SUPPORTING REPORT F

LIVING ENVIRONMENT

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1. Introduction

1) General

The scope of the environmental study is to asses the existing living environmental conditions in the Study Area which includes the Dhaka City, the present urban environment. The important direct environmental aspects concerned to human urban environment are potable water, sewerage and sanitation, and solid waste management. Furthermore slums/squatter settlement predominant in the city signifies the degraded human living environment which virtually lacks in all basic sanitary amenities including sufficient living space.

Accordingly, an inventory study covering the existing water supply, sewerage and sanitation, and solid waste management facilities in the study area was conducted, which was supplemented with available information on slum settlements. Furthermore surface water quality was assessed both based on available data and sampling survey conducted by the study team, which is the prime indicator of human living environmental pollution. These aspects in combination with the existing environmental law, regulations and standards are dealt with in the subsequent sections illustrating the existing baseline living environmental conditions in the Study Area.

The major direct and indirect environmental effects by the proposed master plan is delineated. Moreover, an overall evaluation of future urban environmental condition with and without the flood control and drainage project is made in order to justify the necessity of this master plan as the basic urban environmental improvement measure even with inadequate, other, urban amenities. The necessary urban environmental enhancement measures are recommended, accordingly.

2) Study Area

The study area of about 850 km^2 comprises Dhaka Metropolitan Area and full or portions of Upazila/Thana of adjacent administrative districts. The existing living environmental condition is assessed conforming the sub-division of the Study Area as Greater Dhaka Area, Narayanganj Area, Keraniganj Area, Tongi Area and Savar Area (ref. Fig. A.1). Greater Dhaka consists of Dhaka Municipal area and Cantonment area

which are mostly urban and Demra Thana which is mostly semi-urban and rural farmlands. Narayanganj consists of Narayanganj Thana and 4 unions of Bandar Thana

which is mostly urban and Siddirganj and Fatullah Thanas which are mainly semi urban and rural. Keraniganj area encompasses the entire Keraniganj Upazilia and only a small portion along the Buriganga river opposite to old Dhaka, is semi urban. The Tongi area consists of Tongi Municipality only, while the Savar Area to its west comprises mainly Savar Upazila other than the Simulia union and Quasimpur union of Gazipur Sadar Upazila. Savar area is mostly rural except the semi urban township adjacent to Banshi River and some isolated institutional areas.

The Dhaka Municipality, recently became to known as Dhaka City Corporation (DCC), covers an area of about 226 sq.km, where as the other two Municipalities encompassed by the Study Area, Narayanganj and Tongi respectively covers an area of about 19 sq. km and 32 sq. km.

2. Water Supply Facility

The Study Area could be broadly classified into two (2) categories based on existing condition of potable piped water supply availed of by public or private sector.

They are :

1) Areas with provision of piped water supply facility
2) Areas with no provision of piped water

2.1 Piped Water Service Area

The provision of piped water supply in the study area by Dhaka Water and Sewerage Authority (DWASA) is confined to a portion of existing urban areas of Dhaka and Narayanganj. The service areas cover portions of the respective municipalities, Dhaka City Corporations (DCC) and Narayanganj Municipality as shown in Fig. F.1. The Cantonment area of Dhaka has its own private water supply facility.

2.1.1. Dhaka Water Supply

The water supply for the city of Dhaka commenced in 1874 with the inauguration of Dhaka Water Works at Chandnighat in old Dhaka. The service area at that time

encompassed Nowabgonj, Victoria Park, Gandaria, Armanitola, M.M. Basak Road and Chandighat, all lying along the Northern edge of the Buriganga River covering an area of approximately 1500 ha. The capacity of the treatment plant was 13.5 MLD which is now expanded to 27 MLD.

Since then the city has expanded predominantly toward north and until the establishment of DWASA in 1963, with prime objective of providing potable water supply and sewerage facilities to Dhaka city dwellers, the Municipality was responsible for water supply, sewerage and sanitation facilities. The authority's jurisdiction was later extended to include several urban areas that surround Dhaka City including Narayanganj, Demra, Tongi, Joydevpur and Savar, of which DWASA has assumed the responsibility for Narayanganj water supply recently in 1990.

At present (1990) the piped water service area of Dhaka encompasses about 130 sq·km which represents 58% of the DCC area of 226 sq·km .

1) Water Source and Treatment

The existing sources is composed of both surface water and groundwater. Dispite the abundance of rivers in and around Dhaka, surface water contributes to only a 3% of the total water served of 530 MLD (million litres per day), with 16 MLD from the existing Chandighat treatment plant having its in take source at Buriganga River. The remaining 97% (514 MLD) is met with 146 number deep tubewells, as of 1990, judiciously spaced in the service area so as to minimize transmission facilities in addition to treatment requirement. Chlorination is only used as treatment prior to distribution.The surface water and groundwater systems and their service areas are independent of each other, though both form a virtually interconnected network (ref. Fig. F.1).

The groundwater based water supply system was developed by DWASA I and II projects and is being further expanded by the ongoing DWASA III project scheduled to be completed in 1991 inorder to further improve the water supply in DCC area.

The surface water treatment plant at Chandnighat in old Dhaka use conventional treatment typical to river waters. The treatment process comprises rapid mixing, coagulation and flocculation, sedimentation, rapid sand filtration and chlorination. The existing intake is in a dead channel off from the active flowing stream thereby

drawing rather contaminated water, which is required to the extended into active flowing zone.

As pointed out earlier chlorination is the only treatment for groundwater source, important reason for its preference in comparison to surface water source.

2) Transmission and Distribution

There are 33 elevated storage tanks throughout the Dhaka service area at present of which 30 are operational. In many areas the water pressure is too low to fill the tank, even during low demand periods thus for the most part they are inoperable. Table F.1 shows the list of elevated tanks, their sizes and their present status. The tanks which cannot be filled even during low demand periods are sometimes filled directly from the well or by diverting water to them by closing valves in distribution system. This implies widespread low distribution pressure in Dhaka water supply system.

The major transmission lines interconnecting tubewells and those of the elevated storage tanks are of 300 ~ 450 mm in diameter. Service connections are restricted to 300 mm in diameter and below in order to preclude leakage and loss of pressure. All residential, commercial and industrial connections are provided by WASA upon request from consumers. As of Dec. 1990 there was a total of 109, 738 service connections, 69,825 of which were metered and the remaining 39,913 unmetered. Service connections are predominantly domestic ones and estimated to serve a population of about 2.7 million. This amounts to a percapita water production of about 200 l/day, as the total quantity of water production is 530 MLD. This water served population includes 300,000 person served with public stand posts of about 1200 numbers in old Dhaka area. Hence on average one (1) stand post serves 250 person.

In addition to DWASA served population of 2.7 million, it is estimated that another 500,000, including those of Dhaka cantonement, are provided with privately owned piped water supply. Accordingly, piped water service covers a potential total population of 3.2 million, which is 78% the total Dhaka population of about 4.1 million.

There are numerous old pipings in DWASA distribution system that are in urgent need of replacement. In particular, in some areas secondary distribution system of diameter 150 ~ 300 mm consists of old locally made asbestos cement pipes and

mild steel pipes for which matching replacements are no longer available at present, which further exacerbates the maintenance and repair works. Leakage in these distribution system is widespread, and should be the major cause of low distribution pressure.

3) On-going Improvement Schemes

DWASA is at present implementing two (2) improvement and expansion schemes to its groundwater based water production and distribution network.

They are :

- Urgent Expansion Project (UEP) or WASA-III under financial assistance from IDA.

- Crash Programme Under GOB finance

Under the WASA-III programme, deep tube wells (26 No.) 270 km of pipe networks and 250,000 service connections are being implemented. Areas to be benefited by this programme include Mirpur, Dar-us-Salam, Dhanmondi, Tejgaon, Baridhara/Badda, Rampura, Magbazar, Madertek, Jatrabari and Islambagh.

While the Crash Programme consists of the provision of deep tube wells (60 No.), 100 km of pipe networks, and 6 No. overhead tanks each of capacity 450m^3 in water scare areas. All these 6 overhead tanks are under construction at Mirpur, Kafrul, DOHS Mohakhali, Uttra, Dhania and Shaymoli.

4) Effects of Groundwater Abstraction

It has already been pointed out (ref. (1) above) about 97% of piped water demand in Dhaka is met with deep groundwater tubewells with a combined production of about 514 MLD. Furthermore both the ongoing expansion schemes dealt with in foregone section are also entirely groundwater based. On the other hand surface water based schemes though studied no feasible schemes so far been taken up for implementation. The latest of such study is the detail design of Demra Water Treatment Plant recently completed under IDA finance. This plan was based on the surface water from Lakya river. The scheme was to be financed by IDA but now shelved because of high project cost.

A recent study of Feb. 1991, Dhaka Region Groundwater and Subsidence Model study, accomplished under IDA finance for DWASA deals with the effects of increasing groundwater abstraction for potable water and other uses in Dhaka region. A model was developed by the study to predict both the loweing of groundwater table and the subsequent ground subsidence due to compaction/consolidation of overlying silt/clay strata of the aquifer with increasing groundwater abstraction.

This master plan study area is entirely encompassed by the above IDA model study area. Hence the above model would assist DWASA in assesing the limitation of future groundwater source development for water supply and other uses in the planned urban areas to be enclosed by polders in this master plan study.

The above IDA study estimated the groundwater abstraction by private tube wells in Dhaka is about 114 MLD in 1990. Hence the total abstraction by both public water supply by DWASA and private wells amounts to about 630 MLD in 1990. The corresponding value for the whole study area of 850 sq.km is estimated at 775 MLD.

The IDA study identified significant decline in pezometric levels in the urban areas of Dhaka due to increasing groundwater abstraction, corresponding to increased urbanization. Especially in the highly urbanized Motigheel area an annual pezometric level decline of more than 1 m has been reported during the period of 1987 ~ 1990. Nevertheless, no significant land subsidence is observed, though a bench mark level difference of 1 ~ 3cm was observed during the period of 1964 ~ 1990. This level difference is insignificant in consideration to the long period of 16 years and surveying error would still have been a probable cause.

The existing deep tubewells of DWASA in Dhaka are generally of gravel-packed design and drilled to depths of 65-170 m. Most of the deep tubewells are over 107 m deep according to information received from DWASA. Typically, they have an upper pump chamber section (usually 400-450mm in diameter) to a depth of 33-50 m and a lower intermittently screened section of 200mm diameter steel casing.

The recent rapid decline in pezometric levels in Dhaka should be construed as an overexploitation of groundwater even in the absense of any significant land subsidence. Infact based on the IDA study, no significant land subsidence is anticipated unless the pezometric level decline to a depth of about 200m, the depth at which a 100 ~ 150m thick silt/clay layer was noted by the BWDB borelog in Dhaka, thereby exerting a potential increase in effective pressure (depletion in pore water pressure) on to the silt/clay layer due to groundwater abstraction. Still, a large scale land subsidence as progressing in Bangkok due to groundwater abstraction is rather unlikely in Dhaka. This Bangkok phenomenon is an exceptional case, attributed to the existence of highly compressible Bangkok marine clay layer.

Infact, the topmost ground layer of Dhaka is composed of Madphur clay, the compressibility of which is determined to be very low by the subsidence risk assessment of the IDA study, 1991. This topmost clay layer serves as an effective barrier in mitigating contamination of groundwater by polluted surface waters. Moreover the thick partly unsaturated silty and fine sands underlying the topmost clay layer offers excellent potential for groundwater purification during infiltration. This is confirmed by the raw groundwater quality analysis conducted on existing WASA tube wells by the above IDA study. The nitrate concentration (NO_3N) measured in all the tubewells located at 12 different locations were not more than 0.7mg/l.

Nevertheless, the protection of groundwater quality is a serious concern and in particular, attention should be paid to the means of direct contamination of groundwater with surface waters bypassing the insitu protection offered by the favorable geologic profile of Dhaka, though the resultant pollution effects will be rather localized. Furthermore, as 97% of the Dhaka water supply is met by groundwater its quality assurance in recommended to be monitored by DWASA regularly in its tubewells. This would also serve the purpose of overall deep groundwater quality monitoring in Dhaka, if not shallow groundwater quality.

In regard to the exploitation of groundwater, the recommended design specific yield capacity of a tube well, as determined by DWASA-III Feasibility Study, in Dhaka is about 450 liter per minute per meter of drawdown, which could be considered as the safe yield of aquifer. Any existing well with a specific yield capacity less than about 225 lpm/m of drawdown is recommended to be either redeveloped or abandoned, based on economics of operation. Performance tests

conducted on existing wells indicated specific capacities ranging from 75 to 675 liter per minute/meter. Also some wells produce excessive sand and in such cases it in understood that the pumps are operated with their valves throttled, resulting in reduction of pump operating efficiency to unacceptable levels.

Accordingly, it is recommended that DWASA, in addition to the compliance with the set criteria on safe yield, to establish a criteria for maximum allowable depth of deep tube wells, and hence the maximum allowable pezometric decline, with due consideration to both the geologic profile of the locality and economics of pump head as a means of controlling overexploitation of groundwater and land subsidence.

