million and Tk. 1.8 million respectively to public enterprises in the area. Also, the 1987-scale and 1988-scale floods in 2010 would bring on profit losses amounting to Tk. 3.6 million and Tk. 25.3 million respectively to public enterprises in the Narayanganj West area.

### 5.2.4 Summary of Flood Damages

#### 1) Summary of Flood Damages by Type / Scale of Floods

Direct damages to properties, income / profit losses of economic units, traffic damages, direct damages to infrastructures and profit losses for public enterprises are added together by area, by type / scale of floods and by year. In doing so, 10% addition is done to the results of the above summation to rake up unaccounted-for damages. The 10% addition is explained and substantiated in Annex 2 of Supporting Report B.

The below table summarizes flood damages worked out in the above mentioned way.

(Unit : Tk. Million)

| Area | External Flood | | | Internal Flood | |
|---|---|---|---|---|---|
| | Annual | 1987-Scale | 1988-Scale | Annual | Worst |
| 1. 1990 | | | | | |
| DC - 1 | 2.8 | 89.8 | 293.5 | 1.8 | 6.7 |
| DC - 2 | 1.3 | 53.6 | 233.8 | 0.7 | 2.8 |
| DC - 3 | 21.3 | 219.6 | 1,263.4 | 66.6 | 167.0 |
| DC - 4 | 20.8 | 357.1 | 2,361.2 | 89.3 | 214.6 |
| Dhaka East | 46.2 | 720.1 | 4,151.9 | 158.4 | 391.1 |
| Narayanganj DND | 1.5 | 182.9 | 2,127.4 | 38.6 | 70.2 |
| Narayanganj West | 6.1 | 129.0 | 1,653.6 | 21.9 | 57.3 |
| Total | 53.8 | 1,032.0 | 7,932.9 | 218.9 | 518.6 |
| 2. 2010 | | | | | |
| DC - 1 | 75.8 | 1,415.9 | 3,516.7 | 10.0 | 38.5 |
| DC - 2 | 33.8 | 322.9 | 1,425.3 | 5.1 | 21.0 |
| DC - 3 | 100.0 | 863.1 | 4,746.4 | 128.9 | 345.5 |
| DC - 4 | 112.5 | 1,118.9 | 6,988.0 | 141.8 | 363.2 |
| Dhaka East | 322.1 | 3,720.8 | 16,676.4 | 285.8 | 768.2 |
| Narayanganj DND | 15.1 | 690.4 | 9,743.6 | 160.6 | 293.5 |
| Narayanganj West | 25.9 | 395.7 | 6,909.4 | 68.5 | 172.8 |
| Total | 363.1 | 4,806.9 | 33,329.4 | 514.9 | 1,234.5 |

(For more details refer to Tables B.30 and B.31.)

2) Average Annual Flood Damages

Based on the figures tabulated in the preceding section, average annual flood damages are calculated. (The methodology for the calculation of average annual flood damages is explained in 2.3.5 Estimation of Average Annual Flood Damages in Master Plan Supporting Report I). The results are shown in the below table.

(Unit : Tk. Million)

| Area | 1990 | 2010 |
|---|---|---|
| DC - 1 | 43.2 | 648.4 |
| DC - 2 | 26.4 | 176.7 |
| DC - 3 | 195.1 | 628.5 |
| DC - 4 | 293.0 | 791.3 |
| Greater Dhaka East | 557.7 | 2,244.9 |
| Narayanganj DND | 153.4 | 639.9 |
| Narayanganj West | 113.4 | 395.3 |
| Total | 824.5 | 3,280.1 |

As a specific example the calculative steps leading to the estimation of average annual flood damages for Greater Dhaka East are explained in Annex 3 of Supporting Report B.

The above-tabulated flood damages are expected in the "without" situation. In other words, the benefits of the same amount can be expected in the "with" situation. (The average annual flood damages broken down into external and internal flood damages are shown in Table 5.1).

TABLE 5.1 AVERAGE ANNUAL FLOOD DAMAGES BY AREA BY YEAR

(Unit : Tk. Million)

| Area | Average Annual Flood Damages | | |
|---|---|---|---|
| | External Flood | Internal Flood | Total |
| 1. 1990 | | | |
| Dhaka East - 1 | 40.7 | 2.5 | 43.2 |
| Dhaka East - 2 | 25.4 | 1.0 | 26.4 |
| Dhaka East - 3 | 121.0 | 74.1 | 195.1 |
| Dhaka East - 4 | 195.5 | 97.5 | 293.0 |
| Dhaka East (Sub-Total) | 382.6 | 175.1 | 557.7 |
| Narayanganj DND | 116.0 | 37.4 | 153.4 |
| Narayanganj West | 88.5 | 24.9 | 113.4 |
| Total | 587.1 | 237.4 | 824.5 |
| 2. 2010 | | | |
| Dhaka East - 1 | 634.5 | 13.9 | 648.4 |
| Dhaka East - 2 | 169.3 | 7.4 | 176.7 |
| Dhaka East - 3 | 480.4 | 148.1 | 628.5 |
| Dhaka East - 4 | 631.9 | 159.4 | 791.3 |
| Dhaka East (Sub-Total) | 1,916.1 | 328.8 | 2,244.9 |
| Narayanganj DND | 483.8 | 156.1 | 639.9 |
| Narayanganj West | 318.8 | 76.5 | 395.3 |
| Total | 2,718.7 | 561.4 | 3,280.1 |

Source : JICA

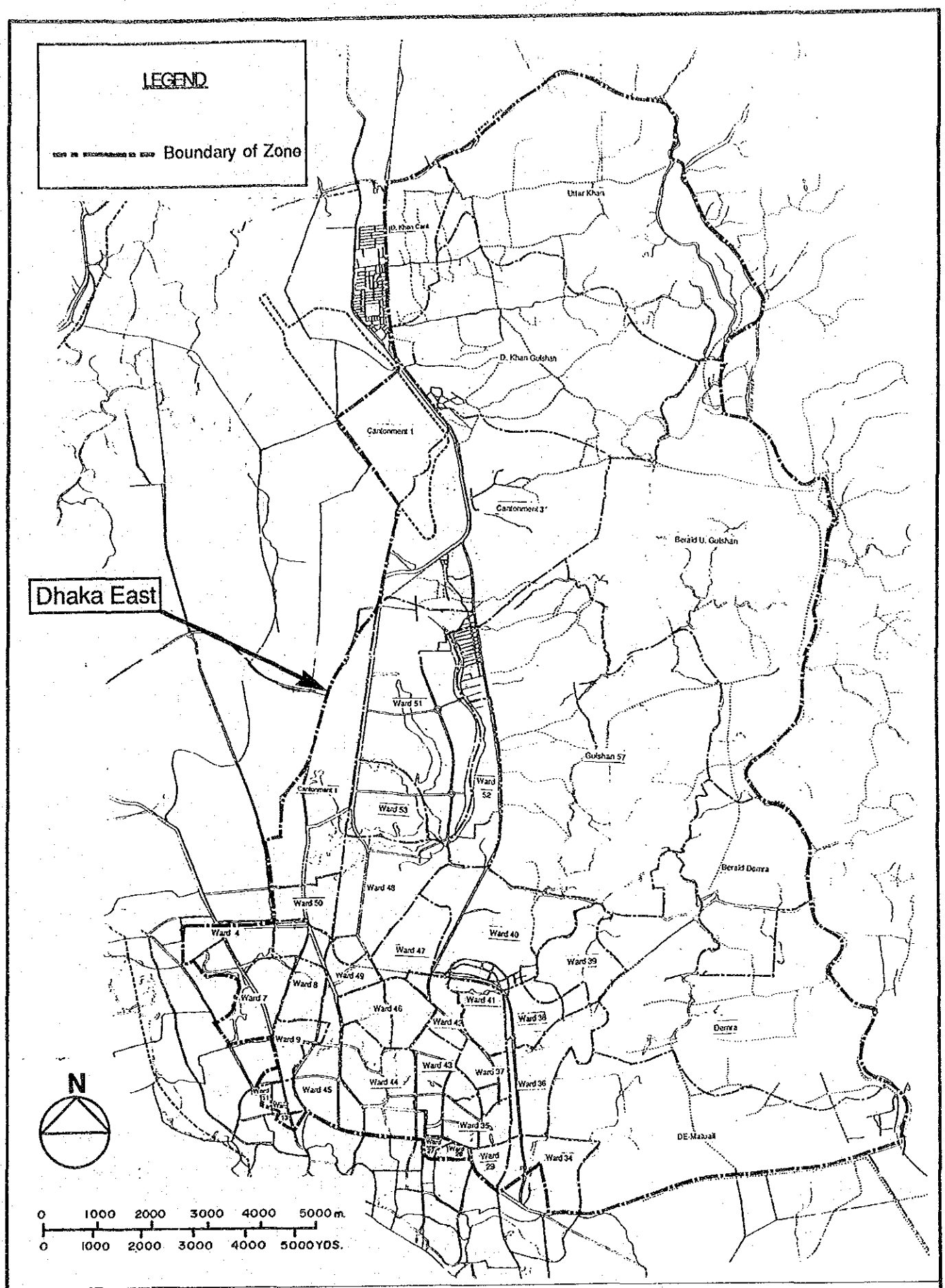


**FIG. 5.1** DIVISION OF STUDY AREA BY ZONE : DHAKA EAST/DRAINAGE RELATED AREA

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



JICA

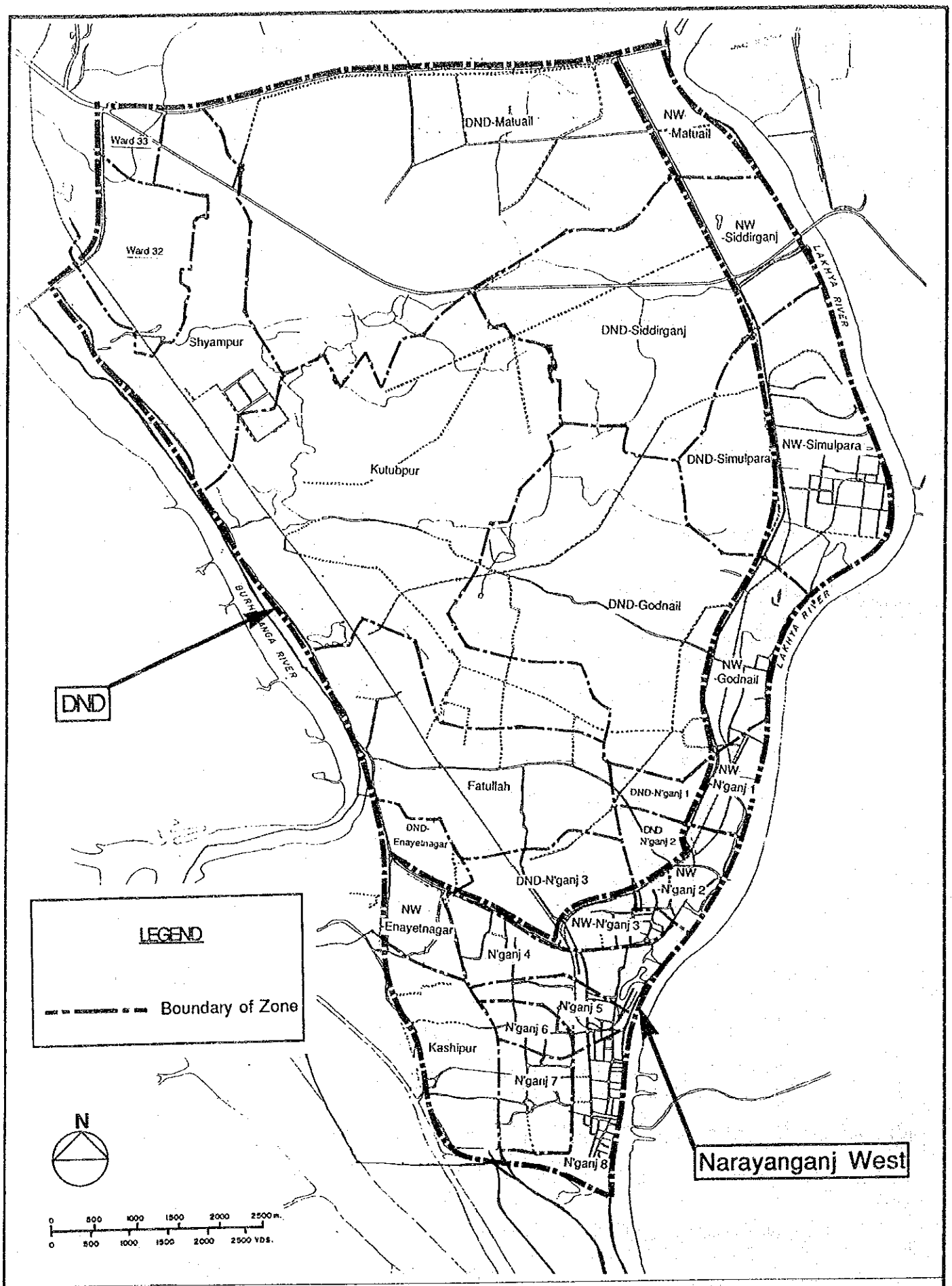


**FIG. 5.2** DIVISION OF STUDY AREA BY ZONE - DND, NARAYANGANJ WEST

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



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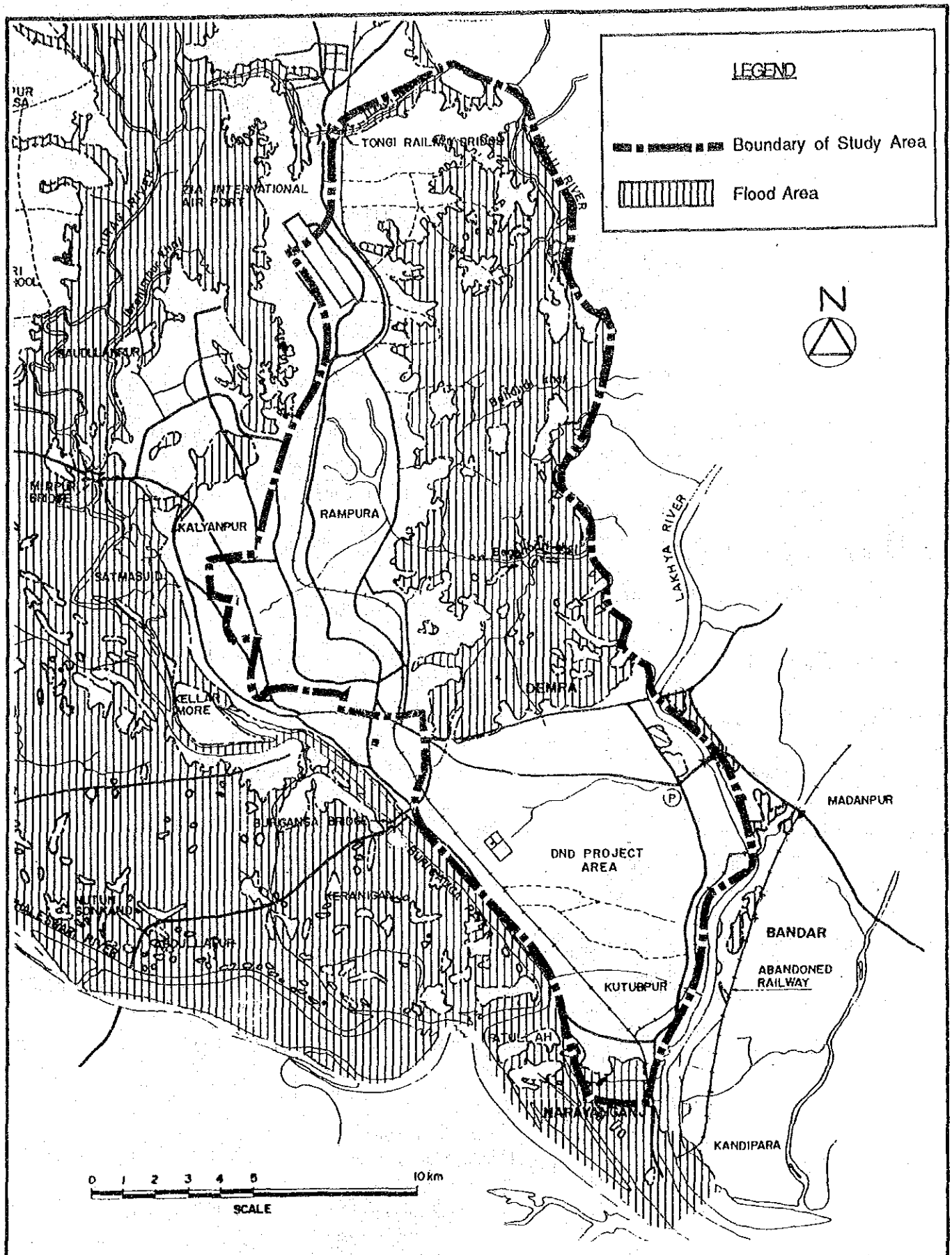


