SPM (suspended particulate matters), NOx and SOx. The results are yet to be reported in detail. However it is confirmed, as anticipated, that vehicular emissions are the principal source of air pollutant in Dhaka city.

7.4 Environmental Standards

Draft environmental quality standards (EQS) were prepared by the Department of Environment in August, 1988 and forwarded for approval by National Government. Though the standards themselves encompass all major environmental elements, water, air and noise, they are based on standards prevailing in other countries and yet to be modified to suit the local conditions. A suitable monitoring system is required not only for a rational standard development but also for its enforcement.

Table 7.1 community Service Level in Dhaka Slum

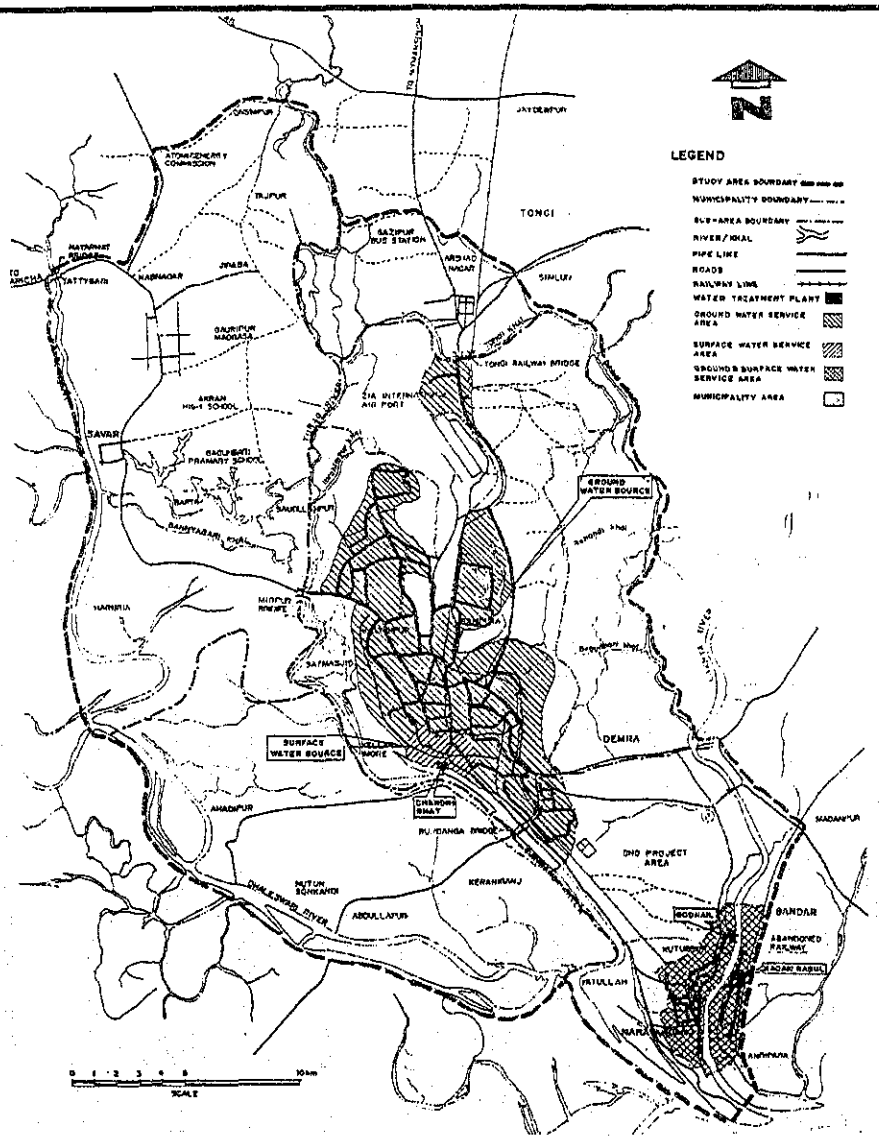
Facilities	No. of Slums	Percentage
Gas	341	30.3
Electricity	627	55.7
Solid waste disposal	97	8.6
Water supply (WASA)	563	50.0
Tubewell	164	14.6
Common or shared latrine	974	86.6
Bathing place	575	51.1
Mosque	116	10.3
Primary school	6	5.7
Open space for children	115	10.2
Shops	296	26.3
Health/Dispensary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

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

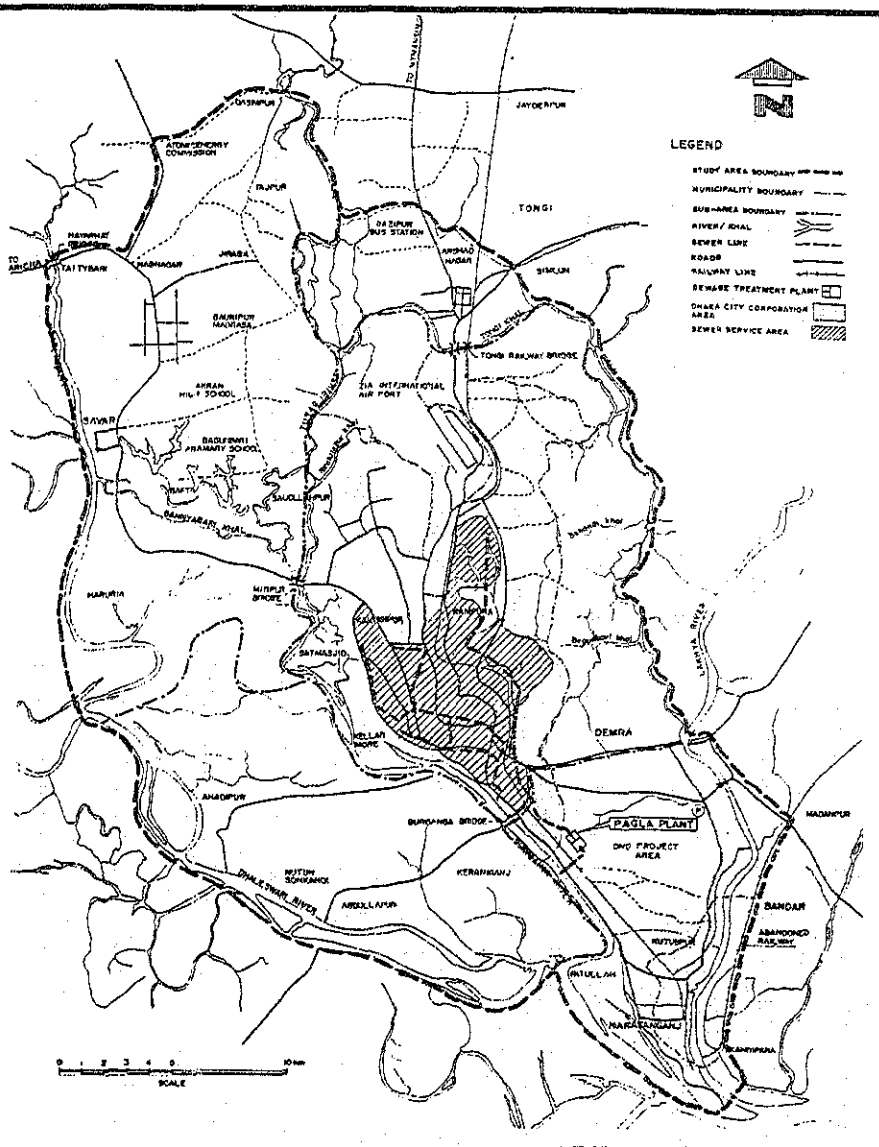
Table 7.2 Water Quality Evaluation Distinguished between Dry and Rainy Season Sampling by JICA

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



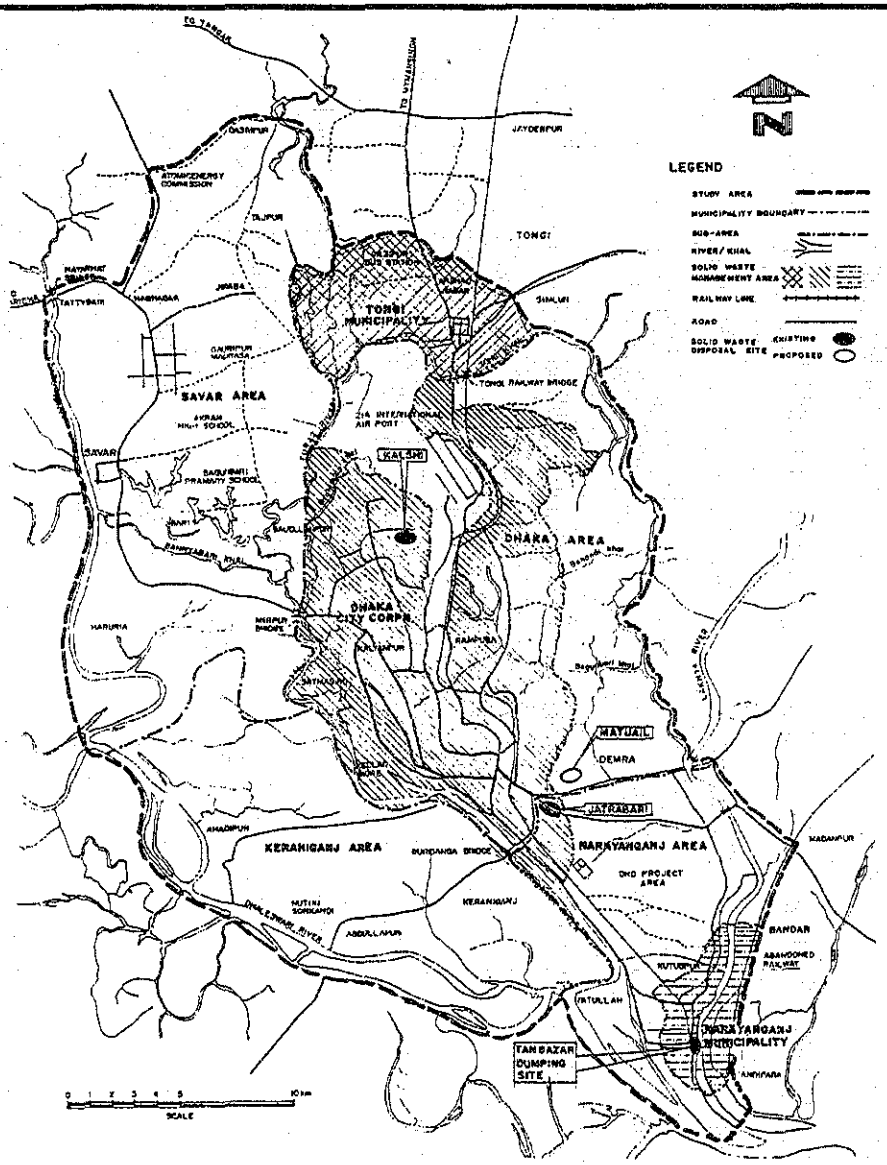
EXISTING PIPED WATER SERVICE AREA



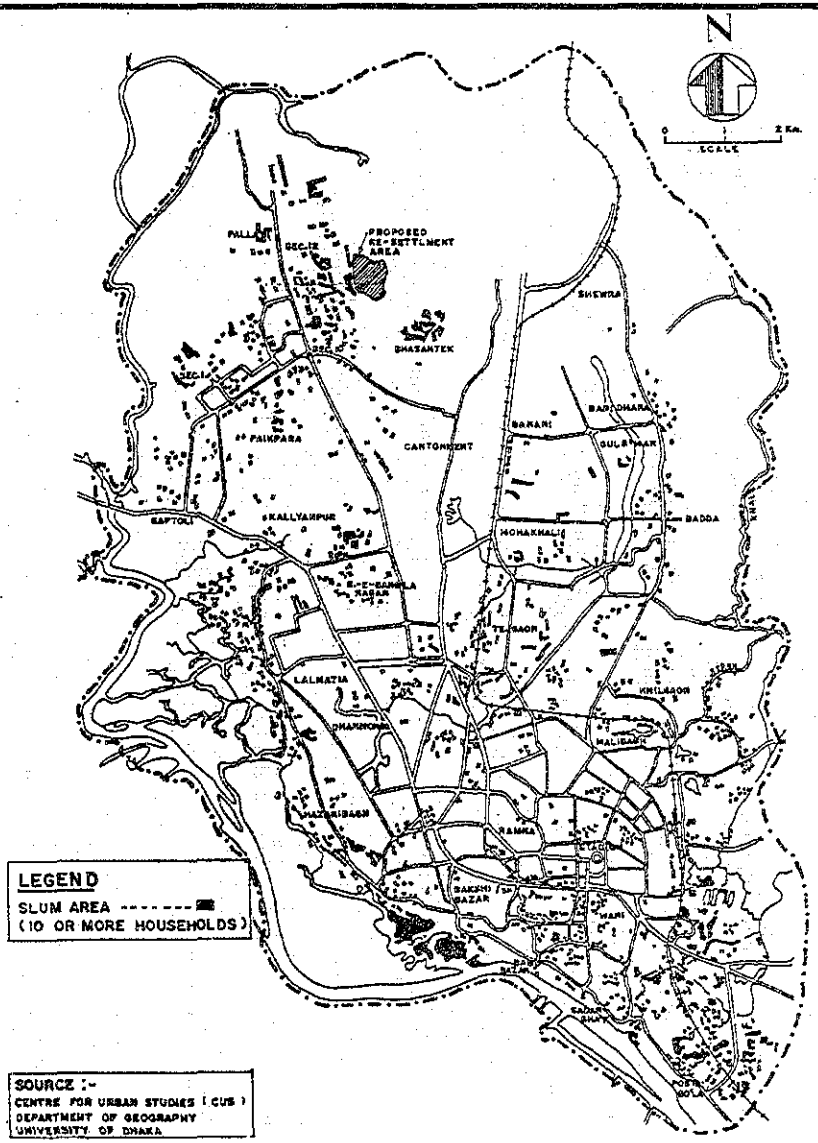
EXISTING SEWERED AREA

FIG. 7.1 EXISTING PIPED WATER SERVICE AREA AND SEWERAGE AREA

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



EXISTING SOLID WASTE SERVICE AREA



EXISTING SLUM SETTLEMENTS IN DHAKA

FIG. 7.2 EXISTING SOLID WATER SERVICE AREA AND SLUM SETTLEMENTS IN DHAKA

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

JICA

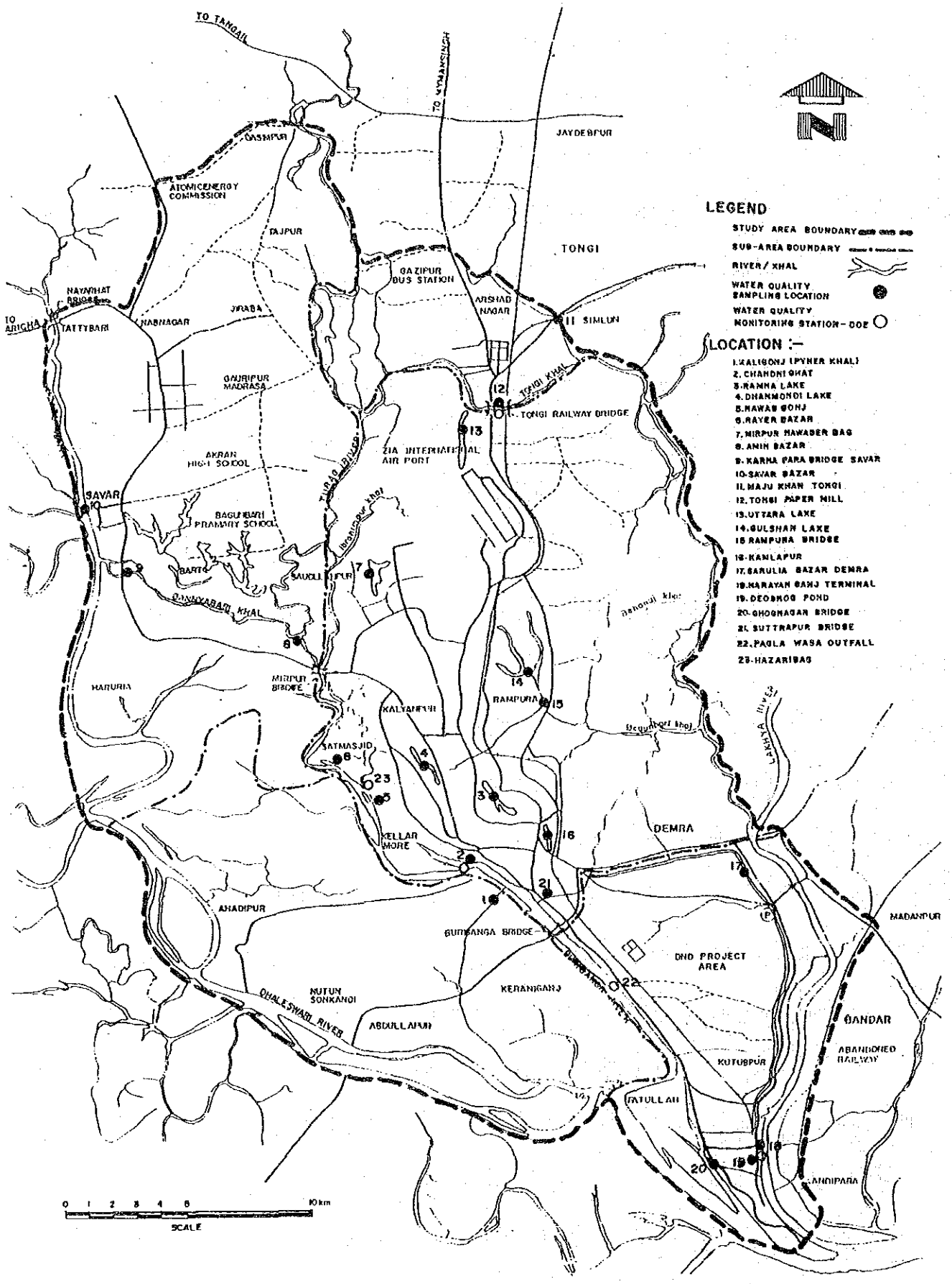
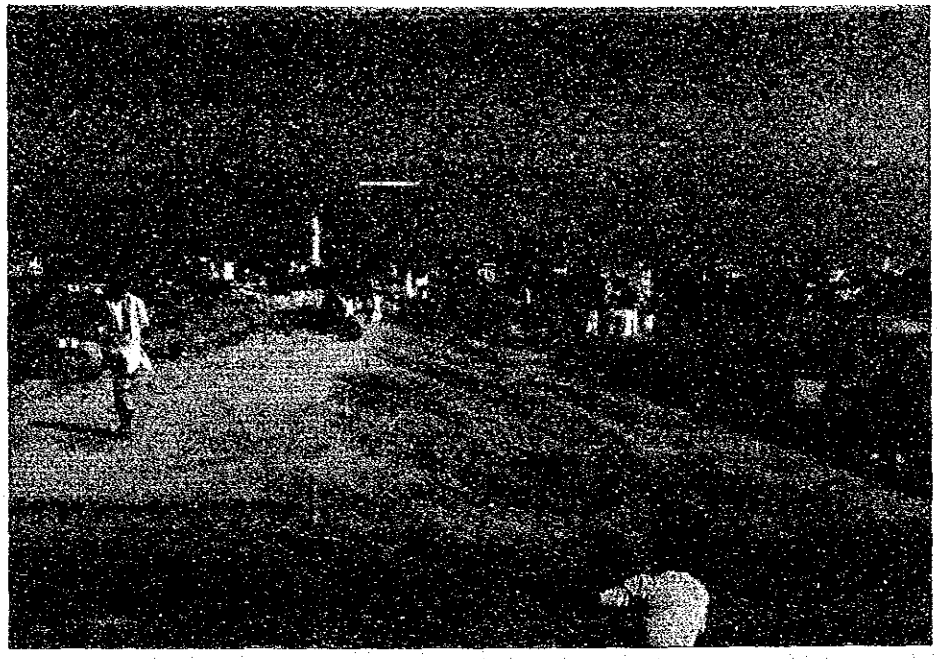


FIG. 7.3 SAMPLING AND MONITORING STATION OF WATER QUALITY

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

JICA



Embankment of Under Construction nearby Kellar More

Concrete Flood Wall of DND project Zone

CHAPTER 8

FLOOD MITIGATION AND STORM WATER DRAINAGE PLAN

CHAPTER 8 FLOOD MITIGATION AND STORM WATER DRAINAGE PLAN

8.1 Basic Concept

The study area is extremely vulnerable to floods and inundation. Approximately 50% of the study area is submerged due to habitual floods and 10% of the urban area is inundated due to yearly stormwater .

During the 1988 flood, which is the largest flood so far observed, 76% of the study area was submerged and 2,233,000 people were estimated to have suffered from the flood.

Population pressure is very high. The population of the study area has increased from 4.0 million in 1981 to 6.3 million in 1990. It will further increase to 9.9 million by 2000 and 13.5 million by the target year of 2010.

The urban area is expanding into the surrounding low-lying area. The urban areas are forecast to be expanded from 200 km^2 in 1990 to 366 km^2 by 2010.

The existing built-up areas is mostly on comparatively high areas free from habitual floods, approximately over 6.0 m PWD. Further built-up areas are, however, likely to be developed in the surrounding low-lying areas even below 4.5m PWD, which will be protected from floods by embankment. Considering the above, a pump drainage system will become a basic measure for draining the future urban area. Demands for an optimum flood and storm water improvement measure will be one of the highest priority terms.

In order to eliminate flood and drainage problems and to enhance the security of people in the study area, an optimum flood mitigation and drainage improvement plan, composed of structural and non-structural measures, is essential, The plan is :

- to protect not only the existing urban areas, but also the forecast future urban development areas in 2010, by structural measures against the flood of a 100-year flood frequency.
- to eliminate drainage problems of future urban areas in 2010 by structural measures,
- to protect the people outside the forecast urban development areas from floods by non-structural measures such as flood warning and evacuation systems etc.

8.2 Flood Mitigation Plan

8.2.1 Flood Mitigation Policy

By considering natural and social conditions of the study area, the following flood mitigation policy was adopted:

- The future development area shall be protected as much as possible.

- The proposed flood mitigation will comprise both structural and non-structural measures.

  The non-structural methods of flood plain management will be applied to those areas that will remain undeveloped rural areas. The structural measures will be applied to developed urban areas.

- The structural measures shall include facilities which are to be constructed as early as possible and within the target year 2010.

8.2.2 Flood Mitigation System

In general, three (3) types of structural measures, namely, 1) dredging of river 2) empoldering and 3) combination of dredging and empoldering are employed for flood mitigation.

The empoldering measure was determined as the most suitable for the study area based on the following consideration.

(1) River training by dredging will not be effective for lowering the flood water level due to the peculiar hydraulic characteristics of the area

(2) It is very difficult to maintain the design river bed due to the sedimentation problem

- Empoldering System

  The following two alternative empoldering systems are conceivable for the study area.

  (1) Independent System : To empolder each area independently

(2) Integrated System : To empolder as many areas by a single polder system i.e. integrated Greater Dhaka and Tongi system and Greater Dhaka and Keraniganj areas system

This alternative study is conducted mainly by comparing the construction costs.

The result shows that the Independent System is much more economical than the Integrated System for Tongi and Keraniganj cases. Furthermore if the operation and maintenance costs are considered, the cost of Integrated System is much higher than that of the Independent System while, hydraulic effects i.e. the rise of water level, the flow velocity due to empoldering will not be of a great difference.

8.2.3 Design Criteria

1) Design High Water Level

The higher water level between that of the 1988 flood and that of a 100-year flood frequency is adopted as the design high water level at each representative river gauging station, based on the following :

(1) The 1988 flood is the largest flood on record, estimated to be of a 70 - year frequency or more.

(2) The existing embankment on the western side of Greater Dhaka was designed against the flood of a 100 - year frequency.

(3) For an important area such as a capital city, the scale of a 100 - year flood frequency is often adopted as the design flood.

The following high water levels are employed as the design high waters, based on the probable water levels of a 100-year frequency and the result of hydraulic simulation of with/without the project.

Design High Water Level

Gauging Station	H.W.L (m)	100-year Frequency	Scale of Flood frequency
Tongi (Sta. No. 299)	8.60	8.30m	100
Mirpur (Sta. No.302)	8.60	8.53	100
Mil Barak (Sta. No.42)	7.80	7.72	100
Hariharapara (Sta. No.43)	7.20	7.10	('88 Flood)*
Rakabi Bazar (Sta. No.71A)	6.70	6.65	100
Demra (Sta. No.7.5)	7.40	7.32	100
Kalagachia (Sta. No.71)	6.40	6.40	100
Savar (Sta. No.69)	9.70	9.36	('88 Flood)*

Note : * The flood water levels are assessed to be more than a 100-year flood frequency.

2) Design Freeboard

The freeboard is determined with due consideration of stability/strength in the case of over flow and temporary rise of the water level caused by wind and wave during floods. The following freeboards are employed based on the calculation results of water rise by 15 m/s wind speed.

- Embankment : 1.2m
- Flood wall : 0.6m

8.2.4 Alignment Study for Flood Mitigation Facilities

1) Alignment of Flood Mitigation Facility

The alignment or location of flood mitigation facilities is to protect the forecast urban development areas by 2010, against the design flood.

Alternative alignments for flood mitigation facilities are based on the existing flood mitigation facilities, hydraulic and social aspects. The alternatives for each urban area are shown in Figs.8.1 (1) to 8.1 (6). The result of evaluation of alignment

alternatives is shown in Table 8.1, and the proposed alignments for the master plan are explained as follows :

(1) Greater Dhaka

a) Western Part (Greater Dhaka West)

The Western Part is defined as the area between the road-cum-embankment along the eastern fringe of the existing Dhaka urban area and the Buriganga River.

No alternative is studied for this area, because most of the embankment and flood walls have already been constructed or are on-going.

b) Kamrangir Char

Kamrangir Char is a part of Greater Dhaka, developed on a sand bar along the Buriganga River, located between Old Dhaka and Keraniganj. The present population is estimated to be over 35,000, This area was not in the proposal by the committee but proposed in the last comments on the Interim Report FAP 8A (March, 1991). According to the flood survey results, the whole area was completely submerged during the 1988 flood.

- Proposed Alignment for the Master Plan (Case B)

The proposed embankment extends from the Dakshin Sonatenga site of the existing embankment along the left bank of the Buriganga River and is connected to the proposed phase I embankment further downstream.

In this case, the stormwater from 2.71 km^2 of the western part of Dhaka city flows into this area, and the area requires a drainage pump system.

c) Eastern Part (Greater Dhaka East)

- Proposed Alignment for the Master Plan (Case B)

This is intended to protect both the existing urban area and the potential urban development area.

The alignment is set along the Balu River and is almost the same as the one proposed by the Committee. However, some revision was made in the poor sub-soil area identified from the soil investigation data from BWDB. The alignment at Bhaturia is shifted on the higher ground near the original alignment .

(2) Narayanganj

a) Western Bank (DND and Narayanganj West)

The Western Bank area is composed of the DND Project area and Narayanganj Town area.

The DND Project area is protected by the flood wall and the railway-cum-embankment. It was marginally safe from the 1988 flood, but the town area was affected severely. The town area has a dense population and industrial areas along the Lakhya River.

- Proposed Alignment for the Master Plan (Case B)

The alignment encloses the whole area of the Western Bank including the narrow strip of industrial land.

b) Eastern Bank (Narayanganj East)

The Eastern Bank is defined as the area between the road from Tarabo via the abandoned railway and the Lakhya river.

For this area, no alternative is considered as it is a narrow strip with small area.

(3) Tongi Area

Tongi Town is an industrial town which has rapidly developed. It is located on comparatively high ground near to Dhaka city.

Two alternatives are studied with due consideration to their high development potential .

- Proposed Alignment for the Master Plan (Case A)

This would protect the existing urban area and part of the potential urban development area.

The alignment encloses most of Tongi Union, but the western low - lying area along a khal is not protected by this alignment.

(4) Savar Area

The center of Savar town, located along the Bansi River, was inundated for more than two weeks and seriously affected by the 1988 flood, However most parts of Savar Area were not affected by the flood. The proposed alignment will protect the area affected during the 1988 flood. The alignment is planned on the existing road along the Bansi River to the west and Banyanbari Khal to the East.

(5) Keraniganj Area

A new bridge construction project between Old Dhaka area and Jinjira, and a new port development project at Pangaon have been envisaged by the Government.

- Proposed Alignment for the Master Plan (Case B)

This alignment extends to protect the Port Development Project area at Pangaon and the potential urban development areas along the Buriganga River. The alignment along the Dhaleswari River is planned to incorporate potential development area to the maximum extent.

8.2.5 Proposed Facility/Rehabilitation Work

1) Standard Sections of Empoldering Facilities

The form of planned polder was selected with due consideration to the land use pattern, land availability for the polder construction, subsoil conditions, topographical conditions, etc.

As standard design, the following types of polder are considered.

1. Embankment
2. Flood Wall (T and I Type)
3. Road-Cum-Embankment

- Embankment

The standard cross sections of BWDB as applied to the existing embankments were adopted as they are found to be satisfactory, based on slope stability analysis, against potential embankment failure. However, under poor subsoil

conditions foundation treatment is necessary to ensure embankment stability. The foundation treatment proposed for poor subsoil is consolidated by means of sand drain/sand compaction or wick drain along with step by step embankment construction.

It is to be noted that many sections of the existing embankment between Tongi to Kellar More via Mirpur have been settled or failed mainly due to poor soil foundation and inadequate compaction.For these portions, rebanking or foundation treatment are required as rehabilitation works.

- Flood Wall

Reinforced concrete wall is used for flood wall.

This flood wall is to be applied at urbanized river reaches with inadequate right of way for embankment, in principle.

- Road-Cum-Embankment

The dimensions of most parts are to be the same as an embankment. However, the embankment crest width shall be 7 m or more with due consideration of traffic purpose. In cases of existing roads with width over 7 m, such road width shall be adopted.

2) Sluice Gate (Regulators)

Sluice gates are planned at the outlet of Khals and proposed pump stations.

The proposed flow areas of the sluice gates are basically determined by means that design discharges divided by design flow velocity of 2.5 m/s.

The proposed facilities and rehabilitation works by each project are described below:

(1) Greater Dhaka

a) Greater Dhaka West

- Western part

Rehabilitation Works (R) and Construction Facilities

- Embankment (R) : 16.7 km of repairing, strengthening works of failure and settlement portion (3.0 km of foundation treatment)
- Flood Wall (R) : 4.7 km of Rehabilitation Work
- Embankment : 0.3 km nearby Kellar More (0.3 km of foundation treatment)
- Flood Wall : 3.0 km between Kellar More to Mitford Hospital
- Sluice Gate : 11 places (On-going Projects by JICA and IBRD are not included)

- Kamrangir Char

Proposed Facility

- Embankment : 6.0 km for Kamrangir Char area (2.0 km of foundation treatment)
- Sluice Gate : 1 places

b) Greater Dhaka East

Proposed Facility

- Embankment : 26.7 km along the Balu river (14.6 km of foundation treatment)
- Sub Embankment : 11.3 km
- Sluice Gate : 5 places

(2) Narayanganj

a) Narayanganj - DND and West

- DND Area

Rehabilitation Works

- Flood Wall (R) : 20.2 km of strengthening work for the eastern part of the existing flood wall

Proposed Facility

- Flood Wall : 10.0 km along the western part of the national road and existing railway track
- Sluice Gate : 2 places

- Narayanganj - West

Proposed Facility

- Embankment : 6.1 km on the north and southern part of Narayanganj town
- Road-Cum-Embankment : 4.3 km on the western part of Narayanganj
- Flood Wall : 10.5 km along the Lakhya river
- Sluice Gate : 7 places

b) Narayanganj - East

Proposed Facility

- Embankment : 6.6 km on the north part of the area
- Railway-Cum-Embankment : 6.5 km on the northern part of the area
- Flood Wall : 26.0 km along the Lakhya river and abandoned railway
- Sluice Gate : 12 places

(3) Tongi

Proposed Facility

- Embankment : 13.0 km on the eastern part of the area (10.4 km of foundation treatment)
- Road-Cum-Embankment : 6.2 km on the northern and western part of the area
- Flood Wall : 2.2 km along the Tongi Khal
- Sluice Gate : 7 places

(4) Savar

Proposed Facility

- Embankment : 9.3 km on the Western and Southern part of the area (3.1 km of foundation treatment)
- Sluice Gate : 3 places

(5) Keraniganj

Proposed Facility

- Embankment : 23.3 km on the eastern and western part of the area (5.1 km of foundation treatment)
- Flood Wall : 3.7 km along the Buriganga river
- Sluice Gate : 10 places

The locations of proposed major facilities are shown on Fig.8.2 and longitudinal cross sections of the proposed embankment and flood wall are shown on Figs. 8.3 (1) to 8.3 (3).

8.3 Storm Water Drainage Improvement Plan

8.3.1 Design Criteria

1) Design Flood Water Level

The following design flood water levels are applied for each drainage area (or zone) based on the calculations of probable water levels at the gauging stations as shown in Fig. 8.4.

(1)	Greater Dhaka		
	- Buriganga River Left Bank Zone	:	5.80 to 6.45 PWD
	- Turag River Left Bank Zone	:	6.45 m PWD
	- Balu River Right Bank Zone	:	5.90 m to 6.45 m PWD
(2)	Tongi	:	6.45 m PWD
(3)	Savar	:	7.20 m PWD
(4)	Narayanganj	:	5.45 to 5.80 m PWD
(5)	Keraniganj	:	5.45 to 5.80 m PWD

The pump equipment is be designed to be able to operate during a 100-year flood frequency. Considering the difference in water levels of about 2 m between a 2-year and a 100-year flood frequency, the design flood water level at the highest pump efficiency of 100% will actually be higher than a 2-year frequency flood water level.

2) Design Rainfall

(1) For Pumping Station and Retarding Pond

2 days consecutive rainfall with a 5 - year frequency is applied as the design rainfall for planning pumping capacities and retarding volumes. The design rainfall amount and its hourly distribution are illustrated on Fig. 8.5.

(2) For Khal Improvement and Trunk Drain

Rainfall intensity with a 5-year frequency, computed using Rational Formula, is employed for the design of trunk drains and khal improvements.
The applied rainfall intensity - duration curve is illustrated also in Fig. 8.5.

3) Area Reduction Factor

The above design rainfalls are made based on the point rainfall data at Dhaka station (B.M.D.). For calculation of the design discharge, the areal reduction factor is considered.

4) Run off Coefficient and Run off Ratio

The following runoff coefficients by land use are used for calculation of the design peak discharge by the Rational Formula.

Land Use	Runoff Coefficient
Commercial Area	0.65
Industrial Area	0.55
High Class Residential Area	0.3
Middle & Low Class Residential Area	0.5
Green Zone and Others	0.2
Water Bodies	1.0

The runoff ratio (total runoff/total rainfall) of 0.8 is employed for estimating required pump capacities and retarding pond volumes.

5) Drainage Criteria

A short duration of internal floods with small flood damage may be allowable. For pump drainage areas, a 2 days draining period by pumps is proposed in view of technical and economical reasons.

6) Specific Peak Run-off

Specific peak run-off is estimated by the Rational formula assuming a rain water inflow time and average flow velocity in khals as 20 minutes and 0.8 m/s, respectively.

7) Specific Requirements of Pumps and Retarding Ponds

The specific capacity and volume for pump and retarding pond planning are estimated by the Storage Basin Model.

The corresponding specific capacity and volume are calculated to be 1.14 $m^3/s/km^2$ and 0.120 x 10^6 m^3/km^2 respectively as shown in Fig. 8.6.

8.3.2 Demarcation of Gravity and Pump Drainage Areas

The drainage area is divided into twelve (12) zones (Fig. 8.7).

Demarcation of gravity and pump drainage areas are correspond to the ground elevation in each zone as follows :

(1) The area above the design flood water level plus 0.5 to 1.0 m can drain storm water by gravity, assuming that :

(a) outlet water levels of drainage pipes or khals are at the water level of a 2-year flood frequency.