5) Action of Improvement

The following immediate actions are recommended to be undertaken by DWASA to enhance the existing water supply service in Dhaka.

(1) Improvement of system pressure and service level by mitigating widespread leaks in the existing old water distribution system shall be given due attention instead of just the expansion of service level based on new source development.

(2) Development of criteria concerning maximum allowable pezometic decline of deep tube wells based on economics of pump head and geologic profile to mitigate the overexploitation of groundwater is recommended in addition to the compliance with the set criteria on safe yield.

2.1.2. Narayanganj Water Supply

1) General

Narayanganj is a predominant river port town having its municipality being separated into east and west portions by the Lakya River. The western zone which is easily accessible from Dhaka is well developed in comparison to eastern portion. In fact according to municipality 75% of the total municipal population lives in its western zone.

2) Water Supply Expansion by JICA

Though Narayanganj has a 70 year history of piped water supply facility, a major expansion and rehabilitation works was accomplished recently, during 1985-1989, with financial assistance from JICA. Accordingly the water service potential has enhanced to a level of 94% from that of 33%.

As evident from Fig. F.1, two independent treatment and distribution system having two separate treatment plants with Lakya River as the predominant surface water source was implemented, replacing the existed treatment plants, in Godnail (west bank) and Kadam Rasul (east bank). The entire source system comprises both surface water and deep groundwater. All these are integrated to from the two (2) independent water distribution networks in both sides of the Lakya river. The water supply facilities of Narayanganj as of 1990 is summarized below.

Facilities	Quantity
Deep tubewell (150 mm. dia)	10 Nos.
Treatment plant, 45 MLD (West Bank-Godnail)	1 No.
19 MLD (East Bank-Kadam Rasul)	1 No.
O.H. Tank, Total Capacity 9800 m^3	10 Nos.
Water pipelines, 100 - 700 mm dia	86 km
Daily water production capacity	58,000 m^3
Daily water production	16,000 m^3
Service coverage planned	94 %
Service coverage achieved	44 %

Of the above mentioned existing facilities, the ones implemented under the JICA project is summarized in Table F.2. Accordingly, the two surface water treatment plants, 3.5 km of transmission mains, 8 No. overhead water distribution tanks and 51 km of distribution lines were recently implemented in 1985 ~ 1989.

The design criteria and the relevant capacities of both the conventional surface water treatment plants in both the west bank (Godnail) and east bank (Kadam Rasul) constructed by JICA, is given below.

Treatment Plant	West bank plant	East bank plant
Capacity (MLD)	45	19

Receiving Well		
Number of basin	1	1
Capacity (m^3/h)	48.0	38.0
Detention time, (min)	1.5	3.0
Velocity of flow, (m/s)	0.06	0.03
Mixing basin		
Number of basin	4	4
Loading per basin, (m^3/h)	470	200
Capacity (m^3)	8.0	3.4
Detention time, (min)	1.0	1.0
Flocculation basin		
Number of basin	4	4
Capacity (m^3)	235	100
Detention time, (min)	30.0	30.0
Settling basin		
Number of basin	4	4
Capacity of basin, (m^3)	1,410	605
Detention time , (hour)	3.0	3.0
Velocity of flow, (m/min)	0.26	0.17
Rapid sand filter		
Number of basin	6	6
Rate of filtration, (m/day)	120	120
Clear water reservoir		
Number of basin	2	2
Capacity (m^3/basin)	1,910	810
Detention time, (hour)	2.0	2.0
Disinfection facility		
Disinfection agent	Bleaching powder	Bleaching powder
Feeding ratio	Max. 2 ppm	Max. 2 ppm
Solution tank, (No)	0.3 m^3 x 2	0.2 m^3 x 2

The new treatment plant at west bank is built in the premises of the existing treatment plant and both the new and the old plants run simultaneously. But the treatment plant on the east bank is built in a new premise and the small existing old plant is abandoned for being uneconomical.

Finally it is pointed out that the water treatment system is underutilized producing only a 16 MLD against the design capacity of 64 MLD. The service level is equally divided between house connection and public stand post pipes. Though public stand post service is entirely achieved, the house connection service target is yet to be progressed.

3) Action of Improvement

Effective utilization of existing production capacity is recommended to be achived with expansion of water service connections to consumers.

2.2 Non-piped Water Area

The only municipality in the Study Area that is not at all covered so far by piped public water supply is Tongi Municipality. The rest of the areas are predominantly rural, other than a confined semiurban areas adjacent to Buriganga river in Keraniganj and Savar town area adjacent to Banshi river and Amin Bazar area adjacent to Turag River in the Savar area.

In all these non piped water areas, in fact Bangladesh in general, ground water both as deep tube wells and shallow wells in the major source of drinking water. However in urban and semiurban centres generally groundwater is used not only for drinking but also of washing and bathing purposes, especially by the mid and high income population who own their own private wells. In rural areas and farmlands people generally use surface water for bathing and washing purposes, and also with the poor even in semiurban and urban areas.

Department of Public health Engineering (DPHE) is responsible for the provision of potable water in all non-municipality areas. With the assistance of UNICEF, DPHE in implementing water supply improvement schemes in Keraniganj, Savar and other areas. For poor, DPHE wells are provided free of cost, where one (1) tubewell generally cover 20-25 families.

In case of Tongi area, which is predominantly an industrial centre and industries generally have their own water supply facilities, there are about 337 dugwells and 264 shallow tubewells and 29 deep tubewells installed by municipality for public water supply mainly for potable use. These are located in common public places or at caretakers place where users have free access.

Moreover, from this survey on condition of existing water supply in the study area it is noted that Keraniganj area, especially its semiurban centers of Subhadia, Zinzira and Kalindi unions, has the lowest coverage of potable water facilities.

It is estimated that in Keraniganj Upazila the total number of DPHE tubewells are around 2800 against the existing population of about 775,000. This results in a coverage of 275 people per tubewell which is much lower than the national average of around 135 people per tubewell. This low coverage in Keraniganj is due to very rapid population growth during the last 10 years. During this period population increased more than twofold but public water supply source did not keep in pace with the population growth. Hence priority attention shall be given to improve the potable water service level in Keraniganj area.

3. Sewerage and Sanitation Facility

In the Study Area, a portion of DCC Area has the only sewerage facility in Bangladesh that was originally developed to serve old Dhaka area in 1923, which was later expanded with the expansion of the city. Hence this area could be defined as sewerage area. However, as the sewerage system does not serve the entire population in its service area, and such non-sewered population depends on on-site sanitation facilities as in the case of an area having no sewerage facility, still the whole study area could be defined as sanitation area. Accordingly the Study Area is classified into the above two (2) categories for the purpose of assessing the existing sewerage and sanitation facilities.

3.1 Sewerage Area

The existing water borne conventional separate sewer covers about 33% of the DCC Area. The main sewer lines and the existing stabilization pond treatment plant in Pagla having its final disposal into Buriganga River are schematically shown in Fig. F.2. Since 1963 Dhaka sewerage is under the jurisdiction of DWASA.

3.1.1 Sewer Network

The existing sewer system consists of laterals, trunk lines, interceptors and lift stations. Due to the general flatness of the city. The sewer network has a number of lift

station to facilitate continuous flow through gravity. The location of the existing 15 number lift stations and their related engineering features are summarized in Table F.3.

The sewer mains in old Dhaka range from 225 to 980 mm and in the remaining areas from 200 to 1360 mm. Throughout the system, particularly in the old city, operation is plagued by infiltration from illegal connections, manholes and sewer pipe joints. DWASA has undertaken and intensive program to control these problems. As of 1990 there exists a 440 km of sewer lines and 37,522 sewer connections. The existing sewer network stretches about 33% of DCC area, but connects not more than 50% of residents, making the remaining to be dependent on on-site sanitation measures, if any. Assuming one sewer connection serves about 25 person, the sewered population is estimated at about one(1) million.

The basic design study for sewerage construction and rehabilitation prepared by JICA for Dhaka determined that the per capita sewerage quantity as 101 l/d. Further a design influent BOD_5 concentration of 200 mg/l was adopted for treatment plant design. Accordingly, per capita pollution load generation becomes 20.2g BOD_5/day.

3.1.2 Sewage Treatment

Facultative waste stabilization pond system to treat the collected sewage in Pagla came into functioning since 1980. Stabilization ponds, though require large area, are highly suited to tropical climatic conditions with abundant sun light due to their simplicity and low cost of operation and maintenance.

The pond system with an area of 35 ha and having three (3) cells could be operated either in series or parallel mode as required. Any one cell could be drained off independently and the entire plant could also be bypassed. In fact the plant is bypassed at present, and sewage is discharged with no treatment to Buriganga River as a temporary measure, to facilitate the on-going expansion works of the pond system by JICA.

3.1.3 On-going Sewerage Improvement Schemes

At present three (3) improvement schemes are on-going by DWASA. They are :

(1) Urban Expansion Project (UEP) or WASA-III under IDA finance
(2) Rehabilitation Programme of Sewer System by JICA

(3) Sewer construction and rehabilation project in Mirpur under Dhaka Urban Infrastructure Development Project with ADB finance.

1) Urgent Expansion Project (UEP)

Under Urgent Expansion Project (UEP), DWASA undertook expansion of sewer network including some rehabilitation of sewer lines. The original target was 48 km of new sewer line and 8000 sewer connections. Area to be benefitted are Mohakhali, Goran-Madertek, Zigatola and Rahamatganj. The scheme is now revised to 75 km of new sewer lines with 15 lift stations. So far 42 km of sewer lines have been completed and the rest are expected to be completed by mid 1991. Out of 15 sewer lift stations, 9 have already been finalized and awaiting execution. Those lift stations are Mohakhali DOHS, Banani DOHS, Armanitola, Zigatola, Madertek and Bashaboo - Goran (4 Nos.). Capacity of new lift stations varies from 15 - 50 1/sec. Implementation of the lift stations is expected to be completed by December 1991.

2) Rehabilitation Programme by JICA

Under the Construction and Rehabilitation of Sewerage programmes financed by JICA, DWASA is presently carrying out the rehabilitation of existing lift stations and expansion of Pagla Sewage Treatment Plant. Under this scheme all the existing lift stations except those at Asad Gate, Tejgaon and Narinda, are being electro-mechanically refurbished including the provision of standby generators for better operation.

In case of Pagla Stabilization Ponds, the system capacity is expanded with the provision of additional ponds and by incorporating primary sedimentation prior to facultative lagoon. The treatment facilities to be provided along with the design criteria and the treatment flow diagram are given below for illustrative purpose.

Facilities	Design Criteria		
Grit chamber (10 x 3.3 x 2 m)	Surface loading rate	:	3600 $m^3/m^2/d$
	Detention time	:	60 sec.
	Average velocity	:	0.30 m/sec.
Primary sedimentation Tank, 4 Nos. (dia 33 x 4.65 m)	Surface loading rate	:	35 $m^3/m^2/d$
	Detention time	:	2.0 hr
	Weir loading rate	:	300 $m^3/m/d$

Facultative Lagoon (6 Nos. 475,024 m^2)	Influent BOD Ambient temperature Pond Depth	: : :	120 mg/1 21^{o} C 2.0 m
Chlorination	Chlorine dosage rate	:	3.0mg/1 (max)
Sludge lagoon (192 x 42 x 2.6 m)	Volumetric loading rate Digesting time Content of volatile solids Reduction rate of volatile solids Moisture content of dried sludge	: : : : :	50 kg/m^3/year 90 days 60% 35% 80%

3) Dhaka Urban Infrastructure Development Project - ADB

Under the Housing Development Project (Mirpur) of Ministry of Works financed by ADB, there is a water and sewer component being executed by Dhaka WASA. Sewerage components include construction of 123 km of new sewer lines with 5 pump stations and substantial sewer rehabilitation works. The project will provide adequate sewer facilities to the people of Mirpur up to the year 2018. The consultancy work for project commenced in January 1991 and the execution in expected to the completed by 1994.

3.1.4 Action of Improvement

Controlling of illegal connections and expansion of service level of sewer connections shall be addressed in addition to the on-going improvement programs.

3.2 Sanitation Area

The sanitation area covers the whole study area including the sewerage area dealt with in the foregone section as sewerage service does not cover the entire population living in the sewered area. Furthermore, the study area is composed of urban centers, semiurban centers and rural areas. The urban centers are the three (3) municipalities of Dhaka (DCC), Narayanganj and Tongi (ref. also Fig. F.3). These three (3) urban centers occupy an area of about 277 km^2 out of the total study area of about 850 km^2. The remaining areas are predominantly rural with limited semiurban centers such as Subhandia area adjacent to Buriganga River in Keraniganj, Savar town area adjacent to Banshi River and others.

