5.2 Target Year

The target year of the North Dhaka Sewerage Master Plan was set forth as 2020, as per the Scope of Work of the Study agreed between JICA and the Government of Bangladesh (the Ministry of Finance, the Ministry of Local Government, Rural Development and Co-operatives, and the Dhaka WASA) on November 25, 1996.

For the Feasibility Study of Priority Project(s), the target year was determined to be 2005 in consideration of a reasonable time frame for project implementation and the importance to maintain consistency with the DMDP Urban Area Plan, which has the same target year.

5.3 Identification of Target Area for Master Plan Preparation

The Strategic Planning Zone (SPZ), as defined by the DMDP, was principally referred to delineate target area for the sewerage master plan. The DMDP classified the urban land use into four categories, namely Established urban Area, Urban Fringe Area, Peripheral Urban Development Area and New Urban Development Area. These land use classifications were arranged and visualised as shown in Figure 5.3. Based on the agreement between DWASA and the Cantonment Authority, domestic sewage discharged from residential area in the Cantonment Security Zone is considered to be included in the sewerage master plan.

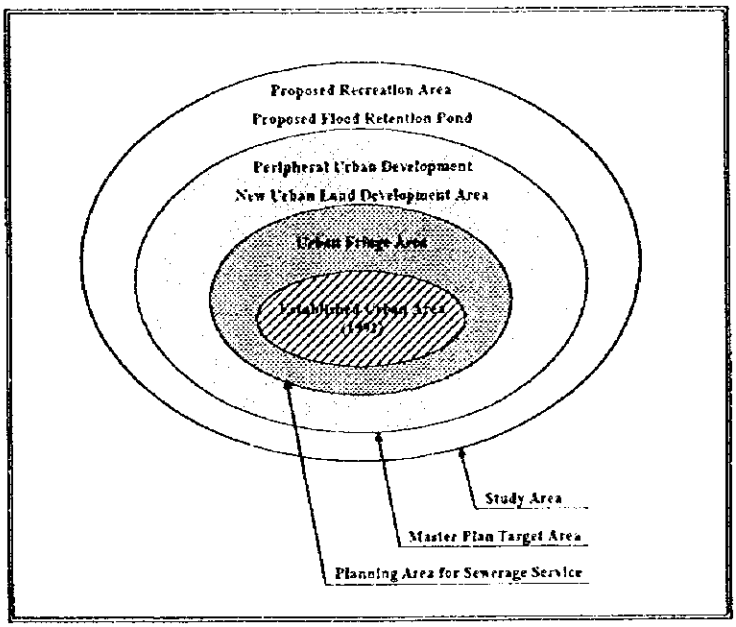
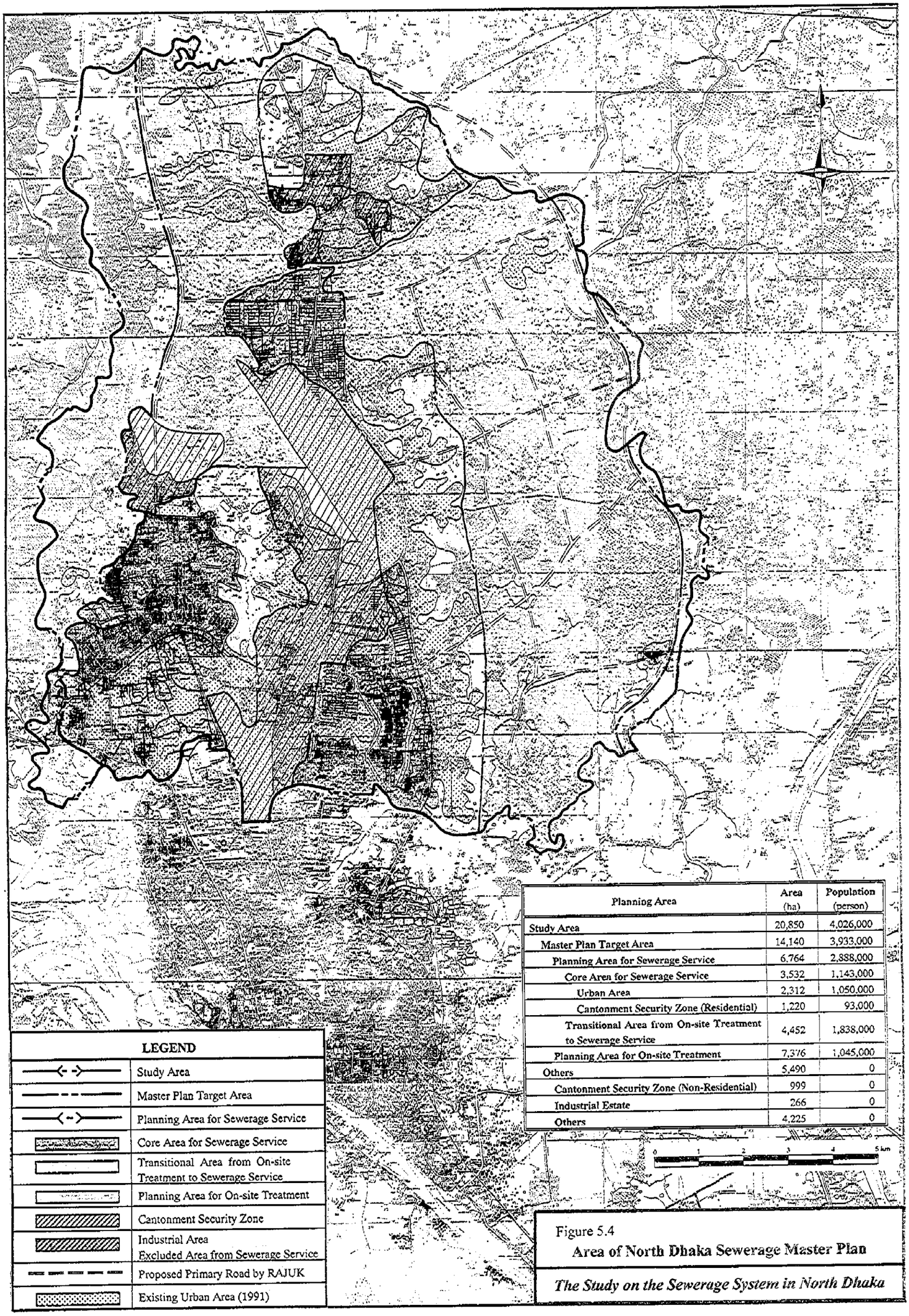


Figure 5.3 Schematic Diagram of the Composition of Master Plan Target Area

Target area of sewerage master plan was then categorised as shown in Table 5.3 and exhibited in Figure 5.4.



Planning Area	Area (ha)	Population (person)
Study Area	20,850	4,026,000
Master Plan Target Area	14,140	3,933,000
Planning Area for Sewerage Service	6,764	2,888,000
Core Area for Sewerage Service	3,532	1,143,000
Urban Area	2,312	1,050,000
Cantonment Security Zone (Residential)	1,220	93,000
Transitional Area from On-site Treatment to Sewerage Service	4,452	1,838,000
Planning Area for On-site Treatment	7,376	1,045,000
Others	5,490	0
Cantonment Security Zone (Non-Residential)	999	0
Industrial Estate	266	0
Others	4,225	0

Figure 5.4
Area of North Dhaka Sewerage Master Plan

The Study on the Sewerage System in North Dhaka

Table 5.3 Area of North Dhaka Sewerage Master Plan

Unit: ha

SPZ No.	Study Area										
	Master Plan Target Area						Others*1				Grand Total
	Sewerage Service Area				On-site Treatment Area	Total	Cantonment (Non-Residential)	Industrial Estate	Flood Control, etc.	Total	
	Core Area		Transitional Area	Sub-Total							
	Urban Area	Cantonment (Residential)									
4	55	0	992	1,047	0	1,047	63	0	163	226	1,273
5	734	232	685	1,651	10	1,661	115	0	849	964	2,625
6	732	68	0	800	0	800	0	0	132	132	932
12	0	0	712	712	1,624	2,336	0	0	1,323	1,323	3,659
13-1	136	855	547	1,538	261	1,799	338	0	0	338	2,137
13-2	504	65	624	1,193	4,714	5,907	483	0	608	1,091	6,998
14	151	0	892	1,043	767	1,810	0	266	1,150	1,416	3,226
Total	2,312	1,220	4,452	7,984	7,376	15,360	999	266	4,225	5,490	20,850

Note: Others include Flood Flow Area, Flood Retention Pond, Watershed, etc.

5.4 Design Population

5.4.1 Methodology to Set-up Future Population in DMDP

The future population for master plan preparation of this Study is principally referred to the DMDP population framework, but minor modification is introduced to population breakdown by SPZ in order to maintain the consistency with the overall figure of the DMDP.

The DMDP projected the future population for 2005 and 2015 by different methods due to considerable uncertainty in the long term planning of urban development, as shown in Table 5.4.

Table 5.4 Future Population Projected in the DMDP

Area	2005 (1)	Target of Growth Distribution (2)	2015* (3) = (1) + (2)
Established Urban Area in 1983	9,431,000	590,000	10,021,000
Established Urban Area in 1991	698,000	590,000	1,288,000
Additional New Area	2,490,000	1,770,000	4,260,000
Total	12,619,000	2,950,000	15,569,000

Note: Population in 2015 includes outside of the Study Area.

5.4.2 Design Population

(1) Methodology to establish design population

Although the population framework of the DMDP is primary reference figure, it can not be applied directly to the planning work in this Study due to its roughness in areal project.

In this master plan, the following methodology is taken up:

1) Area by year of urbanization by SPZ is measured.
2) The DMDP 2015 population is reallocated by year of urbanization (Established Urban Area in 1983 & 1991, and Additional Urban Area) in each SPZ.
3) The population density in 2015 is estimated by year of urbanization by SPZ.
4) Future population in target year of 2020 (2015 in the DMDP) is estimated by multiplying area in 1) and population density in 3).

(2) Design population

The future population in the Study Area was estimated multiplying the areas measured on the Composite Policies Map and the corresponding population density.

Table 5.5 shows the future population and the population density by target year together with base figure in 1991 classified into subject area for planning purpose.

The population projection of the DMDP and the Dhaka Emergency Water Supply Project was compared in Figure 5.5. Although there is a slight difference regarding the trend of population development, the future population is estimated at more or less similar magnitude.

Table 5.5 Future Population in the Study Area

Items	Study Area										
	Master Plan Target Area						Others				Grand Total
	Sewerage Service Area				On-site Treatment Area	Total	Cantonment (Non-Residential)	Industrial Estate	Flood Control, etc.	Total	
	Core Area		Transitional Area	Sub-Total							
	Urban Area	Cantonment (Residential)									
Area (ha)	2,312	1,220	4,452	7,984	7,376	15,360	999	266	4,225	5,490	20,850
Density	454	76	413	373	142	262	0	0	0	0	193
Population	1,050,000	93,000	1,838,000	2,981,000	1,045,000	4,026,000	0	0	0	0	4,026,000

Note: Density-Person/ha; Population-person
Urban Area is Established Urban Area and Additional New Area
Flood Control, etc include Flood Flow Area, Flood Retention Pond, Watershed, etc.

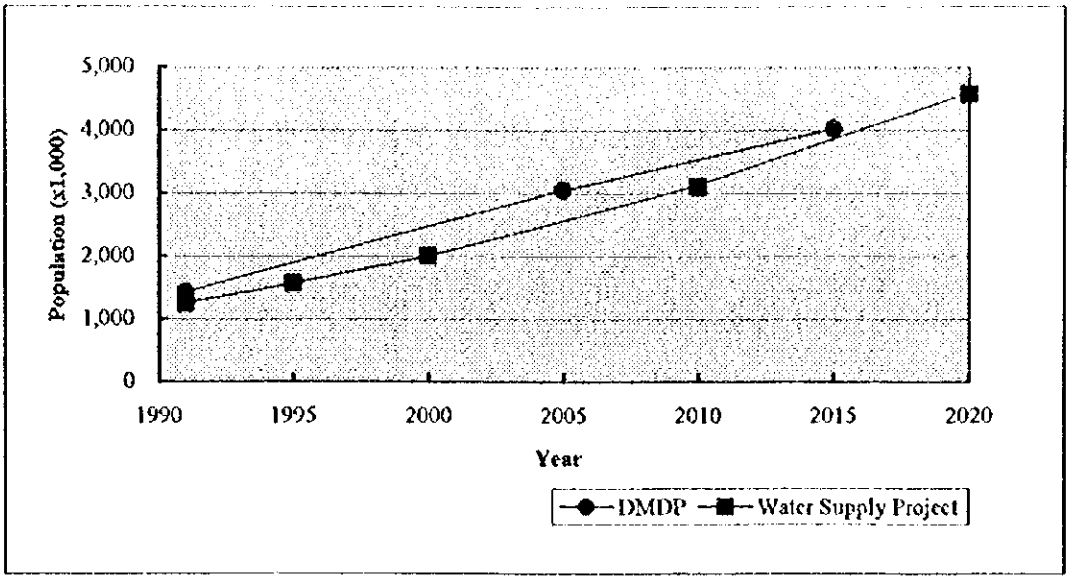


Figure 5.5 Comparison of Future Population of DMDP and Dhaka City Emergency Water supply Project

5.4.3 Delineation of Planned Sewerage Service Area

The future population in the master plan target year 2020 was established mainly based on SPZs. This future population was then subdivided into sewerage planning zones for the purpose of sewerage master plan preparation.