**FIG. 5.3** EXTERNAL FLOOD MAP-ANNUAL FLOOD

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



JICA

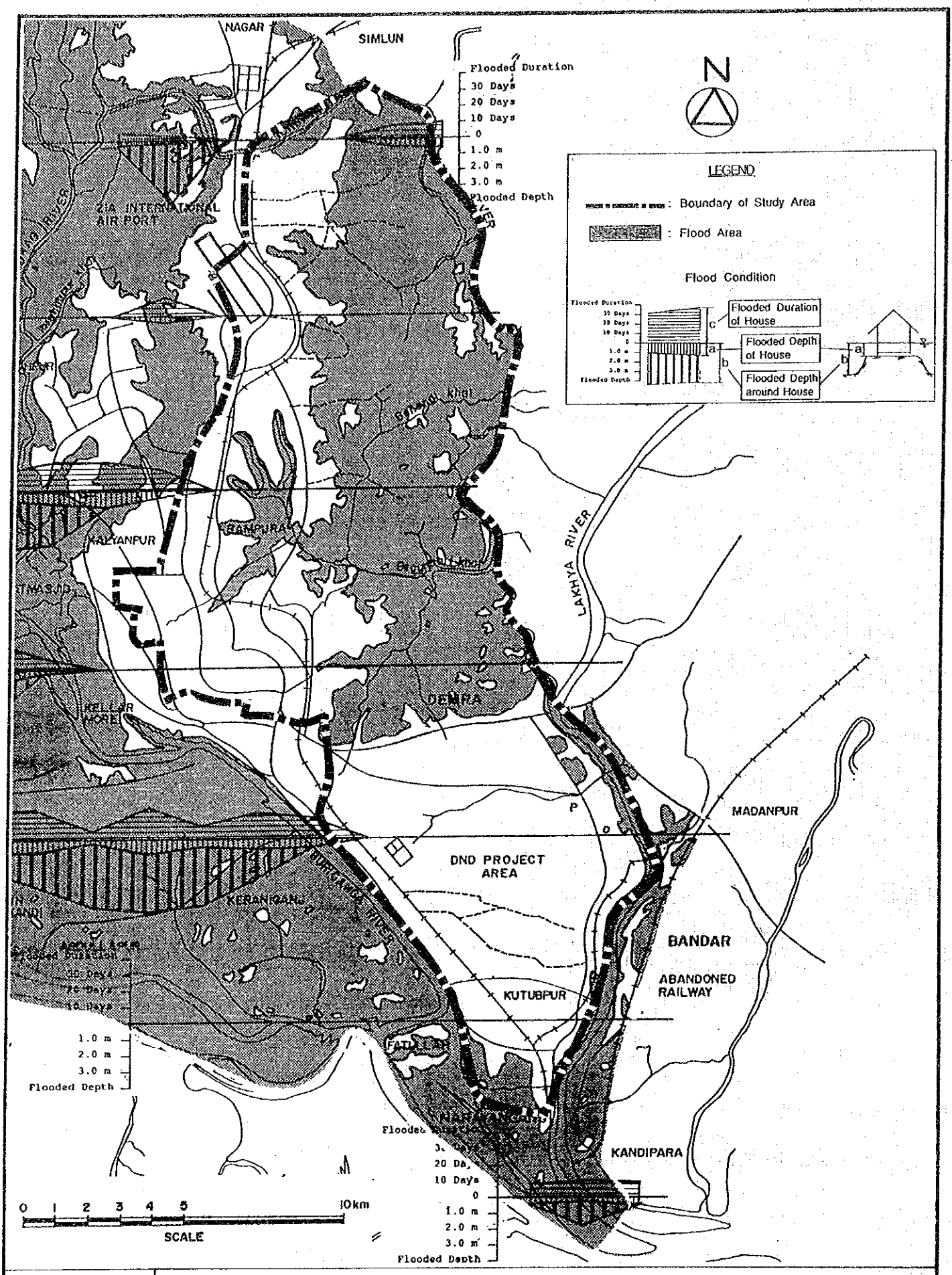


**FIG. 5.4** EXTERNAL FLOOD MAP-1987 FLOOD

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



JICA

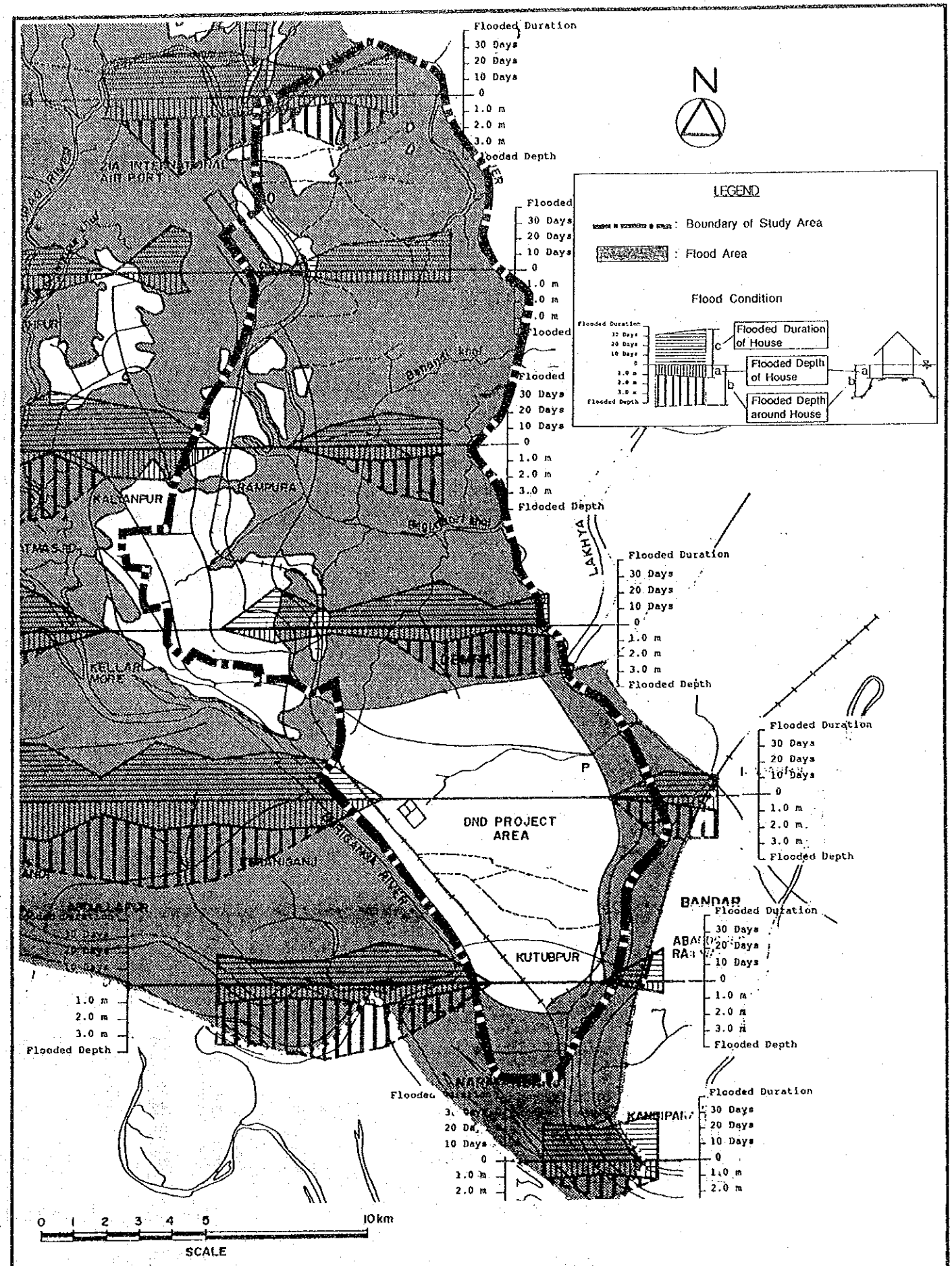


**FIG. 5.5** EXTERNAL FLOOD MAP-1988 FLOOD

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



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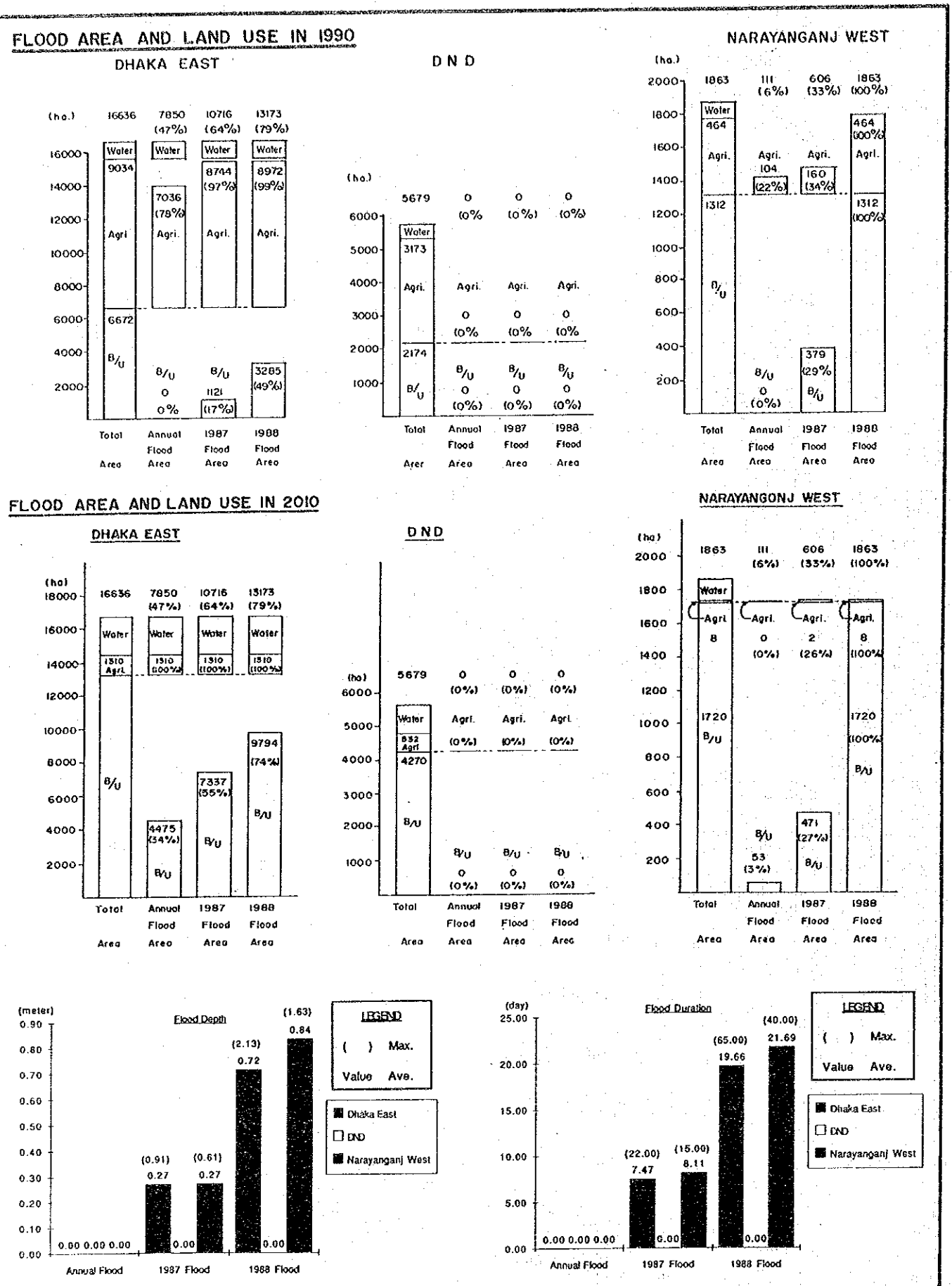



FIG. 5.6 EXTERNAL FLOOD CONDITIONS

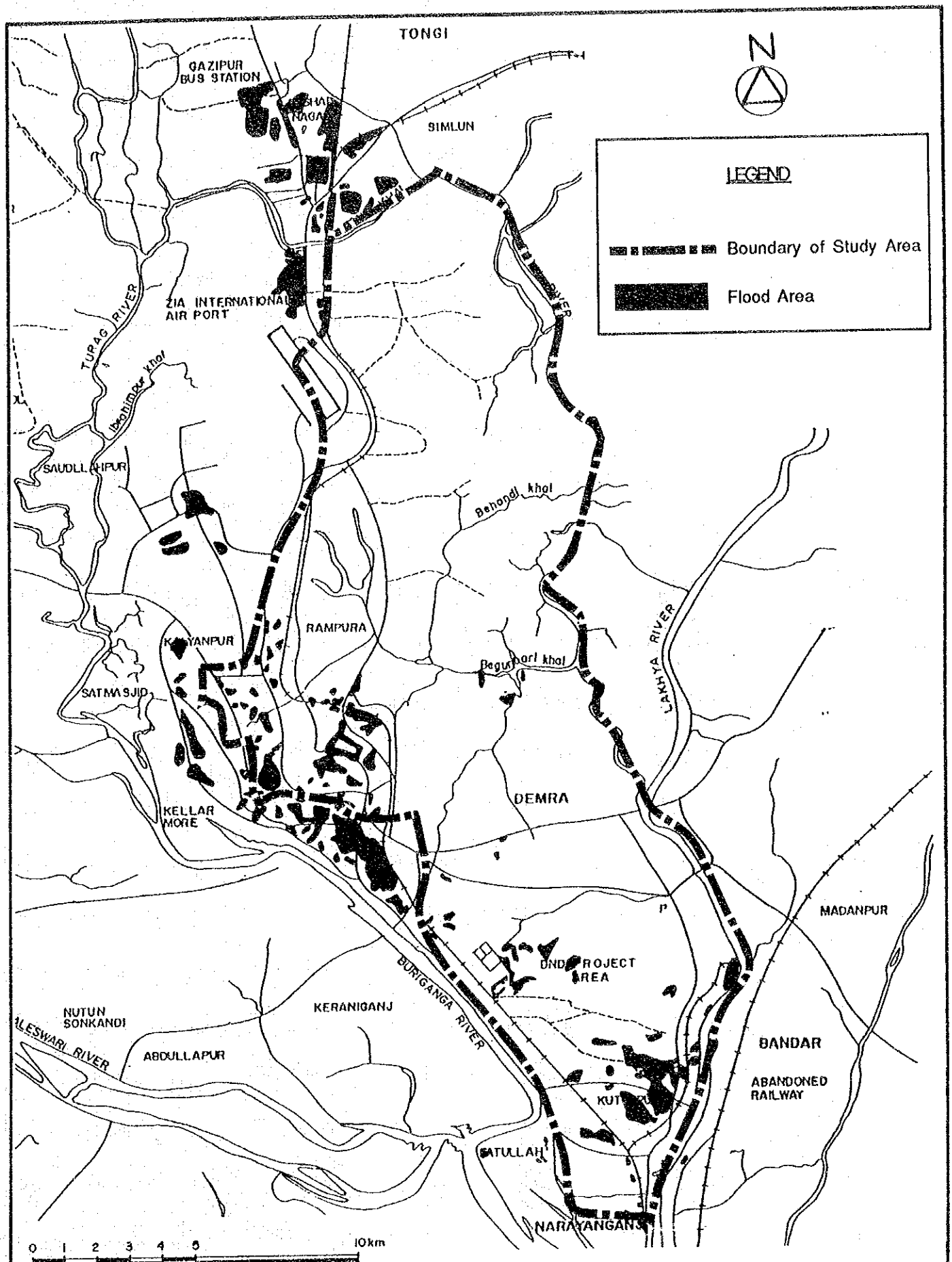
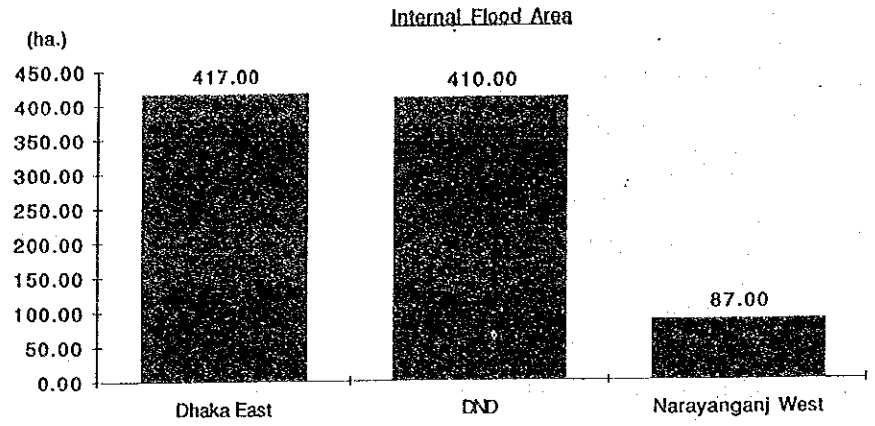


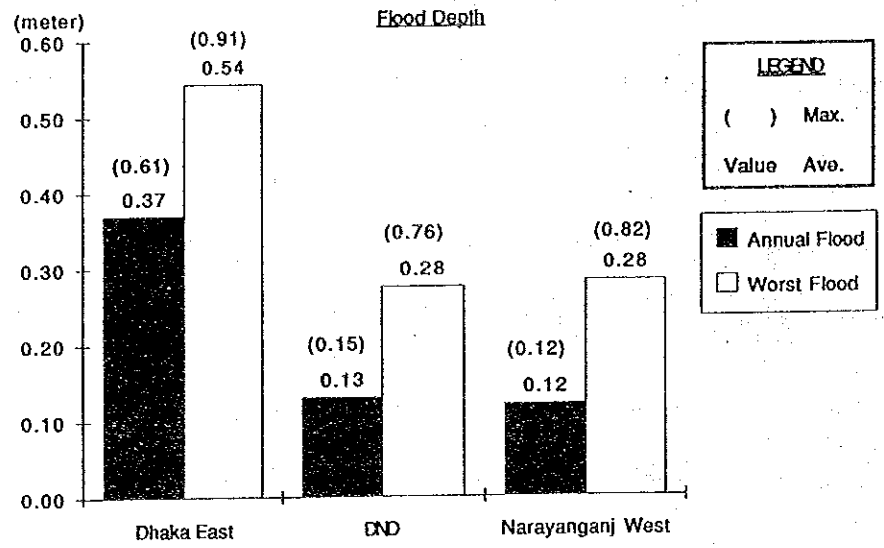

**FIG. 5.7** INTERNAL FLOOD MAP

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



JICA



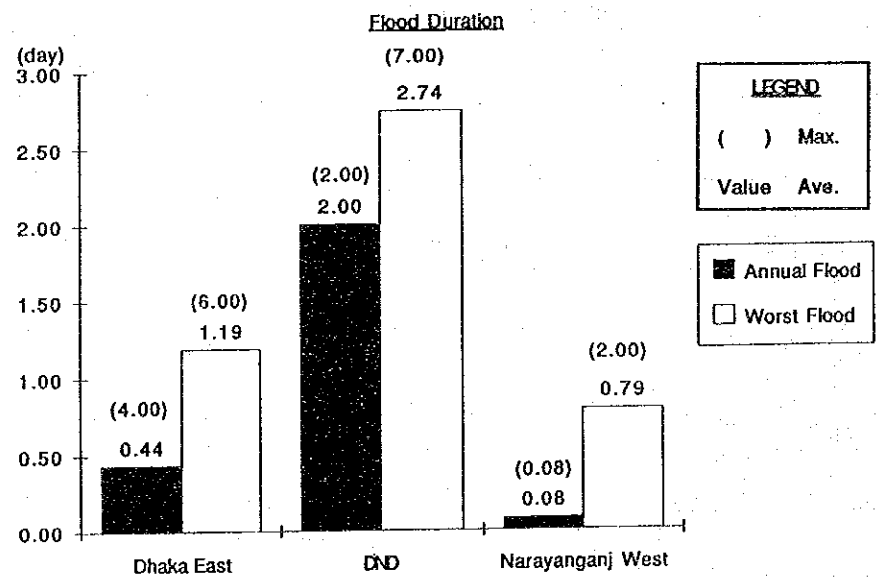




**FIG. 5.8** INTERNAL FLOOD CONDITIONS

# CHAPTER 6
# FLOOD MITIGATION AND STORMWATER DRAINAGE IMPROVEMENT FACILITIES

# Chapter 6 : Flood Mitigation and Stormwater Drainage Improvement Facilities

## 6.1 Greater Dhaka East

### 6.1.1 Flood Mitigation Plan

#### 1) Basic Concept

Landfill has continued for decades in the past and it will continue in future. It means that flood damage potential are increasing yearly, because the level of landfills is normally above the normal flood levels only, hence likely flood free from annual or normal floods. The difference between a 2-year flood stage and a 100-year flood stage is likely more than 1.43 meter, i.e. 2.02 meter at Tongi and 1.43 meter at Demra. It is necessary to protect the built-up areas by embankment against flood damages from the surrounding rivers.

(1) Design High Water Levels and Top Levels of Embankment

The high water level of a 100-year flood frequency is adopted as the design high water level. It is the same protection level with the existing embankment in the Dhaka West. The design freeboard is decided as follows :

- Embankment : 120 cm
- Sub-embankment : 60 cm
- Flood Wall : 60 cm

They are shown in the following table :

Design High Water Level and Design Top Level ( m PWD )

| Place (Sta. No) | Design H.W.L. | Facility | Top EL |
|---|---|---|---|
| Tongi (E. 69) | 8.60 | Embankment | 9.80 |
| Patira (E. 33+200) | 7.99 | Embankment | 9.19 |
| (E. 33+200) | | Sub-Emb. SA | 8.59 |
| | | Flood Wall. R | 8.59 |
| Nigur Aplaid (E. 18+200) | 7.73 | Embankment | 8.93 |
| | | Sub-Emb. SB | 8.33 |
| | | Flood Wall. R | 8.33 |
| Outlet of Begunbari | 7.60 | Embankment | 8.80 |
| Khal (E. 11+150) | | Sub-Emb. SC | 8.20 |
| | | Flood Wall R | 8.20 |
| Demra (E. 0) | 7.40 | Embankment | 8.60 |

(2) Alignments of Embankment and Sub-embankment

The alignment of embankment along the Balu River is decided to follow the proposed alignment by the GOB in the Phase II program of the Greater Dhaka Flood Control Committee. Though alternative alignments were studied at two parts of the Nali River portion and the Begunbari khal portion, it was decided to follow the original alignment of GOB from technical and social aspects.

It is informed that about 10% of the necessary land for the embankment has already been purchased by GOB, however the land acquisition procedure for the remaining is suspended so far, because the related FAP programs are on going.

The alignment of sub-embankments for compartmentalization is basically designed along the existing roads and two of them are designed along the existing roads, but the other is designed along the Begunbari khal. The alignments at urbanized areas, are planned so as to minimize relocations.

The provision of flood mitigation measures has been proposed by FAP-8B along the existing spine road to a 50-year flood frequency overtopping level. If it is implemented on schedule, the proposed flood wall from Tongi railway bridge to Saidabad would not be necessary. The proposed alignment of embankment sub-embankments and flood wall are shown in Fig. 6.1.1.

(3) Compartmentalized Development

In the Master Plan, the Greater Dhaka East was proposed to be divided into three drainage basins of the Boalia khal (31 $km^2$), the Jamair khal (48 $km^2$) and the Begunbari khal (88 $km^2$). However in the F/S the area has been reviewed and the Begunbari khal basin is divided into two basins. The study area is planned to be divided into four drainage compartments. They are summarized as follows and shown in Fig. 6.1.1. :

| Name of compartment | Area of compartment ($km^2$) | Khal | Drainage Area ($km^2$) |
|---|---|---|---|
| 1. Northern Compt. (DC-1) | 40.69 | Boalia Khal | 30.56 |
| 2. Central Compt. (DC-2) | 32.04 | Jamair Khal | 47.88 |
| 3. Southern Compt-1 (DC-3) | 14.57 | Begunbari Khal | 46.58 |
| 4. Southern Compt-2 (DC-4) | 31.32 | Dholai Khal | 41.34 |

(4) Longitudinal Profile of Embankment

The longitudinal profile of the embankment along the Balu River is designed to be 1/23,000 based on the design high water levels at Tongi and at Demra, while those of the sub-embankments are designed level.

(5) Embankment Material

The embankment material is proposed to be obtained from near the site, from the riverside flat lowland.

According to the laboratory test results on soil samples from borrow pits along the alignment, the soil material is suitable in general for construction of a homogeneous type embankment. With the material, the required workability, shear strength and low permeability will likely be attained by a proper quality control during the construction stage.

(6) Foundation Treatment and Stage Construction for Embankment

The soil investigation results along the alignment show low N-values. A soft soil layer with N-values of less than 4 is developed close to the ground surface.

According to the relationship between the ground's bearing strength and the embankment stability by the Taylor's Stability Analysis Chart, the ground's bearing strength is partly not sufficient for the design height of embankment of which the maximum height is 8.5 m and the average height is 5.5 m. When the embankment would be built up to the design height without any foundation treatment, the embankment would likely subject to a sudden settlement or bearing failure.

However the consolidation settlement period is estimated to take approximately 10 years to obtain 80% consolidation of untreated soft bearing ground's top 5 m layer which affects the stability of the embankment.