The Municipal Ordinance stipulates that the responsibility for sanitation services within the municipal jurisdiction lies with the Municipality. Costs for sanitation services are recovered through conservancy taxes. It is to be noted that sewerage in Dhaka is under the responsibility of DWASA. In all non-municipality areas of Bangladesh, which are predominantly rural, DPHE is responsible for both water supply and sanitation aspects. Hence in the study area Keraniganj, Savar and other rural surroundings of DCC area and Narayanganj municipality fall under the jurisdiction of DPHE. Accordingly, municipal (termed as urban) and non-municipal (termed as rural) areas are dealt with separately.

3.2.1 Urban Sanitation

In all three municipal regions in the study area the available on-site sanitation facilities for human waste disposal include pit latrines makeshift latrines (Kutcha latrines), twin pit leaching pits, septic tanks and public toilets. Bucket latrines are also reported to exist in Dhaka and Narayanganj municipalities.

No municipality in Bangladesh has any organized programme for desludging of septic tank and their subsequent sanitary disposal. Dhaka City Corporation also has no arrangement for providing service for desludging the septic tanks of the residents or removing night soil from bucket latrines. The residents arrange for cleaning at their own expense by hiring cleaners and pay about Tk. 500 ~ 1000 for cleaning a septic tank. The septage so cleared are generally dumped in the yard by making pit, while the removed night soil is disposed to drains, both are insanitary means of human waste disposal.

Hence it is evident that though there is a sewerage system serving a segment of population in DCC Area and there are on-going and planned expansion schemes concerned to sewerage as dealt with in section 3.1, there is a serious lack of attention by the concerned municipalities on on-site human waste managements, on which bulk of the population, paradoxically, even in the sewered DCC area is dependent.

In all on-site sanitation areas generally household sullage (graywater) is discharged to nearby ditches/drains, the major culprit of water pollution. Still the disposal of sullage to ditches/drains need not be considered a serious threat atleast from a public health view point, in comparison to insanitary human waste disposal.

1) DCC Area

Of the 132,000 registered holdings in DCC area only about 37,500 are connected by waterborne sewer system. The majority people with no sewerage service depends on on-site human waste disposal means. Though there is no exact figures available on the number of on-site sanitation facilities in DCC area it is understood that most of the households with permanent housing structures are either connected to the sewer system or have septic tank arrangements. Households with semi-permanent or makeshift housings mostly have single pit lartines, twin leaching pits or makeshift latrines. From the housing data supplied by DCC, an estimate is made about the number of various types of latrines now under use within the DCC area except those connected by sewer. It is estimated

that about 42000 holdings have septic tanks, 9000 bucket latrines, 20000 pit latrines and 22000 makeshift latrines. DCC (Dhaka City Corporation) is also operating 15 public toilets at different places of the city having 58 seats for latrines, 45 urinals and 15 washing and bathing rooms.

Other than the registered holdings, there are about 1 million people living in slums/squatters in Dhaka mostly on lands owned by various government departments. They are having no sanitary system of waste disposal and use makeshift or open latrines and open fields. This aspect has a severe implication on environmental/public health, living environmental pollution in general. Conditions of Dhaka slums is dealt with separately in Chapter 5.

DCC has taken up a programme for converting bucket latrines into twin leaching pits under Environmental Improvement Project with IDA finance.

Dhaka cantonment area has its own sanitation system which is mostly septic tanks.

2) Narayanganj Municipal Area

Narayanganj Municipality covers about 19 km^2 and has a population of about 312,000 living in about 12,650 households.

The municipality has no sewer system. Septic tank, pit latrines, makeshift latrines and public latrines are the usual mode of human waste disposal.

According to the information provided by the municipality there are approximately 3000 septic tanks, 2000 pit latrines and rest are bucket, makeshift or open latrines. Municipality operates 11 community latrines with 76 seats. These are mostly located in busy areas or market places, which are free of charge.

Municipality does not provide any services for cleaning the septic tank or bucket latrines. The house owners make their own arrangement for cleaning the tanks by hiring cleaners at their own cost. Toilet waste from makeshift and open latrines ends up in drainage channels, a public health hazard.

3) Tongi Municipal Area

Tongi area comprises the entire municipal area of Tongi which extends over 32 km^2 with an existing (1990) population of about 141,000 (ref. Fig. 7.3). Tongi municipality was established 16 years ago in 1974. The entire area is semi-urban in nature with industrial areas, scattered farmlands and residential units.

The municipality has no sewer system and there are about 8785 householdings.

There is no statistics available with the municipality on the number of various types of on-site sanitation facilities that exist within the municipal area. Municipality is operating 2 public latrines with 9 seats in Duttapara Squatteres Rehabilitation Area.

In the absence of statisties about the existing sanitation facilities, exact coverage cannot be given. According to Water Supply and Sanitation Sector Study by Netherlands assistance, the coverage by septic tank and pit latrines are not more than 7% and 8% respectively in a semi urban centre or small municipal town like Tongi. Rest 85% of the people resort to other non-sanitary methods of defecation. Sanitation facilities in scattered slums are generally non-existent.

3.2.2 Rural Sanitation

Department of Public Health Engineering (DPHE) is responsible for looking after the water supply and sanitation problems of all semi urban and rural areas of Bangladesh, and hence for all the remaining areas of the study area other than the three (3) municipal areas dealt with under the foregone section.

The major semi urban centre that falls under rural sanitation, in the Study Area, lies in Keraniganj area. The semi urban area covers about 20 km^2 along the bank of Buriganga River and covers the unions of Subhadia, Zinzira and Kalindi with an existing population of about 200,000 in 1990. The provision of urban infrastructure has not kept in pace with the population growth. The roads are very narrow, being approachable only by Rickshaws, no adquate drains in addition to no provision of piped water supply (ref. Chapter 2) and a very few on-site sanitary disposal means of human waste. No data is available with the union councils about the number and type of on-site sanitation facilities.

The widely used means of defecation in rural areas is using makeshift or open latrines or defecation in the open field. Coverage by good sanitary latrines including pit latrines, are not more than 4%. Sanitation Sector Study of 1988 estimated the service level by pit latrines in rural areas of Bangladesh until the year 2000 as given below. Pit latrine in the most widely used sanitary disposal means of human waste in rural areas.

Projected sanitation coverage in rural areas
(Number of people per direct pit latrine)

		People per latrine			
Income Class	%	1985	1990	1995	2000
High	25	7	7	7	7
Middle	25	21	18	16	13
Low	50	21	21	21	21
Total :	100	17.5	16.8	16.3	15.5

DPHE with assistance from UNICEF is at present implementing the construction of water sealed leaching pits as low cost sanitary latrines in semi urban and rural areas at subsidised rate, as an improved means of on-site human waste disposal and hence to raise the service level of on-site sanitation from the present level of 4%.

3.2.3 Action of Improvement

1) The respective municipalities and DPHE shall expedite the provision of low cost sanitary toilets including public toilets for congested low income communities and slum areas, as the basic sanitation improvement measure along with the progressing abolition of bucket latrines.

2) Desluding and subsequent sanitary disposal of septic tank sludge or septage, preferably utilizing vacuum pump and storage equiped vehicles, is recommended to be initiated. DWASA is most suited to undertake this responsibility. Combined treatment of sewage and septage in Pagla waste stabilization ponds is an option meriting consideration, atleast on a short term basis.

4. Solid Waste Management

In the Study Area an organized solid waste management, if any, consisting of collection transport and disposal is confined to the three (3) urban municipal areas namely, DCC (Dhaka City Corporation) and Narayanganj and Tongi municipal areas. These three municipal areas which are also the service areas of solid waste management are delineated in Fig. F.3. Other major private solid waste management system in the study area covers the cantonment area of Dhaka and Savar military zone.

It is to be noted that in Bangladesh as a whole, there is no organized solid waste management as such in semiurban and rural areas. In fact solid waste generation rate is not very significant in rural areas, and the generated solid wastes are disposed off locally by the homesteads. Hence, solid waste management as practised with the three (3) municipalities are only illustrated in subsequent sections (ref. Fig. F.3).

4.1 DCC Area

1) Introduction

DCC manages the solid waste collection, transport and disposal in the whole area under its jurisdiction that covers about 226 km^2. Solid waste management is under the responsibility of the conservancy division, one of the nine (9) independent divisions of DCC, which accounted for about 14 to 17% of the total budget of DCC during the last three (3) years.

The DCC area is divided into 10 zones, each zone having a zonal office. The Conservancy Division of the zonal office is responsible for the refuse collection within its zone. Each Conservancy Division has one (1) conservancy officer (CO) who is in change of the division concerned. A CO is assisted by conservancy supervisory Inspectors (CSIs) and Cleansing Inspectors (CIs).

2) Solid Waste Collection

The community bin system of collection is being used. The community bins are made both of corrugated iron (CI) and of masonry construction. No standard is followed for their spacing and are provided depending on convenience and need. The C.I. bins (1622 in total) have a normal size of 900mm dia and 900mm high. Masonry bins (1098 nos) are of variable size but are normally 1m wide, 1m high and 2m long. The waste is often found to be spread around the bins indicating the

need for proper design and siting of bins as well as educating the residents about proper use of bins.

All the waste that reaches the bins or designated collection point is collected. This includes the solid waste coming from residential, commercial as well as industrial establishments. Waste from 4 major hospitals is collected separately but transported to the same disposal sites.

In fact households are expected to take their waste to the dustbins but are sometimes observed to deposit it on the roadsides which gets collected and swept alongwith street refuse by the cleaners (sweepers). Each cleaner is provided with a broom, basket, brush and spade which is replaced every month. The cleaners, both male and female are assigned to clean a predetermined portion of street/road length, which is on average a 500m road length. Hand carts are used to convey heavy collection of refuse as well as silt from drains.

A total of 4221 cleaners normally perform cleaning of the city. Their distribution for each zone along with the respective number of hand carts and dustbins are given below :

Zone	Cleaners	Handcarts	Dustbins	
			Corrugated	Masonry
1. Jatrabari	450	220	218	132
2. Laxmi Bazar	745	224	222	165
3. Azimpur	476	190	221	160
4. Khilgaon	583	230	225	149
5. New Market	551	180	155	130
6. Kawranbazar	486	150	140	105
7. Mirpur	182	115	120	72
8. Mirpur	240	135	131	75
9. Gulshan	442	150	155	95
10. Uttara	66	45	35	15
Total	4221	1639	1622	1098

3) Transportation and Disposal

The refuse collected at the bins and at specific points is removed by a fleet of 190 trucks of 5,3,2 and 1.5 ton capacity as shown below. Majority of them do not

have a tipping arrangement. Some have closed body having openable flaps on back side and 3-4 vertically sliding shutters on both sides.

Sr. Nr.	Capacity		Covered body	Open body
	kg	m^3		
1	5000	5.7	38	34
2	3000	3.0	22	7
3	2000	3.0	-	48
4	1500	2.3	-	41
Total			60	130

It is informed that about 90 trucks are used in night shift and 60-70 in day shift. Every truck makes 1-2 trips/day and is assigned a specific area.

Insanitary land fill by dumping of solid waste is the general practice. The major site of dumping is Jatrabari. Though a major dumping site at Kalshi ceased operation in 1990, still locally collected solid waste from Mirpur area is being dumped just in front of a school, near to the above ceased site (ref. Fig. F.3). Both are lowlying areas, and in addition a number of scattered lowlying areas located in Islambaj, Hazaribag, Mukti Sarani, Dayaganj, Mugda, Amligola Balu Math are also used. In fact whenever a lowlying land needs to be reclaimed or filled up, the beneficiary requests the DCC for solid waste dumping in the area concerned. After the approval of the competent authority the solid waste collection vehicles are directed to the site. It is understood that no proper records of such dump sites are maintained which would further aggravate the public health hazard of such practice.

It seems that solid waste is just considered as a resource of land filling material, in an area where lowlying zones are widespread, and demand for flood free land is very high. In the process, the adverse environmental and public health implications of insanitary land filling such as potential groundwater pollution, proliferation of disease vectors and the resultant direct public health hazards are overlooked. It is strongly recommended to abolish this practice of insanitary land filling, not to mention the insanitary collection and recycling practice.

Under the Environmental Improvement Project funded by IDA, a site covering 25 ha at Matuail along Dhaka Demra road, 3 km outside the DCC limit, has been proposed as the future sanitary land filling area (ref. Fig. F.3). A sanitary lamdfill is expected to be instituted with this IDA assistance, instead of just a solid waste dump site.

4) Solid Waste Generation Rate

A high degree of recycling is practised at the source of generation due to economic reasons and as well by rag pickers not only from dustbins and other temporary storage areas but also at landfilling sites, though the practice is insanitary. Generally non combustibles like glass, metal containers and other plastic items are recycled.

It is understood that on average two(2) trips are made every day by each vehicles. Majority of paper and plastics get reclaimed leaving only grit and organic matter in the waste. As this waste would have a high moisture content a high density value can be assumed. Hence a value of 600 kg/m^3 is reasonable. It is commonly observed that the open body trucks are mostly full while the closed body trucks are not more than 2/3 full. On this basis the total quantity of solid waste collected is estimated at 770 ton/day.

