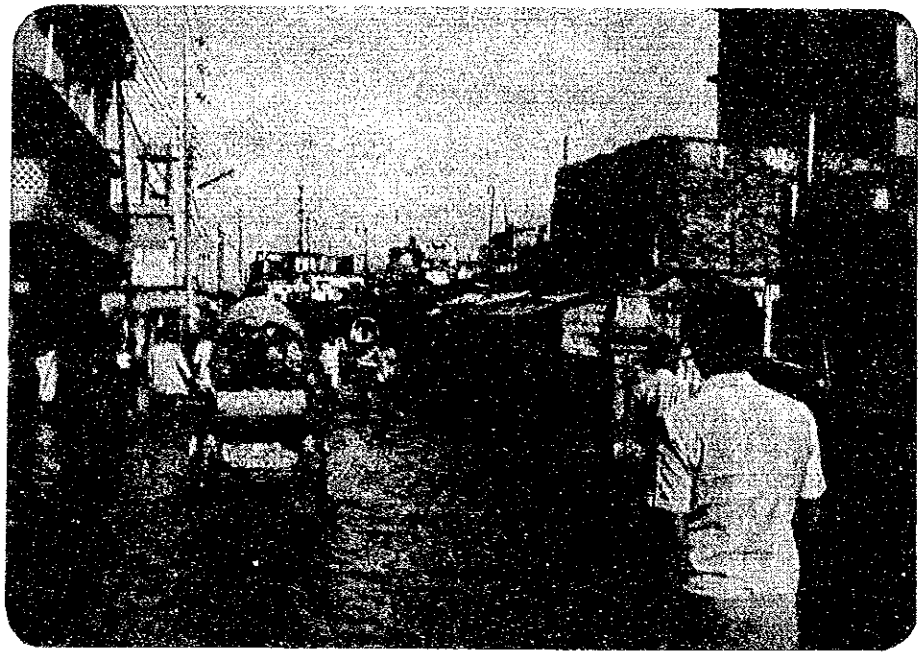


1987 FLOOD AT MANDA IN DHAKA CITY

CHAPTER 4
FLOOD AND FLOOD DAMAGE

CHAPTER 4 FLOOD AND FLOOD DAMAGE

4.1 Flood Area and Flood Condition

4.1.1 General

Floods of the Study Area are classified into two (2) types: one is of flood waters coming from surrounding rivers (external floods) and the other is of flood waters by storm rainfall (internal floods). External floods generally take place in the low-lying fringe areas once five (5) or ten (10) years. However, in some very low-lying areas of Gandaria, South-East Edge (Jatrabari, Kamlapur, Bashabo, Khilgaon) and Kallyanpur areas, the floods occur annually.

On the other hand, internal floods occur in the inner areas of the city several times a year.

The JICA Study Team made a flood survey with regard to the maximum flood recorded during the past 10 years and habitual floods.

4.1.2 Maximum Flood

The flood area at the time of the maximum flooding is estimated to be 5,727 ha, of which 1,930 ha (34%) is in the urbanized area. Of the urban flood area of 1,930 ha, 1,194 ha is affected by the external flood (external flood area) and the remaining 736 ha is by internal flood (internal flood area). The urban area affected by the maximum external flood will increase from 1,194 ha in 1986 to 1,742 ha in 2000, due to urban development in the low-lying fringe areas.

The flood areas are illustrated in Fig. 4.1.

Depths and durations of the maximum external floods range 0.3 to 2.0 m and from 10 to 60 days respectively, from place to place. Internal floods vary 0.37 to 1.00 m and from 5 to 162 hours respectively.

Flood area, depth, and duration by drainage zone and by flood type are illustrated in Fig. 4.2.

4.1.3 Habitual Flood

The size of the habitual flood area is estimated to be 4,567 ha, of which 1,082 ha (24%) exists in the urban areas. The urban flood area of 1,082 ha is broken down into the external flood area of 214 ha and the internal flood area of 868 ha. The urban area affected by external floods will increase from 214 ha in 1986 to 632 ha in 2000, due to urban development in the low-lying peripheral areas.

The flood areas are illustrated in Fig. 4.3.

Depths and durations of the habitual external floods range 0.3 to 1.0 m and from 1 to 30 days respectively, from site to site. Those of the internal floods are 0.31 to 0.76 m and from 2 to 102 hours respectively. Internal floods occur very frequently; 3 to 50 times a year.

Flood area, depth, duration and frequency by drainage zone and by flood type are illustrated in Fig. 4.4.

4.2 Flood Causes

External floods occur due to lack of flood protection works. Internal floods are mainly caused by insufficient drainage facilities and their improper operation and maintenance as follows:

(1) Insufficiency of drainage pipe length
(2) Small discharge capacity of existing drainage pipes
(3) Clogging of existing drainage pipes
(4) Troubles at the existing pump station
(5) Dam-up of khal water due to encroachment of buildings and by bottlenecks caused by road and railway crossings

4.3 Flood Vulnerable Population

The total population of the Study Area is $3,162 \times 10^3$ in 1986, of which $1,012 \times 10^3$ persons are estimated to live in the maximum flood prone area. This population will increase to $1,521 \times 10^3$ in 2000.

The population of 586×10^3 lived in the habitual flood prone area in 1986. It will grow to $1,008 \times 10^3$ in 2000.

The flood vulnerable population in 1986 by drainage zone and by flood type are shown in Table 4.1. Those in 2000 are also shown in the same table.

4.4 Flood Damage

4.4.1 General

The JICA Study Team made a flood damage survey for the drainage zones of B, C, and F where the most serious flood problems are recognized. The survey was made for the maximum flood recorded during the past 10 years (1974 flood) and habitual floods. The surveyed items are as follows:

(1) General property damage
(2) Public property damage
(3) Income and sales loss
(4) Vehicle operating cost increase

Based on the above survey, the flood damage potential of B, C, and F zones in 1986 was estimated for 1-year and 10-year frequency floods. The flood damage potential in 2000 was further projected.

The estimated flood damage potentials are as below:

	1986	2000
1-year frequency flood	187.4 million TK	335.4 million TK
10-year frequency flood	403.5	699.6

4.4.2 General Property Damage Potential

The general property damage potential is estimated for:

(1) Houses including buildings for commercial activities
(2) Household articles

Damage of commercial equipment and goods in stock is negligible and is thus excluded.

Number of houses in the flood prone areas of 1-year and 10-year frequency floods are estimated for the year 1986 and 2000 are shown below:

Year	Flood Frequency	
	1-year	10-year
1986	41,440	90,960
2000	276,050	517,060

The estimated damage potentials of 1-year and 10-year frequency floods for the year 1986 and 2000 are summarized in Table 4.2.

4.4.3 Public Property Damage Potential

The public property damage potential is estimated for:

(1) Electricity facilities
(2) Telecommunication facilities
(3) Roads

The damage of other public facilities is negligible.

The estimated damage potentials of 1-year and 10-year frequency floods in the year 1986 and 2000 are shown in Table 4.2.

Table 4.2 Flood Damage Potential

(Unit : million TK, 1986 Price)

Items	1986		2000	
	1/1	1/10	1/1	1/10
A. General Property				
(1) Houses	99.1	210.0	138.0	272.4
(2) Household articles	1.3	12.1	2.7	25.3
Subtotal	100.4	222.1	140.7	297.7
B. Public Property				
(1) Electric facility	1.0	2.5	2.1	5.3
(2) Telecommunication facility	17.7	44.3	37.0	92.5
(3) Roads	26.8	66.9	55.9	139.7
Subtotal	45.5	113.7	95.0	237.5
C. Income/Sales Loss Potential				
(1) Labour	4.4	5.2	15.2	18.1
(2) Electricity sales	2.9	7.3	6.1	15.2
(3) Transportation charges				
Bus	17.7	36.9	44.2	92.3
Rickshaw	1.7	3.5	4.2	8.8
Subtotal	26.7	52.9	69.7	134.4
D. Vehicle Running Cost				
Operating cost	0.8	0.8	1.6	1.6
Time cost Vehicles	5.4	5.4	10.9	10.9
Passengers	8.6	8.6	17.5	17.5
Subtotal	14.8	14.8	30.0	30.0
Grand Total	187.4	403.5	335.4	699.6

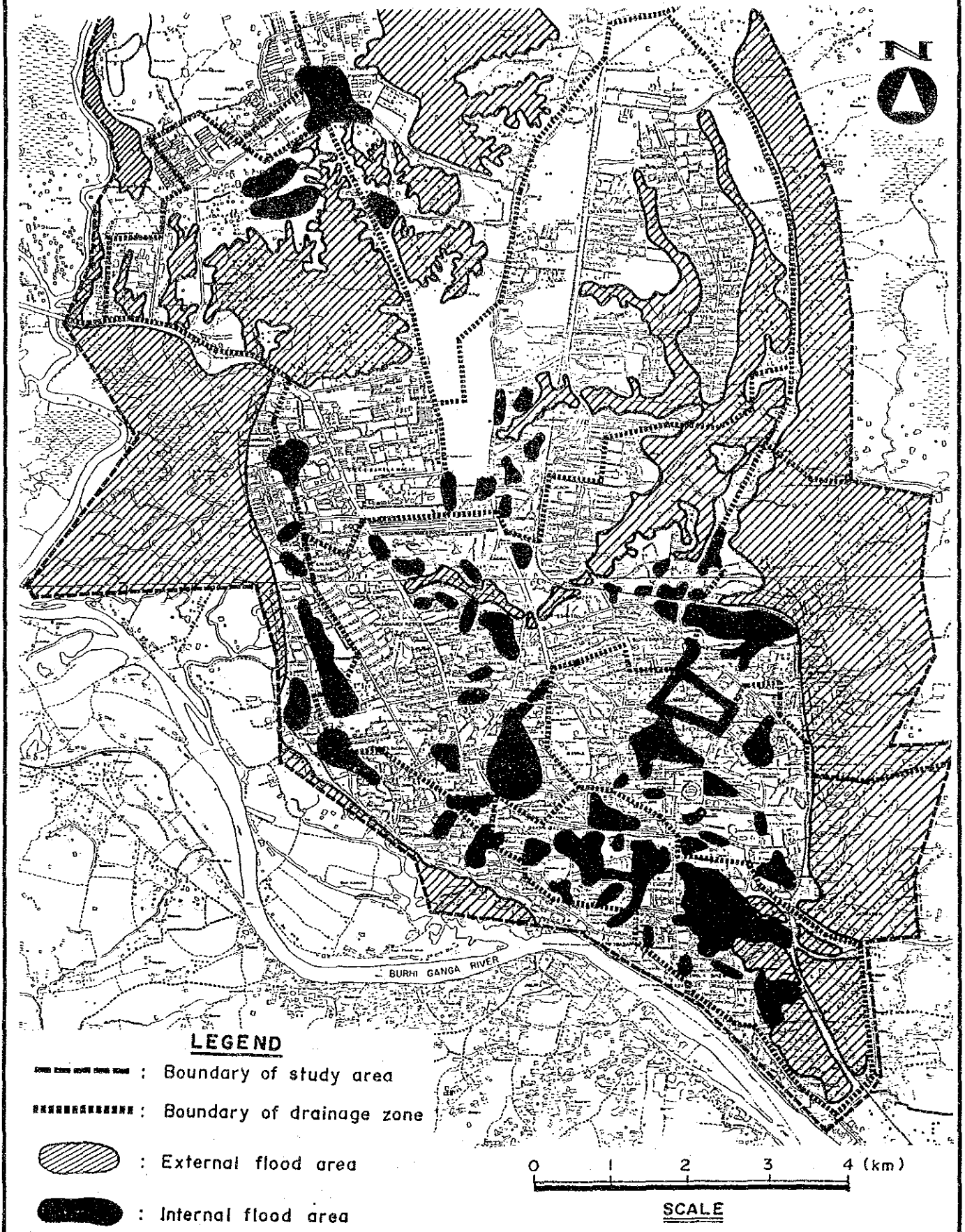
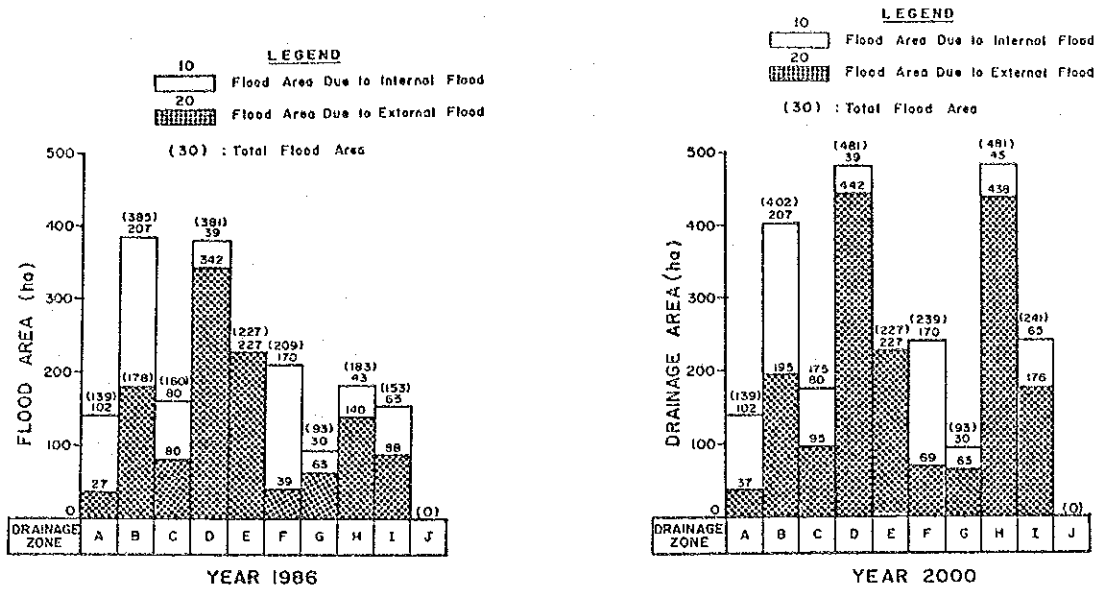
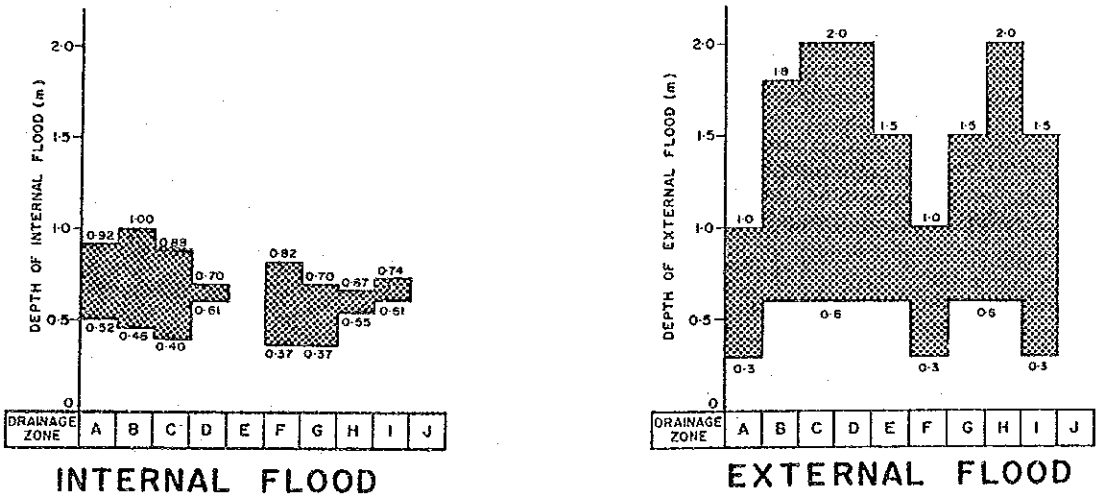


FIG. 4.1 MAXIMUM FLOOD AREA IN PAST 10 YEARS

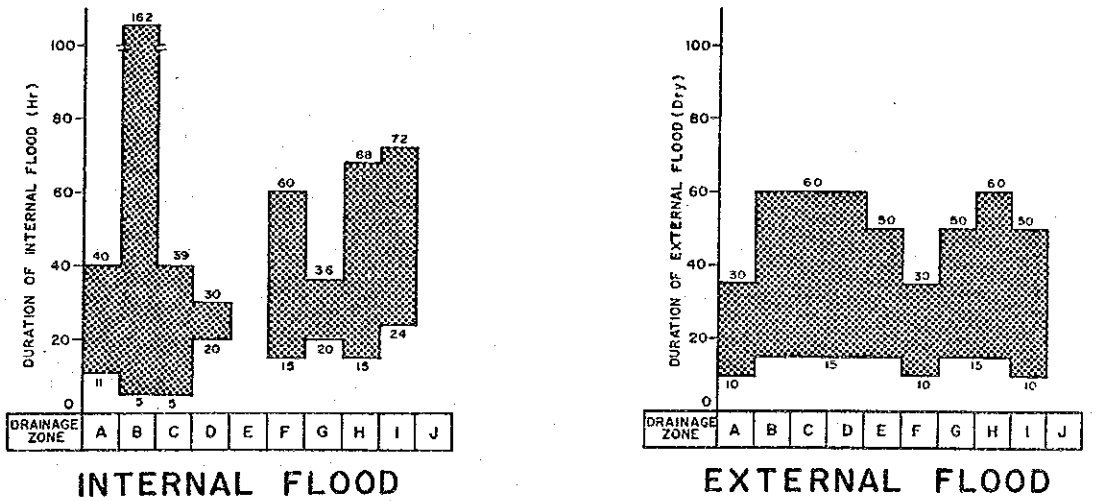
STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH



FLOOD AREA



FLOOD DEPTH



FLOOD DURATION

FIG. 4.2 MAXIMUM FLOOD CONDITIONS IN PAST 10 YEARS

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

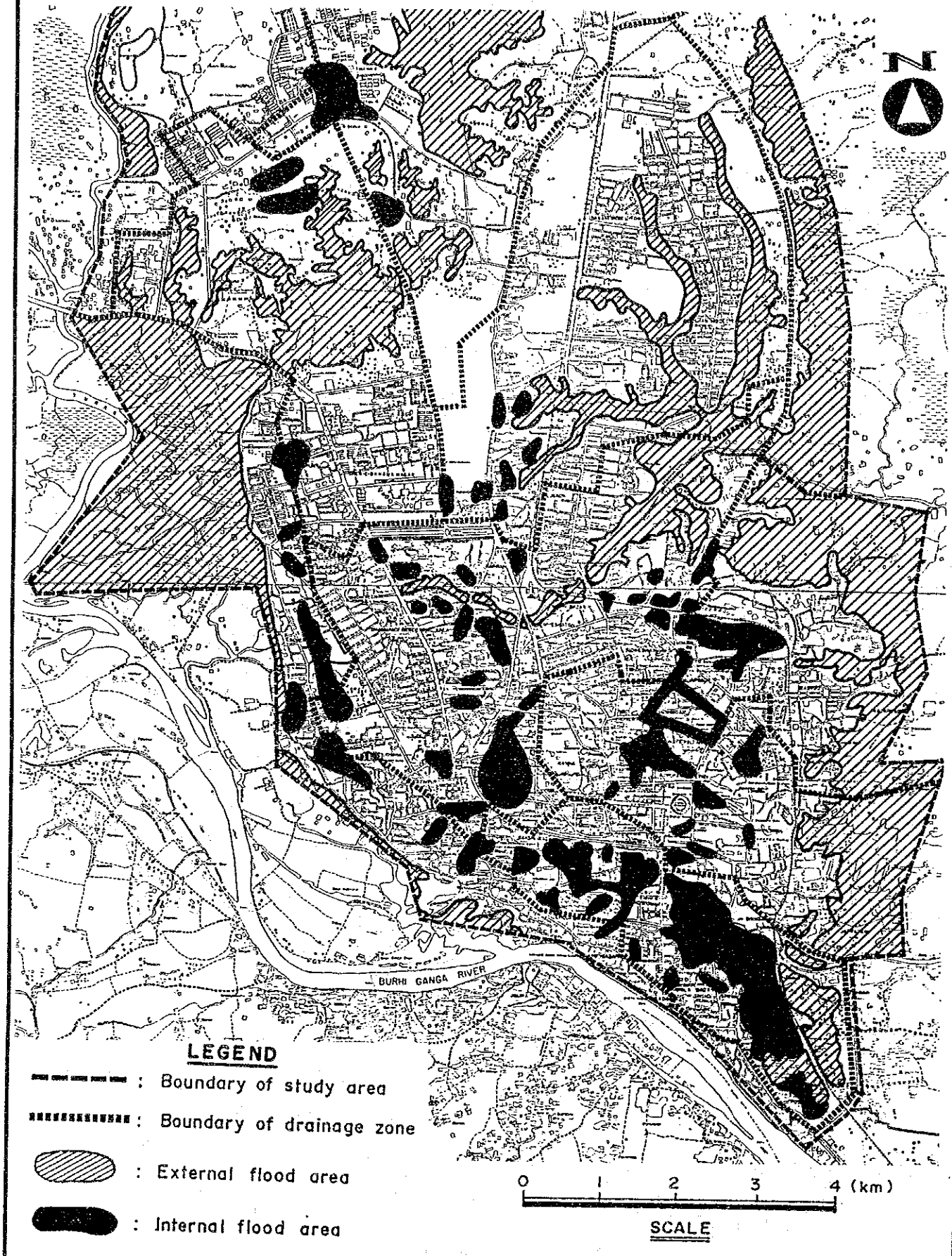


FIG. 4.3 HABITUAL FLOOD AREA

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

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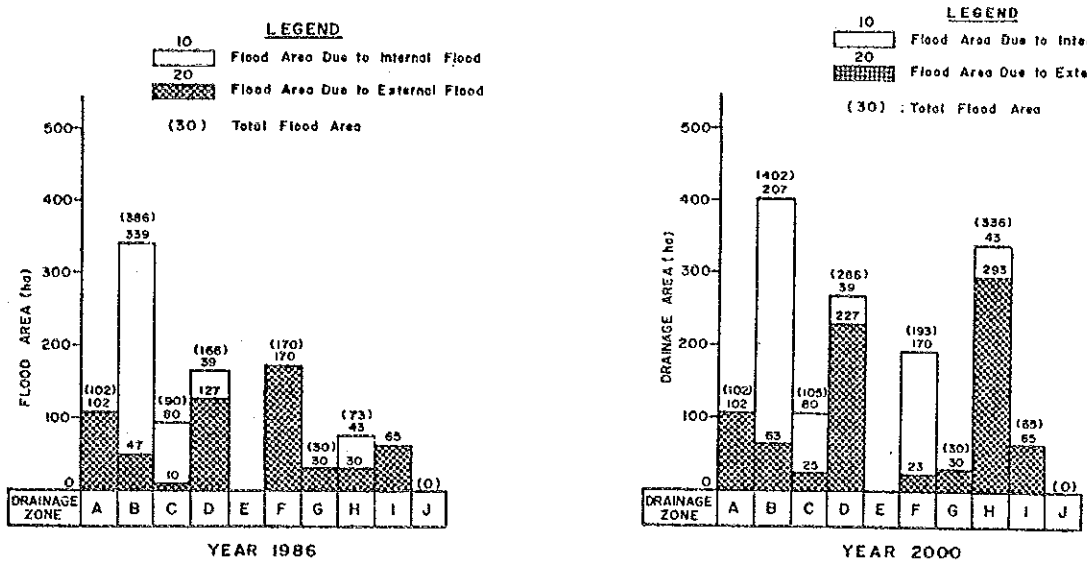
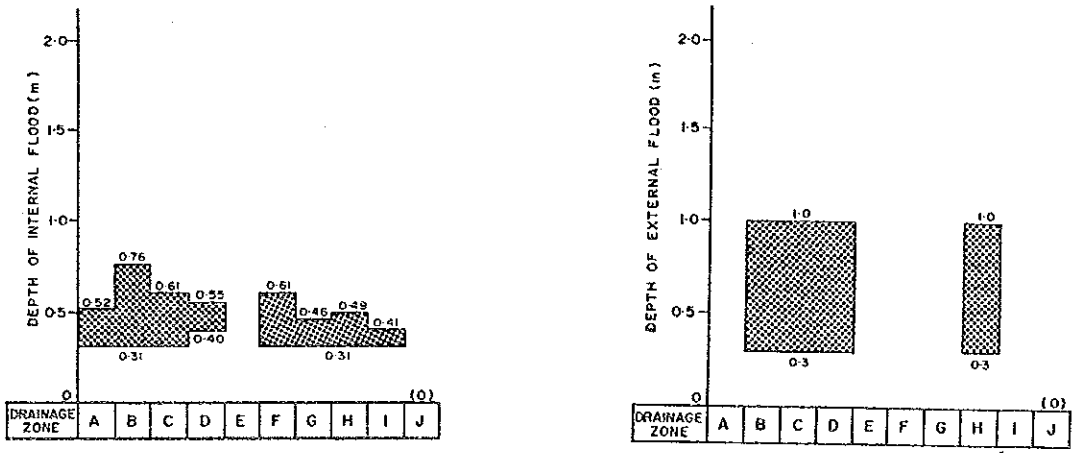
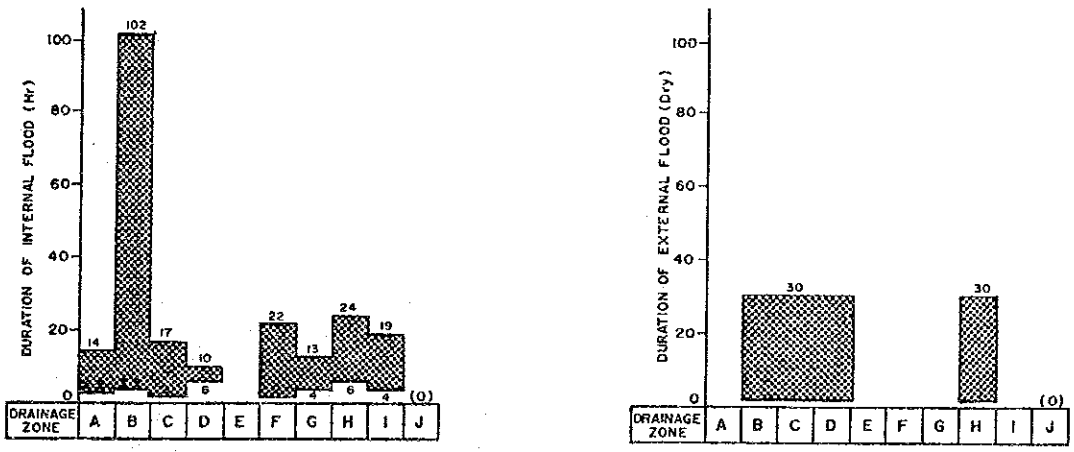


FLOOD AREA



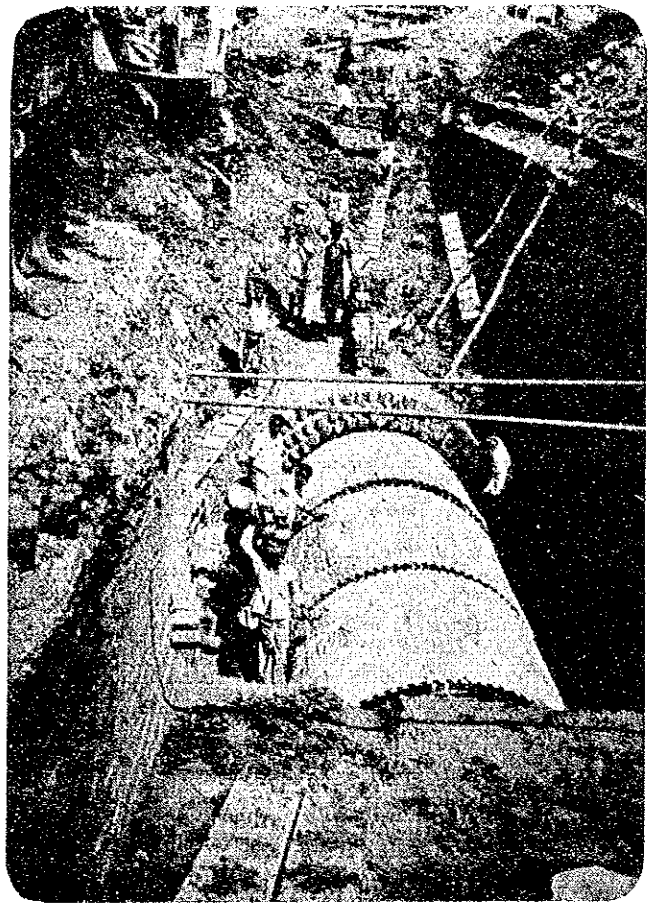
FLOOD DEPTH



FLOOD DURATION

FIG. 4.4 HABITUAL FLOOD CONDITIONS

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH



CONSTRUCTION OF DRAINNAGE
PIPE IN URGENT PROGRAM

CHAPTER 5
PREVIOUS STUDIES AND PROJECTS

CHAPTER 5 PREVIOUS STUDIES AND PROJECTS

5.1 Master Plan and Feasibility Study in 1968

(1) The Master Plan and Feasibility Study of Storm Drainage and Flood Control Project for Dhaka was prepared in 1968 by the Government of East Pakistan.

(2) This study was intended to be the first step in a program to provide a solution to the perennial problem of flooding in Dhaka area covering 75 km^2. The report established and presented a master plan consisting of two basic concepts:

(a) Protect Dhaka from innundation when the Buriganga and other rivers are in flood stage by means of a dike which encircles the area.

(b) Provide an effective internal drainage system within the dike to transfer storm water to locations where it may be discharged to natural drainage courses. Since the levels of the river waters are high during the monsoon season, the storm water would have to be discharged by means of pumping. Retention reservoirs are provided to substantially reduce pumping requirements.

(3) The proposed facilities including dike, pump station, box culvert, open channel, bridge, drainage pipe and reservoir are illustrated in Fig. 5.1.

5.2 Dhaka Metropolitan Area Integrated Urban Development Project

(1) The Dhaka Metropolitan Area Integrated Urban Development Project was prepared by the Government of Bangladesh (GOB) with the assistance of the Asian Development Bank (ADB) and the United Nations Development Programme (UNDP).

The study was carried out between September, 1979 and March, 1981.

(2) In view of existing and future circumstances of the sectors, urban development strategy combined with two alternatives, Peripheral Growth (B) and Northern Expansion (C) were proposed among three alternatives shown in Fig. 5.2. Advantages of the proposed strategy could be achieved at lower level of urban development expenditure with fewer implementation problems, and at lower risk than in the Comprehensive Flood Protection strategy.

(3) As mentioned above, the urban development strategy was proposed to formulate the plan expanded to northern areas, which are free from flood damage. Accordingly, in this project, implementation of small scale structural measures and non-structural measures for flood protection and storm water drainage works were proposed. These are as follows:

- Comprehensive flood protection measures by large scale embankment for lowland areas would not be feasible.

- Small scale or partial embankment and existing road raising would be recommendable for low-lying developed areas connected with existing built-up areas.

- Reclamation and partial embankment would be also recommendable for lowland in new development area.

- It would be proposed to develop operation and maintenance, improvement and construction of partial embankment for the khal in existing urbanized area.

5.3 On-going Project

"Revised Crash Programme for Construction of Storm Water Drainage in Water-logged Areas of Dhaka Metropolis" is ongoing by DPHE. Contents of the scheme are described below:

(1) Objective and Target:

(a) To reduce water-logging problems of the areas like: Dhanmondi, Zhigatola, Lalmatia, Mohammadpur, Kallyanpur, Rayer Bazar, Sher-e-Bangla Nagar, Kathal Bagan, Elephant Road.

(b) Diversion of existing outfall drains leading to Dhanmondi Lake, to prevent it from further pollution.

(2) Implementation Period: 1984 - 1989

(3) Construction Works

The major works are construction of storm water drainage pipes.

Total length: 18.82 km
Pipe diameter: 0.3 - 2.6 m

The locations of the construction works are illustrated in Fig. 5.3.

(4) Project cost

Local currency	Foreign exchange	Total
77,375 x 10^3 TK	-	77,375 x 10^3 TK

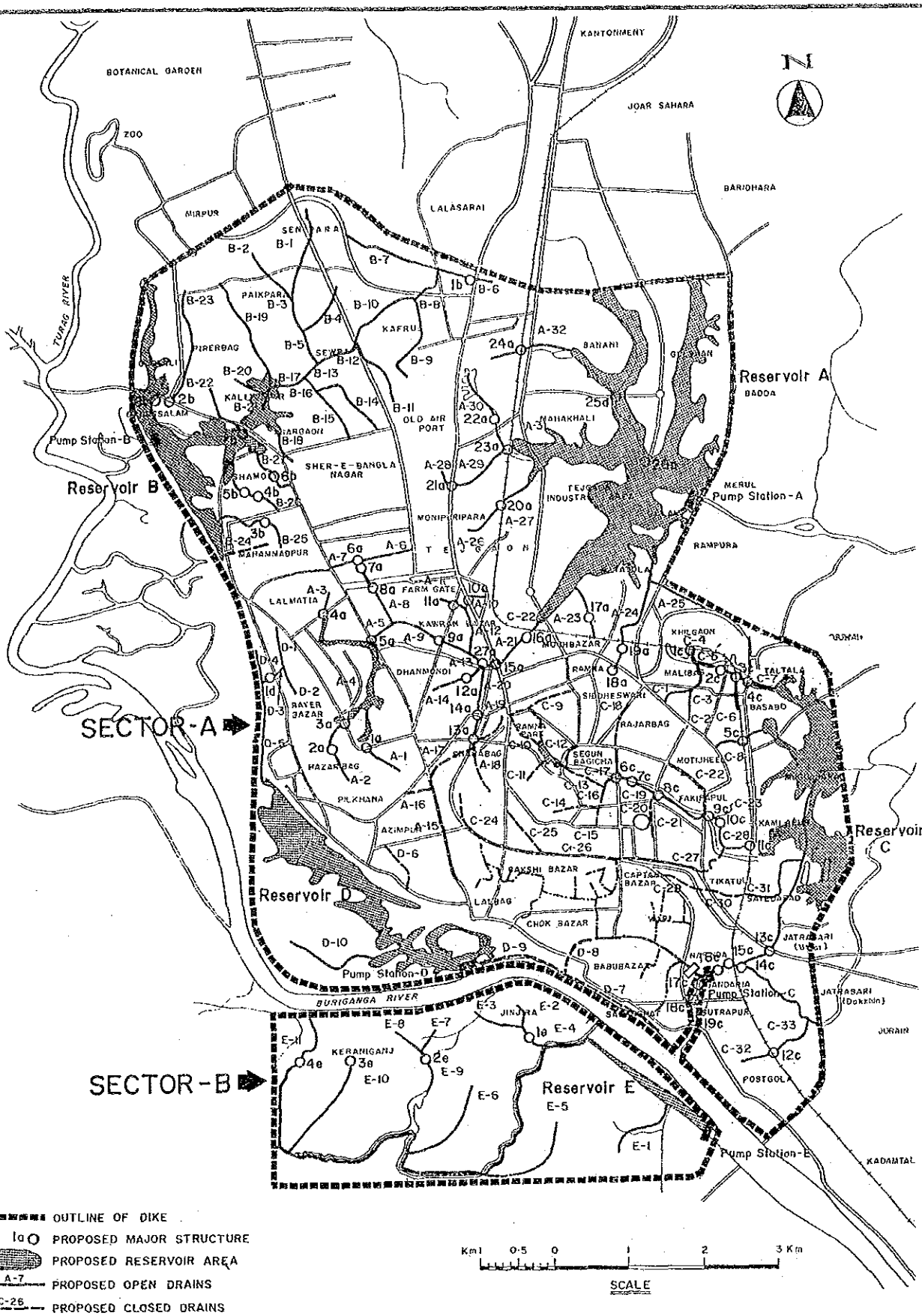


FIG. 5.1 PROPOSED FACILITIES IN MASTER PLAN AND FEASIBILITY STUDY IN 1968

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

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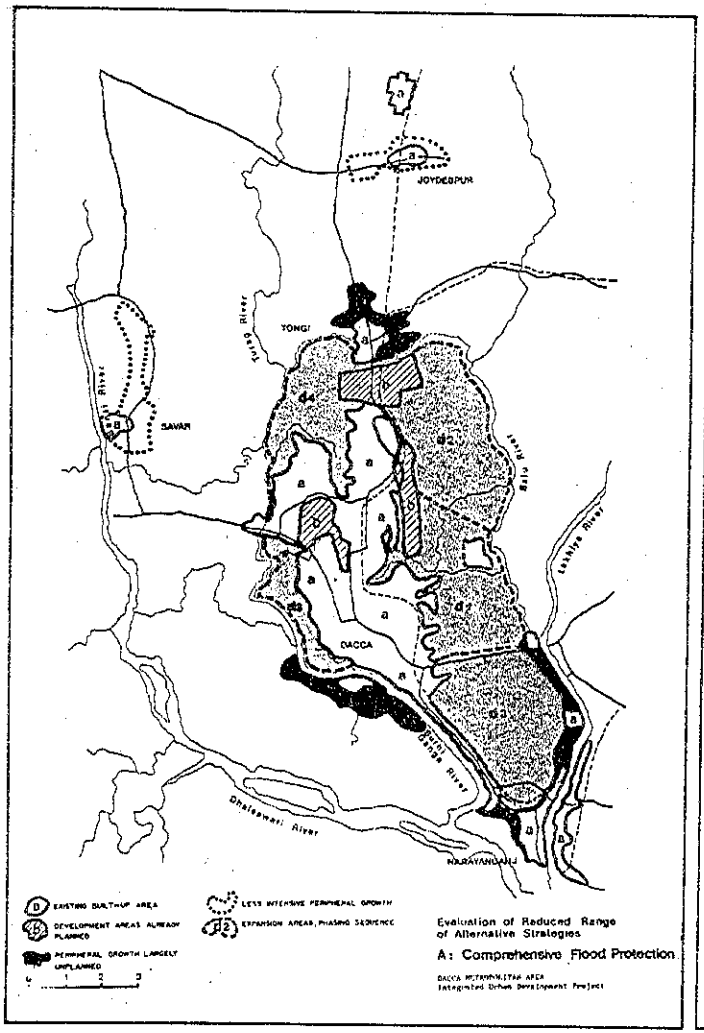
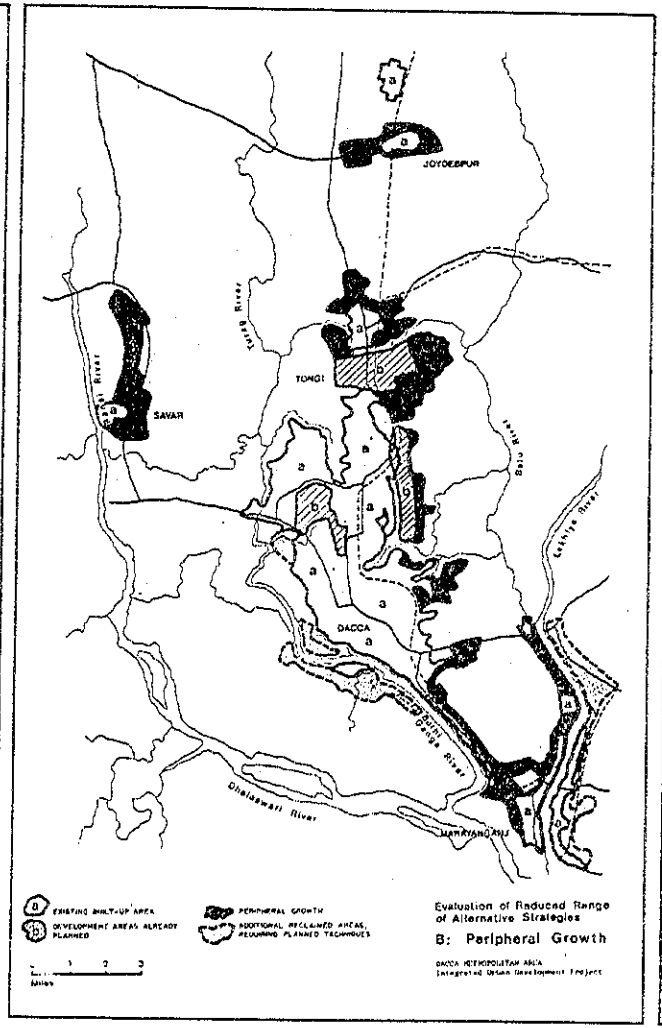
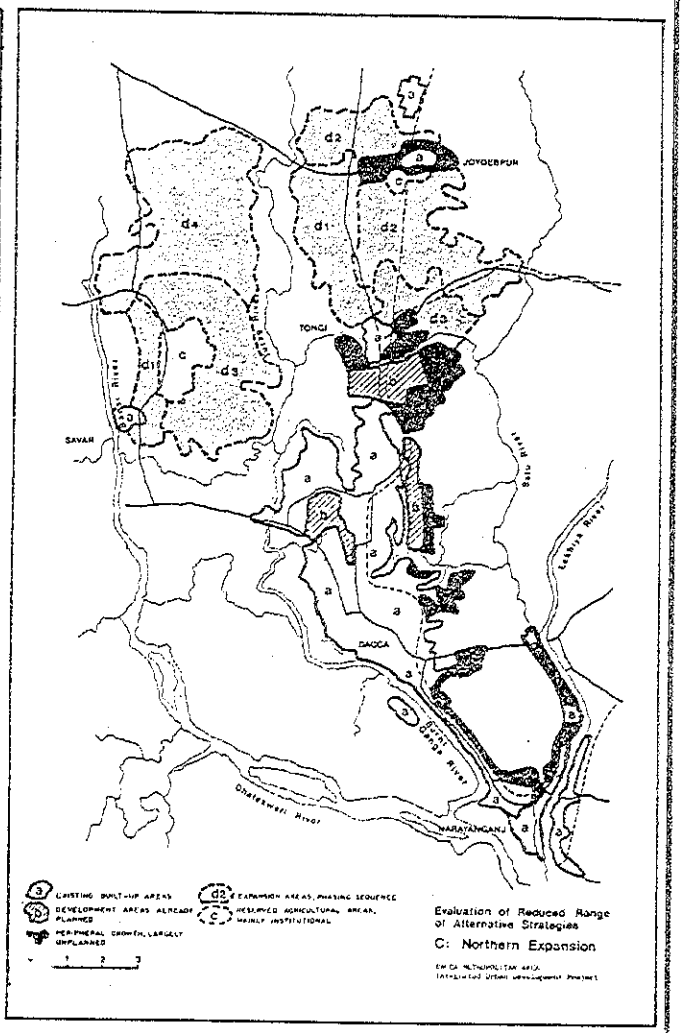


A : Comprehensive Flood Protection



B : Peripheral Growth



C : Northern Expansion

FIG. 5.2 ALTERNATIVE STRATEGIES OF DMAIUD PROJECT

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

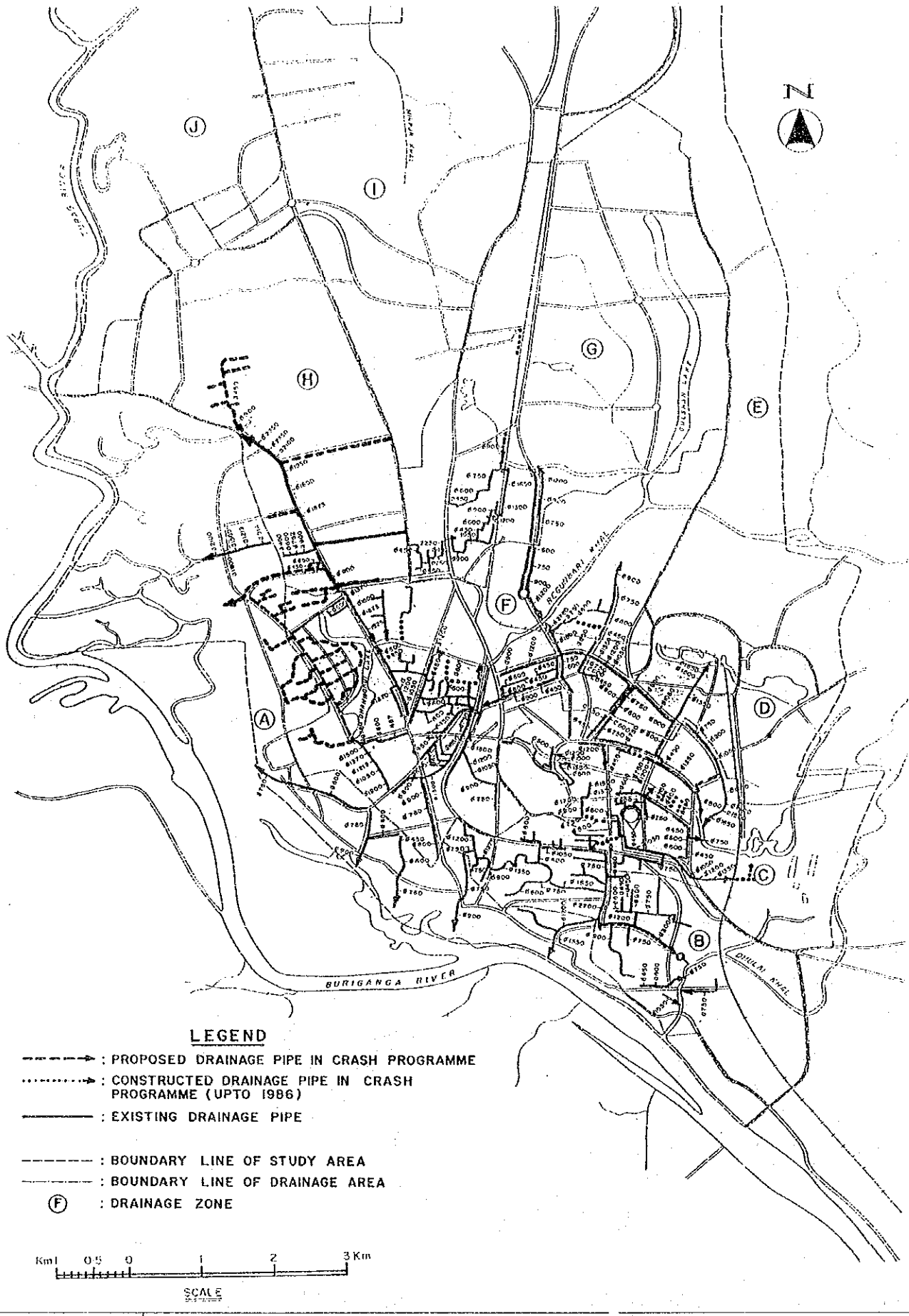


FIG. 5.3 REVISED CRASH PROGRAMME BY DPHE (1984 - 1989)

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

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OLD DHAKA AREA

MOTIJHEEL BUSINESS/COMMERCIAL AREA

CHAPTER 6
PREPARATION OF PHASED PROGRAM

CHAPTER 6 PREPARATION OF PHASED PROGRAM

6.1 Planning Policy and Design Criteria

6.1.1 Target Year : Year 2000

Both the structural and non-structural plans are prepared to meet the population and land use distribution in the year 2000.

6.1.2 Design Flood Water Level

The flood water level with a 30-year frequency is proposed as the design level based on the following facts and considerations. Two (2) design flood water levels are applied for the Study Area, considering the hydraulic gradient of the surrounding rivers:

- 6.60 m G.T.S. for the southern part including the Old Dhaka, Central Dhaka and Gulshan-Banani areas.

- 7.30 m G.T.S. for the northern part including the Mirpur, Kallyanpur, Cantonment and Tongi areas.

(1) The maximum flood water level in the past (1945 - 1986), was 6.59 m G.T.S. at Millbarrak, having an appropriate probability of 30 years.

(2) The design probability for the flood protection plan shall be balanced with that for the internal drainage improvement plan in order to attain an optimum development of flood protection and drainage. The expected design probability for the latter is 5 years (Refer to the following section).

(3) Large-scale urban developments are underway in Gulshan, Mirpur, Cantonment and Tongi areas along such trunk roads as DIT, Mirpur-Cantonment and New Airport Roads. The lands are filled up in conformity with the elevations of the trunk roads. The road elevations are 6.5-7.0 m G.T.S in DIT Road, above 7.0-7.5 m G.T.S in Mirpur-Cantonment Road and above 7.0-7.5 m G.T.S in New Airport Road. The design flood water level shall

be decided in due consideration of these urban developments. Otherwise, significant confusion will take place in planning of the urban development causing a delay in the development progress.

6.1.3 Design Rainfall

Drainage pipes and khal improvements are designed based on an estimated probability rainfall intensity. Five-year probability is applied.

The pump station is designed to meet the rainfall depth with a 5-year frequency, conforming with the drainage pipe and khal improvement in design frequency. The design rainfall depth and its hourly distribution are illustrated in Fig. 6.1 (Refer to 2.3.2.).

6.1.4 Scope of Structural Measures to be Proposed

The structural measures to be proposed are limited to major works required to meet a mid-term range necessity for flood protection and internal drainage improvement with the limited financial resources.

The structural measures to be included are:

(1) Flood protection: all the required works

(2) Internal drainage improvement:

- all the required pump drainage and khal improvements
- installation of trunk drainage pipes

Lateral drains and branch drainage pipes are excluded from the phased program because:

- The existing flood conditions will be mostly solved by the above-mentioned major works.

- Beneficial effects of lateral drains and branch drainage pipes will be expected only after completion of the connected major drainage works.

Lateral drains and branch drainage pipes are to be laid after completion of this project as and when required.

6.2 Flood Protection Plan

6.2.1 Flood Protection Area

A flood protection plan is prepared for all the low-lying built-up areas below the design flood water level. The protection area covers not only the existing developed areas but also the future development areas.

With regard to the future land development, it is assumed that:

(1) Developments in the East Gulshan, Cantonment, Tongi and Buriganga River Bank areas will be made by filling up the grounds above the design flood water level. These development areas will require no flood protection works.

(2) Developments in the other zones will be sprawling ones made by reclaiming the lands up to the elevation of the existing built-up areas in the neighbourhood. These zones include some low-lying areas below the design flood water level for which flood protection works are needed.

Based on the above policies and assumptions, the following areas are identified as flood protection area (See Fig. 4.1).

(1) Gandaria and Old Dhaka areas (part of B zone)
(2) Segunbagicha and Bashabo zone
(3) Kallyanpur area (part of H zone)
(4) Katchukhet area (part of I zone)

6.2.2 Proposed Flood Protection Works and Benefitting Areas

(1) Gandaria and Old Dhaka Areas

Gandaria area is protected by providing the existing road, Dhaka-Narayanganj Diversion Road, with control gate. A control

gate to prevent flood water intrusion through the existing khal is required.

The benefited area is 1.78 km^2.

(2) Segunbagicha and Bashabo Zones

The dikes of 9.4 km long are constructed to protect the area.

The benefited area is 14.0 km^2.

(3) Kallyanpur Area

The existing Dhaka-Aricha Road is raised by about 1.5 m extending for 3 km to protect the area.

The benefited area is 14.0 km^2.

(4) Katchukhet Area

The existing Mirpur-Cantonment Road is raised by about 1.5 m stretching over 2 km to protect the areas covering Katchukhet, Minipur, Senpara and Kafrul.

The benefited area is 0.88 km^2.

6.3 Internal Drainage Plan

6.3.1 Design Discharge of Drainage Pipe and Khal Improvement

Peak runoffs corresponding to 5-year probability rainfall intensity were calculated for the subdivided drainage areas with a variety of area, land use and runoff distance. Calculations were made by the Rational Formula.

Installation of additional 14 trunks of drainage pipe are proposed for A, B, C, D, and F drainage zones. The upstream area (1.03 km^2) of Old Dhaka in B drainage zone is diverted to the Buriganga River (See Fig. 6.2.). No diversion of catchment area is proposed for the

other drainage zones. The design discharge of the proposed drainage pipes ranges between 3.7 m^3/s to 22.0 m^3/s.

Improvement of the 25 existing khals is recommended for A, B, C, D, F, G, H, and I drainage zones. The design discharge of the proposed khal improvement varies from 6.2 m^3/s to 86.0 m^3/s.

6.3.2 Pump Drainage Area

The low-lying areas enclosed by the proposed dikes, or existing roads, require pump stations to drain the storm waters from these areas and from the upstream areas.

These areas as the lowlands of Old Dhaka area, Gandaria area, Segunbagicha Khal zone, Bashabo zone, Kallyanpur area and Katchukhet area.

The covered catchment areas are:

Old Dhaka area (3.20 km^2)
Gandaria area (2.72 km^2)
Segunbagicha Khal zone (9.04 km^2)
Bashabo zone (8.32 km^2)
Kallyanpur area (12.78 km^2)
Katchukhet area (3.94 km^2)
Total: 40.00 km^2

6.3.3 Integration of Pump Drainage Area

The pump drainage areas of Old Dhaka area, Gandaria area, Segunbagicha Khal zone and Bashabo zone can be hydraulically integrated through Dholai Khal, Segunbagicha Khal and Gerani Khal.

Four (4) alternatives are compared as described below:

Alternative I : Four (4) areas and zones are independent.
Alternative II: Old Dhaka and Gandaria areas are integrated.
Alternative III: Old Dhaka area, Gandaria area and Segunbagicha Khal zone are integrated.
Alternative IV: All of the four (4) areas and zones are integrated.

Comparison of Alternatives

	Alt. I	Alt. II	Alt. III	Alt. IV
Required P.S. Rehabilitation (m3/s)	9.6	9.6	9.6	9.6
Required Additional P.S. (Place)	4	2	2	1
Required Additional P.S. (m3/s)	42.9	19.8	17.0	17.3
Required Regulating Pond (ha)	133	154	154	154
Construction Cost	Large	>	>	Small
O & M Cost	Large	>	≒	Small
Stage Construction	Easy	Easy	Moderate	Hard
Water Conveyance Distance	Short	Short	Middle	Long
Security of Regulating Pond	Hard	A little Hard	Easy	Easy

From the above comparisons, Alternative III is proposed.

Kallyanpur drainage zone (H zone) drains through the three (3) natural water courses into the Turag River independently. It is not efficient to provide these water courses with pump stations individually. All the drainage areas are integrated to attain an optimum pump drainage system.

On the other hand, the Katchukhet area is drained independently in an adverse direction although it adjoins the Kallyanpur area, because integration of the two areas requires a long distance diversion of flood water.

6.4 Proposed Flood Protection and Drainage Plan

6.4.1 Structural Plan

The proposed structural plan includes the following major flood protection and internal drainage improvement works.

(1) Construction of dikes: The dikes with a total length of 9.4 km are constructed to protect Segunbagicha Khal Zone and Bashabo Zone from external floods. The average dike height is 6 m.

(2) Raising of road: The existing roads (Dhaka-Aricha Road and Mirpur-Cantonment) are raised and extended through 5 km as protection against external floods of Kallyanpur and Katchukhet areas.

(3) Installation of control gates: 8 water control gates are installed at the crossing point of existing khals with proposed dikes and existing roads and at the proposed pump station sites.

(4) Installation of drainage pipe: The additional trunk drainage pipes, with diameters ranging from 1.5 to 3.7 m, are installed on the 14 routes to drain a total catchment area of 12.45 km^2. The total length is 18.0 km.

(5) Improvement of khal: The existing khals are widened or dredged in 25 stretches to drain a total catchment area of 85 km^2. The total improvement length reaches 39.7 km. The major works included are: dredging of 491×10^3 m^3, reconstruction of box culverts or bridges in 69 places, construction of 1.4 km of retaining walls, and brick protection 3.3 km long.

(6) Installation of pump stations: Four (4) pump stations with a total discharge capacity of 36.1 m^3/s will be installed in addition to the rehabilitation of the existing Narinda pump station (9.6 m^3/s). The pump stations cover a total drainage area of 40.00 km^2.

(7) The above-mentioned major works are proposed for A, B, C, D, F, G, H, and I drainage zones, and are not recommended for E and J drainage zones.

Flood protection and internal drainage improvement of E and J drainage zones will be attained by small-scale structural measures and non-structural measures.

The locations of the proposed facilities are illustrated in Fig. 6.2.

The proposed facilities are summarized by drainage zone in Table 6.1.

The required land acquisition areas by drainage zone are also shown in Table 6.1.

6.4.2 Non-Structural Plan

(1) Reserving swampy areas totaling 264 ha for the proposed pump regulating ponds.

(2) Strict enforcement of controls to prevent any reduction of minimum khal sections proposed which could cause flood flows to be impeded and backing up of water in the upstream areas.

(3) Raising of low-lying fringe areas with land fill sufficiently higher than the proposed desdign flood level for future developments, except in the proposed flood protection areas.

- For the southern part of the Study Area, the filling-up elevation shall be above 6.60 m G.T.S. + an allowance.
- For the northern part of the Study Area, the elevation shall be above 7.30 m G.T.S. + an allowance.

6.4.3 Estimated Project Cost

The total cost of the proposed flood protection and drainage plan is roughly estimated to be 3,433.4 million TK at 1986 price. The estimated costs are broken down by drainage zone and work items as shown in Table 6.1.

6.5 Prioritization of Drainage Zone

Priority sequences of the drainage zones are decided through comparison of the following factors.

(1) Beneficial population
(2) Required project cost

(3) Required land acquisition area
(4) Flood conditions
(5) Damage to commercial and institutional activities
(6) Hindrance to traffic
(7) Land use grade

The factors of beneficial population, and required project cost, and land acquisition area can be compared by the common indicators showing efficiency of financial and land resources expenditures: per capita project cost and land acquisition area.

Comparisons of per capita project cost and land acquisition area among the drainage zones are shown in Table 6.2.

From the above mentioned table, the per capita project cost and land acquisition area regarding habitual flood in 1986 and maximum flood in 2000 are taken up as priority comparison indicators to reflect the existing immediate and future potential requirements of the projects.

A comprehensive comparison viewing all the factors listed above is shown in Table 6.3.

From the above-mentioned table, the priority sequences of the proposed drainage zones are decided as below:

First Priority Zones: B, C, F
Second Priority Zones: A, D (part), G, H
Third Priority Zones: D (part), E, I, J

6.6 Proposed Phased Program

A program consisting of three (3) phases is proposed in conformity with the priority sequences decided in 6.5 above. It is shown in Table 6.4. and Fig. 6.3.

Table 6.1 Proposed Facilities and Cost

(UNIT: million TK, 1986 Price)

DRAINAGE ZONE	FLOOD PROTECTION		INTERNAL DRAINAGE			CONSTRUCTION COST	Contingency & Engineering Supervision	LAND ACQUISITION	TOTAL PROJECT COST
	Protection Dike km	Control Gate places	Pump Station m3/s	Khal Improvement km	Drainage Pipe km			ha	
A	-	-	-	0.3 1.2	3.8 79.4	80.6	15.2	0.1 0.4	96.2
B	-	1 39.5	9.6** 97.1	4.2 38.5	4.3 178.8	353.9	66.5	4.5 9.7	430.1
C	2.4 93.1	1 30.0	7.5 183.8	5.1 151.6	4.8 125.0	583.5	109.7	23.5 35.6	728.8
D	7.0 271.6	2 60.0	9.5 232.8	4.6 108.1	1.7 35.5	708.0	133.1	59.9 80.0	921.1
E	-	-	-	-	-	-	-	-	-
F	-	-	-	3.8 96.6	3.4 71.2	167.8	31.5	4.8 14.7	214.0
G	-	-	-	2.9 27.1	-	27.1	5.1	2.2 8.8	41.0
H	3.0* 57.0	3 90.0	14.6 357.7	11.9 56.5	-	561.2	105.5	9.6 35.6	702.3
I	2.0* 38.0	1 30.0	4.5 110.3	6.9 58.6	-	237.1	44.6	4.9 18.2	299.9
J	-	-	-	-	-	-	-	-	-
TOTAL	14.4 459.7	8 249.5	45.7 981.7	39.7 538.4	18.0 489.9	2719.2	511.2	109.5 203.0	3433.4

Note : * Raising Existing Road Levels

** Utilizing Existing NARINDA Pump Station

Note : Upper figures indicate quantities and lower figures costs.

Table 6.2 Comparison of Per Capita Project Cost and Land Acquisition Area

Item				Drainage Zone										
				A	B	C	D	E	F	G	H	I	J	Total
Beneficial Population Unit:1,000	Maximum Flood	1986	External Flood	24	71	114	232	17	18	21	71	8	-	576
			Internal Flood	45	235	33	16	-	68	8	7	24	-	436
			(U) Total	69	306	147	248	17	86	29	78	32	-	1012
		2000	External Flood	28	96	181	464	17	24	21	161	12	-	1004
			Internal Flood	63	243	36	24	-	80	11	20	40	-	517
			(V) Total	91	339	217	488	17	104	32	181	52	-	1521
	Annual Flood	1986	External Flood	-	14	15	86	-	-	-	5	-	-	120
			Internal Flood	45	265	33	16	-	68	8	7	24	-	466
			(W) Total	45	279	48	102	-	68	8	12	24	-	586
		2000	External Flood	-	57	48	238	-	8	-	108	-	-	459
			Internal Flood	63	275	36	24	-	80	11	20	40	-	549
			(X) Total	63	332	84	262	-	88	11	128	40	-	1008
(Y) Project Cost (million TK)				96.2	430.1	728.8	921.1	-	214.0	41.0	702.3	299.9	-	3433.4
(Z) Land Acquisition Area (ha)				0.1	3.2	24.0	59.9	-	5.1	2.2	9.6	4.9	-	109.0
Per Capita Project Cost (1,000 TK)			Y/U	1.4	1.4	5.0	3.7	-	2.5	1.4	9.0	9.4	-	3.4
			Y/V	1.1	1.3	3.4	1.9	-	2.1	1.3	3.9	5.8	-	2.3
			Y/W	2.1	1.5	15.2	9.0	-	3.1	5.1	58.5	12.5	-	5.9
			Y/X	1.5	1.3	8.7	3.5	-	2.4	3.7	5.5	7.5	-	3.4
Per Capita Land Acquisition Area (m2)			Z/U	0.01	0.10	1.63	2.42	-	0.59	0.76	1.23	1.53	-	1.08
			Z/V	0.01	0.09	1.11	1.23	-	0.49	0.69	0.53	0.94	-	0.72
			Z/W	0.02	0.11	5.00	5.87	-	0.75	2.75	8.00	2.04	-	1.86
			Z/X	0.02	0.10	2.86	2.29	-	0.58	2.00	0.75	1.23	-	1.08

Table 6.3 Priority Comparison

Comparison Factor		Drainage Zone									
		A	B	C	D	E	F	G	H	I	J
[1] Per Capita Project Cost	Case 1	I	I	III	II	-	I	II	III	III	-
	Case 2	I	I	I	I	-	I	I	I	II	-
[2] Per Capita Land Acquisition Area	Case 1	I	I	II	III	-	I	II	III	II	-
	Case 2	I	I	II	II	-	I	I	I	I	-
[3] Flood Condition		II	I	I	I	-	II	II	I	II	-
[4] Damage to Commercial and Institutional Activities		III	I	I	II	III	I	II	II	III	III
[5] Hindrance to Traffic		III	I	I	II	III	I	III	II	III	III
[6] Land Use Grade		III	II	I	II	III	I	I	II	II	III

Note : 1) Case 1 : Annual flood in 1986, Case 2 : Maximum flood in 2000
2) Per capita project cost, Case 1, Y/W : 5.0 > I, 5.0 < II <10.0, III > 10.0
Case 2, Y/V : 5.0 > I, 5.0 < II <10.0, III > 10.0
3) Per capita land acquisition area, Case 1, Z/W : 1.0 > I, 1.0 < II < 5.0, III > 5.0
Case 2, Z/V : 1.0 > I, 1.0 < II < 5.0, III > 5.0
4) Flood condition : Very serious : I, Serious : II
5) Damage to commercial and institutional activities : Large : I, Midium : II, Small : III
6) Hindrance to traffic : Large : I, Midium : II, Small : III
7) Land use grade : High : I, Midium : II, Low : III
8) Comparison factors (3)-(6) are for present condition

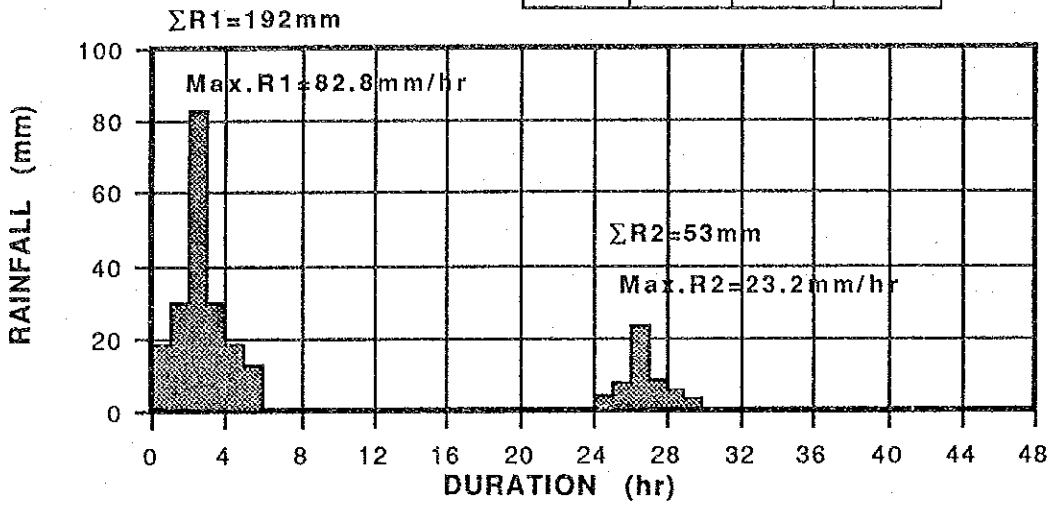
Table 6.4 Proposed Phased Program

(Unit ; million TK, 1986 Price)

Zone	Works	Phase-I	Phase-II	Phase-III	Remarks
A	[1] Drainage Pipe		3.8 km 79.4		
	[2] Khal Improvement		0.3 km 1.2		
	[3] Land Acquisition		0.1 ha 0.4		
B	[1] Drainage Pipe	4.3 km 178.8			
	[2] Khal Improvement	4.2 km 38.5			
	[3] Pump Station	9.6 m3/s* 97.1			*Rehabilitation
	[4] Control Gate	1 place 39.5			
	[5] Land Acquisition	4.5 ha 9.7			
C	[1] Drainage Pipe	4.8 km 125.0			
	[2] Khal Improvement	5.1 km 151.6			
	[3] Pump Station	7.5 m3/s 183.8			
	[4] Dike	2.4 km 93.1			
	[5] Control Gate	1 place 30.0			
	[6] Land Acquisition	23.5 ha 35.6			
D	[1] Drainage Pipe		1.7 km 35.5		
	[2] Khal Improvement		4.6 km 108.1		
	[3] Pump Station			9.5 m3/s* 232.8	
	[4] Dike			7.0 km 271.6	
	[5] Control Gate			2 places 60.0	
	[6] Land Acquisition		2.9 ha 11.6	57.0 ha 68.4	
E					
F	[1] Drainage Pipe	3.4 km 71.2			
	[2] Khal Improvement	3.8 km 96.6			
	[3] Land Acquisition	4.8 ha 14.7			
G	[1] Khal Improvement		2.9 km 27.1		
	[2] Land Acquisition		2.2 ha 8.8		
H	[1] Khal Improvement		11.9 km 56.5		
	[2] Pump Station		14.6 m3/s 357.7		
	[3] Raising of Road		3.0 km 57.0		
	[4] Control Gate		3 places 90.0		
	[5] Land Acquisition		9.6 ha 35.6		
I	[1] Khal Improvement		6.9 km 58.8		
	[2] Pump Station			4.5 m3/s 110.3	
	[3] Raising of Road			2.0 km 38.0	
	[4] Control Gate			1 place 30.0	
	[5] Land Acquisition		4.4 ha 17.6	0.5 ha 0.6	
J					
	Sub-Total	**1,165.2**	**945.3**	**811.7**	
	Physical Contingency & Engineering	**207.7**	**163.9**	**139.6**	
	Total 3,433.4	**1,372.9**	**1,109.2**	**951.3**	

HOURLY DISTRIBUTION

hr	%	R1	R2
1	9	17.4	4.8
2	15	28.3	8.0
3	44	82.8	23.2
4	16	30.6	8.5
5	9	18.0	5.0
6	7	14.9	3.5
TOTAL	100	192.0	53.0



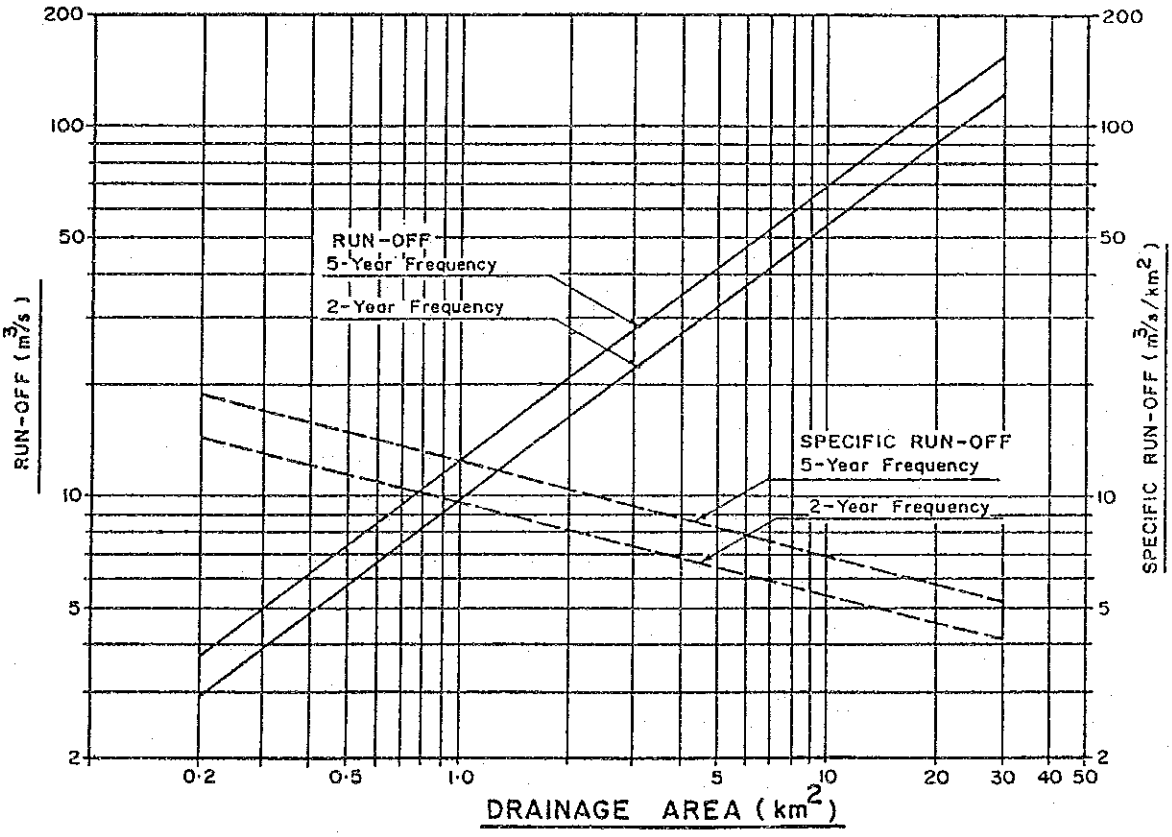


FIG. 6.1 DESIGN RAINFALL DISTRIBUTION AND PEAK RUNOFF - DRAINAGE AREA CURVES

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

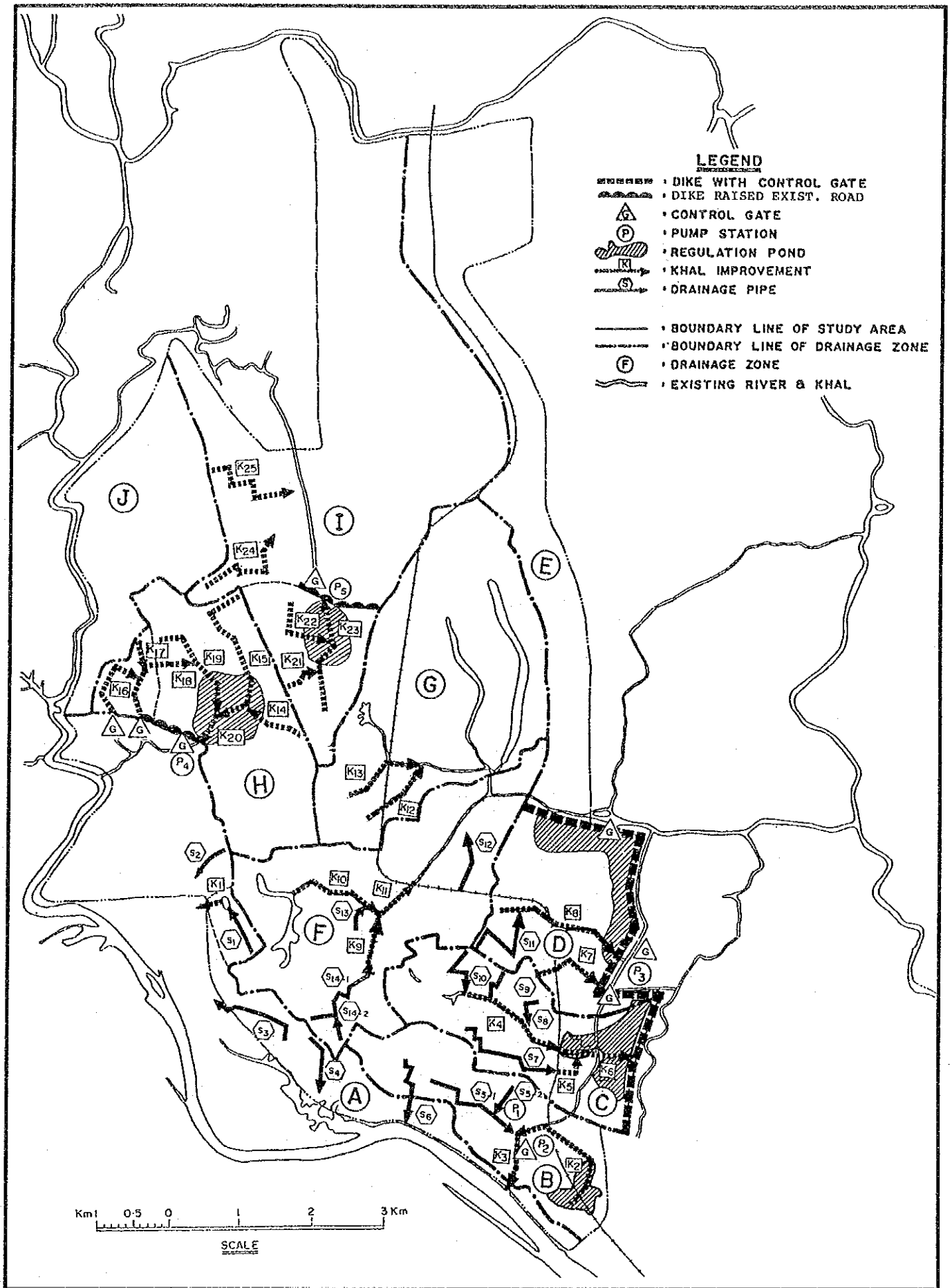


FIG. 6.2 PROPOSED FACILITIES

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

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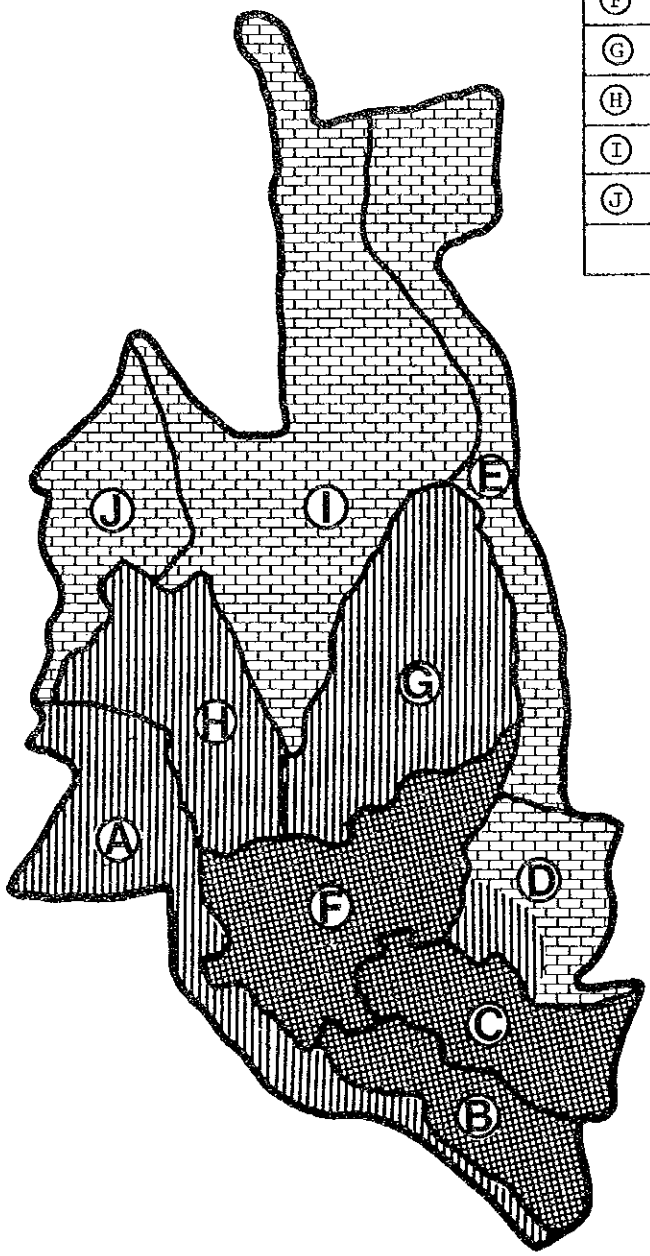
DRAINAGE ZONE AREA

Ⓐ	BURIGANGA RIVER BANK ZONE	12.85 km^2
Ⓑ	DHOLAI KHAL ZONE	7.76 km^2
Ⓒ	SEGUNBAGICHA KHAL ZONE	9.04 km^2
Ⓓ	BASABO ZONE	8.32 km^2
Ⓔ	NORTH-EAST EDGE ZONE	13.93 km^2
Ⓕ	BEGUNBARI KHAL ZONE	16.02 km^2
Ⓖ	GULSHAN-BANANI ZONE	17.64 km^2
Ⓗ	KALLYANPUR ZONE	12.78 km^2
Ⓘ	NORTH ZONE	31.42 km^2
Ⓙ	TURAG RIVER BANK ZONE	7.69 km^2
	TOTAL AREA	137.45 km^2



LEGEND

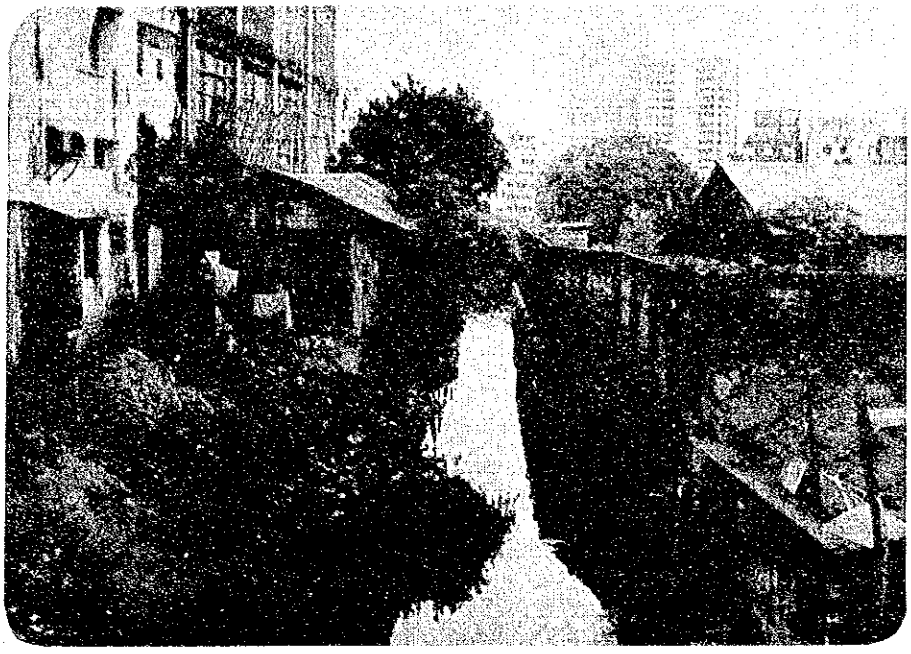
: PHASE - I

: PHASE - II

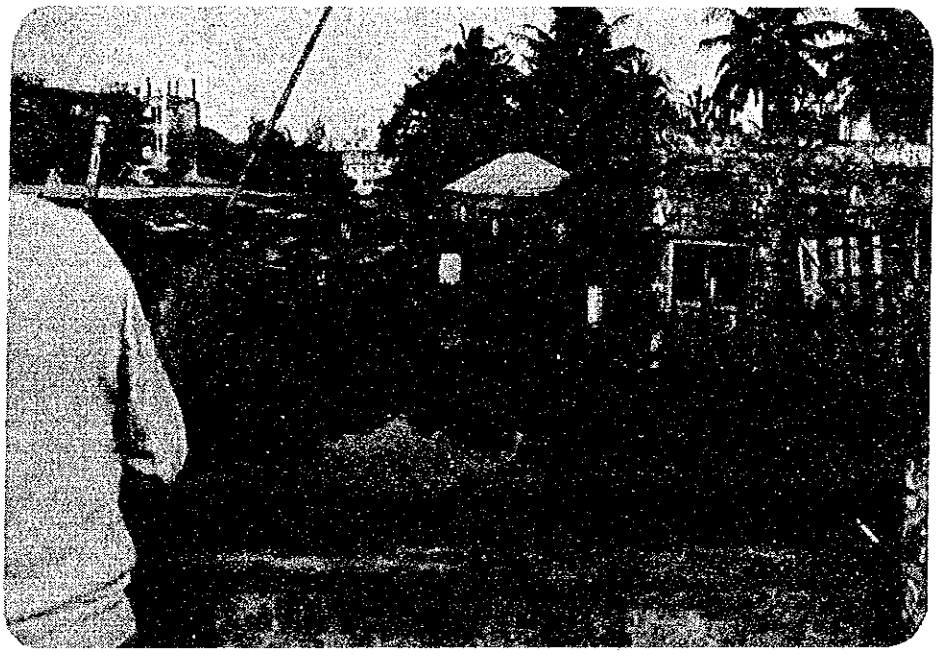
: PHASE - III

FIG. 6.3 PROPOSED IMPLEMENTATION PHASES

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH



REQUIRED KHAL IMPROVEMENT
(SEGUN BAGICHA KHAL)



REQUIRED KHAL IMPROVEMENT
(BEGUNBARI KHAL)

CHAPTER 7
DRAINAGE IMPROVEMENT PLAN OF THE PRIORITY AREAS

CHAPTER 7 DRAINAGE IMPROVEMENT PLAN OF THE PRIORITY AREAS

7.1 Introduction

In this chapter, detailed drainage improvement plans are prepared for the priority areas selected in Chapter 6: Dholai Khal zone (B), Segunbagicha Khal zone (C), and Begunbari Khal zone (F).

7.2 Planning Policy and Hydraulic Design Criteria

In accordance with the discussions made in 6.1, the following planning policies and hydraulic design criteria are proposed:

(1) Target year of plan: year 2000

Both the structural and non-structural plans are prepared to meet the population and land use distribution in the year 2000.

(2) Design flood water level

- The flood water level with a 30-year frequency (6.60 m G.T.S.) is applied for the design of flood protection works.

- The frequent flood water level of 5.36 m G.T.S. (2-year frequency) is employed as the design outlet water level for internal drainage works.

(3) Runoff calculation method

Design discharge for the drainage pipes and khal improvements is calculated by the Rational Formula described below:

$$Q = CiA/360$$

where, Q: Peak discharge (m^3/s)
C: Runoff coefficient
i: Rainfall intensity during time of concentration (mm/hr)
A: Drainage area (ha).

(4) Design rainfall

The rainfall intensity with a 5-year frequency is employed for the design of drainage pipes and khal improvements. The rainfall intensity to be applied for the Rational Formula is calculated by the following formula:

$$i = 9005/(t + 50)$$

where, i: rainfall intensity (mm/hr)
t: duration time (min).

The applied rainfall intensity-duration curve is illustrated in Fig. 2.5.

For the design of pump station, the two days consecutive rainfall with a 5-year frequency is proposed.

The rainfall depth and hourly distribution of the design two days consecutive rainfall are illustrated in Fig. 7.1.

(5) Runoff coefficient and runoff ratio

The following runoff coefficients are used for the calculation of flood runoff peak by the Rational Formula.

Land Use	Run-off Coefficient
Commercial Area	0.65
Industrial Area	0.55
High Class Residential Area	0.30
Middle & Low Class Residential Area	0.5
Green Zone and Others	0.2

The runoff ratio (total runoff/total rainfall) of 0.8 is employed in the estimate of flood runoff volume required for the calculation of pump capacity.

(6) Manning's roughness coefficient

Manning's roughness coefficients applied for hydraulic calculation of drainage pipes, culverts and khal improvements are as follows;

Drainage pipe (brick)	: 0.015
Concrete Box Culvert	: 0.015
Khal Improvement (smooth section)	: 0.025
" " (rough section)	: 0.035

(7) Drainage pipes are designed under the surcharge condition of storm water where the ground elevation is not high enough compared to the design outlet water level.

7.3 Review of Drainage Zone

7.3.1 Revision of Drainage Zone Boundary

The drainage zone boundaries of the Project area: B, C and F zones are revised, based on the detailed studies of the topographic conditions, existing drainage system, on-going drainage program and proposed drainage system.

The revised zone areas of B, C and F are presented in Table 7.1.

7.3.2 Demarcation of Gravity and Pump Drainage Areas

Ground elevation and area curves were made for the following subdivided drainage zones to demarcate gravity and pump drainage areas.

B zone : B I (Old Dhaka upstream area: 1.03 km^2)
B II (Old Dhaka downstream area: 3.11 km^2)
B III (Gandaria area: 2.54 km^2)
C zone : C I (Segunbagicha Khal upstream area: 7.03 km^2)
C II (Segunbagicha Khal downstream area: 3.89 km^2)
F zone : F I (Begunbari Khal upstream area: 9.29 km^2)
F II (Begunbari Khal downstream area: 4.41 km^2)

Ground elevation and area curves of the subdivided drainage zones are illustrated in Fig. 7.2.

Flood and drainage conditions corresponding to ground elevation are as follows:

(1) The area above 6.60 m G.T.S. is free from the river floods.

(2) The area between 6.40 m G.T.S. and 6.60 m G.T.S. is flood prone but can drain storm waters by gravity, assuming that

- outlet water level of drainage pipes is a frequent flood water level (2-year frequency) of 5.36 m G.T.S.
- head difference required for gravity drain of a 5-year frequency discharge through drainage pipes is about 1.0 m.

(3) The area below 6.40 m G.T.S. cannot drain by gravity.

In consideration of the above conditions, the following conclusions are reached for flood protection and drainage of each area:

(1) B I area

Nearly all of the area is higher than 6.60 m G.T.S. Storm waters can be drained by gravity. No flood protection works are required.

(2) B II area

Sixty (60) % of the area is below 6.60 m G.T.S. Fifty (50) % is below 6.40 m G.T.S. Flood protection works and pump drainage are required.

(3) B III area

Almost all the area is below 6.60 m G.T.S. Ninety five (95) % is below 6.40 m G.T.S. Flood protection works and pump drainage are required.

(4) C I area

Fifty (50) % is below 6.60 m G.T.S. Forty (40) % is below 6.40 m G.T.S. Flood protection works and pump drainage are required.

(5) C II area

Almost all the area is below 6.40 m G.T.S. Flood protection works and pump drainage are required.

(6) F I area

All the area, except the khal area is above 6.60 m G.T.S. No flood protection works are required and gravity drainage is available.

(7) F II area

Seventy (70) % of the area is below 6.60 m G.T.S. However, this low-lying area is mostly khal area and little has been developed for urban use. The low-lying developed lands below 6.60 m G.T.S. are 61 ha in total, but these are all situated above 5.50 m G.T.S. Gravity drainage is available even for the low-lying developed areas because the hydraulic headloss required for the drainage of these areas is small.

Proposal of structural flood protection works for these low-lying areas is not practical. These areas shall be relieved from flood damage by adequate non-structural measures.

7.4 Alternative Drainage Improvement Plan

7.4.1 Old Dhaka Drainage System

The proposed drainage area of the Old Dhaka drainage system (BI and BII areas) covers 4.14 km^2 of which 3.68 km^2 is the catchment area of the existing Narinda Pump Station and 0.46 km^2 is the residual area.

The following three (3) alternative plans are proposed for the drainage improvement of the Old Dhaka area in view of the fact that a considerable part of the drainage area is high enough to drain directly to the Buriganga River:

(1) Alternative 1

All the area (3.68 km^2) is covered by pump drainage at Narinda.

(2) Alternative 2

Composed of the Two (2) systems:

- upstream area (1.03 km^2): diversion to the Buriganga River
- middle and downstream areas (2.65 km^2): pump drainage at Narinda

(3) Alternative 3

Composed of the following three (3) systems:

- upstream area (1.03 km^2): diversion to the Buriganga River
- middle stream area (1.05 km^2): pump drainage at the Buriganga River bank
- downstream area (1.60 km^2): pump drainage at Narinda

The three (3) alternative drainage systems are illustrated in Fig. 7.3.

The estimated costs of the alternative plans are shown in Table 7.2.

Alternative 2 is recommended because of the least cost.

7.4.2 Pump Drainage System

As concluded in 7.3.2 and 7.4.1, the Old Dhaka downstream area (B II: 3.11 km^2) consisting of Narinda P.S. area of 2.65 km^2 and the residual area of 0.46 km^2, Gandaria area (B III: 2.54 km^2), and

Segunbagicha Khal zone (C: 10.92 km^2) require pump drainage. For pump drainage of these areas and zone, the following three (3) alternatives are proposed:

(1) Alternative 1: each area and zone is independent.

(2) Alternative 2: B II and B III areas are combined. C zone is independent.

(3) Alternative 3: All areas and zone are integrated.

The pump drainage systems of the three alternatives are illustrated in Fig. 7.4.

The total required pump capacities and construction costs for the alternatives are as below:

(1) Alternative 1: 47.1 m^3/s, 847.8 million TK
(2) Alternative 2: 29.9 m^3/s, 538.2 million TK
(3) Alternative 3: 18.8 m^3/s, 338.4 million TK

Alternative 3 is recommended.

7.4.3 Khal Improvement Type

Two (2) types of khal improvement are conceived for the highly urbanized areas. One is the open channel type and the other is the covered channel type (box culvert type).

The two (2) types are compared for the following stretches:

(1) Segunbagicha Khal: Circular Road to DPHE Store Circle
L= 2.1 km

(2) Begunbari Khal: Airport Road to Dhanmondi Lake
L = 1.8 km

(3) Paribagh Khal: Begunbari Khal Junction to New Elephant Road
L = 1.0 km

Adventages and disadvantages of the two (2) types are summarized in Table 7.

Cost comparison of the two (2) types is shown in Table 7.3.

From the above comparisons, the open channel type is proposed.

7.5 Proposed Drainage Improvement Plan

7.5.1 Flood Protection Plan

(1) Dholai Kahl zone (B zone)

B zone contains 4.5 km^2 of low-lying land below the design flood water level (6.60 m G.T.S.) out of the total area of 6.68 km^2.

However, the low-lying areas are protected from river floods by the Dhaka-Narayanganj Diversion Road, Haricharan Road, and Buriganga River bank. The flood water intrudes only through the Dholai Khal.

Construction of a control gate is required to provide protection against the backwater of the Buriganga River. The gate is attached to the new Narinda pump station proposed in the Dholai Khal.

The gate is 6 x 6 m in size and its design high water level is 6.60 m G.T.S.

(2) Segunbagicha Khal zone (C zone)

C zone covers 7.5 km^2 of land below the design flood water level (6.60 m G.T.S.) out of the total area of 10.92 km^2.

Construction of dikes is proposed to prevent flooding from the Balu River. The alignment of the dikes was determined in due consideration of:

- existing and future land use,
- existing khal networks,
- required regulating pond area for pump drainage,
- multipurpose use for road,
- existing community boundary.

The main features of the proposed dikes are:

- total length: 4.8 km
- design high water level: 6.60 m G.T.S.
- freeboard: 1.0 m
- crown elevation: 7.60 m G.T.S.

The propsoed dikes are provided with control gates of 6 x 6 m in size to drain flash floods in the off-season of pump drainage together with control gate attached to the New Narinda pump station.

Location of the proposed flood protection works is illustrated in Fig. 7.11.

7.5.2 Pump Drainage

(1) Required pump and regulating pond capacities

The design storm rainfall (two days consecutive rainfall with a 5-year frequency) will be drained by the proposed drainage system in 48 hours.

The total required pump and regulating pond capacities were calculated by the mass curve method. The results are:

- required pump capacity: 18.8 m^3/s
- required regulating pond capacity: 2.18×10^6 m^3

(2) High water level (H.W.L.) of regulating pond

The design H.W.L. of the regulating pond is proposed to be 4.5 m G.T.S. through the following considerations:

- The lowest elevation of the existing developed land in the fringe areas of B and C zones is 5.3 - 5.5 m G.T.S.

- It is recommended that future land development be made in conformity with the elevation of the neighbouring built-up lands.

- A head difference of approximately 1.0 m will be required for satisfactory drainage of the above-mentioned low-lying developed land.

(3) Low water level (L.W.L.) of regulating pond

The design L.W.L. of the regulating pond is fixed at 3.2 m G.T.S. in considerations of:

- Ground elevation of the proposed regulating ponds

- River flood hydrographs and required periods of pump operation

(4) Proposed regulating pond

The proposed regulating ponds provided with a required storage capacity between H.W.L. and L.W.L. are delineated as shown in Fig. 7.11, taking into account the future land development.

One is the large pond proposed in Jatrabari area (C II area). The other is the small pond proposed in Gandaria area (B III area). The provided surface area and storage capacity of the regulating ponds are:

- Jatrabari Pond:
  Surface area: 1.38 km^2 (58% of the existing undeveloped low land of 2.39 km^2)
  Storage capacity: 1.78×10^6 m^3

- Gandaria Pond:
  Surface area: 0.47 km^2 (49% of the existing undeveloped low land of 0.96 km^2)
  Storage capacity: 0.40×10^6 m^3

These ponds are effective for reducing the requirements of Dholai Khal and Gandaria Khal improvements as well as pump capacity.

(5) Proposed pump station

For the total required pump capacity of 18.8 m^3/S,

- 9.6 m^3/S is met by rehabilitation of the existing Narinda pump station.
- The remaining 9.2 m^3/S is supplied by construction of an additional pump station.

The location of the new pump station is proposed near the existing Narinda pump station through comparison with the Jatrabari Pond site as described below (See Fig. 7.11):

- The Narinda site is more advantageous for reducing operational and maintenance costs.
- The Narinda site is more favorable from a hydraulic aspect. If the new pump station is installed at Jatrabari, the water level of Narinda will rise 0.45 m higher at the time of the storm runoff peak and worsen the drainage situation of the Old Dhaka area.
- No significant difference is recognized between the two (2) sites in geological and construction conditions.

7.5.3 Khal Improvement and Drainage Pipe

(1) Proposed networks

The networks of the proposed khal improvements and drainage pipes are illustrated in Fig. 7.5.

(2) Design discharge

The design discharges, with a 5-year frequency, were calculated for each stretch of the proposed khals and drainage pipes by the Rational Formula.

The design discharge of the Begunbari khal was calculated taking into account the effect of storm runoff regulation by the Dhanmondi Lake.

The results are shown in Fig. 7.6.

(3) Proposed khal improvement

The longitudinal and cross sections of khal are designed to lower the water level to an economically possible extent since the discharge capacity of drainage pipe is affected by the water level of khal.

(Segunbagicha Khal)

Khal improvement with a total length of 3.0 km is proposed for the stretch between the railway crossing and Ramna Lake. The proposed bed slope is 1/2,000.

The proposed longitudinal and cross sections are illustrated in Fig. 7.7.

(Begunbari Khal)

Khal improvement, with a total length of 2.8 km, is proposed for the stretch between the New Airport Road and the Dhanmondi Lake. The proposed bed slopes are 1/5,000 (downstream side) and 1/3,000 (upstream side).

The proposed longitudinal and cross sections are illustrated in Fig. 7.8.

(Paribagh Khal)

Khal improvement, with a total length of 1.0 km, is proposed for the stretch between the confluence with Begunbari Khal and the Elephant Road. The proposed bed slope is 1/2,000.

The proposed longitudinal and cross sections are illustrated in Fig. 7.9.

(Gandaria Khal)

A small scale improvement is proposed since the storm runoff of the basin will be regulated to a large extent by Gandaria Pond.

The proposed longitudial and cross sections are illustrated in Fig. 7.9.

(Dholai Khal)

The Khal improvement is proposed for the stretch with a total length of 3.0 km between the confluence with the Buriganga River and the Jatrabari regulating pond.

The stretch upstream from the proposed new Narinda pump station is improved according to the longitudinal and cross sections illustrated in Fig. 7.10.

While, for the stretch downstream from the proposed Narinda pump station, only lowering of the khal bottom is proposed since it is wide enough.

Location of the proposed khal improvements are illustrated in Fig. 7.11.

(4) Proposed Drainage Pipe

The additional drainage pipes proposed for each drainage zone are as follows:

Dholai Khal zone (B zone):	2 lines, 4.28 km
Segunbagicha Khal zone (C zone):	4 lines, 4.81 km
Begunbari Khal zone (F zone):	3 lines, 3.41 km
Total:	9 lines, 12.50 km

The cross section of the drainage pipes is designed to allow the flow of the design discharge under surcharge water conditions. Hydraulic gradient of the drainage pipe is obtained from the difference between the outlet water level of the pipe and the ground elevation of the drainage area.

The pipe slope is proposed in 1/2,000, taking into account the khal bed elevation and tractive force of sediment under free flow condition.

Locations of the proposed drainage pipes are illustrated in Fig. 7.11.

7.5.4 Development of Dhanmondi Lake

(1) The existing Dhanmondi Lake serves flood control and recreation. Storm runoff from the catchment area of 0.65 km^2 is regulated by a spillway with the crest elevation of 3.6 m G.T.S. and the width of 6.8 m.

In the dry season, the water level is maintained at 3.6 m G.T.S. to meet recreational requirements.

(2) The Lake is developed for the enhancement of the flood control and recreational uses.

- The crest of the spillway is raised to 5.70 m G.T.S., keeping the existing width of 6.8 m. As a result, the design flood discharge of 15.4 m^3/S decreases to 2.7 m^3/S.

- The low water level is maintained at 5.70 m G.T.S., resulting in growth of recreation benefits.

(3) The main features of the proposed development plan are as below;

Catchment area	:	0.65 km^2
Surface area	:	17.60 ha
H.W.L.	:	6.10 m G.T.S.
L.W.L.	:	5.70 m G.T.S.
Design flood inflow	:	15.2 m^3/S
Design flood outflow	:	2.7 m^3/S

Table 7.1 Revised Drainage Zone Area

Drainage zone	Original (km^2)	Revised (km^2)
B. Dholai Khal Zone	7.76	6.68
C. Segunbagicha Khal Zone	9.04	10.92
F. Begunbari Khal Zone	16.02	13.70
Total	32.83	31.30

Table 7.2 Estimated Cost of Alternative Plan

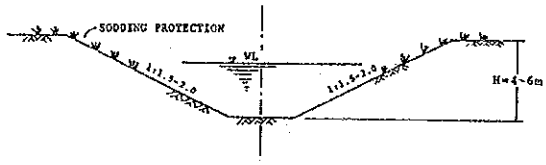
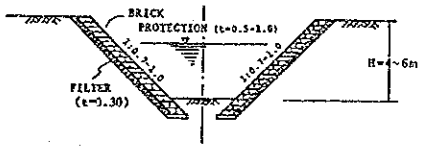
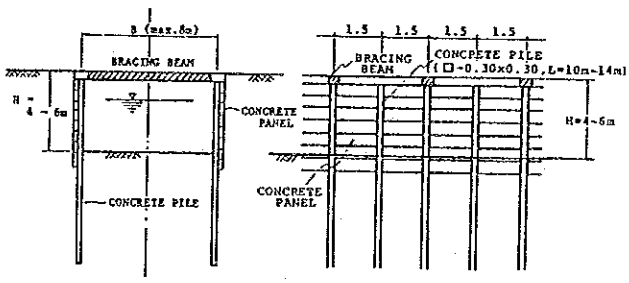
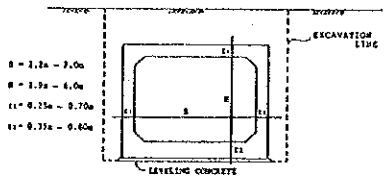
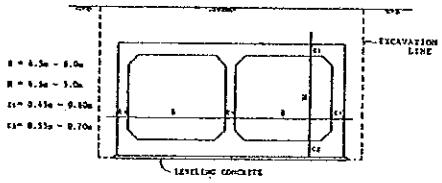
(Unit: million T.K.)

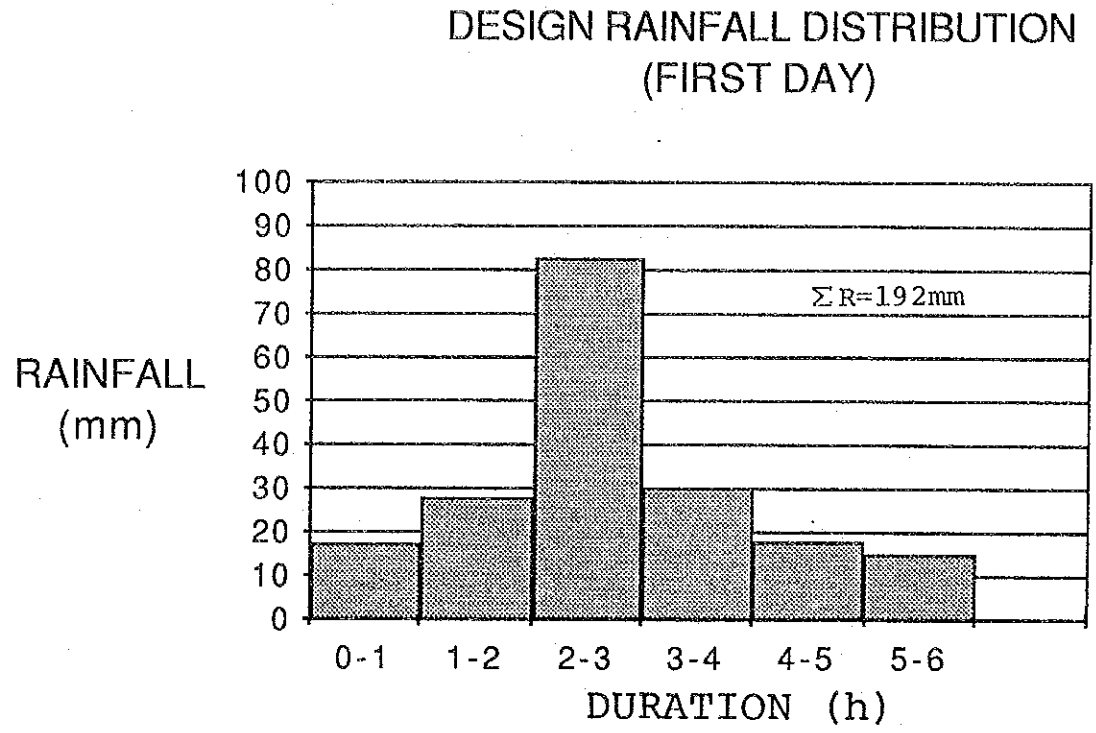
	Alt. 1	Alt. 2	Alt. 3
Const. Cost of Drainage Pipe	194.0	170.0	183.2
Const. Cost of Pump St.	455.4	423.0	498.6
O & M Cost	102.5	95.2	112.2
Total	751.9	688.2	794.0

Table 7.3 Advantage and disadvantage of Khal Improvement Type

Problem	Open Channel Type	Covered Channel Type
(1) Collection of Stormwater	Easy to collect stormwater even before completion of secondary drainage system.	Difficult to collect stormwater before completion of secondary drainage system and causes local floods. Typical example is seem in Old Dhaka area.
(2) Maintenance	Easy	Difficult and expensive.
(3) Construction	Easier than covered channel type.	More difficult than the open channel type.
(4) Re-construction in the future	Easy. Covering of channel in the future is easy.	Difficult. Re-opening of channel in the future would be difficult.
(5) Existing bad smell due to water pollution and water disposal	Difficult to attain satisfactory solution before completion of sewerage system and collection system of waste disposal.	Bad smell due to water pollution will be solved. However, bad smell due to waste disposal will remain unresolved until completion of the collection system of water disposal.
(6) Preservation of open space	Easy. Open channel itself functions as open space.	Depends on land use pattern on covered channel.
(7) Land use on channel	Cannot be used other than for drainage.	Can be used for road or promenade.
(8) Illegal land occupation by squatter	Difficult to prevent without strong administrative control or construction of high guard fences.	Easier to prevent than for open channel type.

Table 7.4 Construction Cost Comparison of Khal Improvement Plan Alternatives

Item	Alternative 1 Open Channel Type	Alternative 2 Covered Channel Type
Standard Cross Section	TYPE - 1 : TRAPEZOIDAL TYPE (1) - SODDING PROTECTION  TYPE - 2 : TRAPEZOIDAL TYPE (2) - BRICK PROTECTION  TYPE - 3 : CONCRETE PANEL WALL TYPE (1) - WITH BRACING BEAM 	TYPE - 1 SINGLE BOX CULVERT  TYPE - 2 DOUBLE BOX CULVERT 
Construction Cost		
(i) Segunbagicha Khal	47,200 TK/m x 2,100 m = 99.12 Million TK	125,000 TK/m x 2,100 m = 262.50 Million TK
(ii) Begunbari Khal	9,000 TK/m x 1,800 m = 16.20 Million TK	130,000 TK/m x 1,800 m = 234.00 Million TK
(iii) Paribagh Khal	71,400 TK/m x 1,000 m = 71.40 Million TK	116,000 TK/m x 1,000 m = 116.00 Million TK
Total	186.72 Million TK	612.50 Million TK
Note	With regard to construction cost per meter, refer to Table L.4 in the Supporting Report L.	With regard to construction cost per meter, refer to Table N.3 in the Supporting Report N.



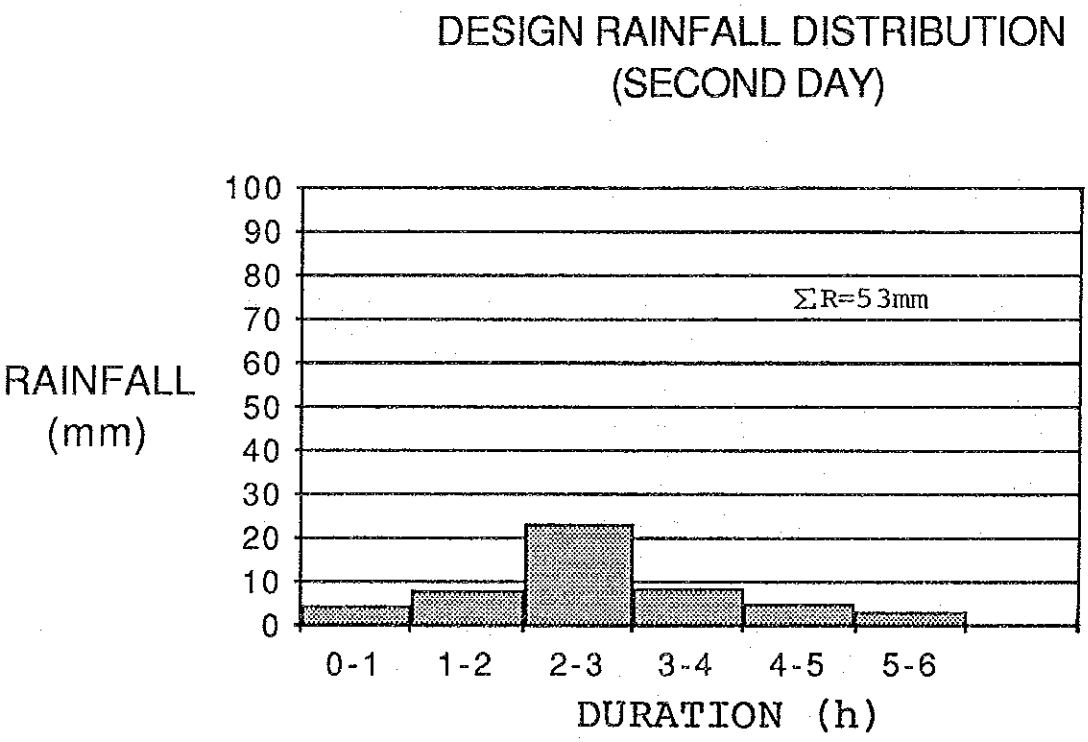


FIG. 7.1 DESIGN TWO DAYS CONSECUTIVE RAINFALL

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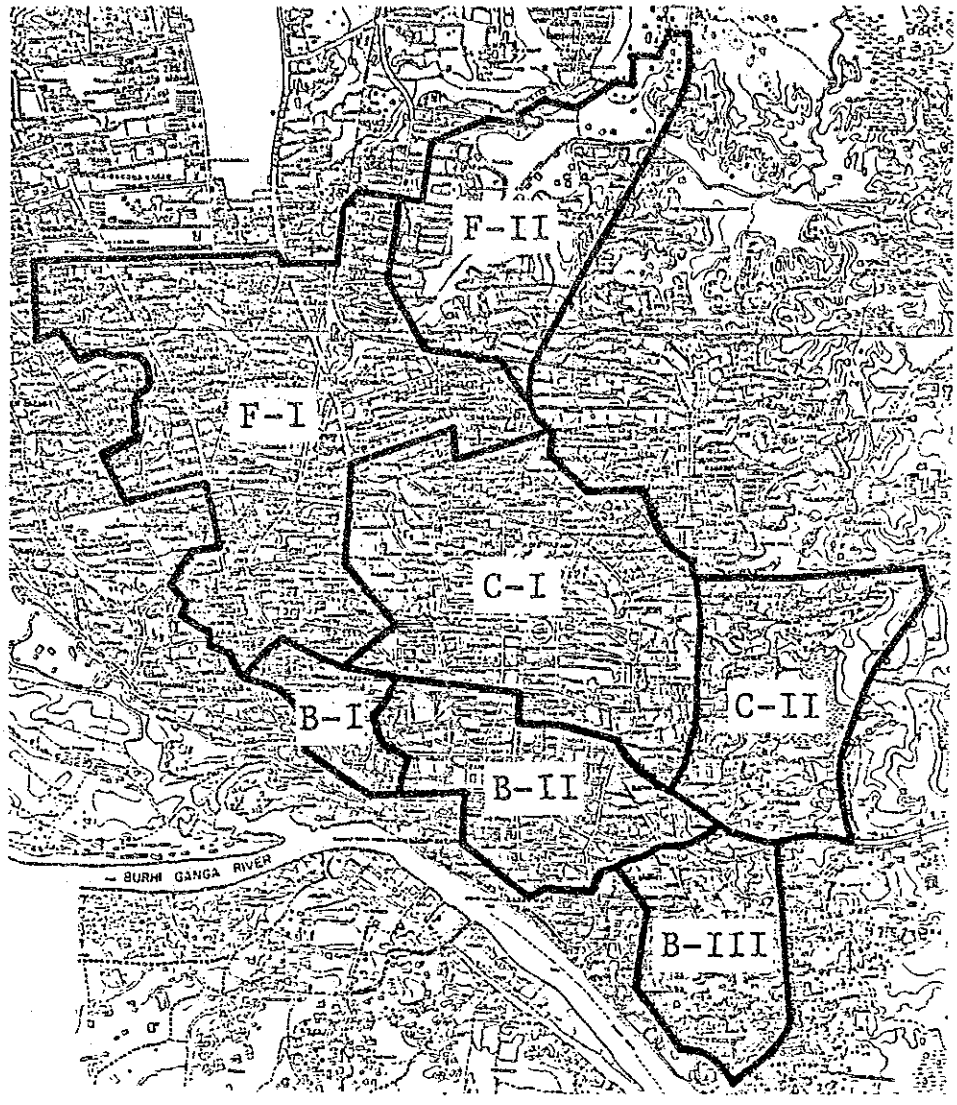


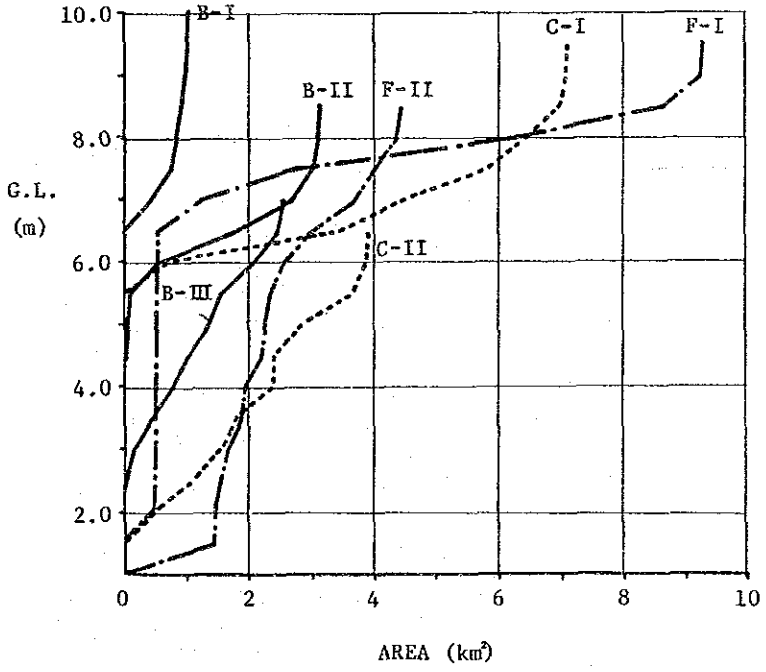


FIG. 7.2 GROUND ELEVATION AND AREA CURVE FOR SUB-DIVIDED AREA

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

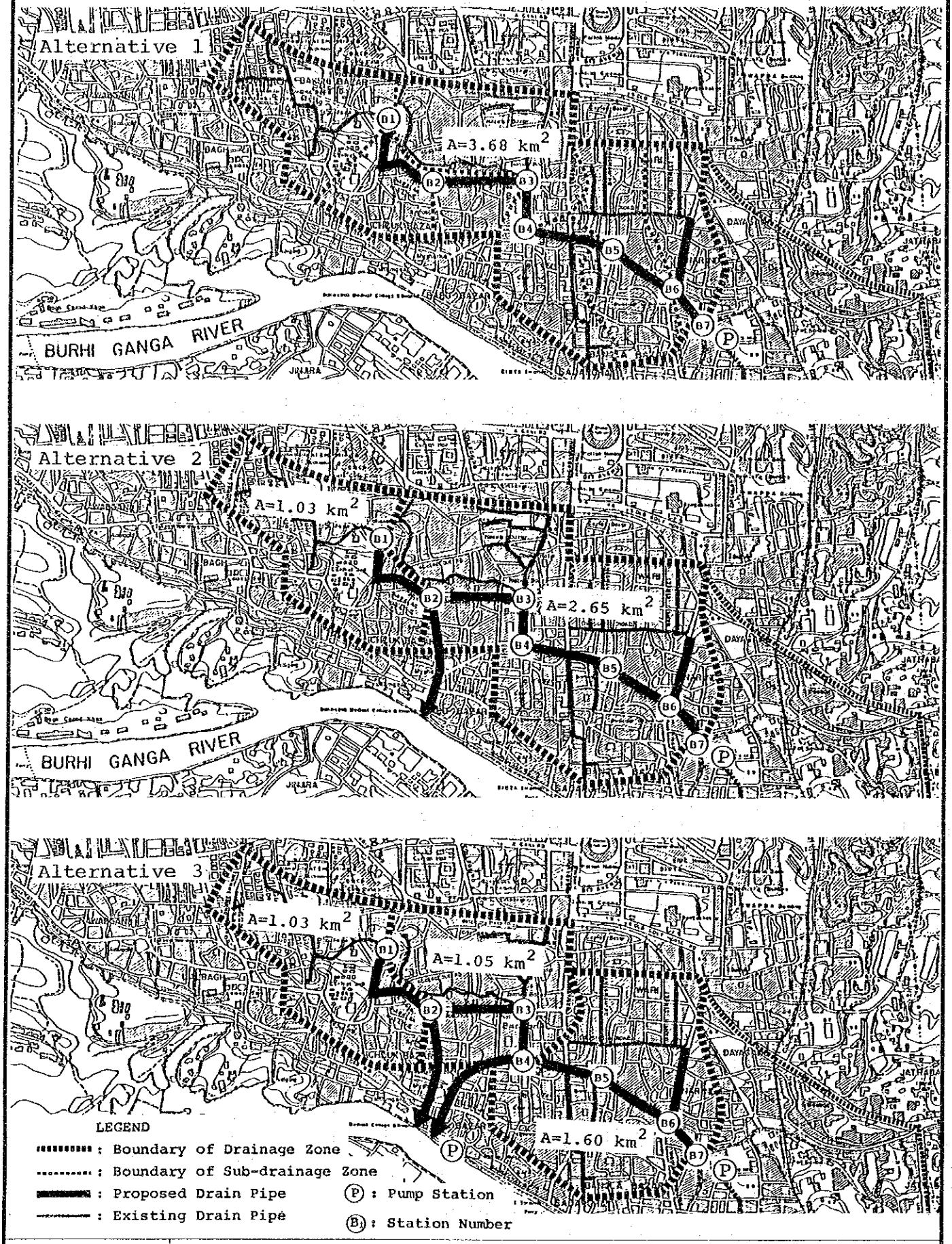


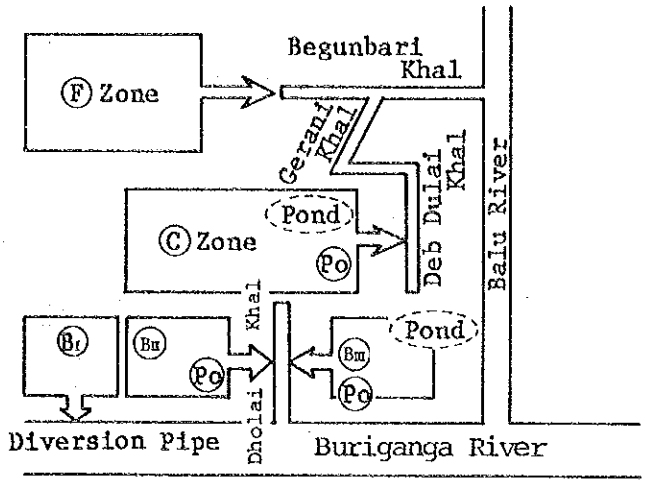
FIG. 7.3 ALTERNATIVE DRAINAGE SYSTEM FOR OLD DHAKA AREA

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

Alternative 1

Drainage Area

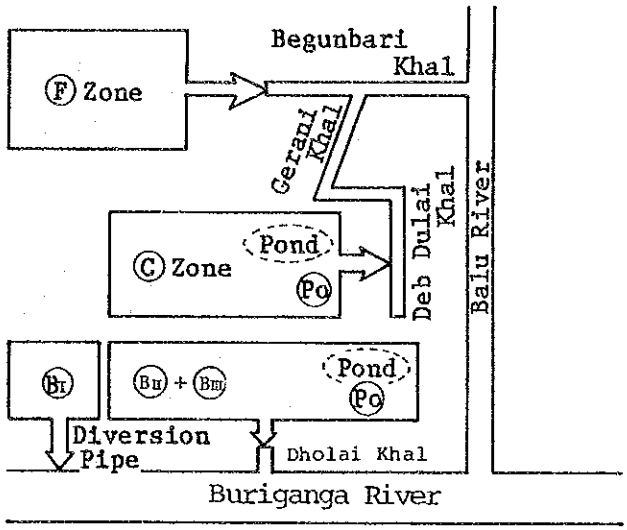
B I Area : 1.03 km^2
B II Area : 3.11 km^2
B III Area : 2.54 km^2
C Zone : 10.92 km^2
F Zone : 13.70 km^2



Alternatuve 2

Drainage Area

B I Area : 1.03 km^2
B II + B III Area : 5.65 km^2
C Zone : 10.92 km^2
F Zone : 13.70 km^2



Alternative 3

Drainage Area

B I Zone : 1.03 km^2
(B II + B III) Area + C Zone : 16.57 km^2
F Zone : 13.70 km^2

LEGEND

Ⓑ , Ⓒ , Ⓕ : Drainage Area, Zone
Ⓟo : Pumping Station
(Pond) : Regulating Pond

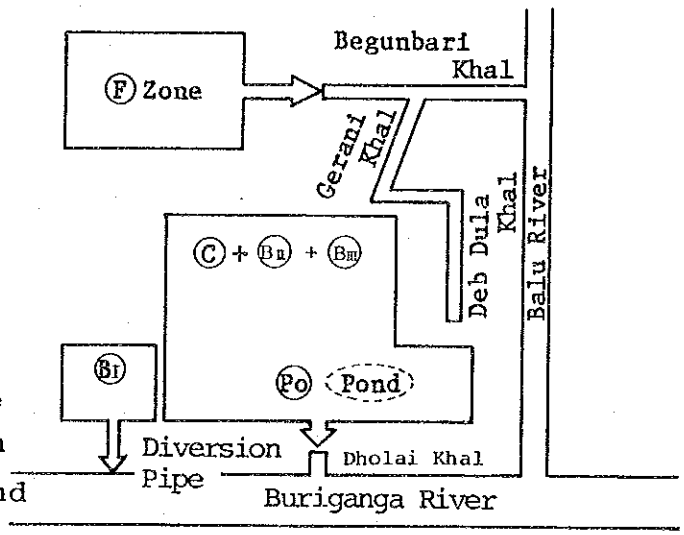


FIG. 7.4 ALTERNATIVE PUMP DRAINAGE SYSTEM

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

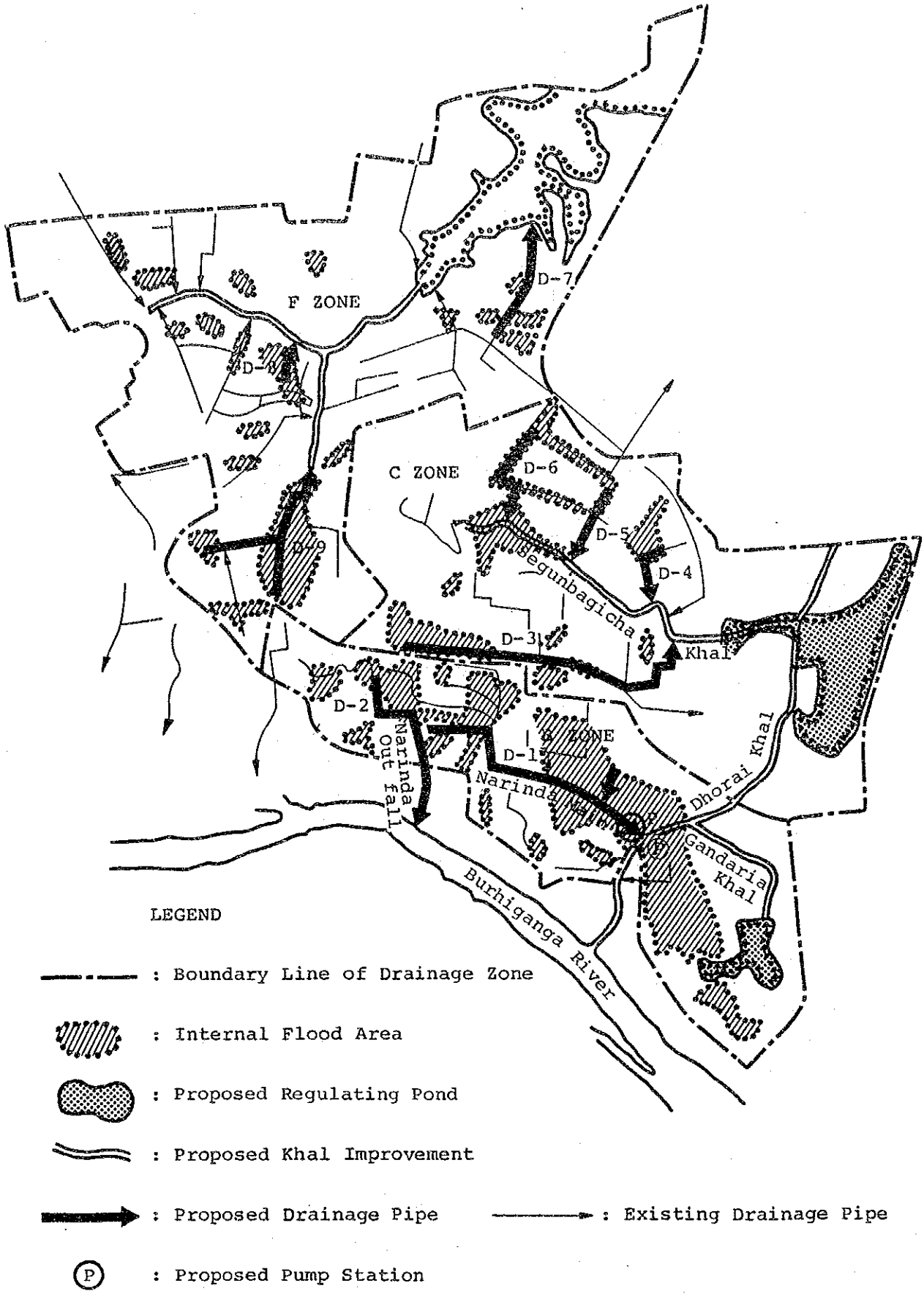


FIG. 7.5 PROPOSED DRAINAGE NETWORKS

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

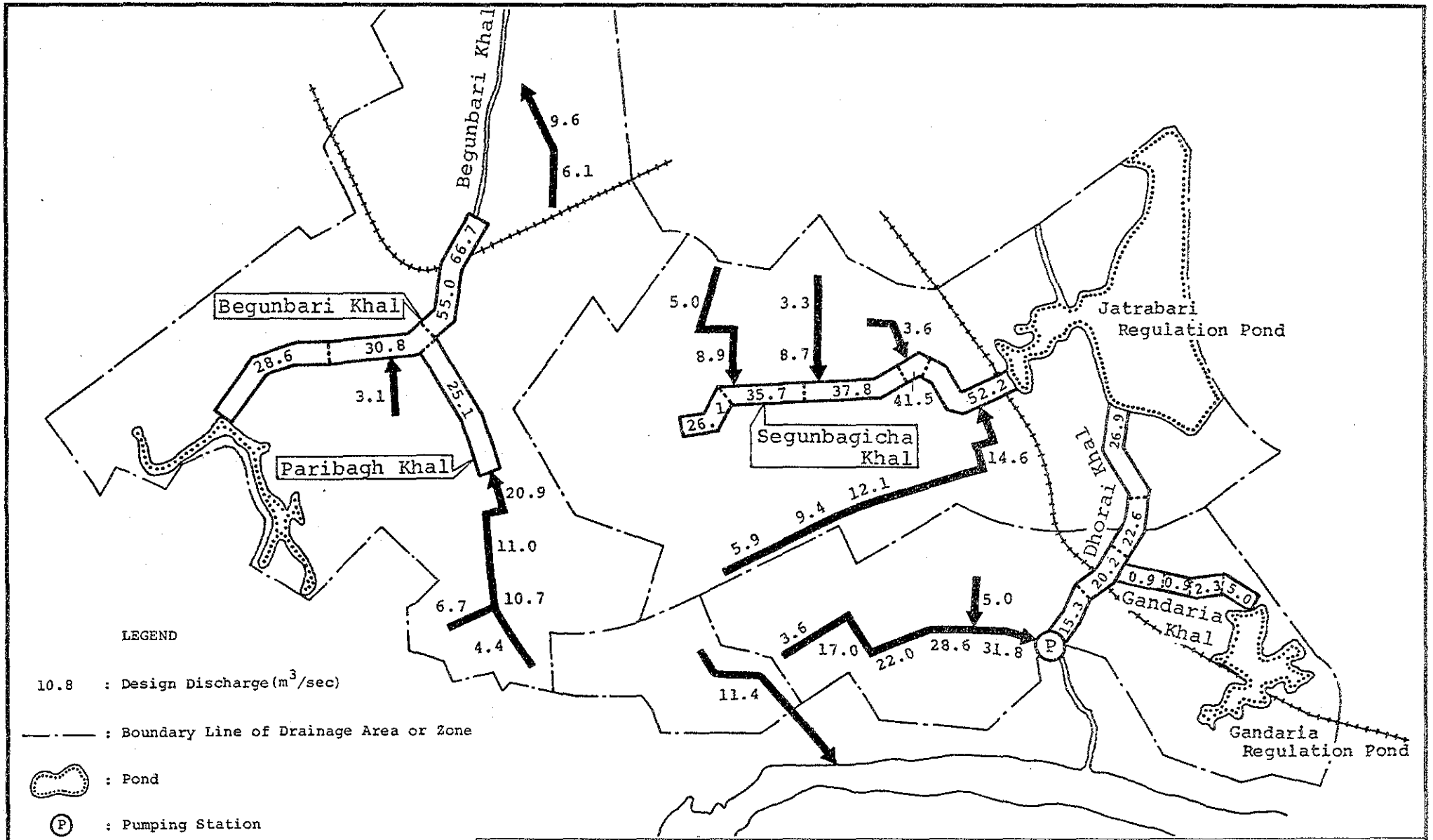


FIG. 7.6 DESIGN DISCHARGE OF KHAL IMPROVEMENT AND DRAINAGE PIPE

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

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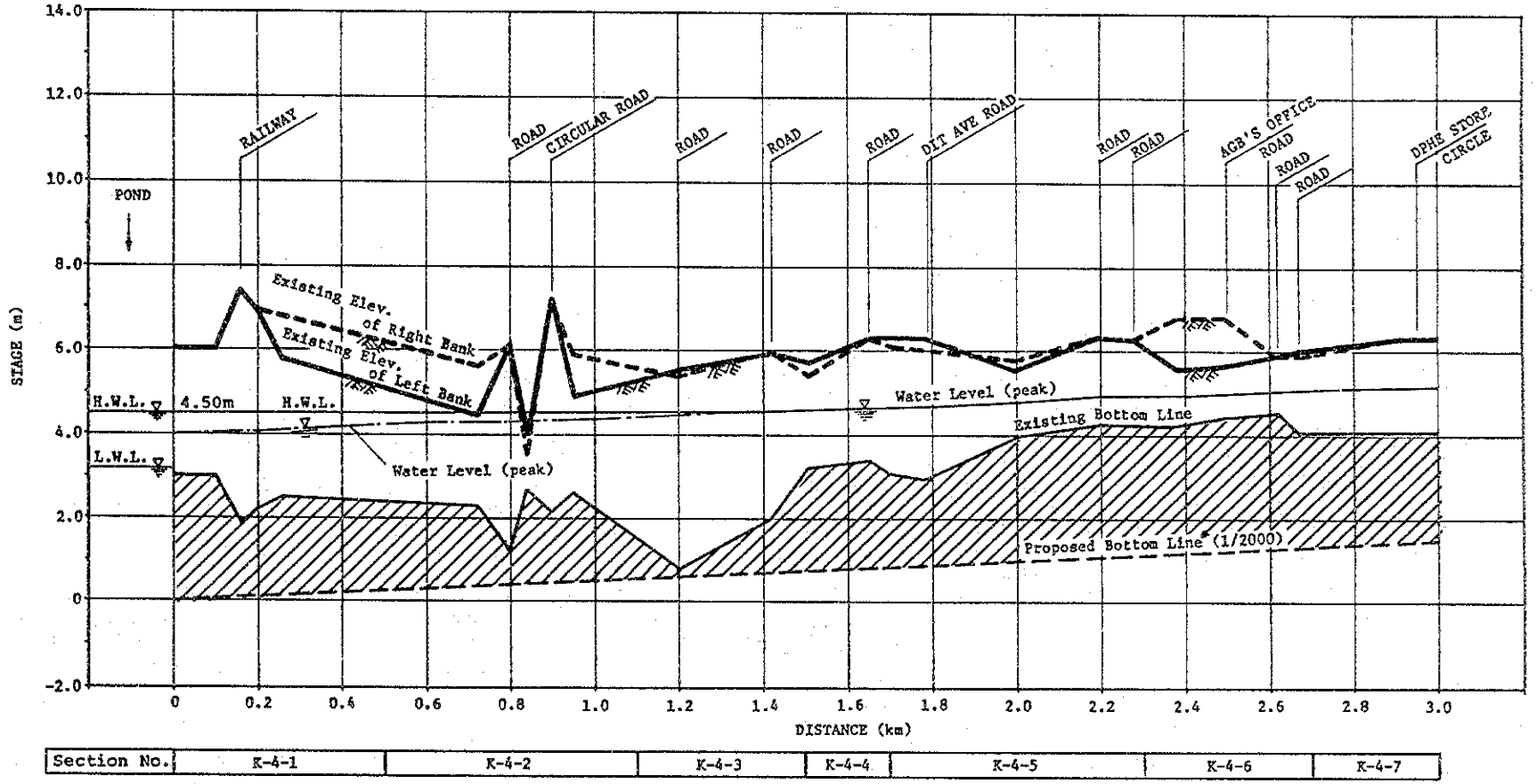

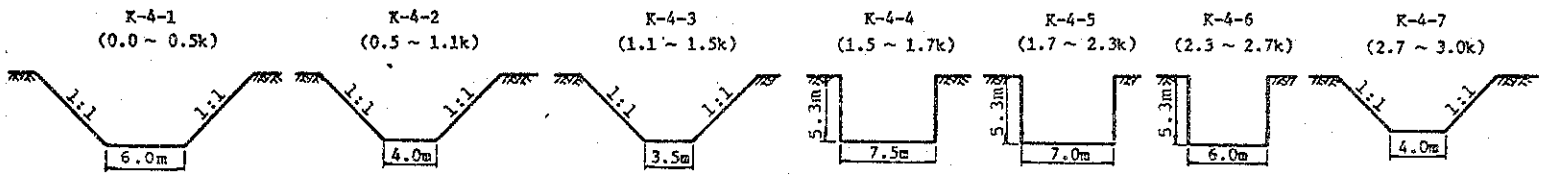

FIG. 7.7 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF SEGUNBAGICHA KHAL

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

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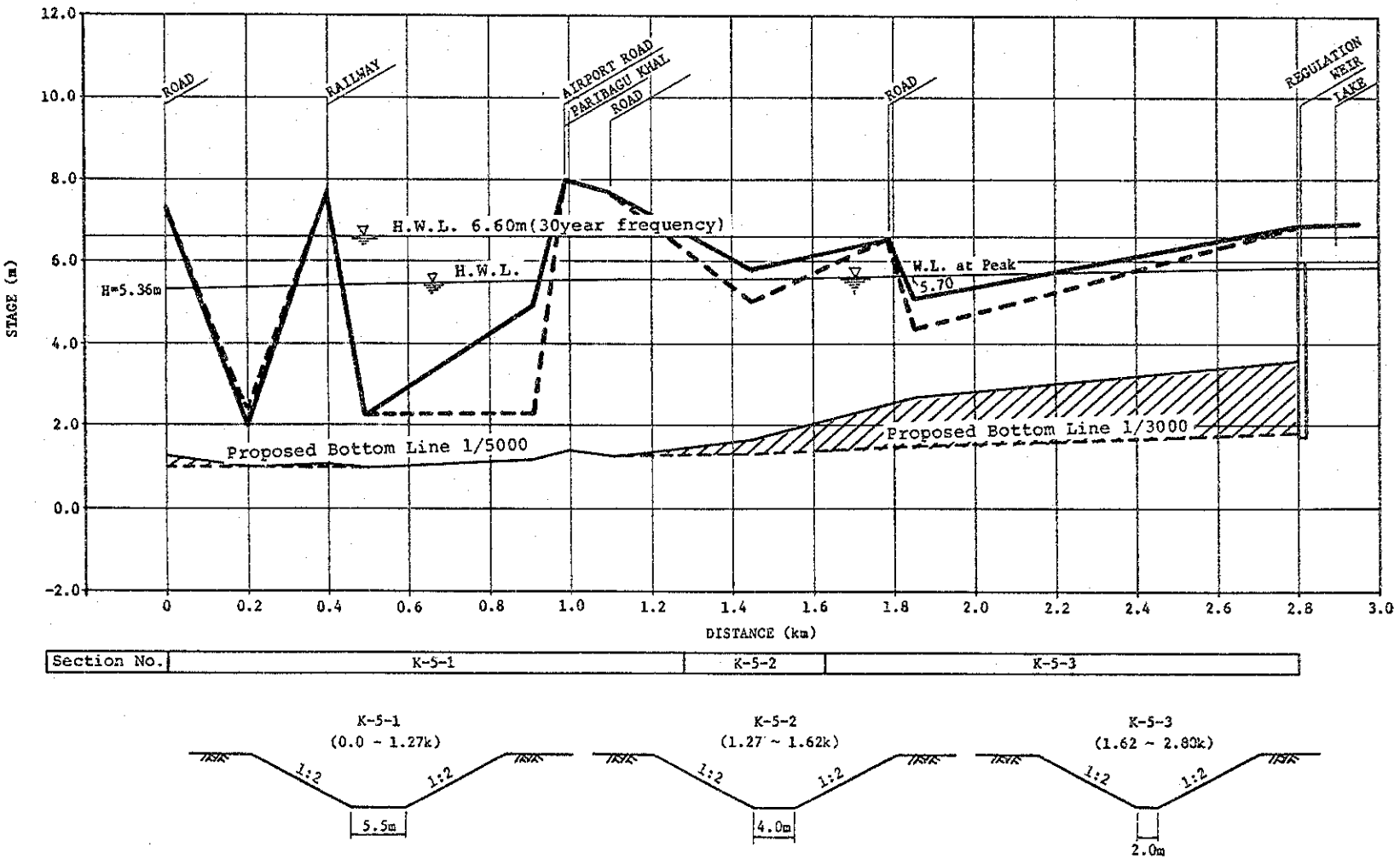

FIG. 7.8 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF BEGUNBARI KHAL

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

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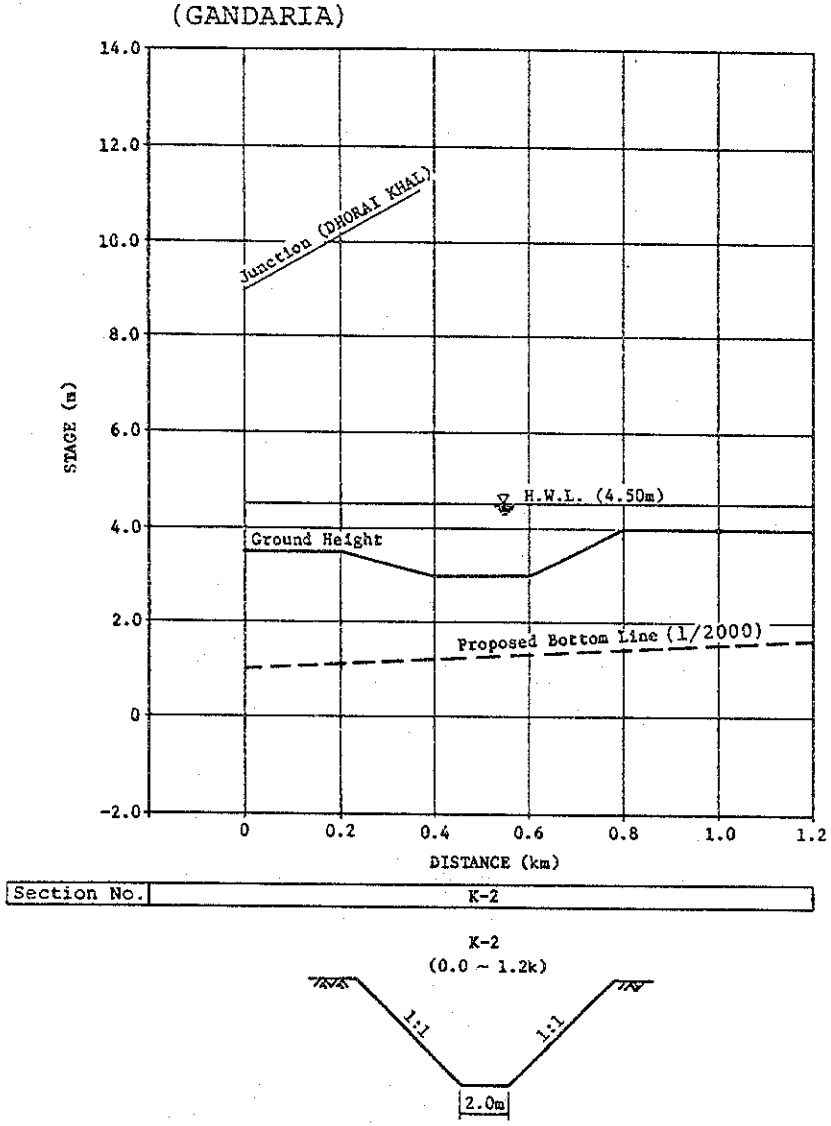

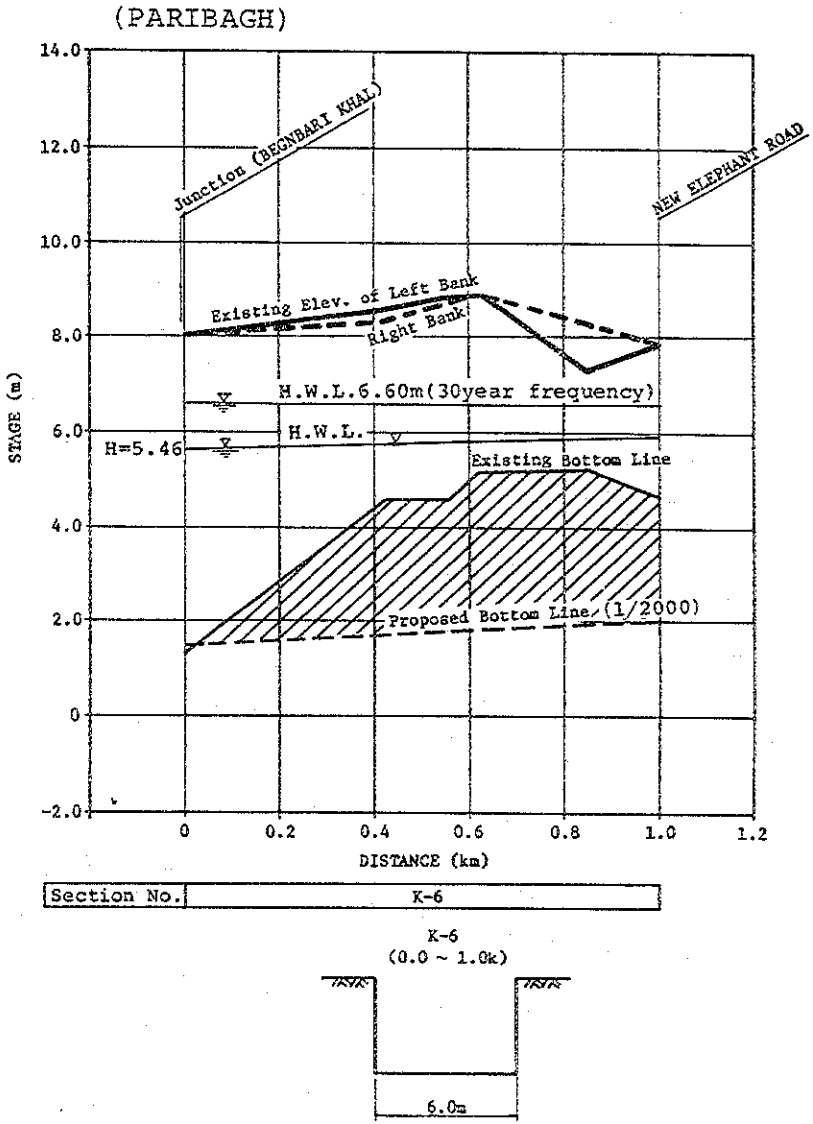

FIG. 7.9 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF PARIBAGH AND GANDARIA KHALS

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

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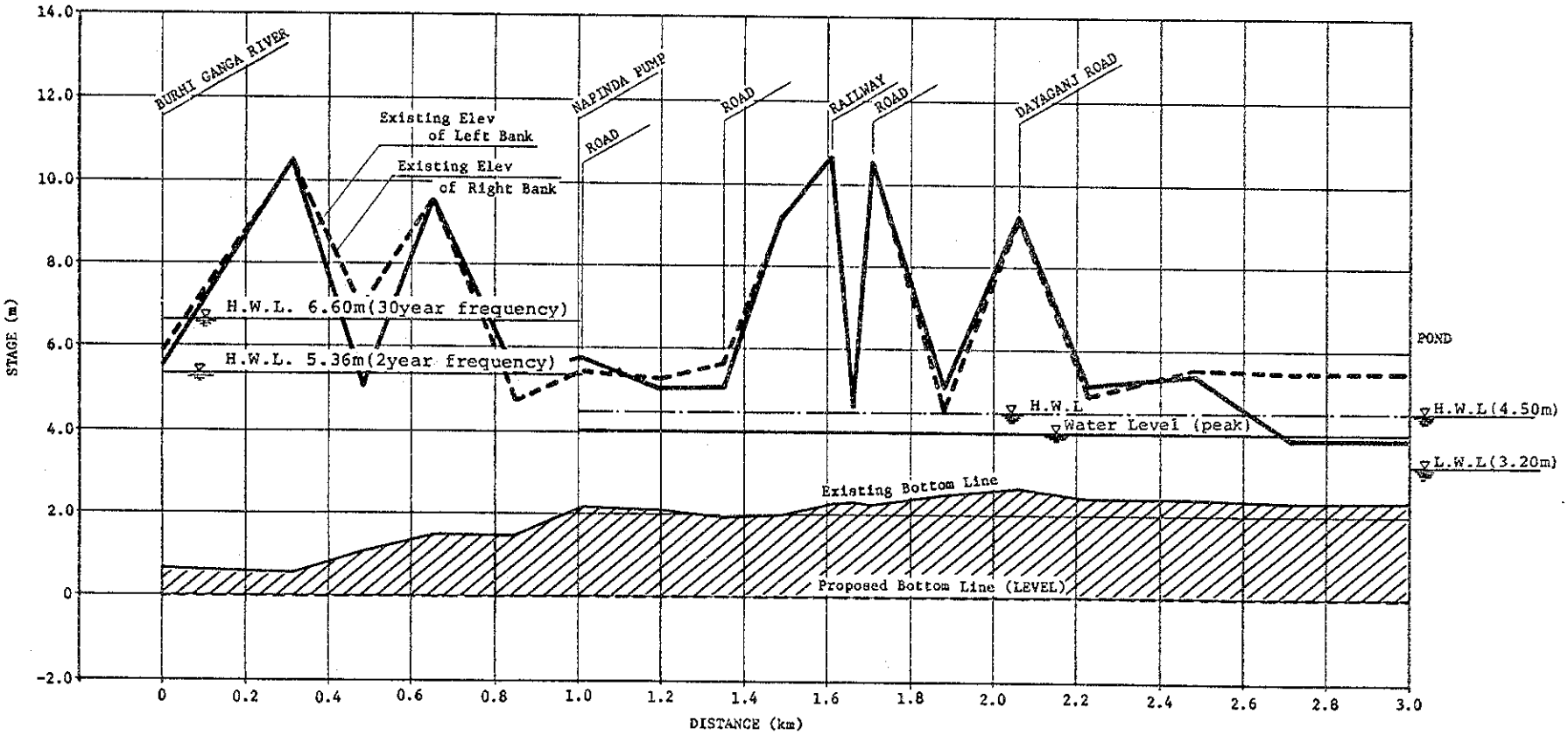

Section No.	K-1-1	K-1-2	K-1-3	K-1-4	K-1-5	K-1-6	K-1-7

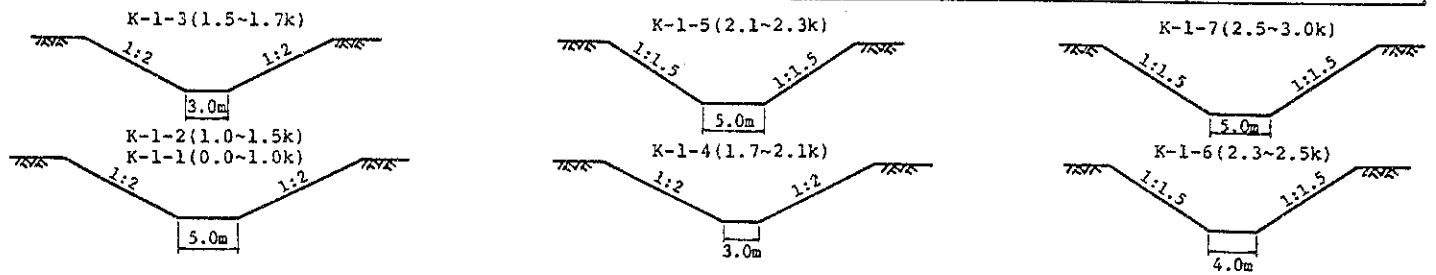

FIG. 7.10 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF DHOLAI KHAL

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

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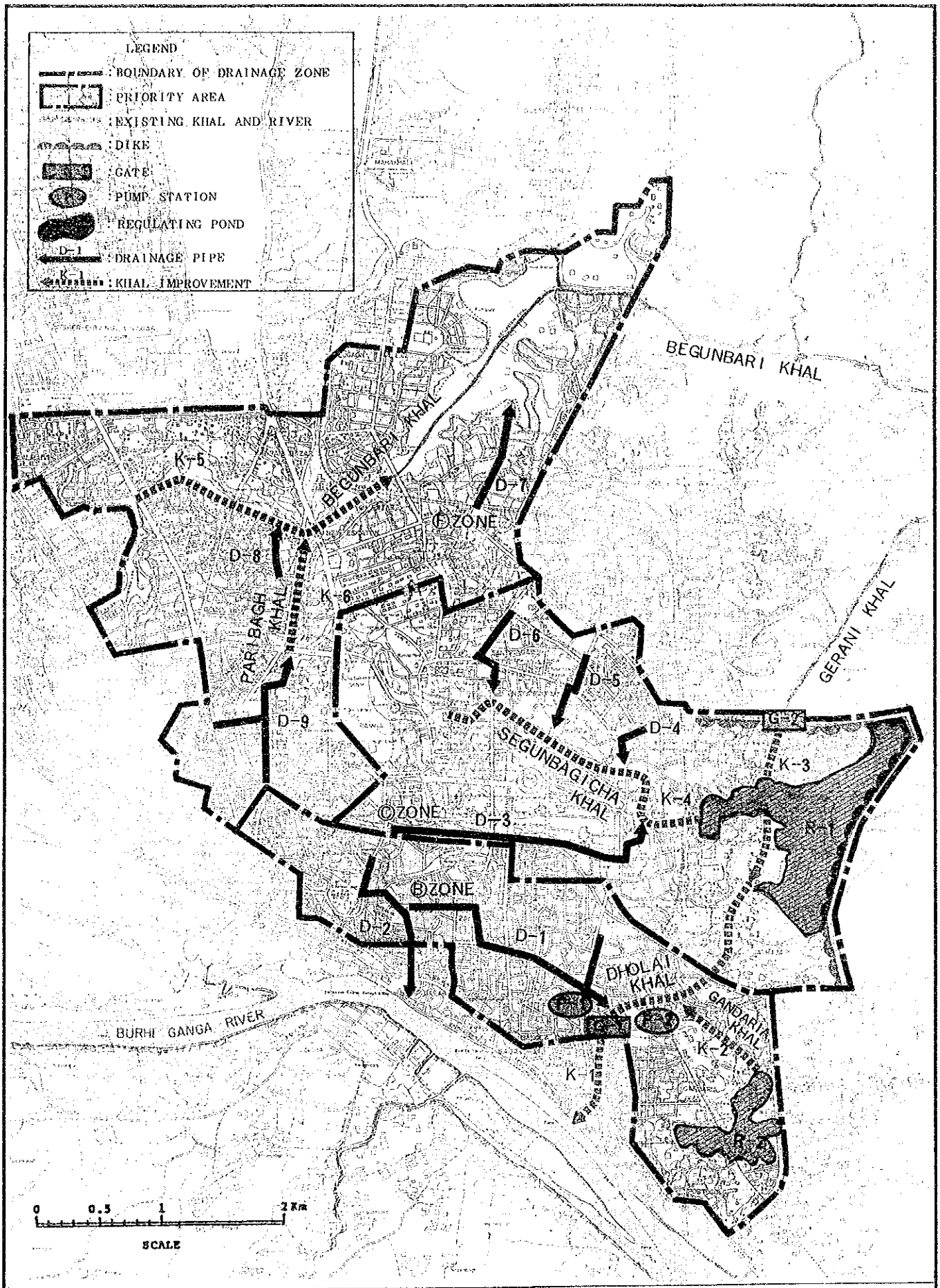

FIG. 7.11 PROPOSED FLOOD PROTECTION AND DARINAGE FACILITIES

STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH

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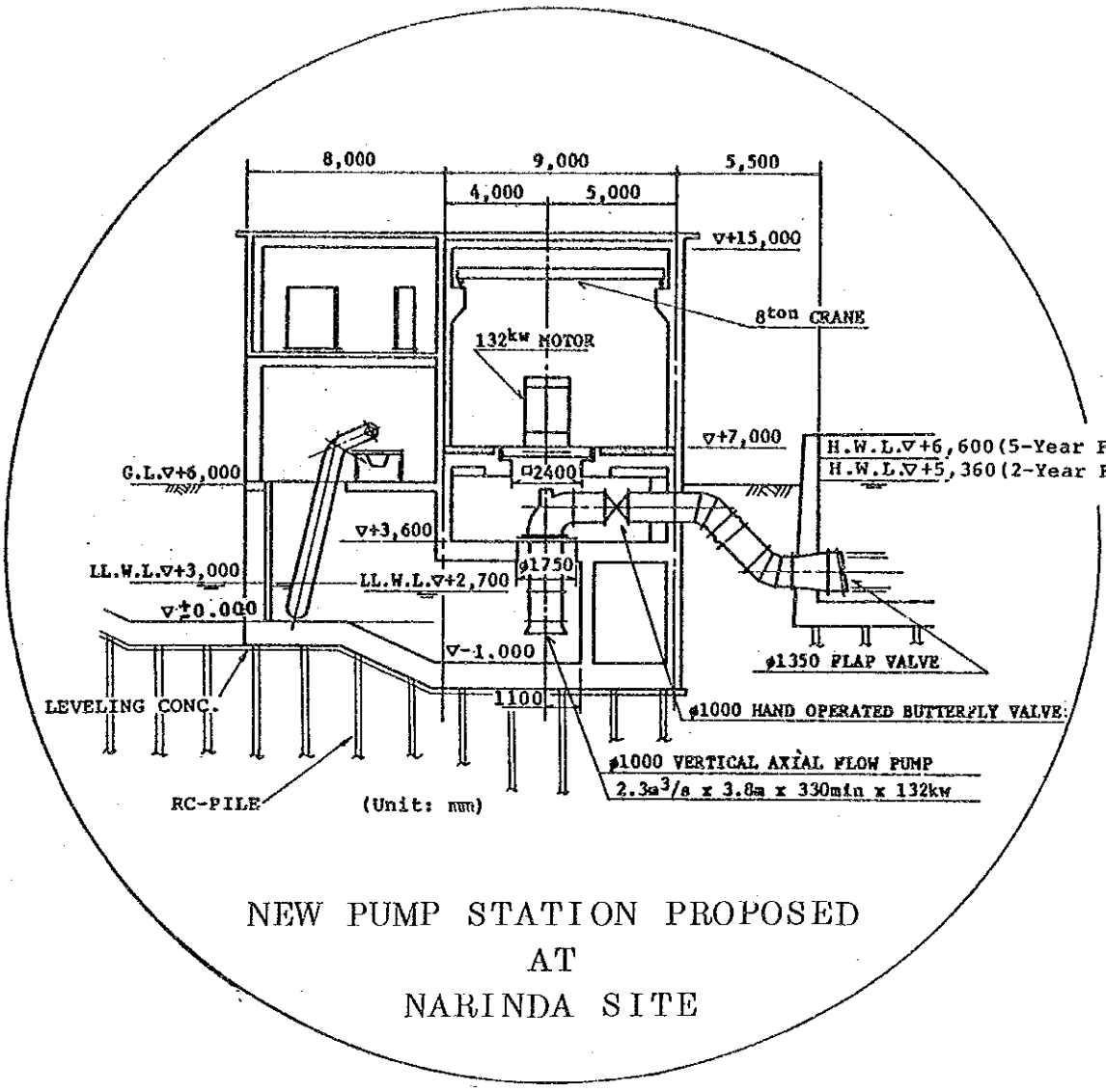

NEW PUMP STATION PROPOSED
AT
NARINDA SITE

CHAPTER 8
PRELIMINARY DESIGN OF DRAINAGE FACILITIES

CHAPTER 8. PRELIMINARY DESIGN OF DRAINAGE FACILITIES

8.1 Flood Protection Dike

The 4.8 km of flood protection dikes is proposed along the eastern and northern boundaries of the Segunbagicha Khal drainage zone (C zone). The alignment runs northward along the Deb Dholai Khal from the Dhaka-Demura Road to Manda and then turns westward until it reaches the Bangladesh Railway (See Fig. 7.11).

The area is not urbanized and either remains as a swamp or is used for rice fields.

The topography of the area is flat at an elevation of about 2.0 m G.T.S. The subsoil is assumed to be silty clay soil with 1 to 10 N-value.

The typical design of the dike is illustrated in Fig. 8.1. Side slope of 1:2 is proposed for stability of the embankment. Grassing is provided to avoid erosion of the slope.

The 6.0 m wide crown is to be paved for operation and maintenance activities, and for local traffic. Half of the dike base will be an L-shaped sand filter provided to protect the dike slope from seepage.

The embankment materials are obtained by dredging the inside areas along the dike. The borrow pits are used as channels for drainage, irrigation and other water uses (See Fig. 8.1).

8.2 Gate

Two (2) gates are proposed. One is attached to the new Narinda pump station and the other is installed at Kamulapur. During rainy seasons, the gates are fully closed for flood protection. During dry seasons, they are operated based on the water use rule of the regulating pond.