In the zoning of the sewerage planning area, following conditions were taken into account:

- Geographical and topographic conditions of the "Core Area"
- Compactness and area configuration of each zone for sewerage service
- Road network proposed in the DMDP Structure Plan

Four zones were considered for planning the sewerage system in North Dhaka as shown in Table 5.6.

Table 5.6 Zoning for Sewerage System Planning in North Dhaka

Sewerage Zone	SPZ	Municipality/Ward
Tongi	SPZ14	Tongi
Uttara	SPZ13-2	Uttara
North Dhaka East	SPZ5, SPZ6, SPZ12, SPZ13-1, SPZ13-2	Badda, Banani, Baridhara, Gulshan, Cantonment
North Dhaka West	SPZ4, SPZ5	Mirpur, Mohammadpur, Cantonment

5.4.4 Future Population in the Sewerage Planning Zone

Based on the aforementioned zoning, the future population, population density and area by SPZ by sewerage zone were finally established for the target year of 2020.

Table 5.7 Planned Area, Population Density and Population by Sewerage Zone in North Dhaka

Unit: Area - ha; Population density - person/ha; Population - person

Sewerage Zone	SPZ	Item	Sewage Service Area								
			Core Area					Transitional Area			Total
			Established Urban Area	Additional New Area	Sub-Total	Cantonment (Residential)	Total	Established Urban Area	Additional New Area	Sub-Total	
Tongi	14	Area	151	0	151	0	151	549	343	892	1,043
		Density	255	0	255	0	255	255	367	297	291
		Population	39,000	0	39,000	0	39,000	139,000	126,000	265,000	304,000
Uttara	13-2	Area	399	105	504	0	504	288	224	512	1,016
		Density	193	87	171	0	171	193	87	146	158
		Population	77,000	9,000	86,000	0	86,000	56,000	19,000	75,000	161,000
North Dhaka East	5	Area	0	0	0	102	102	0	0	0	102
		Density	0	0	0	76	76	0	0	0	78
		Population	0	0	0	8,000	8,000	0	0	0	8,000
	6	Area	732	0	732	68	800	0	0	0	800
		Density	639	0	639	76	591	0	0	0	591
		Population	468,000	0	468,000	5,000	473,000	0	0	0	473,000
	12	Area	0	0	0	0	0	457	255	712	712
		Density	0	0	0	0	0	326	167	270	270
		Population	0	0	0	0	0	149,000	43,000	192,000	192,000
	13-1	Area	136	0	136	855	991	337	210	547	1,538
		Density	140	0	140	76	85	140	291	197	125
		Population	19,000	0	19,000	65,000	84,000	47,000	61,000	108,000	192,000
	13-2	Area	0	0	0	65	65	44	68	112	177
		Density	0	0	0	76	76	193	87	125	107
		Population	0	0	0	5,000	5,000	8,000	6,000	14,000	19,000
	Total	Area	868	0	868	1,090	1,958	838	533	1,371	3,329
		Density	561	0	561	76	291	243	206	229	266
		Population	487,000	0	487,000	83,000	570,000	204,000	110,000	314,000	884,000
North Dhaka West	4	Area	55	0	55	0	55	890	102	992	1,047
		Density	735	0	735	0	735	735	1,559	816	816
		Population	40,000	0	40,000	0	40,000	655,000	159,000	814,000	854,000
	5	Area	734	0	734	130	864	248	437	685	1,549
		Density	541	0	541	76	472	541	541	540	502
		Population	398,000	0	398,000	10,000	408,000	134,000	236,000	370,000	778,000
	Total	Area	789	0	789	130	919	1,138	539	1,677	2,596
		Density	555	0	555	76	487	693	733	706	629
		Population	438,000	0	438,000	10,000	448,000	789,000	395,000	1,184,000	1,632,000
Total		Area	2,207	105	2,312	1,220	3,532	2,813	1,639	4,452	7,984
		Density	472	86	454	76	324	422	397	413	373
		Population	1,041,000	9,000	1,050,000	93,000	1,143,000	1,188,000	650,000	1,838,000	2,981,000

5.5 Collection System

There are two different types of sewer system; the separate system is to drain sanitary sewage and stormwater using different sewer lines, the combined system drains these two water types in the same sewer line.

Since the separate system is to convey only the sanitary sewage into the sewage treatment plant, it does not spill sanitary sewage into the public water body during the rainy periods and therefore it is advantageous for conservation of the aquatic environment.

For the North Dhaka sewerage master plan, the separate sewer system was adopted in consideration of the following:

- The existing sewerage system employs the separate sewer system.
- The Study aims at the prevention of water pollution in the public water body through the provision of a sewerage system, including a sewage treatment plant.
- A comprehensive flood protection and stormwater drainage plan has been developed and this plan includes the Study Area.

5.6 Per Capita Design Sewage Flow and Design Sewage Quality

(1) Per Capita Design Sewage Flow

Based on the field investigations on domestic sewage quantity, per capita water consumption being adopted in the current water supply project, and actual examples in other countries, design per capita sewage flow for this master plan is established as shown in Table 5.8.

Table 5.8 Per Capita Design Sewage Flow by Year

Item	2000	2005	2010	2015	2020
Design Average Daily Flow	85	95	100	100	100
Design Maximum Daily Flow	105	115	125	125	125
Design Maximum Hourly Flow	135	145	160	160	160

(2) Design Sewage Quality

Through in-depth evaluation and consideration of the existing data, including the field investigation results, the design sewage quality is determined at 200 mg/l for both BOD and SS.

5.7 On-Site Treatment

On-site wastewater treatment/disposal is an important service, not only for small rural communities, but also for urban/semi-urban households unserved by the public sewerage system. The study of on-site treatment/disposal was done to offer alternatives from the viewpoints of low-cost sanitation and technical aspects, corresponding to the differences among the beneficiaries, such as a clusters of individual households, an apartments and independent households. The study was also intended to look into technical options as an intermediate countermeasure for those unserved households situated in the transitional area for on-site treatment.

Field inspections of the existing facilities, such as individual septic tanks and small-bore community sewerage system were carried out during the Stage 1 Field Work. Water sampling from various points in the Study Area and their laboratory examination were also implemented.

Reference is made to the "Appropriate Technology for Treatment of Wastewater for Small Rural Communities" (Lyon, 1982, EURO Reports and Studies, WHO Regional Office for Europe).

(1) Standardisation of On-Site Treatment Technologies

Septic tanks are commonly employed in Bangladesh as the typical on-site treatment method. This septic tank is made of bricks lined with mortar and mainly stores nightsoil and discharges effluent into street gutters. This treatment method is one of the most inefficient among the various on-site treatment methods. The effluent from septic tanks commonly accelerates water pollution in the receiving public water bodies.

The on-site treatment method taken up in this Study consists of two tanks to avoid the discharge of untreated solid materials. However, considerations are given to the locality, such as high groundwater level during rainy season, which affects the infiltration of effluent. In this respect, the standardisation of various conditions and technical requirements from view points of structure, construction, operation and maintenance in order to insure applicability to respective households. The study made an effort to extract such issues and problems and to visualise the necessary measures both technically and institutionally.

(2) Legislative and institutional arrangements

When the average income level of the local residents are taken into account, certain financial arrangement are deemed necessary. For example, public finance with a low interest rate and/or a subsidy to accelerate the application of appropriate on-site treatment facilities. Legislative arrangements are also necessary to rationalise the application of different sizes/capacities of on-site treatment facilities corresponding to land use pattern, as well as the smooth transfer from on-site treatment to the public sewerage services in the transitional area. The necessary measures to be taken up by authorities concerned are likewise discussed.

(3) Treatment and disposal of septage from on-site treatment facilities

If the septage accumulated in on-site treatment facilities is not removed periodically, treatment efficiency will definitely decrease. However, there is no particular facility in Dhaka to treat septage. The removed septage is currently disposed into sewer lines, agricultural land, ponds, etc., resulting in serious environmental deterioration. In the North Dhaka Sewerage Master Plan, septage is planned to be accepted to a septage lagoon in the sewage treatment plant.

5.8 Facility Planning for North Dhaka

5.8.1 Design Sewage Flow

The design sewage flow by sewerage zone namely, Tongi, Uttara, North Dhaka East and North Dhaka West, of the target year 2020 is shown in Table 5.9 and Figure 5.6.

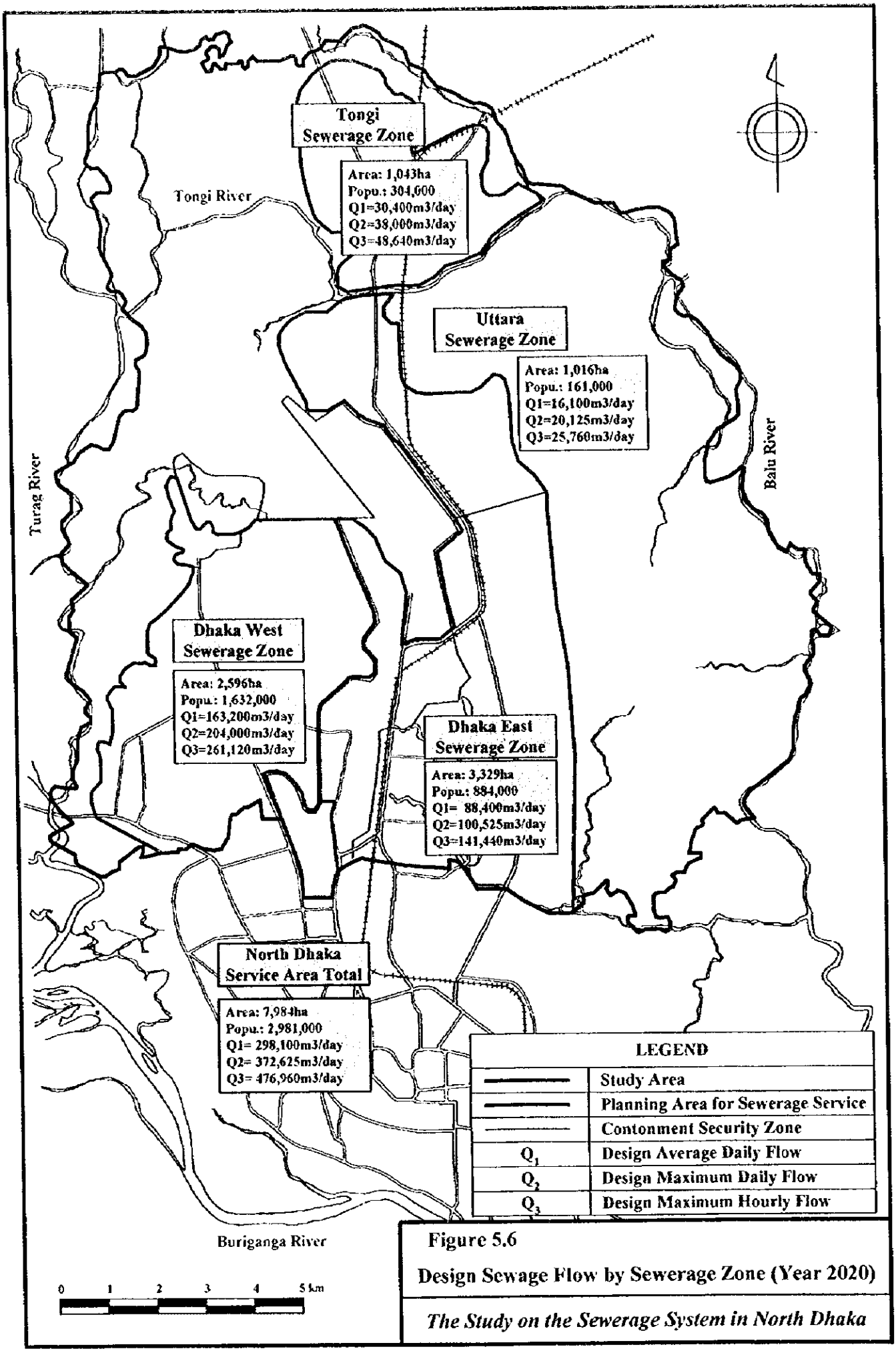


Figure 5.6

Design Sewage Flow by Sewerage Zone (Year 2020)

The Study on the Sewerage System in North Dhaka

Table 5.9 Design Sewage Flow by Sewerage Zone (Year 2020)

Sewerage Zone	Item	Unit	Core Area		Sub-Total	Transitional Area	Total
			Urban Area	Cantonment Security Zone			
Tongi	Area	ha	151	0	151	892	1,043
	Population	person	39,000	0	39,000	265,000	304,000
	Q1	cu.m/day	3,900	0	3,900	26,500	30,400
	Q2	cu.m/day	4,875	0	4,875	33,125	38,000
	Q3	cu.m/day	6,240	0	6,240	42,400	48,640
Uttara	Area	ha	504	0	504	512	1,016
	Population	person	86,000	0	86,000	75,000	161,000
	Q1	cu.m/day	8,600	0	8,600	7,500	16,100
	Q2	cu.m/day	10,750	0	10,750	9,375	20,125
	Q3	cu.m/day	13,760	0	13,760	12,000	25,760
North Dhaka East	Area	ha	868	1,090	1,958	1,371	3,329
	Population	person	487,000	83,000	570,000	314,000	884,000
	Q1	cu.m/day	48,700	8,300	57,000	31,400	88,400
	Q2	cu.m/day	60,875	10,375	71,250	39,250	110,500
	Q3	cu.m/day	77,920	13,280	91,200	50,240	141,440
North Dhaka West	Area	ha	789	130	919	1,677	2,596
	Population	person	438,000	10,000	448,000	1,184,000	1,632,000
	Q1	cu.m/day	43,800	1,000	44,800	118,400	163,200
	Q2	cu.m/day	54,750	1,250	56,000	148,000	204,000
	Q3	cu.m/day	70,080	1,600	71,680	189,440	261,120
Total	Area	ha	2,312	1,220	3,532	4,452	7,984
	Population	person	1,050,000	93,000	1,143,000	1,838,000	2,981,000
	Q1	cu.m/day	105,000	9,300	114,300	183,800	298,100
	Q2	cu.m/day	131,250	11,625	142,875	229,750	372,625
	Q3	cu.m/day	168,000	14,880	182,880	294,080	476,960

Note: 1) Q1: Design Average Daily Flow
2) Q2: Design Maximum Daily Flow
3) Q3: Design Maximum Hourly Daily Flow

5.8.2 Design Criteria

Design criteria were established for the sewer network, pump station and sewage treatment plant, respectively, in due consideration of the available construction equipment and materials in Bangladesh, as well as the construction methods and O&M practices, as follows.