In a developing country municipality like Dhaka the solid waste collection rate is in the order of 50 ~ 60% of generation rate. Assuming a collection rate of 50% and a population of 4.1 million, the per capita solid waste generation rate is estimated at 375g/capita/day, which corresponds to a total generation of 1540 ton/day. This compares with the per capita solid waste generation rate of 330g for Jakarta, Indonesia in the year 1985, estimated by JICA solid waste management study.

The per capita solid waste generation rate of Tokyo in the year 1986 was estimated at 1155g/capita/day, while that of whole Japan at 857g/capita/day.

4.2 Narayanganj Municipality

The Narayanganj municipality which occupies about 19 km^2 is divided into twelve (12) unions. The existing population is estimated at 312,000.

1) Collection, Transport and Disposal

The waste collections is done in a similar manner as that of the Dhaka. Street cleaners of about 400 are employed for cleaning and conveying the refuse to dustbins located at specific locations. The dustbins are of masonry type and are of 2 m^3 capacity in general (1.5m x 1.2m x 1.1m). They are spaced at 150m ~ 250m apart. About 46 bins are spread over the whole municipal area.

The wastes form dustbins are manually transferred to four trucks (5 T capacity 1 no. covered body, 3 T capacity 1 no. covered body and 3 T capacity 2 nos. open body) for disposal. For narrow roads where truck can not enter, van carts (2 nos.) and hand trolley (52 nos.) are used for transportation of solid waste. As the vehicles are of non tipping type, the contents of the truck are manually unloaded at the disposal sites. All the trucks make atleast two trips everyday with a total of 8 trips.

At present the whole waste is transported and dumped mainly in a single area in Tanbazar (approx. 1/2 ha.) where a land development programme is undertaken by the Municipality. Other lowlying areas or ditches scattered throughout the town are also filled regularly. The available recyclable materials in dumped wastes are reclaimed by ragpickers. This practice of insanitary land filling is similar to that of Dhaka area.

2) Solid Waste Generation Rate

At present all the trucks make two trips in a day. With due consideration to the fact that the trips are not always full, and assuming the density as 600kg/m^3, the quantity of solid waste collected by trucks is estimated at 14.0 ton/day. Allowing for those wastes collected and dumped separately by van carts, hand trolley and that remain uncollected and disposed in drains, a collection ratio of 40% is assumed. Accordingly, the total quantity of solid waste generation is estimated to be about 35 ton/day. This gives a per capita solid waste generation rate of 112 g/capita/day, for a population of 312,000.

4.3 Tongi Municipality

The Tongi area of the study area covers the municipality with an area of about 32 km^2. The municipality area is divided into 3 wards and the total population is estimated to be around 141,000.

1) Collection, Transport and Disposal

The waste collection is accomplished by employing about 50 cleaners (sweepers) who convey the waste to dusbins located at specific locations. There are 26 number dustbins, all of masonry type. The capacity is about 3.25 m^3 (1.8m x 1.5m x 1.2m) and the spacing varies from 150m to 500m. It is reported that around half the dustbins are damaged and in need of replacement.

For transportation and disposal 2 no. trucks, one of 3 T capacity and the other of 1.5 T capacity, are used. The 3 T truck is of close body type and the other one is open body type. Both the trucks are of nontipping type and the contents are unloaded manually. Both trucks make two (2) trips per day.

No specific area is designated by the Municipality for solid waste disposal. The waste is disposed at low lands scattered throughout the Municipal area, specially the road side ditches north of Telephone Industry. The waste is simply being dumped in low lying land without following any specific sanitary procedure or plan. Whatever recyclable materials available are reclaimed by ragpickers.

2) Solid Waste Generation Rate

Due consideration to the facts that both trucks make two (2) trips per day, the trucks are not always full and assuming a density of 600kg/m^3 and collection ratio of 40%, the quantity of solid waste is estimated at 12.6 ton/day. Accordingly the per capita generation rate for a population of 141,000 becomes 89 g/capita/day.

4.4 Action of Improvement

1) A minimum condition of sanitary landfilling of solidwastes at strictly specified locations is recommended to be immediately instituted by the concerned municipalities.

2) Insanitary reclaiming of recyclable materials by rag pickers including the insanitary means of solid waste collection is recommended to be abolished.

3) Improved service level of solid waste collection by reaching areas of difficult accessibility like congested areas and narrow road shall be given due consideration.

5. Slum Settlement

The present number of slums and their population has been identified as the burning problem of urban life. Though slums are in existence for centuries in Dhaka, this has taken the shape of serious problem in recent times. Number of slum dwellers are increasing very rapidly, especially in Dhaka. Though there are slums in and around the all three municipalities of the Study Area, most of the available information is confined to slum dwellers in Dhaka, which being the largest city has the highest slum concentration.

Virtually there are no slums in rural areas of the study areas such as Keraniganj and Savar, though the housing conditions in the semi urban centre of Keraniganj adjacent to Buriganga River could be considered virtually a big slum settlement in consideration to its high population density, unplanned urbanization and virtual lack of social amenity. Still it could be considered better than a typical Dhaka slum. Accordingly, the available information on slums in Dhaka, Narayanganj and Tongi are dealt with in the subsequent sections.

5.1 Slums of Dhaka

Sufficient information on slums and slum dwellers in Dhaka are available. The Centre for Urban Studies (CUS) of Geography Department of Dhaka University played an important role in this respect. This organization conducted survey and research on slums of Dhaka City in 1974, 1978, 1980 and 1988. Architecture and Physical Planning Department of Engineering University, Social Welfare Institute of Dhaka University, Geography Department of Jhangirnagar University and individual Engineers, Economists, Planners and Social Scientists working under the government and other organizations prepared many reports on slums of Dhaka City.

However, it is very difficult to get correct and accurate information on the number of slums and their population, though abundant information are available on the physical condition of the slums along with their economic, social, family and individual characteristics. Still the information derived from survey of one organization differs from those of others. There are many reasons for this anomaly. Firstly, all surveys are carried out in a haste within a short span of time. Secondly, different survey was carried out at different time resulting in different figures for slums and their population. Thirdly, the surveyed area for the different organization were not also the same. CUS survey of 1978, 1980 and 1988 included Dhaka Municipal Area whereas Bangladesh

Bureau of Statistics (BBS) conducted survey on Dhaka Statistical Metropolitan Area. So, the survey results tend to differ. Fourthly, number of slums and their population depend on the definition of slums adopted by the organization conducting the survey.

Number of slums and their population depend on the direct count of all of them while characteristics of slum life is obtained by sampling survey. Results on various characteristics of slum life obtained through analysis of data received through sampling survey are quite representative and acceptable.

Accordingly some important slum characteristics as reported by the relevant organization that conducted the survey are presented in tabular form along with brief description.

1) Slum location

The location of slums in DCC area as surveyed by CUS in 1988 is shown Fig. F.4. Everywhere in the city there are slums. Slums are found in all the 75 wards of the DCC area, except that of ward No. 54 (Motijheel Colony Area), and even in Banani and Gulshan area. Slums are there along the vast area of railway lines. In general, there are slums everywhere in Old, Central and New Dhaka and its outskirts and fringes. Slums normally grow nearer to the potential area for work, employment and trade.

Most of the slum grew in recent years. According to the CUS survey in 1988, 25% of slums were established during last 7 years and 70% in 17 years. Slums which existed for more than 20 years are about 23% out of a total of 1125.

2) Slum population distribution

The population density of Dhaka slums is very high, since large number of people live in a comparatively small areas. The population density of Dhaka slums is around 2500 ~ 5000 person/ha. This abnormally high density sometimes appears incredible.

The population distribution of 1125 slums surveyed by CUS in 1988 is shown in Table F.4, and the corresponding family distribution in Table F.5. This illustrates the typical nature of Dhaka slums, high distribution of small sized slums, which could also be visualized from Fig. F.4.

From Table F.4 and Table F.5 it could be concluded that about 35% of the slums have less than 100 people with 10 - 20 families.

3) Slum community service level

Community service level is very poor in Dhaka slums and illegal slums are even worse (ref. Table F.6). Very little sanitation facilities exist in slums. There are only common or shared latrines in 974 slums (86.6%) and in 154 slums (13.4%) there is no latrine at all. Half of the slums (563) have tap water and 14.6% are served by shallow tubewells. Rest 35.4% slums depend on neighbours tap to meet potable water requirement. Slums which are connected by piped water supply have common bathing and washing places and rest depend on surface water. Only 341 (30.3%) of slums have gas connection but comparatively higher number of slums (55.7%) have electricity though many of the connections are illegal. Dhaka City Corporation extends solid waste collection and disposal services to only 97 slums (8.6%). There are nominal primary school facilities in 64 (5.7%), open space for children in 115 (10.2%) and primary medical facilities in 38 (3.4%) city slums.

4) Slum dwellers income level

Based on BBS survey of 1987, conducted covering 109,576 slum families, a majority representing about 31% earned a montly income in the range of 1000 ~ 1500 Taka (ref. Table F.7). Still a 7% earned only up to 500 Tk.

5) Slum dwellers place of origin

Place of origin of slum dwellers in Dhaka city varies rather widely as evident from Table F.8. This is understandable as Dhaka being the capital city, it is considered to be attractive in comparison to economically backward adjoining districts and regions. A large portion of slum people have come from Faridpur, Madaripur, Shariatpur, Chandpur, Barisal, Patuakhali, Mymensingh, Sherpur and Kishoreganj districts. River erosion is one of the major causes of migration and so greater number of people came from Bhederganj, Janzira and Naria of Shariatpur district, Haimchar and Nilkamol of Chandpur and Hizla of Barisal.

6) Slum improvement schemes

Though slums exist in Dhaka City for long period, few appreciable organizational and government measures have been taken up to solve this

problems. In January 1975, about 200,000 squatters/slum dwellers were evicted and 70,000 were shifted to three sites. Later on two schemes were taken up to rehabilitate them permanently at two sites. In Mirpur 2600 families have been rehabilitated. In Duttapara (Tongi) works on rehabilitation scheme for another 3,444 families nearing completion. These two schemes will permanently rehabilitate about 50,000 people. There are about 40 ha of land under each scheme costing a total of Tk. 430 million, amounting a cost per family rehabilitated of Tk. 71,000. In these scheme, each rehabilitated family will get a plot of land, one semi-permanent house with water and sanitation facilities including other physical (roads, drains) and communal (primary school, mosque, dispensary. open area for children) facilities for the complex. The schemes are funded by the Government of Bangladesh (GOB) and international agencies.

5.2 Slums of Narayanganj

There is no available survey records on slums even within the Narayanganj municipality area. The information on slums as obtained from the municipality is summarized below :

Slum location	Area (hectare)	No. of families	Population
Rishipara	0.50	350	1250
Tanbazar (Sweeper Colony)	0.75	750	2800
Kumudini Bagan (1 & 2)	0.50	850	3800
Golachipa (DND road)	0.75	110	450
Khanpur	1.00	225	950
Station Colony	0.25	250	1550
Old Zimkhana	0.50	650	3850
New Zimkhana	0.50	600	3750
Total :	4.75	3785	18400

From the table it appears that about 18400 people are living in an area of 4.75 hectare. This gives an average density of 3874 person/hectare which in much higher than the average population density of Narayanganj town which about 260 person/hectare.

5.3 Slums of Tongi

Not much information is available concerning slums in Tongi municipality which basically froms the Tongi area of the Study Area. The information received from the municipality is summarized below :

Slum location	Area (hectare)	No. of families	Population
Hazi Shabeb's Mazar	1.00	110	450
Tongi bazar (west)	0.50	150	600
Around Bata shoe Company	1.00	155	565
Telephone Industry (west)	0.50	50	150
Co-operative Bank	2.00	115	600
Zinat Textile (around)	3.50	250	850
Total :	850	830	3215

The table shows that 3215 people live in an area of 8.50 hectare, which gives an average population density of approximately 380 person/ha.

5.4 Action of Slum Improvement

The growth of urban slums has a very complex sociological aspect. As such it is not very often practicable to use relocation as the sole means of slum improvement. The most appropriate and economical means is to utilize self help potential of the dwellers to the maximum possible extent to improve the living conditions in-situ.

Provision of basic public amenities such as public stand post water supply, improvement of micro drains and access roads, provision of pubic toilets together with wash and bath facilities if necessary, and solid waste collection system would help in realizing improved living environment to a great extent. The KIP (Kampung Improvement Programme) of Jakarta was implemented successfully with the above objective of in-situ living environmental improvement with no relocation/resettlement of slum dwellers. Utilization of such an approach to improve the conditions of existing slums is proposed for consideration.

6. Environmental Quality

Surface water quality and ambient air quality are the priority elements to be representative to overall environmental quality of an area. The surface water quality of the Study Area is evaluated principally based on sampling survey conducted by the study team, while available information is sought for assessing ambient air quality.

6.1 Surface Water Quality

Surface water quality is the best indicator of recent pollution effects by human and other related activities on water bodies. Its significance to Bangladesh, where surface water encompasses about 6% of the total land area even during dry season need not be further emphasized.