In order to accelerate consolidation settlement, some foundation treatment method will be required even with the step embankment construction method. There are three consolidation acceleration methods. They are:

(1) Sand drain-pile method,
(2) Geotextile drain-pile method,
(3) Sand compaction pile method.

Method (1) and (2) adopt the same vertical draining method and are classified by their material types. Method (3) uses large diameter sand piles only for accelerating consolidation settlement.

For the project the foundation treatment by vertical sand drain ( ø 400 mm 2.0 x 2.0 m) or geotextile drain (100 x 8 mm, 1.25 x 1.25 m) with 2 to 3 stages construction are recommended with due consideration to existing bearing capacity and the required height of embankment.

(7) Standard Profile of Embankment

The following dimensions of the standard embankment are designed :

| | | |
|---|---|---|
| Crest width | : | 4.0 m |
| Side slope | : | 1V : 3 H |
| Berm width | : | 3.0 m for river side |
| | | 5.0 m for land side |

Revetment is designed in order to protect the embankment's toe and the slope from scouring by tractive forces due to current, flow pressure, wave action, etc. The flood water flow velocity is not so fast, about 1.0 ~ 1.5 m/s, so tractive force is not so strong. Scour is caused mainly by wind and navigation. The alignment of embankment has a distance of 20 - 30 meters to low-flow channel, so only high water revetment should be considered.

A ditch is also designed along the embankment of the land side in order to protect the foot of the embankment from local scouring by storm water flows.

The dimensions of sub-embankment are almost the same as those of the embankment, however no revetment is planned.

It would be necessary to locate drainage channels or borrow pits at a certain distance away from the embankment.

During the study, the possibility of wide embankments which would support roads, settlements, recreation areas etc. was discussed. It is recommended that optimum wide embankments be studied in the detailed design stage, after completion of the Metropolitan Development Plan Study by RAJUK, because optimum wide embankments have a close relation to land management and land use development plans along the proposed alignment of flood embankment and is beyond the basic requirement of flood protection.

(8) Standard Profile of Flood Wall

T-shaped flood wall is tentatively planned for road side by taking into account the possibility of crash loading from vehicles.

A I-shaped flood wall is also planned for housing areas.

Both types of flood walls are of reinforce concrete.

No special foundation treatment would be required for the flood wall except at some inverted T-shaped sections. The inverted T-shaped flood wall on soft foundation will require pile foundations.

(9) Sluices

Sluice gates are planned at crossing points of the existing drainage channels / khals with embankments and the proposed pump stations. Small drainage channels are combined with others in order to minimize the number of sluice gates. A sluice gate of Box Culvert Type is planned from economic and technical aspects of its lower cost for construction and easy O & M.

The flow areas of box culvert type sluice gate are decided based on the design discharges of khal improvements and the design velocity of 2.5 m/s. However the minimum flow area is assumed 1.0 $m^2$.

(10) Non-structural Measures

All necessary measures for flood mitigation and drainage improvement are planned to be carried out step by step systematically, based on optimum urban development plans. It will take some decades at least before the proposed measures can be fully implemented. Non-structural flood mitigation measures such as warning and evacuation roads may be required as an interim solution.

(2) Proposed Flood Mitigation Facilities

The proposed facilities are shown in Fig. 6.1.2. They are explained below:

(1) Embankment and Sub-Embankment

The longitudinal sections of the proposed embankment and sub-embankment are shown in Figs 6.1.3 (1) to 6.1.3 (5).

The standard cross sections of them are shown in Fig. 6.1.4.

The parts of embankment which require foundation treatment and stage construction are summarized as follows :

| | Station No. From | To | Distance (km) |
|---|---|---|---|
| - Embankment (27.52km) | E. 7 | E. 33 | 10.52 |
| | E. 42+200 | E. 59 | 6.55 |
| | E. 60 | E. 64+200 | 1.80 |
| | | Sub-Total = | 18.87 |
| - Sub-embankment (SA) (6.40km) | SA. 5+200 | SA. 8+200 | 1.20 |
| | SA. 10+200 | SA.12+200 | 0.80 |
| | | Sub-Total = | 2.00 |
| - Sub-embankment (SB) (4.71km) | SB. 0 | SB. 7+200 | 2.96 |
| - Sub-embankment (SC) (6.31km) | Sc. 5+250 | Sc. 13 | 3.56 |

(2) Revetment Works

The revetment is designed for the reaches where scoring by waves is expected. The strong wind recorded during the monsoon are mostly from the north east. Revetment works are planned to the following reaches :

St. No. E 15 to E 21 : 3.20 km
St. No. E 32 to E 39 : 3.05 km
St. No. E 44 to E 52 : 3.77 km
St. No. E 54 to E 60 : 2.80 km

Total : 12.82 km

(3) Sluice Gates

The main features of the proposed sluice gates are summarized below :

| No. | Gate No. | Name of Khal | Sta. No. | Design Discharge ($m^3/s$ | FL. of Outlet ( m ) | Remarks |
|---|---|---|---|---|---|---|
| 1. | 14 | KD-4 | E. 68+150 | 22.57 | +2.45 | - |
| 2. | 15 | KD-3 | E. 55 | 37.34 | +2.45 | - |
| 3. | 16 | Boalia Khal ( KD-1 ) | E. 43+320 | 83.18 | - 0.7 | Pump Station (P. 5) |
| 4. | 17 | Jamair Khal ( KD-5 ) | E. 28+150 | 114.61 | - 1.0 | Pump Station (P. 6) |
| 5. | 18A | Begunbari Khal ( KD-11 ) | E. 11+340 | 129.49 | - 1.3 | Pump Station (P. 7 A) |
| 6. | 18B | Dholai Khal ( KD-14 ) | E. 8+90 | 140.67 | - 1.3 | Pump Station (P. 7 B) |
| 7. | Sub- | KD-5 | SA 11+100 | 83.20 | + 0.64 | |

Note : 1) About design discharge refer Fig. 6.1.14

The proposed facilities are summarized as follows :

Proposed Flood Mitigation Facility : Dhaka East

| Compartment | Facility | Main Features |
|---|---|---|
| 1. Northern compt. (DC-1) | 1. Embankment | L= 14.00 km (E.33 + 200 ~ E.69) |
| | 2. Sub-Embankment | L= 6.40 km (SA.0 ~ SA.16) |
| | 3. Flood Wall (R) | L = 5.85 km (R.16 + 150 ~ R.22) |
| | 4. Sluice Gate | No = 4 Places (Main Emb. :3, Sub-Emb.1) |
| 2. Central Compt. (DC-2) | 1. Embankment | L= 6.00 km (E.18 + 200 ~ E.33+200) |
| | 2. Sub-Embankment | L= - |
| | 3. Flood Wall | L = 4.85 km (R.11 + 300 ~ R.16+150) |
| | 4. Sluice Gate | No = 1 Place |
| 3. Southern compt-1 (DC-3) | 1. Embankment | L= 2.97 km (E.11 + 150 ~ E.18+200) |
| | 2. Sub-Embankment | L= 4.71 km (SB.0 - SB.12) |
| | 3. Flood Wall (R) | L = 2.50 km (R.8 + 300 ~ R.11+300) |
| | 4. Sluice Gate | No = 1 Place |
| 4. Southern Compt-2 (DC-4) | 1. Embankment | L= 4.55 km (E.0 ~ E.11+150) |
| | 2. Sub-Embankment | L= 6.31 km (SC.0 ~ SC.13) |
| | 3. Flood Wall | L = 8.07 km (R.0 ~ R.8+800) |
| | 4. Sluice Gate | No = 1 Place |
| | Total | |
| (DC-1 to DC-4) | 1. Embankment | L= 27.52 km (E.0 ~ E.69) |
| | 2. Sub-Embankment | L= 17.42 km (3 Sub-Embankments) |
| | 3. Flood Wall | L = 21.27 km (R.0 ~ R.22) |
| | 4. Sluice Gate | No = 7 Places |

## 6.1.2 Stormwater Drainage Improvement Plan

### 1) Basic Concept

#### (1) Drainage Area and Its Zoning

The total drainage area of 166.36 $km^2$ covers not only the entire area of Greater Dhaka East with 118.62 $km^2$, but also a portion of Greater Dhaka West with 47.74 $km^2$. This drainage related area of Dhaka West covers most urbanized and industrialized reaches of Dhaka city.

Apart from the small areas in the north of which drain into the Tongi khal, most of the areas drain into the Balu River through the major khal systems consisting of Segunbagicha khal, Gerani khal, Begunbari khal and Jamair khal (Fig. 6.1.5).

As shown in Fig.6.1.6, the area is divided into four drainage zones of DC-1 to DC-4, and nine sub-zones considering the existing topographic conditions, khal systems, road networks and the proposed four compartments. They are listed as follows :

| Zone | Sub-zone | Area ($km^2$) | Name of Major khal |
|---|---|---|---|
| DC-1 | DC 1-A | 8.45 | |
| | DC 1-B | 22.11 | Nali River, Boalia Khal |
| | Sub-total | 30.56 | |
| DC-2 | DC 2-A | 5.71 | |
| | DC 2-B | 10.13 | Jamair Khal |
| | DC 2-C | 32.04 | |
| | Sub-Total | 47.88 | |
| DC-3 | DC 3-A | 32.01 | Begunbari Khal, Gulshan-Banani Khal |
| | DC 3-B | 14.57 | Begunbari Khal |
| | Sub-Total | 46.58 | |
| DC-4 | DC 4-A | 10.02 | Segunbagicha Khal |
| | DC 4-B | 31.32 | Gerani Khal |
| | Sub-Total | 41.34 | |
| | Total : | 166.36 | |

Note : 1) Refer Fig. 6.1.6

2) DC 2-A is drained to DC 2-C through DC 2-B

(2) Design Flood Water Level

The design flood water levels of a 2-year return period are applied for demarcation of pump or gravity drainage system of each sub-zone along the Tongi Khal and the Balu River, based on the calculation of probable flood water levels at Tongi and Demra gauging stations. They are as follows :

- DC 1-A sub-zone : 6.40 m PWD
- DC 1-B sub-zone : 6.25 m PWD
- DC 2-C sub-zone : 6.15 m PWD
- DC 3-B sub-zone : 6.05 m PWD
- DC 4-B sub-zone : 6.00 m PWD

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

The pump will be designed based on the most effective water level equivalent of the annual maximum water level on average which is equivalent about 2.3 - 2.8 return period.

(3) Design Rainfall

- For Pumping Station and Retarding Pond

  2 day consecutive rainfall with a 5-year return period is applied as the design rainfall for required pumping capacity and retarding pond volume. The design rainfall and its hourly distribution are presented in Fig.6.1.7.

- For Khal Improvement and Trunk Drain

  The rainfall intensity of a 5-year return period, is employed and rainfall runoff calculation is conducted by the rational formula for the design of trunk drain and khal improvements. A design rainfall-duration curve is made based on the point rainfall data at Dhaka station (B.M.D). For calculation of the design discharge, an areal reduction factor is considered. The applied rainfall intensity-duration curve and areal reduction curve are illustrated in Fig.6.1.8

(4) Run-off Coefficient and Run-off Ratio

The following values of run-off coefficient by land use projected for the target year 2010, 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 | 0.30 |
| Middle and Low Class Residential Area | 0.50 |
| Green Zone and Others | 0.20 |
| Water Bodies | 1.00 |

The runoff ratio (total runoff/total rainfall) of 0.80 is employed for estimating required pump capacities and retarding pond volumes.

(5) Countermeasures

A drainage plan is prepared for the Greater Dhaka East of 118.62 $km^2$. The khal improvement works proposed by DIFPP financed by ADB (Fig. 6.1.9) are excluded from it.

Since 72% of the area is expected to become a built-up area by 2010, the proposed measures are composed of pumping facilities, retarding ponds, and khal improvements.

2) Proposed Pump Drainage Plan

(1) Pump Drainage Area

According to the existing topographic conditions and the design flood water levels of a 2-year frequency flood, each drainage zone except sub-zone of 8.45 $km^2$ in the northern part of DC-1, requires a pump drainage system. A gravity drainage system is adequate only for the sub-zone of DC 1-A. The pump drainage areas are summarized as below ;

| Zone | Area ( $km^2$ ) | | |
|---|---|---|---|
| | Pump Drainage | Gravity Drainage | Total |
| DC-1 | 22.11 | 8.45 | 30.56 |
| DC-2 | 47.88 | ---- | 47.88 |
| DC-3 | 46.58 | ---- | 46.58 |
| DC-4 | 41.34 | ---- | 41.34 |
| Total : | 157.91 | 8.45 | 166.36 |

Note : 1) Refer Fig. 6.1.6

(2) Required Pump Capacities and Retarding Pond Volumes

In order to economize the total pump drainage cost by reducing the required pump capacity, each pump drainage system is proposed to be combined with retarding ponds.

Specific requirements of pump capacities and retarding pond volumes are estimated to be P = 1.14 $m^3/s/km^2$ and V = 0.120 x $10^6$ $m^3/km^2$ respectively, by utilizing storage basin model as shown in Fig. 6.1.10.

The required pump capacity and the required volume of retarding pond for each pump drainage area are summarized below ;

| Zone | Area ($km^2$) | Required Pump Capacity ($m^3/s$) | | Required Storage Volume of Retarding Pond ( x $10^6 m^3$) | |
|---|---|---|---|---|---|
| | | Specific | Total | Specific | Total |
| DC-1 | 22.11 | 1.14 | 25.6 | 0.12 | 2.65 |
| DC-2 | 47.88 | 1.14 | 54.6 | 0.12 | 5.75 |
| DC-3 | 46.58 | 1.14 | 53.1 | 0.12 | 5.59 |
| DC-4 | 41.34 | 1.14 | 47.2 | 0.12 | 4.96 |
| Total : | 157.91 | - | 180.5 | - | 18.95 |

Note : 1) Refer tables 6.1.1(1) and (2)

(3) Proposed Pumping Station and Retarding Pond

In view of the existing khal conditions and the economic efficiencies, the pumping station having the required capacity is proposed for each drainage zone at the cross point of the major khal and the proposed embankment along the Balu River.

The locations of the proposed pump stations are listed below :

| Sub-drainage Area | No. of Pump Station | St. No. of Embankment | Name of Khal |
|---|---|---|---|
| DC - 1 | P 5 | E 43 + 320 | KD-1 (Bualia Khal) |
| DC - 2 | P 6 | E 28 + 150 | KD-5 (Jamair Khal) |
| DC - 3 | P 7A | E 11 + 340 | KD-11 (Begunbari Khal) |
| DC - 4 | P 7B | E 8 + 90 | KD-14 |

The frequent flood water level with a 2-year return period is basically applied as the design outlet flood stage of the pump station, considering employment of a more efficient and economic pump drainage system. However the pump facility is designed to meet the design flood stage of a 100-year flood frequency.

The outlet L.W.L is designed to be the average monthly river stage of about 3.00m (PWD) which is usually at the beginning of June and at the end of October (Fig. 6.1.11).

The hydraulic requirements of each pump station are shown in Table 6.1.1(1). The design concept of the pump station (DC-4) with a capacity of 47.2 m3/s is shown in Figs. 6.1.12(1) to (3)

(1) Proposed Retarding Area

The proposed retarding areas are selected at low-lying areas below 3.0 m PWD with likely low potential for development and high hydraulic efficiency. They are :

DC -1 : 2 sites (RP 5-1 and RP 5-2)
DC -2 : 1 site (RP 6)
DC -3 : 1 site (RP 7-1)
DC -4 : 1 site (RP 7-2 and RP 7-3)

The locations of the proposed retarding areas are shown in Fig. 6.1.10.
The design water levels of the retarding area are set at 3.00 m PWD (L.W.L) and at 4.00 m PWD (H.W.L). The retarding areas and the storage capacities are shown in Table 6.1.1(2).

3) Khal Improvement Plan

(1) Design Discharge

Each drainage zone is divided into approximately 10 to 20 sub-drainage zones based on the existing topographic condition and shown in Fig. 6.1.13.

The design discharges for khal improvements are estimated by the rational formula according to the short duration rainfall of a 5-year flood frequency and the land use projection for 2010, forecasting 80% of the catchment area to be urbanized.

Although the use of Mike 11 NAM model for estimation of the peak run-off of each khal was studied, the rational formula was only finally used. This is in due consideration to the fact that rational formula is simple and reasonable and also the required hydrological calibration data for Mike 11 are not available for setting representative values of hydrological parameters.

However the hydraulic storage effect of the retarding area is unlikely assessed by using the rational formula. Accordingly, the design discharge of some khals located downstream of the retarding area were reviewed and modified by utilizing the hydraulic simulation results of Mike 11.

Fig. 6.1.14 shows the proposed design discharges for each drainage zone.

(2) Proposed Khal Improvement

The existing khal channels require improvement by widening and dredging in order to increase their conveyance capacities.

Two types of trapezoidal shape channels with 1:2 slope lined by sodding (Type-1) and 1:1 slope lined by brick (Type-2), are proposed for the khal improvement.

Type (1) is applied for khal sections in the existing agricultural land where land acquisition is likely easy. Type (2) is proposed for those in the existing built-up areas at where land acquisition is likely difficult (Fig. 6.1.15).

Operation and maintenance roads with minimum width of 4.0 m including its shoulder is planned along both sides of a khal.

The proposed longitudinal and cross sections of khals are shown in Figs. 6.1.16(1) to (4).

As related structures, there are bridges to be reconstructed or newly constructed at the khals crossing with road and railway.

The locations of bridges and design concepts are shown in Figs. 6.1.17 and 6.1.18 (1) to (2)

The proposed khal improvement works by drainage zone are shown in Tables 6.1.2 (1) and 6.1.2 (2) and summarized below ;

| Drainage Zone | Khal Improvement Length (km) | | Bridge Construction (Nos.) | |
|---|---|---|---|---|
| | Type (1) | Type (2) | Road Bridge | Railway Bridge |
| DC-1 | 12.70 | --- | --- | --- |
| DC-2 | 24.30 | --- | 8 | 1 |
| DC-3 | 12.10 | --- | --- | --- |
| DC-4 | 21.90 | 2.20 | 4 | --- |
| Total : | 71.00 | 2.20 | 12 | 1 |

## 6.2 DND

### 6.2.1 Flood Mitigation Plan

#### 1) Basic Concept

(1) Design High Water Levels and Top Levels of Embankment

The design high water levels corresponding to a 100-year flood frequency are adopted for the DND area. The design H.W.L. and top levels of the flood wall are shown below :

| Route/Location | | H.W.L (m P.W.D) | Top E.L. (m P.W.D) | Remarks |
|---|---|---|---|---|
| 1. Chasara to Buriganga Bridge (DW) | | | | |
| Chasara | (DW. 0) | 6.96 | 7.56 | |
| Panchabati | (DW. 6+200) | 7.20 | 7.80 | More than 100-year |
| Buriganga Bridge | (DW. 27) | 7.80 | 8.40 | |
| 2. Buriganga Bridge to Demra (DN) | | | | |
| Buriganga Bridge | (DN. 0) | 7.80 | 8.40 | |
| Jatrabari | (DN. 6) | 7.80 / 7.40 | 8.40 / 8.00 | |
| Demra | (DN. 22) | 7.40 | 8.00 | |
| 3. Chasara to Hajiganj (DS) | | | | |
| Chasara | (DS. 0) | 6.96 | 7.56 | |
| Hajiganj | (DS. 6) | 6.96 | 7.56 | |
| 4. Hajiganj to Demra (DE) | | | | |
| Hajiganj | (DE. 0) | 6.96 | 7.56 | |
| Existing Pump Station | (DE. 18) | 7.29 | 8.49 | |
| Demra | (DE. 25) | 7.40 | 8.00 | |

(2) Rehabilitation of the Existing Embankment and Flood Wall

The flood mitigation measures for the DND area are proposed to rehabilitate the existing flood wall.

The DND area is surrounded by the flood wall and the railway-cum-embankment. The I-shape concrete flood wall was built along the road after the 1988 floods.

The design top level of the existing flood wall was designed at the level of 1988 flood water level plus 2 feet.

Accordingly, most part of the flood wall are high enough against the floods of a 50-year frequency flood in terms of flood water level.

From structural view points, most parts of the flood wall are evaluated as a temporary structure due to its strength against expected external loads by heavy vehicle. The total length of the flood wall is measured at 31.5 km in length.

The embankment of the railway from Chasara to the crossing point with the Demra road was raised for flood protection purposes. The top elevation was set about 6.8 m to 7.4 m in P.W.D. While, the 1988 flood water level at Launch Terminal of IWTA of the Lakhya river is measured about 6.6 m PWD. This elevation corresponds to about a 50-year flood frequency in terms of flood water level.

(3) Longitudinal Profile and Standard Cross-Sections

The longitudinal profile of the flood wall is planned based on the design high water levels at specific water gauging stations plus the free board of 0.6m.

There are many portions of the existing flood wall which are higher than the design top level.

The standard cross-section of the existing flood wall is a I-shaped flood wall with 10 to 12 cm thickness.

The proposed rehabilitation works consist of the following based on their structural deficiency.