(b) head difference required to drain the stormwater of a 5 - year flood frequency through drain pipes or khals by gravity is considered in the range of 0.5 to 1.0 m.

(2) The area below the design flood water level plus 0.5 to 1.0 m cannot be drained by gravity flow. A pump drainage system is required.

(3) Future urban development in the existing low-lying areas will be built-up by land filling of minimum 2.0 m.

Based on the above criteria, requirement in each drainage zone are summarized as follows :

1) DA Zone (A = 34.33 km^2)

This zone was investigated by previous JICA studies in 1987 and in 1990, which concluded as follows:

(1) The Old Dhaka area (Drainage zone B in the previous JICA study) is required to adopt a pump drainage system. Improvement of the Dholai Khal, including construction of a pumping station, are on-going as a World Bank Project .

(2) The Narrow strip area along the Buriganga River (Drainage zone A in the previous JICA study) is mostly higher than 6.8 m PWD. Stormwater can be drained by gravity. However, a central part of this area (2.71 km^2) will be combined with the Kamrangir Char area which is lower than 6.8 m PWD and requires a pump drainage system.

(3) Almost 40% of the Kallyanpur area (Drainage zone H in JICA previous study) is lower than 6.95 m PWD. Pump drainage is required. The construction of Kallyanpur pumping station with a capacity of 10 m3/s and the improvement works of the Kallyanpur Khal are on-going as a JICA Grant Aid Project.

2) DB Zone (A = 60.84 km^2)

Almost 75% of the area is below 6.95 m PWD.The area is mostly drained by pump.

3) DC1 Zone (A = 45.86 km^2)

Almost 80% of the area is below 6.85 m PWD. Pump drainage systems are mostly required.

4) DC2 Zone (A = 30.65 km^2)

Almost 90% of the area is below 6.70 m PWD.Pump drainage systems are required.

5) DC3 Zone (A = 90.74 km^2)

Almost 70% of the area is below 6.55 m PWD.Pump drainage systems are required.

6) TA Zone (A = 13.24 km^2)

Almost 72% of the area is below 6.95 m PWD.Pump drainage systems are required. However, the existing urban areas along the Tongi Khal and Tongi-Joydebpur Road are higher than 6.95 m PWD. The stormwater of the areas can be drained by gravity.

7) TB Zone (A = 11.06 km^2)

Almost 80% of the area is below 6.95 m PWD.Pump drainage systems are required. Tongi industrial area is, however, higher than 6.95 m and drained by gravity.

8) S Zone (A = 56.52 km^2)

Only 12% of the area is below 7.70 m PWD. Gravity drainage systems are applicable.

9) NA Zone (56.79 km^2)

Whole areas are below 6.30 m PWD.Pump drainage systems are required.

10) NB Zone (18.63 km^2)

Almost 80% of the area is below 5.95 m PWD.Pump drainage systems are required. The existing Narayanganj town, higher than 5.95 m, is drained by gravity .

11) NC Zone (12.80 km^2)

Almost 78% of the area is below 5.95 m PWD.Pump drainage systems are required. However, the existing built-up areas are mostly higher than 5.95 m PWD, and drained by gravity.

12) K Zone (24.27 km^2)

Almost whole area is below 6.30 m PWD. Pump drainage systems are required.

8.3.3 Alternative Study of Drainage Improvement Plan

In order to identify an optimum drainage improvement plan, alternative studies for drainage systems were conducted for the following three drainage zones:

- Turag River Left Bank Zone (DB)
- Balu River Right Bank Zone (DC)
- DND Project Zone (NA)

1) Options of Drainage Improvement Plan

Considering the existing topographic conditions, drainage network and stage implementation coordinating with future urban development, drainage improvement options proposed for the three zones are described as follows :

(1) Turag River Left Bank Zone (DB, A = 60.84 km^2)

Two options are prepared.

(a) Alternative I : Two independent drainage systems

- southern part (DB_1, A=3.63 km^2) : gravity drainage
- northern part (DB_2, A=57.21 km^2) : pump drainage

(b) Alternative II : Three independent drainage systems

- southern part (DB_1, A=3.63 km^2) : gravity drainage
- central part (DB_2, A=43.40 km^2) : pump drainage
- northern part (DB_3, A=13.81 km^2) : pump drainage

(2) Balu River Right Bank Zone (DC, A = 167.25 km^2)

Three options are prepared.

(a) Alternative I : Single drainage system

- whole area (DC, A=167.25 km^2) : pump drainage

(b) Alternative II : Two independent drainage systems

- northern part (DC_1, A=76.51 km^2) : pump drainage
- southern part (DC_2, A=90.74 km^2) : pump drainage

(c) Alternative III : Three independent drainage systems

- northern part (DC_1, A=45.86 km^2) : pump drainage
- central part (DC_2, A=30.65 km^2) : pump drainage
- southern part (DC_3, A=90.74 km^2) : pump drainage

(3) DND Project Zone (NA, A = 56.79 km^2)

Two options are prepared.

(a) Alternative I : One pump drainage system

- whole area (NA, A=56.79 km^2) : pump drainage by new pumping station

(b) Alternative II : Two pump drainage systems

- northern part (NA_1, A=34.08 km^2) : pump drainage by existing pumping station
- southern part (NA_2, A=22.71 km^2) : pump drainage by additional pumping station

The above drainage system alternatives are illustrated on Figs. 8.8 (1) to (4).

2) Main Features of Alternative Plans

Alternative plans are designed under the following conditions:

(1) The plans for the existing built-up areas of both DB and DC zones shall incorporate previous JICA study recommendation.

(2) Major drainage facilities, such as pumping station with retarding ponds, sluice gates and khals, for the future development areas shall be studied.

3) Identification of Optimum Option

Comparison of alternatives are summarized below:

(1) Turag River Left Bank Zone

Alternative I is recommended because of low cost. In the case of alternative II, land acquisition of DB_2 retarding pond, may be difficult because this area is now being developed.

(2) Balu River Right Bank Zone

Alternative III is recommended. However, costs of alternative II and III are almost the same, so a more intensive study will be required in the feasibility stage.

(3) DND Project Zone

Alternative II is recommended. It will, however, be necessary to conduct a more detailed study for alternative I to establish whether the proposed pumping station can be constructed without demolishing the existing one.

Comparison of Alternatives

Item \ Zone	DB		DC			NA	
Item \ Alternative	I	II	I	II	III	I	II
1. Cost (million Tk.)							
(1) Construction Cost	2,313	2,453	5,992	5,782	5,767	2,247	1,986
(2) O/M Cost	570	614	1,386	1,440	1,485	528	466
(3) L/A Cost	2,286	2,287	6,267	6,158	6,104	3,883	3,863
Total	5,169	5,354	13,645	13,380	13,356	6,658	6,315
2. Stage Construction	Easy	Easy	Difficult	Moderate	Easy	Moderate	Easy
3. Water Conveyance Distance	Medium	Short	Long	Medium	Short	Long	Short
4. Others	—	L/A Problem	—	—	—	Complecated Construction	—

Note : 1. L/A means land acquisition.

2. Main features of each alternative plan and breakdown of costs are shown in Tables H.7 to H.13. of supporting Report H.

8.3.4 Proposed Pump Drainage Plan

1) Pump Operation Period

The climate of the study area is divided into the following three distinct seasons;

-	monsoon season	:	May to October,	R = 1,825 mm
-	cool season	:	November to February,	R = 60 mm
-	warm season	:	March to April,	R = 175 mm

About 90% of the annual rainfall (R = 2,060 mm) occurs during the monsoon season. Maximum monthly rainfall occurs in June, is approximately 400mm, based on the rainfall series from 1953 to 1990.

On the other hand, flood water levels of the surrounding rivers start to rise in April, peak in mid-August, and gradually fall until December. The relationships between the average ground elevation of low lands (3.0 ~ 3.5 m PWD) and average monthly river stage curves at the nearby gauging stations show that the required pump drainage periods in Dhaka, Narayanganj and Keraniganj are estimated to be five (5) months from June to October every year, as shown in Fig. 8.9.

According to the O/M data of the existing Narinda and Demra pumping stations, average pump operation hours during the flood season from June to October are recorded for about 1,200 hr, corresponding to almost 60% of rainy days a total of 88 days (2,112 hr). It means that in flood season the pumps shall be operated during rain.

2) Zoning of Pump Drainage Areas

Zoning of pump drainage areas are based on the results of the pump drainage zone demarcation and the alternative studies. The pump drainage zones by each drainage zone are summarized as follows:

(1) Greater Dhaka

(1) DA zone : 3 (PD_1 = 6.96 km^2, PD_2 = 7.24 km^2, PD_3 = 17.6 km^2)
(2) DB zone : 1 (PD_4 = 57.2 km^2)
(3) DC zone : 3 (PD_5 = 35.6 km^2, PD_6 = 30.7 km^2, PD_7 = 90.7 km^2)

(2) Tongi

(1) TA zone : 1 (PD_8 = 11.8 km^2)
(2) TB zone : 1 (PD_9 = 10.3 km^2)

(3) Narayanganj

(1) NA : 1 ($PD_{10,11}$ = 56.8 km^2)
(2) NB : 3 (PD_{12} = 2.5 km^2, PD_{13} = 5.5 km^2, PD_{14} = 6.3 km^2,)
(3) NC : 4 (PD_{15}=1.0 km^2, PD_{16}=3.9 km^2, PD_{17}=2.3 km^2, PD_{18}=3.7 km^2)

(4) Keraniganj

(1) K zone : 1 (PD_{19} = 24.3 km^2)

Zones of gravity and pump drainage zones are illustrated in Fig. 8.10.

3) Required Pump and Retarding Pond Capacities

In order to economize on pump drainage cost by reducing the required pump capacity, it is proposed to adopt a pump drainage system combined with retarding ponds.

Specific requirements of pump and retarding pond capacities are estimated to be $p = 1.14$ $m^3/s/km^2$ and $v = 0.120 \times 10^6$ m^3/km^2 respectively, by utilizing storage basin model.

The results by each pump drainage area are shown in Tables 8.2 to 8.4. The proposed pumping stations and retarding ponds are illustrated in Figs. 8.12 (1) to (3).

8.3.5 Proposed Khal Improvement and Trunk Drain Plan

1) Proposed Drainage Networks

The proposed drainage network is planned according to the following :

(1) The drainage plans for the existing urban area of Dhaka city should meet the requirements of the on-going projects (JICA and World Bank).

(2) For the other existing urban areas, khal improvement and trunk drains (open channel or pipe) are to be proposed as a drainage networks.

(3) For the future urbanized areas, only trunk khal improvements are to be proposed.

In addition, drainage pipes should be installed only in Dhaka city. Other towns should be drained by ditches or open channels.

2) Design Discharge

(1) Division of Sub-drainage Zone

In order to estimate the design discharge for khal improvements and trunk drains, each drainage zone is divided into sub-drainage zones based on the existing topographic conditions and the proposed drainage networks. The proposed sub-drainage zones are as follows:

Number of Drainage Zones and Sub-drainage zones by the Drainage Areas

Drainage Area	No. of Zone	No. of Sub-zone
- Greater Dhaka	3	41
- Tongi	2	11
- Savar	1	14
- Narayanganj	3	27
- Keraniganj	1	8
Total	8	101

(2) Design Discharge

The design discharges for khal improvement of khals and trunk drains are based on the specific peak run-off with a 5-year frequency of short duration rainfall and stretches of drainage sub-zones.

Tables 8.5 and Figs. 8.11 (1) to (3) show the design discharges.

3) Proposed Improvement of Khals and Trunk Drains

The discharge capacities of the existing khals and trunk drains are insufficient to convey their design discharges. This is one of the main cause of internal floods in the urban areas. Improvements of khals and trunk drains by widening and dredging are required for reducing of internal flood problems.

1) Hydraulic Design

Hydraulic designs for improvement of khals and trunk drains are carried out by the uniform flow model of Manning Formula.

The following coefficients of roughness of khals and trunk drains used for the design ;

- Brick pipe drain : 0.015
- Concrete box culvert : 0.015
- Khal with brick slope protection : 0.025
- Khal with sodding slope protection : 0.035

The proposed hydraulic cross sections, bed slopes, and discharge capacities by the improved stretches are shown in Tables 8.6.

2) Proposed Improvement Works

The proposed typical cross sections for improvement of khals and trunk drains are as follows:

(1) Open channel
- Type (1) : Trapezoidal shape with 1:2 slope protected by sodding,
- Type (2) : Trapezoidal shape with 1:1 slope protected by brick,
- Type (3) : Rectangular shape with concrete panel wall,

(2) Covered channel or pipe
- Type (1) : Concrete box culvert (single or double),
- Type (2) : Brick pipe.

A trapezoidal shape channel is applied for khal sections where comparatively easy land acquisition is expected. A rectangular shape channel is proposed for the khal sections where land acquisition is likely to be difficult. Operation and maintenance roads are proposed to both banks of the trapezoidal shape channels located in the future urban areas.

The concrete box culvert is applied for the khal sections crossing roads. The brick pipe is employed for the trunk drain sections.

The proposed improvement lengths of khals and trunk drains by drainage zone are shown on Figs. 8. 12 (1) to (3) and summarized below :

Drainage Area	Drainage Zone	Improvement Length (Km)		
		Khal	Trunk Drain	Total
Greater Dhaka	DA	20.05	8.08	28.13
	DB	29.40	-	29.40
	DC	73.15	8.92	82.07
	Sub-Total	122.60	17.00	139.60
Tongi	TA	11.00	-	11.00
	TB	16.00	-	16.00
	Sub-Total	27.00	-	27.00
Savar	S	30.00	-	30.00
Narayanganj	NA	38.00	-	38.00
	NB	6.40	-	6.40
	NC	7.35	-	7.35
	Sub-Total	51.75	-	51.75
Keraniganj	K	22.50	-	22.50
Total		253.85	17.00	270.85

Note : 1. Breakdown of the above table by improvement work and drainage zone is shown in table H. 19. (1) to H. 19. (3). of Supporting Report H

8.4 Operation And Maintenance

8.4.1 General

Operation and maintenance (O/M) works include the daily or periodical actions/activities that are necessary to prevent the deterioration of a facility and thus guarantee its effectiveness.

The work required is closely related to the type of facility i.e.pump station, embankment, etc.and its design. The O/M demand of the project facility has to be considered from the very beginning of the planning process and every effort should be made to simplify and minimize the O/M requirement. In addition, the quality of the construction works will have a great influence on the O/M works and the life of the facilities.

Inadequate O/M and the consequent failure of the flood mitigation facilities could lead to even greater damage to life and property than there would have been without the facility. Once completed, the embankment will encourage people to settle in areas where formerly they would not have settled because of high risk of flooding.

Only proper O/M of this flood mitigation project will ensure the realization of the benefits for which the project was initiated.

8.4.2 Existing Condition

1) Flood Mitigation and Stormwater Drainage Facilities

(1) Embankment and Flood Wall

Most existing flood mitigation facilities i.e. embankment, concrete flood wall, road-cum-embankment, have been constructed around the Greater Dhaka and Narayanganj areas after the 1988 flood. They were constructed in an ad-hoc approach by executive orders, executed by different institutions including the Army, DCC and BWDB.

Some sections of the embankment along the western part of the Greater Dhaka need remedial works due to settlement and failure of the embankment.

Compaction of the embankment seems poor in general and a number of rat holes are observed. Human settlements on the embankment, not just during the time of flood, are also observed.

Thus rehabilitation/repair of the existing embankments is required in order to ensure their safety and effectiveness.

(2) Drainage System :

The existing drainage system, in general, consists of a network of local open drains known as khals, totalling approximately 437 km in length, and pump stations at two locations, namely Narinda in Old Dhaka and Demra in the DND

area. In addition, drainage pipes with total length of more than 110 km is provided for the central Dhaka area of 60 km^2.

This existing drainage system is assessed as inadequate for conveying stormwater properly. It is further limited by siltation, dumping of solid wastes and encroachment in the form of roads, settlements and buildings.

DWASA has only recently, in March 1989, been handed over the responsibility for the drainage system of Dhaka municipal area from DPHE. In the other municipalities of Tongi and Narayanganj, the local authorities are responsible for O/M of drainage. However in the DND area, which still remains officially an agricultural development area. BWDB is responsible for both irrigation and drainage.

The required O/M works is not under the responsibility of a single agency leading to further complication of work execution.

(3) Road-Cum-Embankment, Flood Wall, etc.

Raised roads and tracks for flood mitigation and flood protection walls have been constructed by DCC, RAJUK, RHD and the Railroad Authority. It is reported that because the concerned institutions belong to different ministries, the exchange of information takes so long that in most cases the construction is completed before the exchange has taken place.

RAJUK implements and partly finances road construction, but transfers the facility after completion to DCC, within the area of DCC. RHD is the only body responsible for raised roads' O/M, though at present the only road with a flood protectional aspect maintained by RHD is Demra Road.

2) Existing Organizations

(1) BWDB :

BWDB, with over 20,000 staff, is responsible for the planning, construction and O/M of flood protection and irrigation projects nationwide. Within the BWDB there was no separate O/M Department until an analysis of the organizational weaknesses of BWDB was initiated by the World Bank. Roughly 2.5% of the total project performance costs are said to be spent for O/M works.

The existing embankment constructed under BWDB, from Tongi to Mirpur Bridge, is still maintained by the contractors under BWDB.

The present organization is shown in Fig 8.13.

(2) DWASA :

DWASA is responsible for the water supply and drainage of Dhaka City. The O/M of the drainage system is organized by the Drainage Circle belonging to the Engineering Department of DWASA.

The present organization of the Drainage Circle is shown in Fig. 8.14.

Dhaka is divided into 2 sub-divisions and 9 sub-zones, 1 supervisor (work-assistant) and 2 cleaners are assigned to each. The main task of cleaning and repairing confined mainly to rainy season is done by contractors, generally small in size.

They start work by the middle to the end of April till May, with simple tools such as shovels and buckets. The work is supervised regularly by the Circle by means of estimating the volume of sludge removed. This cleaning work has to be done under extremely difficult and health hazardous conditions. Not all of the sludge can be removed by use of only simple tools and this leads to quick blockage during heavy rains.

The annual budget of the Circle is Tk. 70-80 lakh.

(3) DCC :

DCC is in charge of most of the raised roads within the city, especially the road from Joar Sahara to Saydabad, which together with the railway dike north of Joar Sahara and Demra Road is an important flood protection facility facing east towards the Balu River. Construction of Joar Sahara-Saydabad Road was done mainly by RAJUK (12 out of 13 km) and after completion it was handed over to DCC. It is difficult to estimate the actual effort on the O/M of the raised roads. The annual budget is around Tk. 400 lakh, mainly personnel costs.

(4) RHD :

The same difficulty as with DCC exists regarding the O/M works concerning flood protection facilities done by RHD, but they are only responsibile for an approx. 6 km stretch (Demra Road). An O/M team within the Road Circle

equipped with simple tools and one truck executes the maintenance work of typically a 20-25 km stretch of road but without considering any special maintenance needed for raised roads. The personnel costs of a team amount to approx.. Tk. 3.5 lakh per year. The cost for equipment maintenance and operation of the truck is about Tk. 1.5 lakh.

The construction of another raised road from Tongi to Savar has been started, involving large earth moving works in frequently flooded areas, and will require special maintenance.

8.4.3 Proposed Improvement Plan

1) Required Operation and Maintenance Work For Flood Mitigation Facilities

(1) General

In order to sustain the expected beneficial effects of the existing and proposed flood mitigation facilities, the following operation and maintenance work (O/M) shall be carried out daily or periodically depending on the actual conditions.

(a) Embankment/Road-cum-embankment

- Inspection and repairing of erosion by wave action, water flow, storm rainfall, etc. as erosion control works
- Inspection and repairing of seepage, sliding, failure, settlement, etc as stability control works
- Inspection of land use according to the regulations
- Clearing/cutting grass on the maintenance road and the embankment
- Inspection and management of the embankment properly
- Inspection and prohibition of any activities harmful to the embankment

(b) Flood wall

- Inspection and repairing of damage by traffic, etc. as damage control work,
- Inspection and repairing work to ensure structural stability,
- Inspection of adjacent land use.

(c) Regulators

- Inspection and repairing of regulator
- Inspection and maintenance of outlet/inlet condition

(2) Required Operation and Maintenance Equipment

Provision of the following equipment is required to satisfactorily implement the above-mentioned O & M work :

- Inspection and supervision vehicles
- Jeeps and Motorbikes
- Trucks for repairing works
- Tamping machine
- Cleaning equipment and grass cutting eqiupment.

2) Required O&M for Stormwater Drainage Facilities

(1) General

To sustain the beneficial effects of the existing and proposed drainage system of the study area the following major O&M work should be done :

- Cleaning of drainage pipes
- Dredging of deposits and removal of garbage from the khals.
- Operation and maintenance of pump stations.
- Operation and maintenance of control gates.
- Land use control, in cooperation with the agencies concerned, to maintain the regulating ponds and khal areas as planned, and to assure the required elevation of new land development.

(2) Required Operation and Maintenance Equipment

No special equipment except for small pump units are provided at present.

Provision of the following equipment is required to satisfactorily implement the above-mentioned O&M work :

- Garbage trolley (mechanically operated)
- Trucks for sludge transportation
- Cleaning equipment (small, mechanically operated)
- Cleaning equipment (truck mounted)
- Small pumps for discharging
- Supervision vehicles, Jeeps and Pickup Trucks.

(3) Operation and Maintenance of Drainage Pipes and Pump Stations

(a) Cleaning of Drainage Pipes

All the drainage pipes will be cleaned once a year.

The cleaning will be made manually and by cleaning machine.

(b) Operation Rules of Pump Stations

The pump operation period begins when the flood water level of the rivers reaches design operation water level. The period is usually the flood season from early July to mid-October.

During the flood season, the water level of the regulating ponds shall be maintained below the design water level to meet the coming storm runoffs.

(c) Maintenance of Pump Stations

Major maintenance work at the pump station is as follows:

(a) Daily maintenance (during pump operation)

- check electric current of motor
- check temperature of motor bearing
- check vibration of pump and motor

(b) Every six (6) months maintenance

- check pump sealing components
- check motor lubrication oil
- check gauge and indicator
- check insulation of motor

(c) Annual maintenance

- check electric panel
- check motor of automatic trash rake

(d) Every three (3) to four (4) years maintenance

- replace gauge and indicator
- replace parts of electric panel
- replace parts of automatic trash rake

3) Required Organization

The required organization for the operation and maintenance of the flood mitigation and drainage systems in the study area after completion of the proposed project is shown in Fig.8.15

4) Training and Local Participation

The participation of local residents/farmers with actual operating/maintaining or supervising/reporting tasks is important. In rural areas such a decentralization and participation approach has been tried, but within a city, with its totally different social structure, it still needs to be analyzed and it cannot be foreseen if it can be successfully implemented.

Proper O/M can only be done when everybody involved develops an attitude of personal responsibility for the work being done. Training can be given not only regarding skills, but also to change behavior. The training must be conducted at regular intervals and it must be well structured. Such a training programme is expected to be developed under UNDP assistance on behalf of BWDB.

8.5 Cost Estimation

8.5.1 Basic Conditions

The Project Cost is estimated based on the following conditions :

(1) The project cost is composed of "direct cost", "indirect cost" and contingency.

They are :

a)	Direct cost	:	- Construction work
			- Procurement and Installation of equipment,
b)	Indirect cost	:	- Land acquisition and compensation cost for house resettlement,
			- Administration cost,
			- Engineering cost,
c)	Contingency	:	- Physical contingency.

(2) The unit cost is based on BWDB's "Schedule of Rates" and market price prevailing in Dhaka in March 1991.

(3) All the construction works are to be contracted to general contractors by international tendering.

(4) The cost is divided into foreign and local currency portions.

They are :

a) The Foreign currency portion :
- Imported equipment, materials and supplies
- Overhead for contractors
- Expense of expatriate personnel

b) The Local currency portion :
- The construction materials which are available in the local market
- The salary and wages for local personnel
- Overhead for local firms
- Tariff & Tax

(5) The exchange rates of foreign currencies are as follows :

US $ 1 = 3 6 Tk. = ¥ 137

(6) Indirect cost is based on the following assumptions :

(a)	Administration Cost	:	3% of direct construction cost
(b)	Engineering Service	:	10% of direct construction cost
(c)	Physical contingency	:	25% of direct construction cost
(d)	Annual price escalation	:	3% for Foreign currency 8% for local currency

8.5.2 Project cost

The total project cost is estimated at Tk 61,208.1 million (F/C : TK.21,501.6 million, L/C: Tk. 39,706.5 million). The project cost for each project is shown in Table 8.8 and summarized as follows :

Project Cost

(Unit : million Tk.)

Item		F/C	L/C	Total
I.	Structural Measures			
A.	Direct Cost	15,487.4	13,343.6	28,831.0
	(1) Construction Cost	(15,487.4)	(13,343.6)	(28,831.0)
B.	Indirect Cost	1,548.7	22,074.8	23,623.5
	(1) Land Acquisition Cost	(-)	(19,875.4)	(19,875.4)
	(2) Administration Cost	(-)	(865.0)	(865.0)
	(3) Engineering Service Cost	(1,548.7)	(1,334.4)	(2,883.1)
C.	Physical Contingency	3,872.0	3,335.9	7,207.9
	Total :	20,908.1	38,754.3	59,662.4
II.	Non-Structural Measures			
A.	Direct Cost	439.5	598.5	1,038.0
	(1) Construction Cost	(439.5)	(598.5)	(1,038.0)
B.	Indirect Cost	44.0	204.1	248.1
	(1) Land Acquisition Cost	(-)	(113.1)	(113.1)
	(2) Administration Cost	(-)	(31.2)	(31.2)
	(3) Engineering Service Cost	(44.0)	(59.8)	(103.8)
C.	Physical Contingency	110.0	149.6	259.6
	Total :	593.5	952.2	1,545.7
	Grand Total	21,501.6	39,706.5	61,208.1

8.6 Implementation Program

8.6.1 General

The phased implementation program for the project is based on :

(1) The whole proposed flood mitigation and storm water drainage improvement measures are divided into three (3) phased programs and will be completed by the target year of 2010.

(2) The other on-going project or committed projects, such as the immediate investment projects of FAP 8B (ADB), are considered, to ensure consistency with the proposed phased implementation programs.

(3) For phasing the implementation schedule of proposed measures, economic efficiency and social impacts are taken into consideration.

8.6.2 Project Components

1) Project Area and Sub Projects

The master plan for flood mitigation and urban drainage improvement proposes structural measures for the urban areas of the study area and non-structural measures, such as warning and evacuation systems, for the remaining area which consists of peripheral rural and flood plain areas.

The master plan for the flood mitigation and storm water drainage is composed of the following sub projects :

(1) Greater Dhaka West
(2) Greater Dhaka East
(3) Narayanganj DND
(4) Narayanganj West
(5) Narayanganj East
(6) Tongi
(7) Savar
(8) Keraniganj

According to the results of the project evaluation, the priority sequence of the proposed sub-projects are as follows :

(1) 1st priority Area
- Greater Dhaka West (GDW)
- Greater Dhaka East (GDE)
- Narayanganj DND (DND)
- Narayanganj West (N.WEST)

(2) 2nd priority Area
- Tongi
- Keraniganj

(3) 3rd priority Area
- Narayanganj East (N.EAST)
- Savar

In the lowlying areas outside these structural measure areas, evacuation road networks and evacuation shelters shall be provided in order to protect the rural population from flooding.

The priority sequence for the implementation of these evacuation facilities is determined based on the number of inhabitants in flood prone areas and is be as follows :

(1) Keraniganj
(2) Savar
(3) Narayanganj / Tongi

2) Proposed Facility

The proposed facilities are listed and shown in Table 8.7. The location of facilities is shown on Figs 8.16 (1) to (3).

8.6.3 Proposed Phased Program

A proposed program is composed of preparation stage and construction stage as follows :

(1) Preparation stage (1992-1994)

- Rehabilitation of the existing flood mitigation facilities and construction of the remaining works for Greater Dhaka West (GDW).
- Preparation of detailed design and project implementation for the proposed works in the phase I of Greater Dhaka-East (GDE), Narayanganj DND and Narayanganj West (N.WEST).

(2) Phase I (1995-1999)

- Improvement works of storm water drainage facilities for GDW.

- Implementation of the proposed works for phase I (GDW / GDE / DND / N.WEST).
- Preparation works of the proposed works for phase II (Tongi / Keraniganj).

(3) Phase II (2000-2004)

- Implementation of the remaining works for GDW.
- Implementation of the proposed works for Phase II (Tongi / Keraniganj).
- Preparation works of the proposed works for phase III (N.EAST / Savar)

(4) Phase III (2005-2009)

- Implementation of the proposed works for phase III (N.EAST / Savar)

The bar chart of the phased implementation program is shown on Table 8.9.

8.7 Environmental Impacts of the Project

8.7.1 With and Without Project Environment

The project is aimed at protecting the future urban area of 456 km^2 in the year 2010, from potential flood damage by means of structural measures of flood mitigation and stormwater drainage improvement. Non-structural measures, such as flood plain management, are proposed for the remaining low-lying areas of 328 km^2, the area to be left undeveloped with no significant change in land use.

The opportunity for planned urbanization with due flood mitigation and drainage improvement is a major advantage offered by this project.

The direct unfavorable environmental effects by the project, if any, would be highly localized, short term and insignificant in comparison to the necessity for and the benefit of the project. Subsequently, the major impacts by the project would be indirect, due to subsequent urbanization.

It is emphasized that irrespective the service level of urban amenities, flood mitigation and drainage for an urban area in itself is a basic environmental enhancement measure.

Flood induced cross contamination of water resources and the resultant epidemics is adequate to justify this point.

Accordingly the environmental condition in the future urban area would be deteriorated under the 'without project' condition in comparison to that of 'with project' condition.

Nevertheless, in order to fully realize the benefits of flood control and drainage measures, timely investment in human living environmental enhancement measures and other urban amenities is necessary, which would contribute to further enhancement of the urban environmental quality.

Direct and Indirect impacts with and without project are summarized as follows :

	With the Project	Without the Project
Resettlement	A number of population need to be sesettled due to embankment and khal improvement work Resettlement area should be considered in implementation stages.	No resettlement. However proposed resettlement areas are likely habitual flood area, those settlers would like to move to more safer area.
Severance	Water based transport routes, if any will be improved by improvement of khals with proper facilities, or be replaced by road networks.	Water based transport routes are deteriorating from sedimentation and with poor maintenance.
Water logging	By drainage improvement, potential internal flooding/water logging during rainy season will be improved.	Water logging conditions likely become worse and worse yearly.
Public Health	The project improves and mitigates contamination of water resources and the resultant water born disease epidemics on short term.	Public health condition likely become worse and worse yearly.
Land use potential	The project enhance the land use potential of 166 km^2 of habitual flood area for urban, industrial, agricultural and other uses, which will be reflected by increased land value in short term.	Land use potential increase but very low.
Agriculture	Agricultural loss is expected due to changes in land use to urban, though the project would be beneficial if land use remained unchanged.	Agricultural loss caused by flood is the same as ever.

Table 8.1 Comparison of Alternative Alignment

Area	Protected Area (ha)	Future Social Aspect (2010)			Cost (x 10^6 Tk.)			Economic Effectiveness (Cost /Pop.)	Resettlement Population	Remarks
		Population	Land Use (ha)		Polder	Drainage	Total			
			Built up	Agriculture & Open Space						
1. Greater Dhaka										
A. Eastern Bank										
Case A	4,270	1,251,000	3,330	940	5,012	9,626	14,638	11,701	15,800	
Case B	12,390	2,322,000	8,680	3,710	5,269	10,015	15,284	6,582	16,400	
B. Western Bank										
B1. Kamrangir Char										
Case A	390	192,000	370	20	714	412	1,126	5,926	7,700	
Case B	430	211,000	410	20	387	619	1,006	5,295	4,900	
B2. Dhaka West	13,490	6,053,000	11,960	1,530	2,950	12,440	15,390	2,543	4,400	ADB
2. Narayanganj Area										
A. Western Bank										
Case A	6,780	1,949,000	5,230	1,550	1,442	6,717	8,159	4,186	6,900	
Case B	7,610	2,241,000	5,990	1,620	1,701	7,524	9,225	4,116	12,300	
B. Eastern Bank	1,210	266,000	1,150	60	1,654	1,186	2,840	10,677	9,800	
3. Tongi										
Case A	2,430	653,000	1,940	490	1,352	1,670	3,022	4,628	5,700	
Case B	2,770	725,000	2,150	620	1,774	1,909	3,683	5,080	6,500	
4. Savar	2,070	250,000	1,820	250	997	439	1,436	5,241	3,500	
5. Keraniganj										
Case A	1,260	273,000	850	410	1,740	1,184	2,924	10,710	13,700	
Case B	2,430	457,000	2,000	430	2,750	2,116	4,866	10,648	18,400	

Table 8.2 Required Pump Capacity and Storage Volume of Retarding Pond

Name of Area	Drainage Zone	Sub-Zone	Area (km^2)	Required Pump Capacity		Required Storage Volume of Retarding Pond		Remarks
				Specific ($m^3/s/km^2$)	Total (m^3/s)	Specific ($x10^6\ m^3/km^2$)	Total ($x10^6\ m^3$)	
Greater Dhaka	Buriganga River Left Bank Zone (DA)	PD-1(Kamrangi Char)	6.96	1.14	8.0	0.12	0.84	
		PD-2 (Old Dhaka)	6.75	3.29	22.2	0.03	0.21	World Bank Project
		PD-3 (Kallyanpur)	17.60	1.14	20.0	0.12	2.08	JICA Project
	Turag River Left Bank Zone (DB)	PD-4 (Northern Part)	57.19	1.14	65.2	0.12	6.86	
	Balu River Right Bank Zone (DC)	PD-5 (Northern Part))	35.57	1.14	40.6	0.12	5.50	
		PD-6 (Central Part)	30.65	1.14	35.0	0.12	3.68	
		PD-7 (Southern Part)	90.74	1.14	103.5	0.12	10.89	
Tongi	Tongi West Zone (TA) PD-8		11.80	1.14	13.5	0.12	1.42	
	Tongi East Zone (TB) PD-9		10.25	1.14	11.7	0.12	1.23	
Narayanganj	DND Project Zone (NA)	PD-10 (Northern Part)	30.17	1.14	14.5	0.12	3.62	Existing P.S.
		PD-11 (Southern Part)	26.62	1.14	50.2	0.12	3.19	
	Narayanganj West Zone (NB)	PD-12	2.45	1.14	2.8	0.12	0.29	
		PD-13	5.52	1.14	6.3	0.12	0.66	
		PD-14	6.26	1.14	7.1	0.12	0.75	
	Narayanganj East Zone (NC)	PD-15	1.02	1.14	1.2	0.12	0.12	
		PD-16	3.87	1.14	4.4	0.12	0.46	
		PD-17	2.31	1.14	2.7	0.12	0.28	
		PD-18	3.68	1.14	4.2	0.12	0.44	
Keraniganj	Keraniganj Zone (K) PD-19		24.27	1.14	27.7	0.12	2.92	
Total			383.97	—	455.5	—	45.44	

Table 8.3 Design Water Levels and Area of Retarding Pond

Name of Area	Drainage Zone	Sub-Zone	Area (km^2)	Proposed Retarding Pond				Remarks
				Storage Capacity V ($x10^6$ m^3)	H.W.L. (mPWD)	L.W.L. (mPWD)	Area A (ha)	
Greater Dhaka	Buriganga River Left Bank Zone (DA)	PD-1(Kamrangi Char)	6.96	0.84	4.00	3.00	84	
		PD-2 (Old Dhaka)	6.75	0.21	-	3.00	2	World Bank Project
		PD-3 (Kallyanpur)	17.60	2.08	4.00	3.00	208	JICA Project
	Turag River Left Bank Zone (DB)	PD-4 (Northern Part)	57.19	6.86	4.00	3.00	686	
	Balu River Right Bank Zone (DC)	PD-5 (Northern Part))	35.57	5.50	4.00	3.00	427	
		PD-6 (Central Part)	30.65	3.68	4.00	3.00	368	
		PD-7 (Southern Part)	90.74	10.89	4.00	3.00	1,089	
Tongi	Tongi West Zone (TA) PD-8		11.80	1.42	4.00	3.00	142	
	Tongi East Zone (TB) PD-9		10.25	1.23	4.00	3.00	123	
Narayanganj	DND Project Zone (NA)	PD-10 (Northern Part)	30.17	3.62	4.00	3.00	362	
		PD-11 (Southern Part)	26.62	3.19	4.00	3.00	319	
	Narayanganj West Zone (NB)	PD-12	2.45	0.29	4.00	3.00	29	
		PD-13	5.52	0.66	4.00	3.00	66	
		PD-14	6.26	0.75	4.00	3.00	75	
	Narayanganj East Zone (NC)	PD-15	1.02	0.12	4.00	3.00	12	
		PD-16	3.87	0.46	4.00	3.00	46	
		PD-17	2.31	0.28	4.00	3.00	28	
		PD-18	3.68	0.44	4.00	3.00	44	
Keraniganj	Keraniganj Zone (K) PD-19		24.27	2.92	4.00	3.00	292	
Total			383.97	45.44	—	—	4,402	

Table 8.4 Hydraulic Requirements of Proposed Pump Station

Name of Area	Pump Station	Drainage Area (km^2)	Capacity (m^3/s)	Design Water Level (m.PWD)					Static Head (m)		Remarks
				Outer			Inner				
				H.H.W.L.	H.W.L.	L.W.L.	H.W.L.	L.W.L.	Design	Max.	
Greater Dhaka	P1	6.96	8.0	8.00	5.95	3.00	4.00	3.00	2.95	5.00	
	P2	6.75	22.2	8.00	6.45	2.40	5.00	2.40	4.05	5.60	World Bank Project
	P3	17.60	20.0	8.35	6.00	3.00	5.45	3.95	2.05	4.40	JICA Project
	P4	57.19	65.2	8.60	6.45	3.00	4.00	3.00	3.45	5.60	
	P5	35.57	40.6	8.15	6.35	3.00	4.00	3.00	3.35	5.15	
	P6	30.65	35.0	7.90	6.20	3.00	4.00	3.00	3.20	4.90	
	P7	90.74	103.5	7.65	6.05	3.00	4.00	3.00	3.05	4.65	
Tongi	P1	11.80	13.5	8.60	6.45	3.00	4.00	3.00	3.45	5.60	
	P2	10.25	11.7	8.60	6.45	3.00	4.00	3.00	3.45	5.60	
Narayanganj	P1	30.17	14.5	7.40	5.94	3.00	1.80	1.00	4.94	6.40	Existing Pump Station
	P2	26.62	50.2	7.30	5.70	3.00	4.00	3.00	2.70	4.30	
	P3	2.45	2.8	7.40	5.80	3.00	4.00	3.00	2.80	4.40	
	P4	5.52	6.3	7.40	5.80	3.00	4.00	3.00	2.80	4.40	
	P5	6.26	7.1	7.20	5.45	3.00	4.00	3.00	2.45	4.20	
	P6	1.02	1.2	7.40	5.80	3.00	4.00	3.00	2.80	4.40	
	P7	3.87	4.4	7.30	5.70	3.00	4.00	3.00	2.70	4.30	
	P8	2.31	2.7	7.20	5.60	3.00	4.00	3.00	2.60	4.20	
	P9	3.68	4.2	7.00	5.50	3.00	4.00	3.00	2.50	4.00	
Keraniganj	P1	24.27	27.7	7.20	5.45	3.00	4.00	3.00	2.45	4.20	

Note : The values of H.H.W.L. and H.W.L. of outer design water level correspond to 100 - year and 2-year frequency flood water level respectively.

Table 8.5 Design Discharge

Block No.	Drainage Area (km2)	Velocity (m/s)	Time of Concentration (min)	Rainfall Intensity (mm/hr)	Run-off Coefficient	Areal Reduction Factor	Run-Off (m3/s)
Buriganga River Left Bank Zone (DA)							
DA-1	6.96	0.80	97.73	60.96	0.40	0.96	45.25
Turag River Left Bank Zone (DB)							
DB-1	5.88	0.80	91.44	63.67	0.40	0.96	39.93
DB-2	7.48	0.80	100.58	59.80	0.40	0.95	47.22
DB-3	6.33	0.80	94.13	62.48	0.40	0.96	42.19
DB-4	22.89	0.80	160.96	42.69	0.40	0.90	97.71
DB-5	13.88	0.80	129.77	50.09	0.40	0.93	71.85
DB-6	23.95	0.80	164.19	42.04	0.40	0.90	100.69
DB-7	57.21	0.80	242.85	30.75	0.40	0.81	158.33
DB-8	3.63	0.80	76.13	71.39	0.40	0.98	28.22
Balu River Right Bank Zone (DC-1)							
DC-1-1	5.79	0.80	90.89	63.91	0.40	0.96	39.47
DC-1-2	16.84	0.80	140.91	47.17	0.40	0.92	81.20
DC-1-3	5.78	0.80	90.83	63.94	0.40	0.96	39.42
DC-1-4	9.75	0.80	112.00	55.59	0.40	0.94	56.61
DC-1-5	11.49	0.80	119.87	53.01	0.40	0.94	63.62
DC-1-6	35.57	0.80	195.72	36.65	0.40	0.85	123.11
DC-1-7	5.21	0.80	87.25	65.61	0.40	0.97	36.84
DC-1-8	3.14	0.80	72.21	73.69	0.40	0.98	25.19
DC-1-9	1.94	0.80	61.04	81.10	0.40	0.99	17.31
Balu River Right Bank Zone (DC-2)							
DC-2-1	3.97	0.80	78.70	69.97	0.40	0.97	29.94
DC-2-2	4.94	0.80	85.48	66.47	0.40	0.97	35.39
DC-2-3	10.99	0.80	117.67	53.71	0.40	0.94	61.65
DC-2-4	3.22	0.80	72.87	73.29	0.40	0.98	25.70
DC-2-5	21.54	0.80	156.74	43.56	0.40	0.91	94.86
DC-2-6	3.04	0.80	71.37	74.19	0.40	0.98	24.56
DC-2-7	30.65	0.80	183.11	38.63	0.40	0.87	114.45
Balu River Right Bank Zone (DC-3)							
DC-3-1	8.81	1.00	87.83	65.33	0.40	1.00	66.65
DC-3-2	11.80	1.00	100.97	59.65	0.40	0.94	73.51
DC-3-3	17.64	0.80	143.74	46.48	0.40	0.92	83.81
DC-3-4	35.12	0.80	194.60	36.81	0.40	0.85	122.11
DC-3-5	5.36	0.80	88.21	65.15	0.40	0.97	37.64
DC-3-6	47.94	0.80	224.00	32.87	0.40	0.83	145.30
DC-3-7	6.59	1.00	86.67	65.89	0.42	1.00	52.17
DC-3-8	13.15	1.00	105.47	57.92	0.40	0.93	78.70
DC-3-9	7.39	0.80	100.09	60.00	0.40	0.95	46.80
DC-3-10	6.64	0.80	95.92	61.71	0.40	0.96	43.71
DC-3-11	16.99	0.80	141.44	47.04	0.40	0.92	81.69
DC-3-12	90.74	0.80	300.66	25.68	0.40	0.77	199.37
Tongi West Zone (TA)							
TA-1	4.13	0.80	79.88	69.34	0.40	0.97	30.86
TA-2	5.16	0.80	86.93	65.77	0.40	0.96	36.20
TA-3	3.86	0.80	77.89	70.41	0.40	0.97	29.29
TA-4	9.52	0.80	110.91	55.96	0.40	0.94	55.65
TA-5	2.28	0.80	64.49	78.65	0.40	0.99	19.73
TA-6	1.44	0.80	55.36	85.47	0.40	0.99	13.54
Tongi East Zone (TB)							
TB-1	4.64	0.80	83.46	67.47	0.40	0.97	33.74
TB-2	2.72	0.80	68.59	75.93	0.40	0.98	22.49
TB-3	8.17	0.80	104.21	58.39	0.40	0.95	50.36
TB-4	2.08	0.80	62.49	80.05	0.40	0.99	18.32
TB-5	0.81	0.80	46.52	93.30	0.40	1.00	8.40

Table 8.5 Design Discharge

Block No.	Drainage Area (km2)	Velocity (m/s)	Time of Concentration (min)	Rainfall Intensity (mm/hr)	Run-off Coefficient	Areal Reduction Factor	Run-Off (m3/s)
Savar Zone (S)							
S-1	6.23	0.80	93.54	62.74	0.40	0.97	42.12
S-2	10.70	0.80	116.38	54.12	0.40	0.94	60.49
S-3	4.60	0.80	83.19	67.61	0.40	0.97	33.52
S-4	4.16	0.80	80.09	69.22	0.40	0.98	31.36
S-5	14.21	0.80	131.06	49.73	0.40	0.93	73.03
S-6	26.47	0.80	171.58	40.64	0.40	0.88	105.18
S-7	4.94	0.80	85.48	66.47	0.40	0.97	35.39
S-8	1.14	0.80	51.46	88.76	0.40	0.99	11.13
S-9	2.01	0.80	61.77	80.57	0.40	0.99	17.81
S-10	0.86	0.80	47.32	92.53	0.40	1.00	8.84
S-11	6.11	0.80	92.83	63.05	0.40	0.97	41.52
S-12	9.36	0.80	110.14	56.23	0.40	0.94	54.97
S-13	5.19	0.80	87.12	65.67	0.40	0.97	36.73
S-14	16.63	0.80	140.15	47.36	0.40	0.92	80.51
DND Project Area (NA-1)							
NA-1-1	6.81	0.80	96.89	61.31	0.40	0.96	44.53
NA-1-2	3.41	0.80	74.41	72.38	0.40	0.98	26.88
NA-1-3	17.68	0.80	143.88	46.45	0.40	0.92	83.94
NA-1-4	3.30	0.80	73.52	72.90	0.40	0.98	26.20
NA-1-5	24.42	0.80	165.60	41.77	0.40	0.90	102.00
NA-1-6	4.61	0.80	83.26	67.58	0.40	0.97	33.58
NA-1-7	30.17	0.80	181.83	38.84	0.40	0.87	113.28
DND Project Area (NA-2)							
NA-2-1	7.78	0.80	102.18	59.17	0.40	0.95	48.59
NA-2-2	2.36	0.80	65.26	78.13	0.40	0.98	20.08
NA-2-3	14.39	0.80	131.76	49.54	0.40	0.93	73.67
NA-2-4	4.54	0.80	82.78	67.82	0.40	0.97	33.19
NA-2-5	2.68	0.80	68.23	76.16	0.40	0.98	22.23
NA-2-6	11.18	0.80	118.51	53.44	0.40	0.94	62.40
NA-2-7	26.62	0.80	172.01	40.56	0.40	0.88	105.57
Narayanganj West Zone (NB)							
NB-1	2.45	0.80	66.12	77.55	0.40	0.98	20.69
NB-2	5.52	0.80	89.22	64.68	0.40	0.96	38.08
NB-3	1.11	0.80	51.04	89.12	0.40	0.99	10.88
NB-4	2.41	0.80	65.74	77.80	0.40	0.98	20.42
NB-5	0.88	0.80	47.64	92.23	0.40	1.00	9.02
NB-6	3.57	0.80	75.67	71.66	0.40	0.97	27.57
NB-7	2.69	0.80	68.32	76.11	0.40	0.98	22.29
Narayanganj East Zone (NC)							
NC-1	1.02	0.80	49.76	90.27	0.40	0.99	10.13
NC-2	0.60	0.80	42.82	97.01	0.40	1.00	6.47
NC-3	3.27	0.80	73.28	73.05	0.40	0.98	26.01
NC-4	2.31	0.80	64.78	78.45	0.40	0.99	19.94
NC-5	1.92	0.80	60.82	81.25	0.40	0.99	17.16
NC-6	3.68	0.80	76.52	71.17	0.40	0.97	28.23
Keraniganj Zone (K)							
K-1	2.19	0.80	63.60	79.27	0.40	0.98	18.90
K-2	2.70	0.80	68.41	76.05	0.40	0.98	22.36
K-3	5.57	0.80	89.53	64.54	0.40	0.96	38.34
K-4	3.55	0.80	75.51	71.75	0.40	0.97	27.45
K-5	11.40	0.80	119.48	53.13	0.40	0.94	63.26
K-6	1.86	0.80	60.18	81.73	0.40	0.99	16.72
K-7	13.99	0.80	130.20	49.97	0.40	0.93	72.24
K-8	10.28	0.80	114.46	54.75	0.40	0.94	58.79

Table 8.6 Hydraulic Design of Khal Improvement and Trunk Drain

Khal No.	Design Discharge (m3/s)	Section Bottom Wid. (m)	Section Upper Wid. (m)	Section Height (m)	Roughness Coefficient	Bed Slope i (%)	Velocity (m/s)	Discharge Capacity (m3/s)
Buriganga River Left Bank Zone (DA)								
DA-1	45.25	7.00	23.00	4.00	0.035	0.025	0.81	48.73
Turag River Left Bank Zone (DB)								
DB.1-1	158.33	40.00	56.00	4.00	0.035	0.017	0.83	159.07
DB.1-2	100.69	22.00	38.00	4.00	0.035	0.020	0.84	101.05
DB.1-3	71.85	13.00	29.00	4.00	0.035	0.025	0.88	73.93
DB.2-1	97.71	24.00	40.00	4.00	0.035	0.017	0.78	100.41
DB.2-2	39.93	7.00	23.00	4.00	0.035	0.017	0.67	40.19
DB.3	47.22	10.00	26.00	4.00	0.035	0.015	0.66	47.41
DB.4	42.19	5.00	21.00	4.00	0.035	0.033	0.90	46.64
DB.5	28.22	5.00	19.00	3.50	0.035	0.025	0.73	30.46
Balu River Right Bank Zone (DC-1)								
DC.1-1	123.11	34.00	48.00	3.50	0.035	0.022	0.86	123.39
DC.1-2	63.62	17.00	31.00	3.50	0.035	0.022	0.80	66.83
DC.1-3	56.61	14.00	28.00	3.50	0.035	0.022	0.78	57.05
DC.1-4	39.42	9.00	23.00	3.50	0.035	0.022	0.73	41.01
DC.2-1	81.20	15.00	29.00	3.50	0.035	0.040	1.06	81.31
DC.2-2	39.47	6.00	20.00	3.50	0.035	0.040	0.94	42.66
DC.3	36.84	7.00	19.00	3.00	0.035	0.050	0.98	38.36
DC.4	25.19	4.00	18.00	3.50	0.035	0.025	0.71	27.23
DC.5	17.31	1.00	15.00	3.50	0.035	0.025	0.64	17.89
Balu River Right Bank Zone (DC-2)								
DC.6-1	114.45	28.00	44.00	4.00	0.035	0.017	0.80	114.98
DC.6-2	94.86	23.00	39.00	4.00	0.035	0.017	0.78	96.78
DC.6-3	61.65	11.00	27.00	4.00	0.035	0.025	0.86	65.43
DC.6-4	35.39	4.00	20.00	4.00	0.035	0.025	0.76	36.60
DC.7	24.56	1.00	17.00	4.00	0.035	0.033	0.80	28.72
DC.8	25.70	3.00	19.00	4.00	0.035	0.017	0.61	26.93
DC.9	29.94	4.00	20.00	4.00	0.035	0.017	0.63	30.18
Balu River Right Bank Zone (DC-3)								
DC.10-1	199.37	37.00	54.20	4.30	0.035	0.025	1.04	203.69
DC.10-2	145.30	30.00	46.00	4.00	0.035	0.025	0.98	148.30
DC.10-3	122.11	28.00	43.00	3.75	0.035	0.025	0.93	124.36
DC.10-4	73.51	15.00	29.00	3.50	0.035	0.033	0.96	73.85
DC.11-1	81.69	18.00	34.00	4.00	0.035	0.020	0.82	85.41
DC.11-2	46.80	8.00	24.00	4.00	0.035	0.020	0.74	47.28
DC.12	43.71	8.00	24.00	4.00	0.035	0.020	0.74	47.28
DC.13	78.70	17.00	33.00	4.00	0.035	0.020	0.82	81.53
DC.14	37.64	8.00	23.00	3.75	0.035	0.017	0.66	38.24
DC.15	83.81	18.00	32.00	3.50	0.035	0.033	0.98	85.87
Tongi West Zone (TA)								
TA.1-1	55.65	10.00	24.00	3.50	0.035	0.040	1.00	59.58
TA.1-2	36.20	5.00	19.00	3.50	0.035	0.040	0.92	38.52
TA.1-3	30.86	4.00	18.00	3.50	0.035	0.040	0.89	34.44
TA.2	29.29	3.00	15.00	3.00	0.035	0.100	1.26	33.99
TA.3	19.73	3.00	15.00	3.00	0.035	0.040	0.80	21.50
TA.4	13.54	6.00	14.00	2.00	0.035	0.040	0.69	13.88
Tongi East Zone (TB)								
TB.1-1	50.36	8.00	24.00	4.00	0.035	0.025	0.83	52.86
TB.1-2	33.74	4.00	20.00	4.00	0.035	0.025	0.76	36.60
TB.2	22.49	3.00	13.00	2.50	0.035	0.100	1.14	22.73
TB.3	18.32	4.00	16.00	3.00	0.035	0.025	0.65	19.47
TB.4	8.40	1.00	9.00	2.00	0.035	0.100	0.91	9.07

Table 8.6 Hydraulic Design of Khal Improvement and Trunk Drain

Khal No.	Design Discharge (m3/s)	Section			Roughness Coefficient	Bed Slope i (%)	Velocity (m/s)	Discharge Capacity (m3/s)
		Bottom Wid. (m)	Upper Wid. (m)	Height (m)				
Savar Zone (S)								
S.1-1	105.18	21.00	37.00	4.00	0.035	0.025	0.94	108.59
S.1-2	60.49	3.00	19.00	4.00	0.035	0.100	1.48	65.33
S.1-3	42.12	6.00	22.00	4.00	0.035	0.025	0.80	44.64
S.2-1	73.03	18.00	32.00	3.50	0.035	0.025	0.85	74.74
S.2-2	33.52	3.00	17.00	3.50	0.035	0.050	0.97	34.02
S.3	31.36	3.00	17.00	3.50	0.035	0.050	0.97	34.02
S.4	35.39	7.00	19.00	3.00	0.035	0.050	0.98	38.36
S.5	11.13	4.00	12.00	2.00	0.035	0.050	0.74	11.77
S.6	17.81	4.00	16.00	3.00	0.035	0.025	0.65	19.47
S.7	8.84	2.00	12.00	2.50	0.035	0.025	0.55	9.55
S.8-1	80.51	20.00	34.00	3.50	0.035	0.025	0.87	81.76
S.8-2	54.97	13.00	27.00	3.50	0.035	0.025	0.82	57.36
S.8-3	41.52	5.00	19.00	3.50	0.035	0.050	1.03	43.07
S.9	36.73	4.00	16.00	3.00	0.035	0.100	1.30	38.95
DND Project Area (NA-1)								
NA.1-1	113.28	28.00	44.00	4.00	0.035	0.017	0.80	114.98
NA.1-2	102.00	25.00	41.00	4.00	0.035	0.017	0.79	104.04
NA.1-3	83.94	20.00	36.00	4.00	0.035	0.017	0.77	85.94
NA.1-4	44.53	8.00	22.40	3.60	0.035	0.029	0.84	45.99
NA.2	33.58	4.00	20.00	4.00	0.035	0.022	0.72	34.33
NA.3	26.20	3.00	17.80	3.70	0.035	0.029	0.76	29.41
NA.4	26.88	7.00	18.60	2.90	0.035	0.029	0.74	27.30
DND Project Area (NA-2)								
NA.5-1	105.57	19.00	35.00	4.00	0.035	0.029	1.00	107.54
NA.5-2	73.67	12.00	28.00	4.00	0.035	0.029	0.94	75.04
NA.5-3	48.59	7.00	21.80	3.70	0.035	0.040	0.98	52.47
NA.6-1	62.40	14.00	30.00	4.00	0.035	0.017	0.73	64.50
NA.6-2	33.19	4.00	18.40	3.60	0.035	0.033	0.83	33.29
NA.7	22.23	3.00	17.80	3.70	0.035	0.017	0.59	22.52
NA.8	20.08	1.00	15.80	3.70	0.035	0.025	0.66	20.55
Narayanganj West Zone (NB)								
NB.1	20.69	2.00	16.00	3.50	0.035	0.025	0.66	20.94
NB.2	38.08	5.00	21.00	4.00	0.035	0.025	0.78	40.60
NB.3	10.88	1.00	13.00	3.00	0.035	0.025	0.58	12.19
NB.4	20.42	2.00	16.00	3.50	0.035	0.025	0.66	20.94
NB.5	9.02	0.00	12.00	3.00	0.035	0.025	0.55	9.89
NB.6	27.57	5.00	17.00	3.00	0.035	0.040	0.84	27.82
NB.7	22.29	4.00	16.00	3.00	0.035	0.040	0.82	24.63
Narayanganj East Zone (NC)								
NC.1	10.13	1.00	13.00	3.00	0.035	0.025	0.58	12.19
NC.2	6.47	3.00	11.00	2.00	0.035	0.025	0.50	7.03
NC.3	26.01	7.00	19.00	3.00	0.035	0.025	0.70	27.12
NC.4	19.94	5.00	17.00	3.00	0.035	0.025	0.67	21.99
NC.5	17.16	4.00	16.00	3.00	0.035	0.025	0.65	19.47
NC.6	28.23	8.00	20.00	3.00	0.035	0.025	0.71	29.73
Keraniganj Zone (k)								
K.1-1	72.24	14.00	32.00	4.50	0.035	0.015	0.73	75.89
K.1-2	63.26	11.00	29.00	4.50	0.035	0.015	0.71	63.92
K.1-3	38.34	5.00	23.00	4.50	0.035	0.015	0.65	40.69
K.1-4	18.90	0.00	18.00	4.50	0.035	0.022	0.68	27.36
K.2	16.72	2.00	15.60	3.40	0.035	0.022	0.61	18.34
K.3	27.45	3.00	18.40	3.85	0.035	0.022	0.68	28.06
K.4	22.36	1.00	17.00	4.00	0.035	0.022	0.65	23.45
K.5	58.79	5.00	23.00	4.50	0.035	0.033	0.96	60.35

Table 8.7 List of Proposed Facilities

Area	Flood Mitigation			Stormwater Drainage		
1. Greater Dhaka						
1) West	a) Embankment (R)	:	16.7 km	a) Pump Station (No.)	:	73.2 m3/s (2plcs)
	b) Flood wall (R)	:	4.7 km	b) Khal Improvement	:	42.7 km
	c) Embankment	:	6.3 km	c) Drainage Pipe	:	8.1 km
	d) Flood Wall	:	3.0 km	d) Retarding Pond	:	770.0 ha
	e) Sluice Gate	:	11 plcs	e) Land Acquisition	:	43.7 ha
	f) Land Acquisition	:	37.0 ha			
2) East	a) Embankment	:	26.7 km	a) Pump Station (No.)	:	179.1 m3/s (3plcs)
	b) Sub Embankment	:	11.3 km	b) Khal Improvement	:	72.4 km
	c) Sluice Gate	:	5 plcs	c) Drainage pipe	:	8.9 km
	d) Land Acquisition	:	317.4 ha	d) Retarding Pond	:	1,884.0 ha
				e) Land Acquisition	:	168.0 ha
2.Narayanganj						
1)DND Area	a) Flood Wall (R)	:	20.2 km	a) Pump Station (No.)	:	50.2 m3/s (1plcs)
	b) Flood Wall	:	10.0 km	b) Khal Improvement	:	38.0 km
	c) Sluice Gate	:	2 plcs	c) Retarding Pond	:	681.0ha
	d) Land Acquisition	:	5.8 ha	d) Land Acquisition	:	90.8 ha
2) West	a) Embankment	:	6.1 km	a) Pump Station (No.)	:	16.2 m3/s (3plcs)
	b) Road-Cum-Embankment	:	4.3 km	b) Khal Improvement	:	6.4 km
	c) Flood Wall	:	10.5 km	c) Retarding Pond	:	170.0 ha
	d) Sluice Gate	:	7 plcs	d) Land Acquisition	:	12.2 ha
	e) Land Acuqisition	:	61.5 ha			
	% Evacuation Facilities		1 L.S			
3) East	a) Embankment	:	6.6 km	a) Pump Station (No.)	:	12.5 m3/s (4plcs)
	b) Road-Cum-Embankment	:	6.5 km	b) Khal Improvement	:	7.4 km
	c) Flood Wall	:	26.0 km	c) Retarding Pond	:	130.0 ha
	d) Sluice Gate	:	12 plcs	d) Land Acquisition	:	14.1 ha
	e) Land Acquisition	:	99.2 ha			
3. Tongi	a) Embankment	:	13.0 km	a) Pump Station (No.)	:	25.2 m3/s (2plcs)
	b) Road-Cum-Embankment	:	6.2 km	b) Khal Improvement	:	22.0km
	c) Flood Wall	:	2.2 km	c) Retarding Pond	:	265.0 ha
	d) Sluice Gate	:	7 plcs	d) Land Acquisition	:	42.5 ha
	e) Land Acquisition	:	100.9 ha			
	% Evacuation Facilities	:	1 L.S			
4.Savar	a) Embankment	:	9.3 km	a) Khal Improvement	:	30.0 km
	b) Sluice Gate	:	3 plcs	b) Land Acquisition	:	66.2 ha
	c) Land Acquisition	:	62.3 ha			
	% Evacuation Facilities	:	1 L.S			
5. Keraniganj	a) Embankment	:	23.3 km	a) Pump Station (No.)	:	27.7 m3/s (1plcs)
	b) Flood Wall	:	3.7 km	b) Khal Improvement	:	22.5 km
	c) Sluice Gate	:	10 plcs	c) Retarding Pond	:	292.0 ha
	d) Land Acquisition	:	163.7 ha	d) Land Acquisition	:	50.6 ha
	% Evacuation Facilities	:	1 L.S			

Note : 1) Embankment (R) : Rehabilitation Work of Embankment
2) Flood Wall (R) : Rehabilitation Work of Flood Wall
3) Land Acquisition : Retarding Pond is not included
4) Pump station (No.) : Total Capacity (Number of Pump Station)
5) On-Going Projects by JICA and IBRD are not included.

Table 8.8 Project Cost of Each Sub Project

1) Summary

(Unit: million TK)

Project Area	G. Dhaka West			G. Dhaka East			Narayanganj DND			Narayanganj West		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
I. Structural Measures												
1) Construction Cost	2,746.2	2,163.3	4,909.5	6,217.6	5,384.5	11,602.1	1,460.7	1,064.0	2,524.7	697.8	552.3	1,250.1
2) Physical Contingency	686.6	540.8	1,227.4	1,554.4	1,346.1	2,900.5	365.2	266.0	631.2	174.4	138.1	312.5
3) Land Acquisition Cost	-	3,907.2	3,907.2	-	6,285.5	6,285.5	-	4,043.8	4,043.8	-	1,267.1	1,267.1
4) Engineering Cost	274.6	216.4	491.0	621.8	538.4	1,160.2	146.1	106.4	252.5	69.8	55.2	125.0
5) Administration Cost	-	147.3	147.3	-	348.1	348.1	-	75.7	75.7	-	37.5	37.5
6) Previous/On-going Projects	-	-	(3,351.2)	-	-	(226.1)	-	-	(138.5)	-	-	-
Sub-Total	3,707.4	6,975.0	10,682.4	8,393.8	13,902.6	22,296.4	1,972.0	5,555.9	7,527.9	942.0	2,050.2	2,992.2
			(3,351.2)			(226.1)			(138.5)			
II. Non-Structural Measures												
1) Construction Cost	-	-	-	-	-	-	-	-	-	10.0	15.0	25.0
2) Physical Contingency	-	-	-	-	-	-	-	-	-	2.5	3.8	6.3
3) Land Acquisition Cost	-	-	-	-	-	-	-	-	-	-	5.7	5.7
4) Engineering Cost	-	-	-	-	-	-	-	-	-	1.0	1.5	2.5
5) Administration Cost	-	-	-	-	-	-	-	-	-	-	0.8	0.8
Sub-Total										13.5	26.8	40.3
Total	3,707.4	6,975.0	10,682.4	8,393.8	13,902.6	22,296.4	1,972.0	5,555.9	7,527.9	955.5	2,077.0	3,032.5
			(3,351.2)			(226.1)			(138.5)			

Project Area	Narayanganj East			Tongi			Savar			Keraniganj		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
I. Structural Measures												
1) Construction Cost	932.0	781.8	1,713.8	1,129.4	966.0	2,095.4	644.3	755.1	1,399.4	1,659.4	1,676.6	3,336.0
2) Physical Contingency	233.0	195.5	428.5	282.4	241.5	523.9	161.1	188.8	349.9	414.9	419.1	834.0
3) Land Acquisition Cost	-	1,265.0	1,265.0	-	1,102.8	1,102.8	-	282.7	282.7	-	1,721.3	1,721.3
4) Engineering Cost	93.2	78.2	171.4	112.9	96.6	209.5	64.4	75.5	139.9	165.9	167.7	333.6
5) Administration Cost	-	51.4	51.4	-	62.9	62.9	-	42.0	42.0	-	100.1	100.1
6) Previous/On-going Projects	-	-	-	-	-	-	-	-	-	-	-	-
Sub-Total	1,258.2	2,371.9	3,630.1	1,524.7	2,469.8	3,994.5	869.8	1,344.1	2,213.9	2,240.2	4,084.8	6,325.0
II. Non-Structural Measures												
1) Construction Cost	-	-	-	20.0	30.0	50.0	148.5	202.5	351.0	261.0	351.0	612.0
2) Physical Contingency	-	-	-	5.0	7.5	12.5	37.2	50.6	87.8	65.3	87.7	153.0
3) Land Acquisition Cost	-	-	-	-	5.9	5.9	-	28.1	28.1	-	73.4	73.4
4) Engineering Cost	-	-	-	2.0	3.0	5.0	14.9	20.2	35.1	26.1	35.1	61.2
5) Administration Cost	-	-	-	-	1.5	1.5	-	10.5	10.5	-	18.4	18.4
Sub-Total				27.0	47.9	74.9	200.6	311.9	512.5	352.4	565.6	918.0
Total	1,258.2	2,371.9	3,630.1	1,551.7	2,517.7	4,069.4	1,070.4	1,656.0	2,726.4	2,592.6	4,650.4	7,243.0

Grand Total (I)			59,662.4
			(3,915.8)
Grand Total (I)+(II)			61,208.1
			(3,915.8)

2) Breakdown of Project Cost (Greater Dhaka West)

Unit: 1,000 Tk

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
A. Construction Cost								
I. Flood Protection								
1. Rehabilitation -Embankment(R)								
a. Banking	m^3	0.53	40	60	784,000	166,208	249,312	415,520
b. Foundation	m	0.626	70	30	240,000	105,168	45,072	150,240
Sub-total						271,376	294,384	565,760
-Flood wall(R)	m	6.0	50	50	4,700	14,100	14,100	28,200
2. Embankment								
a. Banking	m^3	0.53	40	60	470,000	99,640	149,460	249,100
b. Foundation	m	0.626	70	30	97,000	42,505	18,217	60,722
Sub-total						142,145	167,677	309,822
3. Flood wall	m	27.0	50	50	3,000	40,500	40,500	81,000
4. Sluice Way								
a. Previous JICA Proposal								
Gate 10.2 m^2	set	21,571	65	35	1	14,021	7,550	21,571
" 4.8 "	"	52,470	65	35	3	34,106	18,364	52,470
" 6.3 "	"	6,996	65	35	1	4,547	2,449	6,996
b. Addtional Proposal	"							
Gate 6.9 m^2	"	24,400	65	35	1	15,860	8,540	24,400
" 28.6 "	"	109,800	65	35	1	71,370	38,430	109,800
" 16.0 "	"	70,400	65	35	1	45,760	24,640	70,400
" 51.0 "	"	163,200	65	35	1	106,080	57,120	163,200
" 11.3 "	"	53,100	65	35	1	34,515	18,585	53,100
" 18.1 "	"	77,900	65	35	1	50,635	27,265	77,900
Sub-total						376,894	202,943	579,837
Total of I						845,015	719,604	1,564,619
II. Storm Water Drainage								
1. Pump Station								
P - 65.2 m^3/s								
a. Construction	L.S.	710,700	50	50	1	355,350	355,300	710,700
b. Equipment	L.S.	736,800	85	15	1	626,280	110,520	736,800
Sub-total						981,630	465,870	1,447,500
P -8.0 m3/s								
a. Construction	L.S	125,000	50	50	1	62,500	62,500	125,000
b. Equipment	L.S	100,800	85	15	1	85,680	15,120	100,800
Sub-total						148,180	77,620	225,800
Total of 1						1,129,810	543,490	1,673,300
2. Khal Improvement								
a. Previous JICA Proposal	Km		46.6	53.4	16.2	228,420	261,417	489,837
b. Addtional Proposal	Km		46.6	53.4	26.5	321,200	367,700	688,900
Sub-total						549,620	629,117	1,178,737
3. Drainage pipe								
a. Previous JICA Proposal	Km		45.0	55.0	8.1	221,773	271,095	492,868
Total of II						1,901,203	1,443,702	3,344,905
Total of A						2,746,218	2,163,306	4,909,524

(Greater Dhaka West)

(Continued)

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
B Land Acquisition Cost								
1. Flood Protection	m^2	0.45	---	100	370,000	---	166,500	166,500
2. Storm Water Drainage								
a. Previous JICA Proposal	m^2	1.49	---	100	76,000	---	113,240	113,240
b. Addtional Proposal	m^2	0.45	---	100	8,061,000	---	3,627,450	3,627,450
Sub-total							3,740,690	3,740,690
Total of B							3,907,190	3,907,190
C Previous/On-going Project								
1. GOB Project								2,294,152
2 JICA Project								794,500
3. IBRD Project								462,504
Total of C								3,551,156

NOTE:
1) Previous JICA Proposal :Proposed facilities in the UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY (FEB.1990)
2) additional Proposal :Proposed facilities in this Study
3) Costs of Previous JICA Proposal are converted to 1991 price from 1989 price
4) Costs of Previous/On-going Projects are at 1991 price,converted from 1989 price,which include Construction cost, Physical contingency,Land acquisition cost,Engneering cost,and Administration cost.

3) Breakdown of Project Cost (Greater Dhaka East)

Unit: 1,000 Tk

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
A. Construction Cost								
I. Flood Protection								
1. Embankment								
a. Banking	m^3	0.53	40	60	4,385,000	929,620	1,394,430	2,324,050
b. Foundation	m	0.626	70	30	613,080	300,409	128,747	429,156
Sub-total						1,230,029	1,523,177	2,753,206
2. Sub-Embankment								
Banking	m^3	0.53	40	60	1,563,100	331,377	497,066	828,443
3. Sluice Way								
Gate 79.7 m^2	set	233,700	65	35	1	151,905	81,795	233,700
" 45.8 "	"	111,800	65	35	1	72,670	39,130	111,800
" 49.2 "	"	116,800	65	35	1	75,920	40,880	116,800
" 14.7 "	"	67,000	65	35	1	43,550	23,450	67,000
" 10.1 "	"	27,900	65	35	1	18,135	9,765	27,900
Sub-total						362,180	195,020	557,200
Total of I						1,923,586	2,215,263	4,138,849
II. Storm Water Drainage								
1. Pump Station								
P - 103.5m^3/s								
a. Construction	L.S.	1,189,100	50	50	1	594,550	594,550	1,189,100
b. Equipment	L.S.	1,085,700	85	15	1	922,845	162,855	1,085,700
Sub-total						1,517,395	757,405	2,274,800
P - 35.0 m^3/s								
a. Construction	L.S.	439,700	50	50	1	219,850	219,850	439,700
b. Equipment	L.S.	432,800	85	15	1	367,880	64,920	432,800
Sub-total						587,730	284,770	872,500
P - 40.6 m^3/s								
a. Construction	L.S.	482,000	50	50	1	241,000	241,000	482,000
b. Equipment	L.S.	498,000	85	15	1	423,300	74,700	498,000
Sub-total						664,300	315,700	980,000
Total of 1.						2,769,425	1,357,875	4,127,300
2. Khal Improvement								
a. Previous JICA Proposal	km	—	45.8	45.2	16.4	714,525	845,583	1,560,108
b. Additional Proposal	km	—	45.8	45.2	56.0	624,900	739,600	1,364,500
Sub-total						1,339,425	1,585,183	2,924,608
3. Drainage pipe								
a. Previous JICA Proposal	km		45.0	55.0	8.9	185,161	226,204	411,365
Total of II						4,294,011	3,169,262	7,463,273
Total of A						6,217,597	5,384,525	11,602,122

(Greater Dhaka East)

(Continued)

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
B. Land Acquisition Cost								
1. Flood Protection								
a. Embankment	m^3	0.35	---	100	2,269,500	—	794,325	794,325
b. Sub-Emb.	m^3	0.25	---	100	904,000	—	226,000	226,000
Sub-total	m^3				3,173,500	—	1,020,325	1,020,325
2. Storm Water Drainage								
a. Previous JICA Proposal	m^2	2.43	---	100	62,000	—	150,660	150,660
b. Additional Proposal	m^2	0.25	---	100	20,458,000	—	5,114,500	5,114,500
Sub-total						—	5,265,160	5,265,160
Total of B						—	6,285,485	6,285,485
C. Previous / On-going Project								
1. JICA Project								226,087
Total of C								226,087

NOTE:
1) Previous JICA Proposal :Proposed facilities in the UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY(FEB.1990)
2) Additional Proposal :Proposed facilities in this Study
3) Costs of Previous JICA Proposal are converted to 1991 price from 1989 price
4) Costs of Previous/On-going Projects are at 1991 price,converted from 1989 price,which include Construction cost, Physical contingency,Land acquisition cost,Engneering cost,and Administration cost.

4) Breakdown of Project Cost (Narayanganj DND)

Unit: 1,000 Tk

Item	Unit	Unit Price			Quantity	Construction Cost		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
A. Construction Cost								
I. Flood Protection								
1. Rehabilitation								
a. Flood Wall (R)	m	2.10	50	50	20,200	21,200	21,200	42,400
2. Flood Wall T-type	m	20.70	50	50	10,000	103,500	103,500	207,000
3. Sluice Way								
Gate - 42.2 m^2	set	141,500	65	35	1	91,975	49,525	141,500
" - 45.3 "	"	145,000	65	35	1	94,250	50,750	145,000
Sub-total						186,225	100,275	286,500
Total of I						310,925	224,975	535,900
II. Storm Water Drainage								
1. Pump Station P - 50.2 m^3/s								
a. Construction	L.S	612,600	50	50	1	306,300	306,300	612,600
b. Equipment	L.S	602,400	85	15	1	512,040	90,360	602,400
Sub-total						818,340	396,660	1,215,000
2. Khal Improvement	km	20,363	43	57	38.0	331,496	442,305	773,801
Total of II						1,149,836	838,965	1,988,801
Total of A						1,460,761	1,063,940	2,524,701
B. Land Acquisition Cost								
1. Flood Protection	m^2	0.52	—	100	58,400	—	30,368	30,368
2. Storm Water Drainage	m^2	0.52	—	100	7,718,000	—	4,013,360	4,013,360
Total of B						—	4,043,728	4,043,728
C. Previous/On-going Project								
1.GOB Project	—		—	—	—	—	138,521	138,521
Total of C						—	138,521	138,521

NOTE:
1) Costs of Previous/On-going Projects are at 1991 price,converted from 1989 price,which include Construction cost, Physical contingency,Land acquisition cost,Engneering cost,and Administration cost.

5) Breakdown of Project Cost (Narayanganj West)

Unit: 1,000 Tk

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
A. Construction Cost								
I. Flood Protection								
1. Embankment Banking	m^3	0.53	40	60	321,000	68,052	102,078	170,130
2. Road-Cum-Emb. Banking	m^3	0.53	40	60	203,000	43,036	64,554	107,590
3. Flood Wall I-Type	m	12.50	45	55	10,500	59,062	72,188	131,250
4. Sluice Way								
Gate 8.9 m^2	set	43,200	65	35	1	28,080	15,120	43,200
" 11.0 "	"	52,500	65	35	1	34,125	18,375	52,500
" 3.6 "	"	18,600	65	35	1	12,090	6,510	18,600
" 8.2 "	"	39,900	65	35	1	25,935	13,965	39,900
" 4.4 "	"	22,100	65	35	1	14,365	7,735	22,100
" 15.2 "	"	68,600	65	35	1	44,590	24,010	68,600
" 8.3 "	"	40,500	65	35	1	26,325	14,175	40,500
Sub-total						185,510	99,890	285,400
Total of I						355,660	338,710	694,370
II. Storm Water Drainage								
1. Pump Station								
P-1: 7.1 m^3/s								
a. Civil Work	L.S.	110,000	50	50	1	55,000	55,000	110,000
b. Equipment	L.S.	89,000	85	15	1	75,650	13,350	89,000
Sub-total						130,650	68,350	199,000
P-2: 2.8 m^3/s								
a. Civil Work	L.S.	38,800	50	50	1	19,400	19,400	38,800
b. Equipment	L.S.	42,400	85	15	1	36,040	6,360	42,400
Sub-total						55,440	25,760	81,200
P-3: 6.3 m^3/s								
a. Civil Work	L.S.	92,200	50	50	1	46,100	46,100	92,200
b. Equipment	L.S.	87,400	85	15	1	74,290	13,110	87,400
Sub-total						120,390	59,210	179,600
Total of 1.						306,480	153,320	459,800
2. Khal Improvement	km	14,983	37	63	6.4	35,697	60,194	95,891
Total of II.						342,177	213,514	555,691
Total of A						697,837	552,224	1,250,061

(Narayanganj West)

(Continued)

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
B. Land Acquisition Cost								
1. Flood Protection	m^2	0.52	---	100	614,800	---	319,696	319,696
2. Storm Water Drainage	m^2	0.52	---	100	1,822,000	---	947,440	947,440
Total of B						---	1,267,136	1,267,136
C. Evacuation Facilities								
C.1 Construction Cost								
1. Road Improvement	km	10,000	40	60	2.5	10,000	15,000	25,000
C.2 Land Acquisition Cost	m^2	0.52	---	100	11,000	---	5,720	5,720
Total of C						10,000	20,720	30,720

6) Breakdown of Project Cost (Narayanganj East)

Unit: 1,000 Tk

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
A. Construction Cost								
I. Flood Protection								
1. Embankment Banking	m^3	0.53	40	60	471,000	99,852	149,778	249,630
2. Road-Cum-Emb. Banking	m^3	0.53	40	60	294,000	62,328	93,492	155,820
3. Flood Wall								
T-Type	m	24.40	50	50	14,000	170,800	170,800	341,600
I-Type	"	6.50	50	50	12,000	39,000	39,000	78,000
Sub-total						209,800	209,800	419,600
4. Sluice Way								
Gate 4.1 m^2	set	20,700	65	35	2	26,910	14,490	41,400
" 2.6 "	"	13,700	65	35	2	17,810	9,590	27,400
" 10.4 "	"	49,500	65	35	2	64,350	34,650	99,000
" 8.0 "	"	39,200	65	35	2	50,960	27,440	78,400
" 6.9 "	"	33,900	65	35	2	44,070	23,730	67,800
" 11.3 "	"	53,400	65	35	2	69,420	37,380	106,800
Sub-total						273,520	147,280	420,800
Total of I						645,500	600,350	1,245,850
II. Storm Water Drainage								
1. Pump Station								
P - 1.2 m^3/s								
a. Construction	L.S.	17,200	50	50	1	8,600	8,600	17,200
b. Equipment	L.S.	18,200	85	15	1	15,470	2,730	18,200
Sub-total						24,070	11,330	35,400
P - 2.7 m^3/s								
a. Construction	L.S.	37,400	50	50	1	18,700	18,700	37,400
b. Equipment	L.S.	40,900	85	15	1	34,765	6,135	40,900
Sub-total						53,465	24,835	78,300
P - 4.4 m^3/s								
a. Construction	L.S.	60,120	50	50	1	30,060	30,060	60,120
b. Equipment	L.S.	66,600	85	15	1	56,610	9,990	66,600
Sub-total						86,670	40,050	126,720
P - 4.2 m^3/s								
a. Construction	L.S.	57,000	50	50	1	28,500	28,500	57,000
b. Equipment	L.S.	64,000	85	15	1	54,400	9,600	64,000
Sub-total						82,900	38,100	121,000
Total of 1.						247,105	114,315	361,420
2. Khal Improvement	km	14,409	37	63	7.4	39,435	67,189	106,624
Total of II						286,540	181,504	468,044
Total of A						932,040	781,854	1,713,894

7) Breakdown of Project Cost (Tongi)

Unit: 1,000 Tk

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
A. Construction Cost								
I. Flood Protection								
1. Embankment								
a. Banking	m^3	0.53	40	60	1,022,000	216,664	324,996	541,660
b. Foundation	m	0.626	70	30	197,000	86,325	36,997	123,322
Sub-total						302,989	361,993	664,982
2. Road-Cum-Emb. Banking	m^3	0.53	40	60	103,000	21,836	32,754	54,590
3. Flood Wall								
I-Type	m	3.90	45	55	1,200	2,106	2,574	4,680
T-Type	m	20.70	50	50	1,000	10,350	10,350	20,700
Sub-total						12,456	12,924	25,380
4. Sluice Way								
Gate 15.6 m^2	set	68,600	65	35	1	44,590	24,010	68,600
" 13.5 "	"	62,100	65	35	1	40,365	21,735	62,100
" 12.3 "	"	57,400	65	35	1	37,310	20,090	57,400
" 14.0 "	"	64,200	65	35	1	41,730	22,470	64,200
" 9.2 "	"	44,000	65	35	1	28,600	15,400	44,000
" 5.4 "	"	28,000	65	35	1	18,200	9,800	28,000
" 3.4 "	"	17,400	65	35	1	11,310	6,090	17,400
Sub-total						222,105	119,595	341,700
Total of I						559,386	527,266	1,086,652
II. Storm Water Drainage								
1. Pump Station								
P - 13.5 m^3/s								
a. Construction	L.S.	195,000	50	50	1	97,500	97,500	195,000
b. Equipment	L.S.	169,500	85	15	1	144,075	25,425	169,500
Sub-total						241,575	122,925	364,500
P - 11.7 m^3/s								
a. Construction	L.S.	185,000	50	50	1	92,500	92,500	185,000
b. Equipment	L.S.	137,900	85	15	1	117,215	20,685	137,900
Sub-total						209,715	113,185	322,900
Total of 1.						451,290	236,110	687,400
2. Khal Improvement	km	14,606	37	63	22.0	118,681	202,640	321,321
Total of II						569,971	438,750	1,008,721
Total of A						1,129,357	966,016	2,095,373

(Narayanganj East)

(Continued)

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
B. Land Acquisition Cost								
1. Flood Protection	m^2	0.52	—	100	991,700	—	515,684	515,684
2. Storm Water Drainage	m^2	0.52	—	100	1,441,000	—	749,320	749,320
Total of B						—	1,265,004	1,265,004

NOTE:
1) Road-Cum-Emb.: Road-Cum-Embankment

(Tongi)

(Continued)

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
B. Land Acquisition Cost								
1. Flood Protection	m^2	0.27	—	100	1,009,300	—	272,511	272,511
2. Storm Water Drainage	m^2	0.27	—	100	3,075,000	—	830,250	830,250
Total of B						—	1,102,761	1,102,761
C. Evacuation Facilities								
C.1 Construction Cost								
1. Road Improvement	km	10,000	40	60	5.0	20,000	30,000	50,000
C.2 Land Acquisition Cost	m^2	0.27	---	100	22,000	---	5,940	5,940
Total of C						20,000	35,940	55,940

8) Breakdown of Project Cost (Savar)

Unit: 1,000 Tk

Item	Unit	Total	Unit Price F/C (%)	Unit Price L/C (%)	Quantity	Construction Cost (Tk) F/C	Construction Cost (Tk) L/C	Construction Cost (Tk) Total
A. Construction Cost								
I. Food Protection								
1. Embankment								
a. Banking	km	1	40	60	1,057,000	224,084	336,126	560,210
b. Foundation	m	1	70	30	120,000	52,584	22,536	75,120
Sub-Total						276,668	358,662	635,330
2. Sluice Way								
Gate 16.4 m2	set	72,700	65	35	1	47,255	25,445	72,700
" 9.4 "	"	45,500	65	35	1	29,575	15,925	45,500
" 31.5 "	"	118,200	65	35	1	76,830	41,370	118,200
Sub-Total						153,660	82,740	236,400
Total of I						430,328	441,402	871,730
II. Storm Water Drainage								
1. Khal Improvemet	km	17,590	41	59	30.0	213,945	313,753	527,698
Total of II						213,945	313,753	527,698
Total of A						644,273	755,155	1,399,428
B. Land Acquisition Cost								
1. Flood Protection	m2	0.22	—	100	623,100	—	137,082	137,082
2. Storm Water Drainage	m2	0.22	—	100	662,000	—	145,640	145,640
Total of B								282,722
C. Evacuation Facilities								
C.1 Construction Cost								
1. Evacuation Center	No.	27,000	50	50	3	40,500	40,500	81,000
2. Road Improvement	Km	10,000	40	60	27.0	108,000	162,000	270,000
Sub-total						148,500	202,500	351,000
C.2 Land Acquisition Cost								
1. Evacuation Center	m2	0.22	—	100	9,000	—	1,980	1,980
2. Road Improvement	m2	0.22	—	100	118,800	—	26,136	26,136
Sub-total						—	28,116	28,116
Total of C						148,500	230,616	379,116

9) Breakdown of Project Cost (Keraniganj)

Unit: 1,000 Tk

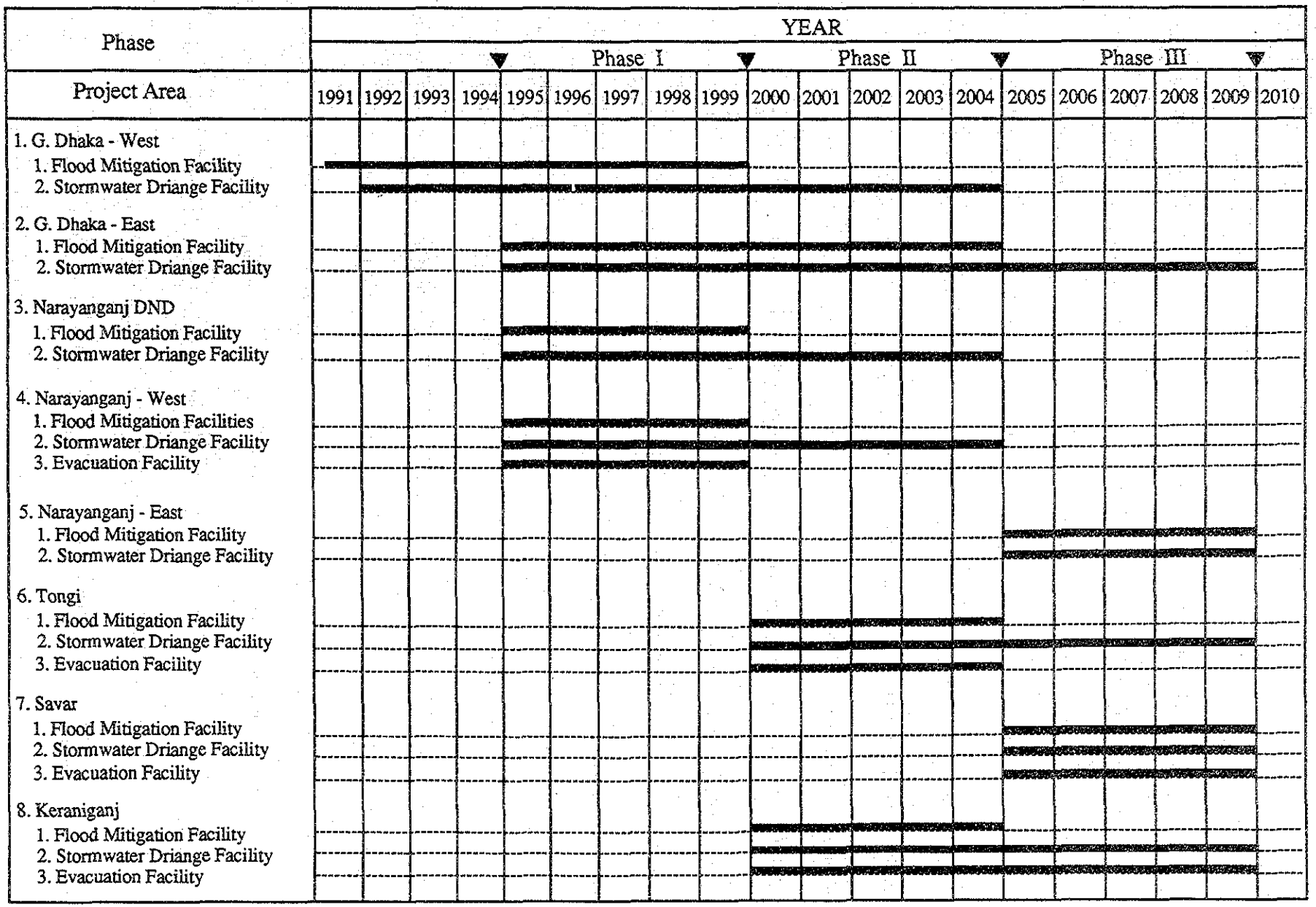
Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
A. Construction Cost								
I. Flood Protection								
1. Embankment								
a. Banking	m^3	0.53	40	60	3,053,000	647,236	970,854	1,618,090
b. Foundation	m	0.626	70	30	126,000	55,213	23,663	78,876
Sub-total						702,449	994,517	1,696,966
2. Flood Wall								
T-Type	m	35.11	48	52	3,700	62,355	67,552	129,907
3. Sluice Way								
Gate 7.6 m^2	set	37,100	65	35	1	24,115	12,985	37,100
" 8.9 "	"	43,500	65	35	1	28,275	15,225	43,500
" 12.6 "	"	58,300	65	35	1	37,895	20,405	58,300
" 12.4 "	"	57,600	65	35	1	37,440	20,160	57,600
" 24.7 "	"	100,100	65	35	1	65,065	35,035	100,100
" 1.0 "	"	15,000	65	35	5	48,750	26,250	75,000
Sub-total						241,540	130,060	371,600
Total of I						1,006,374	1,192,099	2,198,473
II. Storm Water Drainage								
1. Pump Station								
P - 27.7 m^3/s								
a. Construction	L.S.	363,000	50	50	1	181,500	181,500	363,000
b. Equipment	L.S.	346,300	85	15	1	294,355	51,945	346,300
Sub-total						475,855	233,445	709,300
2. Khal Improvement	km	19,032	41	59	22.5	177,168	251,047	428,215
Total of II						653,023	484,492	1,137,515
Total of A						1,659,397	1,676,591	3,335,988
B. Land Acquisition Cost								
1. Flood Protection	m^2	0.34	—	100	1,636,750	—	556,495	556,495
2. Storm Water Drainage	m^2	0.34	—	100	3,426,000	—	1,164,840	1,164,840
Total of B						—	1,721,335	1,721,335

(Keraniganj)

(Continued)

Item	Unit	Unit Price			Quantity	Construction Cost (Tk)		
		Total	F/C (%)	L/C (%)		F/C	L/C	Total
C. Evacuation Facilities								
C.1 Construction Cost								
1. Evacuation Center	No.	27,000	50	50	6	81,000	81,000	162,000
2. Road Improvement	km	10,000	40	60	45.0	180,000	270,000	450,000
Sub-total						261,000	351,000	612,000
C.2 Land Acquisition Cost								
1. Evacuation Center	m^2	0.34	---	100	18,000	---	6,120	6,120
2. Road Improvement	m^2	0.34	---	100	198,000	---	67,320	67,320
Sub-total						---	73,440	73,440
Total of C						26,100	424,440	685,440

Table 8.9 Phased Implementation Program



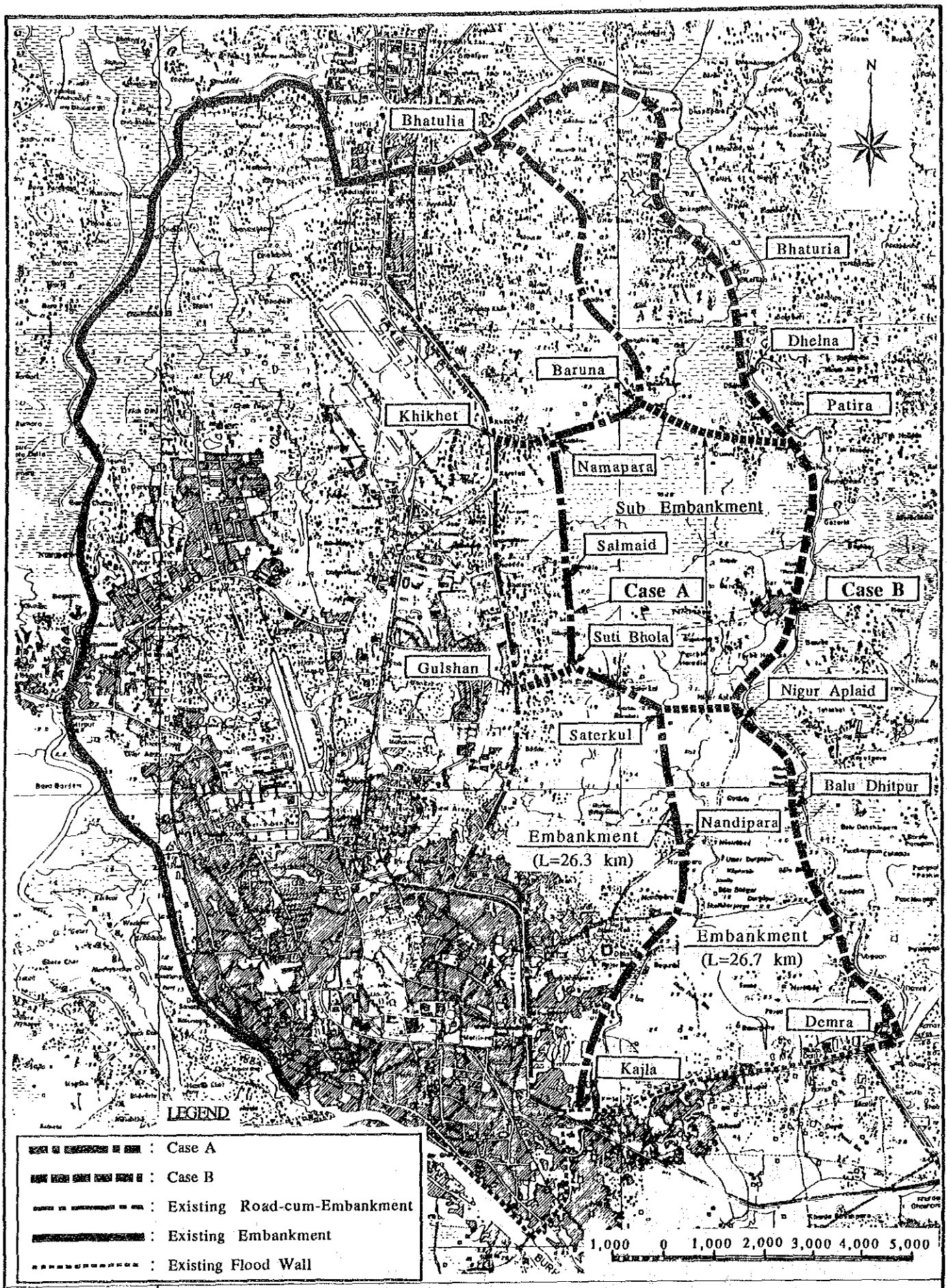


FIG. 8.1 (1) ALIGNMENT ALTERNATIVE - GREATER DHAKA EAST

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

JICA

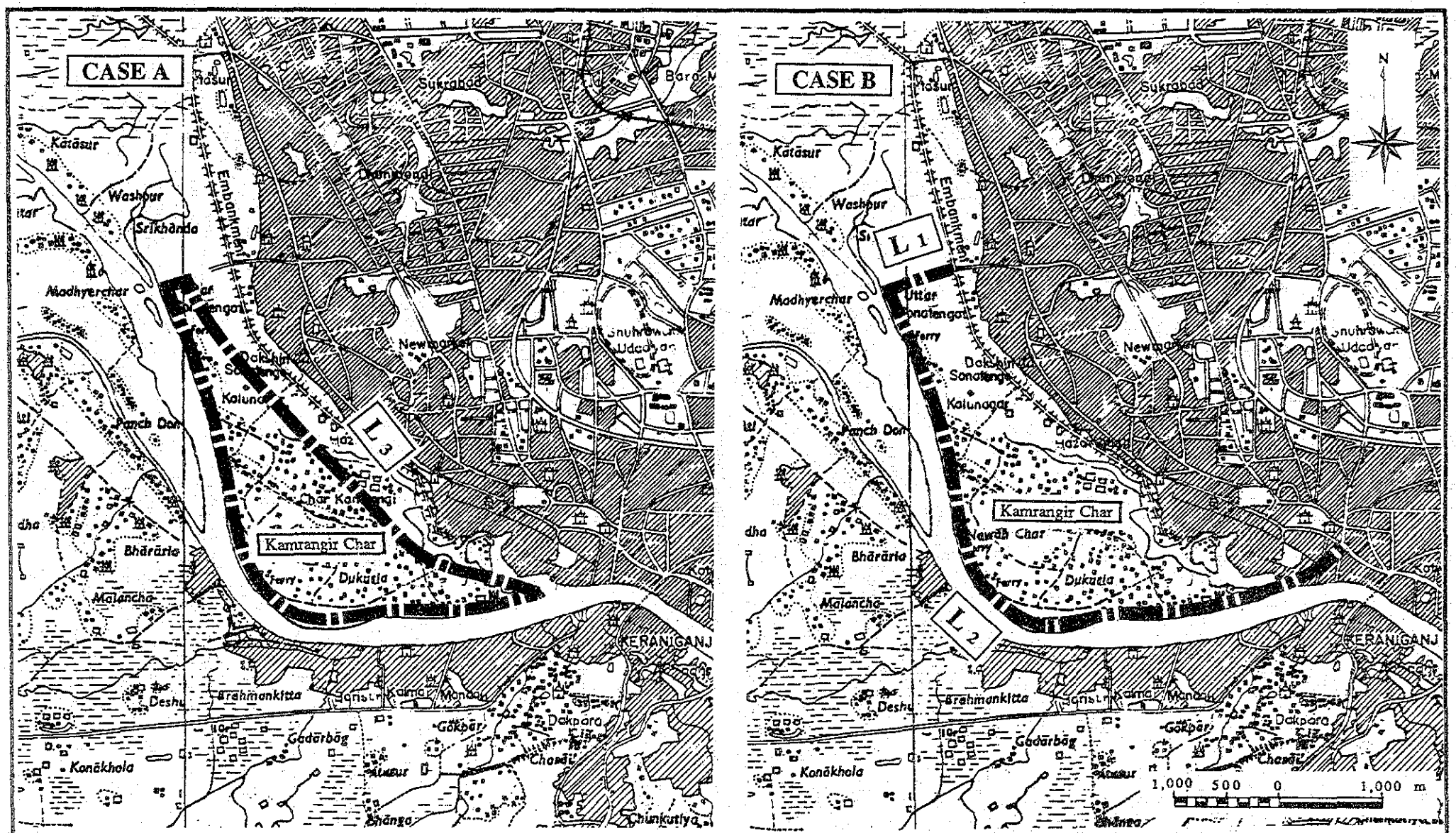


FIG. 8.1 (2) ALIGNMENT ALTERNATIVE - KAMRANGIR CHAR

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

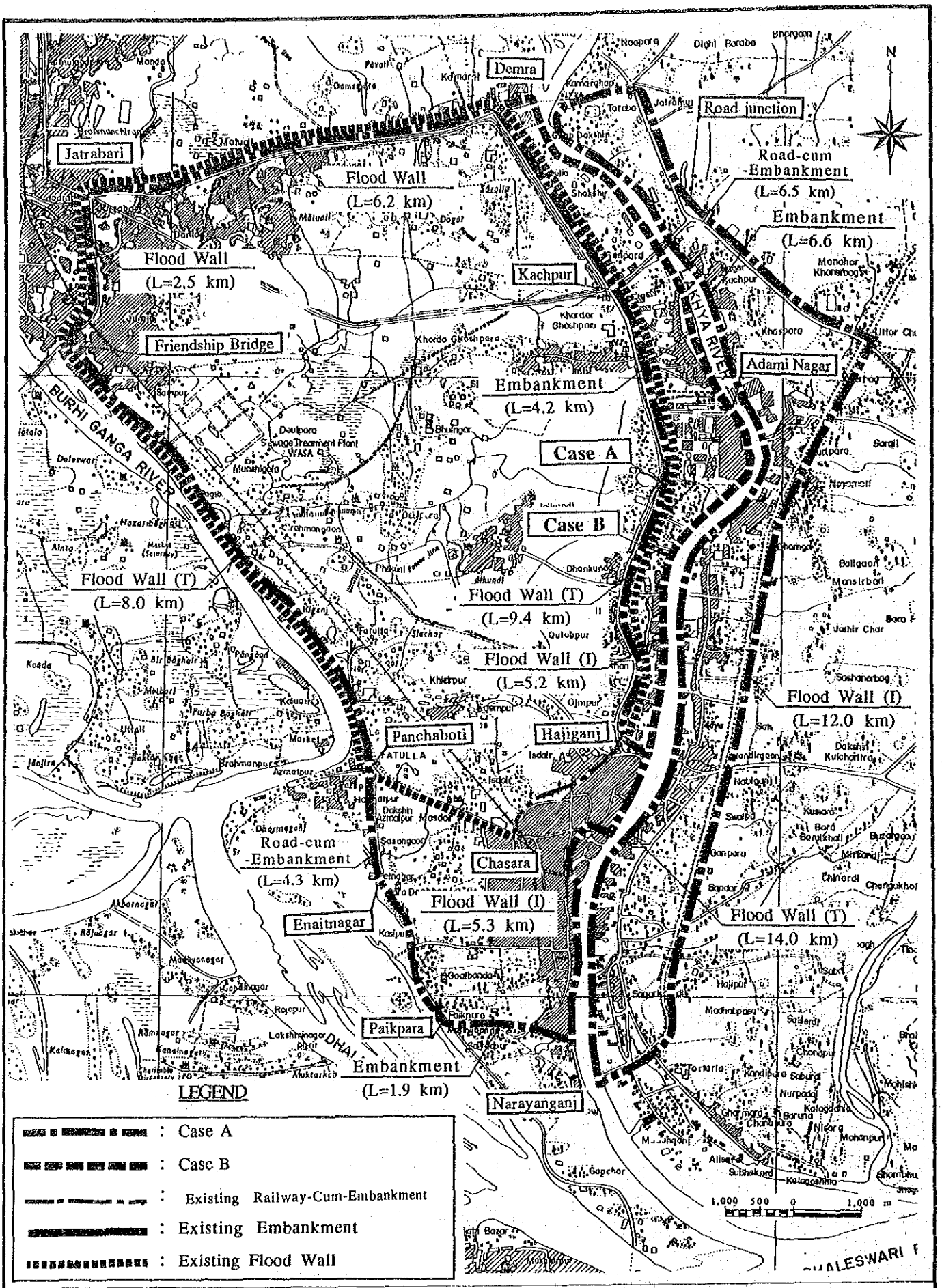
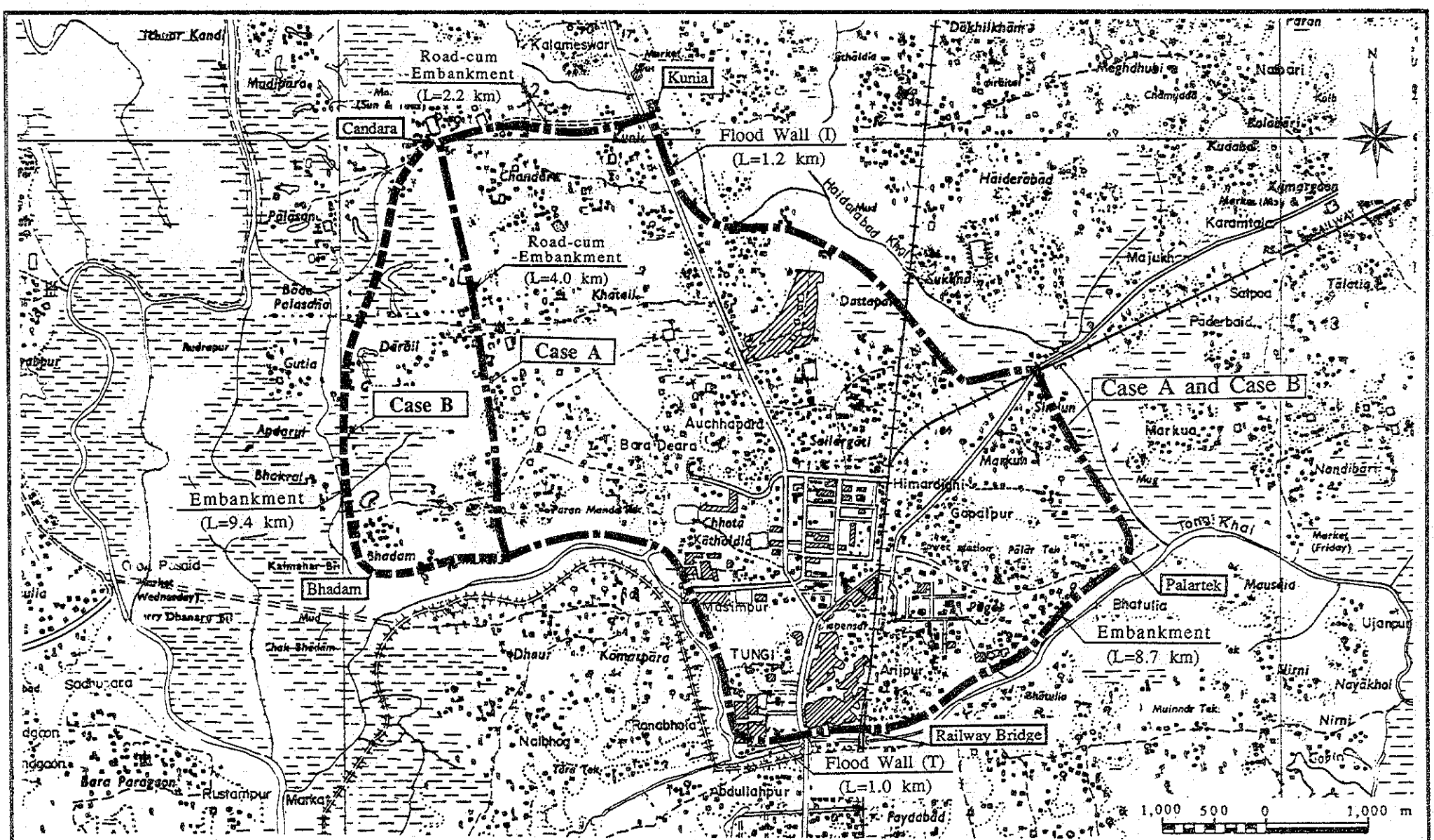


FIG. 8.1 (3) ALIGNMENT ALTERNATIVE - NARAYANGANJ AREA

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

JICA



LEGEND

: Case A

: Case B

FIG. 8.1 (4) ALIGNMENT ALTERNATIVE - TONGI 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