6.1.1 Recent Water Quality

1) Monitoring Stations of DOE

The Department of Environment (DOE) has at present twenty (20) number monitoring stations throughout the whole country. Of these five (5) surface water monitoring stations fall within the study area, Greater Dhaka and its vicinity. The locations are shown in Fig. F.5. All these station are located in the river reaches of Buriganga (3 stations), Balu or Tongi Khal (1 station) and Lakya (1 station). Water quality at all these stations, other than that of Pagla in Buriganga River, is being monitored since 1970s. The monitoring has been irregular though monthly observation is the target. Nevertheless, no significant trend in water quality variation is noted based on the available data. This could be attributed to high assimilative capacity of the rivers which are essentially a part of international Ganges - Jamuna river system. The recent, water quality data of these five stations as monitored by DOE during low flow conditions of dry season, is shown in Table F.9.

2) Sampling by JICA

In due consideration to the scarcity of available monitoring stations by DOE in the study area and their confinement to rivers, which alone can not be considered to be representative to local human induced pollution, JICA study team conducted water quality sampling at 21 selected locations. The sampling were carried out both during dry season of January - February 1991 and rainy season of July ~ August 1991. The sampling locations were selected to encompass rivers, khals,

lakes and ponds in the whole study area, with due prominence to urbanized areas of Dhaka and Narayangang, but still be distributed all over the area. The sampling locations, along with those of DOE monitoring stations, are shown in Fig. F.5. As evident from this figure, three (3) sampling locations, one each in Buriganga, Balu and Lakya rivers, are same as those of the monitoring stations by DOE.

The water quality parameters measured respectively in field and in laboratory are itemized below.

(1) Field measurement : Temperature, Colour, Odour, Turbidity, PH, Electric Conductivity (EC) and Total Dissolved Solids (TDS).

(2) Laboratory measurement : Suspended Solids (SS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Organic Nitrogen (Org-N), Ammonia Nitrogen (NH_4N), and Fecal Coliform Density (FC).

The results of water quality analysis of dry season and rainy season are summarized respectively in Table F.10 and Table F.11.

6.1.2 Water Quality Evaluation

Both the dry season and rainy season water quality as measured by the study team are evaluated with due consideration to typical beneficial use in the Study Area. The important potential beneficial use considered are aquaculture(fishery), irrigation and other water contact activities. The appropriate criteria recommended for tropical developing countries by Pescod (AIT, 1973) and other available relevant standards/criteria were referred for the purpose of evaluation. In general, if a water body could support aquaculture then it would be suitable for all other important beneficial uses, including as a potential water supply source.

The 21 locations sampled are essentially composed of 15 moving water bodies of rivers (5 no.) and khals (10 no.) and 6 stationary ones of lakes (5 no.) and ponds (1 no.).

1) Water Quality Criteria

The stream water quality, with respect to the measured parameters, proposed according to the type of beneficial use is as follows. It is to be mentioned that

compliance with the criteria mentioned below alone may not be entirely satisfactory, necessary and sufficient, for the concerned beneficial use, as all the required parameters for the type of use is not measured and hence not incorporated. Nevertheless, these parameters represent the basic requirement for the concerned beneficial use due to potential living environmental pollution. Still pollution caused by industrial discharge and agricultural run-off (pesticides) might have far reaching consequences but are not measured, as they are beyond the scope of this study.

(1) Aquaculture

For freshwater aquaculture (all the sampled water bodies could be considered as freshwater sources) the recommended threshold minimum, of the measured parameters, are as follows:

DO	:	not less than 2.0 mg/l
NH_4N	:	not greater than 3.0 mg/l
PH	:	in the range of 6.5 ~ 8.5
TDS	:	not greater than 1000 mg/l

(2) Irrigation and other water contact activities like boating

No limitation on fecal coliform density (FC) is proposed as it is customary in Bangladesh to consume only cooked food. However, for vegetables that are eaten raw a FC limitation of 100 No./100 ml is generally adopted for irrigation water. Furthermore, it is extremely difficult to define a threshold concentration of FC for water contact activities, and the subsequent risk of infection, which principally depends on whether the water is swallowed. This aspect relates to public health education, an important but complex issue. The consideration on water contact is aesthetics such as appearance, colour and odour rather than epidemiology.

Accordingly the criteria adopted is;

DO	:	not less than 2.0 mg/l (same as aquaculture)
PH	:	in the range of 6.0 ~ 9.0
TDS	:	not greater than 2000 mg/l
EC	:	not greater than 2250 µmho/cm (25°C)

2) Evaluation

Based on the above criteria as well as aesthetics the water quality of the 21 water bodies sampled were evaluated for their potential beneficial use, assuming insignificant pollution peculiar to industrial discharge and agricultural run-off. The results, distinguished between dry and rainy season sampling results, are summarized in Table F.12.

As expected, dry season sampling results represented the critical water quality conditions in all sampling locations. Some improved beneficial use during rainy season is noted even in most water bodies that could be termed as polluted under critical conditions of dry season. An overall water quality evaluation under critical condition is presented below.

All the rivers sampled are relatively unpolluted (BOD less than 10 mg/l) while most khals are polluted (BOD 200 ~ 400 mg/l). Water quality of all five(5) rivers and three(3) khals, namely Bagunbari Khal in Amin Bazar, Hydrebad Khal in Tongi and Lakya Khal in Narayanganj and found to be suitable for all benefical use including a potential water supply source. However, Balu river at Tongi paper mills imparted reddish blue colour due to dyed water effluent discharged from the mills at the time of sampling. This industrial effluent may be responsible for the extremely low BOD to COD ratio of the analysis results. The three(3) major khals in the highly urbanized area, Begunbari, Segunbagicha and Dolai khals, are infact open sewers with no beneficial use. They are black in colour and emanate offensive odour. Nevertheless, a very significant improvement in the water quality of Bagunbari Khal is noted during rainy season.

The stationary bodies of lakes and ponds are moderately polluted and fall in between the rivers and khals in an overall sense. Ghognagar pond in Narayangnj was the worst polluted with the highest measured ammonia level (NH_4N 50.5 mg/l), while the Nawaberbag lake in Mirpur meets developed country standards for recreational water use even with respect to fecal coliform density, FC 430 no./100 ml, which is the least among all the 21 locations.

Finally, river, khal and lake/pond having the best water quality, based on the dry season sampling results of Table F. 10, or least human living environmental pollution, is identified as follows.

River : Karnatali River in Savar (Location No.9)
Khal : Lakya Khal in Narayanganj (Location No. 20)
Lake/pond : Nawaberbag Lake in Mirpur (Location No.7)

Infact a fecal coliform density of less than 1000 no./100 ml, a criteria applied widely in developed countries for recreational water use such as swimming, was measured only in the above three(3) locations. Also the above three(3) locations are essentially undeveloped areas which justifies their excellent water quality.

6.2. Ambient Air Quality

Even though there are water quality monitoring stations of DOE functioning since 1970s, no air quality monitoring was ever carried out in Bangladesh until 1989. In fact even at present there are no permanent ambient air quality monitoring stations in Dhaka or elsewhere in the country.

Nevertheless, on a demonstration basis ambient air quality at three (3) locations in Dhaka city was monitored by the on-going NEMPCP project for ADB during January - October 1990. The monitored locations are DOE office premise in Lalmadia, DOE laboratory premise in Motijheel and Tejgaon industrial area. The parameters monitored are SPM (suspended particulate matters), NO_x and SO_x. The results are yet to he reported in details, however it is confirmed as anticipated that vehicular emissions are the principal source of air pollutant in Dhaka city. This NEMPCP project is expected to make specific recommendation on air quality monitoring system for whole country.

7. Environmental Legislations and Standards

7.1 Environmental Legislations

The legislations/laws concerned to environmental protection and pollution control of Bangladesh could be broadly classified into three(3) categories as given below (Danida, 1989).

(1) Conservation of natural resources
(2) Protection of environmental health
(3) Environment pollution control

Though the above three categorizations are interrelated, the last two have much relevance to an urban environment, hence to this study, and briefed below.

1) Protection of Environmental Health

The various laws concerned to environmental health include the following :

(1) Local government laws, spanning a long period of enactment and amendments from the Bengal Local Self Government Act of 1885 to recent Local Government (Union Parishads) Ordinance of 1983.

The law assigns municipalities in cities and towns with elaborate responsibilities to deal with water supply, sanitation, solid waste management and other conservancy services including public health education relating to environmental health.

Furthermore, the Town Improvement Act of 1953 made provisions for improvement and development of Dhaka City through the establishment of a development authority. The aspects of improvement covers all public health amenities of water supply, sanitation, drainage and sewerage schemes, retention of parks and other open spaces of recreation.

Provisions to formulate a land use master plan is also made delineating agricultural, residential, industrial and other land uses.

(2) Factories Act of 1965, Shops and Establishment Act of 1965 and Factories rules of 1979.

These laws make ample provisions for necessary health and sanitation requirements for protection of workers from health hazards including water supply, sanitation, drainage, ventilation and others. The factories rule stipulates permission from Directorate of Health Services for disposal of wastes and effluents. However, no stipulation is made on factory emission of air pollutants.

(3) Bengal Motor Vehicle Act of 1939 ~ 1983.

The act qualitatively controls vehicular emission emphasizing on preventing damage to properties and roads by excessive smoke and others. Also it stipulates requirements to prevent qualitatively undue noise by vehicles.

(4) Other laws

Other relevant laws of environmental health are Agricultural Pesticides Ordinance of 1971 ~ 1983 which regulates import, manufacture, distribution and sales and use of pesticides to protect public health and that of animals and plants, and Bangladesh Pure Food Ordinance of 1959 which is aimed at prevention of food adulteration and distribution and sales of food injurious to health.

2) Environment Pollution Control

The Environment Pollution Control Ordinance of 1977 replaced the previous law, the Water Pollution Control ordinance of 1970. All concerned elements of environment, consisting of air, water, soil, food and shelter which support the growth of all forms of life, are incorporated in the law.

The law entrusts the Environment Pollution Control Board to formulate policies for control, prevention and abatement of environmental pollution and to recommend the necessary measures of such policy implementation, while the implementation itself is under the jurisdiction of the Director of Environment Pollution Control.

Though some of these laws and regulations are rather qualitative, they still deal with all necessary elements of urban environmental quality improvement aspects and pollution control measures. Strengthening the institutional and organizational means of environmental law enforcement is more critical rather than the updating of these environmental laws and regulations themselves.

7.2 Environmental Standards

A draft environmental quality standards (EQS) was prepared by the Department of Environment in August, 1988 and forwarded for approval by national government. Though the standard itself encompasses all major environmental elements, water, air and noise, it is formulated based on standards prevailing in other countries and yet to be modified to suit the local conditions. Furthermore, as pointed out in this draft standards itself, setting up of suitable monitoring system is a prerequisite not only to formulate a realistic standards but also to ensure any compliance with it, which still lacks in Bangladesh. The on-going "National Environmental Monitoring and Pollution Control

Project" (NEMPCP) under financial assistance from ADB is concerned to these aspects.

8. Environmental Aspects of Proposed Plan

The environmental effects anticipated by the implementation of the proposed plan could be broadly clarified into two(2) categories of direct effects and indirect effects. Direct effects are those directly caused by the implementation of the project itself, while indirect effects are those due to the subsequent change in land use and urbanization of flood free lands.

8.1 Direct Effects

The major direct environmental effects due to the construction of flood control and drainage facilities, embankments and improved khal cum pump stations, by the project are resettlement and severance. The other effects such as potential extra flooding or creation of new flood prone areas and water logging are infact direct technical aspects of project planning, hence duly considered accordingly.

1) Resettlement

In this master plan, the population living in those lands acquired for embankment is assumed to be displaced by the construction of embankments.

Accordingly, the total displaced household is estimated at 12,367 The corresponding cost of resettlement is 413.3 million Tk (ref. Table L.5 of Supporting Report L). This cost is incorporated in the overall cost-benefit analysis of Master Plan.

2) Severance

The major severance problem will be interference with river/khal transport or navigation. To a great extent urbanization would lead to change in mode of transport, from water based to land based, by means of roads. Nevertheless, important navigation routes, if any, will be identified during the subsequent feasibility study stage for the provision of navigation logs.

The environmental issues of direct technical significance are integrated in the project planning. However they are briefed below with due reference to the respective appendices of the report.

3) Extra Flooding

Out of the total Study Area of 850 sq·km, an area of about 620 sq·km could be considered as flood plain under the existing conditions, based on external flooding of 1988 floods. With the implementation of the proposed plan flood plain area would be reduced to 324 sq·km, a reduction of 48%.

This reduction by flood plain will not cause any significant change in the high watel level of the future flood plain in comparison to the existing one, as illustrated in Chapter 2 of Supporting Report G.

It is to be noted that this aspect of not creating a new flood damage prone area in the process of protecting another such area, in other words flood mitigation rather than flood damage diversion, is an essential technical aspect of a sound flood mitigation planning.