1. Heightening the wall
2. Strengthening the wall at foot portion.
3. Repairing the wall at damaged portion.

New designs of the flood wall is only proposed for a section where the existing wall has been seriously damaged and also its height to be raised.

(4) Sluice Gate

One sluice gate is planned at the proposed pump station at Adamjee Nagar.

One culvert type sluice gate is proposed from technical and economic aspects.

2) Proposed Flood Mitigation Facilities

The proposed facilities are shown in Fig. 6.2.1. They are explained below :

(1) Flood Wall and Rehabilitation Works

The longitudinal sections of the flood wall are shown in Figs 6.2.2(1) to (3), and the standard cross sections of the proposed rehabilitation works are shown in Fig. 6.2.3.

(2) Sluice Gates

One culvert type sluice gate is planned at the proposed pump station at Adamjee Nagar. The main feature of the proposed sluice gate is ;

| Sluice Gate No. | Name of Khal | Sta. No. | Design Discharge ($m^3/s$) | EL. of out let (m PWD) | Remarks |
|---|---|---|---|---|---|
| 20 | K - 4 | DE. 10+300 | 143.5 | -1.4 | Pump Station ( P11 ) |

(3) Stop Log Structure

There are many openings in the existing flood wall, which are being used for private or public access to the road.

As closing structures of the openings during the floods, stop log structures are proposed. The stop logs are designed for the openings of public use.

For small openings less than 5.0 m in width or 1.0 m in height, some simple counter measures such as sand bags and timber stoppers, are proposed.

The proposed facilities are summarized as follows :

Proposed Flood Mitigation Facility ; DND Area

| Route (Total length) | Facility | Main Features |
|---|---|---|
| 1. Chasara to Buriganga Bridge (DW) (L= 10.63 km) | 1) Flood Wall Construction : | L= - |
| | 2) Rehabilitation Work : | |
| | (1) Foot Protection : | L= 3.63 km |
| | (2) Flood Wall Raising: | L= - |
| | 3) Stop Log Structure : | 14 places |
| 2. Buriganga Bridge to Demra (DN) (L= 8.58 km) | 1) Flood Wall Construction : | L= 0.58 km |
| | 2) Rehabilitation Work: | |
| | (1) Foot Protection : | L= 5.6 km |
| | (2) Flood Wall Raising: | L= 4.4 km |
| | 3) Stop Log Structure : | 17 places |
| 3. Chasara to Hajiganj (DS) (L= 2.15 km) | 1) Flood Wall Construction : | L= 1.75 km |
| 4. Hajiganj to Demra (DE) (L= 10.16 km) | 1) Flood Wall Construction : | L= 1.05 km |
| | 2) Rehabilitation Work: | |
| | (1) Foot Protection : | L= 8.40 km |
| | (2) Flood Wall Raising: | L= 3.20 km |
| | 3) Stop Log Structure : | 27 places |
| | 4) Sluice Gate : | 1 place |
| Total | 1) Flood Wall Construction : | 3.38 km |
| | 2) Rehabilitation Works : | |
| | (1) Foot Protection : | 17.60 km |
| | (2) Flood Wall Raising : | 7.60 km |
| | 3) Stop Log Structures : | 58 places |
| | 4) Sluice Gate : | 1 place |

### 6.2.2 Stormwater Drainage Improvement Plan

#### 1) Basic Concept

##### (1) Drainage Area and Its Zoning

The DND area of 56.79 km$^2$ has been developed as an agricultural development area. However, the area is rapidly changing to an urban area. The area has been protected by the surrounding road-cum-embankments with concrete flood walls from flooding of the Buriganga River, the Balu river and the Lakhya river.

The entire area is crisscrossed by irrigation and drainage channels. The storm water is conveyed to Kharder Ghoshpara by the major khal (under one drainage basin) and discharged into the Lakhya River through the Demra pumping station as shown in Fig.6.2.4.

In order to cope with the increasing run-off due to the future forecast urbanization, another pumping station which drains storm water into the Lakhya River, will be required. The area is planned to be divided into two drainage zones, the northern and the southern zones (NA-1, NA-2) as shown in Fig. 6.2.5. Their drainage areas and main khal channels are summarized as follows :

| Zone | Area (km2) | Main Khal |
|---|---|---|
| NA-1 | 25.10 | Shampur Khal |
| NA-2 | 31.69 | Pagla Khal, Fatulla Khal |
| Total : | 56.79 | |

##### (2) Design Flood Water Level

The followings design flood water levels are adopted for each drainage zone based on the probable water levels at Demra and Narayanganj gauging stations.

- NA - 1 : 5.75 m PWD
- NA - 2 : 5.65 m PWD

Hydraulic conditions for the pump equipment design are the same as that of Greater Dhaka East.

(3) Design Rainfall, Run-off Coefficient and Run-off Ratio

The same criteria as for Greater Dhaka East is applied. (Figs. 6.1.7 and 6.1.8)

(4) Countermeasures

A drainage plan is prepared for the entire DND area of 56.79 $km^2$.

The proposed measures consist of pumping stations combined with retarding areas and trunk khal improvement works.

Secondary and tertiary drains are not included in the plan.

2) Proposed Pump Drainage Plan

(1) Pump Drainage Area

The entire DND area of 56.79 $km^2$ require two pump drainage systems due to the low ground elevation than the design flood water level.

(2) Required Pump and Retarding Pond Capacity

A pump drainage system combined with retarding ponds is recommended to economize the pump drainage cost by reducing the required pump capacity.

The required pump and retarding pond capacities are estimated based on the both specific requirements, P = 1.14 $m^3/s/km^2$ and V = 0.0120 x $10^6 m^3/km^2$ respectively as shown below :

| Zone | Area ($km^2$) | Required Pump Capacity | | Required Storage Volume of Retarding Pond | |
|---|---|---|---|---|---|
| | | Specific ($m^3/s/km^2$) | Total ($m^3/s$) | Specific ($m^3/km^2$) | Total ($m^3$) |
| NA-1 | 25.10 | 1.14 | 28.6 | 0.12 | 3.01 |
| NA-2 | 31.69 | 1.14 | 36.1 | 0.12 | 3.80 |
| Total : | 56.79 | - | 64.70 | - | 6.81 |

(3) Proposed Pumping Station

In view of the continuous demand for irrigation and the economized pump drainage cost, the existing Demra pump station will be utilized in the plan. The existing pump capacity of 14.5 $m^3/s$ is less than the required pump capacity of zone NA - 1 (28.6 $m^3/s$ ).

Since it is difficult to obtain the required additional space for the expansion of pump facilities at the Demra pumping station, the pump capacity of 14.1 $m^3/s$ is to be added to the new pumping station planned in Zone NA - 2.

The locations of the proposed pump stations are listed below and shown in Fig. 6.2.6.

| Sub-zone | No. of Pump Station | St. No. of Embankment | Name Khal |
|---|---|---|---|
| NA - 1 | P 10 (Demra P.5) | DE 17 + 350 | KN - 1 |
| NA - 2 | P11 | DE 10 + 300 | KN - 4 |

Hydraulic requirements of the proposed pump stations are shown in Table 6.2.1.

(4) Proposed Retarding Area

Three retarding areas for each zone are proposed in the low lying area where is likely to have a low potential for future urbanization and will remain as an agricultural land in 2010.

The design water levels are set at 3.00 m PWD (L.W.L) and 4.00 m PWD (H.W.L).

Location and hydraulic requirements of both facilities are shown in Table 6.2.1.

3) Proposed Khal Improvement Plan

(1) Design Discharge

In order to prepare deeper khal sections, the drainage zone is divided into 38 sub-drainage zones based on the existing topographic condition and khal networks as shown in Fig. 6.2.7.

The Design discharges for improvement of khals are estimated by the rational formula under the condition of short duration rainfall of a 5-year frequency and the projected land use in 2010.

As in the case of Greater Dhaka East, the design discharges of some khals located at the downstream of the retarding area are reviewed and modified according to the results of the hydraulic simulation using Mike 11.

Fig. 6.2.8 show the estimated design discharges.

(2) Proposed Khal Improvement

The conveyance capacities of the existing khal channels are too low to meet their future requirements. Khal improvements by widening and dredging are required. The provision of a new channel to connect the existing Demra pumping station with the new pump station is necessary.

The proposed types of khal improvement are as follows :

- Type (1) : Trapezoidal shape with 1:2 slope lined by sodding
- Type (2) : Trapezoidal shape with 1:1 slope lined by brick

Type (1) is applied for the khal situated in agricultural area where land acquisition is likely easy. Type (2) is proposed for the khal located in projected built-up areas where land acquisition is likely difficult. The typical cross section of the khal improvement is the same as that of Greater Dhaka East. The proposed longitudinal and cross sections of khals are shown in Figs. 6.2.9(1) and (2).

As related structures, concrete or steel bridges and aqueduct are planned to be reconstructed or newly constructed at khal, crossing with roads, railway and irrigation channels.
The location of the related structures are shown in Fig. 6.2.10.

The proposed khal improvement works are shown in Table 6.2.3 and summarized below :

| | Open Channel (km) | | Road Bridge | | Railway Bridge | Aqueduct |
|---|---|---|---|---|---|---|
| Zone | Type (1) (1) | Type (2) (2) | Recons-truction | New Cons-truction | Recons-truction | Recons-truction |
| NA - 1 | 15.80 | 8.10 | 9 | 3 | - | 1 |
| NA - 2 | 17.90 | 9.40 | 19 | 3 | 4 | 1 |
| | Total : | 33.70 | 17.50 | 28 | 6 | 4 2 |

## 6.3 Narayanganj West

### 6.3.1 Flood Mitigation Plan

#### 1) Basic Concept

##### (1) High Water Level (H.W.L) and Design Top Level

The design high water levels corresponding to the flood stage of a 100-year flood frequency are determined based on the result of statistical analysis of water level data. The design top levels of the embankment and flood wall are calculated by adding freeboards of 1.2 m and 0.60 m respectively.

The design H.W.L and design top levels at specific points are shown below:

Design High Water Level and Design Top Level (m PWD)

| Route/Location | H.W.L (m P.W.D) | Top E.L. (m P.W.D) | Remarks |
|---|---|---|---|
| 1. Narayanganj to Panchabati (NW) | | | |
| Narayanganj (NW. 0) | 6.80 | 8.07/7.40 | Embankment/ Flood wall |
| Panchabati (NW. 29) | 7.20 | 8.40 | Embankment |
| 2. Narayanganj to Demra (NE) | | | |
| Narayanganj (NE. 0) | 6.80 | 7.40 | Flood Wall |
| Adamjee Nagar Back Levee (NE. 48) | 7.10 | 7.70/8.30 | Flood Wall/ Embankment |
| Existing Pump Sta. Back Levee (NE. 72) | 7.29 | 8.49 | Embankment |
| Demra (NE. 88) | 7.40 | 8.60/8.00 | Embankment/ Flood Wall. |

##### (2) Alignment of Embankment ( or Flood Wall )

The road-cum-embankment is planned from Panchabati to Narayanganj along Panchabati via Saiyedpur on the western part. This embankment is connected to the DND flood wall.

The alignment is planned along the existing road, as a trunk road in future.

The flood wall and embankment are planned from Narayanganj to Demra along the Lakhya river.

This alignment is planned along the river bank in order to protect the existing built up area and industrial asset as much as possible and also to minimize their relocations. (Fig. 6.3.1).

(3) Longitudinal and Standard Cross-Sections

The longitudinal profile of the Road-cum-Embankment (NW) is decided based on the design high water levels of Hariharpur and Rakabi Bazar water level Gauging stations.

The longitudinal profiles of flood wall and embankment along the Lakhya river are also decided in the same manner of that of the Western side polder. The H.W.L at Narayanganj down stream is decided based on the H.W.L. of Kalagachia and Rakabi Bazar gauging stations and that of upstream is based on Demra ganging station. The freeboards adopted are 1.2 m for embankment and 0.6 m for flood wall.

The standard cross-section of the road-cum-embankment is almost the same type with the embankment. The road-cum-embankment has a road space in addition to the berm on land side, while embankment section has only berms for the maintenance and stability of the embankment.

Two types of sheet pile type and inverted T-shaped wall type structures are proposed for the flood wall along the Lakhya river. However, some variations are to be made to particular portions according to the site conditions.

The standard cross-section of the embankment along the Lakhya river is the same type as that of Greater Dhaka East.

0.8 km of this stretch requires foundation treatment due to the poor soil foundation.

(4) Sluice Gate

Sluice gates are planned at crossing points of the existing khal channels and at the proposed pump stations.

A culvert type of sluice gate is selected from technical and economical aspects, easy maintenance and low construction cost.

(5) Stop Log Structure

For the flood wall along the Lakhya river, many land locks are required for loading and unloading at the godowns and the factories.

Stop log structures are planned as access to the road or to the river bank.

2) Proposed Flood Mitigation Features

(1) Road-Cum-Embankment, Embankment and Flood Wall

The longitudinal sections of the proposed road-cum-embankment and embankment alone are shown in Figs 6.3.2 (1) to (3). The standard cross sections of them are shown in Fig. 6.3.3

The portions of foundation treatment and stage construction are summarized as follows :

| | Station From | Station To | Distance (km) |
|---|---|---|---|
| Embankment | NE. 65 | NE. 67 | 0.40 |
| (5.70 km) | NE. 70 | NE. 71 | 0.40 |
| | | Sub-Total = | 0.80 |

(2) Revetment Works

| | | |
|---|---|---|
| St. No. NE 48-(1) R to NE 49 | : | 2.25 km |
| St. No. NE 62 A - NE 87 | : | 6.90 km |
| Total | | 9.15 km |

(3) Sluice Gates

Fourteen (14) sluice gates are planned and the main feature of them are summarized below :

| No. | Sluice Gate No. | Name | Sta. No. | Design Discharge ($m^3/s$) | EL. of outlet (m) | Remarks |
|---|---|---|---|---|---|---|
| 1. | 21 | K-18 | NE. 84+120 | 7.33 | 3.30 | |
| 2. | 22 | K-19 | NE. 77+160 | 16.72 | 0.0 | Pump Station (P12) |
| 3. | 23 | K-20 | NE. 69+100 | 20.04 | 3.0 | Pump Station (P13) |
| 4. | 24 | K-22 | NE. 49+100 | 21.90 | 2.63 | |
| 5. | 25 | K-23 | NE. 46+180 | 10.54 | 3.12 | |
| 6. | 26 | K-23 | NE. 40+170 | 10.31 | 3.11 | |
| 7. | 27 | K-25 | NE. 32 | 8.83 | 3.06 | |
| 8. | 28 | K-26 | NE. 26+150 | 9.18 | 3.04 | |
| 9. | 29 | S-1 | NE. 19 | 10.47 | 3.33 | |
| 10. | 30 | S-2 | NE. 8+50 | 6.17 | 3.00 | |
| 11. | 31 | K-27 | NE. 5+70 | 7.18 | 2.98 | |
| 12. | 32 | S-3 | NE. 5+70 | 3.89 | 3.25 | |
| 13. | 33A | K-28 | NW. 1+150 | 26.97 | 0.50 | Pump Station (NW) (P14A) |
| 14. | 33B | K-30 | NW. 14+190 | 43.15 | 0.50 | Pump Station (NW) (P14B) |

The proposed facilities are summarized as follows :

Proposed Flood Mitigation Facility : Narayanganj West

| Route Total length) | Facility | | Main Features |
|---|---|---|---|
| 1. Narayanganj to Panchabati (NW) (L = 5.64 km) | 1) Road-Cum-Embankment | : | 4.10 km (NW.8+100~ NW.29) |
| | 2) Embankment | : | 1.54 km (NW.0~NW.8 +100) |
| | 3) Sluice Gate | : | 2 places |
| 2. Narayanganj to Demra (NE) (L = 21.83 km) | 1) Flood Wall | : | 11.48 km (NE.0~NE.48, NE.55~NE.62, NE.87~NE.88) |
| | 2) Embankment | : | 10.35 km (NE.48~NE.55, NE.62~NE.87) |
| | 3) Sluice Gate | : | 12 places |
| | 4) Stop Log Structure | : | 17 places |
| Total | 1) Road-Cum-Embankment | : | 4.10 km |
| | 2) Embankment | : | 11.89 km |
| | 3) Flood Wall | : | 11.48 km |
| | 4) Sluice Gate | : | 14 places |
| | 5) Stop Log Structure | : | 17 places |

### 6.3.2 Stormwater Drainage Improvement Plan

#### 1) Basic Concept

##### (1) Drainage Area and Zones

The area covering 18.63 $km^2$ consists of a narrow strip between the Demra Narayanganj Road and the Lakhya River, and Narayanganj town area. The area is planned to be protected against external floods from the Dhaleswari River and the Lakhya River by embankment, flood wall and road-cum-embankment. The existing major khal channels are shown in Fig. 6.3.4.

As shown in Fig.6.3.5, the area is divided into small five drainage zones, NB-1 to NB-5, based on the proposed alignment of the flood protection facilities, inner drainage systems and road networks. The drainage area and the main khal of each zone are summarized below :

| Zone | Area ( $km^2$ ) | Main Khal |
|---|---|---|
| NB-1 | 2.30 | K-19 |
| NB-2 | 3.99 | K-20, 21 |
| NB-3 | 5.33 | K-23, 24 |
| NB-4 | 2.36 | Shasongaon Khal (K-25) |
| NB-5 | 4.65 | Mondal Para Khal (K-26) |
| Total : | 18.63 | |

##### (2) Design Flood Water Level

The design flood water levels are adopted for each zone based on the probable water levels at Demra, Narayanganj, Hariharpara and Kalagachia gauging stations. They are:

- NB-1 zone : 5.80 m PWD
- NB-2 zone : 5.70 m PWD
- NB-3 zone : 5.45 m PWD
- NB-4 zone : 5.50 m PWD
- NB-5 zone : 5.45 m PWD

(3) Design Rainfall, Run-off Coefficient and Run-off Ratio

The criteria is the same as that of Greater Dhaka East ( refer to Figs. 6.1.7 and 6.1.8).

(4) Countermeasures

Since 70% of the area is already built-up, the proposed measures comprise pumping facilities with retarding ponds, and khal and trunk drain improvement works.

However lateral drains and tertiary drainage pipes are not considered.

2) Proposed Pump Drainage Plan

(1) Pump Drainage Area

Four drainage zones are proposed as pump drainage areas based on the existing ground levels and the design flood water level. Pump drainage areas are summarized below :

| Zone | Area ( $km^2$ ) | | |
|---|---|---|---|
| | Pump Drainage | Gravity Drainage | Total |
| NB-1 | 1.73 | 0.57 | 2.30 |
| NB-2 | 1.92 | 2.07 | 3.99 |
| NB-3 | --- | 5.33 | 5.33 |
| NB-4 | 2.36 | --- | 2.36 |
| NB-5 | 4.65 | --- | 4.65 |
| Total : | 10.66 | 7.97 | 18.63 |

(2) Required Pump and Retarding Pond Capacity

In order to economize the total 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 x $10^6$ $m^3$ /$km^2$ respectively, by utilizing storage basin model as shown in Fig 6.3.6.

The required pump and retarding pond capacities for each zone are summarized below ;

| Zone | Area ($km^2$) | Required Pump Capacity Specific ($m^3/s/km^2$) | Required Pump Capacity Total ($m^3/s$) | Required Storage Volume of Retarding Pond Specific ( $\times 10^6 m^3/km^2$) | Required Storage Volume of Retarding Pond Total ( $\times 10^6 m^3$) |
|---|---|---|---|---|---|
| NB-1 | 1.73 | 1.14 | 2.0 | 0.12 | 0.21 |
| NB-2 | 1.92 | 1.14 | 2.2 | 0.12 | 0.23 |
| NB-4 | 2.36 | 1.14 | 2.7 | 0.12 | 0.28 |
| NB-5 | 4.65 | 1.14 | 5.3 | 0.12 | 0.56 |
| Total : | 10.66 | --- | 12.2 | --- | 1.28 |

(3) Proposed Pump Station

Considering the required pump capacity, one small pumping station by each zone is proposed at the crossing of the main khal and the proposed flood embankment.

Even if this area is expected to be urbanized fast, low-lying areas having an enough storage potential are proposed as retarding pond areas.

The location of the proposed pump stations are listed below :

| Sub-zone | No. of Pump Station | St. No. of Embankment | Name Khal |
|---|---|---|---|
| NB - 1 | P 11 | NE 77 + 160 | KN - 19 |
| NB - 2 | P13 | NE 69 + 100 | KN - 20 |
| NB - 3 | P 14A | NW 23 | KN - 28 (Shasongaon Khal) |
| NB - 4 | P14B | NW 14 + 190 | KN - 30 (Mondal Para Khal) |

Hydraulic requirements of the proposed pumping station are shown in Table 6.3.1(1).

(4) Proposed Retarding Area

The proposed retarding areas are :

NB - 1 : 1 site (RP 12)
NB - 2 : 1 site (RP 13
NB - 3 : 1 site (RP 14-1)
NB - 4 : 2 site (RP 14-2 and RP 14-3)

The location of the proposed retarding area are shown in Fig.6.3.6. Hydraulic requirements are shown in Table 6.3.1(2).

3) Proposed Khal and Trunk Drain Improvement Plan

(1) Design Discharge

Design discharges for khal and trunk drain improvements are estimated by the rational formula under the condition of short duration rainfall a 5-year frequency and the land use projection in 2010. Sub drainage zones and the values of run-off coefficient are shown in Fig. 6.3.7 and the design discharge of each khal is shown in Fig. 6.3.8.

(2) Proposed Khal and Trunk Drain Improvement

The conveyance capacities of the existing khal and trunk drains located in the Narayanganj town do not meet to the design discharges. Improvement of khal channels by widening and dredging, or replacement of trunk drainage channels or pipes are required.

The proposed types for khal and drainage improvement are as follows :

(i) Open Channel

- Type (1) : Trapezoidal shape with 1:2 slope lined by sodding
- Type (2) : Trapezoidal shape with 1:1 slope lined by brick

(ii) Covered Channel / or Pipe

- Type (1) : Brick pipe (Max. diameter : ø 3000)
- Type (2) : Concrete box culvert (Discharge capacity : more than $10m^3/s$)

Open channel type (1) is applied for khal sections situated in agricultural areas where comparatively easy land acquisition is expected. Open channel type (2) are proposed for khal sections located in built-up areas where land acquisition is likely to be difficult. O & M roads with a minimum width of 4.0 m is proposed along both banks of each khal. Proposed longitudinal and cross sections for KN-30 is shown in Fig. 6.3.9.

The covered channel type (1) is basically applied for trunk drains. However the type (2) is proposed for the trunk drains sections with design discharge more than $10m^3/s$. Typical sections of the trunk drain are shown in Fig. 6.3.10.

As related structures, bridges are planned at khals crossing with the road etc. The locations of proposed bridges are shown in Fig 6.3.11. The design concept of those bridges is the same as that of Greater Dhaka East.

The proposed khal improvement works are shown in Tables 6.3.2(1) and (2) and summarized below :

| Zone | Khal Improvement (km) | | Trunk Drain | | Bridge | |
|---|---|---|---|---|---|---|
| | Type (1) | Type (2) | Type (1) | Type (2) | Road | Railway |
| NB-1 | 1.20 | 0.40 | --- | --- | 1 | --- |
| NB-2 | 0.90 | 2.20 | --- | --- | | |
| NB-3 | --- | 2.60 | 0.90 | 0.50 | 2 | 1 |
| NB-4 | 1.40 | 1.40 | --- | --- | 2 | 2 |
| NB-5 | 0.80 | 4.90 | --- | --- | 6 | --- |
| Total : | 4.30 | 11.50 | 0.90 | 0.50 | 11 | 3 |

TABLE 6.1.1(1) HYDRAULIC REQUIREMENTS OF PROPOSED PUMPING STATION : GREATER DHAKA EAST

| Proposed Pumping Station | Drainage Zone | | Discharge Capacity | Design Water Level (m, PWD) | | | | | Static Head (m) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Area | | Outer | | | Inner | | | | |
| | | ($km^2$) | ($m^3/s$) | H.H.W.L | H.W.L | L.W.L | H.W.L | L.W.L | Design | Max. | |
| P 5 | DC-1 | 22.11 | 25.60 | 8.15 | 6.25 | 3.00 | 4.00 | 3.00 | 3.25 | 5.15 | |
| P 6 | DC-2 | 47.88 | 54.60 | 7.90 | 6.15 | 3.00 | 4.00 | 3.00 | 3.15 | 4.90 | |
| P 7A | DC-3 | 46.58 | 53.10 | 7.60 | 6.05 | 3.00 | 4.00 | 3.00 | 3.05 | 4.60 | |
| P 7B | DC-4 | 41.34 | 47.20 | 7.55 | 6.00 | 3.00 | 4.00 | 3.00 | 3.00 | 4.55 | |

Note : 1. H.H.W.L. and H.W.L. of outer design water level means that of 100-year and 2-year frequency flood respectively



TABLE 6.1.1(2) HYDRAULIC REQUIREMENTS OF PROPOSED RETARDING POND: GREATER DHAKA EAST

| Proposed Retarding Pond | Drainage Zone | Pond Area (ha) | Storage Capacity ($\times 10^6 m^3$) | Design Water Level (m, PWD) | | Remarks |
|---|---|---|---|---|---|---|
| | | | | H.W.L | L.W.L | |
| RP 5-1 | DC-1 | 138 | 1.38 | 4.00 | 3.00 | |
| RP 5-2 | DC-1 | 127 | 1.27 | 4.00 | 3.00 | |
| RP 6 | DC-2 | 575 | 5.75 | 4.00 | 3.00 | |
| RP 7A | DC-3 | 339 | 5.59 | 4.00 | 3.00 | |
| RP 7B-1 | DC-4 | 199 | 1.99 | 4.00 | 3.00 | |
| RP 7B-2 | DC-4 | 297 | 2.97 | 4.00 | 3.00 | |

# TABLE 6.1.2(1) PROPOSED KHAL IMPROVEMENT WORKS : GREATER DHAKA EAST

Dhaka East Zone (DC)

| Zone | Khal No. | Khal Length (km) | Required Hydraulic Section Wb x Wu x H (m x m x m) | Open Channel | | Covered Channel | | Bridge (Places) | Aqueduct (Places) | Dredging (1000m3) | Maintenance Road (km) | Land Acquisition (ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Brick Protection (km) | Sodding (km) | Box Culvert (km) | Brick Pipe (km) | | | | | |
| DC-1 | KD-1-1 | 0.50 | 20.0 34.8 3.7 | - | 0.50 | - | - | - | - | 25.10 | 0.50 | 1.88 |
| | KD-1-2 | 1.90 | 17.5 32.3 3.7 | - | 1.90 | - | - | - | - | 36.90 | 1.90 | 2.35 |
| | KD-1-3 | 2.30 | 13.0 27.8 3.7 | - | 2.30 | - | - | - | - | 65.95 | 2.30 | 7.47 |
| | KD-1-4 | 1.70 | 7.5 22.3 3.7 | - | 1.70 | - | - | - | - | 32.30 | 1.70 | 6.72 |
| | KD-1-5 | 1.00 | 2.0 16.8 3.7 | - | 1.00 | - | - | - | - | 22.90 | 1.00 | 2.93 |
| | KD-2 | 1.40 | 2.0 16.3 3.6 | - | 1.40 | - | - | - | - | 1.86 | 1.40 | 1.66 |
| | KD-3-1 | 1.30 | 5.0 21.0 4.0 | - | 1.30 | - | - | - | - | 0.00 | 1.30 | 3.88 |
| | KD-3-2 | 1.40 | 2.0 18.0 4.0 | - | 1.40 | - | - | - | - | 0.00 | 1.40 | 3.85 |
| | KD-4 | 1.20 | 2.5 10.5 4.0 | 1.20 | - | - | - | - | - | 3.86 | 1.20 | 1.63 |
| | Sub-Total | 12.70 | | 1.20 | 11.50 | 0.00 | 0.00 | 0 | 0 | 188.87 | 12.70 | 32.37 |
| DC-2 | KD-5-1 | 2.50 | 27.5 43.5 4.0 | - | 2.50 | - | - | - | - | 148.44 | 2.50 | 8.01 |
| | KD-5-2 | 0.70 | 27.5 43.5 4.0 | - | 0.70 | - | - | - | - | 49.47 | 0.70 | 3.18 |
| | KD-5-3 | 1.40 | 23.0 39.0 4.0 | - | 1.40 | - | - | - | - | 79.81 | 1.40 | 5.55 |
| | KD-5-4 | 2.00 | 21.5 37.5 4.0 | - | 2.00 | - | - | - | - | 81.70 | 2.00 | 6.80 |
| | KD-5-5 | 2.20 | 19.5 35.5 4.0 | - | 2.20 | - | - | - | - | 61.03 | 2.20 | 8.67 |
| | KD-5-6 | 1.00 | 16.0 31.7 3.9 | - | 1.00 | - | - | - | - | 32.40 | 1.00 | 4.40 |
| | KD-5-7 | 1.40 | 6.5 21.7 3.8 | - | 1.40 | - | - | - | - | 18.80 | 1.40 | 5.18 |
| | KD-6 | 1.80 | 2.0 17.4 3.9 | - | 1.80 | - | - | - | - | 13.62 | 1.80 | 3.08 |
| | KD-7-1 | 1.60 | 7.0 23.0 4.0 | - | 1.60 | - | - | - | - | 27.68 | 1.60 | 3.53 |
| | KD-7-2 | 2.20 | 6.0 21.3 3.8 | - | 2.20 | - | - | - | - | 23.40 | 2.20 | 4.54 |
| | KD-8 | 1.80 | 2.5 17.9 3.9 | - | 1.80 | - | - | - | - | 6.91 | 1.80 | 2.85 |
| | KD-9 | 1.00 | 2.0 17.7 3.9 | - | 1.00 | - | - | - | - | 1.59 | 1.00 | 1.59 |
| | KD-10-1 | 2.00 | 9.0 24.0 3.8 | - | 2.00 | - | - | 3 | - | 39.34 | 2.00 | 7.06 |
| | KD-10-2 | 2.10 | 7.0 14.2 3.6 | 2.10 | - | - | - | 5 | - | 154.25 | 2.10 | 7.29 |
| | Sub-Total | 23.70 | | 2.10 | 21.60 | 0.00 | 0.00 | 8 | 0 | 738.44 | 23.70 | 71.73 |
| DC-3 | KD-11-1 | 2.20 | 24.5 41.7 4.3 | - | 2.20 | - | - | - | - | 135.81 | 2.20 | 2.38 |
| | KD-11-2 | 2.70 | 29.0 46.2 4.3 | - | 2.70 | - | - | - | - | 155.96 | 2.70 | 5.49 |
| | KD-11-3 | 1.70 | 26.5 43.0 4.1 | - | 1.70 | - | - | - | - | 110.73 | 1.70 | 6.66 |
| | KD-12-1 | 1.20 | 2.0 17.2 3.8 | - | 1.20 | - | - | - | - | 37.82 | 1.20 | 2.97 |
| | KD-12-2 | 1.30 | 2.0 15.0 3.3 | - | 1.30 | - | - | - | - | 35.89 | 1.30 | 4.44 |
| | KD-13-1 | 1.80 | 2.0 18.6 4.2 | - | 1.80 | - | - | - | - | 14.81 | 1.80 | 2.73 |
| | KD-13-2 | 1.20 | 2.0 18.2 4.1 | - | 1.20 | - | - | - | - | 4.01 | 1.20 | 1.23 |
| | Sub-Total | 12.10 | | 0.00 | 12.10 | 0.00 | 0.00 | 0 | 0 | 495.03 | 12.10 | 25.90 |
| DC-4 | KD-14-1 | 0.50 | 24.5 41.7 4.3 | - | 0.50 | - | - | - | - | 159.04 | 0.50 | 5.60 |
| | KD-14-2 | 1.90 | 23.5 40.7 4.3 | - | 1.90 | - | - | 1 | - | 153.30 | 1.90 | 8.62 |
| | KD-14-3 | 1.00 | 18.5 35.7 4.3 | - | 1.00 | - | - | - | - | 117.04 | 1.00 | 6.41 |
| | KD-14-4 | 0.70 | 11.5 20.1 4.3 | 0.70 | - | - | - | - | - | 45.15 | 0.70 | 1.27 |
| | KD-14-5 | 1.50 | 10.0 18.4 4.2 | 1.50 | - | - | - | 1 | - | 111.59 | 1.50 | 4.32 |
| | KD-15-1 | 1.20 | 2.0 18.8 4.2 | - | 1.20 | - | - | - | - | 61.56 | 1.20 | 2.96 |
| | KD-15-2 | 1.40 | 2.0 16.5 3.6 | - | 1.40 | - | - | - | - | 86.64 | 1.40 | 5.05 |
| | KD-16 | 1.70 | 2.0 16.4 3.6 | - | 1.70 | - | - | - | - | 78.98 | 1.70 | 5.14 |
| | KD-17-1 | 0.60 | 3.0 20.0 4.3 | - | 0.60 | - | - | - | - | 6.40 | 0.60 | 0.36 |
| | KD-17-2 | 2.20 | 2.0 18.3 4.1 | - | 2.20 | - | - | 1 | - | 81.88 | 2.20 | 3.46 |
| | KD-17-3 | 2.70 | 5.0 20.4 3.8 | - | 2.70 | - | - | - | - | 117.99 | 2.70 | 4.47 |
| | KD-18-1 | 2.20 | 3.0 19.3 4.1 | - | 2.20 | - | - | - | - | 56.14 | 2.20 | 4.23 |
| | KD-18-2 | 0.90 | 2.0 16.8 3.7 | - | 0.90 | - | - | - | - | 19.80 | 0.90 | 1.87 |
| | KD-19 | 1.90 | 2.0 16.0 3.5 | - | 1.90 | - | - | - | - | 14.16 | 1.90 | 1.65 |
| | KD-20-1 | 1.10 | 3.5 20.3 4.2 | - | 1.10 | - | - | 1 | - | 47.40 | 1.10 | 3.45 |
| | KD-20-2 | 1.30 | 3.0 11.2 4.1 | 1.30 | - | - | - | - | - | 34.40 | 1.30 | 3.14 |
| | KD-20-3 | 1.30 | 3.0 11.0 4.0 | 1.30 | - | - | - | - | - | 46.24 | 1.30 | 4.53 |
| | Sub-Total | 24.10 | | 4.80 | 19.30 | 0.00 | 0.00 | 4 | 0 | 1237.71 | 24.10 | 66.53 |
| | Total | 72.60 | | 8.10 | 64.50 | 0.00 | 0.00 | 12 | 0 | 2660.05 | 72.60 | 196.53 |

TABLE 6.1.2(2) PROPOSED KHAL IMPROVEMENT RELATED WORKS (BRIDGE) : GREATER DHAKA EAST

| Zone | Khal No. | Bridge No. | Existing | | Required | Proposed | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | Type | Size (m x m) | Size (m x m) | Type | Size (m x m ) | Width | |
| DC-1 | KD-1-1 | 1 | Cantilever | 17.00 x 4.70 | 10.43 x 7.70 | - | - | - | Road bridge |
| | KD-1-5 | 2 | Girder bridge | 6.58 x 4.70 | 6.58 x 4.70 | - | - | - | " " |
| | KD-3-1 | 3 | " " | 11.50 x 6.50 | 9.10 x 5.00 | - | - | - | " " |
| | KD-4 | 4 | " " | 6.00 x 5.10 | 7.00 x 5.00 | - | - | - | " " |
| DC-2 | KD-5-8 | 5 | Deck-Rly | 6.00 x 3.60 | 9.33 x 4.80 | Deck Girder | 9.4 x 4.80 | 1.7 | Railway bridge |
| | KD-10-1 | 6 | - | - | 11.11 x 4.90 | Girder bridge | 11.2 x 4.90 | 3.66 | Road bridge |
| | " | 7 | - | - | " " | " " | " " | " | " " |
| | " | 8 | - | - | " " | " " | " " | " | " " |
| | KD-10-2 | 9 | - | - | 6.98 x 4.80 | " " | 7.00 x 4.80 | " | " " |
| | " | 10 | - | - | " " | " " | " " | " | " " |
| | " | 11 | - | - | " " | " " | " " | " | " " |
| | " | 12 | - | - | " " | " " | " " | " | " " |
| | " | 13 | - | - | " " | " " | " " | " | " " |
| DC-4 | KD-14-2 | 14 | - | - | 24.92 x 5.30 | Cantilever | 25.00 x 5.30 | 3.66 | " " |
| | KD-14-5 | 15 | Girder bridge | 11.00 x 5.30 | 9.50 5.30 | - | - | - | " " |
| | " | 16 | - | - | 9.88 5.20 | Girder bridge | 10.00 x 5.20 | 3.66 | " " |
| | KD-17-2 | 17 | - | - | 9.59 5.20 | " " | 9.60 x 5.20 | " | " " |
| | KD-20-1 | 18 | - | - | 8.17 x 5.30 | " " | 8.20 x 5.30 | " | " " |