(1) Sewer Network

1) Design capacity of sewer

The design maximum hourly sewage flow is applied in designing sanitary sewers.

2) Allowance for sewer capacity

An allowance is made for sanitary sewer capacity as shown below.

Table 5.10 Allowance for Sewer Capacity

Diameter of Sewer	Allowance for Sewer Capacity
200 - 600 mm	100%
700 - 1,500 mm	50 -- 100%
1,650 - 3,000 mm	25 - 50%

3) Determination of size and slope of sewer

Manning's formula is adopted for gravity sewers and Hazen William's formula for pressure sewers.

4) Restrictions on flow velocity and gradient

The design velocity in sewers shall gradually increase downstream.

Design velocity of sanitary sewer: 0.6 to 3.0 m/sec

5) Sewer material

Sewers are required to be of materials and structure strong enough to withstand continuous external pressure, although they not required to have such great strength against internal pressure except for specific cases. The kinds of sewers are summarised below.

- For gravity pipe

  Reinforced concrete pipes: more than 500 mm

  Polyvinyl chloride pipes:200 mm – 450 mm
- For pressure pipe

  Steel Pipe

6) Minimum pipe diameter

The minimum pipe diameter shall be 200 mm for sanitary sewers.

7) Minimum earth cover

The minimum earth cover shall be 1.0 m for sanitary sewers.

8) Manhole

The manhole should be installed at the end of each pipeline and at any place of change in pipe diameter, junction of pipes and change in vertical or horizontal alignment. Conditions for the installation of the standard circular manhole are summarised below.

(2) Pumping facilities

Type of pump station is determined referring to the selection chart shown in Table 5.11 and design sewage flow.

Table 5.11 Chart for Selection of Pumping Station Type by Design Flow

Item \ Design Flow (m^3/min)	0.6	1.5	3.0	6.0	20.0	30.0
Type of Pumping Station	Manhole Type		Simplified Type		Standard Type	
Grit Chamber	None		Sand Pit	Sand Pit	Standard Grit Chamber	
Grit Removal	None		Sand Pump	Sand Pump	Bucket Conveyor	
Screenings Removal	None		Manual	Automati		
Conveyor	None		Cage	Container		Hopper
Standby Generator	None		None	Yes		Yes
Deodorization	None		None	None		Yes
Pumping Dia (mm)	65	80	100	100	150	150	200	250	300	350	400
Pumping Nos. (standby)	2(1)	2(1)	2(1)	3(1)	3(1)	4(1)	4(1)	4(1)	4(1)	4(1)	4(1)

5.9 Selection of the Optimum Sewerage System

5.9.1 Alternatives of Sewerage System

Alternative combination of four sewerage zones was prepared as shown in Table 5.12, while alternative locations of sewage treatment plants were considered as shown in Figure 5.7. In selecting the alternative sites for sewage treatment plants, the difficulty of land acquisition, the distance from the sewerage service area, and the conditions of the receiving water bodies with regards to the effluent were fully taken into account. As a result, all alternative sites were identified as existing the swamp areas.

Table 5.12 Outline of Alternative Sewerage System

Service Area	Alternative No.	Service Area 1	Service Area 2	Service Area 3	Service Area 4
4 Service Areas	No. 1	Tongi	Uttara	North Dhaka West	North Dhaka East
3 Service Areas	No. 2	Tongi, Uttara	North Dhaka West	North Dhaka East	-
	No. 3	Uttara, North Dhaka West	Tongi	North Dhaka East	-
	No. 4	Uttara, North Dhaka East	Tongi	North Dhaka West	-
	No. 5	North Dhaka West, North Dhaka East	Tongi	Uttara	-
2 Service Areas	No. 6	Tongi, Uttara, North Dhaka West	North Dhaka East	-	-
	No. 7	Uttara, North Dhaka West, North Dhaka East	Tongi	-	-
	No. 8	Tongi, Uttara, North Dhaka East	North Dhaka West		
1 Service Area	No. 9	Tongi, Uttara, North Dhaka West, North Dhaka East	-	-	-

From the above mentioned nine (9) alternative plans, alternative No.4 was selected as the optimum sewerage system in application of selection criteria, which included construction cost, operation and maintenance cost, and ease of operation and maintenance.

Design sewage flow of the optimum sewerage system is shown in Table 5.13.

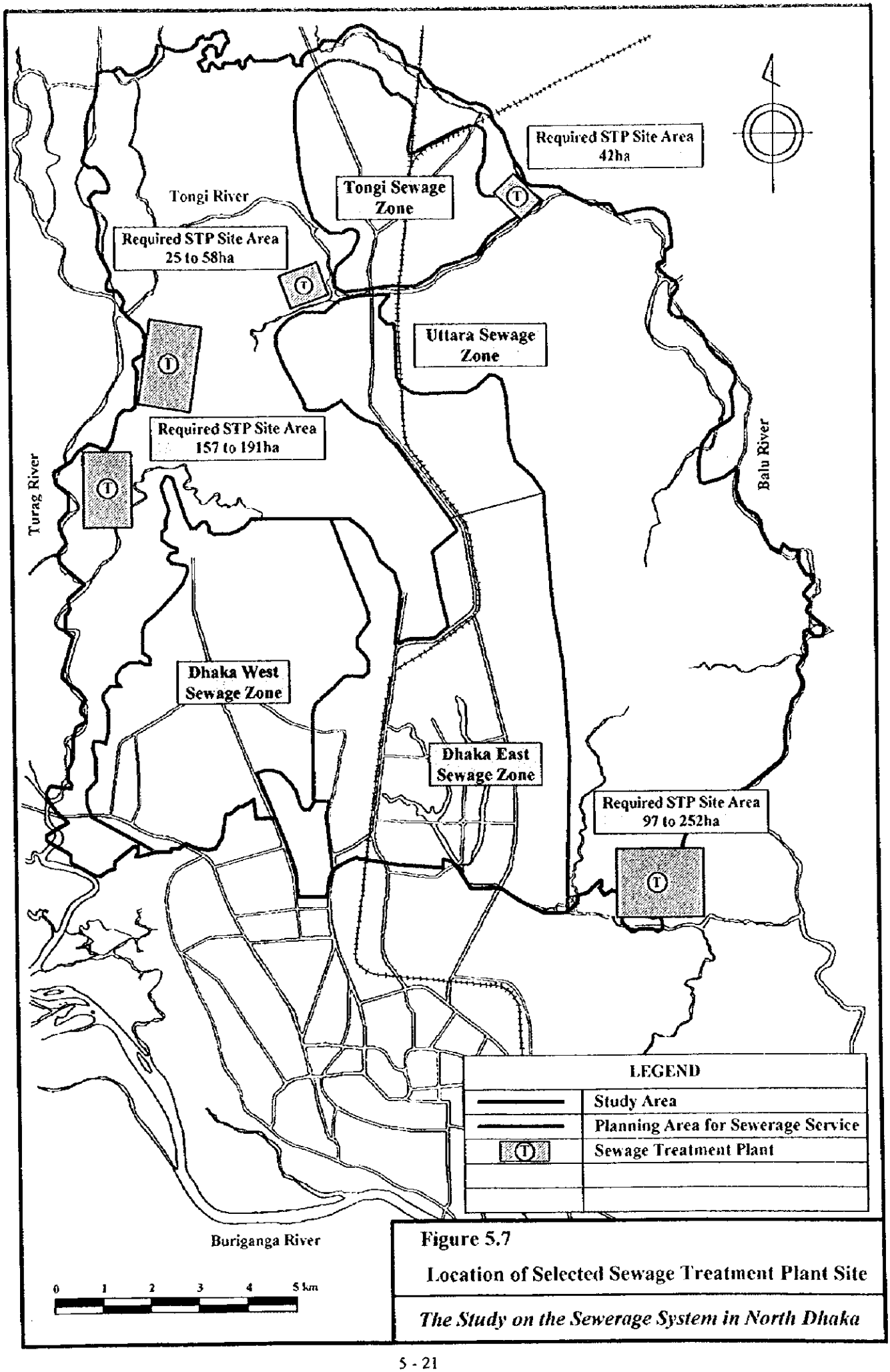


Figure 5.7

Location of Selected Sewage Treatment Plant Site

The Study on the Sewerage System in North Dhaka

Table 5.13 Design Sewage Flow by Sewerage Service Area (Year 2020)

Sewerage Service Area	Sewerage Zone	Item	Unit	Core Area		Sub-Total	Transitional Area	Total
				Urban Area	Cantonment Security Zone			
Tongi	Tongi	Area	ha	151	0	151	892	1,043
		Population	person	39,000	0	39,000	265,000	304,000
		Q1	cu.m/day	3,900	0	3,900	26,500	30,400
		Q2	cu.m/day	4,875	0	4,875	33,125	38,000
		Q3	cu.m/day	6,240	0	6,240	42,400	48,640
North Dhaka East	Uttara	Area	ha	504	0	504	512	1,016
		Population	person	86,000	0	86,000	75,000	161,000
		Q1	cu.m/day	8,600	0	8,600	7,500	16,100
		Q2	cu.m/day	10,750	0	10,750	9,375	20,125
		Q3	cu.m/day	13,760	0	13,760	12,000	25,760
	North Dhaka East	Area	ha	868	1,090	1,958	1,371	3,329
		Population	person	487,000	83,000	570,000	314,000	884,000
		Q1	cu.m/day	48,700	8,300	57,000	31,400	88,400
		Q2	cu.m/day	60,875	10,375	71,250	39,250	110,500
		Q3	cu.m/day	77,920	13,280	91,200	50,240	141,440
	Total	Area	ha	1,372	1,090	2,462	1,883	4,345
		Population	person	573,000	83,000	656,000	389,000	1,045,000
		Q1	cu.m/day	57,300	8,300	65,600	38,900	104,500
		Q2	cu.m/day	71,625	10,375	82,000	48,625	130,625
		Q3	cu.m/day	91,680	13,280	104,960	62,240	167,200
North Dhaka West	North Dhaka West	Area	ha	789	130	919	1,677	2,596
		Population	person	438,000	10,000	448,000	1,184,000	1,632,000
		Q1	cu.m/day	43,800	1,000	44,800	118,400	163,200
		Q2	cu.m/day	54,750	1,250	56,000	148,000	204,000
		Q3	cu.m/day	70,080	1,600	71,680	189,440	261,120
Total		Area	ha	2,312	1,220	3,532	4,452	7,984
		Population	person	1,050,000	93,000	1,143,000	1,838,000	2,981,000
		Q1	cu.m/day	105,000	9,300	114,300	183,800	298,100
		Q2	cu.m/day	131,250	11,625	142,875	229,750	372,625
		Q3	cu.m/day	168,000	14,880	182,880	294,080	476,960

Note: Q1-Design Average Daily Flow, Q2-Design maximum Daily Flow,
Q3-Design Maximum Hourly flow

5.9.2 Sewer System

The sewer system in the master plan stage was limited to main sewers having diameters of 500 mm or larger. The location of the pump stations was determined based on the hydraulic calculation of the sewer system. Owing to local conditions, the sewage treatment plant shall be constructed on reclaimed land in a swamp area. Therefore, sewage from the pump station at the utmost downstream site is planned to be sent to the sewage treatment plant via pressure pipe.

The general layout of sewerage system is shown in Figure 5.8.

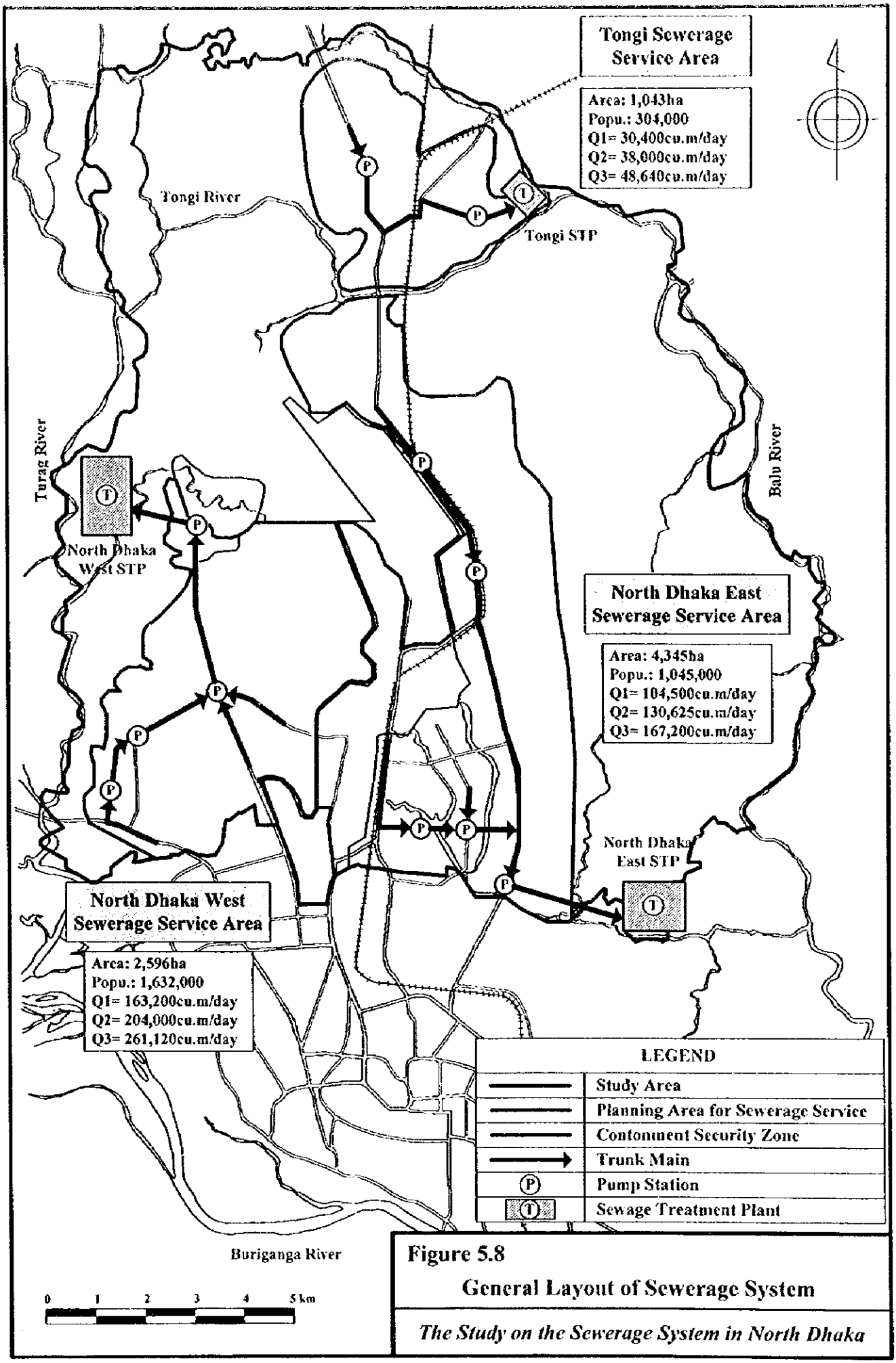


Figure 5.8

General Layout of Sewerage System

The Study on the Sewerage System in North Dhaka

5.10 Sewage Treatment Plant

(1) Selection of Sewage Treatment Method

The most appropriate sewage treatment method was selected based on the selection criteria, which covered the difficulty of operation and maintenance, economical operation and maintenance cost, energy savings, conformity to the effluent quality standard, availability of required land, environmental impact, etc.

A preliminary comparison of the sewage treatment methods is shown in Table 5.14.

Table 5.14 Comparison of Sewage Treatment Methods

Treatment Method	Operation	Maintenance	Cost	Power
Conventional Activated	difficult	difficult	High	large
Extended Aeration	difficult	difficult	High	large
Trickling Filter	fair	fair	High	fair
Rotating Biological Contactor	fair	difficult	Fair	fair
Oxidation Ditch	fair	fair	Fair	fair
Aerated Lagoon	easy	fair	Low	less
Stabilisation Pond	easy	easy	Low	none

As highlighted in the above table, the oxidation ditch, aerated lagoon and stabilisation pond methods were selected as applicable methods and subject to further study. Upon detailed evaluation of these three methods, the stabilisation method was finally selected as the optimum treatment method. The cost comparison of these alternative methods is shown below.

Unit: TK'000

Item	Oxidation Ditch	Aerated Lagoon	Stabilisation Pond
Construction Cost	2,190,404	812,540	300,438
Land Acquisition Cost	154,000	301,000	1,498,000
Sub-total	2,344,404	1,113,540	1,798,438
O&M Cost	1,718,180	1,179,440	0
Total	4,062,584 (US$ 92,897,000)	2,292,980 (US$ 52,432,000)	1,798,438 (US$ 41,124,000)

(2) Design of sewage treatment plant

The outline of major facilities for each sewage treatment plant is described in Tables 5.15 to 5.17, while the layout plan of each plant is shown in Figures 5.9 to 5.11.

Table 5.15 Outline of Tongi Sewage Treatment Plant

1. General

Name:	Tongi Sewage Treatment Plant
Location:	Tongi Paurashava
Site Area:	50.0 ha
Land Use:	Swamp Area
Service Population	304,000 persons
Sewerage System:	Separate system
Treatment Method:	Sewage Treatment = Grit Chamber + Primary Sedimentation Tank + Facultative Pond + Disinfection Chamber Sludge Treatment = Sludge Lagoon
Receiving Water Body:	Tongi River

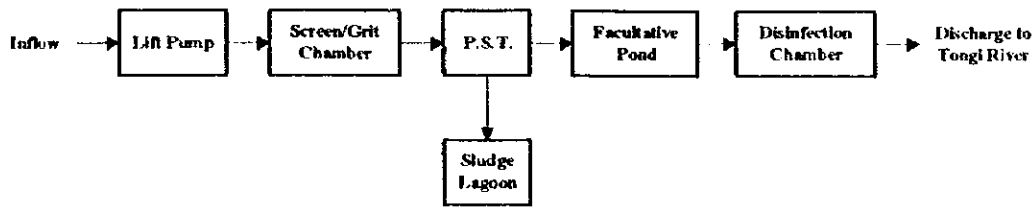
Design Sewage Flow Rat Unit:cu.m/day

Item	Sewage Flow
Daily Average	30,400
Daily Maximum	38,000
Hourly Maximum	48,640

Design Sewage Effluent Quality

Water Quality Index	Influent (mg/l)	Effluent (mg/l)	Total Removal Ratio (%)
BOD	200	40	80
SS	200	100	50

2. Treatment Flow



3. Outline of Major Facilities

Facility	Dimension	No. of Facility	Capacity
Grit Chamber	Horizontal Flow Type W 1.0 m x L 7.0 m x D 0.6 m	4	Surface Load: 1,737 cu.m/sq.m x day
Primary Sedimentation Tank	Centrifloc Sludge Scraper Ø16 m x D 3.5 m	4	Detention Time: 1.8 hr. Overflow Rate: 47 cu.m/sq.m x day
Facultative Pond	Embanked Rectangular Pond W 100 m x L 200 m x D 1.5 m	8	Retention Days: 5.9 BOD Area Load: 238 kg BOD/ha x day
Disinfection Chamber	Embanked Rectangular Pond W 5 m x L 16 m x D 2.0 m	2	Retention Time : 15 min
Sludge Lagoon	Embanked Rectangular Pond W 50 m x L 100 m x D 1.0 m	8	Retention Days : 106 days

Table 5.16 Outline of North Dhaka East Sewage Treatment Plant

1. General

Name:	North Dhaka East Sewage Treatment Plant
Location:	Dhaka City, Baidertek District
Site Area:	120.0 ha
Land Use:	Swamp Area
Service Population	1,045,000 persons
Sewerage System:	Separate system
Treatment Method:	Sewage Treatment = Grit Chamber + Primary Sedimentation Tank + Facultative Pond + Disinfection Chamber
	Sludge Treatment = Sludge Lagoon
Receiving Water Body:	Balu River

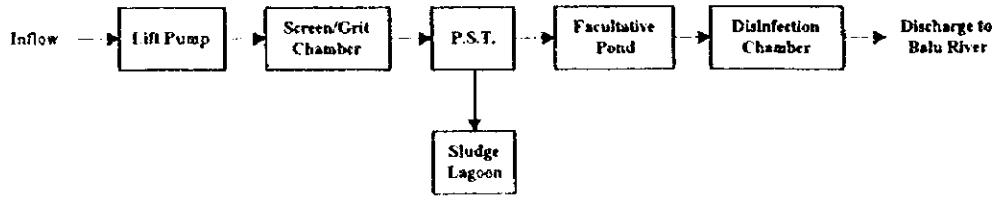
Design Sewage Flow Rate Unit: cu.m/day

Item	Sewage Flow
Daily Average	104,500
Daily Maximum	130,625
Hourly Maximum	167,200

Design Sewage Effluent Quality

Water Quality Index	Influent (mg/l)	Effluent (mg/l)	Total Removal Ratio (%)
BOD	200	40	80
SS	200	100	50

2. Treatment Flow



3. Outline of Major Facilities

Facility	Dimension	No. of Facility	Capacity
Grit Chamber	Horizontal Flow Type W 2.0 m x L 12.0 m x D 0.6 m	4	Surface Load: 1,742 cu.m/sq.m x day
Primary Sedimentation Tank	Centrifloc Sludge Scraper Ø21 m x D 3.5 m	8	Detention Time: 1.8 hr. Overflow Rate: 47 cu.m/sq.m x day
Facultative Pond	Embanked Rectangular Pond W 200 m x L 330 m x D 1.5 m	8	Retention Days: 5.8 BOD Area Load: 238 kg BOD/ha x day
Disinfection Chamber	Embanked Rectangular Pond W 11 m x L 25 m x D 2.0 m	2	Retention Time : 15 min
Sludge Lagoon	Embanked Rectangular Pond W 100 m x L 180 m x D 1.0 m	8	Retention Days : 110 days

Table 5.17 Outline of North Dhaka West Sewage Treatment Plant

1. General

Name:	North Dhaka West Sewage Treatment Plant
Location:	Dhaka City, Diabari District
Site Area:	180.0 ha
Land Use:	Swamp Area
Service Population	1,632,000 persons
Sewerage System:	Separate system
Treatment Method:	Sewage Treatment = Grit Chamber + Primary Sedimentation Tank + Facultative Pond + Disinfection Chamber
	Sludge Treatment = Sludge Lagoon
Receiving Water Body:	Turag River

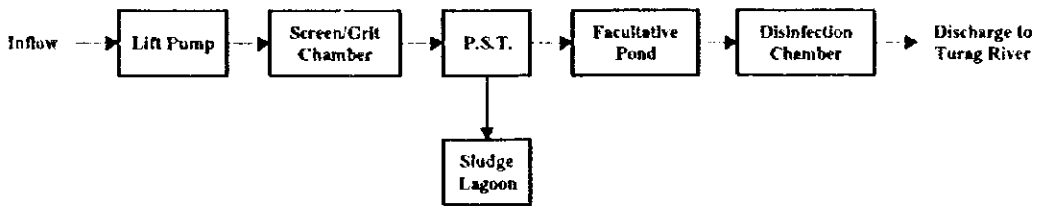
Design Sewage Flow Rate Unit: cu.m/day

Item	Sewage Flow
Daily Average	163,200
Daily Maximum	204,000
Hourly Maximum	261,120

Design Sewage Effluent Quality

Water Quality Index	Influent (mg/l)	Effluent (mg/l)	Total Removal Ratio (%)
BOD	200	40	80
SS	200	100	50

2. Treatment Flow



3. Outline of Major Facilities

Facility	Dimension	No. of Facility	Capacity
Grit Chamber	Horizontal Flow Type W 2.5 m x L 14.5 m x D 0.6 m	4	Surface Load: 1,801 cu.m/sq.m x day
Primary Sedimentation Tank	Centrifloc Sludge Scraper Ø26 m x D 3.5 m	8	Detention Time: 1.7 hr. Overflow Rate: 48 cu.m/sq.m x day
Facultative Pond	Embanked Rectangular Pond W 260 m x L 400 m x D 1.5 m	8	Retention Days: 5.9 BOD Area Load: 235 kg BOD/ha x day
Disinfection Chamber	Embanked Rectangular Pond W 15 m x L 30 m x D 2.0 m	2	Retention Time : 16 min
Sludge Lagoon	Embanked Rectangular Pond W 100 m x L 270 m x D 1.0 m	8	Retention Days : 106 days

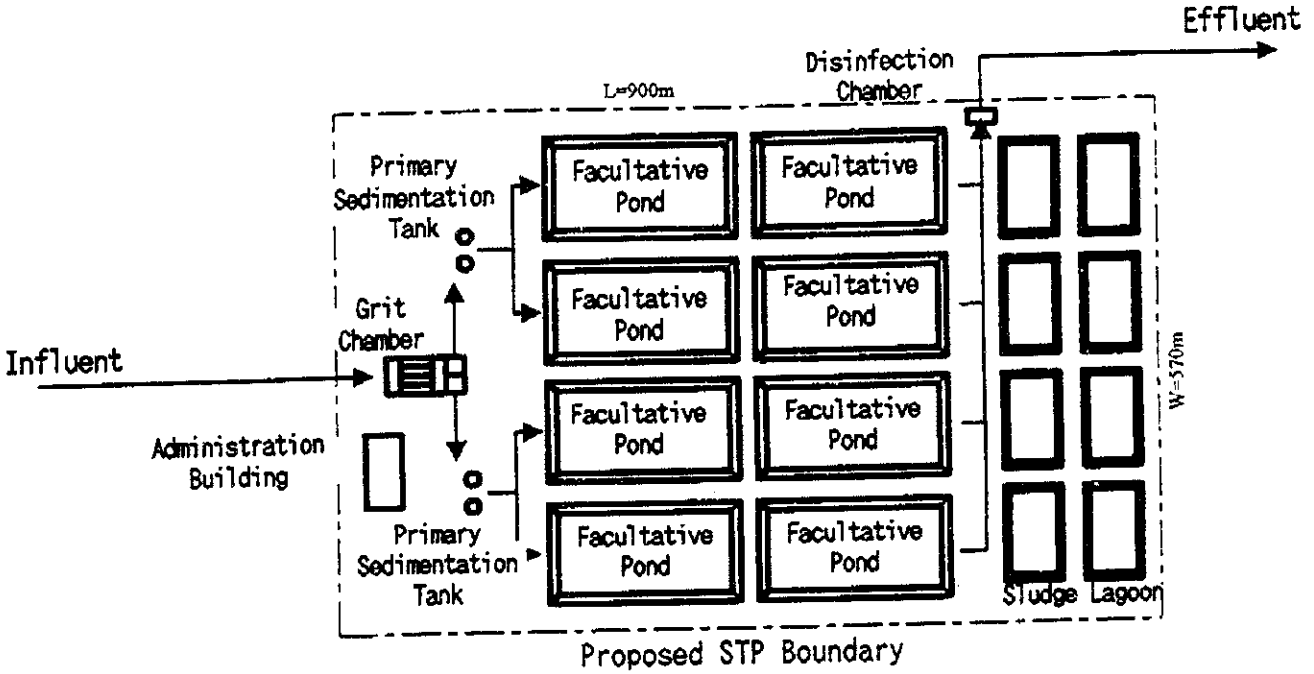


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Figure 5.9
Layout Plan of Tongi STP

The Study on the Sewerage System in North Dhaka

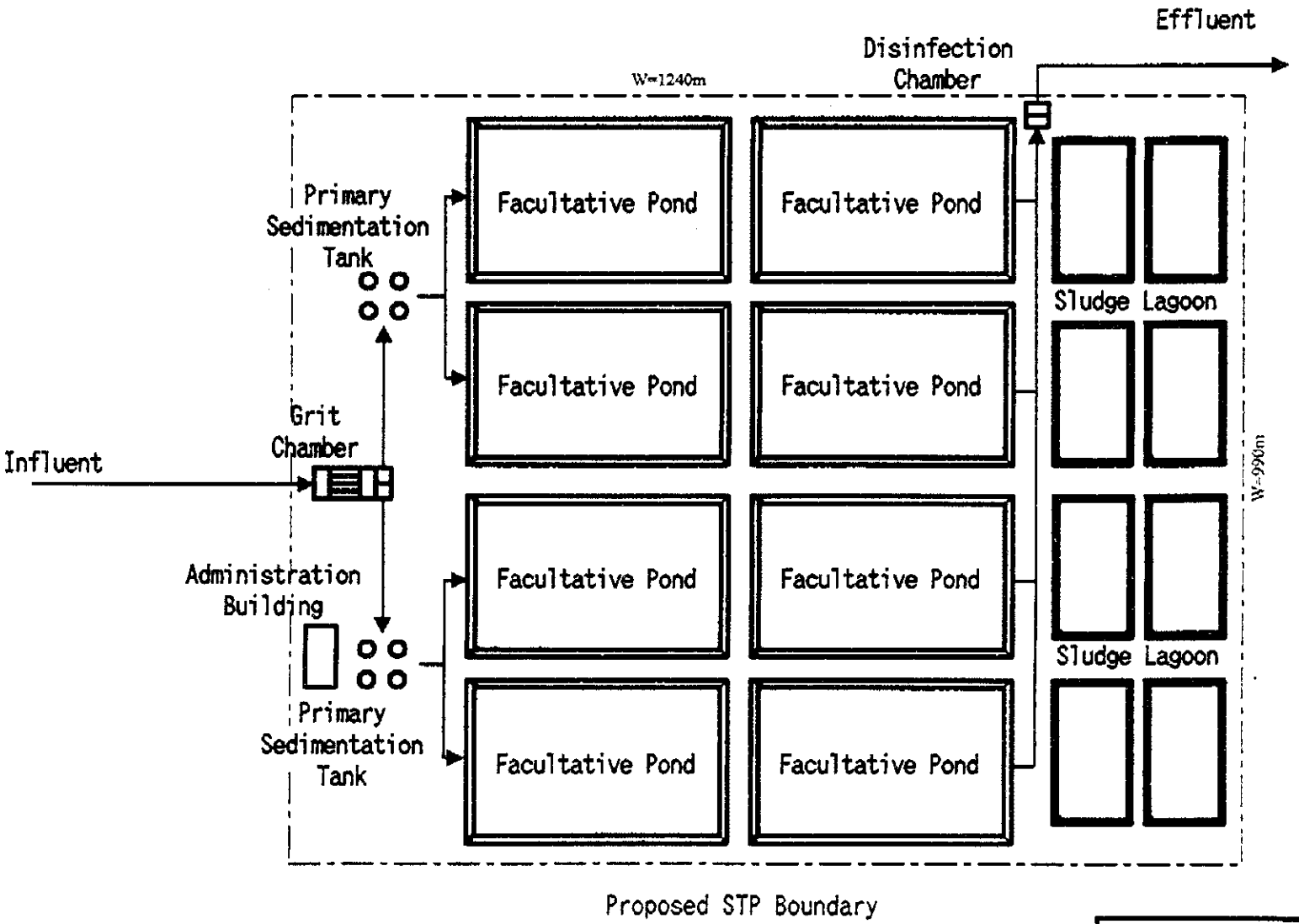

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Figure 5.10
Layout Plan of North Dhaka East STP

The Study on the Sewerage System in North Dhaka

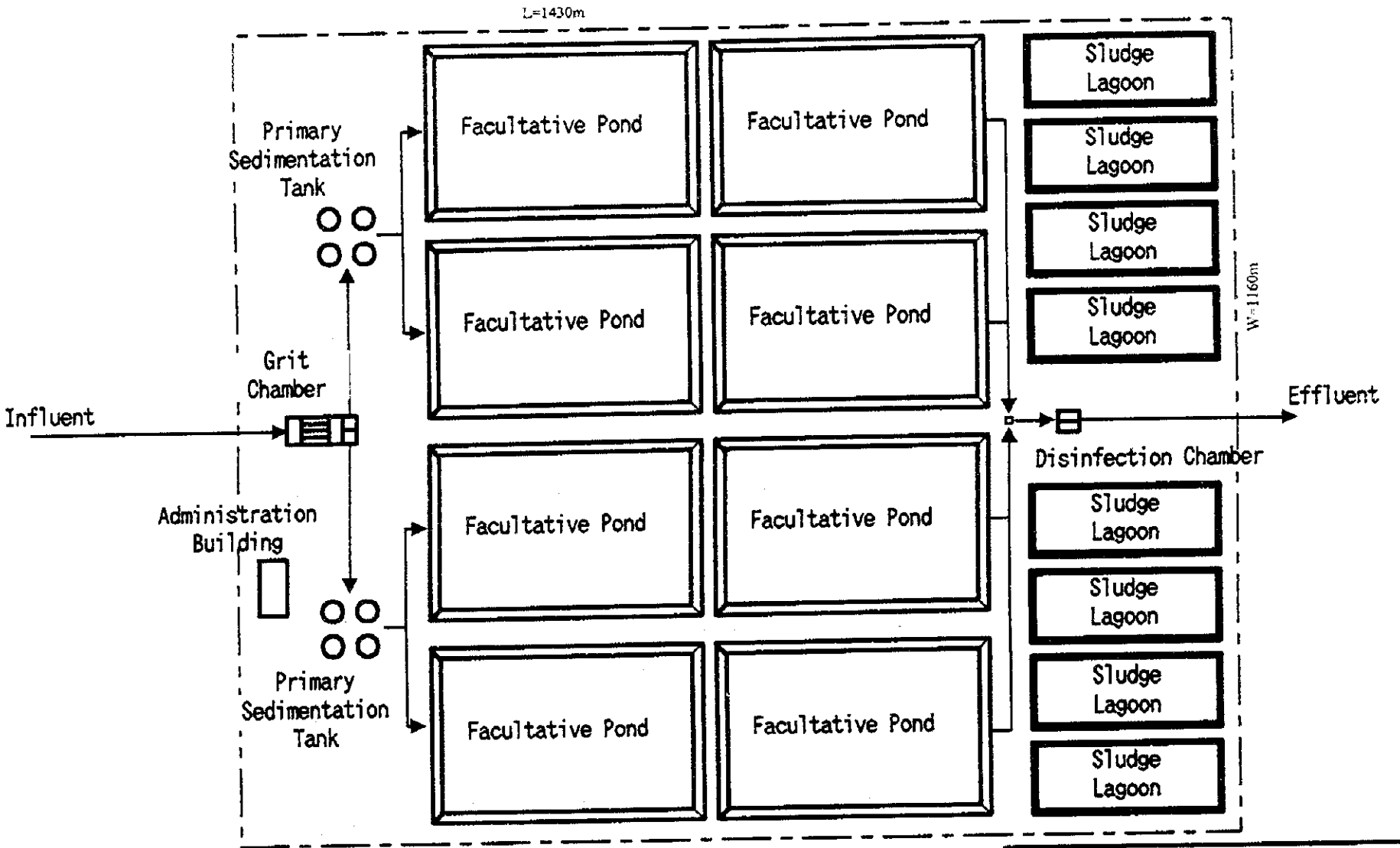


Figure 5.11
Layout Plan of North Dhaka West STP

The Study on the Sewerage System in North Dhaka

5.11 Pre-treatment Facility for Wastewater with High Pollution Load

As has been confirmed through field investigations on industrial wastewater, almost all of the factories within the Study Area do not have pre-treatment facilities and discharge untreated industrial wastewater directly into sewer lines or drainage channels.

Although this master plan has been prepared under the pre-condition that the public sewerage system will not accept industrial wastewater, acceptance of such wastewater into the public sewerage system may be required as a long-term arrangement in order to conserve the aquatic environment in the public water bodies. In this respect, the necessary measures have been studied and contained as a part of the master plan by referring to the existing legislative arrangement in Japan and technical information for the pre-treatment of industrial wastewater, taking into account the prevailing conditions in Bangladesh. Table 5.18 exhibits the required pre-treatment facilities for industrial wastewater commonly seen in the Study Area.

Table 5.18 Typical Pre-treatment Methods of Industrial Wastewater

Type of Industry	Wastewater Quality						Major Substances Removed	Treatment Method
	pH (-)	BOD (mg/l)	SS (mg/l)	COD (mg/l)	T-N (mg/l)	T-P (mg/l)		
Textile Dying	3~11	10~350	20~250	300	25	10		SASM Chemical Clarification Oil Separation
Synthetic Detergent	2~11	200~400	200~2500	150~2000	15~25	40~80	Phenol	Neutralisation Floatation
Pharmaceutical and Chemical Products	2~11	40~2000	70~600	--	80~100	10~20	Organic Solution	
Dry Battery	1~12	300~800	30~150	--	--	--	CN20~200 Cr40~150 Cu, Cd, Zn	Chemical Treatment Neutralisation
Poultry Farming	--	2000	3500	1450	600	100	Excreta	Drying Bed (Sunlight) Drying Bed (Heating) Composting
Food Processing	6~8	300~600	100~300	200~400	50~80	10~15	Soluble Protein, Oils	
Tanning	7~12	500~2000	400~3000	100~2000	250~350	10~20	Cu Sulphide	Recirculating Aeration Organic
Slaughter House	6.2~7.5	800~2000	1200~1600	--	--	--		
Large-scale Restaurant	--	10~900	20~800	--	--	--		Segregation
Matting Factory	1~2	--	30~150	10~200	--	--		Electrolysis

Note: -- indicates no data available; others are standard values

5.12 Operation and Maintenance Plan

5.12.1 Identification of Operation and Maintenance Activities

Upon review and evaluation of operation and maintenance practices being undertaken for the existing sewerage system in South Dhaka, the necessary work plan for operation and maintenance of the North Dhaka Sewerage System was developed according to the type of sewerage facilities as shown in Tables 5.19 to 5.22.

Table 5.19 Work Items by Type of O&M of Sewers

O&M Type	Work Item
Site Investigation	- Location, diameter, material of investigated sewers - Identification of location/cause of damaged/blocked sewers - Identification of location/cause of groundwater intrusion - Investigation of manhole overflow point and its cause - Measurement of the volume of sediments at the sewer bottom
Pipe Cleaning	- Removal of sediments
Rehabilitation	- Replacement/repair of damaged sewer

Table 5.20 Work Items of Lift Station by O&M Types

O&M Type	Work Item
Daily Work	- Manual operation of pump facility - Removal of screenings - Record the daily O&M activities and relevant data (pump operation time, receiving voltage, ampere, major breakdown, etc.) on Log Book - Report to MODS Zone Office in case of breakdown
Periodical Work	- Removal/cleaning of scum, sediments in pump pit in every 6 months - Overhaul of pump facility every 5 to 10 years

Table 5.21 Work Items of Sewage Treatment Plant by O&M Type

O&M Type	Work Item
Daily Work	- Measurement of inflow sewage volume - Removal of screenings - Inspection of mechanical/electrical facilities - Water quality analysis - Record of daily O&M activities
Periodical Work	- Removal of grit and sediments at grit chamber (monthly) - Removal of sludge at stabilization pond and sludge drying bed (annually) - Inspection/repair of mechanical/electrical facilities (annually) - Overhaul of mechanical/electrical facilities (every 5 to 10 years)

Table 5.22 Proposed items and Frequency for Water Quality Analysis

Items	Regulations	O&M
(Sewage)		
Air temperature		●
Water temperature	◎	●
Color		●
Odor		●
Transparency by cylinder test		●
PH		●
DO		●
BOD	◎	○
COD		●
SS	◎	●
Settable solids		●
Chloride		◇
Total solids		◇
Ignition Loss		◇
Volatile solids		◇
Dissolved solids		◇
Total nitrogen		◇
Ammonia (Free)		◇
Ammonia nitrogen		◇
Nitrate	◎	◇
Nitrite		◇
Organic nitrogen		◇
Phosphorus (total as P)	◎	◇
Coliform count	◎	●
Total colonies		●
(Sludge)		
Temperature		●
PH		◎
Moisture content		●
Hazardous substances		◇

Note: Examination frequency

● : More than once a day ○ : More than once a week

◎ : More than twice a week ◇ : As required

5.12.2 Organisational Set-up and Relevant Activities for Operation and Maintenance

Comments and recommendations for operation and maintenance stemmed from the North Dhaka Master Plan preparation are presented hereunder.

(1) Organisation and budget of MODS Zone Office

For efficient O&M activities, the organisation of the MODS Zone Office shall be separated in terms of the water supply and sewerage systems together with their budgets.

(2) Exclusive O&M team and O&M budget for STP and L/S

Exclusive O&M teams are indispensable for the proper operation of the sewerage system. They will be dispatched by the request from the MODS Zone Offices. A budget, vehicles and tools exclusively for O&M work shall be prepared also.

(3) New work shop

Although there is an existing workshop in Mirpur, they mainly repair vehicles. Thus, new a workshop shall be built for water supply and sewerage equipment such as pumps, motors, generators etc. The periodical rewiring of electric motors is an effective preventive maintenance procedure that will be facilitated by the new workshop. A new spare parts shop shall also be constructed to ensure efficient repair work. In related to these activities, a monthly audit report covering O&M shall be prepared.

(4) Waste collection system

In some parts of South Dhaka, waste is piled along the road and some is dumped into sewers from open manholes, causing pipe clogging. A waste collection system shall be set up in close co-operation with the DCC. Sanitation education for the end-users shall also be conducted.

(5) Collection and treatment of accumulated sludge of septic tank

Some parts of Study Area will be covered by on-site treatment facilities such as septic tanks. For efficient treatment, the settled sludge in the off-site facilities should be extracted and treated. Although collected sludge is dumped at a sludge-dumping site at present, considering its impact to the surrounding environment, the sludge shall be treated properly. A sludge treatment facility can be planned within the site for a new STP. The collection work will be covered by the O&M teams for sewer reticulation in the MODS Zone Office. Thus, the team should be equipped with the necessary collecting vehicles and tools.

(6) Data base on sewerage system

A computerised sewerage Data Base System shall be established. The data base shall include the following basic information:

1) Information on consumers

Address, phone number, name of the owner, number of family members, and diameter of connected sewer.

2) Information on sewer reticulation

Pipe ID number, diameter, length, material of sewer, year of completion, capacity, existing flow rate, and repair record.

3) Information on pumping stations and sewage treatment plant

Address, list of facilities and equipment, completion year, design criteria, incoming and effluent sewage rate; repair record.

4) O&M activity record

Date, work contents, and cost.

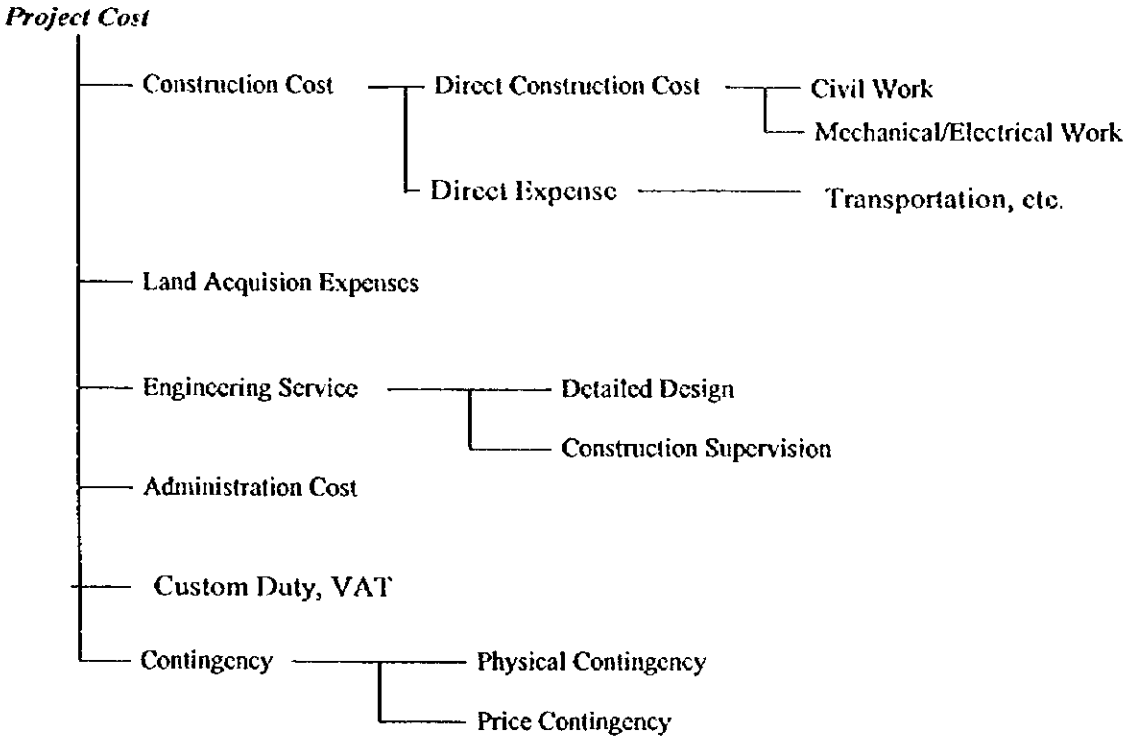
CHAPTER 6 PROJECT COST AND IMPLEMENTATION SCHEDULE

6.1 Project Cost

6.1.1 Composition of Project Cost

(1) Cost composition

Project cost was estimated based on the following cost composition:



It shall be noted that the accuracy and purpose of the project cost estimate at this master planning stage will be limited to grasp the magnitude of the capital investment requirements and to determine the most optimum system from alternative plans for provision of the sewerage system in North Dhaka.

6.1.2 Availability of Materials and Equipment

The unit cost of construction materials and equipment was obtained from local suppliers. This information included the availability of materials/equipment in the local market as well as the countries of origin for commonly imported materials/equipment.

Imported materials, which are not available as indigenous materials, such as structural steel and mechanical/electrical equipment were verified. The type of materials, their availability from neighboring countries together with unit cost and ocean freight was also investigated.

The results of the market survey on the required construction materials/equipment are shown in Table 6.1.

Table 6.1 Procurement Plan for Construction Materials/Equipment

Items	Procured in Bangladesh	Procured to be Imported from Third Country	Name of Third Country
Construction Materials	Crushed Stone, Gravel, Sand, Cement, Reinforcing Bar, Form-board, Scaffolding, Soil for Banking, Reinforced Concrete Pipe, Polyvinyl Chloride Pipe	Sheet Pile, Steel Pipe	India (Calcutta)
Construction Machinery	None	Bulldozer, Back-hoe, Clam-shell, Hydraulic Pile Driver, Wheel-crane	Japan
Sewage Treatment Equipment	None	Gate, Screen, Sewage Pump, Sludge Collector, Sludge Pump, Chlorine In-jection Facilities	Japan

6.1.3 Unit Cost

A cost estimate for the sewerage system was prepared for the sewer, pumping station and sewage treatment plant categories, respectively. The unit cost was prepared as a composite cost covering labour, materials and equipment, or cost function formula.

(1) Sewer

The sewer installation cost estimation was divided into, (1) trunk sewer with diameter above 500 mm, (2) lateral sewer with diameter below 500 mm. The unit construction cost was prepared by diameter, earth coverage and pipe materials, based on the quantity calculation on standard pipe

installation diagram.

(2) Pumping Station and Sewage Treatment Plant

For the cost estimate of the sewage pumping station and the sewage treatment plant, cost estimate formulas were prepared based on the construction cost, required construction site area and O&M cost, including electricity, for each facility with capacity of 20,000, 50,000 and 100,000 cu.m/day. These cost estimate formulas are shown in Table 6.2.

Table 6.2 Cost estimation Formula for Sewage Pumping Station and Sewage Treatment Plant

Unit Cost	Unit	Pumping Station	Sewage Treatment Plant
Area Requirement	-	$y = 6.7699X^{0.3444}$ sq.m	$y = 0.0126X^{0.7856}$ ha
Construction Cost	TK'000	$y = 239.32X^{0.6164}$	$y = 238.18X^{0.7659}$
O & M Cost	TK'000/year	$y = 0.2733X^{0.8515}$	$y = 1.1034X^{0.5269}$

Note: 1) Pumping station: X = Design Maximum Hourly Flow Rate (qu.m/day)
2) Sewage treatment plant: X = Design Daily Average Flow Rate (qu m/day)

6.1.4 Project Cost

(1) Construction cost

The construction cost was estimated as shown in Table 6.3, in accordance with the aforementioned procedure. Relevant costs, which could not be quantified at master plan stage, were estimated in application of certain cost percentage as described below.

1) Direct expense (a) : Direct Construction Cost x 20%
2) Engineering Service (b) : (Direct Construction Cost + (a)) x 3%
3) Administration Cost (c) : (Direct Construction Cost + (a) + (b)) x 5%
4) Physical Contingency : (Direct Construction Cost + (a) + (b) + (c) + Land Acquisition Cost) x 10%

Table 6.3 Project Cost of Sewerage System

Unit: Tk'000 and US$'000

Facilities	Tongi	Uttara	North Dhaka East	North Dhaka West	Total
1. Construction Cost					
Branch Sewer	426,764	415,716	843,306	949,520	2,635,306
Trunk Main	141,357	149,553	539,120	519,893	1,349,923
Pumping Station	294,520	81,493	898,318	1,171,420	2,445,751
Sewage Treatment Plant	646,157	0	1,663,590	2,340,602	4,650,349
Sub-total	1,508,798	646,762	3,944,334	4,981,435	11,081,329
Sub-total (including overhead)	1,810,558	776,114	4,733,201	5,977,722	13,297,595
2. Land Acquisition					
Land Cost for PS	3,030	1,320	30,325	6,905	41,580
Land Cost for STP	733,740	0	1,440,780	2,391,110	4,565,630
Sub-total	736,770	1,320	1,471,105	2,398,015	4,607,210
3. Engineering Service	54,317	23,283	141,996	179,332	398,928
4. Administration Cost	93,244	39,970	243,760	307,853	684,827
Total (1+2+3+4)	2,694,889	840,687	6,590,062	8,862,922	18,988,560
5. Physical Contingency	269,489	84,069	659,006	886,292	1,898,856
Grand Total	2,964,378 (US$67,785)	924,756 (US$21,145)	7,249,068 (US$165,761)	9,749,214 (US$222,930)	20,887,416 (US$477,623)

Note: Foreign exchange rate US$1.00 = 43.73 TK as of July 1997.
The above cost excludes price contingency.

(2) Operation and maintenance cost

The operation and maintenance cost was estimated in accordance with the aforementioned daily work activities and manpower requirement of sewerage facilities as shown in Table 6.4.

Table 6.4 Operation and Maintenance Cost of Sewerage System

Unit: Tk'000/year and US$'000/year

Sewerage Facility	Tongi	Uttara	North Dhaka East	North Dhaka West	Total
Power Consumption					
Pumping Station	3,965	861	14,645	21,770	41,241
Sewage Treatment Plant	254	0	487	616	1,357
Personnel Expense	922	127	1,462	1,844	4,355
Total	5,141 (US$117)	988 (US$22)	16,594 (US$379)	24,230 (US$554)	46,953 (US$1,073)

Note: Foreign exchange rate US$1.00 = 43.73 TK as of July 1997.

6.2 Implementation Plan

The principles of the preparation of a sewerage master plan with target year of 2020 are as follows:

- Project implementation will begin in the year of 2000 and will be completed in 2020, the target year of the master plan. The first year (2000) will be allocated to project preparation, survey and design. Construction will start in 2001.
- Sewerage development shall be implemented in the priority order of North Dhaka East, North Dhaka West and the Tongi service areas.
- Sewerage development in the sewerage zone will also be implemented in the priority order, from the Core Area followed by the Transitional Area.
- Project cost will be estimated based on the prices of July, 1997, when the sewerage master plan was prepared.
- Project implementation plans in each sewerage zone were established based on the required construction period. Their annual costs were calculated by dividing the total project cost for the collection system (6,430,980,000 Tk) comprised of trunk main, branch sewer and pumping station, by the project implementation period (20 years):

  6,430,980,000 Tk ÷ 20 years = 321,549,000 Tk/year

The project cost for each sewerage zone has already been calculated, so the required construction period can be estimated by the said project cost and the annual cost.

- The construction period for sewage treatment plant was assumed as two years for both North Dhaka East and West, while the time anticipated for Tongi, which is smaller than the other two, was one year.
- The price contingency was calculated assuming that price escalation ratio will be equivalent to the present ratio, 5%.

CHAPTER 7 INSTITUTIONAL ASPECTS

7.1 Sector Institutions Involved in Sanitation/Sewerage Provision

7.1.1 Central-Level Institutions

(1) **Ministry of Planning (MP)** – Planning Commission – responsible for formulating and monitoring Five-Year Development Plans.

(2) **Ministry of Finance (MOF)** – External Relations Department – assesses foreign exchange requirements; liaises with external support agencies and negotiates for grant and loan financing facilities for priority projects. Reviews use of external assistance funds.

(3) **Ministry for Local Government, Rural Development and Co-operatives (MLGRDC)** – has overall responsibility for provision of water supply and sanitation activities except for waterborne sewage. Its **Department of Public Health Engineering (DPHE)** has responsibility for water supply and sanitation in small towns and rural areas. In Dhaka and Chittagong, **Water Supply and Sewerage Authorities (WASAs)** have some autonomy but are still under the ministry.

(4) **Ministry of Housing and Public Works – Rajdhani Unnayan Kartripakkha (RAJUK)** reviews major urban development and building plans and issues permits to ensure compliance. Authored Dhaka Metropolitan Development Plan for 1995-2015.

(5) Other Ministries – **Ministry of Land**: for resettlement policies and issues; **Ministry of the Establishment**: carrying out resettlement; **Ministry of Water Resources**: overall water resources management and water quality monitoring; **Ministry of Health and Family Welfare**: responsible for ensuring access to environmental sanitation and public health issues; **Ministry of Environment and Forests**: responsible for setting and enforcing effluent standards.

7.1.2 City-Level Institutions

(1) **Dhaka City Corporation (DCC)** – responsible for planning and general administration of Dhaka. Headed by mayor. Handles onsite sanitation and disposal services; solid waste management.

(2) **Dhaka Water Supply and Sewerage Authority (DWASA)** – responsible for piped water supply and sewerage services in the city.

7.2. Key Legislation ad Sector Policy Statements

(1) Town Planning Act, 1953 – forms the basis of the first master plan in 1959.

(2) Building Construction Act, 1952 – and Building Construction Rules, 1984. Seeks to prevent haphazard construction of buildings and other developments.

(3) Dhaka City Corporation Act, 1983 – created the city corporation and vested it with powers to administer the day-to-day activities of public services in Dhaka.

(4) Water Supply and Sewerage Authority Ordinance, 1963 – authorised the establishment of water supply and sewerage authorities (WASAs) by local governments.

(5) Others

- National Environmental Management Acton Plan (NEMAP)
- Environmental Conservation Act, 1995
- National Conservation Strategy, 1995
- Environmental Protection Act, 1995
- Environmental Pollution Control Act, 1977
- Factory Act, 1965
- Fish Act, 1950

7.3 Dhaka Water Supply and Sewerage Authority (DWASA)

7.3.1 Organisational Structure

DWASA is governed by a seven-man board; the chairman is appointed by the MLGRDC. A Managing Director handles the day-to-day operations the utility assisted by three Deputy Managing Directors. DWASA itself is divided into four departments: Technical, Administrative, Financial and Planning and Development.

Technical Services is responsible for day-to-day operations, maintenance and repair of the water and wastewater system. It is divided into six Maintenance, Operations and Distribution Service (MODS) zones.

7.3.2 Staffing and Human Resources

(1) DWASA employs some 3,264 people and has a staffing ratio of 24 employees per 1,000 connections (a high number). The cost for salaries and wages is around Tk 13,000,000 (approximately US$ 295,454) per year. The staff breakdown is as follows:

Technical Service	1,943
Administrative Service	55
Financial Service	698
Planning and Development Service	568
Total	3,264

(2) The promotion and organisation of training within DWASA is the responsibility of the DWASA Training Institute. The current training courses emphasise water-related issues and the institute does not have the capacity to launch any sewage-related courses due to shortages in staff and other resources. There are only two professional staff members as most lecturers are part-time (from DWASA). The current budget for the institute is Tk 400,000. The available training programs are shown below.

Types Of Training Program
Urban Policy Series (6 modules) • Economics • Municipal Finance and Financing Options • Institutional Arrangements • Technology Options Overview • Urban Regulatory Policies and Enforcement • Environmental Management
Master Planning Series (3 modules) • Review of Urban Development Plans • Development Concepts and Techniques • Data Collection, System Mapping and Assessment Methods
Project Management & Development Series (6 modules) • Prefeasibility/Feasibility Studies • Detailed Design and Costing • Technical Specifications • Preparation of Bidding and Tendering Documents • Procurement Guidelines • Construction Supervision and Monitoring
Social Marketing Series (3 modules) • Research Methods • Health and Hygiene Education Planning • Willingness-to-Pay Surveys
Special Skills Development Series • Computer Training (Word Processing, Data Base, Spreadsheets, Modelling, Project Management, Financial Management)
Utility Management Series (7 modules) • Financial Management and Control • Corporate Planning • Customer Relations • Management Information Systems • Human Resources Development • Sewerage Tariff Setting • Billing and Collection Strategies
Sewerage Operations Series (11 modules) • Sewer Maintenance • Maintenance of Equipment and Appurtenances • Sewage Pumping Stations • Sludge Management • Wastewater Quality Monitoring & Wastewater Effluent Standards • Laboratory Methods • Wastewater Treatment Technology (Biological Treatment) • Industrial Wastewater Management • Sewer/Drains Cleaning and Rehabilitation

CHAPTER 8 FINANCIAL ASPECTS

8.1 Past and Current Financial Conditions

8.1.1 Past Financial Conditions

DWASA's past financial conditions were characterised by a lack of commercialisation, governmental interference and organisational inefficiency. DWASA's manual accounting/record-keeping practices and problems with graft/corruption added to the difficulties.

8.1.2 Current Financial Situation

Despite the ongoing efforts of DWASA, a number of problems remain; a number of these are outlined below.

(1) Inefficient operations

DWASA's ratio of employees per 1,000 connections is 24. This is a high number. For comparison, Delhi (India) has 8.9 and Karachi (Pakistan) has 11.7. Moreover, DWASA only provides water supply service to 50% of the population and sewerage service to 15%.

(2) Unaccounted-for-water (UFW)

The April 1997 Management Information Report (MIR) of DWASA shows that water production amounted to an extremely high 4.6 cu.m/day/connection, indicating a large number of illegal connections. Also, the total number of connections does not tally with the total number of accounts. However, DWASA has embarked on a program for leak detection and a crash meter installation program in an effort to reduce its UFW. As part of the performance agreement between DWASA and the Government of Bangladesh, the target level for UFW is to be a maximum of 39% by December 1998.

(3) Low Collection Ratios

DWASA's collection efficiency, while officially around 78% (June 30, 1996 to June 30, 1997) the actual collection rate is much less. This is due to a number of reasons, including the inefficient nature of the billing system, corruption and other issues.

(4) Accounting System

DWASA uses a double-entry accrual-based commercial accounting system that is primarily a manual operation that makes little/inefficient use of computerisation. Moreover, it only prepares statements once a year and these statements are not trustworthy. However DWASA has begun an improvement program to rectify a wide range of problems with its accounting system.

8.1.3 Improvement Programs

As part of the World Bank's DWASA-IV program, a number of improvement programs have been started. These programs include the following:

(1) Crash Metering Program

This will increase the number of metered connections and hopes to improve the efficiency of DWASA in terms of billing efficiency and water production/distribution.

(2) Leak Detection and Loss Reduction Program

This program will prepare and implement a comprehensive reform of the DWASA Leak Detection Division. Goal is to reduce UFW by 12%.

(3) Management and Operation Support Training Program (Twinning)

This is a partnership between Thames Water International Consultancy Ltd. and Sir William Halcrow & Partners and DWASA. Its key objectives are 1) build operational capacity, 2) develop commercial practices, 3) provide support in day-to-day activities.

(4) Performance Agreement between DWASA and the Government of Bangladesh

This covenant establishes a number of numerical targets within a set time period. Among these targets are: achieving a meter coverage of 95%, reduce UFW to 39%, and enhance staff productivity level to about 17 staff per 1,000 connections.

8.2 Balance Sheet and Assets

The key points for the DWASA assets are as follows:

- Over the 1992-1996 period, DWASA had an overall earnings loss of Tk -43,310,000
- Income increased significantly between 1992 and 1995, but so did expenses and interest payments as DWASA didn't make payments on its loans. The impact was felt in 1996.
- Funding was dispersed for various projects without regard for the actual work schedule, allowing DWASA to carry forward large cash balances.

The DWASA assets for 1992 to 1996 are shown below in Table 8.1 and the income statement is in Table 8.2. The revenue/expenditures of DWASA are in Table 8.3.

Table 8.1 DWASA Assets

(Tk '000)

	1992	1993	1994	1995	1996
Fixed Assets	3,605,428	3,871,815	4,531,619	4,534,524	4,653,054
Depreciation	1,159,665	1,243,169	1,356,980	1,473,129	1,591,339
Net Fixed Assets	2,445,763	2,628,646	3,174,639	3,061,395	3,061,715
Intangible Assets	2,384,916	3,024,518	3,058,498	3,064,024	3,082,158
Works In Progress	64,133	434,479	786,674	1,184,663	2,218,180
Deferred Expenses	283,813	304,271	292,172	280,380	427,809
Investments	-	-	-	-	-
TOTAL LONG-TERM ASSETS	5,178,625	6,391,914	7,311,983	7,590,462	8,789,862
CURRENT ASSETS					
Accounts Receivable	278,414	379,643	582,463	678,968	824,392
Stores and Inventories	424,604	225,043	246,436	301,253	218,081
Advances for Materials	136,570	152,501	150,216	179,877	26,035
Other Current Assets	30,787	46,893	62,441	78,293	89,241
Cash Balance	974,968	932,165	743,787	776,300	785,202
Total Current Assets	1,845,343	1,736,245	1,785,343	2,014,691	1,942,951
TOTAL ASSETS	7,023,968	8,128,159	9,097,326	9,605,153	10,732,813

Table 8.2 Income Statement

(Tk '000)

	1992	1993	1994	1995	1996
WATER					
Actual Production (ML)	219,363	245,985	260,174	275,326	292,920
Water Billed (ML)	96,624	115,110	133,892	152,563	161,106
System Loss (ML)	122,739	130,875	126,282	122,763	131,814
UFW	56.0%	53.2%	48.5%	44.6%	45.0%
REVENUE (x 1,000)					
Water Revenue	310,343	395,329	528,872	558,403	537,050
Sewerage Revenue	153,061	222,256	263,557	252,060	251,942
Water Connection	7,621	12,701	9,576	9,304	8,365
Sewer Connection	612	723	549	787	808
Street Hydrant	-	-	-	2,968	23,813
Direct Water Sales	641	1,156	1,423	1,273	1,064
Meter Sales	6,752	16,102	3,816	14,527	12,652
TOTAL OPERATING REVENUE	479,030	648,267	807,793	839,322	835,694
DIRECT EXPENSES (x 1,000)					
Power	195,114	250,672	298,668	258,592	287,262
Chemicals	10,416	11,944	14,228	17,376	9,855
Repair and Maintenance	31,262	25,981	30,298	75,707	36,553
Direct Salaries and Wages	44,016	48,111	72,540	67,057	78,015
Other Expenses	50,059	58,646	76,118	72,993	93,234
Total Direct Expenses	330,867	395,354	491,852	491,725	504,919
ADMINISTRATION EXPENSES					
Salaries	32,297	49,214	70,987	66,198	80,717
Other Expenses	11,174	14,780	12,763	17,598	19,439
Insurance	95	96	126	128	501
Provision for Doubtful Debt	23,170	30,879	79,243	81,046	78,899
Total Administration Expenses	66,736	94,969	163,119	164,970	179,556
Total Working Expenses	397,603	490,323	654,971	656,695	684,475
Income Before Depreciation	81,427	157,944	152,822	182,627	151,219
Depreciation	115,701	115,701	117,984	127,936	134,876
Operating Profit	(34,274)	42,243	34,838	54,691	16,343
Add Other Income	74,464	78,305	74,390	53,254	61,304
Income Before Interest	40,190	120,548	109,228	107,945	77,647
Interest	35,706	107,794	108,015	128,087	119,266
Net Profit	4,484	12,754	1,213	(20,142)	(41,619)
Payment to the Exchequer	-	-	1,000	1,000	1,000
Net Earnings	4,484	12,754	213	(21,142)	(42,619)

The most current information from DWASA (MIR of April, 1997), which hasn't been audited (note: there are often difference between the normal account books, the audited books, and the MIRs; the audited books take precedence in this Study), shows that DWASA's revenues and expenses are as follows:

Table 8.3 MIR Report on DWASA Revenue Expenditure

Unit: Tk x 1,000

Revenue Income	**1995-1996**	**% of Total**	**1996-1997**	**% of Total**
Water & sewer rates	457,368	89.86	578,890	92.43
Service Conn. Fee	17,597	3.46	13,787	2.20
Meter sales	14,670	2.88	13,198	2.11
Rent	8,845	1.74	3,239	0.52
Miscellaneous	3,225	0.63	3,105	0.50
DTW License/Royalty	6,505	1.28	12,623	2.02
Water sales (direct)	743	0.15	1,432	0.23
TOTAL	508,953	100	626,274	100
Revenue Expditures	**1995-1996**	**% of Total**	**1996-1997**	**% of Total**
Power	239,771	46.40	262,667	47.95
Chemical	4,248	0.82	17,790	3.25
Maintenance	33,679	6.52	35,615	6.50
Salaries & wages	129,858	25.13	129,976	23.73
Overtime	35,161	6.80	36,251	6.62
Others	43,425	8.40	45,131	8.24
Purchase of stores	30,595	5.92	20,374	3.72
TOTAL	516,737	100	547,804	100
Depreciation	0		0	
IDA Loan Interest	50,000		100,000	
Bad Debt	0		0	
Total Expenditure	566,737		647,804	
BALANCE	**(57,784)**		**(21,530)**	

8.3 Tariff Rate

The current tariffs set by DWASA on April 27, 1997 to be effective starting from June 30, 1997. The new water and sewerage tariff rates are significant but more so is the approval of Act No. 6 of 1996 which allows DWASA to raise its tariffs by 5% without approval from the Board of Secretaries of the Government of Bangladesh.

Table 8.4 Current DWASA Tariff Schedule

Holding Category	Without Meter	With Meter	
		1,000 Gallons (Tk)	1,000 Liters (Tk)
Residential Bldg. & Comm. Centers	Annual Value Assessment (23.77% yearly)	16.55	3.67
Office, Industries & Comm. Bldg.	Annual Value Assessment (23.77% yearly)	54.09	11.92
Bldg. Under Construction (w/o meter)	a) ¾" pipeline per connection per month	Residential (Tk)	Commercial (Tk)
	b) 1"- as above-	797.43	2,392.28
	c) ½"- as above-	1,594.85	4,784.55
	d) 2" - as above-	3,322.60	9,967.81
Minimum monthly charge per connection (with & without meter) is Tk 19.00			
Holdings having both water & sewer lines shall pay for sewer at the same amount of water charges. Holdings having only sewer connection shall pay 23.77% annual valuation assessment of holding.			
Holdings that are not connected to the sewer but are situated w/in 100 feet of DWASA's regular sewage line must pay 8.56% annual valuation assessment tax.			

Source: DWASA

8.4 Financial Analysis

8.4.1 Cash Flow

The base cash flow for DWASA was estimated using the existing balance sheets of DWASA and a number of assumptions regarding the future income/expenses. These assumptions included the following:

(2) Cost Escalation

It was estimated that the costs for various expenditures would escalate over time. For example, O&M costs were projected to increase by 15% annually until the year 2006 whereupon they were assumed to increase at an annual rate of 7%. The annual increase in salaries and wages was set at 15% until the year 2006 whereupon it is assumed to drop to 7% per annum.

(3) Land Cost

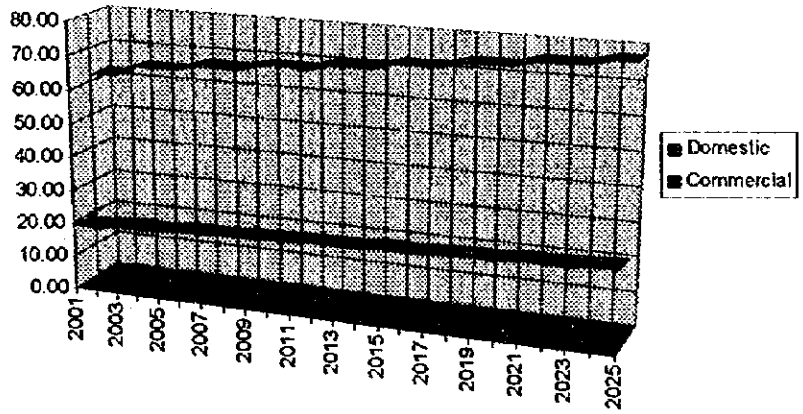
In order to ensure that adequate land would be available for the future needs of the project (and DWASA), it was assumed that the land acquisition would take place early in the project.

(4) Expansion of Water Supply Capacity

It was assumed that the water supply available to DWASA would increase over time as the Saidabad WTP comes on-line and the efficiency of DWASA increases.

(5) Water Tariff

The domestic tariff in the year 2001 was set at 18.98 Taka per 1,000 gallons and climbs gradually to 23.69 Taka per 1,000 gallons in 2025. A summary of these assumptions is shown in the graph below.



8.4.2 FIRR

The costs of the project and the debt service requirements of the project were estimated covering a variety of interest rates as shown below in Table 8.5. In addition, a series of alternative scenarios were analysed to determine the impact of various conditions on the FIRR. This sensitivity analysis is shown in Table 8.6.

Table 8.5 Loan Repayment/FIRR of Alternative Loan Interest Rates

Loan Amount:	15,035,991				
Interest Rate:	10%	8%	6%	4%	2%
Annual Debt Service	1,255,389	1,041,981	870,109	711,999	569,720
FIRR (base)	-0.72%	3.17%	7.08%	11.37%	16.52%

Note: costs in Tk ('000)

TABLE 8.6 SENSITIVITY ANALYSIS FOR RECOMMENDED PROJECT

Base Scenario

YEAR	BALANCE	NPV
2001	-538,418	-525,286
2002	-860,998	-839,998
2003	-901,673	-879,681
2004	-808,438	-788,720
2005	-728,152	-710,392
2006	296,307	289,080
2007	-437,354	-426,687
2008	-875,507	-854,153
2009	-627,825	-612,512
2010	-413,760	-403,668
2011	-549,915	-536,502
2012	78,756	76,835
2013	306,296	298,825
2014	1,015,951	991,172
2015	1,643,537	1,603,451
2016	876,912	855,524
2017	1,217,216	1,187,528
2018	1,116,129	1,088,906
2019	723,017	705,383
2020	495,078	483,003
2021	1,717,703	1,675,807
2022	1,336,282	1,303,690
2023	927,591	904,967
2024	690,190	673,356
2025	220,956	215,567
	FIRR =	5.10%

Sensitivity 1: 20% Increase in O&M Costs

YEAR	BALANCE	NPV
2001	-538,418	-525,286
2002	-862,096	-841,070
2003	-904,047	-881,997
2004	-812,285	-792,474
2005	-733,696	-715,801
2006	288,817	281,773
2007	-447,069	-436,165
2008	-887,757	-866,105
2009	-642,958	-627,276
2010	-432,163	-421,623
2011	-572,019	-558,067
2012	52,472	51,192
2013	275,298	268,584
2014	979,648	955,754
2015	1,592,614	1,553,770
2016	818,689	798,721
2017	1,150,840	1,122,771
2018	1,040,657	1,015,275
2019	637,405	621,859
2020	398,172	388,461
2021	1,608,229	1,569,004
2022	1,212,831	1,183,250
2023	788,608	769,374
2024	533,958	520,934
2025	45,579	44,467
	FIRR =	4.22%

Sensitivity 2: Lower Tariff Collection Rate

YEAR	BALANCE	NPV
2001	-674,172	-657,729
2002	-996,753	-972,442
2003	-1,044,216	-1,018,747
2004	-950,980	-927,786
2005	-870,694	-849,458
2006	150,201	146,538
2007	-583,460	-569,229
2008	-1,021,613	-996,695
2009	-777,583	-758,618
2010	-563,519	-549,774
2011	-699,673	-682,608
2012	-74,747	-72,924
2013	152,793	149,067
2014	862,449	841,413
2015	1,477,542	1,441,504
2016	818,689	798,721
2017	1,150,840	1,122,771
2018	1,040,657	1,015,275
2019	637,405	621,859
2020	398,172	388,461
2021	1,608,229	1,569,004
2022	1,212,831	1,183,250
2023	788,608	769,374
2024	533,958	520,934
2025	45,579	44,467
	FIRR =	2.19%

Sensitivity 3: Land Costs +50%

YEAR	BALANCE	NPV
2001	-538,418	-525,286
2002	-1,041,096	-1,015,703
2003	-1,081,771	-1,055,336
2004	-808,438	-788,720
2005	-728,152	-710,392
2006	296,307	289,080
2007	-736,243	-718,286
2008	-1,174,396	-1,145,752
2009	-627,825	-612,512
2010	-413,760	-403,668
2011	-910,110	-887,912
2012	78,756	76,835
2013	306,296	298,825
2014	1,015,951	991,172
2015	1,634,882	1,595,007
2016	269,874	263,291
2017	1,207,307	1,177,860
2018	1,105,526	1,078,562
2019	528,237	515,353
2020	299,504	292,199
2021	1,704,713	1,663,135
2022	1,322,383	1,290,130
2023	912,720	890,459
2024	674,278	657,832
2025	203,930	198,956
	FIRR =	2.92%

Note: a discount rate of 2.5% is applied due to the public service nature of the project

8.5 Economic Evaluation

8.5.1 Economic Benefits

The value of the project will be viewed in terms of economics as well as purely financial terms. A sewerage project provides the community with a wide range of economic benefits that, while sometimes not readily apparent to the average citizen, are nonetheless significant in terms of health, sanitation and overall living conditions. A number of these benefits are outlined below.

(1) Health Benefits

- Public Health - The health benefits that accrue to the community from the sewerage system have two aspects. Namely, 1) the preventive effect brought about by the sewerage system reduces the burden on the local and central governments concerned with disease prevention and patient treatment activities, and 2) the reduction of opportunities of contact with infected matters reduces the incidence of diseases on the part of the individual.
- Individual Health - The provision of the proposed sewerage system will result in health benefits to individuals in the service area, such as the reduction in the risk and incidence of water-borne diseases, the consequent elongation of people's life spans, reduced expenditure on medical care, reduction in income loss because of absence from work, and others.

(2) Environmental Benefits

The project will contribute to an improvement in the environmental conditions in the area by improving the water quality of the surrounding water bodies. These effects, while immeasurable, will cover a wide variety of environmental benefits; perhaps the most marked benefit will be aesthetic.

(3) Local Economic Benefits

The local economic benefits will be both long-term and short-term. The project will provide an economic boost to the area as workers will be employed to build and maintain the system and the local economy will reap some reward. Also, there land values as well as the intensity of the land use of the area can be expected to increase as a result of the project.

8.5.2 Public Revenue Benefits

Public tax revenue to the local and central governments will be increased in two ways. First, the appreciation in land values will produce an increase in tax revenues. Second, commercial, residential, and other buildings will increase in number and improve in quality; thus, property taxes will increase. This benefit cannot be readily quantified, but it constitutes an important and reliable tax source for the governments concerned.

8.5.3 Economic Analysis

The economic analysis should, ideally, be a comparison of the benefits and costs of a project. However, in sewerage project a major problem occurs in that a majority of the benefits of the project cannot be quantified with any degree of validity. In Dhaka, this situation was further compounded by the lack of reliable data regarding health care costs, land values, etc. Therefore, the overall economic benefits of the project must be taken prima facie and the project should be viewed as economically desirable.

CHAPTER 9 SELECTION OF PRIORITY PROJECT

9.1 Selection Criteria of Priority Project

The feasibility study on the priority project commenced from the Stage 2 Field Work to with the technical feasibility and financial/economic viability. In view of the urgency and importance of the priority project, the target year was set forth in 2005. This coincides with the medium-term target year of the DMDP.

The selection criteria of the priority project were prepared from the viewpoints of two key features; technical suitability and socioeconomic suitability as shown below, in due consideration of the above mentioned nature of the project.

(1) Technical suitability

1) The target area shall be fully served by DWASA's existing water supply system.
2) The target area shall have a well organized road network to allow for installation of the sewer network.
3) The target area shall have a reasonable population density to attain cost effectiveness.

(2) Socio-economic suitability

The priority project shall have high potential for:

1) realization of investment effects in the shortest time possible.
2) cost recovery of capital investment and O&M cost as demonstrated by prospective beneficiaries in terms of willingness-to-pay and affordability-to-pay for the sewerage services.
3) financial affordability of prospective beneficiaries to shoulder the cost to connect with the sewer network.
4) sufficient level of motivation to participate in the project.

Project implementation will require preparatory work, such as the institutional strengthening of DWASA, funding arrangements for capital investment, legislative arrangements to provide a clear-cut the cost recovery policies, etc. The target area shall fulfill the above-mentioned selection criteria and allow for the successful achievement of the project objectives. Needless to say, the target area will be chosen from the core areas of the master plan output.

9.2 Selection of Priority Project(s)

(1) Candidate area

The candidate areas (core area of each sewerage zone) in the master plan are as follows:

- Tongi
- Uttara
- North Dhaka East (Badda, Banani, Baridhara & Gulshan)
- North Dhaka West (Mirpur & Mohammadpur)

(2) Comparison of candidate areas

The candidate areas were evaluated based on the selection criteria as shown in Table 9.1.

Table 9.1 Comparative Evaluation of Candidate Areas

Selection Criteria	Tongi	Uttara	North Dhaka East	North Dhaka West
Technical Suitability				
1) Water supply coverage	Poor (Not served by DWASA	Good	Good	Good
2) Road network	Poor	Good	Good	Good
3) Population density	High	Low	Medium	Medium
Socio-economic Suitability				
1) Realization of investment effects	High (small area)	Low (large vacant space)	Highest (existing sewers)	Low (large area)
2) Cost recovery	Low	Medium	Highest	Medium
3) Financial affordability	Low	High	Highest	Medium
4) Motivation	Moderate	High	Highest	Moderate
Overall Evaluation	**4th**	**3rd**	**1st**	**2nd**

Resultant from the above evaluation, the Core Area in North Dhaka East was determined to have the highest priority, both in technical and socioeconomic suitability. The main focus of the overall evaluation was cost recovery, aside from the technical evaluation, since the burden of cost sharing by the prospective beneficiaries was anticipated.