4) Water Logging

The major trunk drainage networks along with their respective retarding areas and pump stations are planned for a 5 year rain fall frequency as described in Supporting Report H. As far as possible drainage by means of gravity is planned in order to economize pump cost and to minimize operation and maintenance requirement. However, unfavorable topographic conditions, other than in Savar area, necessitated mostly pumped drainage under critical conditions of rainy season.

During dry season, under low dry weather flow conditions, drainage is solely by means of gravity and there will be no water logging problem even due to potential pump failure.

During rainy season water logging problem would occur as localised internal flooding either in case the rainfall or external river stage exceeds the design pump capacity or an inadvertent pump failure.

Under the condition of high degree of urbanization with inadequate sewerage, as in the case of existing urbanized area, the local drains would essentially function as open sewers, especially during dry season, like the Dolai, Segumbagecha and Begumbari khals. However, the rainy season water quality would be better than that of dry season due to dilution effects of local rainfall.

Accordingly a potential water logging will be confined to a short period during rainy season with relatively better quality khal water. The dry season gravity drainage ensures no water logging of highly polluted water. Hence unfavorable effects by potential water logging will be minimal on a year round basis. Furthermore, as in the case of existing conditions, the solution to water quality deterioration problem lies in instituting the required pollution control measures and its cause is urbanization. Drainage will contribute to reduced retention of polluted water and not toward water logging, in an overall sense, though it would lead to increased pollution load discharge to receiving waters.

Potential water logging in the form of internal flooding will be considered in details in the subsequent feasibility study.

8.2 Indirect Effects

Indirect environmental effects by subsequent urbanization of the flood free lands is very significant. The major effects are concerned to change in land use and the corresponding living environmental conditions.

1) Land Use

The existing land use pattern in the whole Study Area of 850 sq·km consists 62% of agricultural land (ref. Chapter 3 of Supporting Report C). It is assumed that no major change in land use would occur in the future flood plain area of 328 sq·km, which would remain unprotected by structural flood mitigation measures, and the high land agricultural no project area of 43 sq·km located in Savar.

Hence the degree of conversion from agricultural land use under existing conditions to urban land use under future conditions in the year 2010 requires consideration for the potential future urban area, or the areas of structural flood mitigation measure in general, of 456 sq·km (ref. Fig C.17~ C.18 of Supporting Report C).

The existing and future landuse of this portion of future urban area is as follows:

(1) Existing (1990)

Agricultural	:	21377 ha (47%)
Built-up	:	19971 ha (44%)
Others	:	4289 ha (9%)

(2) Future (2010)

Agricultural	:	3736ha (8%)
Built-up	:	36631 ha (80%)
Others	:	5270 ha (12%)
Total	:	45637 ha

Accordingly, the future urbanization involves a loss of about 17,640 ha of productive agricultural land to urban use. This amounts to a total annual net agricultural production loss of 202.9million Tk./year in monitary terms, based on the existing specific average agricultural production value of 14,000 Tk./ha./year, with a cropping intensity of 140% (ref. Chapter 11 of Supporting Report C).

However the productivity of remaining agricultural lands will be enhanced both due to mitigation of potential agricultural flood damage and year round availability of existing, protected, flood plains for cultivation.

Hence it is evident that flood control and drainage project itself will have beneficial effects on agriculture, provided change in landuse to urban is non existent.

Furthermore, the above determination in loss of agricultural lands do not incorporate the retarding areas of pump stations. Atleast a portion of retarding area, the area excluding that of permanent pond, has potential agricultural use during dry season. Hence, this agricultural loss is infact the maximum potential loss under critical conditions.

Accordingly, net agricultural production loss, if any, due to reduction in agriculture lands is considered as an intangible loss and not incorporated in the cost benefit analysis of the proposed plan. The loss is indirect, due to the fact that even under the no project conditions such a change in landuse to urban would

most probably occur, as per the "pull area" concept of Supporting Report C, because the major factor inducing the change is the existing urban area rather than anything else.

2) Future Living Environment

It is attemped to quantity the exertion of demand on "living environment" to the extent possible, by comparing the growth in water demand, wastewater generation, pollution load generation and solid waste generation of both existing and future urban areas in the Study Area due to the projected population increase.

The considerations and assumptions employed for the quantification of these living environmental parameters along with the summarized results are given below. The results are presented in Table F.13.

(1) Water Demand

The existing specific piped water demand of house connection (1990) is assumed at 120 l/person/day, based on Narayanganj water supply project of JICA in 1984.

The corresponding figure for public stand post and rural type well water is assumed at 50 l/person/day, based on DPHE-UNICEF-DANIDA study of 1985-1986.

The future specific piped water demand of house connection (2010) is assumed at 150 l/person/day, with due consideration to similar cases and allowing for potential enhancement in quality of life.

Rural type and stand post water demand is assumed to remain constant at 50 l/person/day, even in future.

High and mid income population in urban area is assumed to exert piped in house water demand, while low income population the rural type and stand post water demand.

Accordingly the total potable water demand under the existing and future conditions in the future urban area of 456km^2 is estimated at respectively

488 MLD and 1526MLD as shown in Table F.13, accounting for an annual average growth of 15.6%.

(2) Wastewater Generation

The quantity of wastewater generation could be approximated to that of water demand, though a reduction up to 20% occurs depending on local conditions. However, the pollution load generation is more an important parameter rather than wastewater generation and is estimated under the following conditions.

The existing specific pollution load generation (1990) is determined to be 20.2 g BOD_5/person/day as given below.

Per capita sewage generation is 101 l/person/day. BOD_5 concentration of sewage is 200mg/l. Both the above data were as per the basic design report of JICA on sewage construction and rehabilitation in 1988.

A recent master plan study by JICA on sewerage development of Jakarta, Indonesia (1990) determined the average existing and future (2010) pollution load generation as follows.

Existing pollution load generation (1989) : 27.9 g BOD_5/person/day
Future pollution load generation (2010) : 33.4 g BOD_5/person/day

As it is reasonable to assume a growth in pollution load generation with enhanced quality of life, in the absence of suitable data, the same growth rate as per Jakarta is assumed for Dhaka as well.

Accordingly the future specific pollution load generation is estimated at 24.2 g BOD_5/person/day.

The above specific pollution load generation is considered to be an overall average value independent of income class distribution.

The total pollution load generation under existing and future conditions is estimated respectively at 121 ton BOD_5/day and 305 on BOD_5/day, an annual average increase of 12.6% (ref. Table F.13).

(3) Solid Waste Generation

Based on inventory study results the existing average specific solid waste generation is estimated at 348 g/person/day.

Generally in Japan, a developed country, the per capita solid waste generation rate is estimated to increase at an annual rate of 3%. However, for an urban area of a developing country like Dhaka an annual increase of 1.5% is considered to be reasonable in order to take into account improved standard of living and reduced recycling.

Accordingly, future (2010) specific solid waste generation is determined to be 470 g/person/day.

The above specific generation rates are gross average and independent of income class distribution.

The total solid waste generation under the existing and future conditions in the respective urban areas is estimated at 2080 ton/day and 5930 ton/day, an annual average increase of 14.3% (ref. Table F.13).

Finally, the above quantities of living environmental demand, though somewhat approximate, demonstrates the magnitude of indirect consequence of this master plan due to subsequent urbanization.

9. Environmental Evaluation

9.1 With and Without Project Environment

The project is principally aimed at protecting the future urban area of 456 km^2 in and around Dhaka, the Dhaka metropolis until the year 2010, from potential flood damage by means of structural measures of flood mitigation. Nonstructural measures, as flood plain management, is proposed for remaining lowlying areas of 328 km^2, the area to be left undeveloped with no signifant change in land use, and hence the baseline environmental conditions. There is also a high land "no any measure" rural agricultural area of 43 km^2, that does now fall under any of the above two categories, in Savar area.

Accordingly, the scenario with and without project, the flood control and drainage master plan, in the future urban area is examined in order to justify the project as the basic environmental improvement measure.

First of all, the necessity of the project is the result of existing urban area, Dhaka City, which is not a creation by this project. It is most likely that even without the proposed project, the "pull areas" as demarcated in Supporting Report C would undergo urbanization, more precisely an unplanned urbanization, and hence change in land use, being induced by the existing urban area.

The opportunity of planned urbanization with due flood control and drainage means is the major advantage offerd by this project. This is specially so in consideration to the subsequent metropolitan planning study to be conducted with UNDP assistance.

The direct unfavorable environmental effects by the project, as dealt with in the foregone section, would be highly localized, short term and not very significant, other than the resettlement issue, in comparison to the necessity and benefit of the project.

Then the major impact by the project would be indirect caused by subsequent urbanization. Hence it is very realistic to view this master plan from a broad perspective of necessity, effects and enhancement of an urban environment.

Once the task of urbanization is recognized as inevitable it is obvious that flood control and drainage facility would become the basic urban environmental enhancement measure of planned urbanization, preceding other sectoral investment in order to fully realize the benefits of such subsequent investment. Such other sectoral investments of priority include those concerned to human living environmental quality, namely potable water, sewerage/sanitation and solid waste management, transportation system and others.

This point is made to clearly emphasize the threat of epidemics of water borne disease due to widespread cross water contamination inherent to flooding, not to mention the other flood damages. Simply, flooding is a public health threat that compounds the public health hazards which may already prevalent, or become to be prevalent in future, due to inadequate living environmental sanitation measures.

The existing flood related public health hazards in the present urban areas of Dhaka, which lacks proper living environmental sanitation measures as emphasized in the

foregone chapters, is a testimony to the above point. The immediately foreseen benefit by the project is the public health related environmental improvement of existing urban areas of Dhaka.

Table L.1 of Supporting Report L presents the available information on population affected by major communicable water borne diseases in Dhaka Region by the 1987 and 1988 floods.

Hence, it is very clear that the environmental condition in the objective area (future urban area) would be deteriorated under the without project conditions in comparison to that of with project, irrespective of the service level of other urban amenities including that of living environment. Accordingly, flood control and drainage facilities for an urban environment in itself is a basic environmental enhancement measure.

Nevertheless, in order to fully realize the benefits of flood control and drainage measures, timely investment on human living environmental enhancement measures and other urban amenities is necessary, and not to be overlooked, as emphasized in the subsequent section. Obviously, such a programme should commence with the enhancement of existing urban living environmental conditions.

9.2 Future Environmental Enhancement Measures

The required future living environmental enhancement measures are identified and recommended. This identification is principally based on the deficiencies both with respect to the existing environment related facilities and the respective legal, organizational and institutional concerns that were elucidated by the inventory study as described in the foregone Chapter 1 ~ 7.

The required environmental enhancement measures for the existing major urban environment of DCC area, including the legal, institutional and organizational aspects, have been dealt with in details in the FAP-8B interim report of May, 1991 by ADB.

The above report presents an integrated environmental management plan as a component of the feasibility study for Dhaka Flood Protection Project. Hence, detailed considerations on environmental enhancement measures for Dhaka could be referred to the above report, which incorporates the basic data generated by this living environmental study as well. The project area of the above feasibility study (FAP-8B) is entirely encompassed by this master plan study (FAP-8A), and accordingly both the

studies are well co-ordinated. Nevertheless, some important and priority environmental enhancement measures are summarized below.

1) Environmental Monitoring

Monitoring is the basic step in realizing a sound environmental management. Without an effective monitoring system, the laws, regulations and standards would be toothless with no means of enforcement. The ongoing NEMPCP project by ADB is aimed at institutional strengthening of DOE, which includes setting up environmental data base, upgrading of laboratory facilities and others.

At present mainly some major river water quality are monitored on a monthly basis by DOE. However, not only the frequency of monitoring, but also the parameters monitored are irregular. Apart from this there exists no organized monitoring programme either for groundwater or air quality. Hence the following strengthening measures of environmental monitoring is proposed for the three (3) major elements, surface water, groundwater and ambient air.

(1) Surface Water Quality

The monitoring system shall incorporate a variety of water bodies, and not just major rivers, rivers, Khals, lakes and ponds. The parameters to be monitored being selected based on anticipated beneficial use. However, it is recommended to monitor for the same sample atleast all those parameters measured by the study team during sampling (ref. Table F.10), in order to facilitate a reliable assement of water quality concerned to living environmental pollution. Less frequent monitoring of other parameters, such as heavy metals, pesticides, be considered to regulate industry and agriculture based pollutants, that might impair the concerned beneficial use. DOE shall be the agency, as at present, responsible for monitoring and ensuring its compliance.

(2) Groundwater Quality

DWASA owns about 150 deep tube water supply wells in Dhaka and Narayanganj, the raw water quality of which is a concern from a public health view point. It is understood that DWASA has a regular monitoring program for its water sources in order to ensure their conformity for potable use. However, it is necessary to incorporate shallow groundwater, all

DWASA wells are more than 100 m deep, as well in the monitoring programme for which DWASA is the most suitable organization. It is further recommended such results of analysis are forwarded to DOE, so that DOE would be the ultimate authority of monitoring program and its compliance.