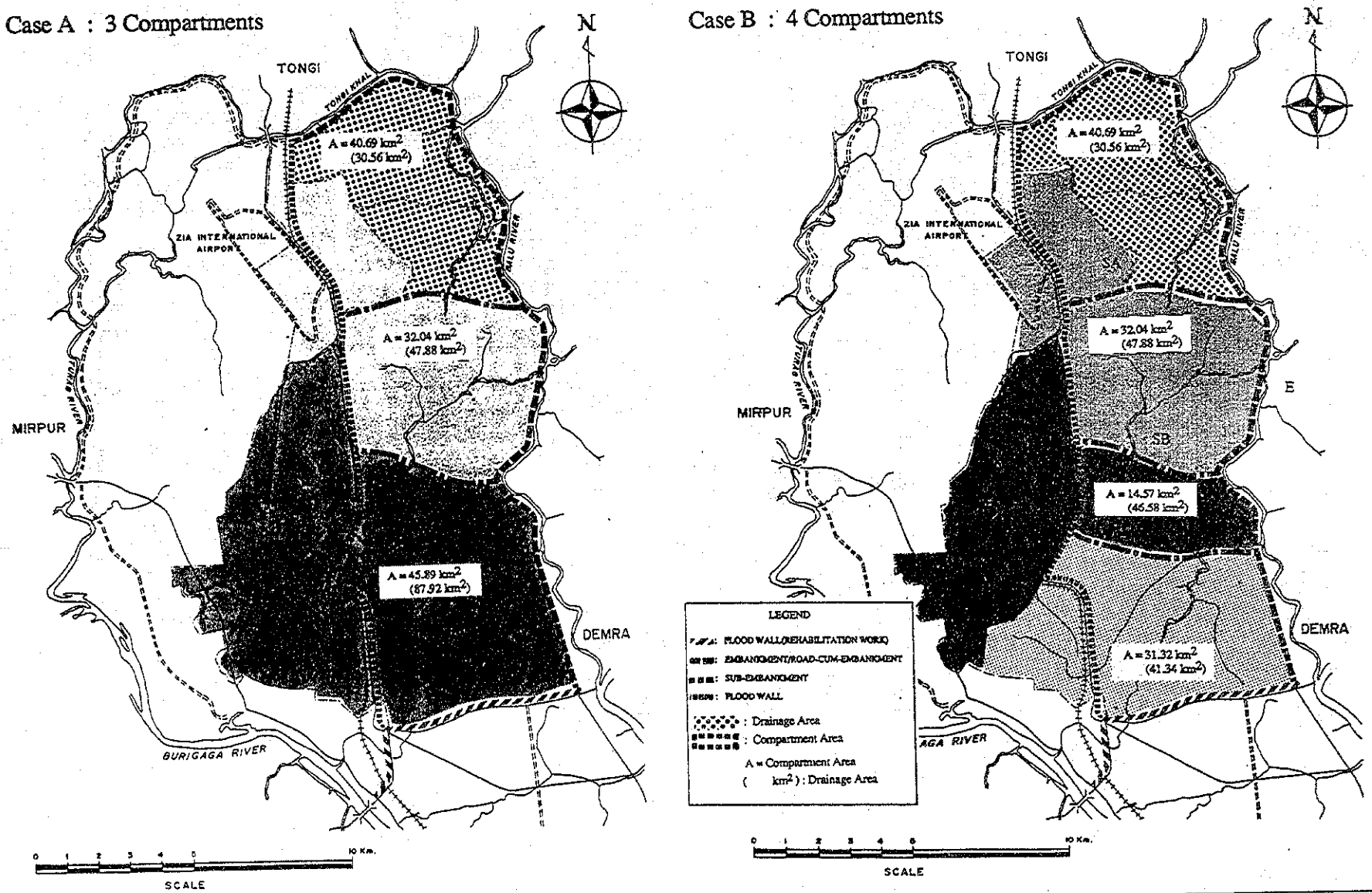



**FIG. 6.1.1** ALTERNATIVE OF COMPARTMENTALIZATION

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



JICA

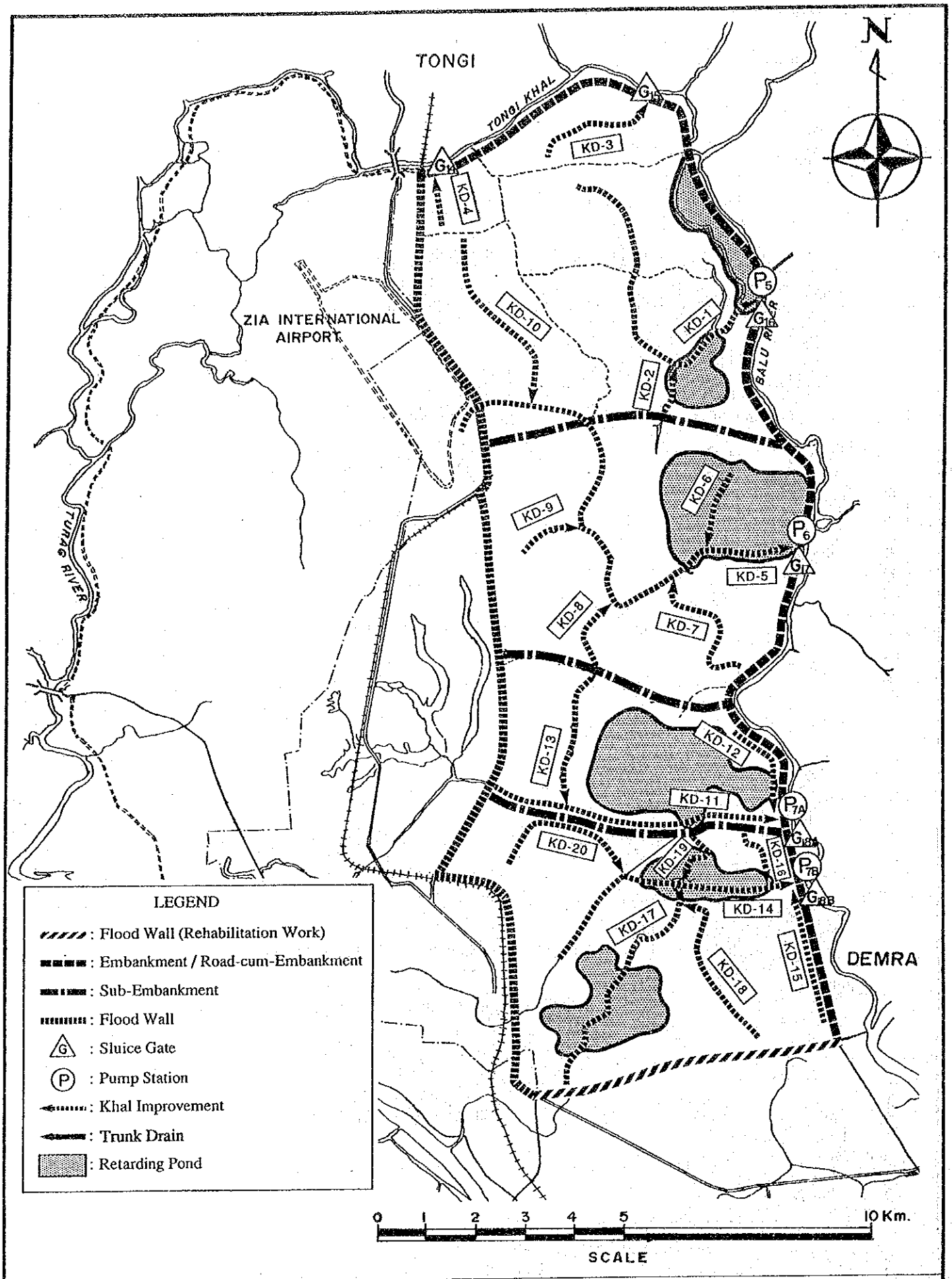



**FIG.** 6.1.2 PROPOSED FACILITIES : GREATER DHAKA EAST

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



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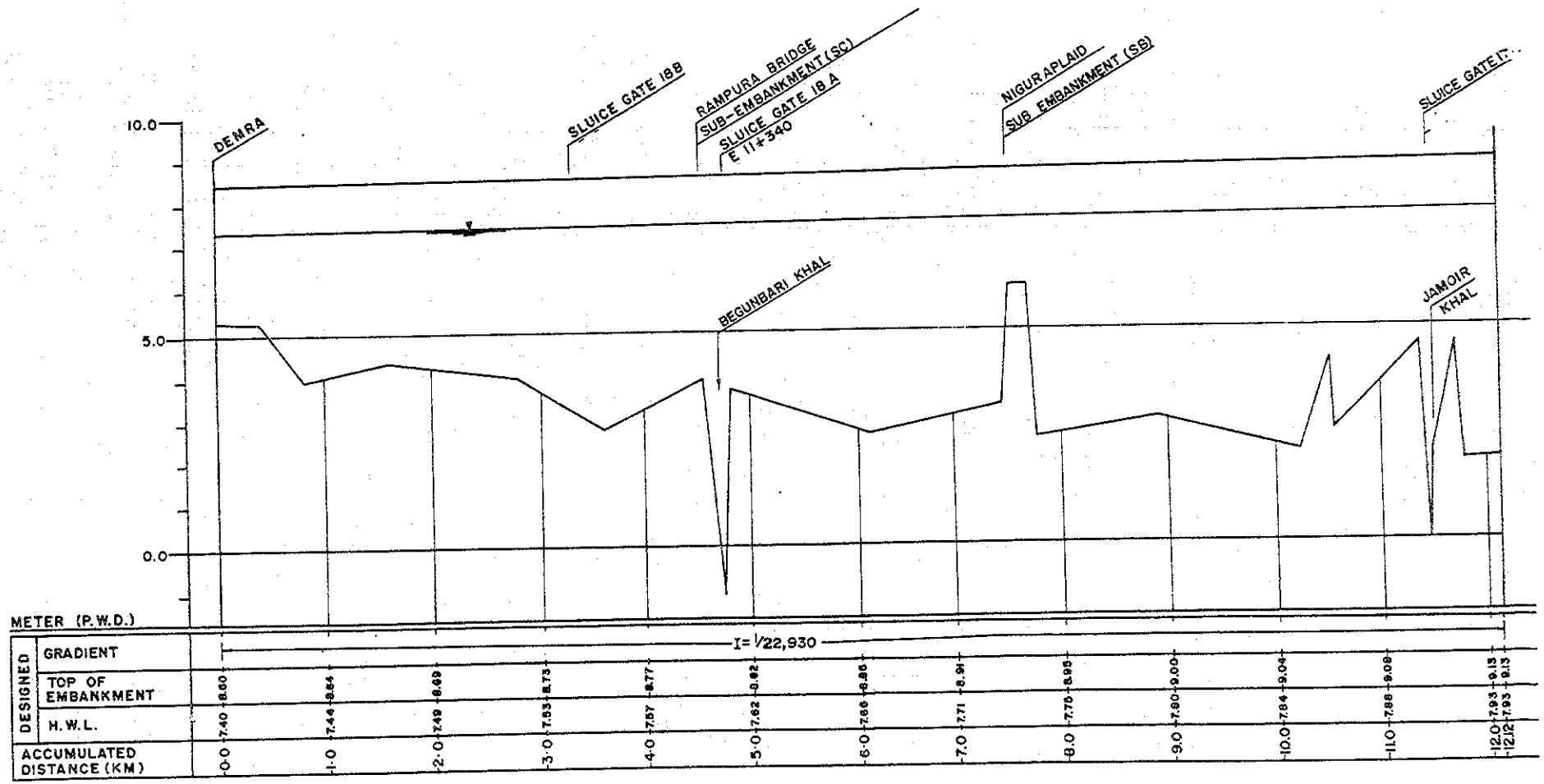


**FIG. 6.1.3(1)** LONGITUDINAL SECTION OF EMBANKMENT : DHAKA EAST ($E_1$)

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



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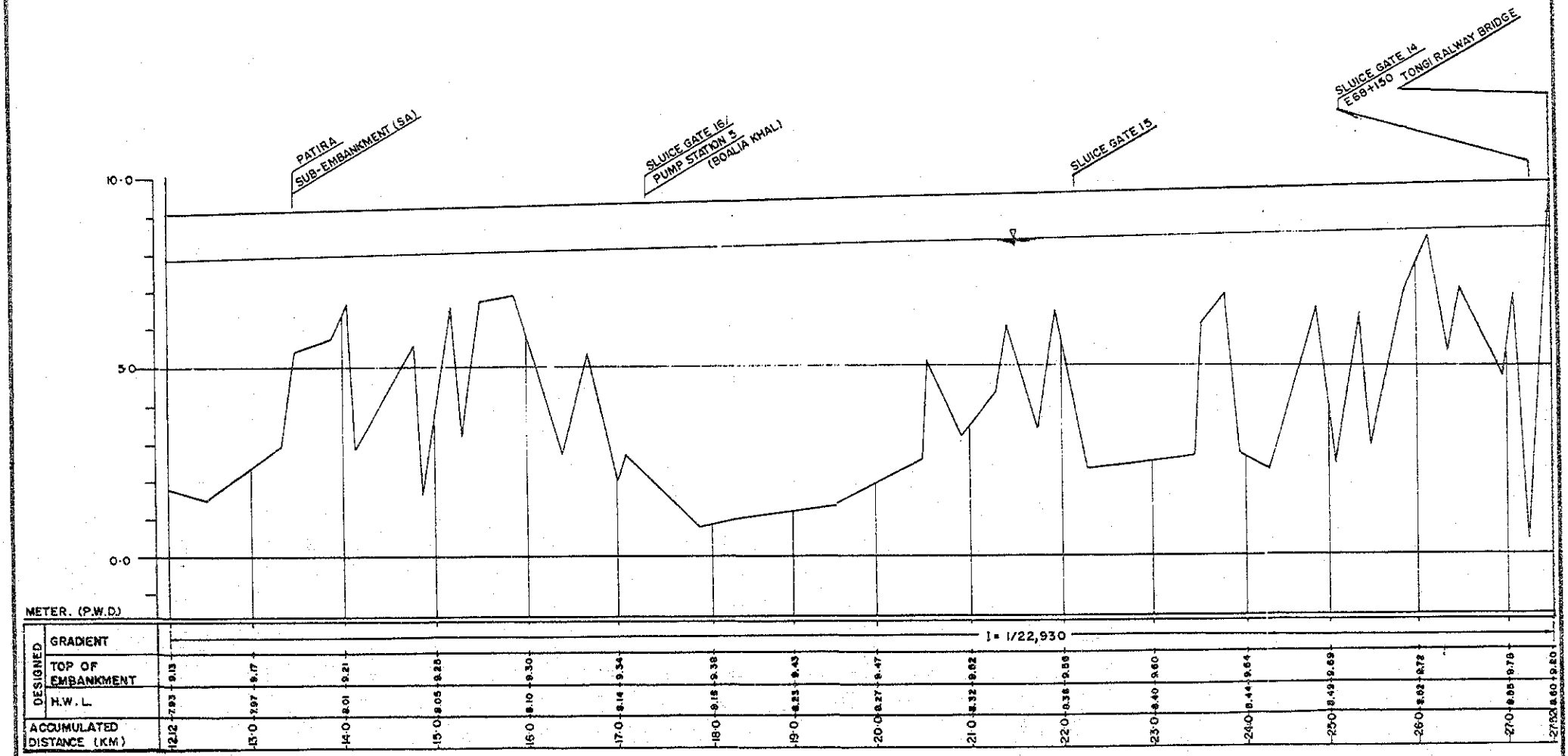


**FIG. 6.1.3(2)** LONGITUDINAL SECTION OF EMBANKMENT : DHAKA EAST ($E_2$)

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



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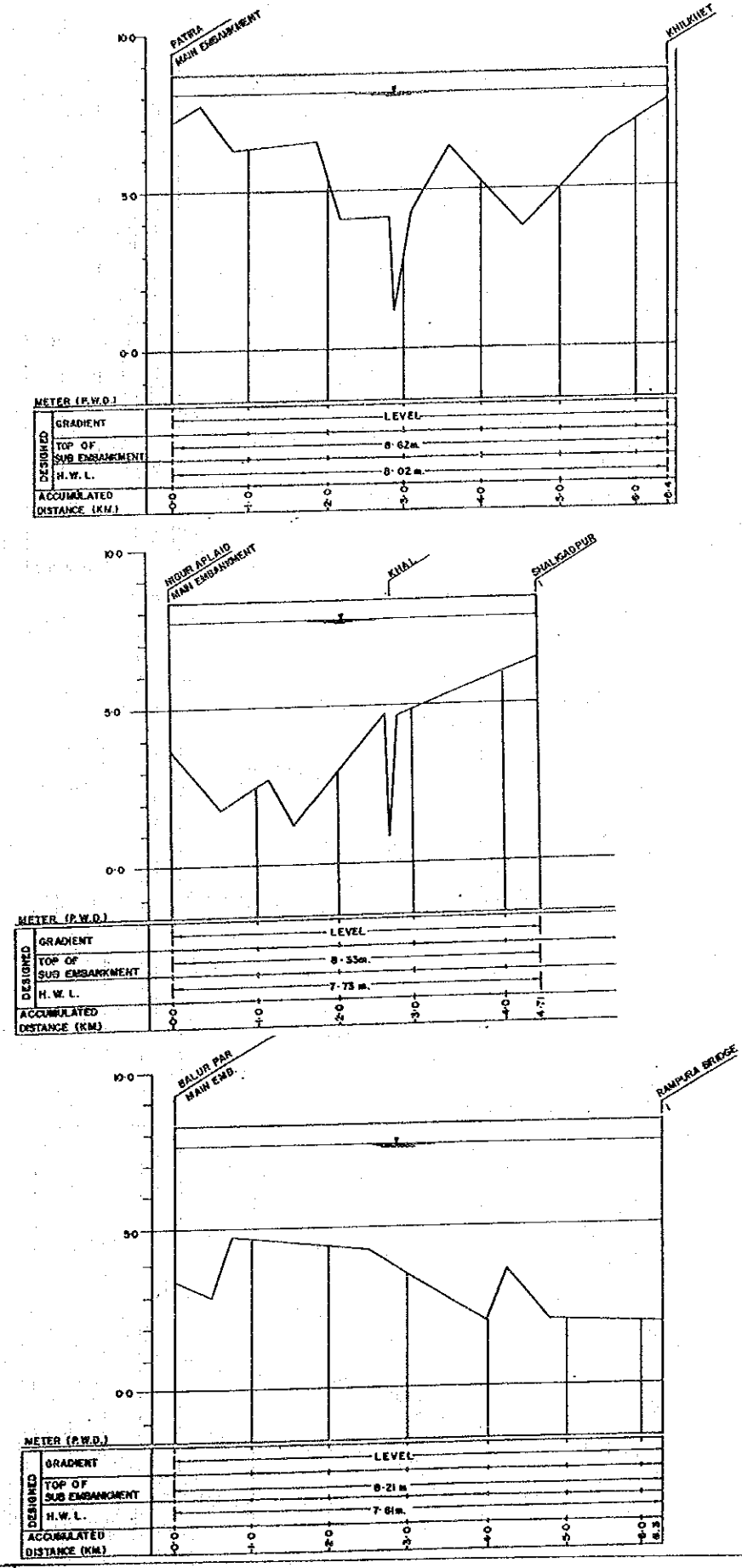



**FIG.** 6.1.3(3) LONGITUDINAL SECTION OF EMBANKMENT : DHAKA EAST (SA, SB AND SC)

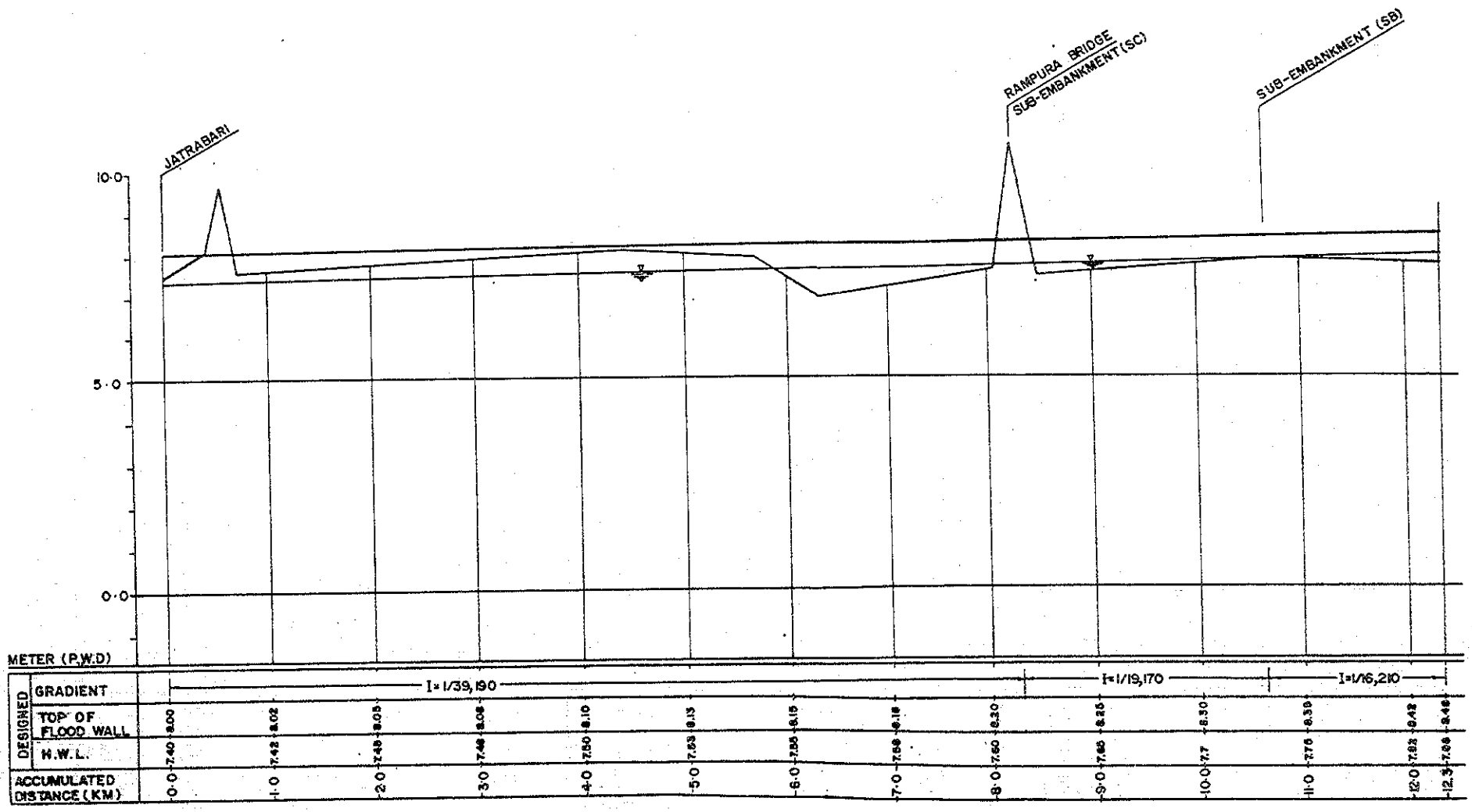



**FIG.** 6.1.3(4) LONGITUDINAL SECTION OF FLOOD WALL : DHAKA EAST ($R_1$)

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

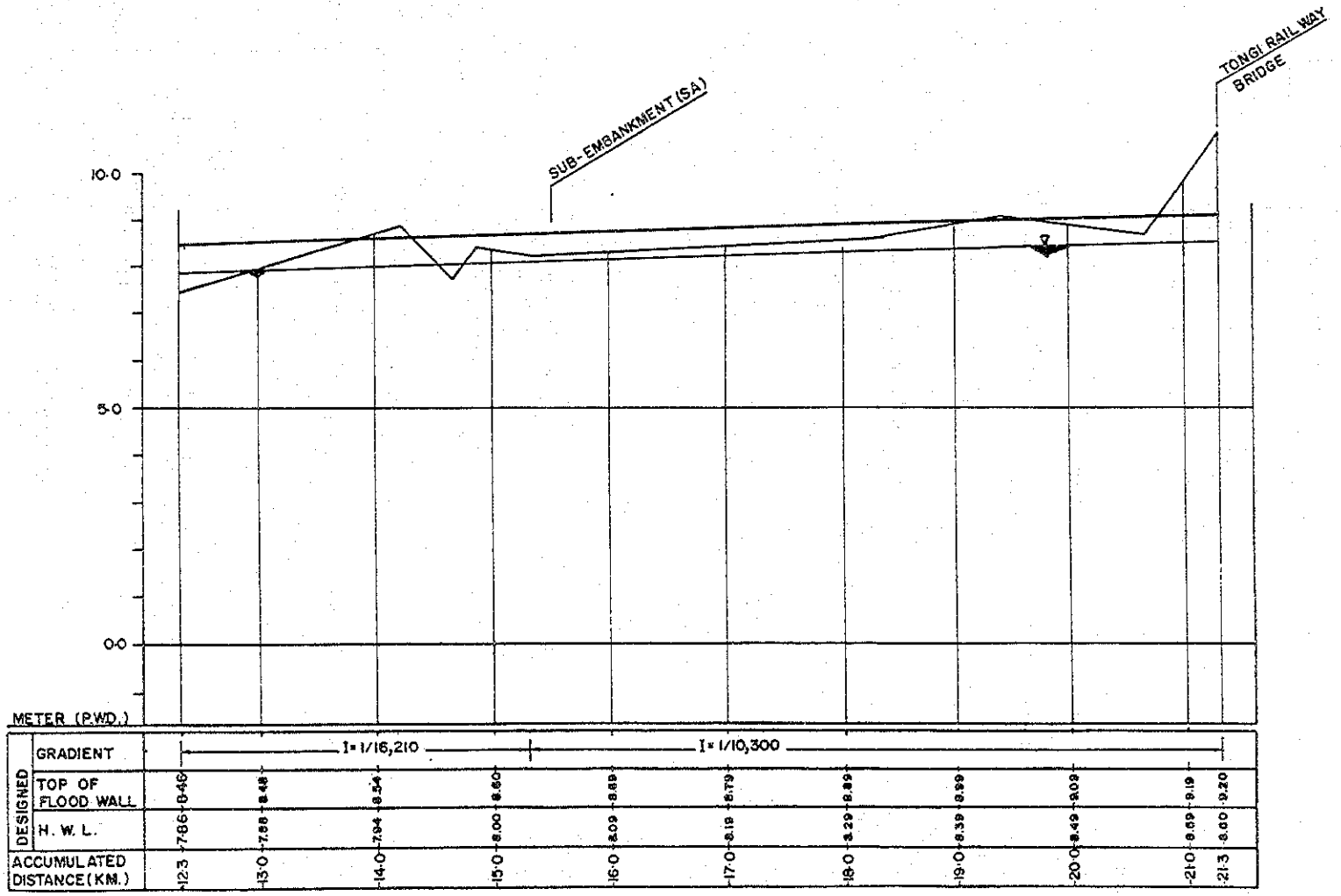
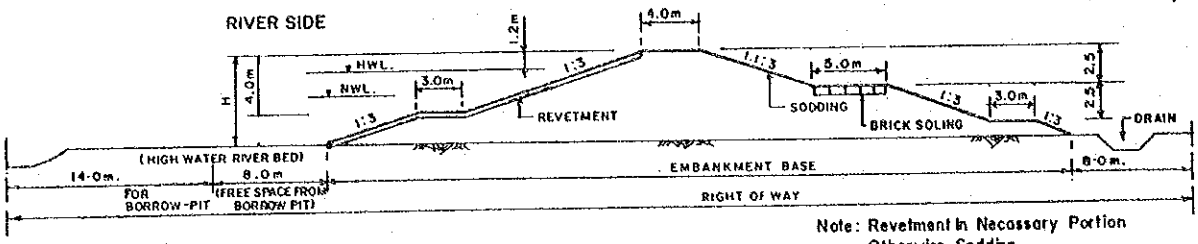



FIG. 6.1.3(5) LONGITUDINAL SECTION OF FLOOD WALL : DHAKA EAST ($R_2$)

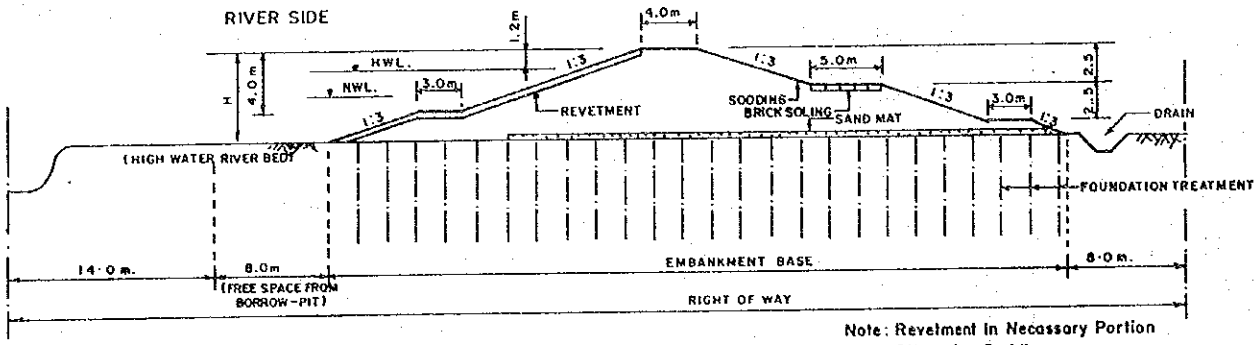
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

TYPICAL SECTION OF EMBANKMENT



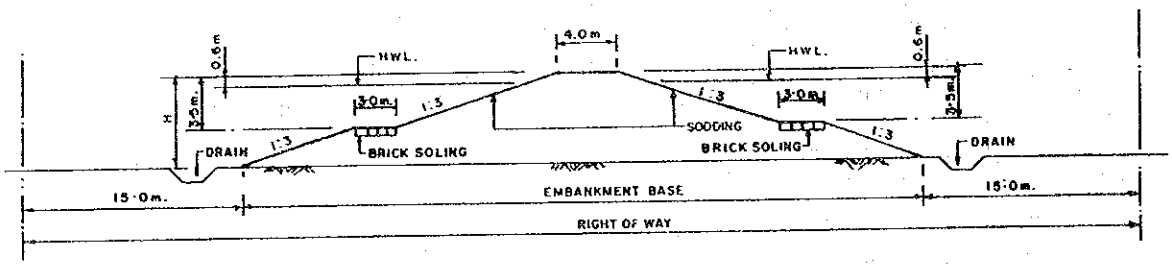

Note: Revetment In Necessary Portion Otherwise Sodding

TYPICAL SECTION OF EMBANKMENT WITH FOUNDATION TREATMENT




Note: Revetment In Necessary Portion Otherwise Sodding.

TYPICAL SECTION OF SUB-EMBANKMENT




TYPICAL SECTION OF SUB-EMBANKMENT WITH FOUNDATION TREATMENT

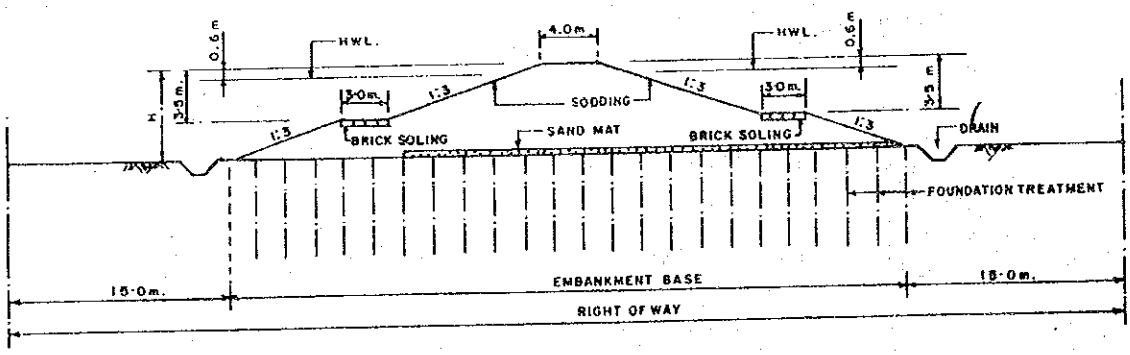



**FIG.** 6.1.4 STANDARD CROSS-SECTION OF EMBANKMENT/SUB-EMBANKMENT : DHAKA EAST

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

Khal Length

| No. | Length(m) |
|---|---|
| K 1 | 820 |
| K 2 | 1,640 |
| K 3 | 4,100 |
| K 4 | 440 |
| K 5 | 3,040 |
| K 6 | 1,940 |
| K 7 | 640 |
| K 8 | 3,540 |
| K 9 | 1,760 |
| K 10 | 1,600 |
| K 11 | 1,400 |
| K 12 | 740 |
| K 13 | 1,700 |
| K 14 | 740 |
| K 15 | 2,600 |
| K 16 | 2,200 |
| K 17 | 800 |
| K 18 | 1,920 |
| K 19 | 3,220 |
| K 20 | 1,640 |
| K 21 | 2,700 |
| K 22 | 5,320 |
| K 23 | 4,820 |
| K 24 | 3,420 |
| K 25 | 2,420 |
| K 26 | 1,800 |
| K 27 | 2,200 |
| Total | 59,160 |

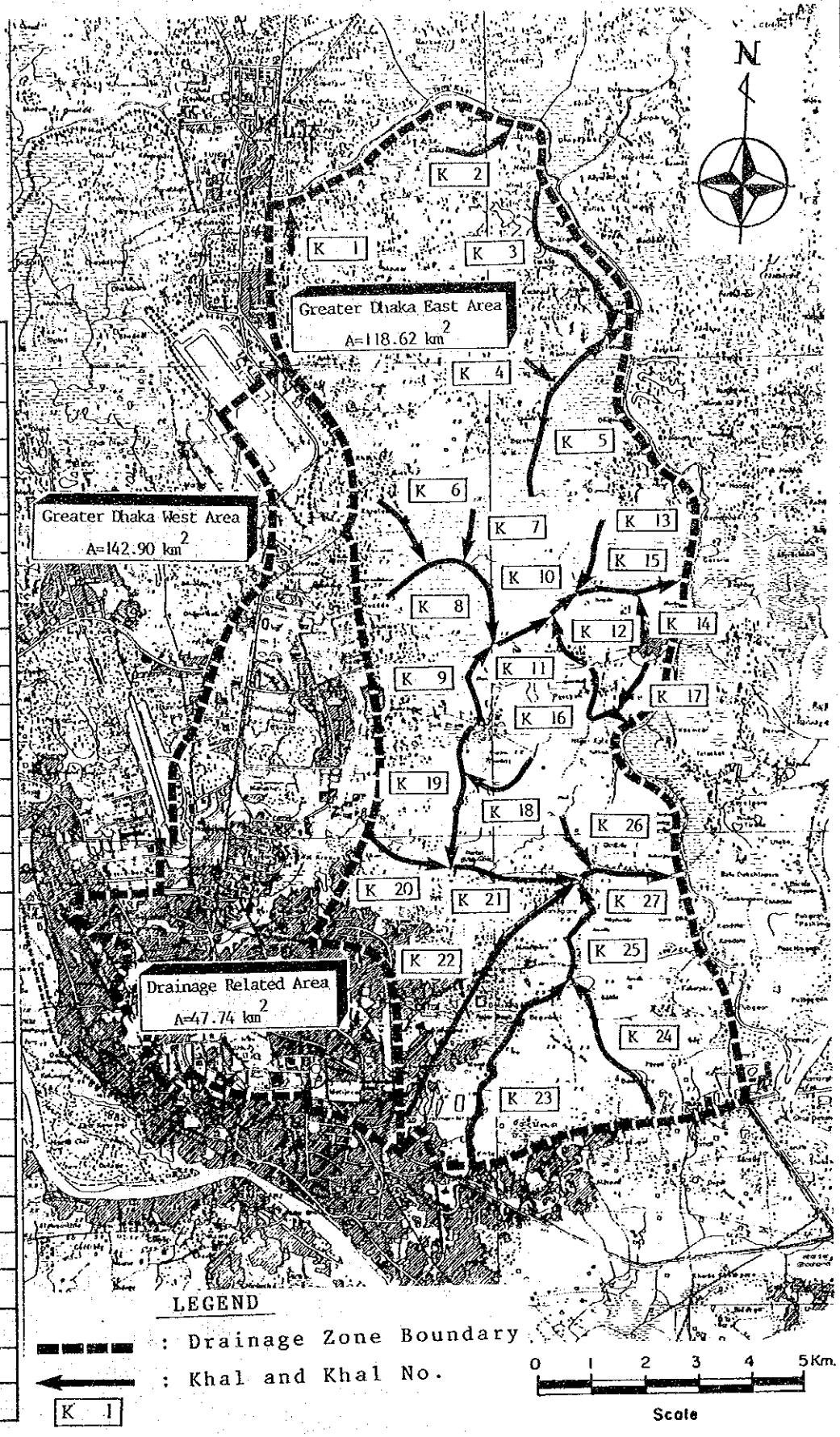



**FIG. 6.1.5** EXISTING MAJOR KHALS : GREATER DHAKA EAST

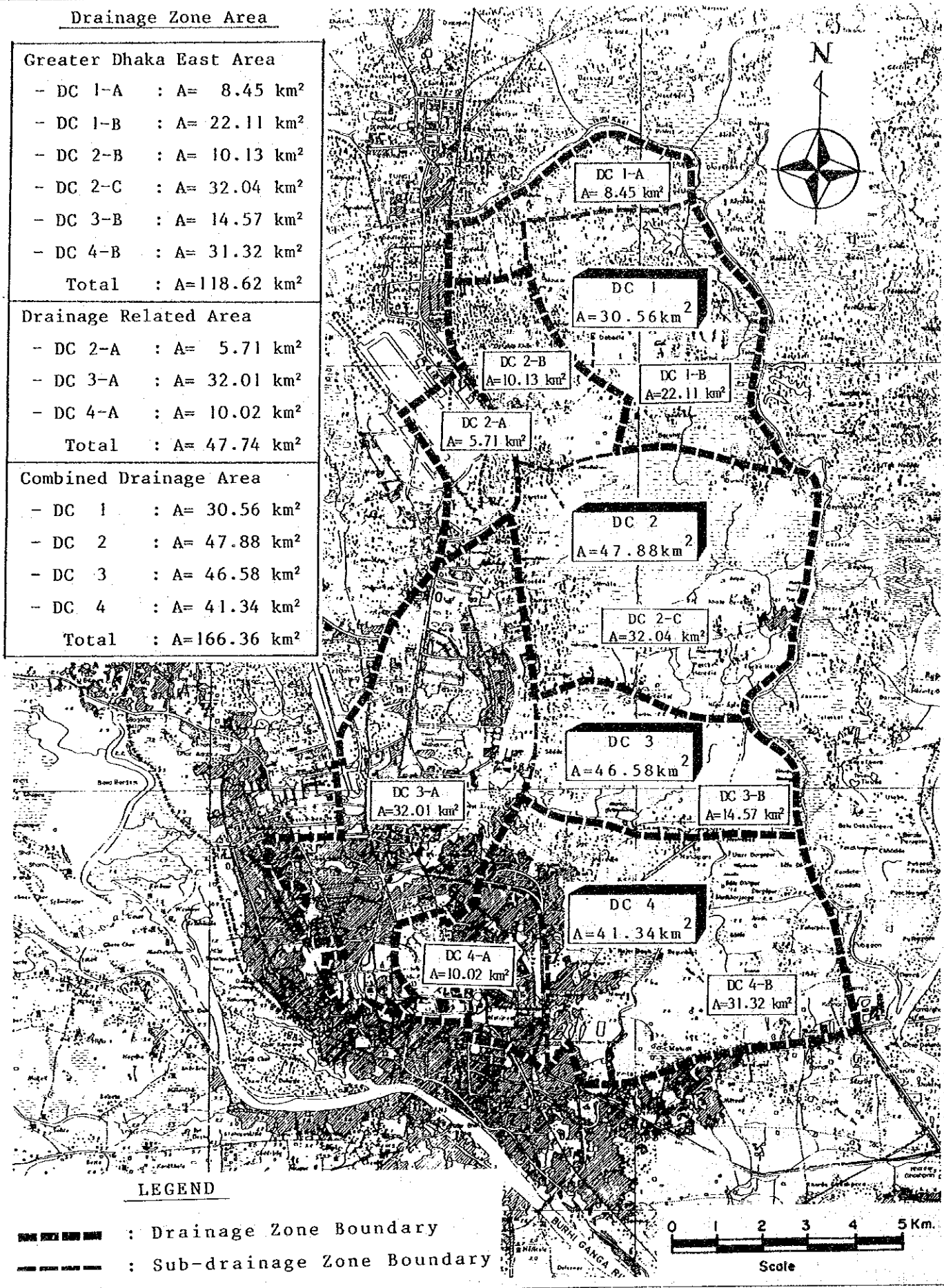
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



JICA

Drainage Zone Area

| | | |
|---|---|---|
| **Greater Dhaka East Area** | | |
| - DC 1-A | : A= | 8.45 km² |
| - DC 1-B | : A= | 22.11 km² |
| - DC 2-B | : A= | 10.13 km² |
| - DC 2-C | : A= | 32.04 km² |
| - DC 3-B | : A= | 14.57 km² |
| - DC 4-B | : A= | 31.32 km² |
| Total | : A= | 118.62 km² |
| **Drainage Related Area** | | |
| - DC 2-A | : A= | 5.71 km² |
| - DC 3-A | : A= | 32.01 km² |
| - DC 4-A | : A= | 10.02 km² |
| Total | : A= | 47.74 km² |
| **Combined Drainage Area** | | |
| - DC 1 | : A= | 30.56 km² |
| - DC 2 | : A= | 47.88 km² |
| - DC 3 | : A= | 46.58 km² |
| - DC 4 | : A= | 41.34 km² |
| Total | : A= | 166.36 km² |




LEGEND

: Drainage Zone Boundary

: Sub-drainage Zone Boundary

**FIG. 6.1.6** DRAINAGE ZONE : GREATER DHAKA EAST

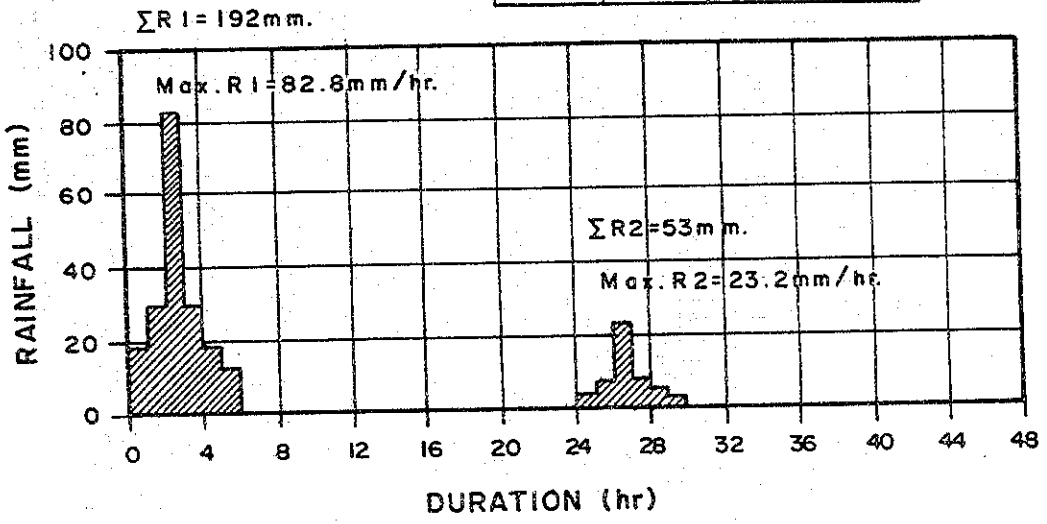
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

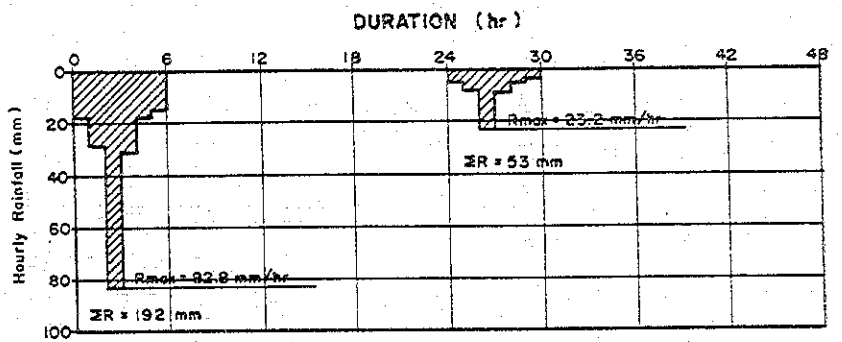


JICA

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 |



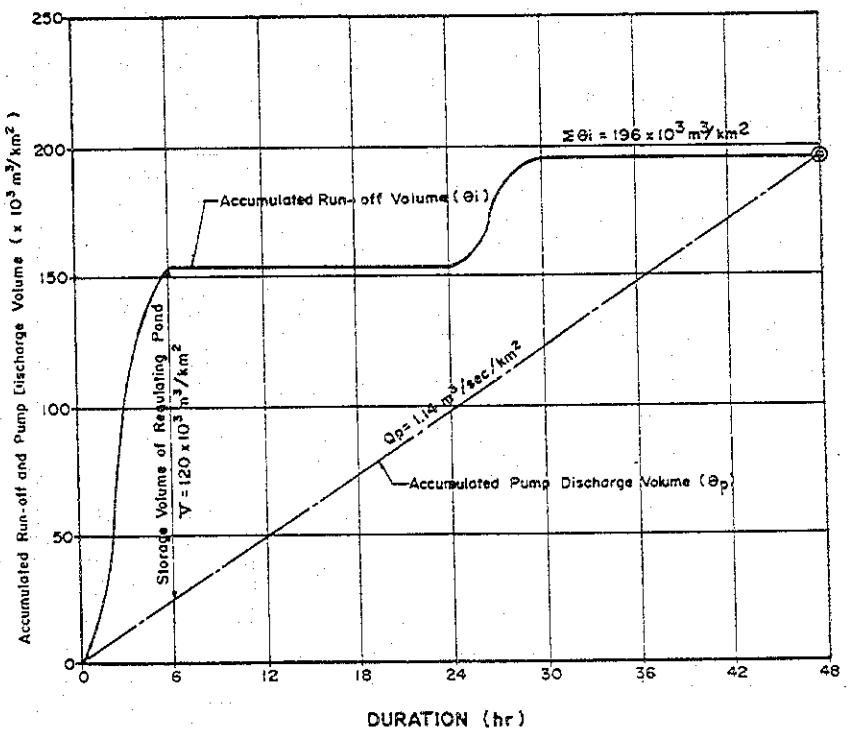
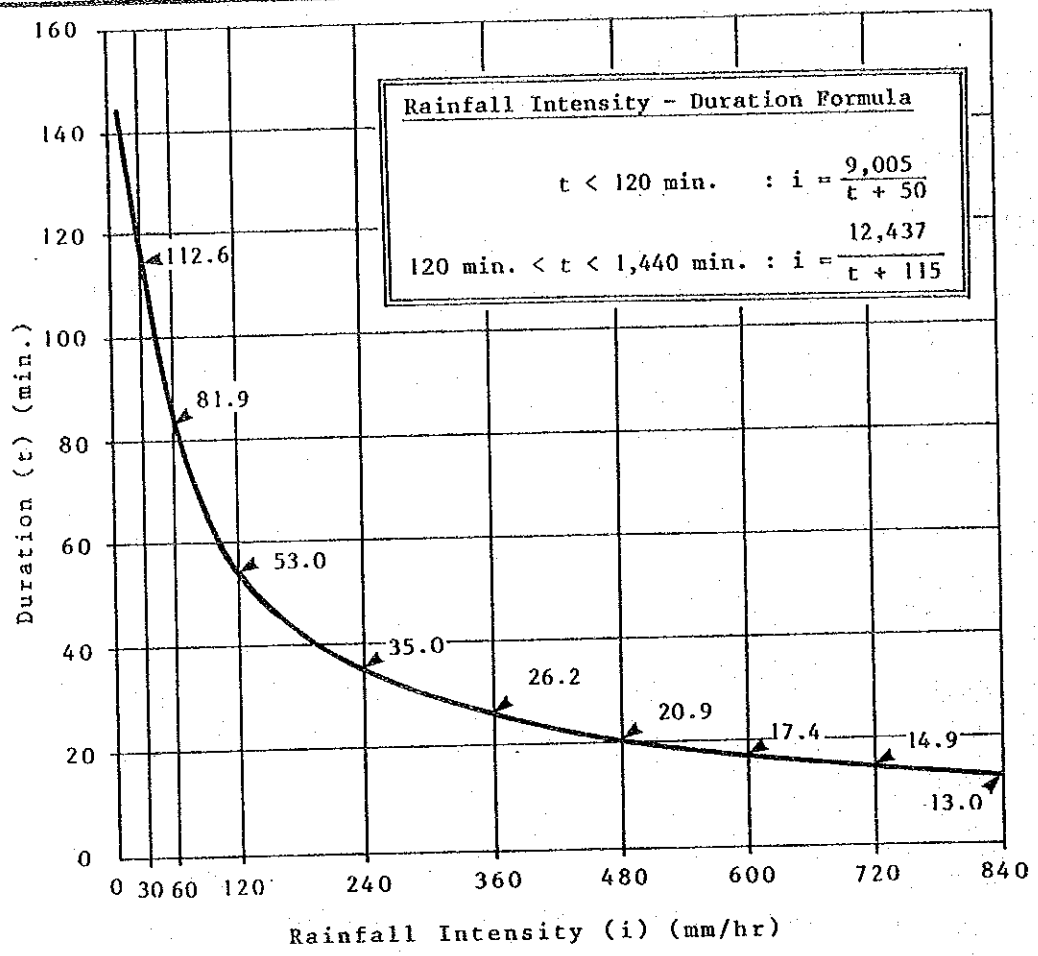
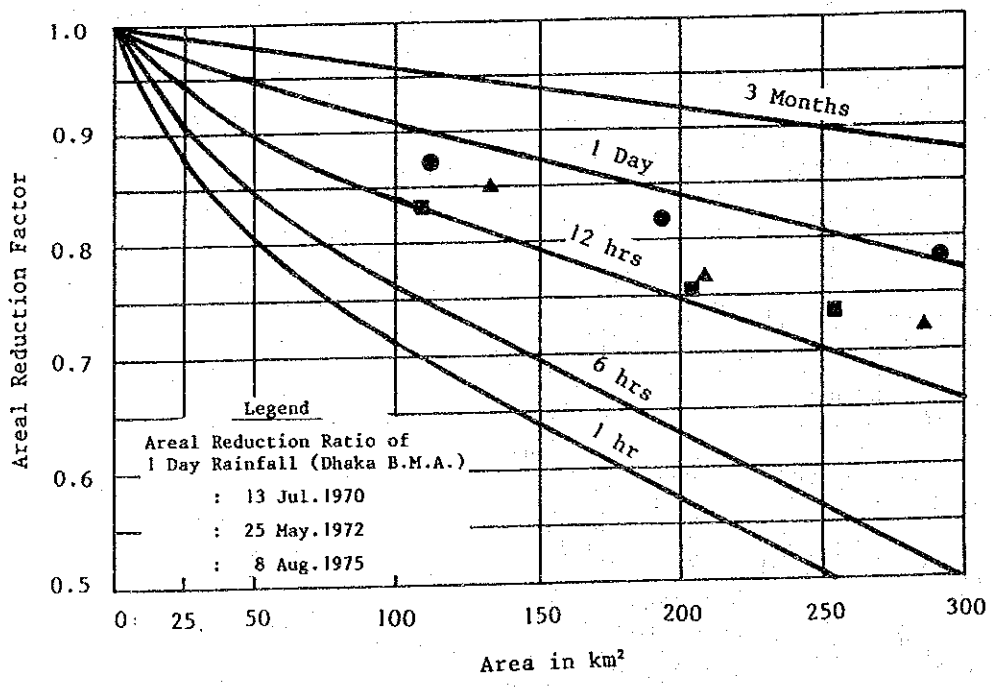




**FIG. 6.1.7** DESIGN RAINFALL FOR PUMP DRAINAGE PLAN AND DESIGN SPECIFIC REQUIREMENTS OF PUMP AND RETARDING POND

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

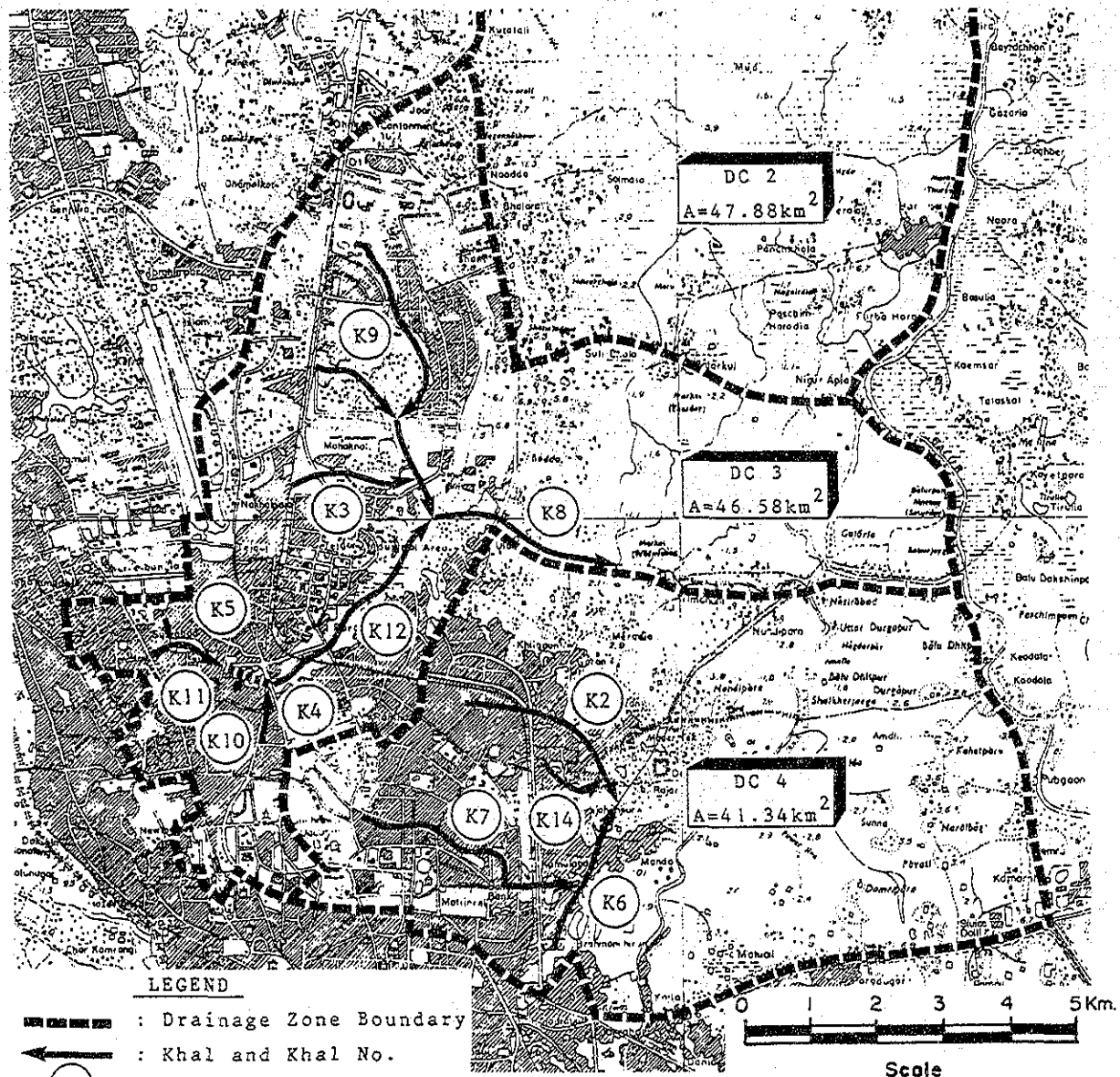



Souece : JICA,Study on Storm Water Drainage System Improvement Project in Dhaka City,1987




Source : NEDECO,Master Plan for Drainage and Flood Control of Jakarta,1973

**FIG. 6.1.8** DESIGN RAINFALL AND AREAL REDUCTION CURVE FOR KHAL IMPROVEMENT PLAN



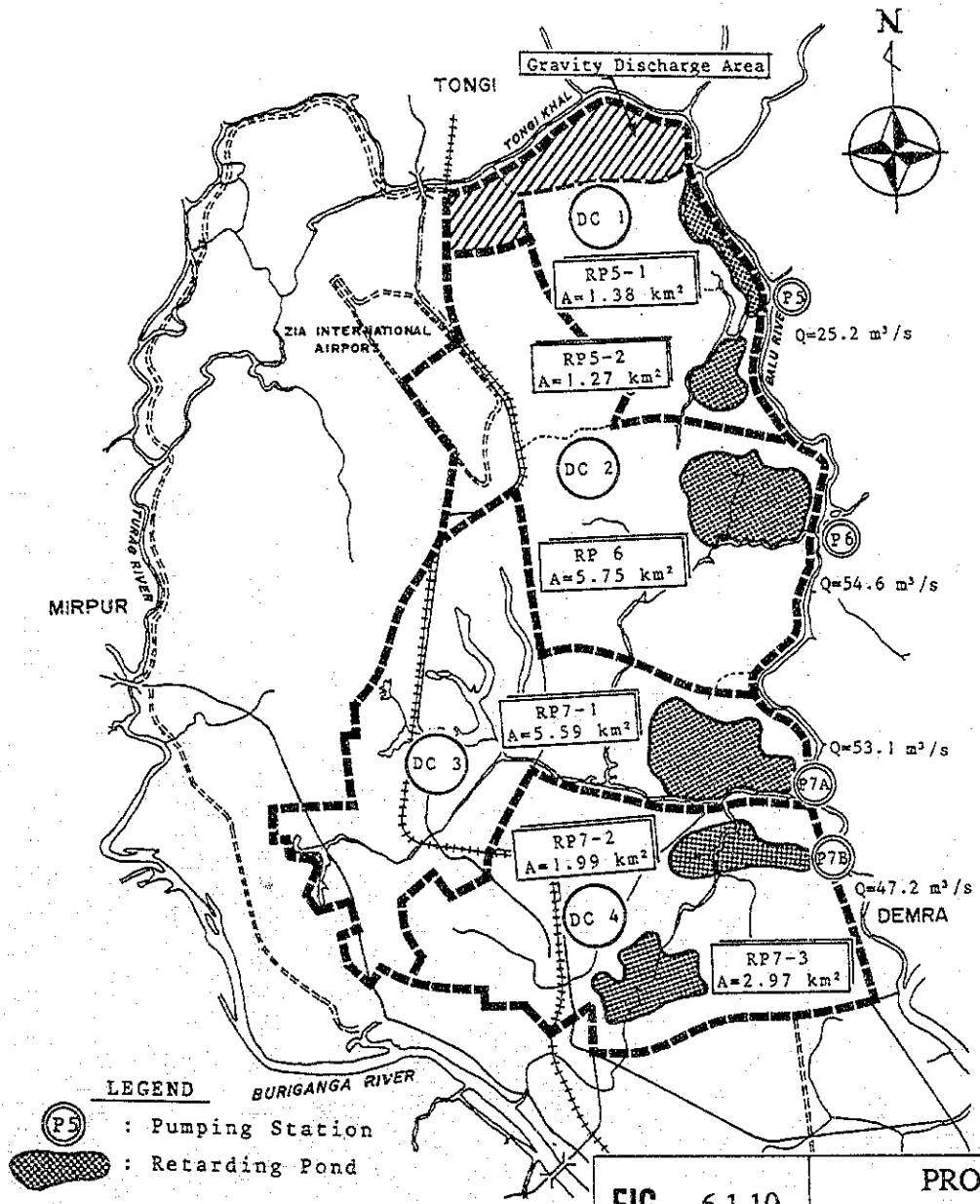

Phased Khal Improvement Work

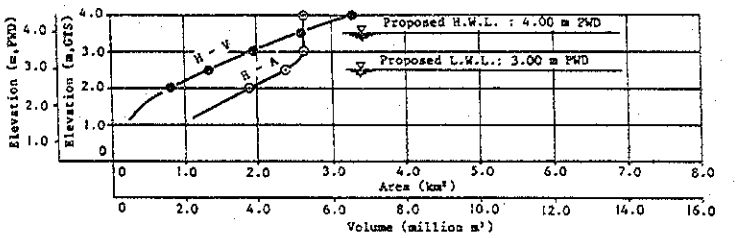
| Khal No. | Name of Khal | Improved Length(m) |
|---|---|---|
| Phase I Work (1991 - 1992) | | |
| K 3 | Mohakhali Khal | 2,220 |
| K11 | BegunbariKhal | 1,000 |
| K 7 | Segunbagicha Khal | 2,366 |
| K 5 | Rajabazar Khal | 195 |
| K10 | Kathalbagan Khal | 110 |
| Sub-total | | 5,891 |
| Phase II Work (1992 - 1993) | | |
| K 2 | Khilgaon-Basabo Khal | 3,035 |
| K 6 | Gerani Khal | 1,204 |
| K 7 | Segunbagicha Khal | 1,576 |
| K12 | Begunbari Khal | 1,000 |
| K 9 | Banani-Gulshan Khal | 4,500 |
| K 4 | Paribagh Khal | 767 |
| Sub-total | | 12,082 |
| Phase III Work (1993 - 1994) | | |
| K14 | Mugda Khal | 2,200 |
| K 8 | Begunbari Khal | 4,820 |
| Sub-total | | 7,020 |
| Total | | 24,993 |

Sourse : ADB,Dhaka Integrated Flood Protection,FAP-8R,Sep.1991

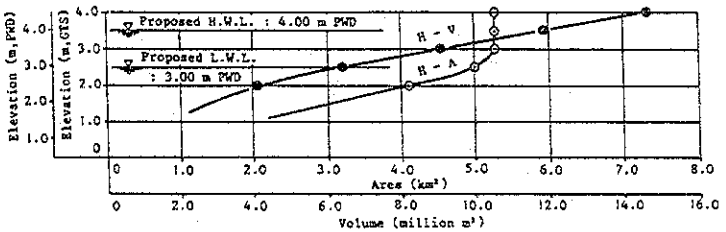
**FIG. 6.1.9** KHAL IMPROVEMENT WORKS PROPOSED IN DIFPP FINANCED BY ADB

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

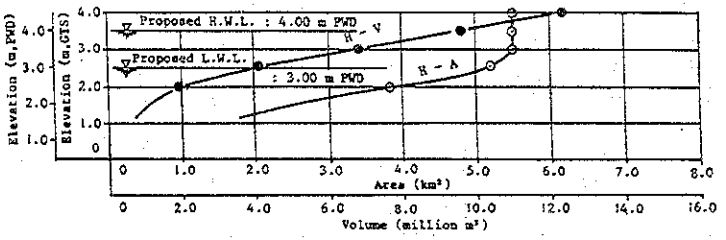


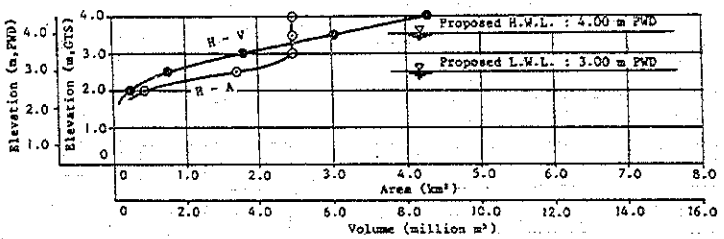

Retarding Pond : 5-1 and 5-2




Retarding Pond : 6




Retarding Pond : 7-1




Retarding Pond : 7-2 and 7-3

**FIG. 6.1.10** PROPOSED REQUIREMENTS OF PUMP AND RETARDING POND : GREATER DHAKA EAST

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

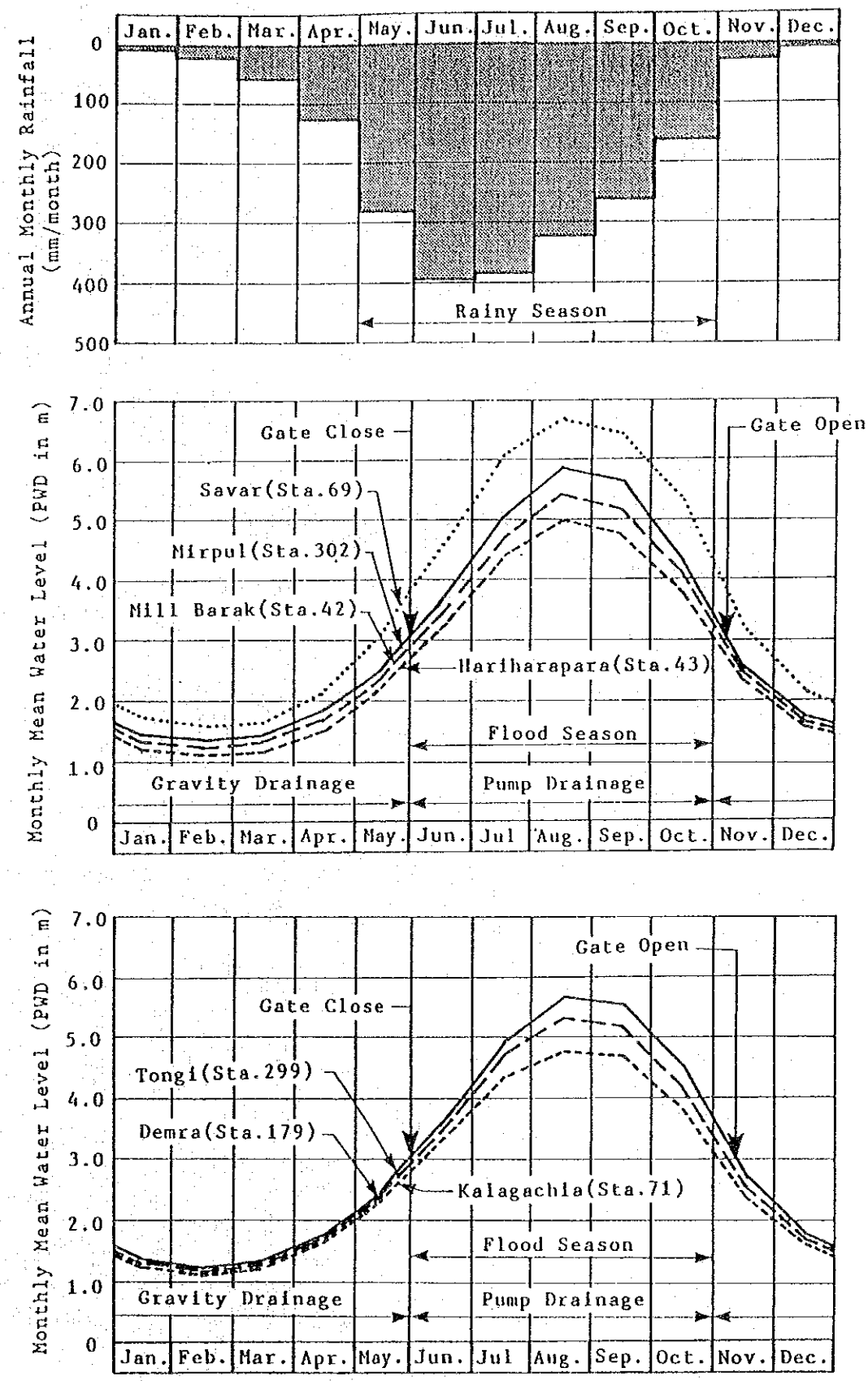



**FIG. 6.1.11** SEASONAL VARIATION OF RAINFALL AND FLOOD WATER LEVEL IN DHAKA METROPOLITAN AREA