(II) 1) Vehicles, machines and plant shall be properly and adequately maintained. 2) Water trucks shall be used and material stockpiles shall be located away from sensitive receptors. Vehicle speed limits shall be enforced. (III) To prevent accidental chlorine gas leakage from chlorine storage facilities and chlorine injection facilities, mitigation measures such as use of automatic injection equipment, safe operation and maintenance practices and provision of training to O&M personnel will be incorporated in the design of the facilities (as for Phase 1) and lessons learned from Phase 1 will be included in Phase 2. In addition, the existing Mohara water treatment which includes chlorination has been operated safely since commencement of operation.
(29) Water pollution	D	B-	C-	(II) 1) Measures for preventing spillover of soil and other construction materials due to earthmoving work. Proper treatment of water pollutants generated from construction work to comply with water quality regulation. (III) 1) Sludge generated from the water treatment plant should be dried and reused as manure and/or strengthening soil foundation. 2) After sludge treatment most of supernatant water will be sent back to WTP and some portion of supernatant water will be overflown to Karnaphuli river through nearby canal.
(30) Soil contamination	D	B-	C-	(II) Prevent spill over or leakage of toxic materials such as lubricant oil and asphalt emulsifiers into the soil.
(32) Waste	D	C-	C-	(II) 1) Consider ways to minimize waste generation in the construction work plan. 2) Proper treatment and disposal of wastes generated from construction work. 3) The open areas that are grasslands can be used for construction but with appropriate safeguards to maintain materials and dump sites from contaminating watercourses/rivers. 4) Where new pipelines are to be laid along the route of existing asbestos cement pipes and it is necessary to remove the existing pipes, these shall be handled and disposed of safely.
(33) Noise and Vibration	D	B-	C-	(II, III) 1) Vehicles, machines and plants shall be maintained regularly. 2) Working during sensitive hours and locating machinery close to sensitive receptors shall be avoided. 3) Use equipment with low noise and vibration. 4) Installation of soundproof walls/acoustic enclosures and provision of buffer zones.
(35) Offensive odor	D	D	C-	(III) 1) Strict management for use of chlorine. 2) Monitoring of leakage. 3) Good maintenance/ storage and injection facilities.

10.5.2 Environmental Management Plan (EMP)

The Environmental Management Plan (EMP) should be prepared for effectively implementing the mitigation measures. The EMP includes various monitoring plans, which may be necessary to confirm the level of impacts or the effectiveness of the mitigation measures. The EMP is shown in Table 10.5.2.

Table 10.5.2 Environmental Management Plan

Possible Negative Impact	Rating	Mitigation Measures (Further Survey, Mitigations and Monitoring)	Responsibility	
			Imple-mentation	Super-vising
I. Pre-Construction Stage				
No negative impact				
II. Construction Stage				
(1) Temporary occupancy of space for construction related facilities (office, worker's camp, material storage, waste disposal) may cause nuisance to the community and people.	C-	Plan to avoid or minimize nuisance to residents and local communities and disturbance of road transport.	Contractor	CWASA, Consultant, DOE
(2) Construction works, especially laying pipelines along existing roads may bring about traffic congestion and nuisance to business activities and living conditions.	B-	1) In case of pipe laying work along roads, permission from concerned authorities should be obtained before start of construction works (and in the case of construction along Kaptai Road in the planning stage), by submission of drawings of pipe laying works in the roads, schedules, safety traffic control plan, etc. 2) To avoid or minimize traffic disturbance and nuisance to local people and communities, consideration should be given to pipe laying in one lane of a two way road (to allow vehicular access to be maintained), as well as providing construction signs and post with color taping, temporary fences and using watchmen. 3) In addition, at night time, the Contractor shall provide electric lighting/signal equipment indicating the location of the construction site to ensure safe traffic control and management.	Contractor	CWASA, Consultant, DOE
(3) Construction work may have an adverse effect on health conditions of residents and workers due to pollution and nuisance such as dust, noise and traffic congestion.	B-	Proper and adequate sanitation facilities shall be ensured in labor camps throughout the proposed project period. Measures to minimize dust, noise and traffic congestion shall be taken, as mentioned in other items.	Contractor	CWASA, Consultant, DOE
(4) In other developing countries construction workers and construction vehicle drivers are considered as having high potential for the spread of sexually transmitted diseases (STDs) and HIV/AIDS virus due to their mobility. Infection with HIV/AIDS and venereal disease has often been reported at worker's camps in other countries.	B-	1) Education of and campaign of prevention and cure of HIV/AIDS to residents and construction workers. 2) Monitoring of cases of HIV/AIDS before, during and after the construction stage.	Contractor	CWASA, Consultant, DOE

Possible Negative Impact	Rating	Mitigation Measures (Further Survey, Mitigations and Monitoring)	Responsibility	
			Imple-mentation	Super-vising
(5) Many workers will be engaged in construction work and stay in worker's camps under poor living condition. Thus, the health and safety of the workers may be jeopardized, especially due to the physical work required in construction.	B-	1) Proper and adequate sanitation facilities shall be ensured in labor camps throughout the proposed project period. 2) Medical check for workers, as required.	Contractor	CWASA, Consult-ant, DOE
(6) Risk of security and crime are somewhat expected due to construction workers who move into and stay in the project area.	B-	(1) Consult with police and local govern-ment, and establish vigilantes composed of CBOs and residents, if necessary. 2) Educa-tion of workers to keep manners and obey community rules. 3) Monitoring of cases and causes of hazard risks.	Contractor	CWASA, Consult-ant, DOE
(7) An increase in number of traffic accidents could occur due to traffic congestion and disturbance laying pipe-lines along roads.	B-	(II) 1) Suitable planning and management of construction work to prevent the number and minimize the consequences of accidents. 2) Monitoring cases and causes of accidents.	Contractor	CWASA, Consult-ant, DOE
(8) Soil erosion is somewhat expected due to excavation, cutting and filling of earthmoving work and removal of veg-etation cover.	B-	1) Soil erosion caused by removal of vegeta-tion cover and excavated loose soil shall be checked and replantation with local vegeta-tion carried out as soon as possible, as nec-essary. 2) Loose soil shall be covered and stored away from the edge of the hoar/river.	Contractor	CWASA, Consult-ant, DOE
(9) Groundwater will be used for some construction work subject to permission being received from the concerned authorities.	C-	Measures to prevent infiltration of polluted water to the ground and groundwater shall be implemented.	Contractor	CWASA, Consult-ant, DOE
(10) Emission of air pollutants (dust, NOx, etc.) from vehicles and equipment during construction works is expected.	B-	1) Vehicles, machines and plant shall be properly and regularly maintained. 2) Water trucks shall be used and material stockpiles shall be located away from sensitive recep-tors. Vehicle speed limits shall be enforced.	Contractor	CWASA, Consult-ant, DOE
(11) Discharge of wastewater from construction work and worker's camps is expected.	B-	1) Wastewater should be collected to the pit temporary constructed and discharged to water bodies after treatment by sedimentation process to comply with wastewater quality standards. 2) Sludge and/or sediment includ-ing clay and silt etc. should be reused or dis-posed of.	Contractor	CWASA, Consult-ant, DOE
(12) Toxic materials such as lubricant oil and asphalt emulsifiers for construc-tion works may give rise to soil con-tamination.	B-	In order to prevent spillover or leakage of toxic materials such as lubricant oil and as-phalt emulsifiers into soil, following measures should be implemented: (i) To keep clean storage sites of construction equipment, (ii) To install storage tank for preventing spill and leakage of lubricating oil and grease, etc. and (iii) Training of workers for proper handling of toxic materials.	Contractor	CWASA, Consult-ant, DOE

Possible Negative Impact	Rating	Mitigation Measures (Further Survey, Mitigations and Monitoring)	Responsibility	
			Imple-mentation	Super-vising
(13) Generation of construction waste and garbage from worker's camp.	C-	1) Consider ways to minimize waste generation in the construction work plan. 2) Proper treatment and disposal of waste generated from construction work. 3) The open areas that are grasslands can be used for construction but with appropriate safeguards to maintain materials and dump sites from contaminating watercourses/river waters.	Contractor	CWASA, Consultant, DOE
(14) Asbestos cement pipes are used for existing distribution pipes in some parts of the project area.	B-	1) If asbestos cement pipes are found, they should be abandoned and replaced by pipes made of other materials, which are safe enough. 2) At present in Bangladesh there is no clear provision regarding regulation of asbestos waste. Therefore, at first to consult measures for safe treatment and disposal of asbestos cement pipes and asbestos debris with DOE and other responsible organizations. In this regards Japanese laws and manuals such as Waste Management and Public Cleansing Law, Industrial Safety and Health Law, and "Manual for asbestos treatment and disposal of asbestos containing wastes" (Ministry of Environment, 2007.3. In Japanese) will be useful. 3) To confirm the existence of asbestos cement pipes for the replacement of pipes. 4) The replacement work of old asbestos cement pipes should be treated carefully taking into consideration possible health effect to workers by inhaling and adhering scattered fine fibers. Thus, the workers should be equipped with helmets, masks, shoes and wears to prevent inhalation and adhesion of asbestos fibers. All the equipped materials should be separately stored and safely disposed after replacement work. 5) While loading, unloading and transport, dug out asbestos cement pipes should be covered with plastic sheets and/or packed with closed containers or bags marking a sign of hazardous asbestos. 6) Collected asbestos pipes should be solidified with cement and/or transferred to secured final disposal site.	Contractor	CWASA, Consultant, DOE
(15) Generation of noise and vibration from construction vehicles, machines and plant.	B-	(II, III) 1) Vehicles, machines and plant shall be properly and regularly maintained. 2) Working during sensitive hours and locating machinery close to sensitive receptors shall be avoided. 3) Use equipment with low-noise and vibration. 4) Installation of soundproof walls/acoustic enclosures and provision of buffer zones.	Contractor	CWASA, Consultant, DOE
III. Operation Stage				

Possible Negative Impact	Rating	Mitigation Measures (Further Survey, Mitigations and Monitoring)	Responsibility	
			Imple-mentation	Super-vising
(1) The increase in the quantity of water supply will result in an increase in the quantity of wastewater and sludge.	C-	Sludge generated from water treatment plant should be dried and reused. 2) Supernatant separated from sludge will be sent back to water treatment process, some portion of which will be overflown to Karnaphuli river through nearby canal. Water quality of the supernatant complies with Bangladesh wastewater standards (such as SS 150 mg/l and BOD 50 mg/l) by flocculation, sedimentation and sand filtration process.	CWASA	CWASA, DOE
(2) The increase of water supply will generate an increase in the quantity of discharged water and sludge.	C-	Proper implementation plan to manage that only supernatant after water treatment process will be discharged and sludge produced in water treatment process will be dried and reused.	CWASA	CWASA, DOE
(3) Toxic materials such as lubricant oil and asphalt emulsifiers for construction works may give rise to soil contamination.	C-	(II) Prevent spillover or leakage of toxic materials such as lubricant oil and asphalt emulsifiers into the soil.	CWASA	CWASA, DOE
(4) Generation of sludge from water treatment plants. However, water treatment sludge was dried and already utilized to manure.	C-	(II) 1) Consider ways to minimize waste generation in the construction work plan. 2) Proper treatment and disposal of wastes generated from construction work. 3) The open areas that are grassland can be used for construction but with appropriate safeguards to maintain materials and dump sites from contaminating hoar/river waters.	CWASA	CWASA, DOE
(5) Generation of noise and vibration from water supply facilities (pumps, diesel generator, etc.)	C-	(II, III) 1) Vehicles, machines and plant shall be properly and regularly maintained. 2) Working during sensitive hours and locating machinery close to sensitive receptors shall be avoided. 3) Use equipment with low noise and vibration. 4) Installation of soundproof walls/acoustic enclosures and provision of buffer zones.	CWASA	CWASA, DOE
(6) Malodor due to leakage of chlorine	C-	(III) 1) Strict management for use of chlorine. 2) Monitoring of leakage. 3) Good maintenance/ storage of injection facilities.	CWASA	CWASA, DOE
IV. One or More Stages				
(1) If information disclosure of the project plan and procedure and public participation are not properly conducted, anxieties and complaints may spread amongst the people and communities, resulting in difficulties in obtaining a thorough understanding of the project and obtaining a consensus with them.	B-	(I, II, III) Information disclosure and public participation should be fully considered for all the stakeholders from early stage of planning in order to obtain a thorough understanding of the project and consensus of the people and communities.	CWASA	CWASA, DOE

Possible Negative Impact	Rating	Mitigation Measures (Further Survey, Mitigations and Monitoring)	Responsibility	
			Imple-mentation	Super-vising
(2) There is some possibility of misdistribution of benefit and damage, if the project plan for the water service areas and implementation plan for the construction work are not properly disseminated and consultation with residents, communities and other stakeholders is not carried out at an early stage.	B-	(I, II, III) Consultation with stakeholders, including residents and community organizations should be planned from an early stage to obtain understanding and consent amongst the stakeholders in order to share equally benefits and damage.	CWASA	CWASA, DOE
(3) There is some possibility of local conflict of interests, if the project plan for the water service areas and implementation plan for the construction work are not properly disseminated and consultation with residents, communities and other stakeholders is not carried out at an early stage.	B-	(I, II, III) Consultation with stakeholders, including residents and community organizations, should be planned from early stage to obtain understanding and consent amongst the stakeholders in order to avoid or minimize local conflict of interests.	CWASA	CWASA, DOE
(4) 1) Karnaphuli River discharges into the Bay of Bengal. It is a tidal river and the tidal flow was observed to take place up to about 10 km upstream of the confluence with the Halda River However, the rising tide cannot come up to the intake point and no salinity problem was reported due to salt intrusion from the rising tide. 2) The impact on the river regime is expected to be negligible considering the size of the rivers and the flow discharge.	C-	(II, III) 1) Monitoring hydrological situations of Karnaphuli River relevant to river regime such as water level and discharge from Kaptai Lake, tidal/saline water intrusion, etc. by collecting data from meteorological and hydrological observatories in the Karnaphuli River Basin and by visual inspection.	CWASA	CWASA, DOE
(5) No rare, endangered or endemic terrestrial plant or animal species are expected in the project area. However, planted trees along the road contribute to the greenery and visual amenity providing relaxation and recreation area to local residents.	C-	(II, III) 1) Proper and adequate on-site precautionary measures and safety measures shall be ensured so that no habitat of any flora and fauna would be demolished or destroyed. 2) No activity of cutting/razing/dressing of hill or hilly land is endorsed without permission/clearance of the concerned authority of the government.3) Monitoring by visual inspection, as required.	Contractor, CWASA	CWASA, DOE
(6) The project area being estuarine is rich in fish resources as both marine and freshwater fish roam the area. There are 76 species and 35 families of fishes. Out of the 76 species 49 species are either endangered or threatened. Both Karnaphuli and Halda rivers are rich in fish and good location for hatcheries. River fishing is active in both rivers. However, the project would not involve any direct interference with water bodies and water resources. Thus, effect on fishery resources activity is not expected.	C-	(II, III) Proper and adequate on-site precautionary measures shall be ensured so that discharge of water (that does not meet the prevailing legislation), fuel, chemicals, etc. to rivers, watercourses does not occur.	Contractor, CWASA	CWASA, DOE

In preparation for implementation of the EMP, the following items should be considered.

(1) Institutional arrangement with staffing

The establishment of a practical organization for the implementation of effective and necessary environmental mitigation measures is essential.

Although there are alternative organizations that could be considered, the most suitable one is as follows:

- Establishment of an Environment department/section in CWASA. The Environmental section would be in charge of all environmental issues, including preparing the definite/detailed plans for environmental management and monitoring, as well as implement these plans effectively. This section would also be in charge of legal procedures and public relation matters with local residents, CBOs and relevant stakeholders.
- Establishment of cooperative relationship with related government offices/agencies including the Chittagong regional office of DOE.

(2) Compliance with Bangladesh Laws, Standards and Regulations as well as the JICA Guidelines

In general, attention to environmental matters by the GOB is high. There is already a well-established legislative system in Bangladesh including ECA, ECR and EIA guidelines. The Bangladesh environmental standards cover all the basic items such as water pollution, air pollution, noise, odor, etc.

(3) People's Participation

People's participation in the environmental control and management is considered to be an essential matter. It will be effective from various viewpoints such as cost saving, avoiding disputes, enhancement of people's concerns, taking quick measures, etc.

The environment section (to be established) is required to consider the people's participation for preparation of the implementation plan.

(4) Preparation of Implementation Plan

For implementing the mitigation measures of the predicted environmental impacts, a definite implementation plan is required to be prepared. The implementation plan needs to contain the implementation schedule, the organization and staffing, the section/division of objective sites, the survey and monitoring program, the budget allocation, the facilities & equipment list, etc.

10.5.3 Emergency Response Plan

In the terms and conditions, which accompanied with Issuance of ESC and Approval of EIA Report on Karnaphuli Water Supply Project by DOE, the following issues shall be considered (See Table 10.2.2 III (10) Environmental Management Plan).

- 1.9 All the required mitigation measures suggested in the IEE and EIA reports along with the emergency response plan are to be strictly implemented and kept operative/functioning on a continuous basis.

Therefore, an Emergency Response Plan (ERP) shall be prepared for the Phase 2 Project referring to the IEE and EIA report and considering additional items to address emergent environmental risks.

(1) Emergency situation and design of ERP

In general, the following emergency situations may occur during the construction and operation stage.

- Serious injury or fatality
- Vehicle accident
- Major property or equipment damage
- Electric shock
- Fire
- Gas leakage
- Natural hazards
- Security breach

(2) Emergency response system and procedure

It is required in any pre-set emergency response procedure that the ERP includes at least implementation and training in the following procedures.

All the construction and operation work shall be done utilizing good practice in responding to the requirement of emergency work and as such:

- All tools, equipment, machinery and materials shall be properly stored such that they can be used immediately on call.
- Procedures and routes for emergency escape shall be established
- Presence of employees and members of the public, if involved, must be taken into account for evacuation
- Emergency shut-down procedures should be established and qualified personnel should be available
- Accounting for all employees after emergency evacuation shall be carried out
- Rescue procedures shall be established, as well as medical duties for employees who will perform rescues
- Preferred means of reporting fires and other emergencies shall be established
- Names and job titles of persons to contact for more information about the plan shall be included.

(3) Alarm systems

The CWASA shall establish a system to alert all employees of an emergency within the operation facility. If the alarm system is meant to serve more than one purpose, it should emit a different sound for each purpose. As a result, no one should mistake an evacuation alarm for one that signals the need for the emergency response team.

(4) Training

CWASA shall train all concerned employees regarding use and purpose of the Emergency Response Plan, including:

- When the plan is developed
- Whenever emergency action plan responsibilities change
- Whenever the plan changes.

(5) Standard Operating Practices (SOPs)

Carefully written practices (procedures) will form the basis for implementing and recommendations as well as action plan for environmental and safety.

Practices will specify who is to carry out tasks, give step-by-step instructions for how tasks are to be accomplished, and include directions for dealing with departures from the practices. Setting and maintaining effective practices involves five stages:

1) hazard identification,
2) risk assessment,
3) identifying risk control measures,
4) preparing and implementing procedures to maintain control; and
5) on-going audit and review of those procedures.

(6) Approach to emergency response

Emergency response systems should be in place to deal with dangerous goods if any, uncontrolled releases spills, natural calamities, fires, burns and injuries. There shall be trained emergency response teams, specific contingency plans and incident specific equipment packages in place to cope with the above types of emergency. Should an incident occur immediate action must be taken to mitigate the impacts. In order to minimize the possibility of injury to the people who respond to an emergency and others it is important that the people who respond follow a specific sequence of actions, which are clearly stated in the SOPs of CWASA.

10.5.4 Environmental Monitoring Plan

As part of the environmental management plan, environmental monitoring needs to be undertaken to ensure that the mitigation measures are implemented and have the intended result.

In order to implement the environmental monitoring effectively following institutional arrangement should be done:

(1) CWASA

In CWASA officer(s) in charge of environment and safety management should be assigned. In addition, the officer(s) should collaborate with the officer(s) in charge of Operation & Maintenance for following matters:

- Ensure worker's health and safety and to cope with accidents during both construction and operation stages and;
- Comply with Bangladesh environmental standards during operation.

Environmental Specialist (officer) shall be transferred to O&M organization after construction work.

(2) Contractor

The Contractor side should assign staff/engineer(s) who will be responsible to environment and safety management for the whole construction work. The staff/engineer(s) should consult with CWASA as required.

The environmental monitoring plan is shown in Table 10.5.3.

Table 10.5.3 JICA Monitoring Plan - Karnaphuli Water Supply Improvement Project (Phase 2)

Monitoring Item	Parameter	Subject /Location of Monitoring	Meth-ods/Relevant Standards	Frequency	Responsibility
I. Pre-Construction Stage (Planning Stage)					
(1) Social Environment					
Involuntary Resettle-ment	Not applicable - Neither land acquisition nor resettlement id expected.				
(2) Natural Environment					
Almost all items	Not applicable – already surveyed in Phase 1 project.				
(3) Environmental Pollution					
1) Air quality	Dust from surface soil and exhaust emissions	Around WTP and related facilities	1) Complaint by people, 2) Visual inspection	As required	CWASA (Officers in charge of Environment Management)
2) Noise and vibration	Nuisance due to noise and vibration	Project area	1) Complaint by people, 2) Physical observation	As required	CWASA (Officers in charge of Environment Management)
3) Surface water qual-ity	pH, turbidity, Chlo-ride, COD	3 Stations of Karnaphuli and Halda River*	Bangladesh Standard for In-land Surface Water	Monthly	CWASA (Officers in charge of Environment Management)
II. Construction Stage					
(1) Social Environment					
1) Nui-sance/disturbance of living conditions and business activities	Cases and causes	Construction sites	(1) Complaint by people, (2) Physi-cal observation	As required	Contractor (Staff in charge of Environmen-tal Management)
2) Accident	Cases and causes	Construction sites	(1) Report of ac-cidents, (2) Com-plaint by people	As required	Contractor (Staff in charge of Environmen-tal and Safety Manage-ment)
3) Worker's health	General health condition and communicable diseases such as water-borne dis-eases	Construction sites	Medical consulta-tion and examina-tion	Occasional and as re-quired	Contractor (Staff in charge of Environmen-tal and Safety Manage-ment)
4) Worker's safety	Cases and causes of accidents	Construction sites	(1) Report of ac-cidents, (2) Com-plaint by workers	As required	Contractor (Staff in charge of Environmen-tal and Safety Manage-ment)
(2) Natural Environment					
1) Soil erosion	Cases and causes	Construction sites	(1) Complaint by people, (2) Visual inspection	As required	Contractor (Staff in charge of Environmen-tal Management)
2) Change in flora, fauna and terrestrial and aquatic ecosystem	Habitat of flora and fauna	Project area	(1) Complaint by people, (2) Visual inspection	As required	Contractor (Staff in charge of Environmen-tal Management)
3) Change in fishery resources	Habitat of fish and fish breeding, feeding and nursery sites	Project area	(1) Complaint by people, (2) Visual inspection	As required	Contractor (Staff in charge of Environmen-tal Management)
(3) Environmental Pollution					
1) Air quality	Dust from surface	Construction	(1) Complaint by	As required	Contractor (Staff in

Monitoring Item	Parameter	Subject /Location of Monitoring	Methods/Relevant Standards	Frequency	Responsibility
	soil and exhaust emissions	Sites	people, (2) Visual inspection		charge of Environmental Management)
2) Noise and vibration	Nuisance due to noise and vibration	Construction Sites	(1) Complaint by people, (2) Physical observation	As required	Contractor (Staff in charge of Environmental Management)
3) Surface water quality	Temperature, pH, turbidity, Chloride, COD	3 Stations of Karnaphuli and Halda River*	Bangladesh Standard for Inland Surface Water	Monthly	Contractor (Staff in charge of Environmental Management)
4) Wastewater	Countermeasures for wastewater control	Construction sites	(1) Visual inspection, (2) Complaint by people	Monthly	Contractor (Staff in charge of Environmental Management)
5) Solid waste	Countermeasures for solid waste disposal	Construction sites	(1) Visual inspection, (3) Complaint by people	Monthly	Contractor (Staff in charge of Environmental Management)
III. Operation Stage					
(1) Social Environment					
1) Acceptability of the project	Complaints	Project area	1) Complaint by people, 2) Interview survey, if necessary	Occasional and as required	CWASA (Officers in charge of Environment Management)
2) Accident	Cases and causes	Project area	(1) Report of accidents, (2) Complaint by people	As required	CWASA (Officers in charge of Environment Management/Operation & Maintenance)
(2) Natural Environment					
1) Change in flora, fauna and terrestrial and aquatic ecosystem	Habitat of flora and fauna	Project area	(1) Complaint by people, (2) Visual inspection	As required	CWASA (Officers in charge of Environment Management)
2) Change in fishery resources	Habitat of fish and fish breeding, feeding and nursery sites	Project area	(1) Complaint by people, (2) Visual inspection	As required	CWASA (Officers in charge of Environment Management)
(3) Environmental Pollution					
1) Noise and vibration	Nuisance due to noise and vibration	Around WTP, Nashirabad reservoir and Halishahar Elevated tank	(1) Complaint by people, (2) Physical observation	As required	CWASA (Officers in charge of Environment Management/Operation & Maintenance)
2) Surface water quality	Temperature, pH, turbidity, Chloride, COD	3 Stations of Karnaphuli and Halda River*	Bangladesh Standard for Inland Surface Water	Monthly	CWASA (Officers in charge of Environment Management/Operation & Maintenance)
3) Effluent quality	Temperature, pH, turbidity, Chloride, SS, COD	Effluent discharge from WTP	Standards for Industrial and Project Effluent	Monthly	CWASA (Officers in charge of Environment Management/Operation & Maintenance)
4) Drinking water quality	pH, turbidity, Chloride, hardness, re-	At least one tap water for	Bangladesh Standards for	Monthly	CWASA (Officers in charge of Environment

Monitoring Item	Parameter	Subject /Location of Monitoring	Meth-ods/Relevant Standards	Frequency	Responsibility
	sidual Chlorine, Total Coliform group bacteria	each sub-system	Drinking Water		Management/Operation & Maintenance)

*Note: * 3 monitoring stations of river water quality (Upstream of intake point of Karnaphuli River, downstream of WTP effluent discharge point, and downstream of confluence with Halda River)*

In the terms and conditions, which accompanied the Issuance of ESC and Approval of EIA Report on Karnaphuli Water Supply Project by DOE (See Table 10.2.2 V), following matters are required for environmental monitoring.

(1) Record of monitoring

Monitoring and Recording conditions

1) The results of any monitoring required to be conducted by this Clearance Certificate must be recorded.

2) The following records must be kept in respect of any samples required to be collected for the purpose of this Clearance certificate: (a) The date(s) on which the sample was taken; (b) The time(s) at which the sample was collected; (c) The point at which the sample was taken; and (d) The name of the person who collected the sample.

(2) Monitoring items and timing

Requirement to monitor concentration of pollutants discharged. For each monitoring, the Clearance Certificate holder must monitor (by sampling and obtaining results by analysis) the following parameter; (a) water flow, water quality, air quality (SPM), the surrounding areas for spread of invasive species, the changes in aquatic habitats before, during and after construction, (b) fish catching during and after construction.

(3) Reporting

Reporting Conditions: Environmental Monitoring Reports shall be made available simultaneously to Head Quarters and respective Divisional offices of the Department of Environment on a quarterly basis during the whole period of the project.

(4) Notification of Environmental Harm

The Clearance Certificate holder or its employees must notify the Department of Environment of incidents causing or threatening material harm to the environment as soon as practicable after the person becomes aware of the incident.

10.6 Environmental Checklist

10.6.1 Bangladesh Environmental Checklist

Screening of potential environmental impacts and mitigation measures has been carried out for Phase 2 Project according to the Bangladesh Environmental Checklist. The results are shown in Supporting Report 10.6.1.

10.6.2 JICA Environmental Checklist and Monitoring Form

Based on the results in 10.4, confirmation of environmental and social considerations for the Phase 2 Project are carried out according to the JICA Environmental Checklist (No.14 Water Supply) and included in Supporting Report 10.6.2.

CHAPTER 11

IMPLEMENTATION PLAN AND CONSTRUCTION COST ESTIMATES

CHAPTER 11 IMPLEMENTATION PLAN AND CONSTRUCTION COST ESTIMATES

11.1 Issues and Problems in the Implementation of Phase 1 Project

The Phase 1 Project was planned to be completed by the year 2010; however, as of September 2012 an additional 5 years may be necessary up to the year 2015 considering the present progress of the construction work. The major reasons for the delay of the Project are summarized below. Referring to the problems in Phase 1, the Phase 2 Project shall be planned.

(1) Procurement of Consultants and Contractors

1) Consultants Selection

It took about 2 years for the selection of Consultants for design and construction supervision of the water supply facilities covering all packages in the Phase 1 Project. At least about one year more than the original schedule was required, mainly because of following reasons.

- Lack of experience of personnel in charge in the evaluation of the technical proposal and timely completion of selection process by CWASA in the procurement process was weak.
- It took a longer time than scheduled to obtain approval from the GOB.

2) Contractor Selection

Additional time was required for the contract negotiations, due to insufficient documents being submitted by the bidders on their qualification and experience for particular items to be procured, such as experience in manufacturing of large diameter pipes.

(2) Land acquisition for the WTP

It took a long time to obtain the land area for the WTP, which resulted in the preparation of the detailed design of the WTP being delayed by more than 1.5 years compared to the schedule.

(3) Management capacity of the contractors

The capability of the Contractor undertaking Package 1 (Intake and WTP) in construction management is poor (including management of sub-contractors and ability to communicate in English) and the Project Manager has been changed several times. The construction plan and shop drawings have not properly prepared and submitted timely to the Consultant, because of the limited experience and quality of the assigned engineers, as well as the overall management capacity. Among four packages, C1contract for construction of intake facilities and WTP, and C3 contractor for construction of reservoir are quite behind the schedule as of October, 2012 (17 % delay against planned performance of 23% for C1 and 27% delay against planned performance of 87% for C3).

(4) Influence by the climate

The rainy season this year has been extended with some heavy rainy days, which disturbed site preparation work including construction of access roads.

11.2 Conditions and Assumptions for Preparation of Implementation Plan

The implementation Plan for the Phase 2 Project shall be established referring to the lessons from the Phase 1 Project, as summarized in sub-section 11.1, and particular conditions and assumptions to be considered for the Phase 2 project.

(1) Needs for Improvement from the Phase 1 arrangements

1) Procurement of Consultants and Contractors

a) Selection of Consultants: CWASA shall employ an experienced and capable procurement specialist and on-the-job training by the Consultants specialist shall be provided for him before and during bidding stage for the selection of contractors. The approval process for the selection of the Consultants shall be simplified in the GOB.
b) Selection of Contractors: Conditions on the qualifications and experience of the bidders shall be stricter with a requirement to submit comprehensive and complete documents to show clearly evidence of experience of procurement of larger diameter pipes and equipment to be imported. The required qualifications shall at least satisfy those for Phase 1 Project (including certificate from the clients on the experienced projects).
c) Reduction in the duration of approval process in GOB: Bangladesh side shall study continuously to find a short cut way in the approval process for the procurement.

2) PQ conditions on the company's experience and quality and experience of Project manager (P/M) and engineers for construction work

a) Eligibility of bidders: The prime contractor shall be selected through International Competitive Bidding (ICB). However, local sub-contractors may be used for civil/architectural work. Nominated staff members shall have qualifications more than those for Phase 1 Project.
b) The qualification of bidders shall include the experience in the operation of WTP and leakage monitoring and repair to ensure quality of the construction work in order to ensure higher quality of the bidders (understanding by the bidders on the overall water supply system through the experience of concerned component works for water supply).
c) Quality and experience of staff: Conditions on the qualifications and experience of the P/M and engineers of the bidders (including communication capability in English) shall be stricter than that in Phase 1. The PQ and bid documents shall request bidders to submit comprehensive and complete documents including pictures at the project sites on experienced similar projects and certificates of completed project by the clients in the similar scope of work as Phase 2 Project, in order to show clearly the evidence of the capability of the P/M and engineers, as well as experience of the bidder on similar project(s) in Asian countries.

(2) Special conditions to be considered in Phase 2 Project

The Phase 1 Project is scheduled to be completed in 2015. However, the scope of the Project for the distribution network is limited up to primary and secondary distribution pipelines to the entrances to the sectors and it does not include pipeline systems in the DMAs. Such pipes up to the service connections in the DMAs are included in the Phase 2 Project covering the entire Karnaphuli service area. Therefore, after completion of the Phase 1 Project, the main/ sub-main pipelines will be temporarily connected to the existing main/sub-main pipes to continue water supply until the completion of the Phase 2 Project.

Construction of pipelines in the DMAs shall be given priority in the Phase 2 Project for the PANI area (Sectors C to H; total of 6 sectors). Aside from water supply service to the residents, Phase 2 Project will help increase the income of CWASA by the provision of distribution networks with water meters at

appropriate locations.

In order to complete the construction of distribution networks in DMAs for the priority area (Sectors C to H) as early as possible (at the latest within 3 years after completion of the Phase 1 Project), the procurement of Consultants shall be started as soon as possible (upon finish of appraisal of the Project).

11.3 Scope of Work of Phase 2 Project

The scope of work for Phase 2 of the Karnaphuli Water Supply Project is tabulated in Table 11.3.1.

Table 11.3.1 Components of the Karnaphuli Water Supply Project

Facilities		Phase 1	Phase 2
1	Intake	C/A: 300,000m^3/d M/E: 150,000m^3/d	C/A: - M/E: 150,000m^3/d
2	Conveyance Pipeline	DN1200mm, L=3.6 km (including surge tank)	DN1200mm, L=3.6 km (including surge tank)
3	WTP	Production Capacity = 143,000m^3/d	Production Capacity =143,000m^3/d
4	Transmission Pipeline 1 (WTP to Nashirabad Reservoir)	DN1200mm, 24.4km (including surge tank)	DN1200mm, 24.4km (including surge tank)
5	Nashirabad Reservoir	Reservoir: 26,300m^3 Elevated Tank: 2,200m^3	Reservoir: 24,800m^3
6	Transmission Pipeline 2	Nashirabad – Battali Hill: L=5.2km DN1200/1000mm	Nashirabad – Halishahar : L≒10km DN1100mm
7	Halishahar Elevated tank	-	2,400m^3
8	Optical Fiber Cable	L=37km	L=20km
9	Primary and Secondary Distribution Pipeline	Northern, Central & Southern areas, DN300-DN1200mm L= 42.8km	Distribution Reservoir/ Elevated Tank to the ten (10) Sectors - Primary Distribution (Upstream from Sector Valve to Reservoir); L= 7.9km - Secondary Distribution (Downstream from Sector Valve to DMA; L=107.5km
10	Tertiary distribution pipeline （Within DMAs）	-	3,063ha (L=367.6km)
11	Service connection with water meter	-	About 51,360 connections
12	Consulting Services	Detailed Design & Construction Supervision	Detailed Design & Construction Supervision

11.4 Alternative Study on Implementation Plan

11.4.1 Packaging for Project Components

The major components of the Phase 2 Project are Intake, Conveyance Pipeline, WTP, Transmission Pipeline and Distribution facilities. The packaging of the Project for the major components shall be made by basically referring to the arrangements for the Phase 1 Project. However, for the distribution facilities, which include primary, secondary and tertiary pipelines (refer to the definition of pipeline in Chapter 6), distribution reservoir/elevated tank and distribution networks including service connections in the DMAs, it is considered to divide these facilities into two categories (1) primary pipelines to service connections in the DMAs; and (2) reservoir/ elevated tank (structure). Because of the magnitude and complexity of the work and required period for the detailed design (D/D) including investigations/survey and construction work, item (1) mentioned above shall be the priority package of all the required packages.

The following are the required packages for the Phase 2 project giving priority to the Distribution pipelines for early realization of water supply to the priority service area. For Package 4 procurement of equipment and vehicles, several lots shall be considered by different equipment and vehicle.

(1) Package 1: Intake Facilities, WTP and Distribution Reservoir/ Elevated Tank
(2) Package 2: Conveyance and Transmission Pipelines, and Optical fiber cable (from Nashirabad Reservoir to Halishahar E.T)
(3) Package 3: Primary, Secondary and Tertiary Distribution Pipelines, Lateral pipes and Service Connections in DMAs (giving priority to PANI area; six Sectors in PANI area); and Optical fiber cable (expanding from several manholes planned in Phase 1 to Sectors A to G and from Halishahar E.T to Sectors H, I and J)
(4) Package 4: Procurement of equipment and vehicles

Package 3 is a very urgent component in the overall Karnaphuli Water Supply Project in order to provide water supply at an early stage in a cost effective manner. While, other packages may be implemented applying procedures that are normally used in loan projects for the implementation of the project components.

Package 3 shall be implemented considering priority area. The concerned priority Sectors in PANI area are C to H. Sectors I and J, which are located in the Western service area, will be served by Halishahar Elevated tank after completion of the Phase 2 construction work; however, during the transition period after completion of the Phase 1 Project, water supply to the sectors will be provided by a pipeline from the Central service area via Battali Hill Reservoir.

11.4.2 Procurement Methods for the Implementation of the Project

All packages may be implemented by application of the method used for normal loan projects.

(1) Possibility of Local Bidding

With regard to the manner of bidding for construction work, generally, Local Competitive Bidding (LCB) is more advantageous than International Competitive Bidding (ICB) in terms of the time required from the start of bidding to contract award. However, it seems to be difficult to adopt LCB for the Phase 2 Project, even for the construction of distribution networks under the arrangement of DMAs for the entire KSA. The major reasons are listed below.

- The work includes international procurement of DIP (Ductile Iron Pipe) with large diameters. However, local contractors are not familiar with international procurement.

- Capable engineers to construct pipelines in DMAs are limited in number at the present time. Local laborers, who are trained and have experience in pipe laying work are also limited in number.

Therefore, ICB shall be used for all packages to maintain the quality of the required facilities and timely completion of construction works, although local Contractors may be employed as sub-contractors.

(2) Package 3 Arrangement both for Consulting Services and Construction Work

1) Consulting Services

The scope of work for Package 3 covers construction of primary, secondary and tertiary pipelines, and lateral/ service connections in the DMAs. Detailed design in the Consulting services includes trial excavation along main pipelines (primary and secondary pipelines) to find underground facilities and topographic survey for a total of about 120 km of pipelines. The following are assumptions on the required days for trial excavation considering the present capacity of local contractors (mainly those from Dhaka based on the experience from the Phase 1 Project) and traffic/ living disturbance in the city, also based on Phase 1 experience.

a) Required number of excavation points: Assuming one point per 100m along distribution pipelines, about 1,200 points are required.
b) Number of excavation teams to be mobilized and performance by a team per day: 10 teams (about 80 persons are required) are assumed to work for 25 days/month (about 5 foremen are required). In other words, investigation on 10 points/day will be completed; however, the majority of work shall be implemented during the dry season.
c) Required months for trial excavation (about 1,200 points): Based on the assumptions on the number of points and performance per team, 120 days are necessary, about 4 months are required during the work in the dry season.

Topographic survey will be completed within 4 months in parallel to the implementation of the trial excavation work. The required period for D/D shall include for data/information collection and mapping thereto on underground facilities before trial excavation (2 months) and after the investigation and topographic survey has been completed, mapping on the findings (2 months) is also required, prior to design work being commenced. Thus, at least 8 months will be required before the start of detailed design work when investigation/ survey is commenced at the beginning of dry season and implemented smoothly. If unfavorable weather conditions and other hindrances occur, additional months will be required. Thus, it may be safe to consider a longer design period.

2) Construction Work

The construction capacity of local contractors was evaluated based on the experience of the Phase 1 Project with reference to the construction of distribution pipelines. Eleven local contractors were considered as potential sub-contractors by the prime contractor for Phase 1. Based on the experience during Phase 1 project implementation, the following conclusions can be made:

a) Some local companies do not have sufficient experience on the construction of pipelines
b) Permanent employees (engineers) are limited and engineers are employed on a project basis.

Construction of distribution pipelines with a length of about 483 km is planned in Package 3. In this connection, two cases are studied considering the mobilization of local laborers.

- Case 1: Construction of pipelines for all 10 Sectors is commenced at one time and completed

within about one year

It is assumed that at least 10 construction teams per Sector (about 3 km/ Sector) are required to complete the work within 1 year. Therefor 100 construction teams are necessary for 10 sectors. Based on the experience in Phase 1, about 2,000 laborers are required (20 persons x 100 teams). This number of laborers (generally unskilled) may be found and employed, but it is very difficult to find 20-30 engineers who have knowledge of pipe laying to supervise the laborers at one time.

- Case 2: A smaller group of the Sectors (3 Sectors/group) with a priority will be implemented sequentially with a longer construction period than Case 1, which will give some allowance for a longer completion period of the work by the Contractor.

  On the assumption of the construction schedule per construction team as Case 1, 30 construction teams would be mobilized with the total number of laborers required being 600 persons, as well as about 10 engineers. In this case, about two times of mobilization of laborers and engineers shall be made comparing with the arrangements by Phase 1 for pipeline construction.

As discussed above, Case 2 seems to be more realistic than Case 1 in construction arrangements. However, detailed planning and countermeasures by concerned parties against possible problems are required as the work will affect the living conditions of residents, businesses, etc. in many locations.

(3) Alternative Procurement Methods

In application of ICB, two alternatives for Package 3 are studied, focusing on the Consulting services. The manner of construction as discussed above (application of Case 2) is common to the two cases. The normal procurement procedure is recommended for the other packages (Packages 1, 2 and 4), based on the discussions in the above sub-sections.

1) Case 1: Common procurement method used in loan projects both for the selection of Consultants and Contractors by the use of ICB for the implementation of all 4 packages is adopted. However, for the Consulting services for Package 3, a longer D/D period (a total of 18 months) is considered to manage unexpected hindrances due to weather conditions, employment of 40 working teams at one time and night time working with reference to trial excavation for about 3,500 points.
2) Case 2: Common procurement method used in loan projects both for the selection of Consultants and Contractors by the use of ICB for the implementation of all 4 packages is adopted, which is the same as for Case 1. In order to expedite providing water supply to the priority area, the period required for Package 3 D/D is reduce to the minimum, which is considered to viable (a total of 13 months). For this case, the trial excavations should be arranged such that they commence and are completed within the dry season and augmentation of design engineers for distribution pipelines is a requisite (compared to Case 1).

The differences between Case 1 and Case 2 are related to the duration of the Consulting services, which is dependent to a large extent on the duration required to carry out the large number of trial excavation points along the pipelines. The construction schedule for the two cases are the same, as work is implemented in grouped sectors sequentially giving allowance for completion of the work by the Contractor, taking into account the present capability of local contractors. Table 11.4.1 summarizes the procurement methods both for Consultants and Contractors.

Table 11.4.1 Procurement Method

Procurement	Scope of Work	Manner of Procurement with required process/ events
Consultants	One consultancy package: D/D & C/S for all packages of work	ICB (PQ, Bid, Approval)
Contractor	Construction of facilities	ICB (PQ, Bid, Approval)

11.4.3 Implementation Schedule by Package /Procurement Case

(1) Conditions of Implementation Schedule

Appraisal of the Project and Exchange of the Note between GOB and GOJ and Loan agreement are assumed to be completed in December 2012 and March 2013, respectively, as shown in Table 11.4.2.

Table 11.4.2 Loan Agreement Schedule

Appraisal of the Project	December, 2012
Pledge of JICA Loan	February 2013
Exchange of Note between GOB and GOJ	March 2013
Signing of Loan Agreement	March 2013

Table 11.4.3 shows the required months for the implementation of the Project by case, under the following site conditions and contractual construction period for Phase 1.

- Rainy season from May to October affects the pipe laying works (50% reduction in working days during rainy season)
- Construction period of Phase 1 is assumed at 30 months
- Shop inspection for procurement of materials/equipment is included in the construction period.

Figure 11.4.1 shows the Work-flow of bidding procedure to select contractors (Two-Envelope Bidding under JICA Procedure) and required time by major work is summarized below.

- P/Q; 3 months
- Preparation of Bidding Document including JICA concurrence; 3 months
- Submission of Bid; 2 months
- Technical Evaluation/Price Evaluation including JICA concurrence; 6 months
- Negotiation to L/C; 2 months

The construction period for distribution pipelines in case of Sector A (L=31.4km) is calculated as follows:

Additional Trial excavation by contractor: 1 month
Submission of working drawings: 2 month
Pipe laying: 12 months (= 31.4km/12m/day/0.75/10 party = 348 days)
Working rate: 0.75 (= 0.5 + 0.5 x 50% rainy season)
Construction period in Sector (L=31.3km) =15 months

The construction period for other sectors is estimated in the same manner as shown for Sector A. Figure 11.4.2 shows a comparison of the implementation schedule for the two alternative cases for the procurement of consultants (refer to discussion prior to Table 11.4.1). Case 2 is better than Case 1 as completion is 5 months earlier, although there may be a risk with this case, as discussed previously.

Table 11.4.3 Package and Construction Periods

Item	Case-1 Consulting Services with safety period	Case 2 Consulting Services with minimized period
Expected Completion of Phase 1 Project	May 2015	
Project Appraisal/Loan Agreement	Dec., 2012/ Mar. 2013	
Selection of Consultant	9 months, Dec. 2012 to Aug. 2013	
Detailed Design	18 months, Sep. 2013 to Feb. 2015	13 months, Sep. 2013 to Sep. 2014
Selection of Contractor		
Package 1	Jan. 2015 to Apr. 2016	Aug. 2014 to Nov. 2015
Package 2	ditto	ditto
Package 3	ditto	ditto
Package 4	Jul.2014 to Feb. 2014	Feb. 2014 to Sep. 2014
Construction Stage		
Package 1	36 months May. 2016 to Apr.2019	36 months Dec. 2015 to Nov. 2018
Package 2	36 months May. 2016 to Apr. 2019	36 months Dec. 2015 to Nov. 2018
Package 3	62 months May. 2016 to Jun. 2021	62 months Dec. 2015 to Jan. 2021
Completion of Project including defects liability period	Jun. 2022	Jan. 2022

Note: Package 4, Procurement of equipment, is included in the part of consulting services.

11.4.4 Implementation Plan

In Case 1, completion of the project (excluding defects liability period) will be June 2021. For the distribution network for priority sectors (6 sectors in PANI area), it is planned to complete before the middle of 2019 starting from the middle of 2016 (construction period is about 3 years).

In order to expedite the phase 2 Project with reference to Package 3, giving priority to the sectors covered by PANI area, the period for consulting services is reduced to 13 months in Case 2, mainly by reducing the period required for trial excavations along the pipeline routes. For the application of this case, the start and completion dates for trial excavation should be during one dry season. In addition, the number of engineers for design of pipelines should be more than in Case 1. Under Case 2, construction of distribution pipelines for the priority 6 Sectors will be started the beginning of 2016 to be completed in the end of 2018.

It is favorable to adopt Case 2 in order to expedite water supply, especially to the priority sectors. The schedule for overall completion of the Project in Case 2 (January 2021) is also better than Case 1. However, in consideration of the large amount of work for Package 3 requiring many engineers of the Contractor and construction working teams as well as timely completion of consulting services with absolute conditions (dry season period for trial excavation, which is a critical condition to keep contract period), careful preparation and arrangements for Case 2 are indispensable.

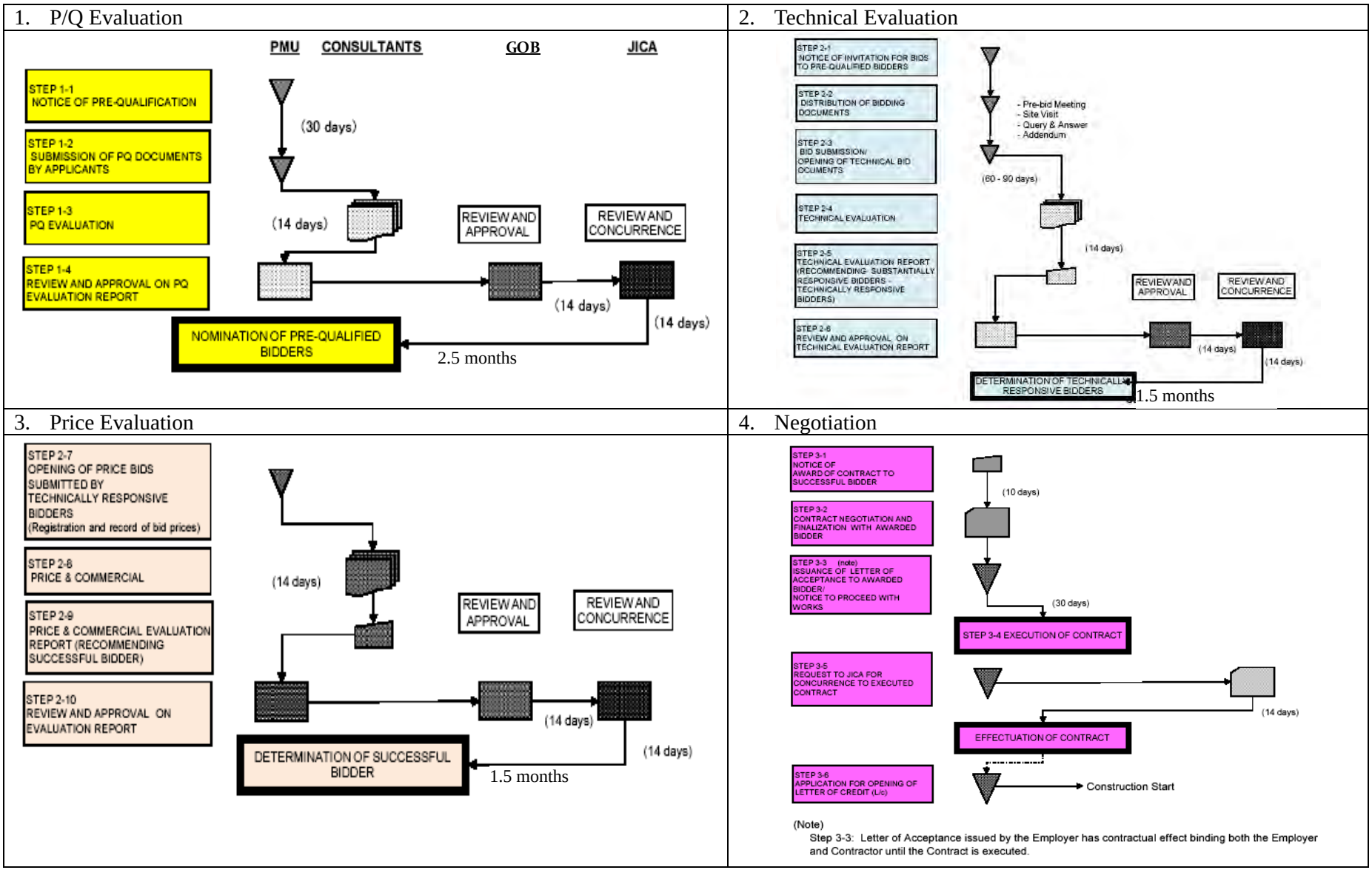

Figure 11.4.1 Work-flow of bidding Procedure (Two-Envelope Bidding under JICA Procedure)

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Case 1 Consulting Services with safety period

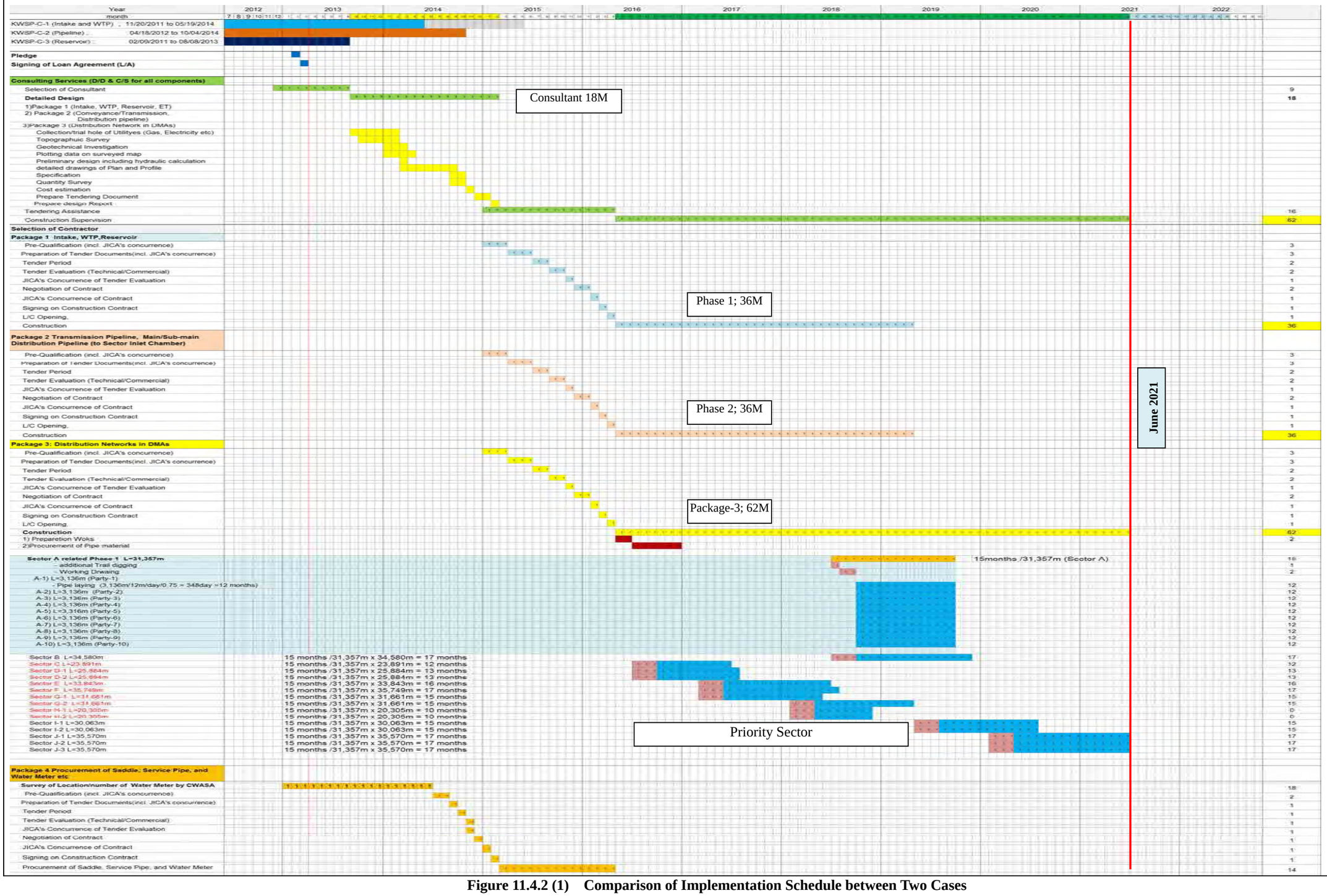


Figure 11.4.2 (1) Comparison of Implementation Schedule between Two Cases

Case 2 Consulting Services with minimized period

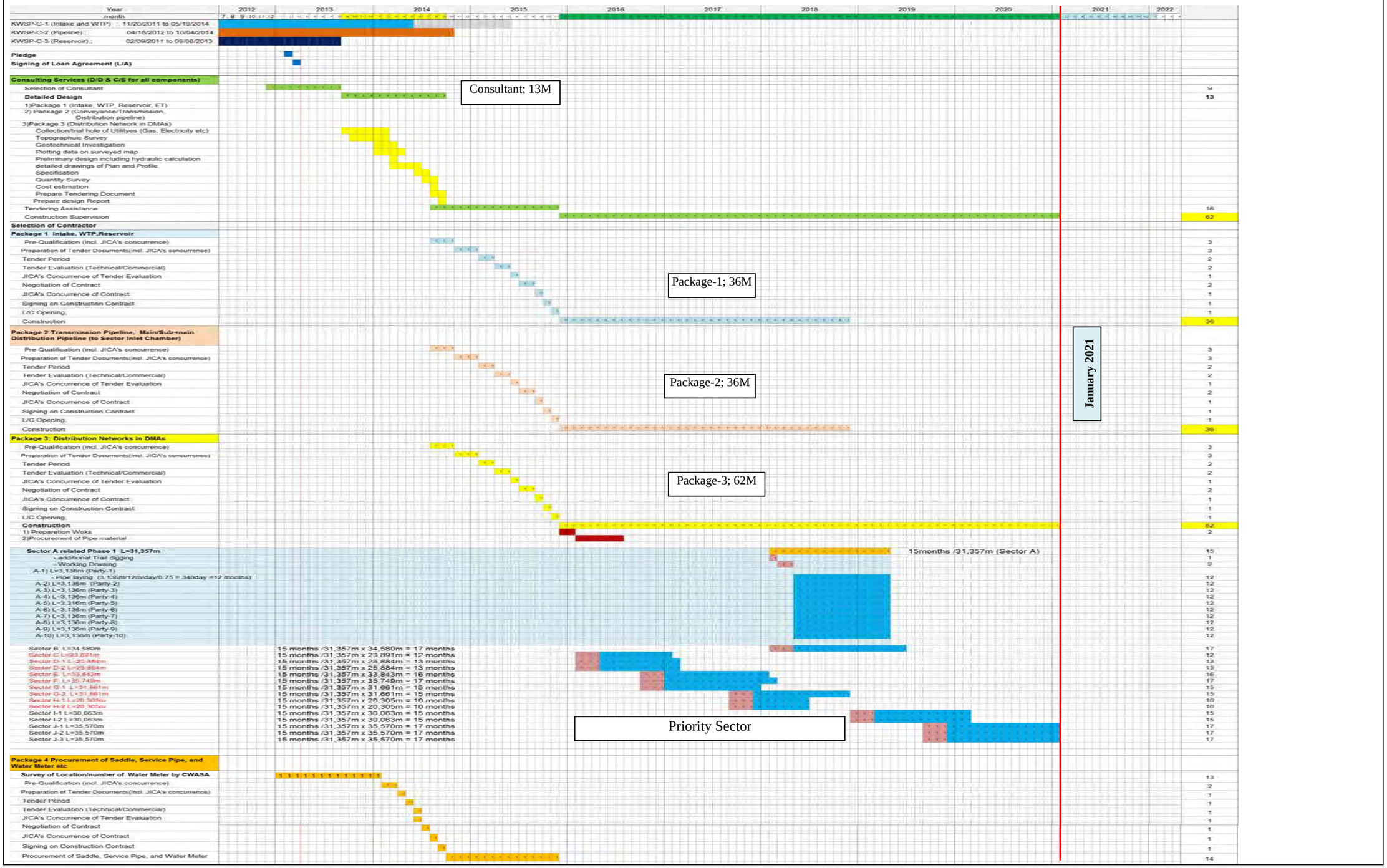


Figure 11.4.2 (2) Comparison of Implementation Schedule between Two Cases

11.5 Project Implementing Unit (PIU)

For the purpose of the smooth implementation of the Project, the Project Implementation Unit (PIU) shall be established within CWASA after approval of DPP. The PIU will have the authority to take necessary decisions and actions on all matters related to the Project implementation except selection of consultant and contractor: selection of consultant and contractor need to be approved by the committee, CWASA board, the line ministry, and the cabinet purchase committee. The PIU will be consisted of 97 staff and headed by the full-time Project Director (PD), supported by one full-time Deputy Project Director (DPD). The PD of KWSP2 and the PD of KWSP1 shall closely coordinate each other. The transitional PIU will be established in December 2012, appointing full-time PD and DPD from CWASA. After approval of DPP, CWASA will appoint necessary staff of PIU in accordance with the employment plan:

(i) two Accounting Officers by June 30, 2013,
(ii) one Procurement Specialist, one Environment Specialist, three Project Managers, seven Assistant Engineers by September 30, 2013, and
(iii) other staff by February 2016. CWASA will notify JICA of the list of appointed members within one week after appointment of staff.

The PD, DPD, Executive Engineer, as well as the officers/staff members who are assigned to the PIU will be engaged exclusively in the Project on full-time basis. Also, for the smooth implementation of the Project, CWASA will hire members for supporting project implementation ("Project implementation support") through open market competition, which consists of Procurement Engineer, Accounting Officer, Social Relationship Officer, Environment Specialist, Project Managers, and supporting staff. Also, PD and DPD may be recruited from outside in the course of the project implementation, those expense will be borne under JICA loan. Project implementation support members will be engaged exclusively in the Project on full-time basis and appointed to PIU. In the case of appointing CWASA staff to Project implementation support members, CWASA will supplement vacant posts not to affect CWASA's work other than KWSP2. The proposed Project Implementing Unit (PIU) in CWASA is shown in Figure 11.5.1.

Knowledge and experience obtained in the course of the project implementation need to be transferred and succeeded to CWASA. Therefore, the Project implementation support members need to be appointed as CWASA's proper staff after the completion of the Project. CWASA will consider appointing the members as CWASA staff, introducing suitable market-based payment scale and organizational arrangement by 2019 before the project completion. Job description and qualification requirements are shown in Table 11.5.1.

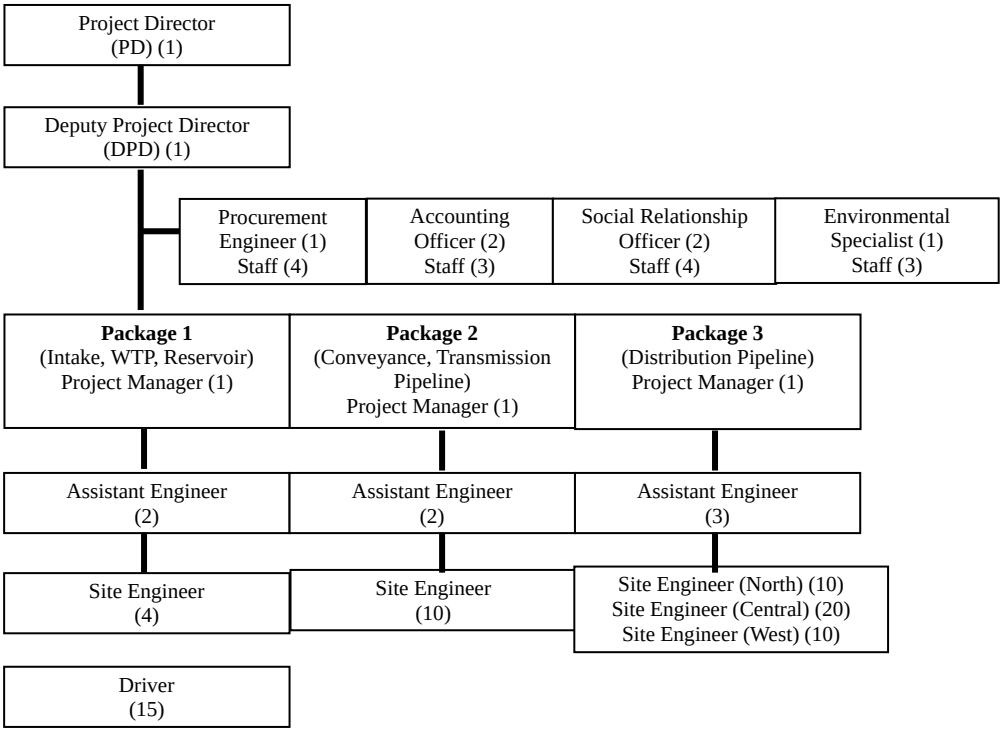


Figure 11.5.1 Proposed PIU in the CWASA Organization

Table 11.5.1 Job Description and Qualifications

Job Title	Job Description	Qualifications
Project Director (PD) (1)	• Responsible for project implementation and management of the PIU.	• Experiences of project management for infrastructure projects, including selection of international consultants and contractors/suppliers through international competitive bidding, as PD or DPD. • Experiences of water supply related projects. • Being familiar with the coordination among the government agencies.
Deputy Project Director (DPD) (1)	• Responsible for supporting PD for overall project management.	• Experiences of project management for infrastructure projects, including selection of international consultants and contractors/suppliers through international competitive bidding, as DPD or Executive Engineer. • Experiences of water supply related projects. • Being familiar with the coordination among the government agencies.
Procurement Engineer (1)	• Responsible for all procurement procedures of the Project.	• Experiences of selection of international consultants and contractors/suppliers through international competitive bidding.
Accounts Officer (2)	• Responsible for all accounting related issues of the Project	• Experience of project accounting/payment control. • Being familiar with the cash flow monitoring of multiple sub-projects, as well as international payment procedures.
Environmental Specialist (1)	• Responsible for environmental monitoring/countermeasures	• Experience for environmental monitoring and providing countermeasures

Job Title	Job Description	Qualifications
Social Relationship Officer (2)	• Responsible for all social (customers and residents) related issues of the Project.	• Experience of mitigation measure for social impact in infrastructure projects. • Being capable of coordinating the works carried out by the engineering consultants/contractors who will explain the implementation schedule of the project etc. to the residents, especially, for construction works of distribution network.
Project Manager (1)	• Responsible for activities of construction works	• Experiences of the project management in relatively large size as a construction manager or an assistant construction manager in water supply projects.
sistant Engineer (7)	• Responsible for supporting Executive Engineer as construction manager	• Experiences of the project management in relatively large size as a construction manager or an assistant construction manager in water supply projects.
Site Engineer (54)	• Responsible for supporting Assistant Engineer as assistant construction manager	• Degree or experiences of civil engineer.
Driver (15)		• Driver's experience

11.6 Consulting Services

11.6.1 Terms of Reference

(1) Consulting Service for Detail Design, Assistance for Bidding, Procurement of equipment and Construction Supervision

CWASA will procure consulting services for detailed design, assistance to bidding, procurement of equipment and construction supervision of Phase 2 Project through ICB. The consultants' team shall consist of international and local professional and supporting staff. Consultants will be selected through a short list method to avoid lowering of quality and in accordance with the "Guidelines for the Employment of Consultants under Japanese ODA Loans".

The scope of work in the Terms of Reference (TOR) for the consulting services includes detailed design of the intake facilities, conveyance pipeline, WTP, transmission pipeline, and distribution facilities and construction supervision aside from the assistance to WASA. It will also include preparation of tender documents entailing detailed technical specifications for the four packages; (1) intake facilities, WTP and distribution reservoir/elevated tank, (2) conveyance and transmission pipelines and optical fiber cable, (3) distribution pipelines up to installation of service connections, and (4) procurement of saddles, service pipes, valves and water meters for service connections.

The TOR is prepared considering requirements discussed in the previous sub-sections, especially with reference to the critical conditions for Package 3, detailed design for distribution pipelines with a length of about 483 km.

The TOR for Consulting Services for Detailed Design and Construction Supervision is included in Supporting Report 11.6.1.

11.6.2 Cost Estimates for Consulting Services

The contract of consulting services includes preparation of detailed design, assistance for bidding and construction supervision, and procurement of equipment for Phase 2 Project. A total of 505 man-months of foreign and 856 man-months of local engineers are considered. The service will also include on-the job training for CWASA staff from investigation/design, construction supervision and trial operation of facilities. The engineers assigned for the work will transfer technologies to CWASA staff who shall be assigned as counterpart staff members during the implementation of the Project. CWASA staff will stay with Consultants staff in the field during the period of on-the-job training without additional expenditures.

Under the above conditions total cost for the consulting services is estimated at approximately 2,526 million yen (Foreign portion: 1,538 million yen, Local portion: 1,023 million Taka). The detailed cost estimate for the consulting services is shown in Table 11.6.1.

Table 11.6.1 Estimated Cost for Consulting Services

TK = 0.966 Yen

		Unit	Qty.	Foreign Portion (Yen)		Local Portion TK		Combined Total Yen
				Rate	Amount ('000)	Rate	Amount ('000)	('000)
A. Remuneration								
1	Professional (A)	M/M	505	2,562,000	1,293,810	0	0	1,293,810
2	Professional (B)	M/M	856	0	0	400,000	342,400	330,758
3	Supporting Staffs	M/M	0	0	0	0	0	0
	Subtotal of A				1,293,810		342,400	1,624,568
B. Direct Cost								
1	International Airfare		168	400,000	67,200		0	67,200
2	Domestic Airfare		168		0	10,000	1,680	1,623
4	Domestic Travel				0		0	0
5	Accommodation Allowance							0
	Professional (A)	Month	505	350,000	176,750		0	176,750
	Professional (B)	Month	0	350,000	0		0	0
	Supporting Staffs	Month	856		0	100,000	85,600	82,690
6	Vehicle Rental	Month	168		0	100,000	16,800	16,229
7	Office Rental	M/M	1,361		0	200,000	272,200	262,945
8	International Communications	M/M	505		0	150,000	75,750	73,175
9	Domestic Communications	M/M	1,361		0	50,000	68,050	65,736
10	Office Supply	M/M	1,361		0	50,000	68,050	65,736
11	Office Furniture and Equipment	Ls	1		0	2,000,000	2,000	1,932
12	Report Preparation	Month	100			1,000	100	97
13	Topographic & Soil Survey	Ls	1			20,000,000	20,000	19,320
14	Trial Digging	Ls	1			70,000,000	70,000	67,620
	Subtotal of B				243,950		680,230	901,052
	Total				1,537,760		1,022,630	2,525,621

11.7 Preliminary Cost Estimates

11.7.1 Conditions and Assumptions for Cost Estimates

Following conditions were assumed for the cost estimates of construction, and administrative cost and tax.

(1) Construction Cost

1)	Base Year	December, 2012
2)	Exchange Rate	1 Taka = 0.966Japanese Yen 1 USD = 81.7 Taka = 79.0 Japanese Yen
3)	Price Escalation Rate per annum	Foreign Currency = 2.1%, Local Currency = 4.9%
4)	Physical Contingency	5%

(2) Administration Cost and Service Tax

1)	Administration Cost	5% (of the Eligible Portion)
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)

11.7.2 Construction Costs

Details of the construction cost are shown in Table 11.7.1 and annual fund requirement for the Project are tabulated in Table 11.7.2. The detailed breakdown of the construction cost is included in Supporting Report 11.7.1.

Table 11.7.1 Construction Cost for Phase 2 Project

Item		Total (million)		
		FC (JPY)	LC (BDT)	Total (JPY)
A. ELIGIBLE PORTION				
I) Procurement / Construction		16,677	15,599	31,746
1	Intake facilities, WTP, reservoirs and elevated tanks	3,501	2,223	5,649
2	Conveyance and transmission pipeline	5,942	1,310	7,207
3	Distribution pipeline and service connections	4,470	7,628	11,839
4	Procurement of goods	337	0	337
5	Project Implementation Support Unit	0	148	143
	Base cost for JICA financing	14,250	11,310	25,175
	Price escalation	1,634	3,546	5,059
	Physical contingency	794	743	1,512
II) Consulting services		1,784	1,363	3,101
	Base cost	1,538	1,023	2,526
	Price escalation	162	275	428
	Physical contingency	85	65	148
Total (I + II)		**18,462**	**16,962**	**34,847**
B. NON ELIGIBLE PORTION				
a	Procurement / Construction	0	0	0
	Base cost for JICA financing	0	0	0
	Price escalation	0	0	0
	Physical contingency	0	0	0
b	Land Acquisition	0	0	0
	Base cost	0	0	0
	Price escalation	0	0	0
	Physical contingency	0	0	0
c	Administration cost	0	1,804	1,742
d	VAT	0	2,821	2,725
e	Import Tax	0	5,179	5,003
f	Banking charge	0	54	52
Total (a + b + c + d + e + f)		**0**	**9,859**	**9,524**
TOTAL (A+B)		**18,462**	**26,821**	**44,371**
C. Interest during Construction		19	0	19
	Interest during Construction(Const.)	18	0	18
	Interest during Construction (Consul.)	2	0	2
D. Commitment Charge		0	0	0
GRAND TOTAL (A+B+C+D)		**18,481**	**26,821**	**44,390**
E. JICA finance portion (A)		**18,462**	**16,962**	**34,847**

Table 11.7.2 Annual Fund Requirement for KWSP (Phase 2)

Item	Total			2012			2013			2014			2015			2016			2017			2018			2019			2020			2021			2022		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	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	16,677	15,599	31,746	0	0	0	0	11	11	79	20	98	669	289	948	4,579	3,396	7,860	4,675	3,563	8,117	4,461	3,600	7,939	1,051	2,192	3,168	1,073	2,299	3,294	91	226	310	0	2	2
1 Intake facilities, WTP, reservoirs and elevated tanks	3,501	2,223	5,649	0	0	0	0	0	0	0	0	0	97	62	157	1,167	741	1,883	1,167	741	1,883	1,070	679	1,726	0	0	0	0	0	0	0	0	0	0	0	0
2 Conveyance and transmission pipeline	5,942	1,310	7,207	0	0	0	0	0	0	0	0	0	165	36	200	1,981	437	2,402	1,981	437	2,402	1,816	400	2,202	0	0	0	0	0	0	0	0	0	0	0	0
3 Distribution pipeline and service connections	4,470	7,628	11,839	0	0	0	0	0	0	0	0	0	72	123	191	865	1,476	2,291	865	1,476	2,291	865	1,476	2,291	865	1,476	2,291	865	1,476	2,291	72	123	191	0	0	0
4 Procurement of goods	337	0	337	0	0	0	0	0	0	72	0	72	264	0	264	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 Project Implementation Suppot Unit	0	148	143	0	0	0	0	10	10	0	17	17	0	17	17	0	17	17	0	17	17	0	17	17	0	17	17	0	17	17	0	17	17	0	1	1
Base cost for JICA financing	14,250	11,310	25,175	0	0	0	0	10	10	72	17	89	599	238	829	4,013	2,671	6,593	4,013	2,671	6,593	3,751	2,573	6,236	865	1,494	2,308	865	1,494	2,308	72	140	207	0	1	1
Price escalation	1,634	3,546	5,059	0	0	0	0	0	0	3	2	5	39	37	74	348	563	892	439	722	1,137	498	855	1,324	135	594	709	156	696	829	15	75	88	0	1	1
Physical contingency	794	743	1,512	0	0	0	0	1	1	4	1	5	32	14	45	218	162	374	223	170	387	212	171	378	50	104	151	51	109	157	4	11	15	0	0	0
II) Consulting services	1,784	1,363	3,101	0	0	0	130	87	215	286	199	479	104	37	140	263	190	447	246	210	448	252	229	473	231	173	398	193	163	350	71	70	138	8	5	12
Base cost	1,538	1,023	2,526	0	0	0	121	79	198	262	173	428	93	31	123	231	150	375	211	157	363	212	164	370	190	118	304	156	106	258	56	43	98	6	3	9
Price escalation	162	275	428	0	0	0	3	4	6	11	17	28	6	5	11	20	32	50	23	42	64	28	54	81	30	47	75	28	49	76	12	23	34	1	2	3
Physical contingency	85	65	148	0	0	0	6	4	10	14	9	23	5	2	7	13	9	21	12	10	21	12	11	23	11	8	19	9	8	17	3	3	7	0	0	1
Total (I + II)	**18,462**	**16,962**	34,847	0	0	0	130	98	225	365	219	577	774	326	1,089	4,842	3,587	8,306	4,921	3,773	8,565	4,713	3,829	8,412	1,281	2,365	3,566	1,266	2,462	3,644	162	296	448	8	7	14
B. NON ELIGIBLE PORTION																																				
a Procurement / Construction	0	0	0	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b Land Acquisition	0	0	0	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0	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 Administration cost	0	1,804	1,742	0	0	0	0	12	11	0	30	29	0	56	54	0	430	415	0	443	428	0	435	421	0	185	178	0	189	182	0	23	22	0	1	1
d VAT	0	2,821	2,725	0	0	0	0	35	34	0	77	75	0	65	63	0	579	559	0	604	584	0	614	593	0	391	377	0	399	386	0	55	54	0	2	2
e Import Tax	0	5,179	5,003	0	0	0	0	0	0	0	25	24	0	208	201	0	1,422	1,374	0	1,452	1,402	0	1,385	1,338	0	326	315	0	333	322	0	28	27	0	0	0
f Banking charge	0	54	52	0	0	0	0	0	0	0	0	0	0	2	2	0	15	14	0	15	15	0	15	14	0	3	3	0	3	3	0	0	0	0	0	0
Total (a+b+c+d+e+f)	0	9,859	9,524	0	0	0	0	47	45	0	132	127	0	332	320	0	2,446	2,362	0	2,514	2,429	0	2,449	2,366	0	905	874	0	925	893	0	107	104	0	3	3
TOTAL (A+B)	18,462	26,821	44,371	0	0	0	130	145	270	365	351	704	774	658	1,409	4,842	6,032	10,669	4,921	6,287	10,994	4,713	6,278	10,778	1,281	3,270	4,440	1,266	3,386	4,537	162	403	552	8	10	17
C. Interest during Construction	19	0	19	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	2	3	0	3	3	0	3	3	0	3	3	0	3	3	0	3
Interest during Construction(Const.)	18	0	18	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	2	2	0	2	3	0	3	3	0	3	3	0	3	3	0	3
Interest during Construction (Consul.)	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Commitment Charge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GRAND TOTAL (A+B+C+D)	18,481	26,821	44,390	0	0	0	130	145	270	365	351	705	774	658	1,409	4,843	6,032	10,670	4,922	6,287	10,996	4,716	6,278	10,781	1,284	3,270	4,443	1,269	3,386	4,541	166	403	556	11	10	21
E. JICA finance portion (A)	18,462	16,962	34,847	0	0	0	130	98	225	365	219	577	774	326	1,089	4,842	3,587	8,306	4,921	3,773	8,565	4,713	3,829	8,412	1,281	2,365	3,566	1,266	2,462	3,644	162	296	448	8	7	14

Administration Cost = 5%
VAT= 15% of the expenditure in local currency of the eligible portion
Import Tax= 30%

Price Escalation				2012			2013			2014			2015			2016			2017			2018			2019			2020			2021			2022		
Price Escale				1	1		1.021	1.049		1.042	1.1		1.064	1.154		1.087	1.211		1.11	1.27		1.133	1.332		1.157	1.398		1.181	1.466		1.206	1.538		1.231	1.613	
d Price Escal				0	0		0.021	0.049		0.042	0.1		0.064	0.154		0.087	0.211		0.11	0.27		0.133	0.332		0.157	0.398		0.181	0.466		0.206	0.538		0.231	0.613	
Loan interest during const.																																				
Financing Rate	100.00%																																			
Interest rate for YEN loan	0.01%																																			
Temporaly allocation				0		0	11		11	98		98	948		948	7,860		7,860	8,117		8,117	7,939		7,939	3,168		3,168	3,294		3,294	310		310	2		2
Debt at the end of term				0			11			109			1,057			8,917			17,033			24,972			28,140			31,434			31,744			31,746		
Interest during const				0			0			0			0			1			2			2			3			3			3			3		
Loan interest during const. (Consul.)																																				
Financing Rate	100.00%																																			
Interest rate for YEN loan	0.01%																																			
Temporaly allocation				0		0	215		215	479		479	140		140	447		447	448		448	473		473	398		398	350		350	138		138	12		12
Debt at the end of term				0			215			694			834			1,281			1,729			2,203			2,600			2,951			3,089			3,101		
Interest during const				0			0			0			0			0			0			0			0			0			0			0		
	100.00%																																			
Commitment Charge	0.00%																																			
Balance of yen loan	34,847			34,847	34,847		34,847	34,847		34,847	34,847		34,847	34,847		34,847	34,847		34,847	34,847		34,847	34,847		34,847	34,847		34,847	34,847		34,847	34,847		34,847	34,847	
Commitment Charge				0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0		0

11.8 Comparison of Construction Cost with Similar projects

For the purposes of comparing the construction cost with other projects, the most relevant project in Bangladesh is the Saidabad WTP Phase II project in Dhaka. This project includes:

(1) WTP with a production capacity of 225,000 m^3/d, constructed on the same site as the Phase 1 WTP, including intake facilities. Some of the Phase I facilities such as laboratory, workshop and sludge treatment facilities are used to some extent.
(2) Pretreatment plant for Phase I and II with a production capacity of 450,000 m^3/d. This is provided to reduce levels of ammonia (which is high during the dry months) in the raw water
(3) Transmission mains with a total length of about 10 km
(4) 3 years operation and maintenance

The project is being implemented as a design-build contract, financed by the Government of Denmark, with the GOB financing taxes and other local costs. In accordance with the requirements of the donor, tendering was limited to eligible Danish firms, or in the event of joint venture, joint ventures with a Danish leader.

The invitation for prequalification was issued in May 2007, with tenders submitted in November 2008. The contract commenced in June 2010, with a nominal contract period of 30 months (excluding the operation and maintenance period). As of September 2012, it is envisaged that completion of the contract will be within the contract period.

There is no provision in the contract for price escalation and as such the Contractor had to allow for this when preparing the tender, as well as for carrying out the detailed design and allowing for various risks, which may not be in a conventional contract.

The Accepted Contract Amount for items (1) to (3) above is approximately EUR 85 million (excluding taxes), as shown in Table 11.8.1, which also includes a breakdown of the amount. In the following discussion all amounts are exclusive of taxes.

Further details of the above and other issues are included in Table 11.8.1.

Table 11.8.1 Accepted Contract Amount for Saidabad WTP Phase II project in Dhaka

Saidabad Water Treatment Plant Phase-II						
S.L	Facilities	Capital Cost (Million in EURO)				
		Civil	Mechanical	Electrical and ICA	Total	
1	Treatment Plant Design & Construction (225 mld)	18.00	16.95	3.17	38.12	←
2	Pre-Treatment Unit (450mld)		14.93	1.27	16.20	←
3	Site Works (Site Provissions & Prelimenaries)				16.40	
4	Transmission Pipe Line (10 K.M)	8.60			8.60	
5	Ancillary Structures	5.68			5.68	←
					85.00	WTP

Source: hearing from DWASA

There are various similarities between the WTP in the KWSP (Phase 2) and the Saidabad WTP Phase II project, including as follows:

- Treated water quality requirements
- Use of the existing site

- Use of some of the facilities constructed in/or being constructed in an earlier phase
- Scale of the project is similar (considering the capacity of the respective WTPs and the fact that other works are planned to be included in the same contact as the WTP in the KWSP (Phase 2)

However there are some important differences, including as follows, which are specific to the Saidabad WTP Phase II Project:

- Design-build contract used
- Contract period is the same as that proposed for the WTP and other works, Package 1 in KWSP (Phase 2). However within the contract period the Contractor has to carry out the detailed design (as well as obtaining approval to the design), which means that the period available for construction, commissioning and testing of the works is less than for the KWSP(Phase 2)
- No price escalation
- Tendering restricted
- Relatively long period between submission of tenders and contract commencement

Comparison of the construction cost needs to take account of the following main items, in addition to the scope of the project:

- Procurement method
- Provisions for price escalation
- Relative timing of the two projects
- Currency

The approximate Accepted Contract Amount for item (i) of the above only (including site provisions and preliminaries) is approximately EUR 45 million. If the contract had been implemented as a conventional contract then it is estimated that the Accepted Contract Amount would be of the order of EUR 40 million, allowing for the fact that under the design-build contract, the Contractor (i) has to carry out the detailed design, (ii) allow for some risks that may be partly or totally borne by the Employer under a conventional contract and (iii) allow for the payment provisions regarding escalation. Based on an approximate exchange rate on the date of submission of the tender for the Saidabad WTP Phase II project of JPY 120 = EURO 1, then the above cost of EUR 40 million is equivalent to JPY 4,800 million (or about JPY 21,000/m^3 of production capacity).

Allowing for a nominal average increase in the construction cost of 5% per annum between the date of submission of the tender for the Saidabad WTP Phase II and the date of the estimate for this project then the cost of the Saidabad WTP Phase II project (at the date of the estimate) in terms of JPY/ m^3 of production capacity is about JPY 32,400/m^3 of production capacity. This is comparable with the estimate of JPY 31,500/m^3 (= about 4,505 million/143,000m^3/d, excluding civil/architectural works at the Intake facilities) of production capacity for the WTP in the KWSP (Phase 2).

The construction costs of the WTPs at the Saidabad Phase II and KWSP (Phase 2) are summarized in Table 11.8.2.

Table 11.8.2 Comparison of Construction Cost

Item	Saidabad Phase II (Dhaka)	KWSP (Phase 2)
Production Capacity (m^3/d)	225,000	143,000
Tender submitted	November, 2008	-
Base year for Cost estimation	-	September, 2012
Cost of WTP (million)	EUR 40 million JPY 4,800 (EUR 1= JPY120) (approx. 21,000JPY/m^3)	JPY 4,505 million (excluding C/A of Intake facilities) (31,500 JPY/m^3)

Item	Saidabad Phase II (Dhaka)	KWSP (Phase 2)
	In case of average of 5% price escalation from 2008 to 2012; EUR 48 million JPY 7,300 (EUR 1= JPY100) (32,400JPY/m^3)	

11.9 Performance Indicators

The performance indicators are studied 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.

Construction works for KWSP (Phase 2) will be completed in November, 2020. The projected indicators by target year are shown in Table 11.9.1. Service coverage will increase from 47% in 2012 to 51% in 2023. However, population to be served in 2023 against present population is about 70% (population is projected to increase about 40% from 2012 to 2023).

Table 11.9.1 Performance Indicators in Phase 2 Project in CCC

Indicator	2012	2023 (2 years after completion of facility)	
Water Production (Phase 1 + Phase 2)(m^3/d)	219,000	505,000	
Population Served/to be served (person)	1,363,000	2,008,500	90% in KSA Deep well; 343,000 persons
Daily maximum water consumption (m^3/d)	146,700	388,900	
Service coverage (%)	47	51	70% to present population
Water Supply per Capita (l/person/day)	107	120	
Percentage of facility utilization (%)	100	100	
NRW	33%	23%	

Note: 1) 2012;
Water Production =Mohara WTP + Kalurghat IRP + Deep Tube Well = 219,000m^3/d
Population in CCC = 2,900,000 person
Population Served =1,363,000person (51,000connection x 20person/connection + 343,000person)
Service coverage = 47% (including deep well supply)
2) 2023;
Water Production = 219,000 + 286,000 = 505,000m^3/d
Population in CCC= 3,964,000 person
Population in KSA =1,272,800 person
Population Served = 1,272,800 person x 90% + (51,000connection-25,000connection)
x 20person/connection + 343,000person= 2,008,500person
Service coverage = 2,008,500 / 3,964,000 = 51% (70% to present population, 2,900,000)
NRW% in 2030 = (0.33x0.43+0.15x0.57) =23%

CHAPTER 12

FINANCIAL AND ECONOMIC CONSIDERATIONS

CHAPTER 12 FINANCIAL AND ECONOMIC CONSIDERATIONS

12.1 Budgetary Plan for the Project

12.1.1 Fund Requirements

Based on the estimated capital costs presented in Section 11.7.2, the fund requirements for the Phase 2 Project are summarized in Table 12.1.1.

Table 12.1.1 Fund Requirements for Phase 2 Project

Particulars	FC Portion*1) (JPY mil.)	LC Portion*2) (BDT mil.)	Combined Total in JPY *3) (mil.)	Combined Total in BDT*3) (mil.)
A. Construction Works				
A-1. Base Cost	14,250	11,310	25,175	26,061
A-2. Price Escalation	1,634	3,546	5,059	5,237
A-3. Physical Contingency	794	743	1,512	1,565
A-4. Sub-total	16,678	15,599	31,746	32,863
B. Consulting Services				
B-1. Base Cost	1,538	1,023	2,526	2,615
B-2. Price Escalation	162	275	428	443
B-3. Physical Contingency	84	65	147	153
B-4. Sub-total	1,784	1,363	3,101	3,211
C. Total Cost (A.+ B.)	18,462	16,962	34,847	36,074
D. CWASA Administration Costs	0	1,804	1,743	1,804
E. VAT	0	2,821	2,725	2,821
F. Import Duties	0	5,179	5,003	5,179
G. Bank Charges	0	54	53	54
H. Interest during Construction	19	0	19	20
Total Amount of Funds Required	18,481	26,820	44,390	45,952

*Note: *1) FC Portion: Foreign Currency Portion (JPY: Japanese Yen)*
**2) LC Portion: Local Currency Portion (BDT: Bangladesh Taka)*
**3) Currency Exchange Rate: US$1 = BDT81.7 =JPY79.0*
(The sub-total and total amounts may not be the same as the sum due to the round-off.)

Enumerated below are the base and assumptions used for estimating the fund requirement amounts shown in the above. These assumptions accord to the conditions predetermined by JICA for the estimation of the fund requirements.

(1) Base Cost for Construction Works and Consulting Services: As of December 2012
(2) Price Escalation: calculated for the estimated annual disbursement amounts of the base costs for construction works and consulting services (given in Table 12.1.2) by applying an annual escalation rate of 2.1% for FC (Foreign Currency) Portion and 4.9% for LC (Local Currency) Portion.
(3) Contingency: calculated at 5% of the escalated costs respectively for the construction works and consulting services.
(4) CWASA Administration Cost: estimated at 5% of the total cost for FC and LC Portions (Item C) combined in terms of Bangladesh Taka.
(5) VAT: estimated at 15% of the total costs for LC Portion (Item C).
(6) Import Duties: estimated at 30% of the total costs for FC Portion (Item C).

Table 12.1.2 shows the estimated disbursements of the base costs for construction works and consulting services given in Items A-1 and B-1 of Table 12.1.1.

Table 12.1.2 Estimated Annual Disbursement Amounts of Base Costs for Construction Works and Consulting Services

FC Portion: JPY million, LC Portion: BDT million

Year	Construction Works		Consulting Services		Total	
	FC Portion	LC Portion	FC Portion	LC Portion	FC Portion	LC Portion
2013	0	10	121	79	121	89
2014	72	17	262	173	334	190
2015	599	238	93	31	692	269
2016	4,013	2,671	231	150	4,244	2,821
2017	4,013	2,671	211	157	4,224	2,828
2018	3,751	2,573	212	164	3,963	2,737
2019	865	1,494	190	118	1,055	1,612
2020	865	1,494	156	106	1,021	1,600
2021	72	140	56	43	128	183
2022	0	1	6	3	6	4
Total	14,250	11,310	1,538	1,023	15,788	12,333

Note 1. The total amount may not be the same as the sum due to the round-off.
2. Currency Exchange Rate: US$1 = BDT81.7 =JPY79.0

This estimate is made on the assumption that payments for the construction works and consulting services will accrue during ten years from 2013 through to 2022.

12.1.2 Financing Plan

It is proposed that the funds required for the Phase 2 Project will be financed with a JICA Loan to cover the whole amount of the components which are eligible for Loans, and the rest will be financed by GOB's development fund. Table 12.1.3 shows the financing plan for the Phase 2 Project formulated in accordance with the above policy.

Table 12.1.3 Financing Plan for Phase 2 Project

Particulars	FC Portion[1] (JPY mil.)	LC Portion (BDT mil.)	Combined Total in JPY (mil.)	Combined Total in BDT (mil.)
A Amounts proposed for financing with JICA Loan				
1) Construction Works	16,678	15,599	31,746	32,863
2) Consulting Services	1,784	1,363	3,101	3,211
Total	18,462	16,962	34,847	36,074
B Amounts proposed for financing with GOB Fund				
1) CWASA Administration Costs	0	1,804	1,743	1,804
2) VAT	0	2,821	2,725	2,821
3) Import Duties	0	5,179	5,003	5,179
4) Bank Charges	0	54	53	54
5) Interest during Construction	19	0	19	20
Total	19	9,858	9,543	9,878
Grand Total (A + B)	18,481	26,820	44,390	45,952

Note: 1) The total amount is not the same as the sum, due to the round-off.
2) Currency Exchange Rate: US$1 = BDT81.7 =JPY79.0

Table 12.1.4 shows the projection of the annual disbursement of the proposed JICA Loan and GOB fund.

Table 12.1.4 Projection on Annual Disbursement of Proposed JICA Loan and GOB Fund

Year	JICA Loan (JPY mil.)	GOB Fund (BDT mil.)	Combined Total in JPY (mil.)	Combined Total in BDT (mil.)
2013	225	46	270	279
2014	577	132	705	730
2015	1,089	331	1,409	1,459
2016	8,306	2,446	10,669	11,044
2017	8,565	2,517	10,996	11,383
2018	8,412	2,451	10,780	11,159
2019	3,568	908	4,443	4,599
2020	3,644	929	4,541	4,701
2021	448	111	556	576
2022	14	6	21	22
Total	34,847	9,878	44,390	45,952

Note: 1) The total amount is not the same as the sum, due to the round-off.
2) Currency Exchange Rate: US$1 = BDT81.7 =JPY79.0

12.2 Forecast of Financial Position of the Project

12.2.1 General

The objective is to forecast the long-term financial structure of the Phase 1 and 2 Projects in terms of revenue, expenses and profit/loss to examine appropriate terms and conditions of the Government's subsidiary loan (re-lending of the JICA loan and lending of any additional GOB loans) to be considered for enabling these projects to be financially sustainable.

For this purpose, a long-term financial forecast is made in terms of annual income statement (showing income, expenses and profit/loss) and cash/fund-flow on both the Phase 1 and Phase 2 Projects.

12.2.2 Methodology of Financial Forecast and Assumptions

(1) Financial Forecast Model

The financial model used for the financial forecast is composed of the following three computation programs:

- Program A: computing annual operation net income (profit/loss) of the Phase 1 and Phase 2 Projects over a long-term period as defined later (called the "Long-term Forecast Period") with (i) annual water revenue from the Phase 1 and Phase 2 Projects less (ii) annual O&M costs and depreciation of these Projects
- Program B: computing annual debt-services (i.e., annual interest payable and annual repayment of loan proceeds) related to GOB's subsidiary loans (i.e., re-lending of JICA Loan and lending of GOB fund) to be provided for the Phase 1 and Phase 2 Projects over the Long-term Forecast Period
- Program C: computing annual cash/fund-flow and accumulated cash/fund flow and accumulated cash/fund flow over the Long-term Forecast Period based on the outputs of Programs A & B (i.e., (i) annual net operation cash/fund inflow less (ii) annual cash/fund outflow for the annual debt-services.

(2) Major Assumptions for Financial Forecast

The financial forecast is made on the basis of the major assumptions stated below.

1) Scope of water supply.

Scope of water supply is assumed as follows:

a) Supply of 143,000m^3/d from Karnaphuli Water Supply Project (Phase 1) to start in July 2015.
b) Supply of a further 143,000m^3/d from the Phase 2 Project to start in July 2020.

2) Billable water consumption (Accounted-for Water Consumption)

Assuming that the number of house connections with meters will be increased to meet the quantity of water supplied by the Phase 1 Project and then to meet the quantity of water supplied by the Phase 2 Project, the billable water consumption quantity is estimated by means of the following formulae:

DC.BWC + NDC.BWC = BWTC = WSV x (1 – NRWR)
where;

- BWTC: Billable water total consumption (Accounted-for water)
- DC.BWC: Billable water consumption for domestic customers (Accounted–for water for domestic use)
- NDC.BWC: Billable Water Consumption for non-domestic customers (Accounted-for water for non-domestic use)
- WSV: Water Supply Volume
- NRWR: Non-revenue Water Ratio (Unaccounted-for water ratio)

BWTC in each year is divided into DC.BWC and NDC.BWC based on the demand projection for the KSA service area, as presented in Chapter 4 and Chapter 5.

NRWR is assumed to be 33% in 2015 and then to decrease year by year so as to achieve 15% in 2025 along with the progress in construction of new secondary/tertiary distribution networks in the Karnaphuli Water Supply (KWS) service areas in accordance with the implement plan presented in Chapter 11.

The NRWR assumed for the financial forecast is given below.

Fiscal Year (FY)	NRWR (%)
2016	33
2017	30
2018	27
2019	25
2020	23
2021	20
2022	19
2023	18
2024	17
2025	16
2026 onward	15

(3) Water revenue

Water revenue is estimated by multiplying the estimated billable water (accounted-for water) consumption quantities for domestic consumers and non-domestic consumers respectively with applicable water tariff rates in the following formulae:

1) WR = DCR.WR + NDC.WR
2) DCR.WR = DC.BWC x WT/DC
3) NDC.WR = NDC.BWC x WT/NDC

where;

- WR: Water revenue
- DC.WR: Water revenue for domestic customers
- NDC.WR: Water revenue for non-domestic customers
- WCT/DC: Water tariff for domestic customers
- WCT/NDC: Water tariff for non-domestic customers

The current water tariff is used with escalation at 5% per annum every year as allowed under the WASA Act 1996. Collection of billed amounts has been improved and the current records on collection rate show about 97% in average. Assuming further improvement, the financial forecast is made on a 100% collection basis.

The water tariff rates used for the financial forecast are shown in Table 12.2.1.

Table 12.2.1 Water Tariff Rates used for Financial Forecast

Year	Water Tariff for Domestic Customers (BDT/m^3)	Water Tariff for Non-domestic Customers (BDT/m^3)
2012	6.57	18.61
FY 2016	7.61	21.56
FY 2021	9.71	27.52
onward	5% increase every year	

(4) Other revenue

The CWASA's current financial statement shows several other revenues including service connection charges, besides the water revenue. The financial forecast, however, focuses only on the water revenue in order to analyze the revenue and expense structures directly related to the operation of the Phase 1 Project and Phase 2 Project.

Service connection charges are not taken into account, since the current connection charges collected from customers are more than adequate to cover all costs for house connection facility including meters and O&M costs for those facilities, such that income from house connection charges and relevant costs house connections will be self-balanced. As such, the income and expenses related to the house connections are excluded from the financial forecast.

(5) Expenses

The expenses accounted in the financial forecast are those to be incurred for the water production and distribution of the Phase 1and 2 Projects.

The expenses will include:

1) Itemized operating costs for each of the Phase 1 and 2 facilities (labor costs, power and fuel costs, chemical costs, maintenance costs, other administration expenses.); and
2) Depreciation calculated in accordance with the depreciation rates adopted by CWASA.

In view of the CWASA's financial statements, the costs and expenses for the Head Office can be covered by several revenues other than those from the Phase 1 and 2 Projects. Hence the financial forecast does not take such head office expenses into account.

(6) Debt-services of GOB subsidiary loans

The GOB's policy, as stated in Chapter 3, is to provide autonomous/ semi-autonomous bodies and public sector corporations with all funds required for the implementation of their projects in the form of GOB subsidiary loans including re-lending of foreign loans provided for those projects by any external lenders, under the conditions forcing repayment of subsidiary loan proceeds with 15 annual installments within 20 years including 5 years grace period from the initial year of commercial operation and also payment of interest at 4% per annul for local currency loans and 5% per annum for foreign currency loans to be accrued from the initial operation year.

The policy also states that the Government will consider larger equity participation or limited grant by the Government because of public interest in terms of urbanization/human settlements, provided that recovery of full cost (investment and operation) should be justified.

Along with the above policy, the base-line forecast takes into account of debt-services based on the GOB's terms (i.e., (i) repayment of loan proceeds with 15 annual installments for 20 years including a 5 years grace period, and (ii) payment of interest at 5% per annum for the proposed JICA Loan portion and 4% per annum for the GOB fund portion) with provision for no grant and no equity participation by the Government. If the base-line forecast indicates a negative financial structures burden with the GOB's subsidiary loan terms, alternative terms, in particular provision of grant or equity participation by the Government and also relaxation of interest rates are examined in order to seek conditions for enabling the Phase 1 and 2 Projects to be financially sustainable.

12.2.3 Estimates of Inputs for Financial Forecast

As discussed above, there are five inputs for the financial forecast of the Phase 1 and 2 Projects, namely,

(1) Capital Costs and Financing Arrangements
(2) Water revenue
(3) O&M costs
(4) Depreciation
(5) Debt-services

The estimates of these inputs are presented in the subsequent sections.

(1) Capital Costs and Financing Arrangements

The capital costs for Phase 1 Project are estimated on the basis of the actual contract amounts for (a) three contract packages for construction works (i.e., (i) Package 1: Intake Facility and WTP; (ii) Conveyance and Transmission Pipelines and Distribution Main Pipelines; and (iii) Two Water Reservoirs), (b) procurement of meters, saddles and vehicles; and (c) two consulting services (i.e., (i) Engineering Consulting Services and (ii) Institutional Development Consulting Services) and also additional budget for non-contracted items that have been indicated in the Revised Development Project Proposal (RDPP) for the Phase 1 Project approved by the GOB in December 2010.

The capital costs for Phase 2 Project are based on the estimated project costs presented in Chapter 11.

It is noted that the capital costs excludes the costs for service connection works and costs for the procurement of water meters to be used for service connections, since income and expenses related to service connections, as stated in 12.2.2 (4) above, are excluded from the financial forecast.

The capital costs used for the financial forecast of Phase 1 Project are shown in Table 12.2.2.

Table 12.2.2 Capital Costs used for Financial Forecast of Phase 1 Project

Particulars		Project Costs		
		LC (BDT mil.)	FC (JPY mil.)	Combined Total in BDT (mil.)
A.	Land and land development **	207.00	0.00	207.00
B.	Construction Works			
B-1.	Building & Civil Construction			
a.	Intake facilities & WTP ##	1,474.65	222.56	1,674.95
b.	Reservoirs & Elevated Tanks ##	774.65	195.87	950.93
	Sub-total	2,249.30	418.43	2,625.88
B-2.	Plant, Equipment & Pipes			
a.	Intake facilities & WTP: Plant, Equip., etc.##	0.00	1,711.69	1,540.52
b.	Reservoirs & Elevated Tanks: Equipment, tic. ##	23.66	659.50	617.21
c.	Laboratory Equipment ##	0.00	39.35	35.42
	Sub-total	23.66	2,410.54	2,193.15
B-3.	Water Pipelines & Network			
a.	Conveyance & transmission pipelines ##	1,093.84	5,018.24	5,610.26
b.	Distribution pipelines (mains) ##	663.96	1,554.27	2,062.80
c.	Optical Fibre Cable ##	17.18	64.01	74.79
	Sub-total	1,774.98	6,636.52	7,747.85
B-4.	CWASA Direct Works, incl. Procurement			
a.	Secondary distribution network **	48.60	0.00	48.60
b.	Staff Quarters **	30.72	0.00	30.72
	Sub-total	79.32	0.00	79.32
B-5.	Construction Works - Total	4,127.26	9,465.49	12,646.20
B-6.	Physical & Price Contingency (5% of B-5)	206.36	473.27	632.31
B-7.	Grand Total of Construction Works	4,333.62	9,938.76	13,278.51
C.	Vehicles ##	0.00	10.53	9.48
D.	Furniture **	1.44	0.00	1.44
E.	Consultancy Services			
a.	Engineering Consultants ##	192.43	818.13	928.75
b.	Institutional Development Consultants ##	8.88	75.70	77.01
	Sub-total	201.31	893.83	1,005.76
F.	Grand Total (A to E) (A to E)	4,743.37	10,843.12	14,502.19
G.	Taxes			
a.	VAT & Taxes (14.5% of F)	2,118.54	0.00	2,118.54
b.	Import Duties	2,011.81	0.00	2,011.81
	Sub-total	4,130.35	0.00	4,130.35
H.	CWASA Project Management Expenses **	1,000.00	0.00	1,000.00
	Project Costs - Total	9,873.72	10,843.12	19,632.54

Note: Costs for **Items: Revised DPP
Costs for ##Items: Contract Prices
Currency Exchange Rate: JPY 1 = BDT 0.9

Details of the estimated import duties are shown in Table 12.2.3.

Table 12.2.3 Import Duties for Phase 1 Project

Estimates of Import Duties		
Package 1		
Equipment: JPY 1,423.95 mil. x BDT0.91/JPY x 21%	(BDT mil.)	272.11
Pipes JPY 95.92 mil. x BDT0.91/JPY x 25%	(BDT mil.)	21.82
Sub-total		293.93
Package 2		
DI Pipes JPY 3,842.76 mil. x BDT0.91/JPY x 25%	(BDT mil.)	874.28
Valves, etc. JPY 854.65 mil. x BDT0.91/JPY x 15%	(BDT mil.)	116.66
OF Cable JPY 14.06 x BDT0.91/JPY x 15%	(BDT mil.)	1.92
Sub-total		1,580.72
Package 3		
Equipment: JPY 344.81 mil. x BDT0.91/JPY x 21%	(BDT mil.)	65.89
Pipes JPY 298.45 mil. x BDT0.91/JPY x 25%	(BDT mil.)	67.90
Sub-total		133.79
Vehicles JPY 10.53 mil. x BDT0.8/JPY x 40%	(BDT mil.)	3.37
		2,011.81

The JICA Loan for the Phase 1 Project amounts to JPY12,224 million, of which JPY92.11 million was disbursed for the procurement of meters and saddles to be used for house connections. The JICA Loan provided for Phase 1 Project, excluding the amounts for the procured meters and saddles, is therefore JPY 12,131.89 million. The rest of the capital cost shown in Table 12.2.1 is financed by the GOB fund. Thus, the financial forecast for Phase 1 Project is based on the financing arrangements given in Table 12.2.4.

Table 12.2.4 Financing Arrangements used for Financial Forecast of Phase 1 Project

Particulars	FC (JPY mil.)	LC (BDT mil.)	Combined Total in BDT (mil.)
A. JICA Loan	12,131.89		10,918.70
B. GOB Fund		8,713.84	8,713.84
Total	12,131.89	8,713.84	19,632.54

Note: Exchange Rate: JPY 1 = BDT 0.9

The capital costs used for the financial forecast of Phase 2 Project are shown in Table 12.2.5. This table shows A. Base Capital Costs and B. Capital Costs used for Financial Forecast. The Capital Costs used for Financial Forecast, as stated earlier in this section, are based on the Base Capital Costs with the following adjustments on the items indicated with Remark Nos. in the table:

1) A-3 (f) Service Connections:
   Excluded these costs, as these costs can be covered with service connection charges
2) A-3 (g) Supply for Low Income Communities:
   Excluded 20% of the costs estimated for the Base Capital Costs with the same reason as above, as the Costs for Supply for Low Income Communities include the costs for service connections
3) A-4 (c) Distribution Pipelines:
   Excluded some portion of the costs estimated for the Base Capital Costs with the same reason as above, as the Costs for Distribution Pipelines include the costs for facilities related to the service connections
4) A-5 (a) Water Meters:
   Excluded these costs with the same reason as above
5) D. CWASA Administration Costs:

Table 12.2.5 Capital Costs used for Financial Forecast of Phase 2 Project

		A. Base Project Costs		B. Project Costs used for Financial Forecast		
		LC Portion (BDT mil.)	FC Portion (JPY mil.)	LC Portion (BDT mil.)	FC Portion (JPY mil.)	Combined Total in BDT (mil.)
A.	Construction Works					
A-1.	Building & Civil Construction					
a.	Intake facilities & WTP	1,338.81	530.42	1,338.81	530.42	1,887.90
b.	Reservoirs & Elevated Tanks	444.36	111.56	444.36	111.56	559.85
	Sub-total	1,783.17	641.98	1,783.17	641.98	2,447.75
A-2.	Plant, Machinery & Pipes etc.					
a.	Intake facilities & WTP	224.66	2,108.40	224.66	2,108.40	2407.27
b.	Reservoirs & Elevated Tanks	50.92	459.46	50.92	459.46	526.55
	Sub-total	275.58	2,567.86	275.58	2,567.86	2,933.82
A-3.	Water Pipelines & Network					
a.	Conveyance & transmission pipelines	1,208.40	5,450.00	1,208.40	5,450.00	6,850.22
b.	Optical Fibre Cable	9.00	40.00	9.00	40.00	50.41
c.	Primary Distribution Pipelines (Mains)	182.73	778.60	182.73	778.60	988.73
d.	Monitoring & Control System	10.00	304.70	10.00	304.70	325.42
e.	Secondary/tertiary Distribution Network Pipelines	6,596.78	2,577.00	6,596.78	2,577.00	9,264.48
f.	Service connections **1)	130.29	333.65	0.00	0.00	0.00
g.	Supply for Low Income Communities **2)	197.90	77 .31	158.32	61.85	222.34
	Sub-total	8,335.10	9,561.26	8,165.23	9,212.15	17,701.60
A-4.	General Requirements & Dispute Board for Construction Works					
a.	Intake facilities, WTP, Reservoirs & Elevated Tanks	164.70	291.15	164.70	291.15	466.10
b.	Conveyance & transmission Pipelines	97.03	471.97	97.03	471.97	585.61
c.	Primary/secondary/tertiary Distribution Pipelines **3)	505.97	378.38	495.85	336.76	844.46
	Sub-total	767.70	1,141.50	757.58	1,099.88	1,896.17
A-5.	Procurement of Equipment & Materials					
a.	Water Meters **4)	0.00	205.44	0.00	0.00	0.00
b.	Maintenance Vehicles	0.00	96.00	0.00	96.00	99.38
c.	Maintenance Equipment	0.00	35.15	0.00	35.15	36.39
	Sub-total	0.00	336.59	0.00	131.15	135.77
A-6.	Project Implementation Support Unit	148.46	0.00	148.46	0.00	148.46
A-7.	Construction Works - Total (A-1 to A-6).	11,310.01	14,249.19	11,130.02	13,653.02	25,263.57
A-8.	Price Escalation for Construction Works (FC 2.1% A-7, LC 4.9% of A-7)	3,546.00	1,634.00	3,489.57	1,565.63	5,110.30
A-9.	Contingency for Construction Works (5% of A-7 & A-8)	743.00	794.00	731.18	760.78	1,518.74
A-10	Grand Total of Construction Works	15,599.01	16,677.19	15,350.77	15,979.43	31,892.61
B.	Consultancy Services					
B-1.	Engineering Consulting Services	1,023.00	1,538.00	1,023.00	1,538.00	2,615.13
B-2	Price Escalation (2.1% B-1 FC, 4.9% of B-1 LC)	275.00	162.00	275.00	162.00	442.70
B-3	Contingency (5% of B-1& B-2)	65.00	85.00	65.00	85.00	152.99
B-4	Consultancy Services - Total (B-1 to B-3).	1,363.00	1,785.00	1,363.00	1,785.00	3,210.82
C.	Grand Total (A & B)	16,962.01	18,462.19	16,713.77	17,764.43	35,103.43
D.	CWASA Administration Cost **5)	1,804.00	0.00	10.00	0.00	10.00
E.	Taxes & Charges					
a.	VAT (15% of C+D_ LC)	2,821.00	0.00	2,514.00	0.00	2,514.00
b.	Import Duties (30% of A-10 FC)	5,179.00	0.00	4,962.31	0.00	4,962.31
c.	Banking Charges	54.00	0.00	52.55	0.00	52.55
	Sub-total	8,054.00	0.00	7,528.86	0.00	7,528.86
F.	Project Cost - Grand Total (C + D + E)	26,820.01	18,462.19	24,252.63	17,764.43	42,642.29
G.	Interest during Construction					
a.	Interest during Construction for Construction Works	0.00	18.00	0.00	17.47	18.08
b.	Interest during Construction for Consulting Services	0.00	2.00	0.00	2.00	2.07
	Sub-total	0.00	20.00	0.00	19.47	20.15
	GRAND TOTAL (F + G)	26,820.01	18,482.19	24,252.63	17,783.90	42,662.44

Note: Exchange Rate: BDT 1 = JPY 0.966 (US$1 = BDT81.7 =JPY79.0)

Included BDT10 million for Financial Forecast out of BDT1,804 million estimated for the Base Capital Costs, since the overwhelming majority of the estimated costs is the costs that may be incurred for the enhancement of CWASA' s overall administrative organization and activities and the enhancement of organization and activities for water meter reading and water charge billing and collection, and these costs can be covered with the services connection charges and other revenue.

6) Adjustment of incidental costs:
Adjusted price escalation, contingencies, VAT, import duties, banking charges, interest during construction along with the above cost adjustment

Whereas the financing plan for the Phase 2 Project, as shown in Table 12.1.2, proposes to be JPY34,847 million by a JICA Loan and BDT9,878 million by the GOB fund, the financial forecast for the Phase 2 Project is based on the financing plan formulated on the basis of the Capital Costs adjusted for the financial forecast, as shown in Table 12.2.6.

Table 12.2.6 Financing Plan used for Financial Forecast of Phase 2 Project

Particulars	FC Portion (JPY mil.)	LC Portion (BDT mil.)	Combined Total in (BDT mil.)
A. JICA Loan	17,764.43	16,713.77	35,103.43
B. GOB Fund	19.47	7,538.86	7,559.01
Total	17,783.90	24,252.63	42,662.44

Note: Exchange Rate: BDT 1 = JPY 0.966 (US$1 = BDT81.7 =JPY79.0)

(2) Water Revenue

Water revenue for the Phase 1 and 2 Projects is estimated on the basis of the methodology and assumptions stated in 12.2.2 (2). Table 12.2.7 shows the estimated water revenue.

Table 12.2.7 Water Revenue Estimated for Phase 1 & 2 Projects

Fiscal Year	Water Tariff Rate (BDT/m^3)		Phase I Project								Phase 2 Project							
			Available Water Volume (mill m^3)	NWR %	Billed Water Volume (mil m^3)			Water Revenues (BDT million)			Available Water Volume (mill m^3)	NWR %	Billed Water Volume (mil m^3)			Water Revenues (BDT million)		
	Dom.	Non-Dom.			Dom.	Non-Dom.	Total	Dom.	Non-Dom.	Total			Dom.	Non-Dom.	Total	Dom.	Non-Dom.	Total
2016	7.61	21.56	41.76	33%	22.63	5.35	27.98	172.21	115.35	287.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2017	7.99	22.64	44.37	30%	24.93	6.13	31.06	199.19	138.78	337.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2018	8.39	23.77	46.98	27%	27.27	7.03	34.30	228.80	167.10	395.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2019	8.81	24.96	49.59	25%	29.13	8.06	37.19	256.64	201.18	457.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2020	9.25	26.21	52.20	23%	31.49	8.70	40.19	291.28	228.03	519.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2021	9.71	27.52	52.20	20%	32.99	8.77	41.76	320.33	241.35	561.68	41.76	0.20	28.14	5.27	33.41	273.24	145.03	418.27
2022	10.20	28.90	52.20	19%	33.40	8.88	42.28	340.68	256.63	597.31	44.37	0.19	30.07	5.87	35.94	306.71	169.64	476.35
2023	10.71	30.35	52.20	18%	33.55	9.25	42.80	359.32	280.74	640.06	46.98	0.18	32.28	6.24	38.52	345.72	189.38	535.10
2024	11.25	31.87	52.20	17%	34.13	9.20	43.33	383.96	293.20	677.16	49.59	0.17	34.12	7.04	41.16	383.85	224.36	608.21
2025	11.81	33.46	52.20	16%	35.38	8.47	43.85	417.84	283.41	701.25	52.20	0.16	35.38	8.47	43.85	417.84	283.41	701.25
2026	12.40	35.13	52.20	15%	35.05	9.32	44.37	434.62	327.41	762.03	52.20	0.15	35.05	9.32	44.37	434.62	327.41	762.03
2027	13.02	36.89	52.20	15%	35.05	9.32	44.37	456.35	343.81	800.16	52.20	0.15	35.05	9.32	44.37	456.35	343.81	800.16
2028	13.67	38.73	52.20	15%	34.60	9.77	44.37	472.98	378.39	851.37	52.20	0.15	34.60	9.77	44.37	472.98	378.39	851.37
2029	14.35	40.67	52.20	15%	34.15	10.22	44.37	490.05	415.65	905.70	52.20	0.15	34.15	10.22	44.37	490.05	415.65	905.70
2030	15.07	42.70	52.20	15%	33.70	10.67	44.37	507.86	455.61	963.47	52.20	0.15	33.69	10.68	44.37	507.71	456.04	963.75
2031	15.82	44.84	52.20	15%	33.55	10.82	44.37	530.76	485.17	1,015.93	52.20	0.15	33.54	10.83	44.37	530.60	485.62	1,016.22
2032	16.61	47.08	52.20	15%	33.55	10.82	44.37	557.27	509.41	1,066.68	52.20	0.15	33.54	10.83	44.37	557.10	509.88	1,066.98
2033	17.44	49.43	52.20	15%	33.55	10.82	44.37	585.11	534.83	1,119.94	52.20	0.15	33.54	10.83	44.37	584.94	535.33	1,120.27
2034	18.31	51.90	52.20	15%	33.55	10.82	44.37	614.30	561.56	1,175.86	52.20	0.15	33.54	10.83	44.37	614.12	562.08	1,176.20
2035	19.23	54.50	52.20	15%	33.55	10.82	44.37	645.17	589.69	1,234.86	52.20	0.15	33.54	10.83	44.37	644.97	590.24	1,235.21
2036	20.19	57.23	52.20	15%	33.55	10.82	44.37	677.37	619.23	1,296.60	52.20	0.15	33.54	10.83	44.37	677.17	619.80	1,296.97
2037	21.20	60.09	52.20	15%	33.55	10.82	44.37	711.26	650.17	1,361.43	52.20	0.15	33.54	10.83	44.37	711.05	650.77	1,361.82
2038	22.26	63.09	52.20	15%	33.55	10.82	44.37	746.82	682.63	1,429.45	52.20	0.15	33.54	10.83	44.37	746.60	683.26	1,429.86
2039	23.37	66.24	52.20	15%	33.55	10.82	44.37	784.06	716.72	1,500.78	52.20	0.15	33.54	10.83	44.37	783.83	717.38	1,501.21
2040	24.54	69.55	52.20	15%	33.55	10.82	44.37	823.32	752.53	1,575.85	52.20	0.15	33.54	10.83	44.37	823.07	753.23	1,576.30
2041	25.77	73.03	52.20	15%	33.55	10.82	44.37	864.58	790.18	1,654.76	52.20	0.15	33.54	10.83	44.37	864.33	790.91	1,655.24
2042	27.06	76.68	52.20	15%	33.55	10.82	44.37	907.81	829.69	1,737.50	52.20	0.15	33.54	10.83	44.37	907.54	830.46	1,738.00

(3) O & M Costs

The O & M costs comprise the following cost components:

A. Variable Costs
   a. Power cost
   b. Fuel cost
   c. Chemical cost
      i) Chlorine
      ii) Alum
      iii) Lime

B. Fixed Costs
   a. Personnel cost
   b. Welfare and administration cost
   c. Maintenance cost

Table 12.2.8 shows O&M Variable Costs for Phase 1 and Phase 2 Projects estimated as those as of the year 2012.

Table 12.2.8 O&M Variable Costs (as of 2012) estimated for Phase 1 & 2 Projects

Particulars		Unit Cost (BDT)	Phase 1			Phase 2		
			Unit Consumption in 100% operation	Cost /day (BDT)	Cost/Year (BDT)	Unit Consumption in 100% operation	Cost /Day (BDT)	Cost/Year (BDT)
A.	Variable Cost							
A-1	Power Cost							
a.	Intake							
	Energy Charge *1)	5.61 /kWh	650 kW/h	83,578	30,505,890	650 kW/h	83,578	30,505,890
	Demand Charge *2)	45.00 /kWh	975 kW/h		526,500	975 kW/h		526,500
b.	WTP							
	Energy Charge	5.61 /kWh	1,950 kW/h	250,733	91,517,669	1,950 kW/h	250,733	91,517,669
	Demand Charge	45.00 /kWh	2,900 kW/h		1,566,000	2,900 kW/h		1,566,000
c.	Nashirabad Reservoir							
	Energy Charge	5.61 /kWh	752 kW/h	96,693	35,292,968	752 kW/h	96,693	35,292,968
	Demand Charge	45.00 /kWh	1,575 kW/h		850,500	1,575 kW/h		850,500
Total					160,259,527			160,259,527
	(Power Cost per m^3)				3.07			3.07
A-2	Fuel (Diesel Oil) *3)							
a.	Intake	60.00 /l	176 l/h	11,405	4,162,752	176 l/h	11,405	4,162,752
b.	WTP	60.00 /l	527 l/h	34,150	12,464,604	527 l/h	34,150	12,464,604
c.	Nashirabad Reservoir	60.00 /l	203 l/h	13,154	4,801,356	203 l/h	13,154	4,801,356
Total					21,428,712			21,428,712
	(Fuel Cost per m^3)				0.41			0.41
A-3	Chemicals							
a.	Chlorine (Cl_2)	25,000 /ton	0.6 ton/d	15,000	5,475,000	0.6 ton/d	15,000	5,475,000
b.	ALUM	24,000 /ton	3.15 ton/d	75,600	27,594,000	3.15 ton/d	75,600	27,594,000
c.	LIME	12,000 /ton	0.75 ton/d	9,000	3,285,000	0.75 ton/d	9,000	3,285,000
Total					36,354,000			36,354,000
	(Chemicals Cost per m^3)				0.70			0.70
A-4	Variable Cost - Total (A1+ A2 + A3)				218,042,239			218,042,239
	(Variable Cost per m^3)				4.18			4.18

*1) Energy Charge: - Cost/day: Unit Cost x Consumption/h x 95.5% x 24hrs.
- Cost/year: Daily cost x 365 days

*2) Demand Charge: - Cost/month: Unit Cost x Monthly demand volume
- Cost/year: Monthly cost x 12 months

*3) Fuel (Diesel Oil) Cost: - Cost/day: Unit Cost x Daily power Cons. x .0.27 l/kWh x 4.5%
- Cost/year: Daily cost x 365 days

The structure of variable costs (as of the year 2012) given in the above is represented in terms of unit costs per m^3 of the produced water as follows:

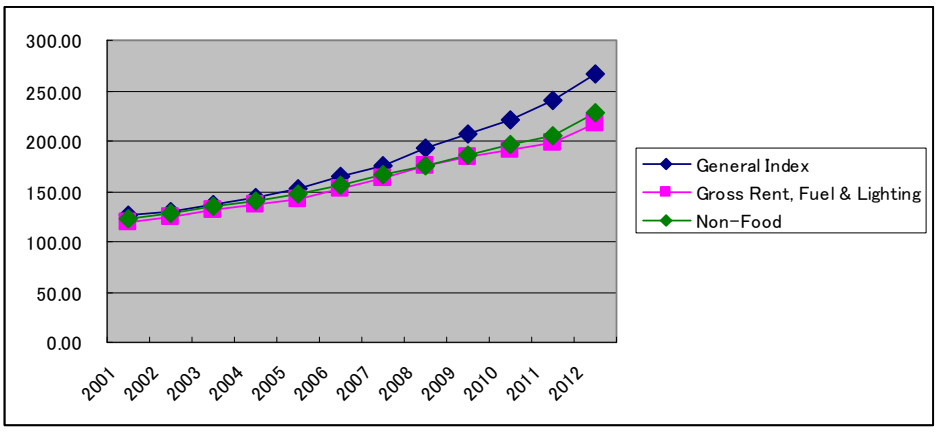
Cost Items	Unit Cost per m^3 of Produced Water	Composition (%)
Power Cost	3.07	73.44
Fuel Cost	0.41	9.81
Chemicals Cost	0.70	16.75
Variable Cost - Total	4.18	100.00

As power and fuel costs account for 83.25% of the total variable costs, it can be assumed that future prices of the variable costs may be dependent upon the energy prices in Bangladesh. Table 12.2.9 shows the Price Index in Bangladesh for 11 years from 2001 to 2012.

Table 12.2.9 Price Index in Bangladesh (2001 – 2012)

Fiscal Year	National						Urban					
	General Index		Gross Rent, Fuel & Lighting		Non-Food		General Index		Gross Rent, Fuel & Lighting		Non-Food	
2001	126.72		119.41		122.25		125.70		110.91		118.61	
2002	130.26	2.79%	124.95	4.64%	127.89	4.61%	129.92	3.36%	115.60	4.23%	124.19	4.70%
2003	135.97	4.38%	131.20	5.00%	135.13	5.66%	134.49	3.52%	119.51	3.38%	130.40	5.00%
2004	143.90	5.83%	136.19	3.80%	141.03	4.37%	142.54	5.99%	122.56	2.55%	135.80	4.14%
2005	153.23	6.48%	141.43	3.85%	147.14	4.33%	151.29	6.14%	126.31	3.06%	141.90	4.49%
2006	164.21	7.17%	152.02	7.49%	156.56	6.40%	161.39	6.68%	131.07	3.77%	149.20	5.14%
2007	176.06	7.22%	162.32	6.78%	165.79	5.90%	172.73	7.03%	138.41	5.60%	157.17	5.34%
2008	193.54	9.93%	174.70	7.63%	176.26	6.32%	189.65	9.80%	147.54	6.60%	166.69	6.06%
2009	206.43	6.66%	184.46	5.59%	186.67	5.91%	201.49	6.24%	148.24	0.47%	174.69	4.80%
2010	221.53	7.31%	191.49	3.81%	196.84	5.45%	216.98	7.69%	152.58	2.93%	183.40	4.99%
2011	241.02	8.80%	197.92	3.36%	205.01	4.15%	232.81	7.30%	155.01	1.59%	190.87	4.07%
2012	266.61	10.62%	218.26	10.28%	227.87	11.15%	260.01	11.68%	165.44	6.73%	211.82	10.98%
Ave.1		7.02%		5.66%		5.84%		6.86%		3.72%		5.43%
Ave.2		7.00%		5.64%		5.82%		6.83%		3.70%		5.41%
Ave.3		8.41%		6.21%		6.46%		8.27%		3.96%		6.01%

Ave.1: Average % from 2002 to 2012
Ave.2: Annual Average % from 2001 to 2012
Ave.3: Annual Average % from 2006 to 2012
Source: Bangladesh Bureau of Statistics



The price index of gross rental, fuel and lighting sector in urban areas indicates an increase of 3.7% per annum on average for the 11 years from 2001 to 2012 and 4.0% per annum on average for the six years from 2006 to 2012, even though there were significant increases of 6.6% in 2008 and 6.73% in 2012. Taking the average price trend of the gross rental, fuel and lighting sector in the past 11 years, the variable cost is assumed to increase at annual rate of 3.7%.

Personnel costs for the Phase 1 and Phase 2 Projects are estimated on the basis of the O & M personnel requirements presented in Chapter 9 and CWASA's current payroll structures. The CWASA follows the payrolls approved by LGRD&C for each class of officer and staff, which fix the base salary rates and annual increase rates. Table 12.2.10 shows the base salary scale including, annual increases approved by LGRD&C in 2009 and currently adjusted by CWASA.

Table 12.2.10 Base Salary Scale

Class of Engineers /Officers / Staff	Base Salary Scale (Effective in 2009 onward)			Adjusted Salary Base	Monthly Incr.
A Superintendent Engineer	25,750:	1,000 x 8:	33,750	50,800	1,600
B Exclusive Engineer / Chemist	18,500:	800 x 14:	29,700	35,000	1,300
C Engineer	12,000:	600 x 16:	21,600	25,000	1,000
D Assistant Engineer	11,000:	400 x 7: 540 x 11:	14,430 20,370	20,000	800
E Sub-assistant Engineer	8,000:	450 x 7: 490 x 11:	11,150 16,540	15,000	720
F Technician / Plumber	5,200:	320 x 7: 345 x 11:	7,440 11,235	12,000	510
G Operator / Assistant Staff	4,700:	265 x 7: 290 x 11:	6,555 9,745	10,000	420
H Clarks	4,100:	190 x 7: 210 x 11:	5,430 7,740	8,000	300

Table 12.2.11 shows the personnel costs for O & M of the Phase 1 Project and the Phase 2 Project, with the costs for the Phase 1 Project as in the first operation year of FY 2016 and those for the Phase 2 Project as in the first operation year of FY2021.

Table 12.2.11 O & M Personnel Costs for Phase 1 & 2 Projects

Department	Section	Function		Class of Engr/ Officer/ Staff	No. of Persons			Phase 1		Phase 2	
					Ph. 1	Ph. 2	Total	1st Year (FY2016)	Annual Increase	1st Year (FY2021)	Annual Increase
A. KWS System Division	Monitoring & Control	A1.	Division General Manager	A	0	1	1	-	-	609,600	19,200
		A2.	Assistant G.M.	B	1	0	1	420,000	15,600	-	-
		A3.	Chief	C	1	0	1	300,000	12,000	-	-
		A4.	Officer	D	0	1	1	-	-	240,000	9,600
		A5.	Staff	E	1	1	2	180,000	8,640	180,000	8,640
	Data Processing & Analysis	A6.	Chief	C	0	1	1	-	-	300,000	12,000
		A7.	Staff	D	0	1	1	-	-	240,000	9,600
	General Assistance	A8.	Clarks	H	6	2	8	576,000	21,600	192,000	7,200
	Sub-total				9	7	16	1,476,000	57,840	1,761,600	66,240
B. O&M for Intake Facility, Water Treatment Plant & Transmission Pipeline		B1.	Department Manager	B	1	0	1	420,000	15,600	-	-
		B2.	Process Engr	C	1	0	1	300,000	12,000	-	-
		B3.	Mechanical Engineer	C	1	0	1	300,000	12,000	-	-
		B4.	Electrical Engr	C	1	0	1	300,000	12,000	-	-
		B5.	Instrumentation Engr	C	1	0	1	300,000	12,000	-	-
	1.Intke Facility	B6.	Section Chief	D	1	0	1	240,000	9,600	-	-
		B7.	Technicians	F	1	1	2	144,000	6,120	144,000	6,120
		B8.	Operators	G	2	2	4	240,000	10,080	240,000	10,080
	2.Water Treatment	B9.	Section Chief	C	1	0	1	300,000	12,000	-	-
		B10.	Technicians	F	2	3	5	288,000	12,240	432,000	18,360
		B11.	Operators	G	5	5	10	600,000	25,200	600,000	25,200
	3.Sludge Treatment	B12.	Section Chief	D	0	1	1	-	-	240,000	9,600
		B13.	Technicians	F	1	1	2	144,000	6,120	144,000	6,120
		B14.	Operators	G	3	3	6	360,000	15,120	360,000	15,120
	4.Laboratory	B15.	Section Chief	C	1	0	1	300,000	12,000	-	-
		B16.	Assistant	G	2	2	4	240,000	10,080	240,000	10,080
	5.Pipeline Maintenance	B17.	Section Chief	D	1	0	1	240,000	9,600	-	-
		B18.	Plumbers	F	2	2	4	288,000	12,240	288,000	12,240
	General Assistance	B19.	Clarks	H	10	8	18	960,000	36,000	768,000	28,800
	Sub-total				37	28	65	5,964,000	240,000	3,456,000	141,720
C. O&M for Distribution Facilities		C1.	Department Manager	B	0	1	1	-	-	420,000	15,600
		C2.	Mechanical Engineer	C	0	1	1	-	-	300,000	12,000
		C3.	Electrical Engr	C	0	1	1	-	-	300,000	12,000
		C4.	Instrumentation Engr	C	0	1	1	-	-	300,000	12,000
	1.Reservoir/ Elevated Tank	C5.	Section Chief	C	1	0	1	300,000	12,000	-	-
		C6.	Technicians	F	2	1	3	288,000	12,240	144,000	6,120
		C7.	Operators	G	4	3	7	480,000	20,160	360,000	15,120
	2.Main Pipe/Sector Chamber & DMA	C8.	Section Chief	C	1	0	1	300,000	12,000	-	-
		C9.	Leakage Monitoring Team (composed of 3 groups)	E	1	2	3	180,000	8,640	360,000	17,280
				F	1	2	3	144,000	6,120	288,000	12,240
				G	3	6	9	360,000	15,120	720,000	30,240
		C10.	Investigation & Repair Team	E	1	1	2	180,000	8,640	180,000	8,640
				F	1	1	2	144,000	6,120	144,000	6,120
				G	3	3	6	360,000	15,120	360,000	15,120
	3.Water Meter Maintenance Centre	C11.	Centre Manager	C	1	0	1	300,000	12,000	-	-
		C12.	Water Meter Maintenance Staff	D	0	1	1	-	-	240,000	9,600
				E	1	1	2	180,000	8,640	180,000	8,640
				F	2	2	4	288,000	12,240	288,000	12,240
				G	5	8	13	600,000	25,200	960,000	40,320
	General Assistance	C13.	Clarks	H	10	8	18	960,000	36,000	768,000	28,800
	Sub-total				37	43	80	5,064,000	210,240	6,312,000	262,080
Grand Total					83	78	161	12,504,000	508,080	11,529,600	470,040

Table 12.2.12 shows the annual O & M personnel costs for the Phase 1 and Phase 2 Projects based on the annual increase rates for salaries, which are fixed for the different classes of officers and staff.

Table 12.2.12 Estimated O & M Personnel Costs for Phase 1 & 2 Projects

Phase 1 Project		Phase 2 Project	
Year	Amount	Year	Amount
2016	12,504,000	2021	11,529,600
2017	13,012,080	2022	11,999,640
2018	13,520,160	2023	12,469,680
2019	14,028,240	2024	12,939,720
2020	14,536,320	2025	13,409,760
2021	15,044,400	2026	13,879,800
2022	15,552,480	2027	14,349,840
2023	16,060,560	2028	14,819,880
2024	16,568,640	2029	15,289,920
2025	17,076,720	2030	15,759,960
2026	17,584,800	2031	16,230,000
Av. Inc/Yr.	3.47%	Av. Inc/Yr.	3.48%

Based on the above estimated personnel costs, the O & M personnel costs for the Phase 1 and 2 Projects are assumed to increase at 3.5% per annum. Welfare and administration expenses are estimated at 50% of the personnel costs (i.e., 20% for welfare expenses and 30% for administration expenses).

The annual maintenance cost is estimated as BDT 1,100,000 per year as in 2012 respectively for Phase 1 Project and Phase 2 Project.

The welfare and administration expenses are assumed to increase at 3.5% per annum following the increases in the personnel costs, while the maintenance cost is assumed to increase at 2% per annum following the current price trends of international machinery costs.

Table 12.2.13 shows the estimated O & M costs for the Phase 1 and 2 Projects, and Table 12.2.14 shows the base costs, as of the year 2012.

Table 12.2.13 Estimated O & M Costs for Phase 1 & 2 Projects

Fiscal Year	Escalation Rate (%)			Unit Cost			Phase 1 Project					Phase 2 Project					Phase 1 & 2 Total Annual O & M Cost (BDT '000)
							Ope. Ratio (%)	Annual Production Water Volume ('000 m^3)	Annual O & M Cost (BDT '000)			Ope. Ratio (%)	Annual Production Water Volume ('000 m^3)	Annual O & M Cost (BDT '000)			
	Variable Cost	Fixed Cost (A.)	Fixed Cost (B.)	Variable Cost (BDT/m^3)	Fixed Cost (A) (BDT '000/y)	Fixed Cost (B) (BDT '000/y)			Variable Cost	Fixed Cost	Total O& M Cost			Variable Cost	Fixed Cost	Total O& M Cost	
2012				4.18	18,756	11,000											
2013	3.7	3.5	2.0	4.33	19,412	11,220											
2014	3.7	3.5	2.0	4.50	20,092	11,444											
2015	3.7	3.5	2.0	4.66	20,795	11,673											
2016	3.7	3.5	2.0	4.83	21,523	11,907	80	41,756	201,841	33,430	235,271						235,271
2017	3.7	3.5	2.0	5.01	22,276	12,145	85	44,366	222,393	34,421	256,814						256,814
2018	3.7	3.5	2.0	5.20	23,056	12,388	90	46,976	244,188	35,444	279,632						279,632
2019	3.7	3.5	2.0	5.39	23,863	12,636	95	49,585	267,287	36,498	303,785						303,785
2020	3.7	3.5	2.0	5.59	24,698	12,888	100	52,195	291,766	37,586	329,353						329,353
2021	3.7	3.5	2.0	5.80	25,563	13,146	100	52,195	302,562	38,709	341,270	80	41,756	242,049	36,717	278,766	620,036
2022	3.7	3.5	2.0	6.01	26,457	13,409	100	52,195	313,757	39,866	353,623	85	44,366	266,695	37,804	304,499	658,122
2023	3.7	3.5	2.0	6.23	27,383	13,677	100	52,195	325,366	41,060	366,426	90	46,976	292,832	38,926	331,758	698,184
2024	3.7	3.5	2.0	6.46	28,342	13,951	100	52,195	337,404	42,292	379,696	95	49,585	320,532	40,084	360,616	740,312
2025	3.7	3.5	2.0	6.70	29,334	14,230	100	52,195	349,888	43,563	393,451	100	52,195	349,888	41,277	391,165	784,617
2026	3.7	3.5	2.0	6.95	30,360	14,514	100	52,195	362,834	44,875	407,708	100	52,195	362,834	42,509	405,342	813,051
2027	3.7	3.5	2.0	7.21	31,423	14,805	100	52,195	376,259	46,227	422,486	100	52,195	376,259	43,779	420,037	842,523
2028	3.7	3.5	2.0	7.48	32,523	15,101	100	52,195	390,180	47,623	437,804	100	52,195	390,180	45,089	435,269	873,073
2029	3.7	3.5	2.0	7.75	33,661	15,403	100	52,195	404,617	49,064	453,681	100	52,195	404,617	46,440	451,057	904,738
2030	3.7	3.5	2.0	8.04	34,839	15,711	100	52,195	419,588	50,550	470,138	100	52,195	419,588	47,835	467,423	937,560
2031	3.7	3.5	2.0	8.34	36,058	16,025	100	52,195	435,112	52,083	487,196	100	52,195	435,112	49,273	484,386	971,582
2032	3.7	3.5	2.0	8.64	37,320	16,345	100	52,195	451,212	53,666	504,878	100	52,195	451,212	50,758	501,969	1,006,847
2033	3.7	3.5	2.0	8.96	38,627	16,672	100	52,195	467,906	55,299	523,206	100	52,195	467,906	52,289	520,195	1,043,401
2034	3.7	3.5	2.0	9.30	39,979	17,006	100	52,195	485,219	56,984	542,203	100	52,195	485,219	53,869	539,088	1,081,291
2035	3.7	3.5	2.0	9.64	41,378	17,346	100	52,195	503,172	58,724	561,896	100	52,195	503,172	55,499	558,671	1,120,567
2036	3.7	3.5	2.0	10.00	42,826	17,693	100	52,195	521,790	60,519	582,308	100	52,195	521,790	57,182	578,971	1,161,280
2037	3.7	3.5	2.0	10.37	44,325	18,047	100	52,195	541,096	62,372	603,467	100	52,195	541,096	58,918	600,013	1,203,481
2038	3.7	3.5	2.0	10.75	45,876	18,408	100	52,195	561,116	64,284	625,400	100	52,195	561,116	60,709	621,825	1,247,225
2039	3.7	3.5	2.0	11.15	47,482	18,776	100	52,195	581,878	66,258	648,135	100	52,195	581,878	62,558	644,435	1,292,571
2040	3.7	3.5	2.0	11.56	49,144	19,151	100	52,195	603,407	68,295	671,702	100	52,195	603,407	64,466	667,873	1,339,575
2041	3.7	3.5	2.0	11.99	50,864	19,534	100	52,195	625,733	70,398	696,131	100	52,195	625,733	66,435	692,168	1,388,299
2042	3.7	3.5	2.0	12.43	52,644	19,925	100	52,195	648,885	72,569	721,454	100	52,195	648,885	68,467	717,352	1,438,806

Table 12.2.14 Base O & M Costs for Phase 1 & 2 Projects (as of 2012)

	Phase 1	Phase 2
A. Variable Cost	(BDT/m^3)	(BDT/m^3)
a. Power	3.07	3.07
b. Fuel	0.41	0.41
c. Chemicals	0.70	0.70
Total	4.18	4.18
B. Fixed Cost	(BDT'000/yr)	(BDT'000/yr)
a. Personnel	12,504	11,530
b. Welfare & Adm.	6,252	5,765
c. Maint. & Repair	11,000	11,000
Total	29,756	28,294

(4) Depreciation

Depreciation for the Phase 1 and 2 Projects is estimated based on the value of fixed assets indicated respectively in the capital costs for the Phase 1 Project in Table 12.2.1 and the Phase 2 Project in Table 12.2.4 and applying depreciation rates used by CWASA against the depreciable asset values, holding 10% as residual value in accordance with the CWASA's financial accounting practice.

Tables 12.2.15 and 12.2.16 show the estimated depreciation for the Phase 1 and Phase 2 Projects respectively.

Table 12.2.15 Depreciation for Phase 1 Project

Particulars	Original Value			Additional (BDT mil.)			Total Asset Value for Dep.** (BDT mil.)	Dep. Rate (%)	Annual Depreciation Amount (BDT mil.)			
	LC (BDT mil.)	FC (JPY mil.)	Combined Total (BDT mil.)	Contingencies	Import Duties	VAT			1st yr -- 5th yr	6th yr -- 17th yr	18th yr – 25th yr	26th yr – 50th yr
A. Buildings and Structures												
a. Intake facilities & WTP	1,474.65	222.56	1,677.18	83.86		79.25	1,840.29	4%	66.25	66.25	66.25	
b. Reservoirs & Elevated Tanks	774.65	195.87	952.89	47.64		45.02	1,045.55	2%	18.82	18.82	18.82	18.82
B. Plant Equipment												
a. Intake facilities & WTP: Plant, Equip., etc.	-	1,751.04	1,593.45	79.67	293.93	75.29	2,042.34	6%	110.29	110.29		
b. Reservoirs & Elevated Tanks: Equipment, etc.	23.66	659.50	623.81	31.19	133.79	29.48	818.27	6%	44.19	44.19		
C. Water Pipelines & Network												
a. Conveyance, transmission & distribution (main) pipelines	1,757.80	6,572.51	7,738.78	386.94	990.94	365.66	9,482.32	2%	170.68	170.68	170.68	170.68
b. Secondary distribution network	48.60	-	48.60	2.43		2.30		2%	0.00	0.00	0.00	0.00
c. Optical Fiber Cables	17.18	64.01	75.43	3.77	1.92	3.56	84.68	6%	4.57	4.57		
D. Other Assets												
a. Staff Quarters	30.72		30.72	1.54		1.45	33.71	4%	1.21	1.21	1.21	
b. Vehicles	-	10.53	9.58		3.37	0.43	13.38	20%	2.41			
									418.42	416.01	256.96	189.50

*Note: 1) **Residue Value: 10% of Asset Value for Depreciation*

2) Excluding house connection costs and costs for meters, saddles, pipes, etc. for connection pipes, as these costs can be recovered with service connection charges.

Table 12.2.16 Depreciation for Phase 2 Project

Unit: LC; BDT mil. FC; JPY mil.

Particulars		A. Base Cost		B. General Requirement & Dispute Board		C. Base Cost including (B)		D. Price Escalation		E. .Contingency		F. Construction Cost incl. D & E			G.. VAT	H. Import Duties	Total Asset Value for Dep.** (BDT mil.)	Dep. Rate (%)	Annual Depreciation Amount (BDT mil.)			
		LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	Combined Total in BDT (mil.)	LC	LC			1st yr -- 5th yr	6th yr -- 17th yr	18th yr -- 25th yr	26th yr -- 50th yr
A.	Buildings and Structures																					
a.	Intake facilities & WTP	1,338.81	530.42	107.10	48.11	1,445.91	578.53	453.33	66.34	29.78	3.70	1,929.02	648.57	2,600.42	290.15	181.17	3,071.74	4%	110.58	110.58	110.58	
b.	Reservoirs & Elevated Tanks	444.36	111.56	35.55	10.12	479.91	121.68	150.47	13.95	9.89	0.78	640.27	136.41	781.48	96.31	38.10	915.89	2%	16.49	16.49	16.49	16.49
B.	Plant Equipment																					
a.	Intake facilities & WTP: Plant, Equip., etc.	224.66	2,108.40	17.97	191.24	242.63	2,299.64	76.07	263.71	5.00	14.69	323.70	2,578.04	2,992.48	48.69	720.15	3,761.32	6%	203.11	203.11	203.11	203.11
b.	Reservoirs & Elevated Tanks: Equipment, etc..	50.92	459.46	4.07	41.68	54.99	501.14	17.24	57.47	1.13	3.20	73.36	561.81	654.94	11.03	156.94	822.91	6%	44.44	44.44		
c.	Water Pipelines & Network													-	-		-					
a.	Conveyance & transmission pipelines	1,208.40	5,450.00	97.03	471.97	1,305.43	5,921.97	409.29	679.09	26.89	37.84	1,741.61	6,638.90	8,614.18	261.96	1,854.51	10,730.65	2%	193.15	193.15	193.15	193.15
b.	Optical Fiber Cable	9.00	40.00	0.64	3.57	9.64	43.57	3.02	5.00	0.20	0.28	12.86	48.85	63.43	1.93	13.65	79.01	6%	4.27	4.27		
c.	Monitoring & Control System	10.00	304.70	0.71	27.16	10.71	331.86	3.36	38.06	0.22	2.12	14.29	372.04	399.42	2.15	103.93	505.50	6%	27.30	27.30		
d.	Primary/secondary/tertiary/distribution network	6,779.51	3,355.60	480.48	299.14	7,259.99	3,654.74	2,276.21	419.10	149.53	23.35	9,685.73	4,097.19	13,927.13	1,456.88	1,144.51	16,528.52	2%	297.51	297.51	297.51	297.51
e.	Supply for low income communities	197.90	77.31	14.03	6.89	211.93	84.20	66.45	9.66	4.37	0.54	282.75	94.40	380.47	42.53	26.37	449.37	2%	8.09	8.09	8.09	8.09
D.	Other Assets																					
a.	Maintenance Equipment	-	35.15			-	35.15	-	4.03	-	0.22	-	39.40	40.79	-	11.01	51.80	10%	4.66	4.66		
b.	Maintenance Vehicles	-	96.00			-	96.00	-	11.01	-	0.61	-	107.62	111.41	-	30.06	141.47	20%	25.46			
	TOTAL	10,263.56	12,568.60	757.58	1,099.88	11,021.14	13,668.48	3,455.44	1,567.42	227.01	87.33	14,703.59	15,323.23	30,566.15	2,211.63	4,280.40	37,058.18		935.06	909.60	828.93	718.35

*Note: 1) **Residue Value: 10% of Asset Value for Depreciation*

2) Excluding costs for service connections, water meters and connection pipes, as these costs can be recovered with service connection charges.

(5) Debt-services

The debt-services for the Phase 1 and 2 Projects are estimated based on the financing arrangements for Phase 1 Project in Table 12.2.4 and the financing plan proposed for the Phase 2 Project in Table 12.2.6 and the GOB's subsidiary loan terms, as stated in 12.2.2.(6). Table 12.2.17 shows the thus estimated debt-services for the Phase 1 and 2 Projects.

Table 12.2.17 Debt-services for Phase 1 and Phase 2 Projects

Subsidiary Loan Amount	Phase 1		Phase 2	
Foreign Loan (FL) Portion (BDT mil.)	10,918.70	55.62%	35,103.46	82.28%
Local Loan (LL) Portion (BDT mil.)	8,713.84	44.38%	7,559.02	17.72%
Total Amount (BDT mil.)	19,632.54	100.00%	42,662.48	100.00%

Terms and Conditions of Subsidiary Loan
- Repayment of loans with 15 annual installments after 5 years grace period
- Interest at 5% for Foreign Loan Portion and 4% for BOD Local Loan Portion
- Assuming Phase 1 starts operation in FY2016 and Phase 2 in FY 2021

(In BDT mil.)

Fiscal Year	Phase 1						Phase 2					
	Outstanding of Principal at the Beginning of FY	Repayment during the Year	Outstanding of Principal at the Closing FY	Interest for FL (5%)	Interest for LL (4%)	Interest - Total	Outstanding of Principal at the Beginning of FY	Repayment during the Year	Outstanding of Principal at the Closing FY	Interest for FL (5%)	Interest for LL (4%)	Interest - Total
2016	19,632.54	0.00	19,632.54	545.94	348.55	894.49						
2017	19,632.54	0.00	19,632.54	545.94	348.55	894.49						
2018	19,632.54	0.00	19,632.54	545.94	348.55	894.49						
2019	19,632.54	0.00	19,632.54	545.94	348.55	894.49						
2020	19,632.54	0.00	19,632.54	545.94	348.55	894.49						
2021	19,632.54	1,308.84	18,323.70	509.54	325.32	834.86	42,662.48	0.00	42,662.48	1,755.17	302.36	2,057.53
2022	18,323.70	1,308.84	17,014.86	473.14	302.08	775.22	42,662.48	0.00	42,662.48	1,755.17	302.36	2,057.53
2023	17,014.86	1,308.84	15,706.02	436.75	278.84	715.59	42,662.48	0.00	42,662.48	1,755.17	302.36	2,057.53
2024	15,706.02	1,308.84	14,397.18	400.35	255.61	655.96	42,662.48	0.00	42,662.48	1,755.17	302.36	2,057.53
2025	14,397.18	1,308.84	13,088.34	363.96	232.37	596.33	42,662.48	0.00	42,662.48	1,755.17	302.36	2,057.53
2026	13,088.34	1,308.84	11,779.50	327.56	209.13	536.69	42,662.48	2,844.17	39,818.31	1,638.16	282.20	1,920.36
2027	11,779.50	1,308.84	10,470.66	291.16	185.89	477.05	39,818.31	2,844.17	36,974.14	1,521.15	262.05	1,783.20
2028	10,470.66	1,308.84	9,161.82	254.77	162.66	417.43	36,974.14	2,844.17	34,129.97	1,404.14	241.89	1,646.03
2029	9,161.82	1,308.84	7,852.98	218.37	139.42	357.79	34,129.97	2,844.17	31,285.80	1,287.13	221.73	1,508.86
2030	7,852.98	1,308.84	6,544.14	181.98	116.18	298.16	31,285.80	2,844.17	28,441.63	1,170.11	201.57	1,371.68
2031	6,544.14	1,308.84	5,235.30	145.58	92.95	238.53	28,441.63	2,844.17	25,597.46	1,053.10	181.42	1,234.52
2032	5,235.30	1,308.84	3,926.46	109.19	69.71	178.90	25,597.46	2,844.17	22,753.29	936.09	161.26	1,097.35
2033	3,926.46	1,308.84	2,617.62	72.79	46.47	119.26	22,753.29	2,844.17	19,909.12	819.08	141.10	960.18
2034	2,617.62	1,308.84	1,308.78	36.39	23.24	59.63	19,909.12	2,844.17	17,064.95	702.07	120.94	823.01
2035	1,308.78	1,308.78	0.00	0.00	0.00	0.00	17,064.95	2,844.17	14,220.78	585.06	100.79	685.85
2036	0.00	0.00	0.00	0.00	0.00	0.00	14,220.78	2,844.17	11,376.61	468.04	80.63	548.67
2037	0.00	0.00	0.00	0.00	0.00	0.00	11,376.61	2,844.17	8,532.44	351.03	60.47	411.50
2038	0.00	0.00	0.00	0.00	0.00	0.00	8,532.44	2,844.17	5,688.27	234.02	40.31	274.33
2039	0.00	0.00	0.00	0.00	0.00	0.00	5,688.27	2,844.17	2,844.10	117.01	20.16	137.17
2040	0.00	0.00	0.00	0.00	0.00	0.00	2,844.10	2,844.10	0.00	0.00	0.00	0.00
2041	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2042	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

12.2.4 Forecast and Analysis of Financial Positions and Structures

(1) Base-line Forecast and Analysis

Based on the assumptions and inputs as stated in 12.2.4 and 12.2.5, the base-line forecast of financial positions and structures is made for the Phase 1 and 2 Projects. Tables 12.2.18 and 12.2.19 show the base-line forecast of operating income (profit/loss) respectively for the Phase 1 and 2 Projects, and Table 12.2.20 shows the forecast of base-line cash/fund flow for the Phase 1 and 2 Projects.

The base-line forecast for the Phase 1 Project indicates that the annual operating income will be a loss every year during the initial 13 years from FY2016 until FY2028 and then turn positive to show a profit in every year from FY2029 onwards, since the water revenue income is adequate to recover the O & M costs but not adequate to recover depreciation until FY2028. Similarly, the base-line forecast for the

Phase 2 Project indicates that the annual operating income will be a loss every year during the initial 18 years from FY2021 until FY2038 and then turn positive to show a profit in FY2039 onward due to the structure being similar to the Phase 1 Project. The main reason for showing a loss over more than the initial ten years is that the current water tariff rates are considerably lower than the break-even level to recover O &M costs and depreciation.

Further to weakness of the financial structure, the GOB's subsidiary loan terms cause a heavy financial burden to the financial positions of the Phase 1 and 2 Projects. The cash/fund flow of the Phase 1 Project indicates a deficit in fund every year during the initial 20 years from FY2016 until FY2035 due to heavy debt-services and turns to a surplus only in FY2036 and onwards. Similarly, the cash/fund flow of the Phase 2 Project indicates a deficit in fund every year during the initial 20 years from FY2021 until FY2040 due to heavy debt-services and turns to a surplus only in FY2041 and onwards.

These financial positions imply that both the Phase 1 and 2 Projects require taking specific measures for strengthening sustainable financial structures.

(2) Discussion on Measures to be taken for Establishing Sustainable Financial Structures

To seek conditions that enable Phase 1 and Phase 2 Projects to maintain sustainable financial structure, several tests on the cash-flow forecasts have been exercised by changing conditions. The outcome of these tests is presented in Supporting Report 12. As a result of these tests, there are three (3) options for possible measures to be taken for strengthening the sustainable financial structures of the Phase 1 and 2 Projects. These are either adopting higher water tariff rates or relaxing the terms and conditions of the GOB's subsidiary loans to be provided for the Phase 1 and Phase 2 Projects.

Option 1 Adopting higher tariff rates to the extent that the Phase 1 and 2 Projects can be financially sustainable

[Specific Measures]

1) To raise the tariff rates in FY2016 to BDT30.22 per m^3 for domestic consumers and BDT85.61 per m^3 for non-domestic consumers by 4.6 times of the rates in FY2012 (i.e., BDT6.57 m^3 for domestic consumers and BDT18.61 per m^3 for non-domestic consumers), and then rise by 3.0% every year until FY2020.
2) To raise the rates in FY2021 by 1.4 times of the FY2020 rates for domestic and non-domestic consumers, and then rise by 2% every year until FY2025.
3) To raise the rates in FY2026 by 10% of the FY2025 rates for domestic and non-domestic consumers.
   No need to raise the rates in FY2027 onwards, unless any external conditions change.

Option 2 Relaxing lending terms of GOB's subsidiary loan to the extent that the Phase 1 and 2 Projects can be financially sustainable

[Specific Measures]

1) To provide grant and/or equity participation for the whole amount of funds required for the Phase 1 Project, which is equivalent to about 30% of the total fund requirements for the Phase 1 and 2 Projects.
2) For Phase 2 Project, relaxing the lending terms as follows:
   a) Repayment of loan with 30 years installments after a 10 years grace period
   b) Interest rate at 1% per annum both for the Foreign and Local Loan Portions
   c) Capitalize interest accrued during the initial 10 years so that annual payment of interest can be released during these years.

Option 3: Intermediate arrangement between Option 1 and Option 2

Table 12.2.18 Base-line Forecast of Operating Income (Profit/Loss) for Phase 1 Project

Fiscal Year	Water Tariff Rate (BDT/m³)		Available Water Volume (mill m³)	NWR %	Billed Water Volume (mil m³)			I. Water Revenues (BDT million)			II. Expenses (BDT million)			III. Gross Operating Income (I. - II.) (BDT mil.)
	Domestic	Non-Dom.			Domestic	Non-dom.	Total	Domestic	Non-Dom.	Total	O&M Cost	Depreciation	Total	
2016	7.61	21.56	41.76	33%	22.63	5.35	27.98	172.21	115.35	287.56	235.27	418.42	653.69	-366.13
2017	7.99	22.64	44.37	30%	24.93	6.13	31.06	199.19	138.78	337.97	256.81	418.42	675.23	-337.26
2018	8.39	23.77	46.98	27%	27.27	7.03	34.30	228.80	167.10	395.90	279.63	418.42	698.05	-302.15
2019	8.81	24.96	49.59	25%	29.13	8.06	37.19	256.64	201.18	457.82	303.79	418.42	722.21	-264.39
2020	9.25	26.21	52.20	23%	31.49	8.70	40.19	291.28	228.03	519.31	329.35	418.42	747.77	-228.46
2021	9.71	27.52	52.20	20%	32.99	8.77	41.76	320.33	241.35	561.68	341.27	416.01	757.28	-195.60
2022	10.20	28.90	52.20	19%	33.40	8.88	42.28	340.68	256.63	597.31	353.62	416.01	769.63	-172.32
2023	10.71	30.35	52.20	18%	33.55	9.25	42.80	359.32	280.74	640.06	366.43	416.01	782.44	-142.38
2024	11.25	31.87	52.20	17%	34.13	9.20	43.33	383.96	293.20	677.16	379.70	416.01	795.71	-118.55
2025	11.81	33.46	52.20	16%	35.38	8.47	43.85	417.84	283.41	701.25	393.45	416.01	809.46	-108.21
2026	12.40	35.13	52.20	15%	35.05	9.32	44.37	434.62	327.41	762.03	407.71	416.01	823.72	-61.69
2027	13.02	36.89	52.20	15%	35.05	9.32	44.37	456.35	343.81	800.16	422.49	416.01	838.50	-38.34
2028	13.67	38.73	52.20	15%	34.60	9.77	44.37	472.98	378.39	851.37	437.80	416.01	853.81	-2.44
2029	14.35	40.67	52.20	15%	34.15	10.22	44.37	490.05	415.65	905.70	453.68	416.01	869.69	36.01
2030	15.07	42.70	52.20	15%	33.70	10.67	44.37	507.86	455.61	963.47	470.14	416.01	886.15	77.32
2031	15.82	44.84	52.20	15%	33.55	10.82	44.37	530.76	485.17	1,015.93	487.20	416.01	903.21	112.72
2032	16.61	47.08	52.20	15%	33.55	10.82	44.37	557.27	509.41	1,066.68	504.88	416.01	920.89	145.79
2033	17.44	49.43	52.20	15%	33.55	10.82	44.37	585.11	534.83	1,119.94	523.21	256.96	780.17	339.77
2034	18.31	51.90	52.20	15%	33.55	10.82	44.37	614.30	561.56	1,175.86	542.20	256.96	799.16	376.70
2035	19.23	54.50	52.20	15%	33.55	10.82	44.37	645.17	589.69	1,234.86	561.90	256.96	818.86	416.00
2036	20.19	57.23	52.20	15%	33.55	10.82	44.37	677.37	619.23	1,296.60	582.31	256.96	839.27	457.33
2037	21.20	60.09	52.20	15%	33.55	10.82	44.37	711.26	650.17	1,361.43	603.47	256.96	860.43	501.00
2038	22.26	63.09	52.20	15%	33.55	10.82	44.37	746.82	682.63	1,429.45	625.40	256.96	882.36	547.09
2039	23.37	66.24	52.20	15%	33.55	10.82	44.37	784.06	716.72	1,500.78	648.14	256.96	905.10	595.68
2040	24.54	69.55	52.20	15%	33.55	10.82	44.37	823.32	752.53	1,575.85	671.70	256.96	928.66	647.19
2041	25.77	73.03	52.20	15%	33.55	10.82	44.37	864.58	790.18	1,654.76	696.13	189.50	885.63	769.13
2042	27.06	76.68	52.20	15%	33.55	10.82	44.37	907.81	829.69	1,737.50	721.45	189.50	910.95	826.55

Table 12.2.19 Base-line Forecast of Operating Income (Profit/Loss) for Phase 2 Project

Fiscal Year	Water Tariff Rate (BDT/m³)		Available Water Volume (mill m³)	NWR %	Billed Water Volume (mil m³)			I. Water Revenues (BDT million)			II. Expenses (BDT million)			III. Gross Operating Income (I. - II.) (BDT mil.)
	Domestic	Non-Dom.			Domestic	Non-dom.	Total	Domestic	Non-Dom.	Total	O&M	Depreciation	Total	
2016														
2017														
2018														
2019														
2020														
2021	9.71	27.52	41.76	20%	28.14	5.27	33.41	273.24	145.03	418.27	278.77	935.06	1,213.83	-795.56
2022	10.20	28.90	44.37	19%	30.07	5.87	35.94	306.71	169.64	476.35	304.50	935.06	1,239.56	-763.21
2023	10.71	30.35	46.98	18%	32.28	6.24	38.52	345.72	189.38	535.10	331.76	935.06	1,266.82	-731.72
2024	11.25	31.87	49.59	17%	34.12	7.04	41.16	383.85	224.36	608.21	360.62	935.06	1,295.68	-687.47
2025	11.81	33.46	52.20	16%	35.38	8.47	43.85	417.84	283.41	701.25	391.17	935.06	1,326.23	-624.98
2026	12.40	35.13	52.20	15%	35.05	9.32	44.37	434.62	327.41	762.03	405.34	909.60	1,314.94	-552.91
2027	13.02	36.89	52.20	15%	35.05	9.32	44.37	456.35	343.81	800.16	420.04	909.60	1,329.64	-529.48
2028	13.67	38.73	52.20	15%	34.60	9.77	44.37	472.98	378.39	851.37	435.27	909.60	1,344.87	-493.50
2029	14.35	40.67	52.20	15%	34.15	10.22	44.37	490.05	415.65	905.70	451.06	909.60	1,360.66	-454.96
2030	15.07	42.70	52.20	15%	33.69	10.68	44.37	507.71	456.04	963.75	467.42	909.60	1,377.02	-413.27
2031	15.82	44.84	52.20	15%	33.54	10.83	44.37	530.60	485.62	1,016.22	484.39	909.60	1,393.99	-377.77
2032	16.61	47.08	52.20	15%	33.54	10.83	44.37	557.10	509.88	1,066.98	501.97	909.60	1,411.57	-344.59
2033	17.44	49.43	52.20	15%	33.54	10.83	44.37	584.94	535.33	1,120.27	520.20	909.60	1,429.80	-309.53
2034	18.31	51.90	52.20	15%	33.54	10.83	44.37	614.12	562.08	1,176.20	539.09	909.60	1,448.69	-272.49
2035	19.23	54.50	52.20	15%	33.54	10.83	44.37	644.97	590.24	1,235.21	558.67	909.60	1,468.27	-233.06
2036	20.19	57.23	52.20	15%	33.54	10.83	44.37	677.17	619.80	1,296.97	578.97	909.60	1,488.57	-191.60
2037	21.20	60.09	52.20	15%	33.54	10.83	44.37	711.05	650.77	1,361.82	600.01	909.60	1,509.61	-147.79
2038	22.26	63.09	52.20	15%	33.54	10.83	44.37	746.60	683.26	1,429.86	621.83	828.93	1,450.76	-20.90
2039	23.37	66.24	52.20	15%	33.54	10.83	44.37	783.83	717.38	1,501.21	644.44	828.93	1,473.37	27.84
2040	24.54	69.55	52.20	15%	33.54	10.83	44.37	823.07	753.23	1,576.30	667.87	828.93	1,496.80	79.50
2041	25.77	73.03	52.20	15%	33.54	10.83	44.37	864.33	790.91	1,655.24	692.17	828.93	1,521.10	134.14
2042	27.06	76.68	52.20	15%	33.54	10.83	44.37	907.54	830.46	1,738.00	717.35	828.93	1,546.28	191.72

Table 12.2.20 Base-line Forecast of Cash/Fund Flow for Phase 1 and Phase 2 Projects

Fiscal Year	Phase 1 Project								Phase 2 Project								Phase 1&2 Combined	
	A. Fund Inflow			B. Fund Outflow			Balance (A.-B.)	Accum. Fund	A. Fund Inflow			B. Fund Outflow			Balance (A.-B.)	Accum. Fund	Annual Cash /Fund Flow Balance	Accum. Fund
	Operating Income	Depr.	Total	Repayment of Loan	Interest Payment	Total			Operating Income (Profit /Loss)	Depr.	Total	Repay -ment of Loan	Interest Payment	Total				
2016	-366.13	418.42	52.29	0.00	894.49	894.49	-842.20	-842.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-842.20	-842.20
2017	-337.26	418.42	81.16	0.00	894.49	894.49	-813.33	-1,655.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-813.33	-1,655.53
2018	-302.15	418.42	116.27	0.00	894.49	894.49	-778.22	-2,433.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-778.22	-2,433.76
2019	-264.39	418.42	154.03	0.00	894.49	894.49	-740.46	-3,174.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-740.46	-3,174.21
2020	-228.46	418.42	189.96	0.00	894.49	894.49	-704.53	-3,878.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-704.53	-3,878.74
2021	-195.60	416.01	220.41	1,308.84	834.86	2,143.70	-1,923.29	-5,802.04	-795.56	935.06	139.50	0.00	2,057.53	2,057.53	-1,918.03	-1,918.03	-3,841.32	-7,720.06
2022	-172.32	416.01	243.69	1,308.84	775.22	2,084.06	-1,840.37	-7,642.41	-763.21	935.06	171.85	0.00	2,057.53	2,057.53	-1,885.68	-3,803.70	-3,726.05	-11,446.11
2023	-142.38	416.01	273.63	1,308.84	715.59	2,024.43	-1,750.80	-9,393.20	-731.72	935.06	203.34	0.00	2,057.53	2,057.53	-1,854.19	-5,657.89	-3,604.98	-15,051.10
2024	-118.55	416.01	297.46	1,308.84	655.96	1,964.80	-1,667.34	-11,060.54	-687.47	935.06	247.59	0.00	2,057.53	2,057.53	-1,809.94	-7,467.83	-3,477.27	-18,528.37
2025	-108.21	416.01	307.80	1,308.84	596.33	1,905.17	-1,597.37	-12,657.91	-624.98	935.06	310.08	0.00	2,057.53	2,057.53	-1,747.45	-9,215.27	-3,344.82	-21,873.19
2026	-61.69	416.01	354.32	1,308.84	536.69	1,845.53	-1,491.21	-14,149.12	-552.91	909.60	356.69	2,844.17	1,920.36	4,764.53	-4,407.84	-13,623.12	-5,899.05	-27,772.24
2027	-38.34	416.01	377.67	1,308.84	477.05	1,785.89	-1,408.22	-15,557.34	-529.48	909.60	380.12	2,844.17	1,783.20	4,627.37	-4,247.25	-17,870.36	-5,655.46	-33,427.70
2028	-2.44	416.01	413.57	1,308.84	417.43	1,726.27	-1,312.70	-16,870.04	-493.50	909.60	416.10	2,844.17	1,646.03	4,490.20	-4,074.10	-21,944.46	-5,386.80	-38,814.50
2029	36.01	416.01	452.02	1,308.84	357.79	1,666.63	-1,214.61	-18,084.65	-454.96	909.60	454.64	2,844.17	1,508.86	4,353.03	-3,898.39	-25,842.85	-5,113.00	-43,927.50
2030	77.32	416.01	493.33	1,308.84	298.16	1,607.00	-1,113.67	-19,198.32	-413.27	909.60	496.33	2,844.17	1,371.68	4,215.85	-3,719.52	-29,562.37	-4,833.19	-48,760.69
2031	112.72	416.01	528.73	1,308.84	238.53	1,547.37	-1,018.64	-20,216.95	-377.77	909.60	531.83	2,844.17	1,234.52	4,078.69	-3,546.86	-33,109.23	-4,565.49	-53,326.18
2032	145.79	416.01	561.80	1,308.84	178.90	1,487.74	-925.94	-21,142.89	-344.59	909.60	565.01	2,844.17	1,097.35	3,941.52	-3,376.51	-36,485.74	-4,302.45	-57,628.63
2033	339.77	256.96	596.73	1,308.84	119.26	1,428.10	-831.37	-21,974.26	-309.53	909.60	600.07	2,844.17	960.18	3,804.35	-3,204.28	-39,690.01	-4,035.64	-61,664.27
2034	376.70	256.96	633.66	1,308.84	59.63	1,368.47	-734.81	-22,709.07	-272.49	909.60	637.11	2,844.17	823.01	3,667.18	-3,030.07	-42,720.08	-3,764.88	-65,429.15
2035	416.00	256.96	672.96	1,308.78	0.00	1,308.78	-635.82	-23,344.89	-233.06	909.60	676.54	2,844.17	685.85	3,530.02	-2,853.48	-45,573.56	-3,489.30	-68,918.45
2036	457.33	256.96	714.29	0.00	0.00	0.00	714.29	-22,630.59	-191.60	909.60	718.00	2,844.17	548.67	3,392.84	-2,674.84	-48,248.40	-1,960.55	-70,879.00
2037	501.00	256.96	757.96	0.00	0.00	0.00	757.96	-21,872.63	-147.79	909.60	761.81	2,844.17	411.50	3,255.67	-2,493.86	-50,742.27	-1,735.90	-72,614.90
2038	547.09	256.96	804.05	0.00	0.00	0.00	804.05	-21,068.58	-20.90	828.93	808.03	2,844.17	274.33	3,118.50	-2,310.47	-53,052.73	-1,506.42	-74,121.31
2039	595.68	256.96	852.64	0.00	0.00	0.00	852.64	-20,215.94	27.84	828.93	856.77	2,844.17	137.17	2,981.34	-2,124.57	-55,177.30	-1,271.92	-75,393.24
2040	647.19	256.96	904.15	0.00	0.00	0.00	904.15	-19,311.79	79.50	828.93	908.43	2,844.10	0.00	2,844.10	-1,935.67	-57,112.97	-1,031.52	-76,424.76
2041	769.13	189.50	958.63	0.00	0.00	0.00	958.63	-18,353.16	134.14	828.93	963.07	0.00	0.00	0.00	963.07	-56,149.90	1,921.70	-74,503.06
2042	826.55	189.50	1,016.05	0.00	0.00	0.00	1,016.05	-17,337.11	0.00	828.93	828.93	0.00	0.00	0.00	828.93	-55,320.97	1,844.98	-72,658.08

It is recommended to consider taking either one of the above three measures in order to make the Phase 1 and 2 Projects financially sustainable.

The financial forecasts examining these options are presented in Supporting Report 12.

12.3 Financial Evaluation of the Project

12.3.1 Methodology and Assumptions

The financial internal rate of return (FIRR) and financial net present value (FNPV) of the Phase 2 Project are computed for the financial evaluation. The FIRR is the discount rate at which the net present value of costs of the Phase 2 Project equals the net present values of its revenues. The FIRR of the Phase 2 Project is computed by using a computation model developed on the basis of the discounted cash-flow method. IRR is shown as a percentage. It shows the rate of the real value of return on the capital investment. The IRR computation formula is defined as follows;

$$0 = \sum_{i=0}^{T} \frac{C_i}{(1+IRR)^i}$$

where;
C_i = cash flow for the given period
i = positive integral between 0 and T
T = total number of periods

The financial opportunity cost of capital (FOCC) is compared against the FIRR to evaluate the financial viability of the Phase 2 Project. The FOCC is expressed as a percentage. This value represents the opportunity cost of the capital. The computation formula for FOCC is defined as follows;

$$FOCC = \frac{(1+r_x)}{(1+r_y)} - 1$$

where;
r_x = Treasury bill rate
r_y = Consumer Price Index (Inflation)

The FNPV is also calculated by using a discount rate equal to the FOCC to evaluate whether the Project can earn adequate FNPV. The NPV calculation formula is defined as follows;

$$NPV = \sum_{i=0}^{T} \frac{C_i}{(1+r)^i}$$

where;
C_i = cash flow for the given period
i = positive integral between 0 and T
T = total number of periods
r = Opportunity cost of capital (discount rate)

Major assumptions and key parameters for the computation of the FIRR are as follows.

(1) Project life

Years will be Bangladeshi fiscal years, starting in July 1 and ending at June 30 in the subsequent year. Capital investment including consulting services for the Project will start in 2013 and end in 2021. The

project life is taken as 30 years from the initial operation year of the completed facilities i.e., from 2021 to 2050. The financial analysis is conducted for a period from 2013, the initial disbursement year through to 2050.

(2) Prices

All the financial estimates are made at constant 2021 prices.

(3) Exchange rate

An exchange rate of 1BDT to 0.966JPY is used at a constant conversion rate over the entire project life.

(4) Project Cost Disbursement

The project cost for the Phase 2 Project include costs for the construction of secondary/tertiary distribution pipelines covering the service areas of both the Phase 1 and 2 Projects, house connection works and the procurement of meters and materials (e.g., saddles, valves, pipes, etc.) to be used for house connections. The cash-flow for computing FIRR is based on water revenue earned through the distribution of water produced by the Phase 2 Project and capital and O&M costs incurred in doing so. Thus, for the computation of cash-flow, the costs for house connection works, the costs for the procurement of meters and materials to be used for house connections, a half of the costs for secondary/tertiary distribution pipelines, as well as ancillary costs related to these cost components are excluded from the project cost of the Phase 2 Project.

In addition, interest during construction is also excluded from the project cost, since the FIRR is calculated on the basis of net capital costs excluding any financial costs.

Thus the adjusted capital cost of the Phase 2 Project amounts to BDT 33,002.32 million. Table 12.3.1 shows the estimated disbursement of the capital cost for the period from FY2013, the initial disbursement year through to FY2020 in which the construction is completed and FY2021 in which consulting services are completed.

Table 12.3.1 Project Cost Disbursement

Fiscal Year	Disbursement (BDT mil.)
2013	262.58
2014	620.98
2015	991.84
2016	8,614.20
2017	8,863.68
2018	8,582.95
2019	2,333.75
2020	2,352.05
2021	360.75
2022	19.54
	33,002.32

(5) Replacement Costs

The economic life span of civil structures and pipelines is 50 years and these will not be required to be replaced during the financial assessment period.

The mechanical and electrical equipment has an average life span of 15 to 20 years and thus some

components will required to be replaced or refurbished after these times. The financial calculation assumes that the replacement cost is in an amount equivalent to 30% of the initial capital cost, which will accrue during the period from 2035 to 2040. Thus the estimated replacement cost amounts to BDT 1,334.69 million in 2021 prices. Table 12.3.2 shows the breakdown of the replacement cost estimates.

Table 12.3.2 Breakdown of Replacement Cost Estimates

Replacement Costs	Total Cost	% of total cost	Import Duties	VAT & Taxes	Duties & Taxes	Total Replacement Cost (BDT mil.)
Plant & Machinery LC	376.72	30%		15.0%	16.95	129.97
Plant & Machinery FC	3,105.62	30%	30%		279.51	1,211.19
					Total	1,341.16

(6) O & M Costs

The financial computation for FIRR uses the O & M costs for the Phase 2 Project, as presented in Table 12.2.13. The O & M costs are based on 2012 prices and converted to 2021 constant prices by using price escalation factors of 3.7%, 3.5% and 2% per year for Variable Costs, Fixed Cost A (Personnel Cost plus Welfare and Administration Costs), and Fixed Cost B (Maintenance Cost) respectively.

(7) Water Production and Non-revenue Water Rate

The financial calculation for FIRR uses the water production and distribution volumes, NRW rates and billable (accounted-for) water consumption volumes given in Table 12.2.7.

(8) Tariff Rates and Collection Efficiency

The financial calculation of FIRR is based on the same assumptions as stated in 12.2.2 (2) and (3), and the tariff rates in 2021 shown in Table 12.2.1.

(9) Water Revenue

Table 12.3.3 shows the water revenue used for the financial computation of FIRR.

Table 12.3.3 Water Revenue

Fiscal Year	Operation Ratio (%)	Water Production (mil.m³/year)	NRW (%)	Billabe Water Volume (mil.m³/year)		Tariff (BDT/m³)		Water Revenue (BDTmil./year)		Collection Efficiency	Water Revenue (BDTmil.)
				Domestic	Non-Domestic	Domestic	Non-Domestic	Domestic	Non-Domestic		
2021	80%	41.76	20%	25.25	8.15	9.71	27.51	245.22	224.23	100%	469.44
2022	85%	44.37	19%	27.17	8.77	9.71	27.51	263.80	241.22	100%	505.02
2023	90%	46.98	18%	29.12	9.40	9.71	27.51	282.77	258.56	100%	541.33
2024	95%	49.59	17%	31.11	10.04	9.71	27.51	302.11	276.26	100%	578.37
2025	100%	52.20	16%	33.15	10.70	9.71	27.51	321.85	294.30	100%	616.15
2026	100%	52.20	15%	33.54	10.83	9.71	27.51	325.68	297.80	100%	623.48
2027-2049 No change											
2050	100%	52.20	15%	33.54	10.83	9.71	27.51	325.68	297.80	100%	623.48

12.3.2 Financial Viability Analysis

The financial opportunity cost of capital (FOCC) was estimated for the financial evaluation, based on the Treasury bill rate of Bangladesh and the inflation rate in Bangladesh. The weighted average yield of a 5-year Bangladesh Government Treasury Bill was 11.48% in July 2012, and the inflation rate of the general CPI was 10.62% in the same month. Thus the real FOCC is 0.78% after adjustment using the

formulae [= (1+0.1148)/(1+0.1062)-1].

Table 12.3.4 shows the computation of the discounted cash-flow, FNPV and FIRR for Phase 2 Project, providing in the following indicators:

- FNPV: BDT 25,904.14 million (negative)
- FIRR: 7.07% (negative)

The analysis implies that the water revenue is adequate to recover O&M costs but inadequate to recover the capital investment costs due to the current water tariff rates set comparatively lower.

Table 12.3.4 Financial Cash Flow

(BDT million)

Fiscal Year	Capital Investment	Replacement Costs	O&M Cost	Water Revenue	Net Return
2013	262.58	-	-	-	(262.58)
2014	620.98	-	-	-	(620.98)
2015	991.84	-	-	-	(991.84)
2016	8,614.20	-	-	-	(8,614.20)
2017	8,863.68	-	-	-	(8,863.68)
2018	8,582.95	-	-	-	(8,582.95)
2019	2,333.75	-	-	-	(2,333.75)
2020	2,352.04	-	-	-	(2,352.04)
2021	360.75	-	278.77	469.44	(170.07)
2022	19.54	-	293.89	505.02	191.59
2023	-	-	309.02	541.33	232.31
2024	-	-	324.15	578.37	254.22
2025	-	-	339.28	616.15	276.87
2026	-	-	339.28	623.48	284.20
2027-2033	No change	|	|	|	|
2034	-	-	339.28	623.48	284.20
2035	-	447.05	339.28	623.48	(162.85)
2036	-	-	339.28	623.48	284.20
2037	-	447.05	339.28	623.48	(162.85)
2038	-	-	339.28	623.48	284.20
2039	-	-	339.28	623.48	284.20
2040	-	447.05	339.28	623.48	(162.85)
2041	-	-	339.28	623.48	284.20
2042-2049	No change	|	|	|	|
2050	-	-	339.28	623.48	284.20
Total	33,002.31	1,341.16	10,027.07	18,297.33	(26,073.21)
FNPV:	**(25,904.14)**	**FOCC:**	**0.78%**	**FIRR:**	**-7.07%**

12.3.3 Sensitivity Analysis of Financial Viability

A sensitivity analysis is conducted to evaluate the possible effect of variances from the base case assumptions. The factors included in the sensitivity analysis are an increase/decrease in the O&M cost by 5% and 10%. The results of the sensitivity analysis are shown in Table 12.3.5 and Figure 12.3.1.

Table 12.3.5 Summary of Financial Sensitivity Analysis

Description	FIRR	FNPV
O&M cost decrease with 10%	-6.55%	(25,067.76)
O&M cost decrease with 5%	-6.80%	(25,485.95)
Base Case	-7.07%	(25,904.14)
O&M cost increase with 5%	-7.35%	(26,322.33)
O&M cost increase with 10%	-7.65%	(26,740.52)

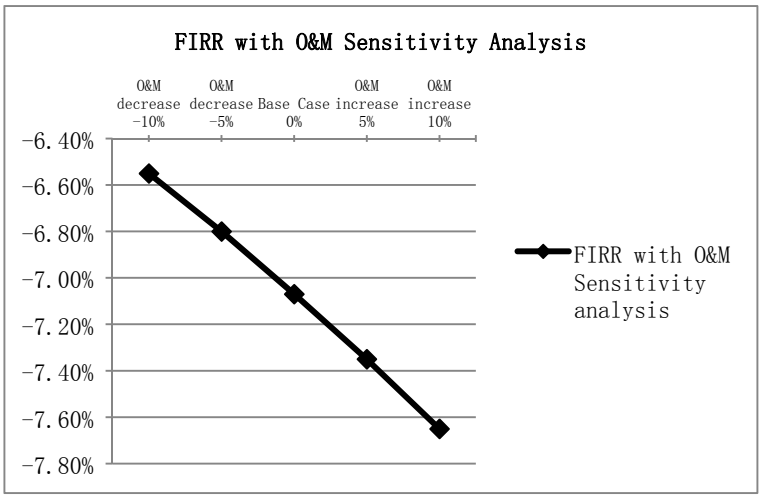


Figure 12.3.1 Graph showing Sensitivity Analysis

The water revenue based on the current tariff levels, as discussed earlier, are adequate to recover O & M costs, but inadequate to recover the capital costs. Thus a key for the Phase 2 Project to earn a reasonable return on investment is to adopt higher water tariff rates. Table 12.3.6 summarizes the sensitivity analysis of FIRR and FNPV based on higher tariff rates.

Table 12.3.6 FIRR & FNPV with Higher Tariff Rates

Description	FIRR	FNPV
Base Case	-7.07%	(25,904.14)
Domestic rate in 2021		
9.71BDT/m^3		
Non-Domestic rate in 2021		
27.51BDT/m^3		
Tariff Rate increase with 170%	0.78%	25.37
Domestic rate in 2021		
26.22BDT/m^3		
Non-Domestic rate in 2021		
74.28BDT/m^3		

This analysis indicates that with an increase in the tariff rates by 170% of the 2021 tariff rates to BDT26.22/m^3 for domestic consumers and BDT74.28/m^3 for non-domestic consumers in 2021 constant prices the FIRR and FNPV are BDT25.37 million (positive) at a 0.78% discount rate.

The 2021 tariff rates used for the computation of FIRR are higher by 148% in comparison with the current 2012 rates (i.e., BDT6.57/m^3 for domestic consumers and BDT18.61/m^3 for non-domestic consumers). Should the rates be further increased by another 170%, it becomes to be higher by 252% than

the 2012 rates. It seems difficult to adopt such higher tariff rates.

Considering economic benefits that may be brought about by the Project, it is recommended for the Government to consider providing financial support as discussed in 12.2.4 (2) even though gaining inadequate financial returns on investment.

12.4 Economic Evaluation of the Project

12.4.1 Methodology and Assumptions

The economic internal rate of return (EIRR) and economic net present value (ENPV) of the Phase 2 Project are computed to evaluate the economic effectiveness of the Project.

Major assumptions and key parameters used for the computation of the EIRR and ENPV are the same as those used for the computation of the FIRR and FNPV, as stated in 12.3.1. Only the specific factors different from those used for the financial computation are stated hereunder.

(1) Economic Costs

The financial costs are converted into economic cost in 2021 constant prices. The costs for the capital investment and O&M costs are divided into tradable and non-tradable costs. The financial prices of non-tradable components are adjusted using a Standard Conversion Factor (SCF) to convert into economic prices. Tradable components do not need further adjustment. The import duties, taxes and VAT, which are included in the capital investment and O&M costs are considered as transfer payments that are defined as the amounts transferred from one party to another without reducing nor increasing the amount of real resources available to the economy as a whole; hence such costs are not considered as an economic cost.

(2) Standard Conversion Factor

The SCF is an approximation to convert non-tradable components into border prices. The SCF compares the world prices with the domestic prices. Based on similar countries with the same conditions as for the Phase 2 Project, the financial prices are adjusted using an SCF of 0.9 to convert into economic prices[1].

(3) Capital Investment

The capital cost is considered at the constant price level for economic analysis. The capital cost estimates are adjusted to arrive at the true economic value of the project. Such adjustment is considered on account of the imperfections in the local market economy. The foreign currency portion of the capital costs are considered as tradable, while the local currency portion of the capital costs are assumed to include non-tradable, skilled laborers and non-skilled laborers at 90%, 1% and 9% respectively.

These compositions are based on the assumption that 60% of the LC portion is the cost for materials to be procured and 40% is for the contractors' internal costs and profit. Out of the 40%, a half (20% of LC amount) is considered as costs for the contractor, one fourth (10% of LC amount) is the profit for the

[1] Reference: Pakistan Water Sector Strategy Medium Term Investment Plan Volume 3 October 2002, Padma Multipurpose Bridge Project Economic Analysis 2010 RRP BAN 35049-01, Implementation Completion and results Report for the Kerala Rural Water Supply and Environmental Sanitation Project 2009 Report No ICR0000482.

contractors and the remaining one fourth (10% of LC amount) is for labor costs, out of which 1% is for skilled labor and 9% is unskilled labor. The non-tradable cost is converted into economic cost by applying the SCF of 0.9.

The wages for the skilled workers are a non-tradable cost and the SCF of 0.9 will be applied to convert it into economic cost. Wages of unskilled laborers is normally set by the government under a Minimum Wage law to protect the welfare of such workers. For this reason, wages of laborers are valued higher than when it is left to the forces of demand and supply in the free market. Therefore a conversion factor of 0.7[2] is used to correct the over valuation of the wages for the unskilled workers. The SCF rate of 0.9 will be applied and the conversion rate of the financial cost to economic cost will be 0.63 [=0.7 x 0.9].

The import duties, taxes and VAT are excluded from the capital costs, as these elements constitute transfer payments from contractors to the GOB. Table 12.4.1 summarizes the conversion of financial costs to economic costs

The weighted conversion factors for the capital investment are 0.95 as shown in Table 12.4.2.

Table 12.4.2 Conversion Factors

Description	Financial Cost excl. tax (BDT)	% of total cost	Conversion Factor	Economic Cost (BDT)
FC of Construction and procurement	13,846,051,190	52.3%	1.00	13,846,051,190
LC of Construction and procurement	10,097,198,410			8,814,854,212
Non-Tradable (90% of LC)	8,986,506,585	34.0%	0.90	8,087,855,926
Skilled labor (1% of LC)	100,971,984	0.4%	0.90	90,874,786
Unskilled labor (9% of LC)	1,009,719,841	3.8%	0.63	636,123,500
Consulting Services				
FC	1,449,377,935	5.5%	1.00	1,449,377,935
LC	1,069,390,185	4.0%	0.90	962,451,167
Total	26,462,017,720	100.0%	0.95	25,072,734,504

(4) Replacement Costs

The replacement costs comprise of two components, one part is the Plant & Machinery of the FC, which is a tradable component with a conversion factor of 1, and the other part is the Plant & Machinery of the LC which is a non-tradable component with a conversion factor of 0.9. Table 12.4.3 shows the breakdown of the computation of economic replacement costs.

Table 12.4.3 Economic Replacement Costs

(BDT mil.)

Replacement costs	Total Cost	% of total cost	Import Duties	VAT & Taxes	Duties & Taxes	Replacement Cost excl. tax	Conversion Factor	Economic Cost
Plant & Machinery LC	376.72	30%		15.0%	16.95	113.02	0.90	101.71
Plant & Machinery FC	3,105.62	30%	30%		279.51	931.69	1.00	931.69
Total					296.46	1,044.70	0.99	1,033.40

[2] Reference: SAPROF for Karnaphuli Water supply Project

Table 12.4.1 Conversion to Economic Capital Costs

	Particulars	Financial Cost (BDT mil.)	Economic Cost (BDT mil.)
A.	Construction Works		
A-1.	Building & Civil Construction		
a.	Intake facilities & WTP	1,887.90	1,788.78
b.	Reservoirs & Elevated Tanks	559.85	530.45
	Sub-total	2,447.75	2,319.24
A-2.	Plant, Machinery & Pipes etc.		
a.	Intake facilities	2,407.27	2,280.88
b.	Reservoirs & Elevated Tanks	526.55	498.91
	Sub-total	2,933.82	2,779.79
A-3.	Water Pipelines & Network		
a.	Conveyance & transmission pipelines	6,850.22	6,490.58
b.	Optical Fibre Cable	50.41	47.76
c.	Distribution pipelines (mains)	494.36	468.41
d.	Monitoring & Control System	162.71	154.17
e.	Secondary distribution network	4,632.24	4,389.04
f.	Service connections	0.00	0.00
g.	Supply for low income communities	138.96	131.66
	Sub-total	12,328.91	11,681.63
A-4.	General Requirements & Dispute Board for Construction Works		
a.	Intake facilities, WTP, Reservoirs & Elevated Tanks	465.96	441.50
b.	Conveyance & transmission Pipelines	585.61	554.87
c.	Primary/secondary/tertiary Distribution Pipelines	433.30	410.55
	Sub-total	1,484.87	1,406.91
A-5.	Procurement of Equipment & Materials		
a.	Water Meters		
b.	Maintenance Vehicles	49.69	47.08
c.	Maintenance Equipment	18.20	17.24
	Sub-total	67.89	64.32
A-6	Project Implementation Support Unit	148.46	140.67
A-7.	Construction Works-Total (A-1 to A-6)	19,411.69	18,392.56
A-8.	Price Escalation for Construction Works (2.1% of A-7 FC, 4.9% of A-7 LC)	3,589.58	3,401.13
A.9.	Contingency for Construction Works (5% of A-7 & A-8)	1,153.47	1,092.91
A-10.	Grand Total of Construction Works	24,154.74	22,886.59
a.	Material cost (60% of A-10)	14,492.85	13,731.96
b.	Contractor cost (40% of A-10)	9,661.90	9,154.64
c.	Profit of Contractors costs (10% of A-10 b)	966.19	915.46
d.	Taxation on profit (27.5% of A-10 c)	265.70	251.75
	Grand Total of A. Construction Works (A-9 - A-9 d)	23,889.04	22,634.84
B.	Consultancy Services		
B-1.	Engineering Consulting Services	2,091.61	1,981.80
B-2.	Price Escalation (2.1% of B-1 FC, 4.9% of B-1 LC)	354.30	335.70
B-3.	Contingency (5% of B-1 & B-2)	122.29	115.87
a.	Consultancy Direct Cost (30% of B-1 to B-3)	770.46	730.01
b.	Consultancy Cost (70% of B-1 to B-3)	1,797.74	1,703.36
c.	Profit of Consultancy costs (10% of B-3 b)	179.77	170.34
d.	Taxation on profit (27.5% of B-3 c)	49.44	46.84
	Total of B. (B-1 to B-3 – B-3 d)	2,518.77	2,386.53
C.	Grand Total (A & B)	26,407.81	25,021.37
D.	CWASA Administration Cost	10.00	9.47
E.	Other Charges		
a.	Bank Charges	44.21	41.89
	Project Cost-Total	26,462.02	25,072.73
		Conversion factor:	0.95

(5) O & M Costs

O & M costs comprise Power & Fuel, Chemical, Personnel, Welfare and Administration, and Maintenance & Repair costs. Power & Fuel and Chemical costs are assumed as tradable costs, thus using a conversion factor of 1.0. Personnel, Welfare and Administration costs are converted by using a conversion factor of 0.9. The maintenance & repair cost are assumed as non-tradable and converted by using a conversion factor of 0.9. VAT and taxes for O&M costs are excluded. Table 12.4.4 shows the breakdown of the converted economic O&M costs and Table 12.4.5 shows the conversion factors used.

Table 12.4.4 O&M Costs in Constant 2012 Prices

in constant 2012 prices

Particulars	Unit Cost (BDT)	Taxation (%)	Phase2			
			Daily Consumption in 100% capacity operation	Cost/day (BDT)	Tax	Total Cost/Year excl. tax (BDT)
A. Variable Cost						
A-1. Power Cost						
a. Intake						
Energy Charge	5.61 /kWh	15%	650 kW/h	83,578	3,979,029	26,526,861
Demand Charge	45.00 /kWh	15%	975 kW/h		68,674	457,826
b. WTP						
Energy Charge	5.61 /kWh	15%	1,950 kW/h	250,733	11,937,087	79,580,582
Demand Charge	45.00 /kWh	15%	2,900 kW/h		204,261	1,361,739
c. Nashirabad Reservoir						
Energy Charge	5.61 /kWh	15%	752 kW/h	96,693	4,603,431	30,689,537
Demand Charge	45.00 /kWh	15%	1,575 kW/h		110,935	739,565
				Total	20,903,417	139,356,110
				(Power Cost per m^3)	0.40	2.67
A-2. Fuel (Diesel Oil)						
a. Intake	60.00 /l	15%	176 l/h	11,405	542,968	3,619,784
b. WTP	60.00 /l	15%	527 l/h	34,150	1,625,818	10,838,786
c. Nashirabad Reservoir	60.00 /l	15%	203 l/h	13,154	626,264	4,175,092
				Total	2,795,050	18,633,662
				(Fuel Cost per m^3)	0.05	0.36
A-3. Chemicals						
a. Chlorine (Cl_2)	25,000 /ton	15%	0.6 ton/d	15,000	714,130	4,760,870
b. ALUM	24,000 /ton	15%	3.15 ton/d	75,600	3,599,217	23,994,783
c. LIME	12,000 /ton	15%	0.75 ton/d	9,000	428,478	2,856,522
				Total	4,741,825	31,612,175
				(Chemicals Cost per m^3)	0.09	0.61
A-4. Variable Cost-Total (A1+A2+A3)					28,440,292	189,601,947
(Variable Costperm^3)					0.54	3.63
B. a. Personnel	12,318 /psn.	10%	78 psns.		1,048,145	10,481,455
b. Welfare & Administration		10%			524,073	5,240,727
c. Maintenance & Repair		15%			1,434,783	9,565,217
B-2.Fixed Cost-Total (B1.atoB1.c)					3,007,001	25,287,399

*1) Energy Charge: -Cost/day: Unit Cost x Consumption/h x 95.5% x 24hrs.
-Cost/year: Daily cost x 365days

*2) Demand Charge: -Cost/month: Unit Cost x Monthly demand volume
-Cost/year: Monthly costx12months

*3) Fuel (Diesel Oil) Cost -Cost/day: Unit Cost x Daily power Cons. x. 0.27l /kW x 4.5%
-Cost/year: Daily cost x 365days

Table 12.4.5 O&M Costs Conversion Factors

Description	Financial Cost excl. tax (BDT)	% of total cost	Conversion Factor	Economic Cost
Fuel Cost Variable cost Per m^3 cost	0.36	9.89%	1.00	0.36
Electricity Cost Per m^3 cost	2.67	73.35%	1.00	2.67
Chemical Cost Per m^3 cost	0.61	16.76%	1.00	0.61
Total cost per m^3 cost	3.64	100.00%	1.00	3.64
Personnel Cost	10,481,455	41.45%	0.90	9,433,310
Welfare & Administration	5,240,727	20.72%	0.90	4,716,654
Maintenance & Repair	9,565,217	37.83%	0.90	8,608,695
Total Fixed Cost	25,287,399	100.00%	0.90	22,758,659

The O & M costs are based on 2012 prices and converted to 2021 constant prices by using price escalation factors of 3.7%, 3.5% and 2% per year for variable cost, fixed cost A (Personnel Cost and Welfare & Administration) and fixed cost B (Maintenance & Repair) respectively. Table 12.4.6 shows the economic O&M costs in constant 2021 prices used for the computation of economic cash-flow.

Table 12.4.6 O&M cost in Constant 2021 Prices

Fiscal Year	Unit Cost			Ope. Ratio (%)	Annual Production Water Volume (m^3)	Annual O&M Economic Cost (BDT)			
	Variable Cost (BDT/m^3)	Fixed Cost A. (BDT/year)	Fixed Cost B. (BDT/year)			Variable Economic Cost	Fixed Economic Cost A.	Fixed Economic Cost B.	Total O & M Economic Cost
2021	5.05	19,284,948	10,288,188	80%	41,756,000	210,779,845	19,284,948	10,288,188	240,352,981
2022	5.05	19,284,948	10,288,188	85%	44,365,750	223,953,585	19,284,948	10,288,188	253,526,721
2023	5.05	19,284,948	10,288,188	90%	46,975,500	237,127,325	19,284,948	10,288,188	266,700,461
2024	5.05	19,284,948	10,288,188	95%	49,585,250	250,301,066	19,284,948	10,288,188	279,874,201
2025	5.05	19,284,948	10,288,188	100%	52,195,000	263,474,806	19,284,948	10,288,188	293,047,942
2026-2049 No Change									
2050	5.05	19,284,948	10,288,188	100%	52,195,000	263,474,806	19,284,948	10,288,188	293,047,942

(6) Economic Benefits

There are two categories of economic benefits (namely, direct benefit and indirect benefit) that can be quantified for the Phase 2 Project. The direct benefit is a monetary value of distributed water from the Phase 2 Project that is estimated based on a value of "Willingness to Pay" (WTP), the indirect benefit is a monetary value of water cost saving by consumers that may be benefitted with the supply of water from the Project

1) Direct Benefit (Willingness to Pay Value)

The direct benefit is valued on a basis of "Willingness to Pay" (WTP). According to the socio-economic survey conducted in this Preparatory Survey, 511 responses or 76% out of 672 responses indicated willing to pay up to 1.5 times of the present tariff or more. The water tariffs in 2021 used for financial evaluation are BDT9.71/m^3 for domestic consumers and BDT27.51/m^3 for non-domestic consumers. These tariff rates are 1.48 times of the tariff rates in 2012 (i.e., BDT6.57/m^3 for domestic consumers and BDT18.61/m^3 for non-domestic consumers).

In view of the above, the value of Willingness to Pay (WTP) is deemed to be equivalent to the water tariff rates in 2021 used for the financial evaluation. Thus the value of WTP is equivalent to the Water Revenue amounts used for the financial evaluation.

2) Indirect Benefit (Consumers' Water Cost Saving)

Due to the limited supply of CWASA's piped water, many water consumers use the water supplied by bowsers or pumped from private tube wells. As the consumers spend much higher costs for obtaining water from such sources, the Phase 2 Project benefits such consumers by reduction of expenses incurred for water.

The World Bank Report[3] includes a comparison of water costs of different supply sources, as shown in Table 12.4.7.

Table 12.4.7 Comparison between Water Tariff with Cost of alternative Water Sources (2009)

	Piped Water by CWASA	Water purchased by 10 m^3 capacity bowser	Water purchased by 6 m^3 capacity bowser	Average cost of water from Private tube well (licensed)*	Average cost of water from Private tube well (not licensed)*
Cost (BDT/m^3)	5.7	65	75	110	15

* Exclude initial capital cost

The spot survey conducted by the JICA Preparatory Survey Team showed that the cost of Bowser Tank water has been constant since 2009, while the cost from the private tube wells has increased slightly mainly due to increases in fuel and electricity prices between 2009 and 2012. Table 12.4.8 summarizes the results of the spot survey.

Table 12.4.8 Spot Survey Results of Water Comparison

	Piped Water by CWASA	Water purchased by 10 m^3 capacity bowser	Water purchased by 6 m^3 capacity bowser	Average cost of water from Private tube well (licensed)*	Average cost of water from Private tube well (not licensed)*
Cost (BDT/m^3)	6.57/m^3	BDT.650.00/10m^3 BDT. 65.00/m^3 Emergency Rate: BDT.1300.00/10m^3 BDT. 130.00/m^3	BDT.450.00/6m^3 BDT. 75.00/m^3 Emergency Rate: BDT.900.00/6m^3 BDT.150.00/m^3	119.73/m^3	Not Available

* Exclude initial capital cost

From the above data, a weighted average cost of water obtained from sources other than CWASA's piped water is estimated as BDT109.6/m^3 in 2009 prices as shown in Table 12.4.9.

Table 12.4.9 Average Cost for Water obtained from Other Sources

Alternative water source cost	Cost (BDT/m^3)	Weight	Annual Increase
Bowser Tank 10m^3	65	0.5%	0%
Bowser Tank 6m^3	75	0.5%	0%
Private Tube Well	110	99%	3.7%
Average cost	109.6	100%	

The 2021 price costs for water obtained from sources other than CWASA's piped water is estimated by increasing the above cost at an escalation rate of 3.7% per annum, which is the annual average increase rate of Gross Rent, Fuel and Lighting in the Bangladesh CPI from 2001 to 2012, as given in Table 12.2.8.

[3] Reference: "Project appraisal document on Chittagong Water Supply Improvement and Sanitation Project", World Bank, 27 May 2010, Report No: 54697-BD

The next assumption is the quantity of water that can be transferred from other supply sources to the use of CWASA's piped water when water is supplied from the Phase 2 Project.

Table 12.4.10 shows the estimate of the water quantity to be transferred from other sources when there is a supply from the Phase 2 Project.

Table 12.4.10 Volume of Water to be transferred from Other Sources

A	Existing Water Connections		25,000
B	Estimated Water Connections required for Phases 1 & 2 Service Areas		59,300
C	Connections to be Increased by Phase 2 project	(B-A)/2	17,150
D	Estimated Water Consumption for Phases 1 & 2 (m^3/year)		88,400,000
E	Estimated Water Consumption/connection for Phases 1 & 2 (m^3/year)	D/B	1,490.725
F	Estimated Volume attributed by the Project for Cost Saving Benefit	C*E	25,565,936

The distribution of water from Phase 1 and Phase 2 Projects require about 59,300 house connections. As there are about 25,000 existing house connections in the service areas of the Phase 1 and Phase 2 Projects, about 34,300 additional connections are needed, of which a half (i.e. 17,150 connections) are considered as additional for the distribution from the Phase 2 Project. As the total consumption volume of water from the Phase 1 and Phase 2 Projects is estimated as 88.4 million m^3 per annum, an average consumption volume per connection is estimated to be about 1,490.73m^3/year. Assuming an additional 17,150 connections will stop using other supply sources, the volume of water to be transferred is estimated at 25,565,936 m^3 per annum.

The quantity of water to be transferred from private tube wells and bowser tanks is estimated. Table 12.4.11 shows the basis for the estimate of the quantity of the water volume, which is transferred from bowser water.

Table 12.4.11 Composition of Estimated Bowser Tank Water Volume in Service Area

Entire Chittagong Area			
A.	Total Water Billed m^3 (May 2012)	4,518,135	
B.	Total Bowser Water Sold m^3 (May 2012)	20,614	
C.	Percent of Total Water	0.46%	C=B/A
Service Area			
D.	Estimated Water Saving Volume m^3	25,565,936	
E.	Bowser Water Sold m^3	123,683	E=B*12*0.5
F.	Percentage of Total Water	0.48%	F=E/D

The total volume of bowser water which was sold in May, 2012 was 20,614 m^3, accounting for about 0.46% of the total water distributed by CWASA in the same month. Assuming that a half of the bowser tank water is distributed in the service areas of the Phase 1 and 2 Projects, the ratio of the bowser tank water distributed in the service areas accounts for 0.48% of the total estimated volume of water transferred from other sources (i.e., 25,565,936m^3). For the estimation of economic benefits brought about by the water cost saving of consumers, it is conservatively estimated that 99% is due to transfer from private tube well water and 1% from bowser tank water, which is sub- divided into 0.5% from 10m^3 capacity bowser tanks and 0.5% from 6m^3 capacity bowser tanks, as the costs of water from bowser tanks is lower than the cost from private tube wells.

Table 12.4.12 shows the estimated economic benefit brought about by the water cost saving of consumers that can be realized by transferring from the use of water from private tube wells and bowser tanks.

Table 12.4.12 Benefit of Consumers' Water Cost Saving derived from the Project

Water saving volume (m^3/year)	Alternative water source 1 price (BDT/m^3)	Alternative water source 2 price (BDT/m^3)	Alternative water source 3 price (BDT/m^3)	Average Cost of alternative water source (BDT/m^3)	Average Tariff Rate (BDT/m^3)	Cost Saving (BDT/m^3)	Total Economic Benefit (BDT)
25,565,936	65.00	75.00	170.11	169.11	14.05	155.06	3,964,254,036

The average cost to be paid by consumers for water to be obtained from other sources is estimated as BDT 169.11/m^3 and the cost to be paid by them for CWASA's piped water is BDT 14.05/m^3 both in 2021 constant prices, which means that consumers can benefit by an amount of BDT 155.06/m^3. Thus an economic benefit of BDT 3,964,254,036 is estimated on the basis of 25,565,936m^3 of water being transferred from other supply sources.

12.4.2 Analysis of Economic Return on Investment

Table 12.4.13 shows the EIRR and ENPV computed for the Phase 2 Project.

Table 12.4.13 Economic Cash Flow

(BDT mil.)

Year	Capital Investment	Replacement Costs	O&M Cost	Willingness to Pay (WTP)	Indirect Benefit	Net Benefit
2013	199.49	-	-	-	-	(199.49)
2014	471.78	-	-	-	-	(471.78)
2015	753.53	-	-	-	-	(753.53)
2016	6,544.44	-	-	-	-	(6,544.44)
2017	6,733.97	-	-	-	-	(6,733.97)
2018	6,520.70	-	-	-	-	(6,520.70)
2019	1,773.01	-	-	-	-	(1,773.01)
2020	1,786.91	-	-	-	-	(1,786.91)
2021	274.07	-	240.35	469.44	3,964.25	3,919.27
2022	14.84	-	253.53	505.02	3,964.25	4,200.90
2023	-	-	266.70	541.33	3,964.25	4,238.88
2024	-	-	279.87	578.37	3,964.25	4,262.75
2025	-	-	293.05	616.15	3,964.25	4,287.35
2026	-	-	293.05	623.48	3,964.25	4,294.69
2027-2033 No Change			|	|	|	|
2034	-	-	293.05	623.48	3,964.25	4,294.69
2035	-	344.47	293.05	623.48	3,964.25	3,950.22
2036	-	-	293.05	623.48	3,964.25	4,294.69
2037	-	344.47	293.05	623.48	3,964.25	3,950.22
2038	-	-	293.05	623.48	3,964.25	4,294.69
2039	-	-	293.05	623.48	3,964.25	4,294.69
2040	-	344.47	293.05	623.48	3,964.25	3,950.22
2041	-	-	293.05	623.48	3,964.25	4,294.69
2042-2049 No Change			|	|	|	|
2050	-	-	293.05	623.48	3,964.25	4,294.69
Total	25,072.73	1,033.40	8,659.70	18,297.33	118,927.62	102,459.12
ENPV: 3,352.68			**EOCC: 10%**		**EIRR: 11.87%**	

It indicates the following results:

- EIRR: 11.87%

- ENPV: BDT 3,352.68 million at 10% discount rate

The economic opportunity cost of capital (EOCC) for water projects is normally estimated at between 10% and 12%.

In light of the EIRR and ENPV vs. EOCC, the Phase 2 Project is evaluated to have a justifiable economic return on investment.

12.4.3 Sensitivity Analysis of Economic Return

A sensitivity analysis on the economic return is conducted to evaluate the possible effect of variances in the assumptions. The factors to be included in the sensitivity analysis are an increase/decrease in the O&M cost, Direct Benefit (Willingness to Pay: WTP) and Indirect Economic Benefit (IEB) by 5% and 10%.

The results of the sensitivity analysis are shown in Table 12.4.14 and Figure 12.4.1.

Table 12.4.14 Summary of Economic Sensitivity Analysis

Description	EIRR	ENPV
O&M cost decrease with 10%	11.94%	3,476.45
O&M cost decrease with 5%	11.91%	3,414.57
Base Case	11.87%	3,352.68
O&M cost increase with 5%	11.84%	3,290.79
O&M cost increase with 10%	11.81%	3,228.91
WTP decrease with 10%	11.82%	3,251.71
WTP decrease with 5%	11.85%	3,301.27
Base Case	11.87%	3,352.68
WTP increase with 5%	11.90%	3,402.96
WTP increase with 10%	11.93%	3,452.53
EB decrease with 10%	10.84%	1,451.46
EB decrease with 5%	11.36%	2,402.63
Base Case	11.87%	3,352.68
EB increase with 5%	12.37%	4,303.86
EB increase with 10%	12.85%	5,253.93

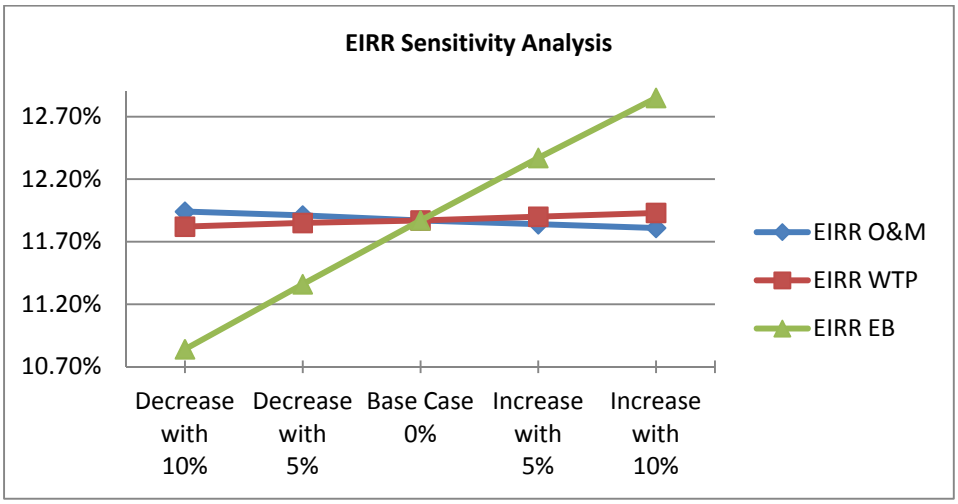


Figure 12.4.1 Sensitivity of EIRR

The sensitivity analysis indicates that the EIRR is higher than 11% even with a 10% increase in O&M costs, being higher than 11% even with a 10% decrease in Willingness to Pay (WTP), and being higher than 10% even with a 10% decrease in Indirect Economic Benefit (IEB). Thus the economic effectiveness of Phase 2 Project is quantitatively justifiable.

12.4.4 Overall Evaluation of Economic Benefit

Adequate supply of quality water is essential to meet the increasing water demand in Chittagong. The Phase 2, as well as the Phase 1Project will contribute significantly in responding to public needs for an improved water supply and in particular in the improvement of the sanitary environment and health of the people.

In view of the quantitative economic return on investment and these qualitative effects, the Phase 2 Project is strongly justifiable, although the financial position is difficult.