(3) Ambient Air Quality

There is no air quality monitoring system in the country. Hence it is recommended to establish initially such a system in the major cities and industrial areas. DOE shall be the concerned responsible agency for monitoring.

It is recommended that DOE, while awaiting of the approval of draft standards by the national government, shall strive to become capable both institutionally and technically, including the required laboratory facilities, to monitor all those parameters of the respective environmental elements for which limitations are proposed in the draft standards. It is also essential to organize the relevant monitoring programme immediately. In this regards, atleast as an urgent measure, DOE could seek the cooperation to utilize the laboratory facilities of DWASA, AEC, ICDDRB and others, in realizing the monitoring requirements.

Even a long term cooperative programme with these organizations for utilizing their laboratory facilities may be considered for optimal utilization of available laboratory, technical expertise and other resources.

It is to be emphasized that though environmental monitoring is essential to formulate the necessary strategies and the subsequent action programmes either to mitigate deterioration of or to enhance the environmental quality, it should not be construed as the panacea to identify all required environmental enhancement measures. The notable exceptions are potable water, sanitation and solid waste management aspects. These are basic public health requirements, hence need not await for an environmental monitoring evaluation. These living environmental aspects, provision of which indirectly contributes atleast marginally to enhancement of overall environmental quality, are dealt with below.

2) Living Environment

Enhancement of basic public health related living environmental conditions of Dhaka is an uphill task in consideration to the extent of its deteriorated baseline conditions as illustrated in the foregone chapters. Increasing urban population would further exacerbate these problems unless the required measures are taken, initially to rectify the existing deteriorated urban environment.

The priority actions, based on the evaluation of existing conditions are as follows:

(1) Improvement of service level of on-site sanitation aspects such as provision of low cost sanitary toilets, desludging of septic tanks and others. It is recommended that DWASA in addition to water supply, sewerage and drainage to undertake the responsibility of desludging and subsequent sanitary disposal of septic tank sludge.

The possibility of combined treatment of sewage and septic tank sludge (septage) in the Pagla stabilization pond system is an option recommended for consideration.

(2) The practice of insanitary land filling of solid wastes, in particular, its dumping in just a lowlying area as a land filling material is recommended to be abolished. Though, an ideal sanitary land fill is composed an impermeable bed with leachete collection and treatment system, atleast the site is recommended to be prepared with a compacted clay layer to mitigated leachete infiltration into underground.

(3) Improvement of living environmental conditions of slums in the form of slum improvement programme is very necessary, though tedious, and in this regard the KIP (Kampung Improvement Programme) experience of Jakarta, Indonesia would assist in formulating an appropriate strategy. KIP experience demonstrates such programme could be best accomplished with entirely local initiative and without any significant external contribution. In this regards, as dealt with in Chapter 5, those organizations contributed in the research and investigation of socio-economic conditions of Dhaka slums could play an active role in planning and implementation of real slum improvement measures.

Furthermore, as a measure to mitigate slum proliferation in the future urban areas reservation of lands for low cost housing, and the respective housing developments are recommended to be undertaken by the concerned state agency like RAJUK. The population to be resettled by embankment construction shall be given priority as tenants of such housing schemes.

(4) It is indeed necessary to plan and execute expansion schemes of water supply, sewerage/sanitation and solid waste management with increasing urbanization, as the provision of basic public health facilities. The information on the baseline condition of these existing facilities presented in this report would contribute not only as the basis of future planning but also in securing the required funds for such projects in realizing a pleasant living environment.

Table : F.1 Elevated Water Distribution Tanks in Dhaka - DWASA

Location	Capacity (m^3)	Type of Structure	Remarks
Old Town			
Water Works	910	R.C. Tank	
Armanitola	365	Steel Tank	Not serviceable.
Victoria Park	545	Brick Masonary	
Islampur	910	Steel Tank	Not serviceable.
Gandaria	365	Brick Masonary	
Railway Station (Fulbaria)	910	R.C. Tank	
Hazaribagh	910	- do -	
Bonogram	910	- do -	
Hatkhola	910	- do -	
New Town			
Motijheel (B. Bank)	455	R.C.Tank	Not in service
Bijoy Nagar	455	- do -	
Kakrail	455	- do -	
Bakshi Bazar	455	- do -	
Azimpur	455	- do -	
B.D.R.	70	- do -	
Mohakhali	135	- do -	
T.B. Hospital	90	- do -	
Gulshan	680	Brick Masonary	
Dhanmondi No. I	455	R.C. Tank	
Dhanmondi No. II	455	- do -	
Mohammadpur No. I	455	R.C. Tank	
Mohammadpur No. II	455	- do -	
Mirpur Sec. No. I	455	- do -	
Mirpur Sec. No. II	455	- do -	
Mirpur Sec. No. VI	680	- do -	
Mirpur Sec. No. X	680	- do -	
Mirpur Sec. No. XII	680	- do -	
Pallabi	455	- do -	
Tejgaon No. I	455	- do -	
Tejgaon No. II	455	- do -	
Lalmatia	4550	Steel Tank	
Gulshan	4550	Steel Tank	
Fakirapool	4550	Steel Tank	
Total	29770		

Table F.2 Water Supply Facilities Implemented by JICA in Narayanganj

Facilities provided	Westbank	Eastbank	Total
1. Treatment Plant	One site (45 MLD)	One site (19 MLD)	Two sites (64 MLD)
2. Transmission pipes 300 - 700mm dia DCIP	2,772.0 m	750.0 m	3,522.0 m
3. Overhead tanks 300 - 2,000 m^3	6	2	8
4. Distribution pipes			
DCIP 600 mm dia	1,990.0 m	-	1,990.0 m
" 500 mm dia	1,540.0 m	-	1,540.0 m
" 450 mm dia	-	1,630.0 m	1,630.0 m
" 400 mm dia	1,140.0 m	410.0 m	1,550.0 m
" 350 mm dia	950.0 m	760.0 m	1,710.0 m
" 300 mm dia	2,350.0 m	1,060.0 m	3,410.0 m
" 250 mm dia	5,190.0 m	1,890.0 m	7,080.0 m
PVC 200 mm dia	4,490.0 m	2,930.0 m	7,420.0 m
" 150 mm dia	4,310.0 m	1,880.0 m	6,190.0 m
" 100 mm dia	11,705.0 m	6,800.0 m	18,505.0 m
Total :	33,665.0 m	17,360.0 m	51,025.0 m

Table F.3 Sewage Lift Station in Dhaka - DWASA

Location	No. of Pumps	Discharge (m^3)	Head (m)	Power (kw)	Remarks
Asad Gate	3	5.7	7.5	11.25	
Azimpur	2	3.8	9.0	18.75	
Faridabad	2	3.8	12.0	18.75	Being replaced by submersible pumps 2 x 7.5 kw
Bashaboo	5	28.4	12.0	86.25	
Magh Bazar	2	3.8	9.0	18.75	Being replaced by submersible pumps 2 x 15 kw
Medical College	3	3.8	7.5	11.25	
Narinda (Old)	4	64.4	12.0	244	
Narinda (New)	7	106.0	17.0	394	
Nawabgonj	2	3.8	9.0	22.5	Being repladed by submersible pumps 2 x 7.5 kw
New Market	4	11.4	7.5	22.5	
P & T	2	9.5	12.0	30	
Swamibag	5	28.4	12.0	86.25	
Hazaribag	4	11.4	7.5	22.5	Being replaced by submersible pumps 2 x 15 kw and 2 x 30 kw.
Tejgaon	5	24.6	12.0	82.5	
Pagla (Outfall)	7	106.0	10.5	244	

Table F.4 Population Distribution in Dhaka Slums

Population	No. of Slums	Percentage
Less than 100	395	35.1
101 - 200	252	22.4
201 - 300	117	10.4
301 - 400	52	4.6
401 - 500	68	6.1
501 - 750	59	5.2
751 - 1000	55	4.9
1001 - 1500	44	3.9
1501 - 2000	19	1.7
2001 - 3000	16	1.4
3001 - 5000	18	1.6
5000 +	30	2.7
Total :	1125	100.0

Ref. : CUS, Slums and Squatters in Dhaka, 1988

Table F.5 Family Distribution in Dhaka Slums

No. of Family	No. of Slums	Percentage
10 - 20	411	36.5
21 - 40	222	19.7
41 - 80	177	15.7
81 - 100	64	5.7
101 - 150	72	6.5
151 - 200	54	4.8
201 - 300	45	4.0
301 - 500	28	2.5
500 +	52	4.6
Total :	1125	100.0

Ref. : CUS, Slums and Squatters in Dhaka, 1988

Table F.6 Community Service Level in Dhaka Slums

Facilities	No. of Slums	Percentage
Gas	341	30.3
Electricity	627	55.7
Solid waste disposal	97	8.6
Water supply (WASA)	563	50.0
Tubewell	164	14.6
Common or shared latrine	974	86.6
Bathing place	575	51.1
Mosque	116	10.3
Primary school	6	5.7
Open space for children	115	10.2
Shops	296	26.3
Health/Dispensary	38	3.4

Ref. : CUS, Slums and Squatters in Dhaka, 1988 (Total slums 1125)

Table F.7 Income Level of Dhaka Slum Dwellers

Income (Tk. / Month)	No. of Families	Percentage
Up to 500	7703	7.03
501 - 1000	21795	19.89
1001 - 1500	34166	31.18
1501 - 2000	21773	19.87
2001 - 3000	15176	13.85
Above 3000	8963	8.18
Total :	109576	100.00

Ref. : BBS Survey of 1987

Table F.8 Place of Origin of Dhaka Slum Dwellers

Origin/Division/District	Percentage
Dhaka Division	**52.0**
Faridpur	20.8
Dhaka	19.8
Mymenshingh	7.1
Jamalpur	2.9
Tangail	1.4
Chittagong Division	**20.2**
Comilla	15.5
Noakhali	3.3
Sylhet	0.7
Chittagong	0.6
Chittagong Hill tracts	0.1
Rajshahi Division	**4.2**
Rangpur	2.1
Pabna	1.0
Dinajpur	0.5
Rajshahi	0.4
Bogra	0.2
Khulna Division	**22.4**
Barisal	18.5
Patuakhali	1.9
Khulna	1.2
Jessore	0.5
Kustia	0.3
Other district	1.2
Total	100.0

Ref : Based on data derived from survey conducted by CUS and other Agencies (1980 - 89) on a total 10439 slum families.

Table F.9 Recent Dry Season Water Quality Data of DOE Stations (Jan. ~ Mar. 1988, 1989)

Monitoring Station		Sampling Period	PH	EC (Umho/cm)	TDS (mg/l)	SS (mg/l)	DO (mg/l)	BOD (mg/l)	No. of Sample
Index No.	Location								
DOE - 1 (2)	Chandnighat WASA Intake in Buriganga River	Jan. - Feb. 1988 Jan. - Mar. 1989	6.8 ~ 7.1 7.2 ~ 7.4	102 ~ 140 290 ~ 450	140 ~ 172 200 ~ 310	45 ~ 114 33 ~ 57	5.0 ~ 6.0 4.7 ~ 5.2	2.1 ~ 3.2 0.2 ~ 2.8	8 9
DOE - 2 (12)	Balu River near Tongi paper mill	April 1989 *	7.1 ~ 7.2	376 ~ 380	262 ~ 265	42 ~ 45	6.6 ~ 7.2	110 ~ 190	3
DOE - 11 (18)	Lakya River in Narayanganj	Jan. - Mar. 1989	7.2 ~ 7.4	205 ~ 230	145 ~ 162	30 ~ 61	5.0 ~ 7.4	0.9 ~ 2.4	9
DOE - 3 (22)	Pagla-WASA sewage effluent in Buriganga River	Jan. - Mar. 1989	7.1 ~ 7.4	290 ~ 460	4 ~ 320	9 ~ 92	5.0 ~ 6.7	2.0 ~ 3. 2	9
DOE - 6 (23)	Hazaribag - Buriganga River	Feb. 1988 Jan - Feb. 1989	6.8 ~ 7.0 7.2 ~ 7.4	160 ~ 202 245 ~ 360	322 ~ 340 174 ~ 252	122 ~ 127 34 ~ 101	5.8 ~ 6.2 5.8 ~ 7.1	- 1.2 ~ 1.9	3 6

Note : Index No. as DOE is that of the Department of Environment as per national grid.
Index No. in parenthesis is as per that of station location shown in Fig. F.5
* No available data for Jan. ~ Mar. 1988, 1989.

Table F.10 Dry Season Water Quality Sampling Results of JICA (Jan. ~ Feb. 1991)

Location		PH	EC	TDS	SS	DO	BOD	COD	Org - N	NH_4 - N	FC
No.	Description		(Umho/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(No./100ml)
1	Painar Khal Keranigang	6.9	492	246	100	0.9	198	381	1.1	0.5	$1.8x10^6$
2*	Chandighat WASA Intake	7.1	431	215	69	3.6	9.8	64	0.7	1.3	$1.2x10^5$
3	Ramna Lake	6.8	264	130	56	3.2	3.7	83	0.8	1.1	$1.2x10^4$
4	Dhanmondi Lake	6.9	632	316	68	9.8	2.9	21	1.5	12.5	$3.2x10^5$
5	Nawabganj Khal	7.0	719	358	310	2.5	232	799	1.1	11.9	$3.6x10^6$
6	Rayer Bazar Khal	7.2	775	388	175	4.0	199	420	1.0	8.1	$4.4x10^5$
7	Nawaberbag Lake	7.1	121	61	14	6.3	1.9	5.0	0.9	1.8	$4.3x10^2$
8	Amin Bazar Bagunbari Khal	7.7	368	184	98	8.3	2.4	28	0.4	0.6	$9.0x10^3$
9	Savar Bank Town Karnatali River	7.3	473	237	22	7.8	2.8	42	1.4	0.9	$9.0x10^2$
10	Savar Bazar Banshi River	7.7	424	213	132	8.0	5.0	31	0.4	0.6	$5.0x10^3$
11	Majukhan Railway Bridge Hydrebad Khal	7.6	244	120	388	7.9	4.0	6.9	0.4	0.9	$1.3x10^4$

Location		PH	EC	TDS	SS	DO	BOD	COD	Org - N	NH_4- N	FC
No.	Description		(Umho/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(No./100ml)
12*	Balu River near Tongi paper mill	7.0	338	169	108	3.4	0.4	353	0.7	1.1	$3.2x10^4$
13	Uttara Lake	6.9	159	79	228	7.6	7.0	69	0.5	0.6	$4.0x10^3$
14	Gulshan Lake	7.0	221	110	118	3.2	4.8	76	0.4	1.2	$5.1x10^3$
15	Rampura bridge Begunbari Khal	6.6	754	404	230	0	400	1334	0.8	21.8	$8.4x10^5$
16	Kamalapur Segunbagicha Khal	6.7	831	415	1560	0	348	982	1.4	23.5	$8.0x10^5$
17	Sarulia Bazar DND Khal	7.2	381	562	110.0	3.8	76	275	1.8	5.3	$3.2x10^4$
18*	Narayanganj terminal-Lakya river	7.4	303	147	12	10.6	1.5	6.9	0.3	2.6	$4.5x10^3$
19	Daobhog pond Narayanganj	7.2	1262	631	202	2.4	290	570	1.7	50.5	$1.2x10^5$
20	Ghognagar bridge Lakya khal	7.2	457	228	62	10.8	0.9	6.5	0.6	1.3	$5.0x10^2$
21	Sutrapur bridge Dholai khal	6.6	1117	562	372	0	220	812	1.6	41.0	$3.6x10^7$

Note : For locations Ref. Fig. F.5
* Also monitoring stations of DOE

Table F.11 Rainy Season Water Quality Sampling Results of JICA (July ~ Aug. 1991)

Location		PH	EC	TDS	SS	DO	BOD	COD	Org - N	NH_4 - N	FC
No.	Description		(Umho/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(No./100ml)
1	Painar Khal Keranigang	7.3	124	62	56	6.0	2.2	120	0.7	0.4	$9.1x10^3$
2*	Chandighat WASA Intake	6.9	140	72	85	5.8	2.5	16	0.6	0.6	$1.8x10^4$
3	Ramna Lake	7.1	131	65	15	5.3	1.5	46	1.0	1.0	$1.0x10^3$
4	Dhanmondi Lake	6.9	260	111	42	7.2	1.9	10	0.3	0.9	$1.0x10^4$
5	Nawabganj Khal	7.2	130	65	94	5.6	13	104	0.4	0.8	$3.0x10^3$
6	Rayer Bazar Khal	7.0	602	291	60	0.4	20	150	0.2	6.6	$4.5x10^5$
7	Nawaberbag Lake	7.0	140	72	17	5.9	0.4	4.0	0.5	1.1	$1.5x10^2$
8	Amin Bazar Bagunbari Khal	6.9	120	61	16	3.4	1.0	8.0	0.5	1.3	$4.0x10^3$
9	Savar Bank Town Karnatali River	6.8	110	59	48	6.2	1.0	24	0.4	0.8	$1.8x10^2$
10	Savar Bazar Banshi River	7.0	110	56	157	5.8	3.4	12	0.4	0.9	$7.0x10^2$
11	Majukhan Railway Bridge Hydrebad Khal	7.1	89	41	43	5.0	1.1	4.0	0.5	0.4	$3.0x10^2$

Location		PH	EC	TDS	SS	DO	BOD	COD	Org - N	NH_4- N	FC
No.	Description		(Umho/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(No./100ml)
12*	Balu River near Tongi paper mill	7.9	107	54	43	6.2	4.6	22	1.2	0.4	$2.5x10^4$
13	Uttara Lake	7.0	129	65	17	6.8	5.6	11	0.8	0.4	$1.0x10^4$
14	Gulshan Lake	7.0	129	93	78	8.6	1.2	18	0.6	0.5	$1.5x10^4$
15	Rampura bridge Begunbari Khal	7.6	384	192	22	7.2	27	156	1.5	6.3	$1.5x10^4$
16	Kamalapur Segunbagicha Khal	6.7	601	299	192	0	33	176	1.5	16.0	$5.0x10^4$
17	Sarulia Bazar DND Khal	7.2	2.30	130	65	5.7	24	64	0.5	0.2	$8.0x10^4$
18*	Narayanganj terminal-Lakya river	7.0	130	59	36	5.7	0.4	7.0	0.8	0.2	$2.5x10^3$
19	Daobhog pond Narayanganj	7.9	640	329	49	3.5	5.0	98	0.8	10.3	$7.0x10^4$
20	Ghognagar bridge Lakya khal	6.8	110	56	22	3.9	1.0	3.0	0.8	0.3	$3.0x10^2$
21	Sutrapur bridge Dholai khal	7.4	727	364	105	0	25	108	0.7	17.8	$2.0x10^4$

Note : For locations Ref. Fig. F.5
* Also monitoring stations of DOE

Table F.12 Water Quality Evaluation Distinguished between Dry and Rainy Season Sampling by JICA

Location		Potential Beneficial Use
No.	Description	
1	Painar Khal Keranigang	Limited to water contact only Aquaculture/irrigation/water supply
2	Chandighat WASA Intake	Aquaculture/irrigation/water supply Same as dry season
3	Ramna Lake	Aquaculture/irrigation/water supply (threshold) Aquaculture/irrigation/water supply
4	Dhanmondi Lake	Irrigation/water contact Aquaculture/irrigation/water supply
5	Nawabganj Khal	Limited to water contact only Aquaculture/irrigation/water supply
6	Rayer Bazar Khal	Limited to water contact only Same as dry season
7	Nawaberbag Lake	Aquaculture/irrigation/water supply Same as dry season
8	Amin Bazar Bagunbari Khal	Aquaculture/irrigation/water supply Same as dry season
9	Savar Bank Town Karnatali River	Aquaculture/irrigation/water supply Same as dry season
10	Savar Bazar Banshi River	Aquaculture/irrigation /water supply Same as dry season
11	Majukhan Railway Bridge Hydrebad Khal	Aquaculture/irrigation/water supply Same as dry season
12	Balu River near Tongi paper mill	Aquaculture/irrigation/water supply Same as dry season
13	Uttara Lake	Aquaculture/irrigation/water supply Same as dry season
14	Gulshan Lake	Aquaculture/irrigation/water supply (threshold) Aquaculture/irrigation/water supply
15	Rampura bridge Begunbari Khal	None Irrigation/water contact
16	Kamalapur Segunbagicha Khal	None Same as dry season
17	Sarulia Bazar DND Khal	Irrigation/water contact Aquaculture/irrigation/water supply
18	Narayanganj terminal-Lakya river	Aquaculture/irrigation/water supply Same as dry season
19	Daobhog pond Narayanganj	Limited to water contact only (threshold) Irrigation/water contact
20	Ghognagar bridge Lakya Khal	Aquaculture/irrigation/water supply Same as dry season
21	Sutrapur bridge Dholai Khal	None Same as dry season

Note: "None" means no potential beneficial use
"Threshold" means limiting condition for concerned beneficial use
Upper row beneficial use based on dry season sampling and lower row vice-versa.

Table F.13 Comparison of Living Environmental Demand due to Urbanization in Future Urban Area

Item	Change in Condition			Remarks
	Existing (1990)	Future (2010)	Percent (%) Annual Increase	
Study Area (km^2)	850	850	-	Total area of structural and nonstructural flood protection measures.
Total Urban Population (million)	6.0	12.6	10.5	Population in potential future urban area as defined in Chapter 11 of Supporting Report C
High and Mid Income Population (million)	2.7	9.0	16.6	Population exerting piped house connection demand
Low Income Population (million)	3.3	3.6	5.6	Population exerting stand post and well water demand
Potable Water Demand (MLD)	488	1526	15.6	Existing production capacity of surface water supply system is limited to about 80 MLD only.
Pollution Load Generation (ton BOD_5/day)	121	305	12.6	Estimation is based on per capita average
Solid Waste Generation (ton/day)	2080	5930	14.3	Estimation is based on per capita average

Note: The above population figures are rounded off values

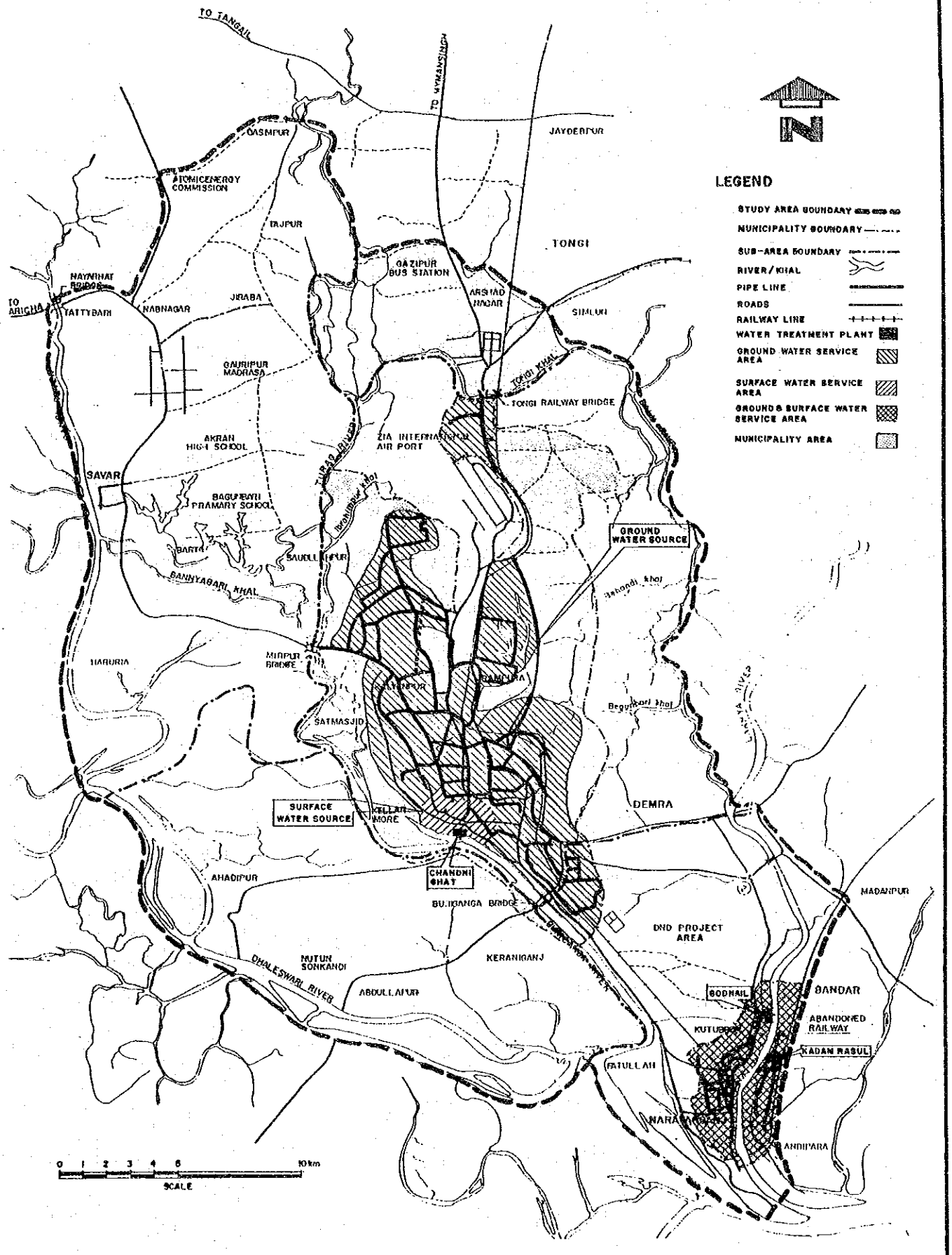

FIG. F.1 EXISTING PIPED WATER SERVICE AREA

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA