

FIG. 8.1 (5)

ALIGNMENT ALTERNATIVE - SAVAR AREA

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

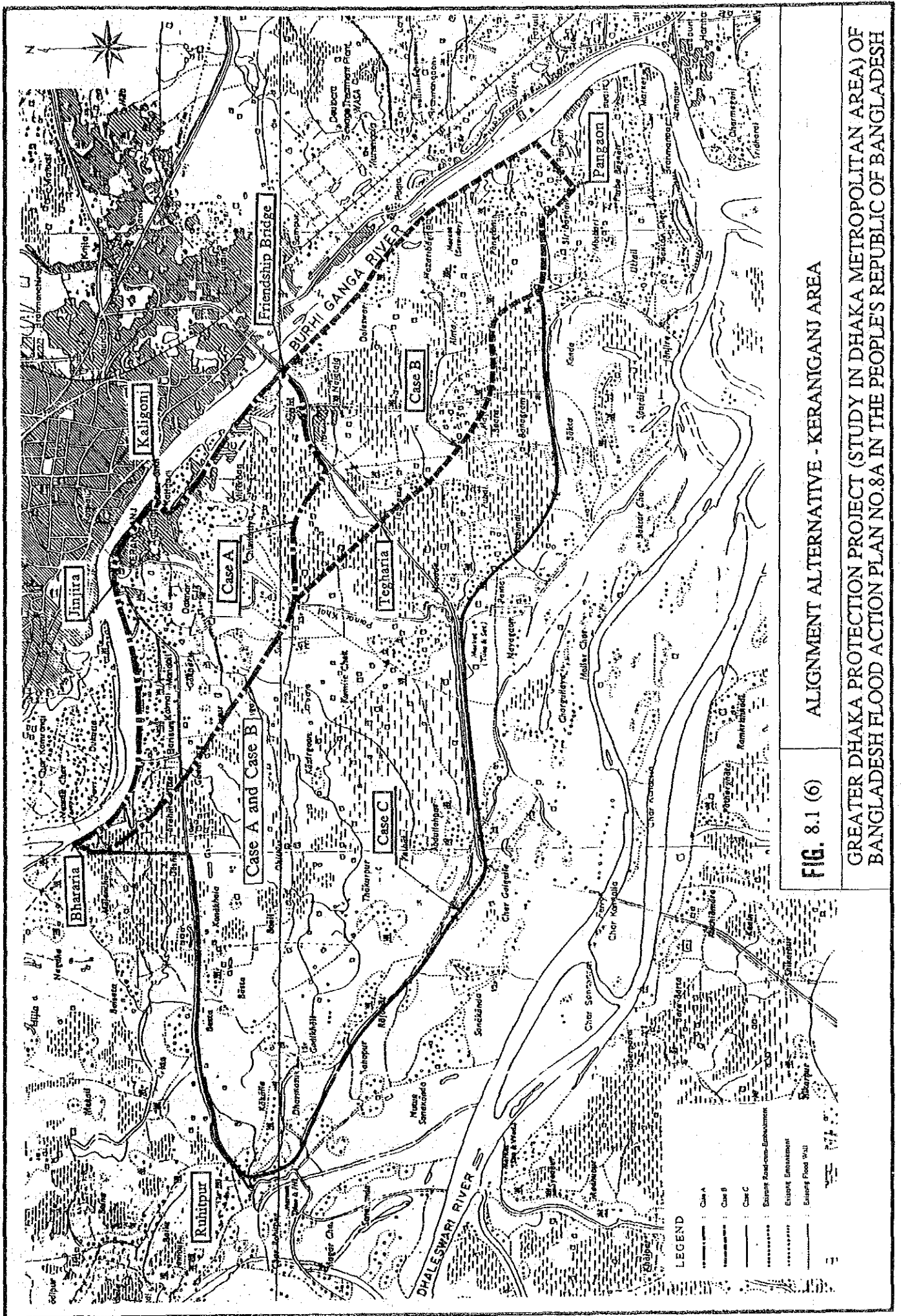


FIG. 8.1 (6) ALIGNMENT ALTERNATIVE - KERANIGANJ AREA

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



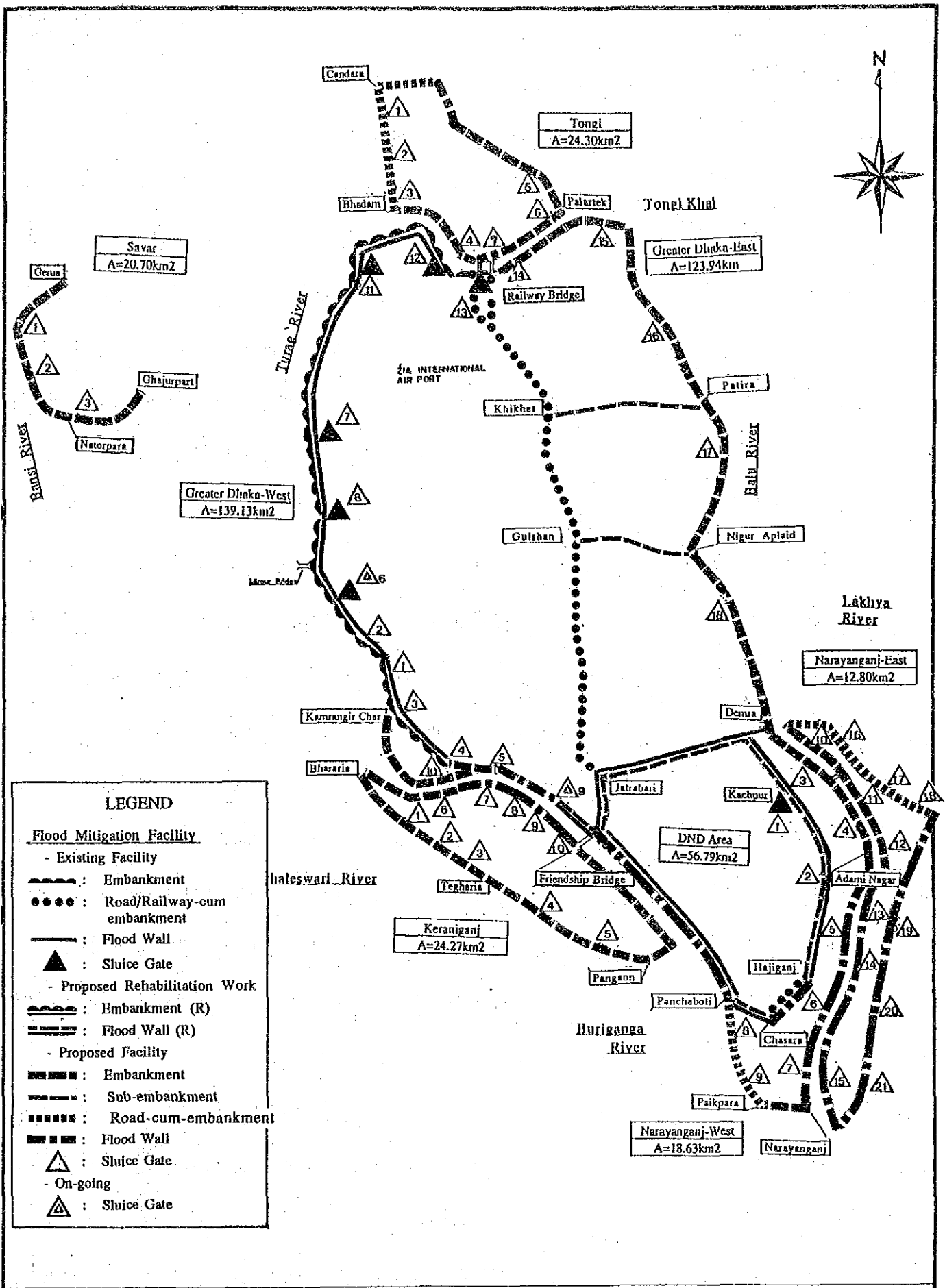
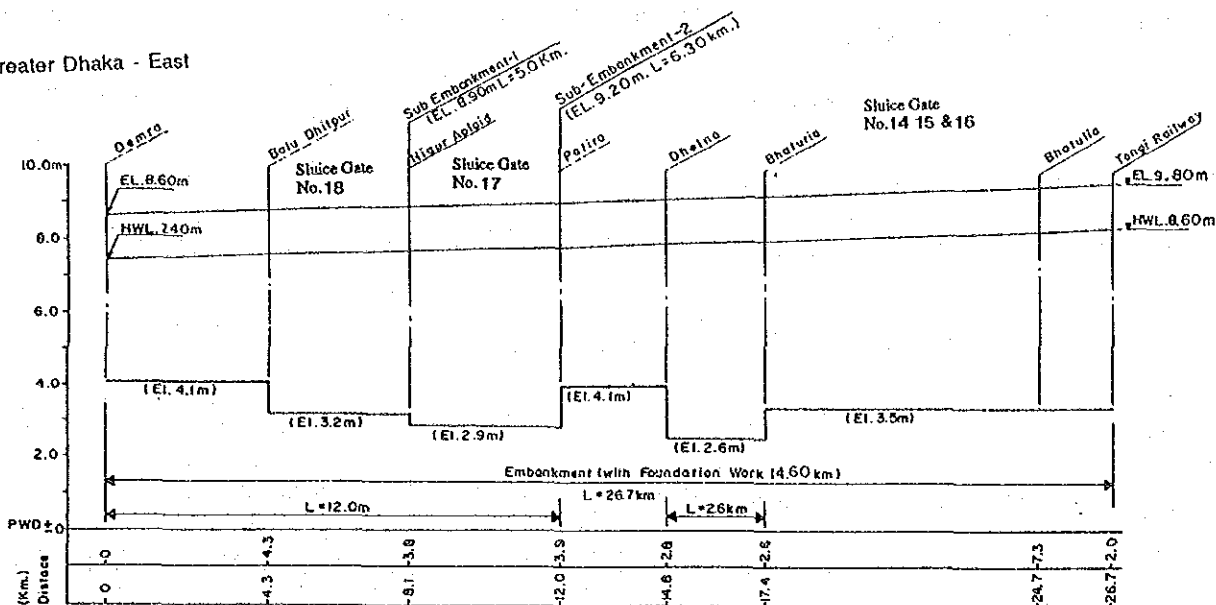


FIG. 8.2

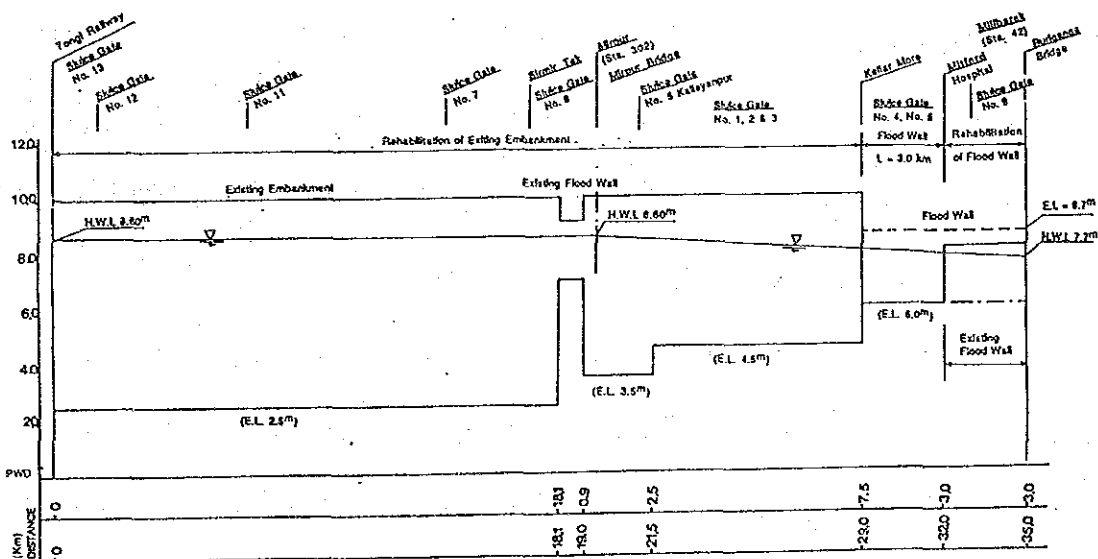
PROPOSED PROJECT AREAS WITH MAJOR FACILITIES

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

Greater Dhaka - East



Greater Dhaka - West



Kamrangir Char

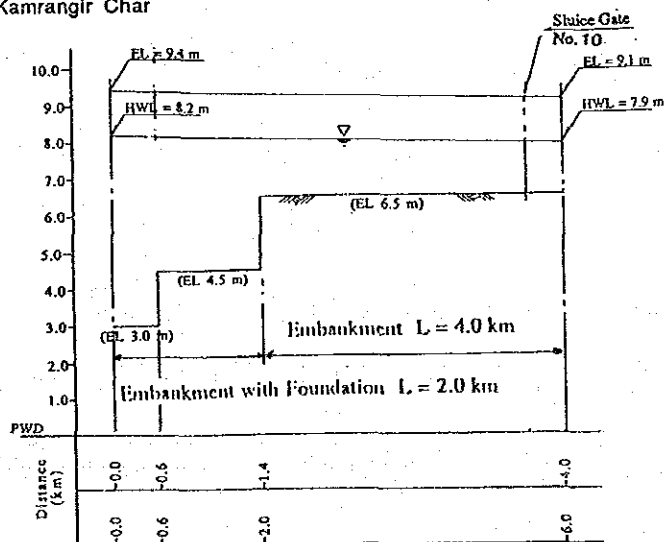
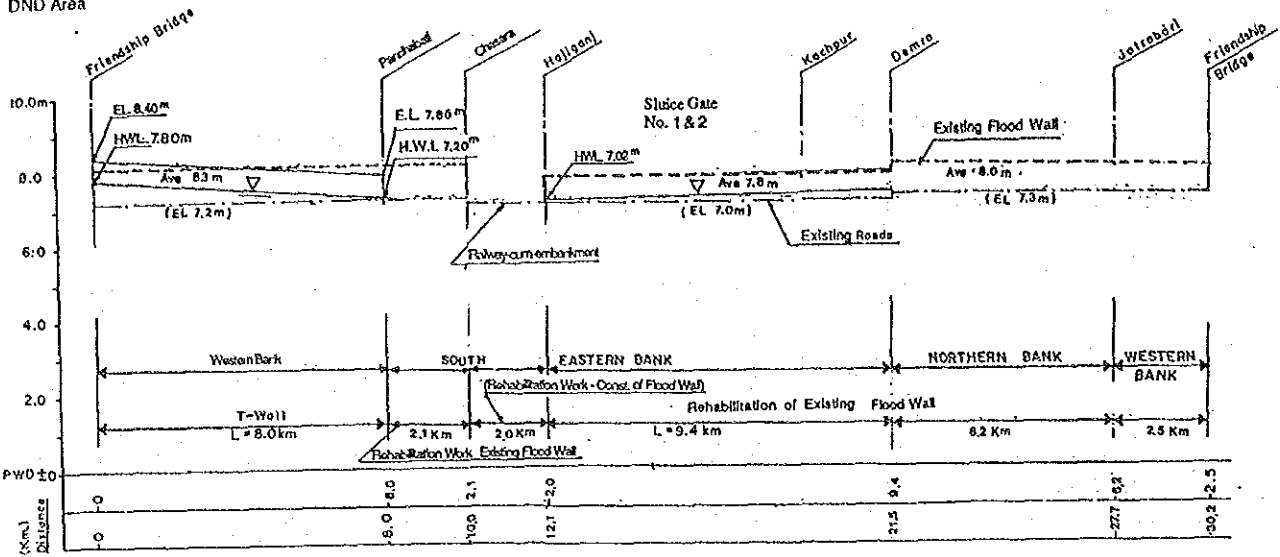


FIG. 8.3 (1)

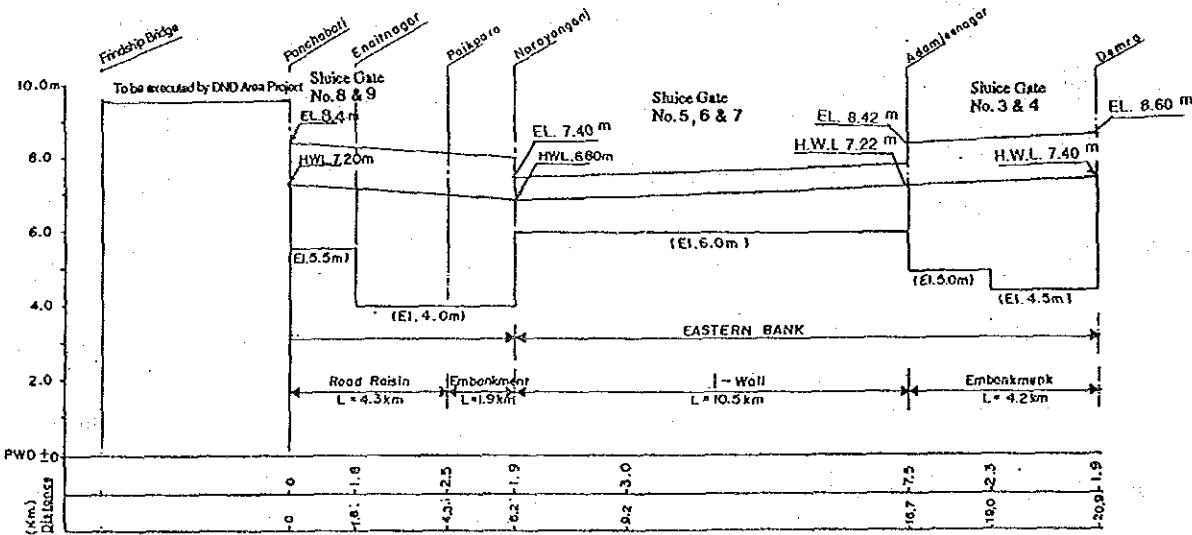
PROPOSED LONGITUDINAL SECTIONS : GREATER DHAKA-EAST, GREATER DHAKA-WEST AND KAMRANGIR CHAR

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

DND Area



Narayanganj - West



Narayanganj - East

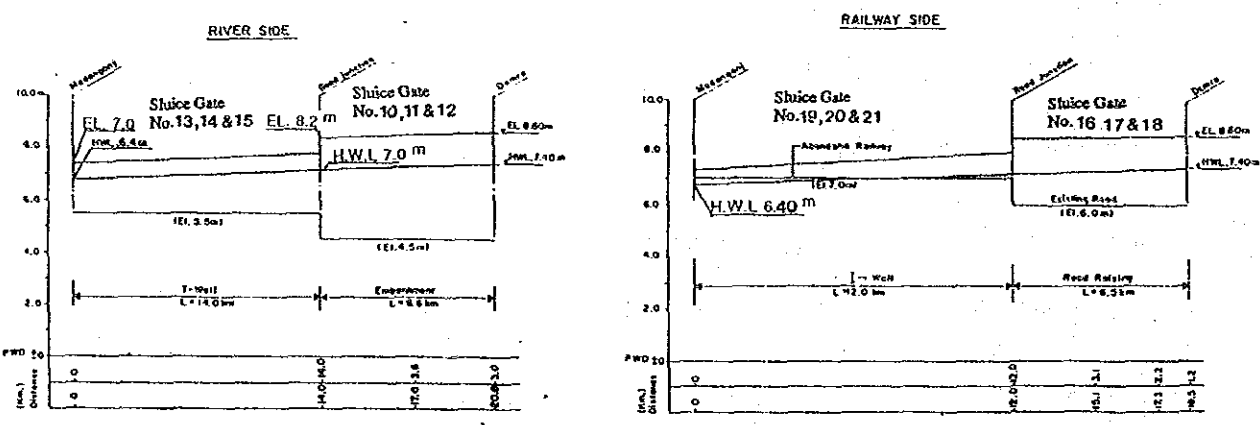
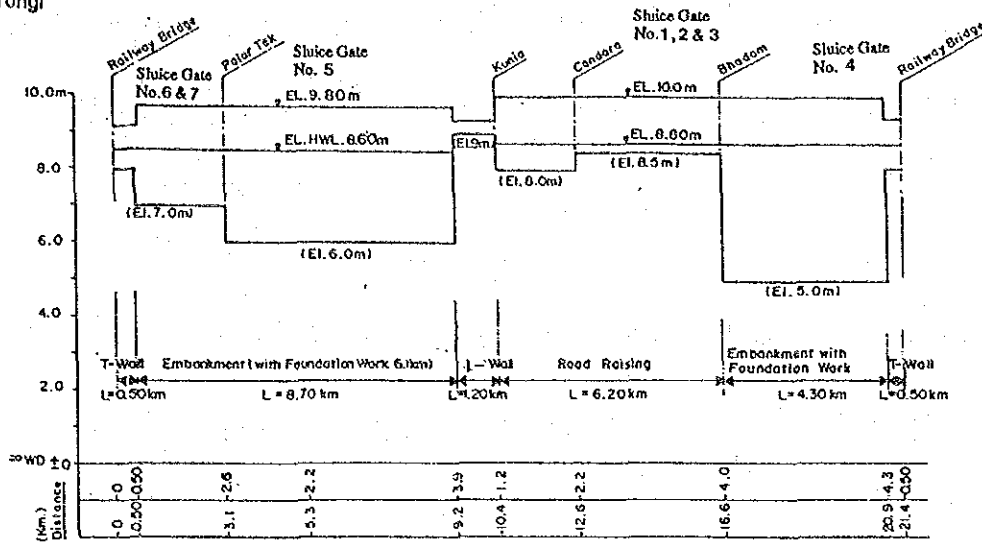


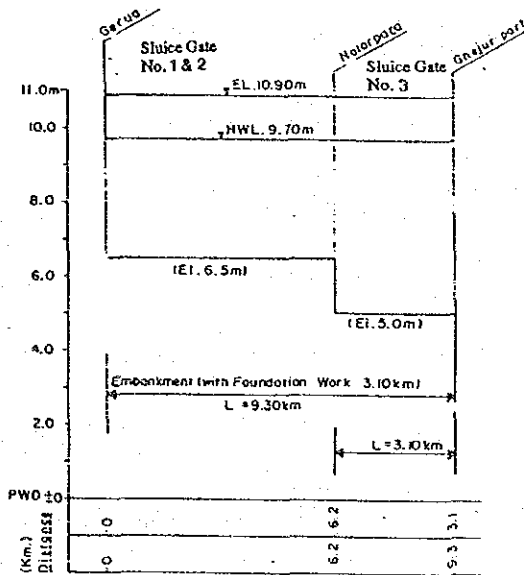
FIG. 8.3 (2) PROPOSED LONGITUDINAL SECTIONS : NARAYANGANJ DND AREA, NARAYANGANJ-WEST AND NARAYANGANJ-EAST
 GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



Tongi



Savar



Keraniganj

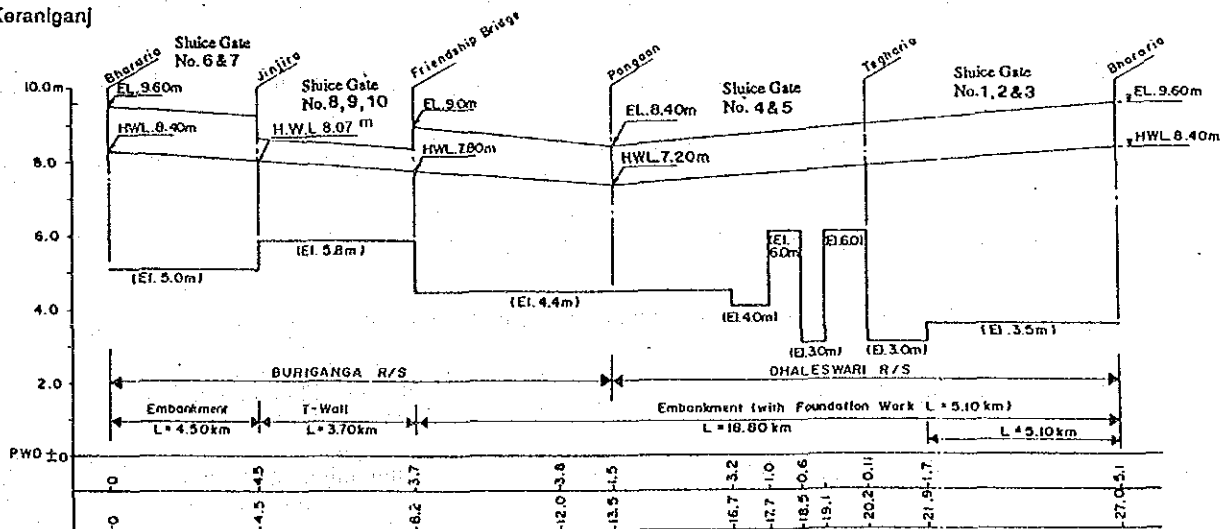
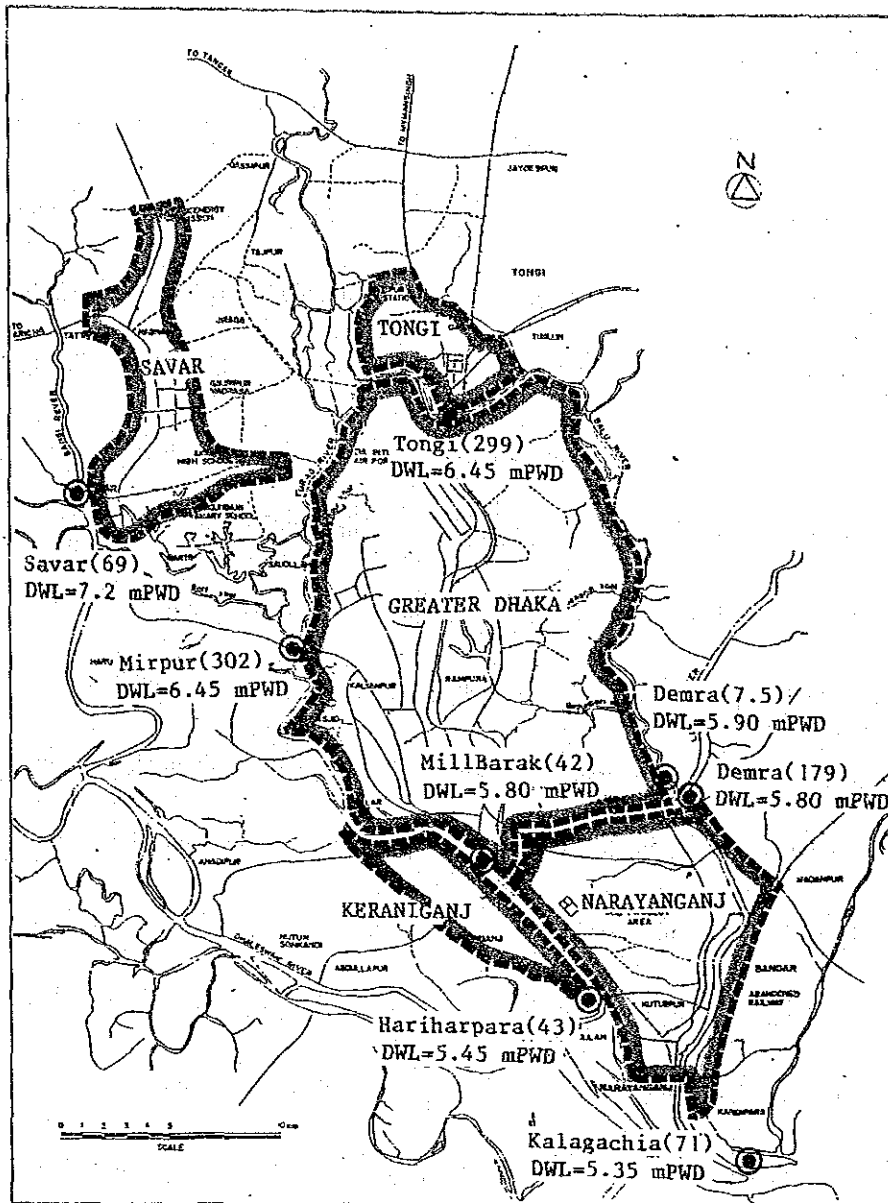


FIG. 8.3 (3)

PROPOSED LONGITUDINAL SECTIONS : TONGI, SAVAR AND KERANIGANJ

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



Design Flood Water Levels of Stormwater Drainage

(1) Greater Dhaka Area

- Buriganga River Left Bank Zone : 5.80 to 6.45 m PWD
- Turag River Left Bank Zone : 6.45 m PWD
- Balu River Right Bank Zone : 5.90 to 6.45 m PWD

(2) Tongi Area

- Tongi East and West Zone : 6.45 m PWD

(3) Narayanganj Area

- DND Project, Narayanganj East and West Zone : 5.45 to 5.80 m PWD

(4) Keraniganj Area

: 5.45 to 5.80 m PWD

(5) Savar Area

: 7.20 m PWD

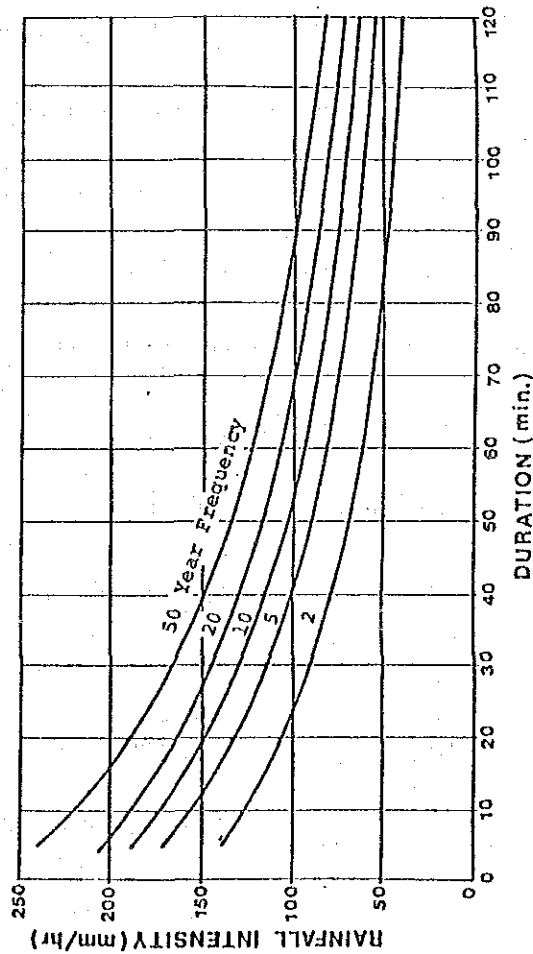
FIG. 8.4

DESIGN FLOOD WATER LEVELS IN MASTER PLAN AREA

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

RAINFALL INTENSITY-DURATION FORMULA

RETURN PERIOD	EQUATION	RAINFALL INTENSITY				
		15	30	60	120	
2	$\frac{6589}{1+44}$	113.4	90.4	64.3	40.8	
3	$\frac{7674}{1+47}$	125.6	99.7	71.7	45.0	
5	$\frac{9005}{1+50}$	138.5	112.6	81.9	53.0	
10	$\frac{10690}{1+53}$	157.2	129.8	94.6	61.8	
20	$\frac{12311}{1+55}$	173.5	143.8	107.0	70.3	
50	$\frac{14415}{1+57}$	200.2	165.7	123.2	81.4	



HOURLY DISTRIBUTION

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

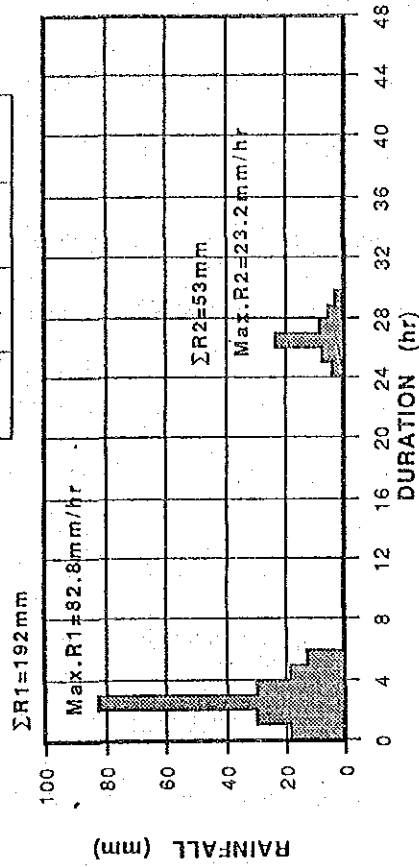


FIG. 8.5

DESIGN RAINFALL

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



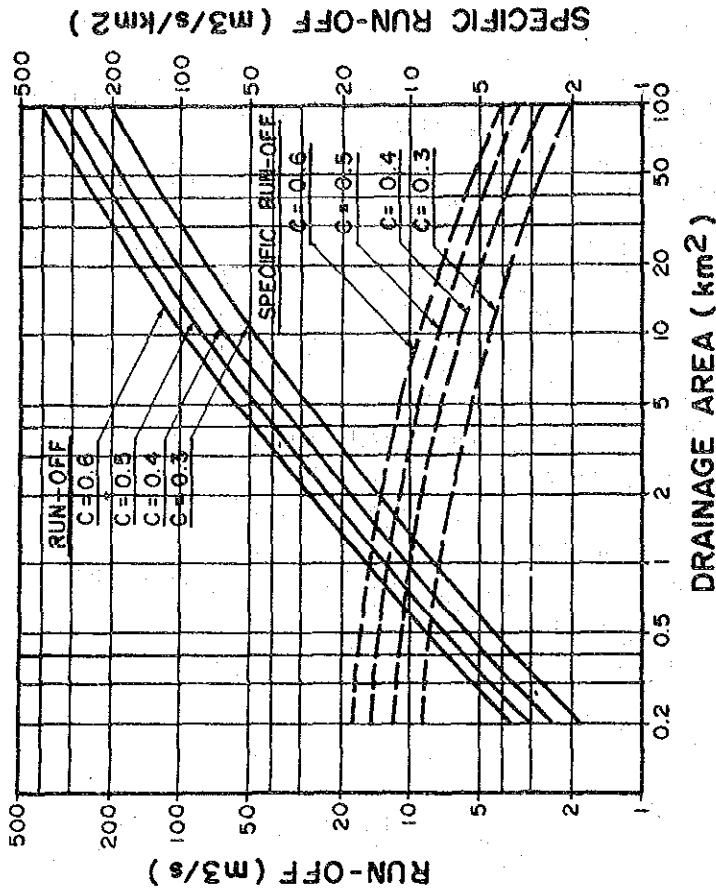
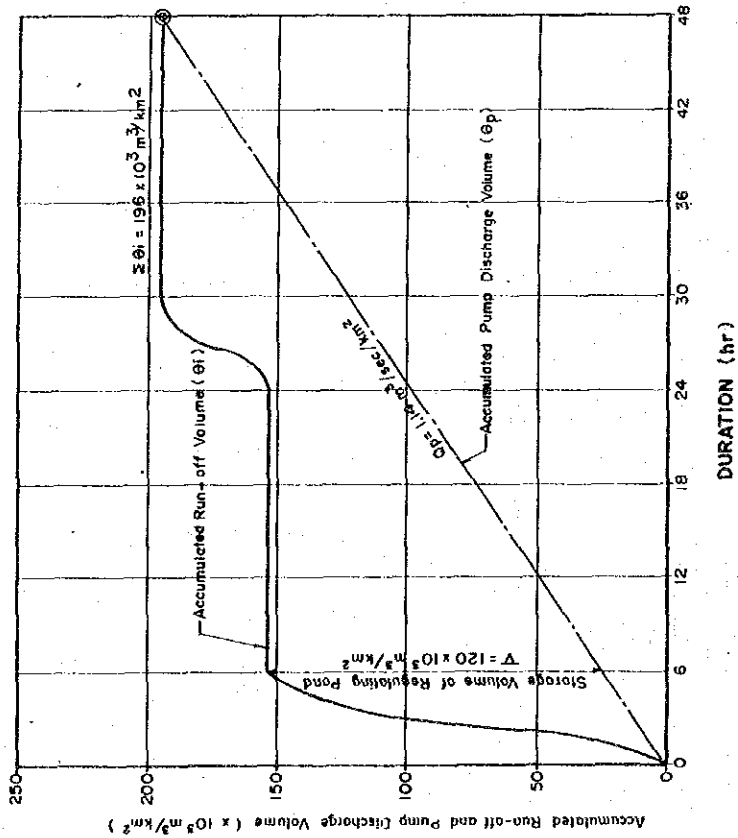
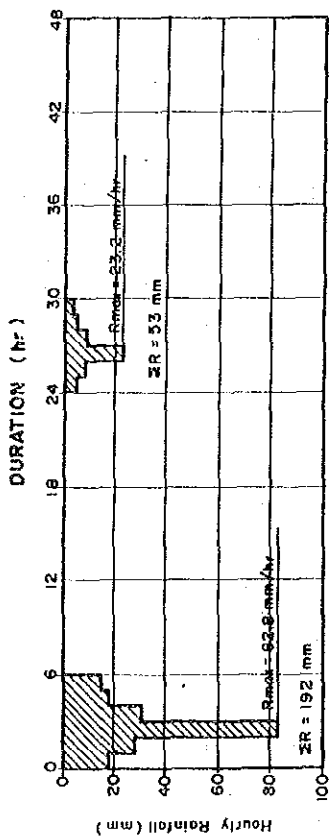


FIG. 8.6

SPECIFIC REQUIREMENTS OF PUMP AND REGULATING POND, AND SPECIFIC PEAK RUN-OFF AND DRAINAGE AREA CURVES

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



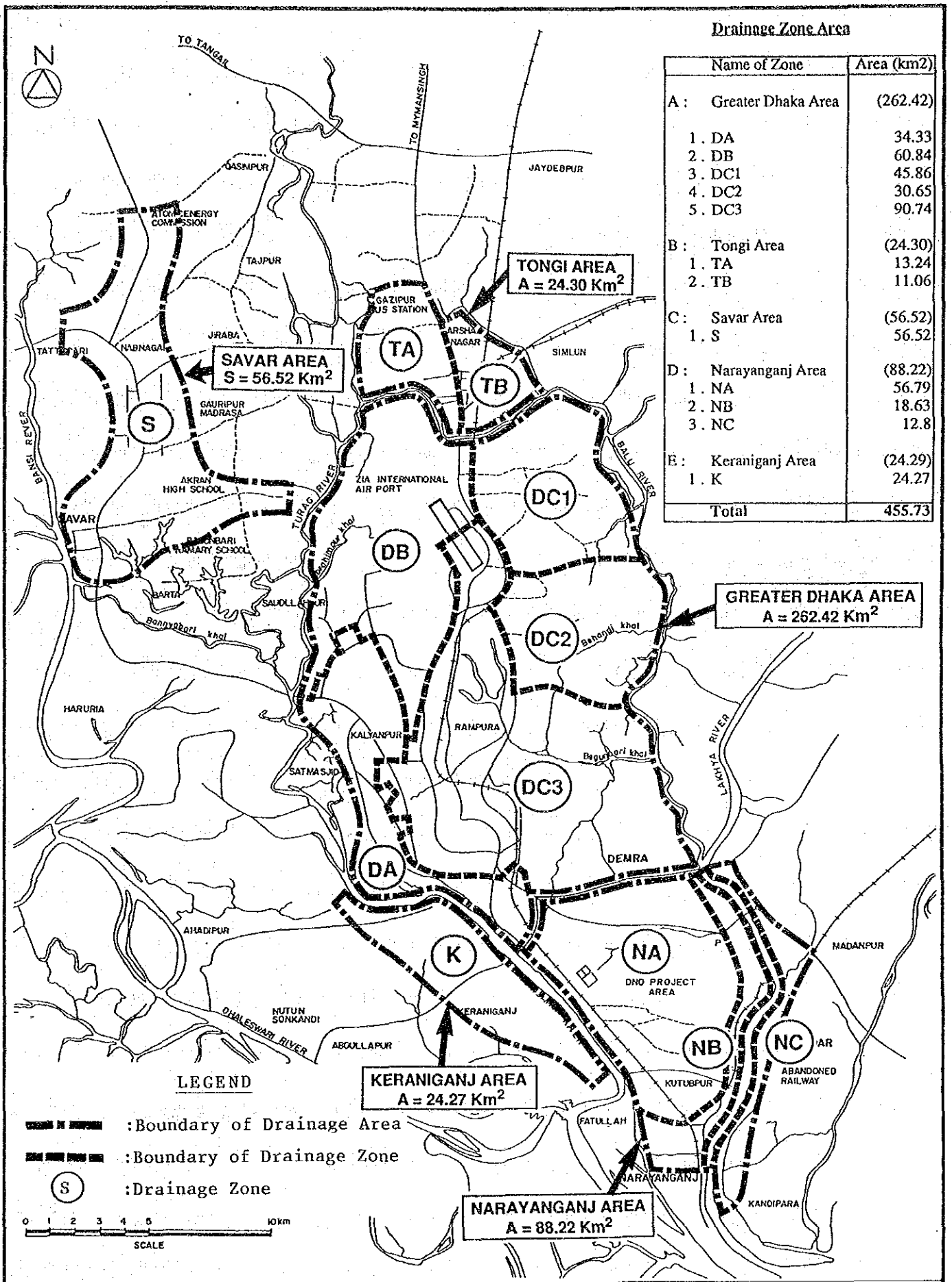
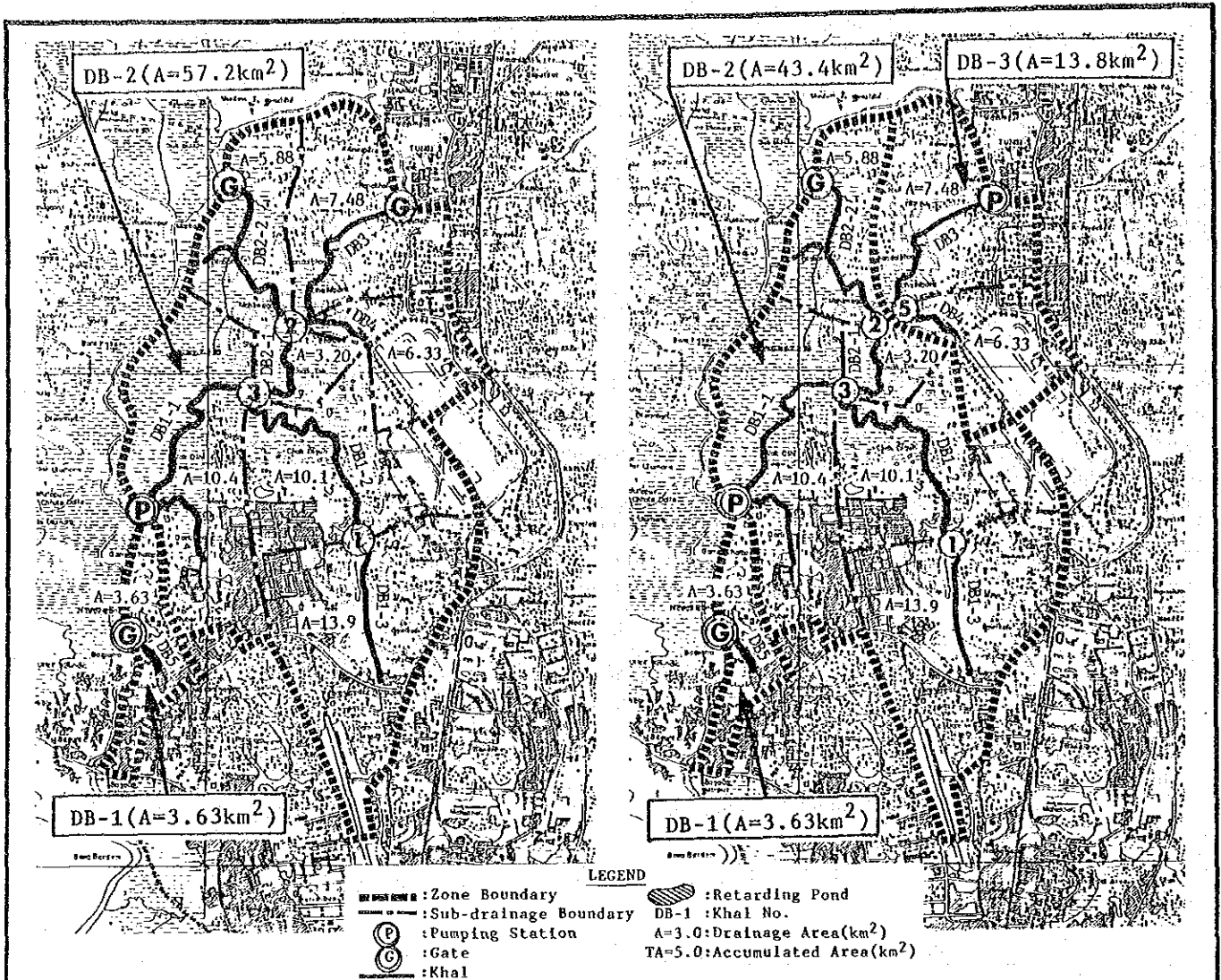


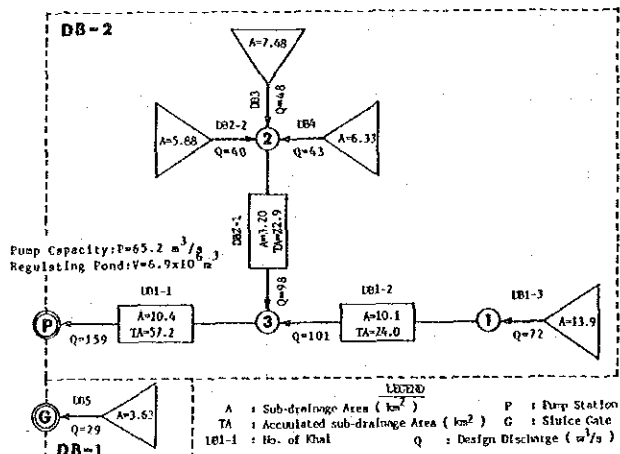
FIG. 8.7

PROPOSED DRAINAGE ZONES

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



Drainage Plan

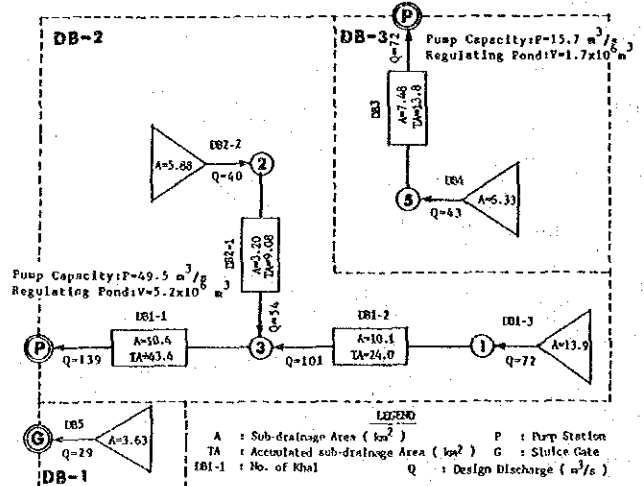


Drainage Model

Alternative I

(Two Independent Drainage System)

Drainage Plan



Drainage Model

Alternative II

(Three Independent Drainage System)

FIG. 8.8 (1)

DRAINAGE SYSTEM ALTERNATIVES (TURAG RIVER LEFT BANK ZONE)

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

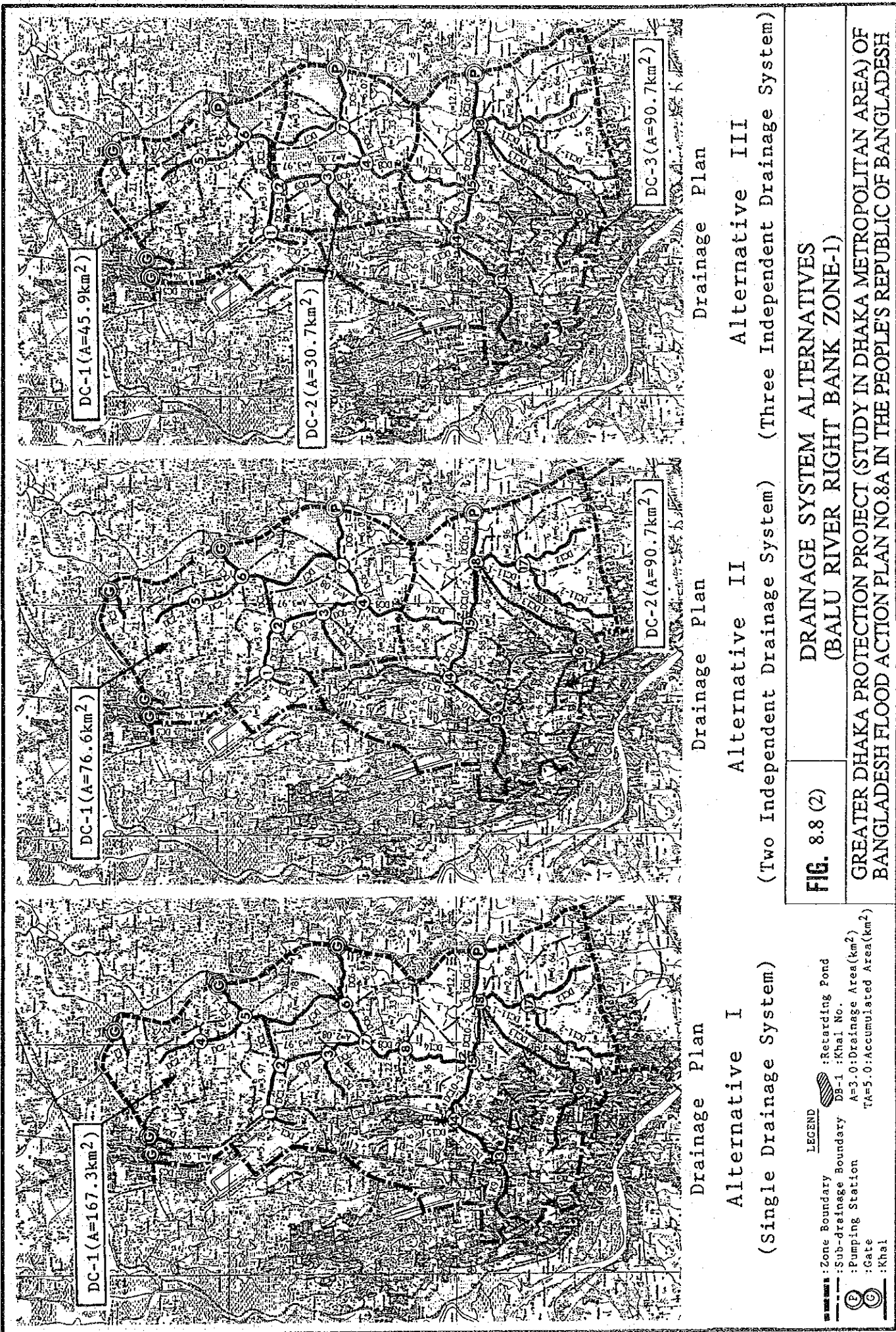
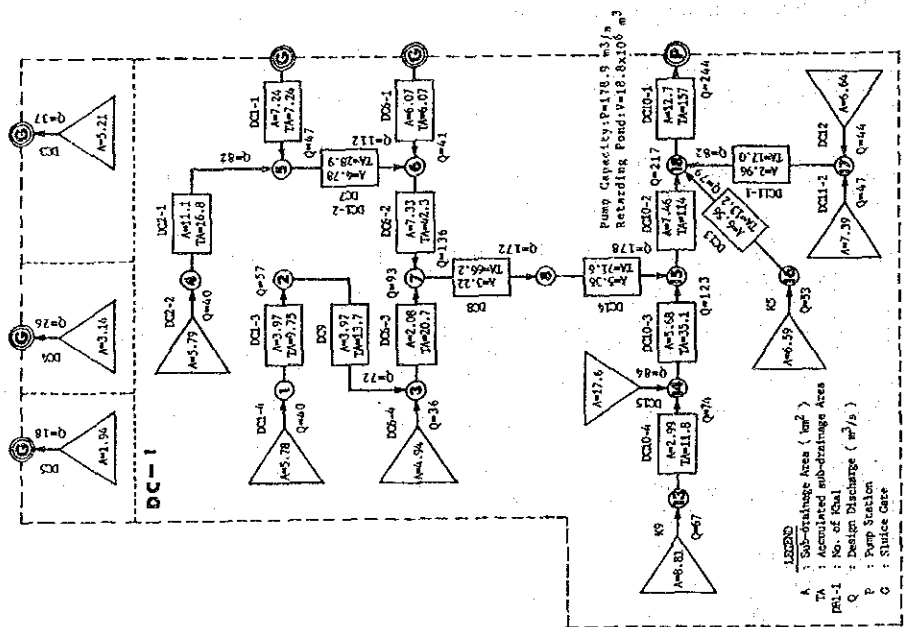


FIG. 8.8 (2)

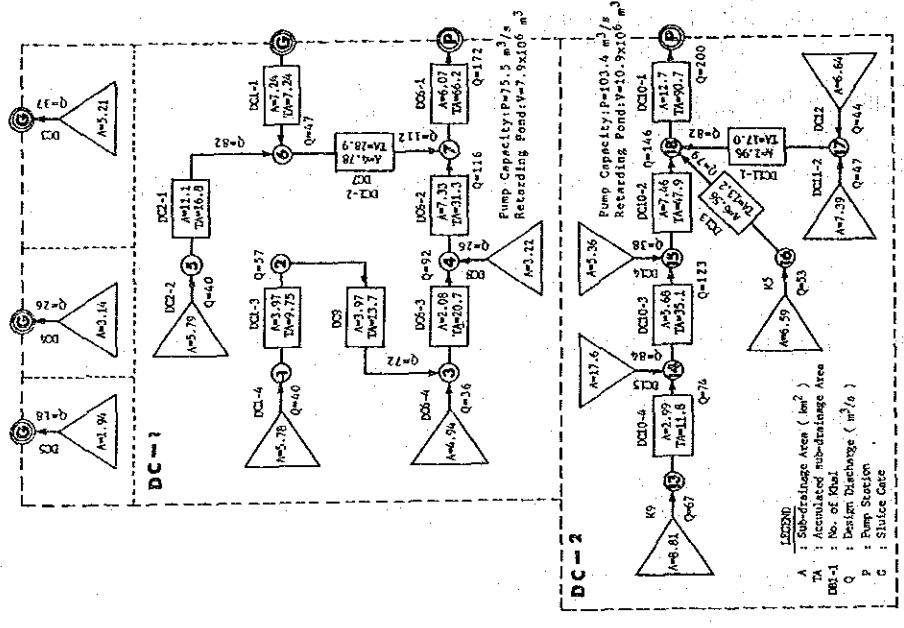
**DRAINAGE SYSTEM ALTERNATIVES
 (BALU RIVER RIGHT BANK ZONE-1)**

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

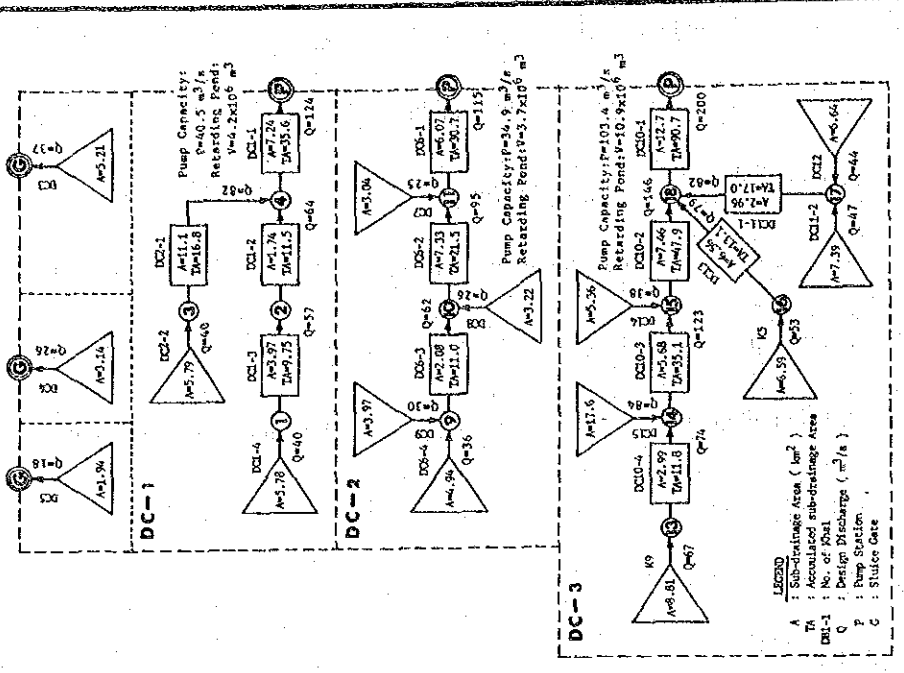




Alternative I
 (Single Drainage System)



Alternative II
 (Two Independent Drainage System)

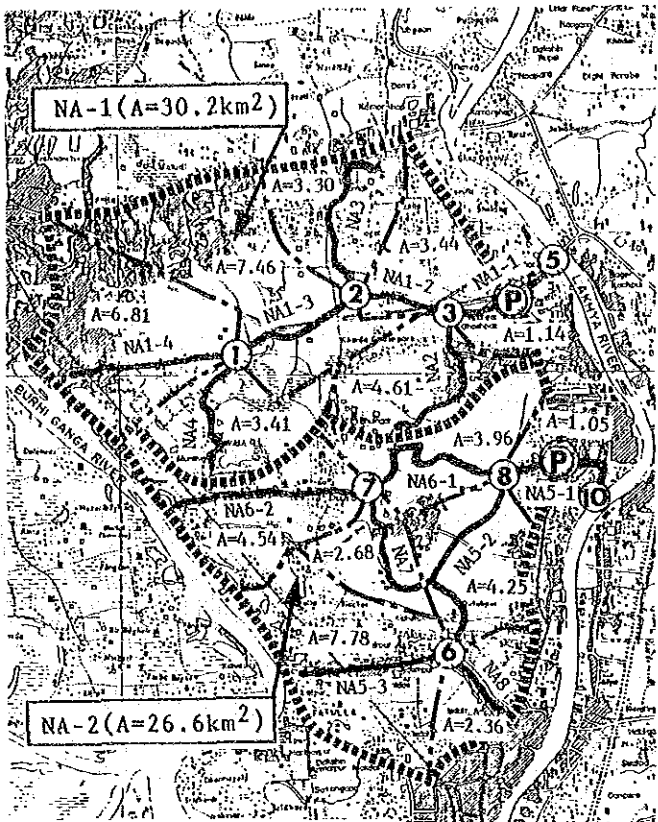
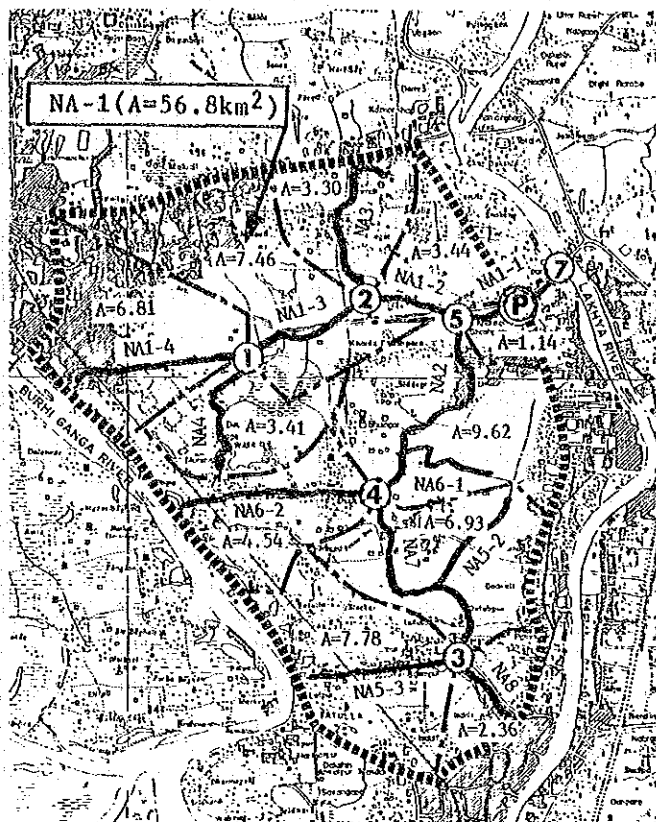


Alternative III
 (Three Independent Drainage System)

FIG. 8.8 (3)
DRAINAGE SYSTEM ALTERNATIVES
(BALU RIVER RIGHT BANK ZONE-2)

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

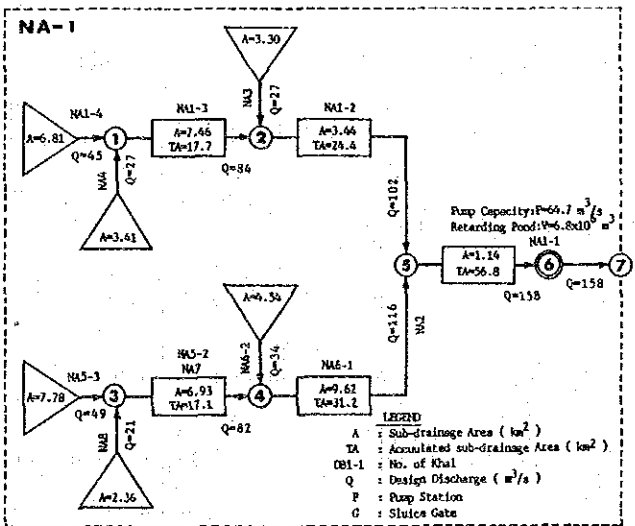




- LEGEND**
- : Zone Boundary
 - : Sub-drainage Boundary
 - : Pumping Station
 - : Gate
 - : Retarding Pond
 - DB-1 : Khal No.
 - A=3.0: Drainage Area(km²)
 - TA=5.0: Accumulated Area(km²)

Drainage Plan

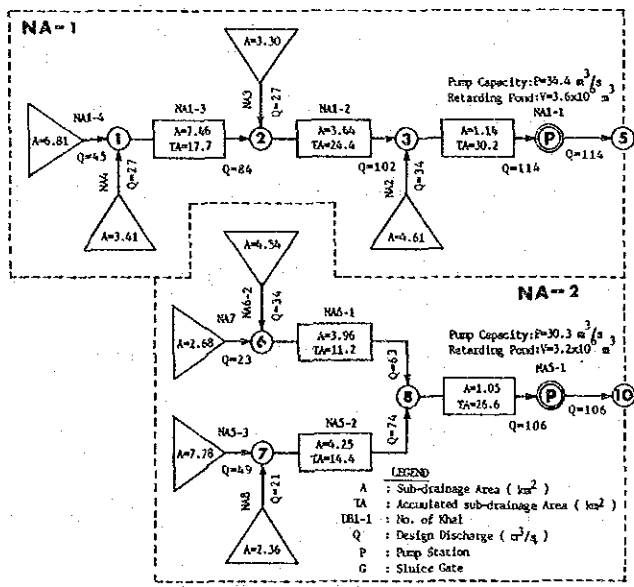
Drainage Plan



Drainage Model

Alternative I

(Single Drainage System)



Drainage Model

Alternative II

(Two Independent Drainage System)

FIG. 8.8 (4)

**DRAINAGE SYSTEM ALTERNATIVES
(DND PROJECT ZONE)**

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

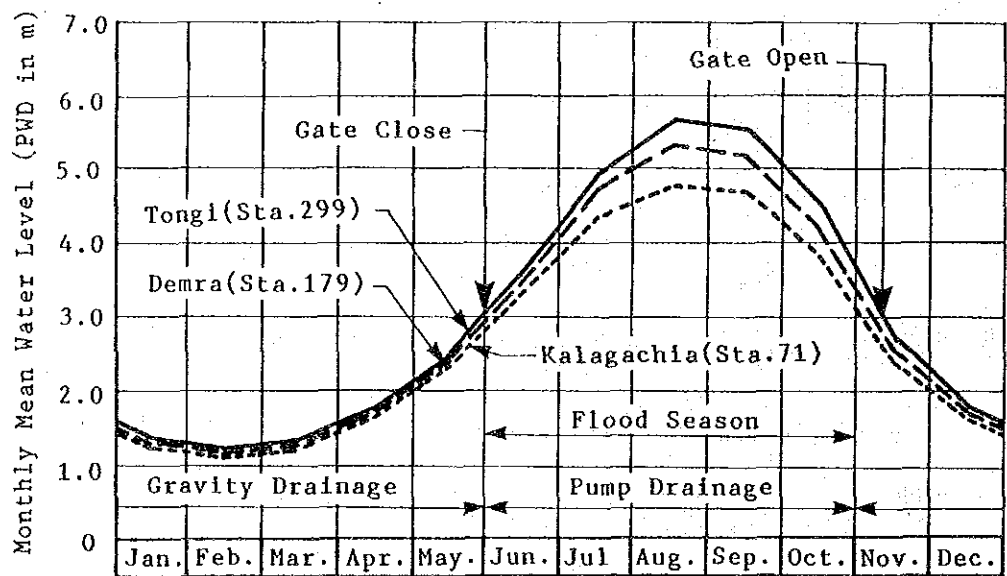
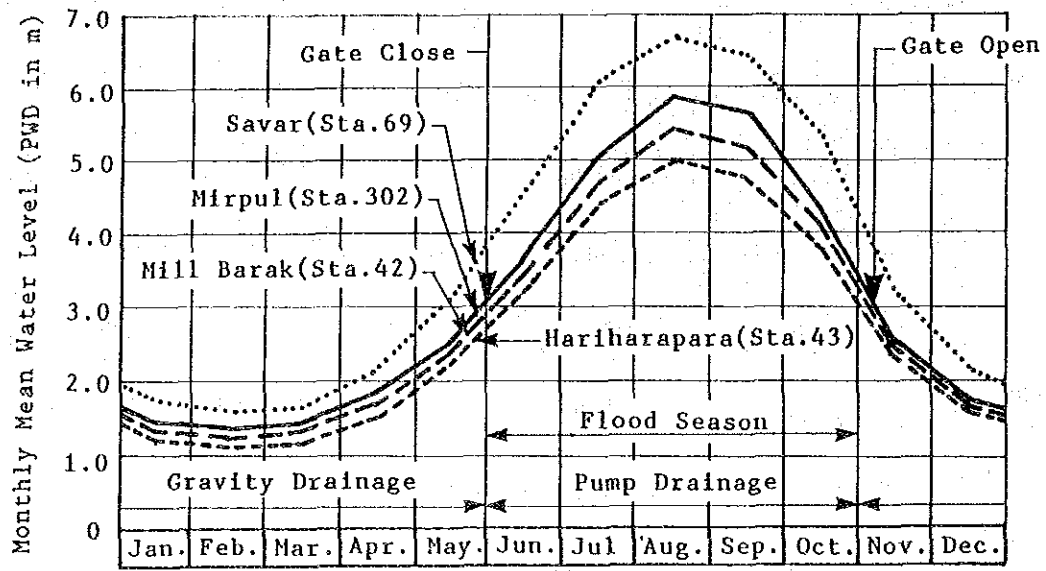
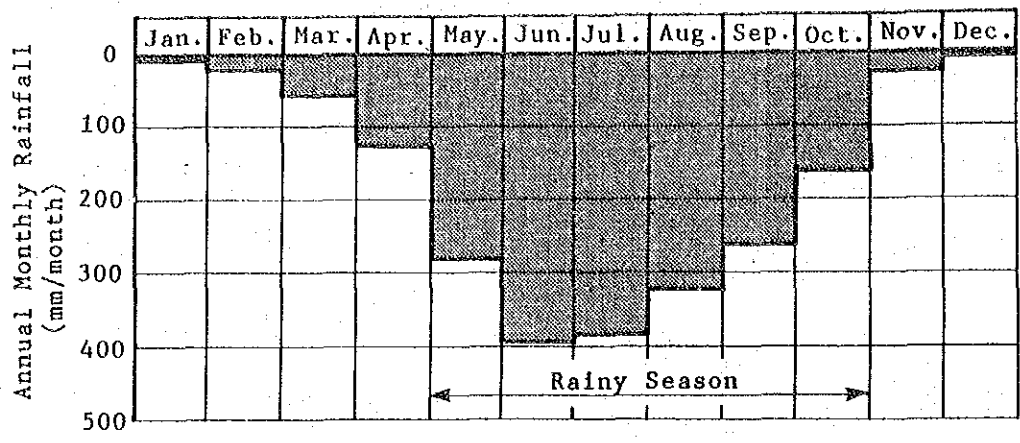


FIG. 8.9

SEASONAL VARIATION OF RAINFALL AND FLOOD WATER LEVEL IN DHAKA METROPOLITAN AREA

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

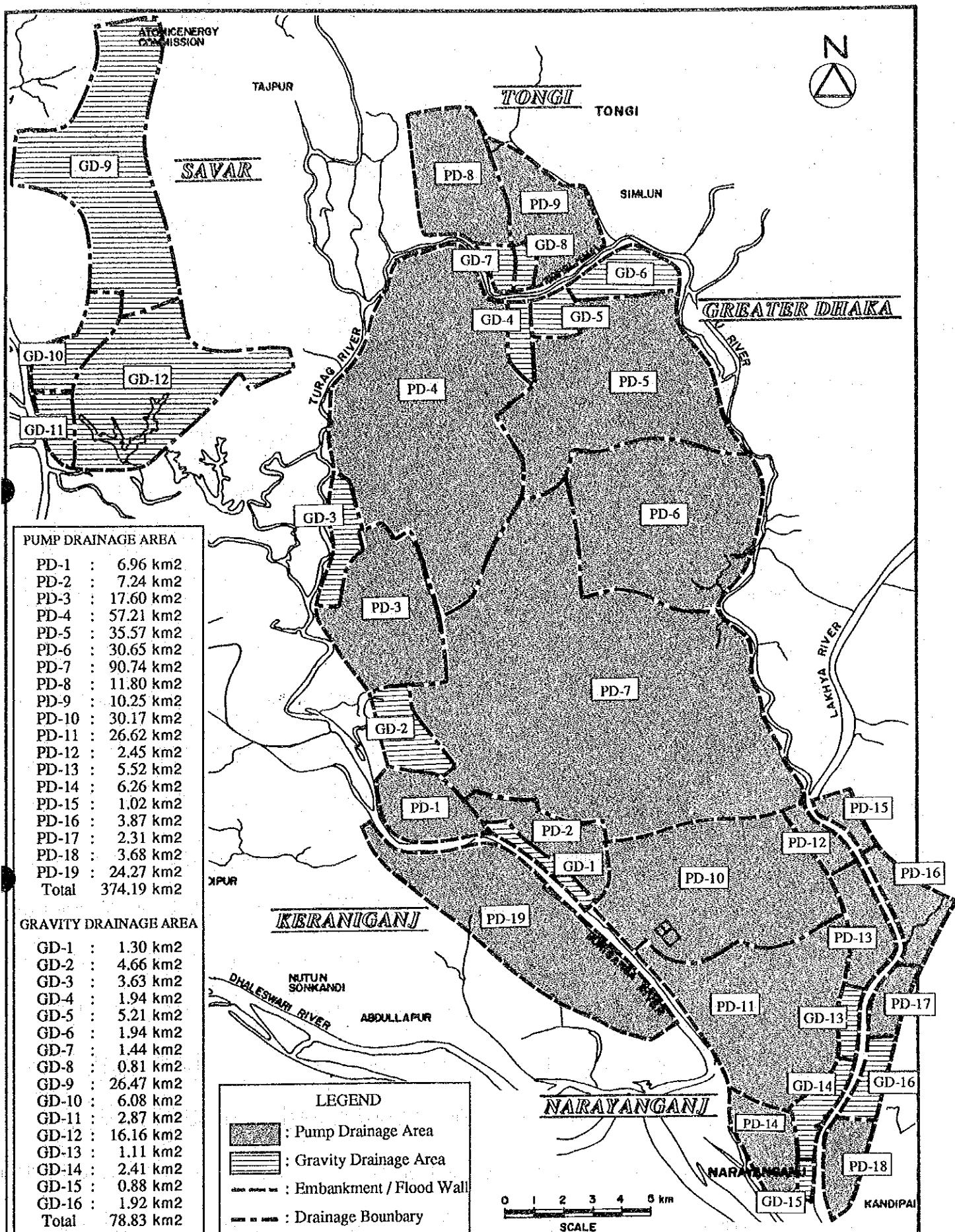


FIG. 8.10

ZONING OF GRAVITY AND PUMP DRAINAGE AREA

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

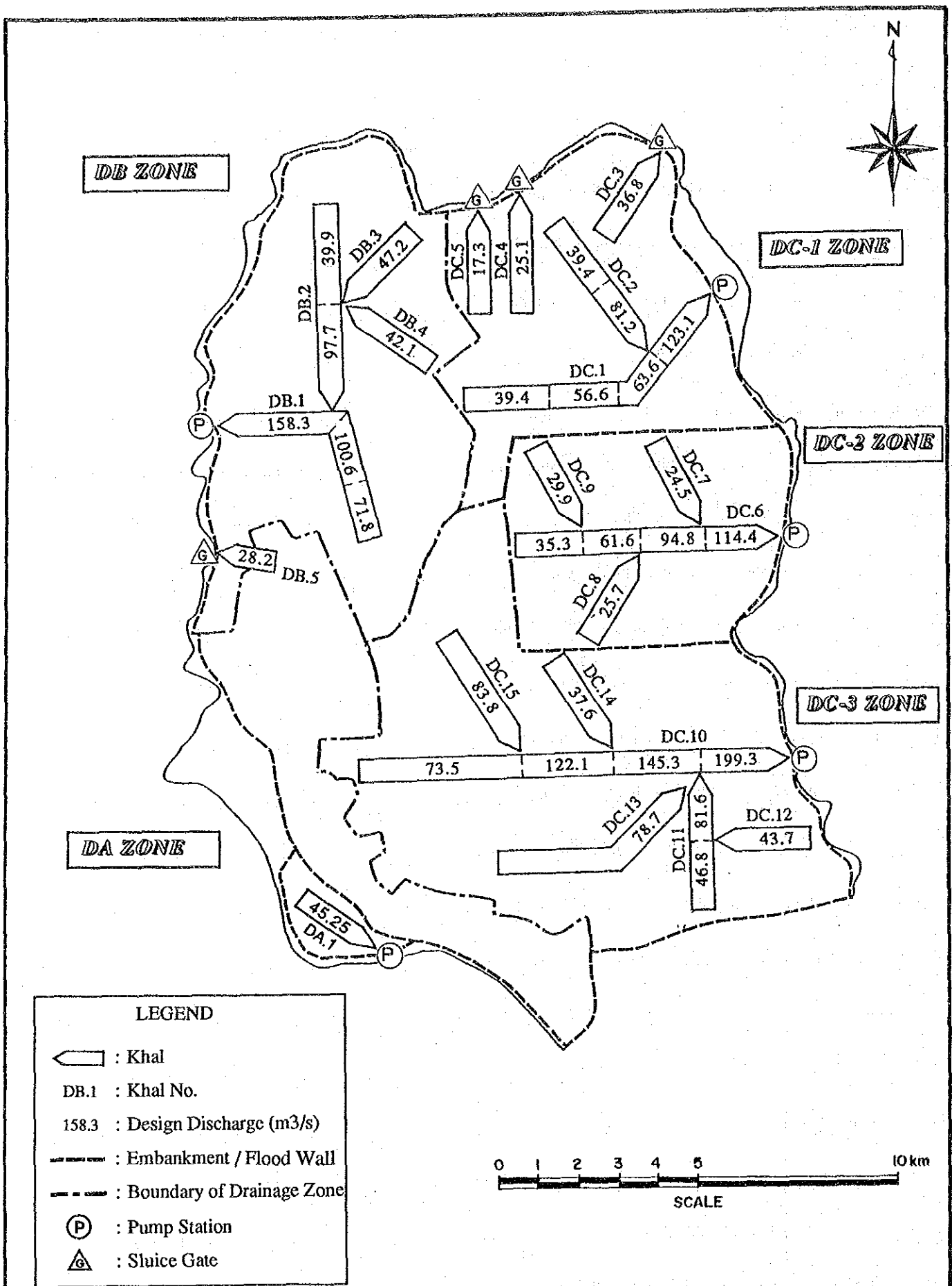
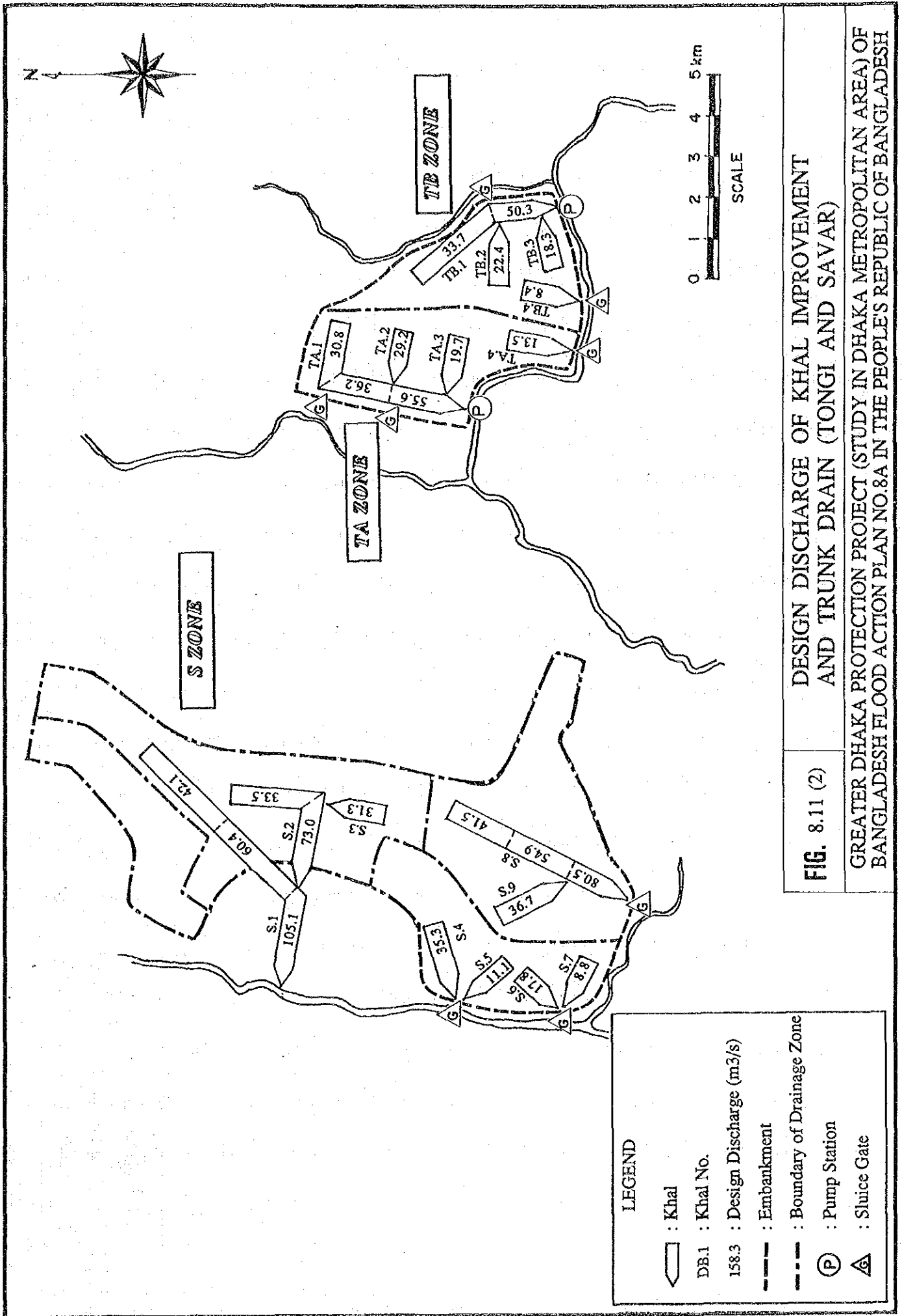
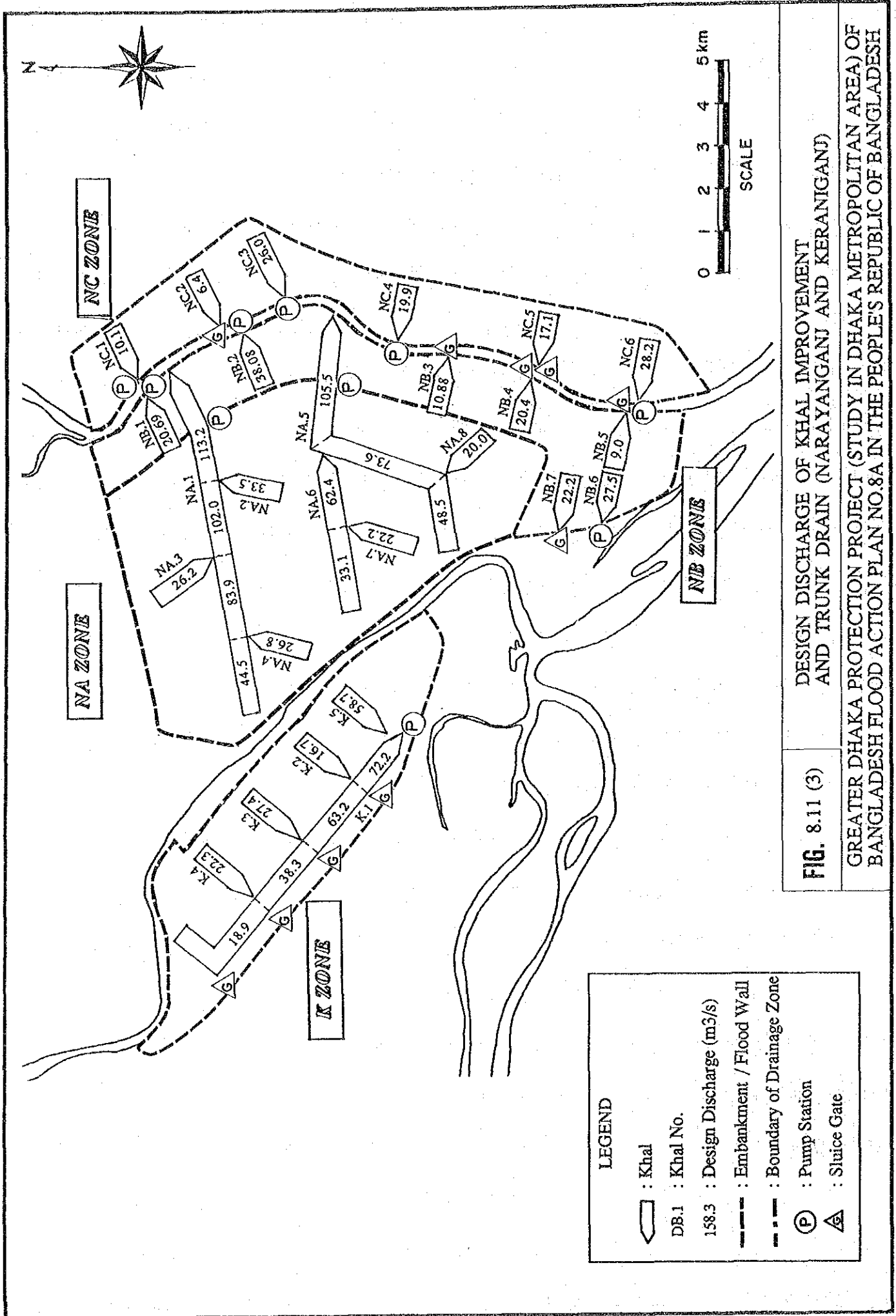


FIG. 8.11 (1)

DESIGN DISCHARGE OF KHAL IMPROVEMENT AND TRUNK DRAIN (GREATER DHAKA)

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





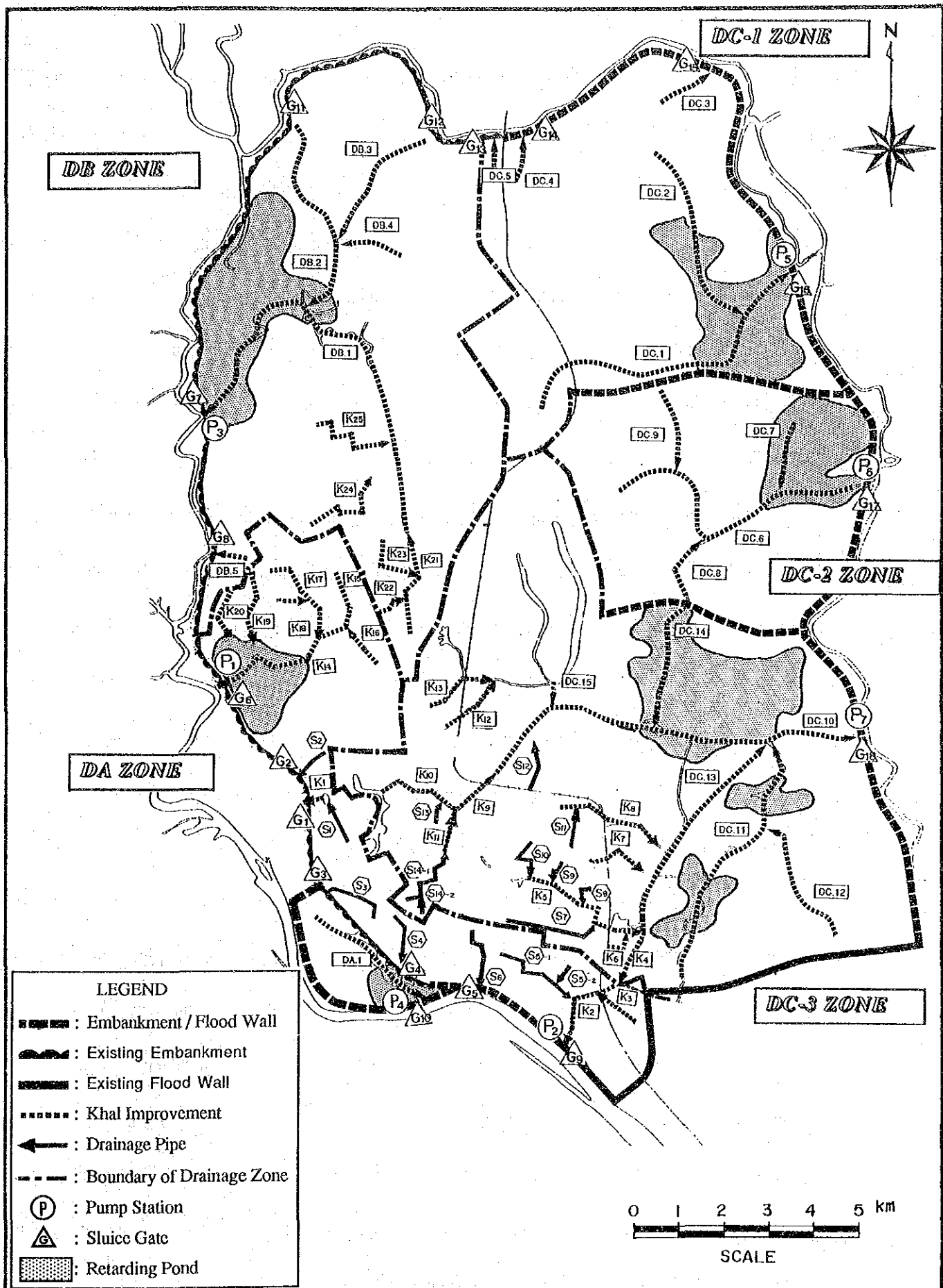


FIG. 8.12 (1)

PROPOSED FACILITIES (GREATER DHAKA)

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

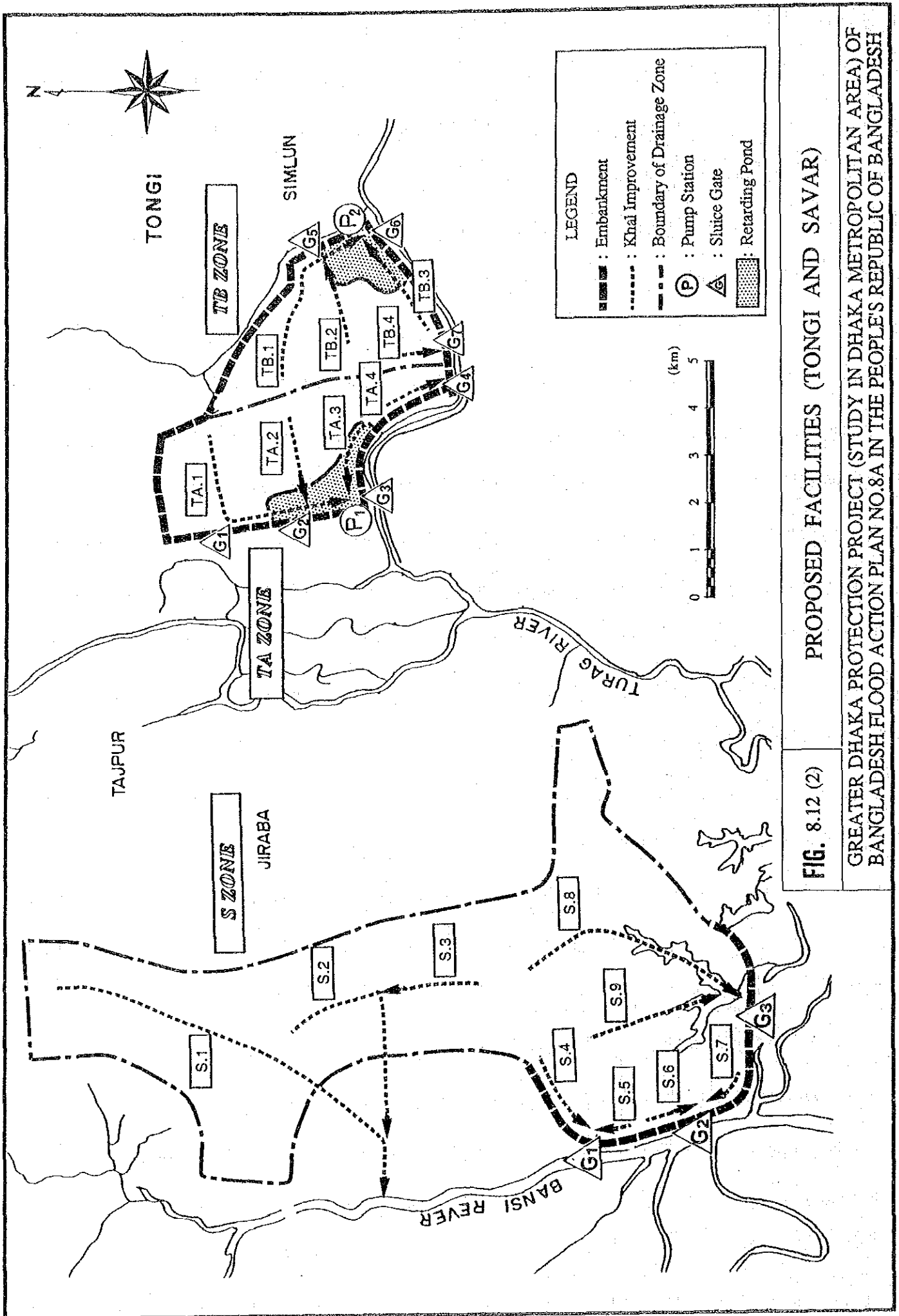


FIG. 8.12 (2)

PROPOSED FACILITIES (TONGI AND SAVAR)

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



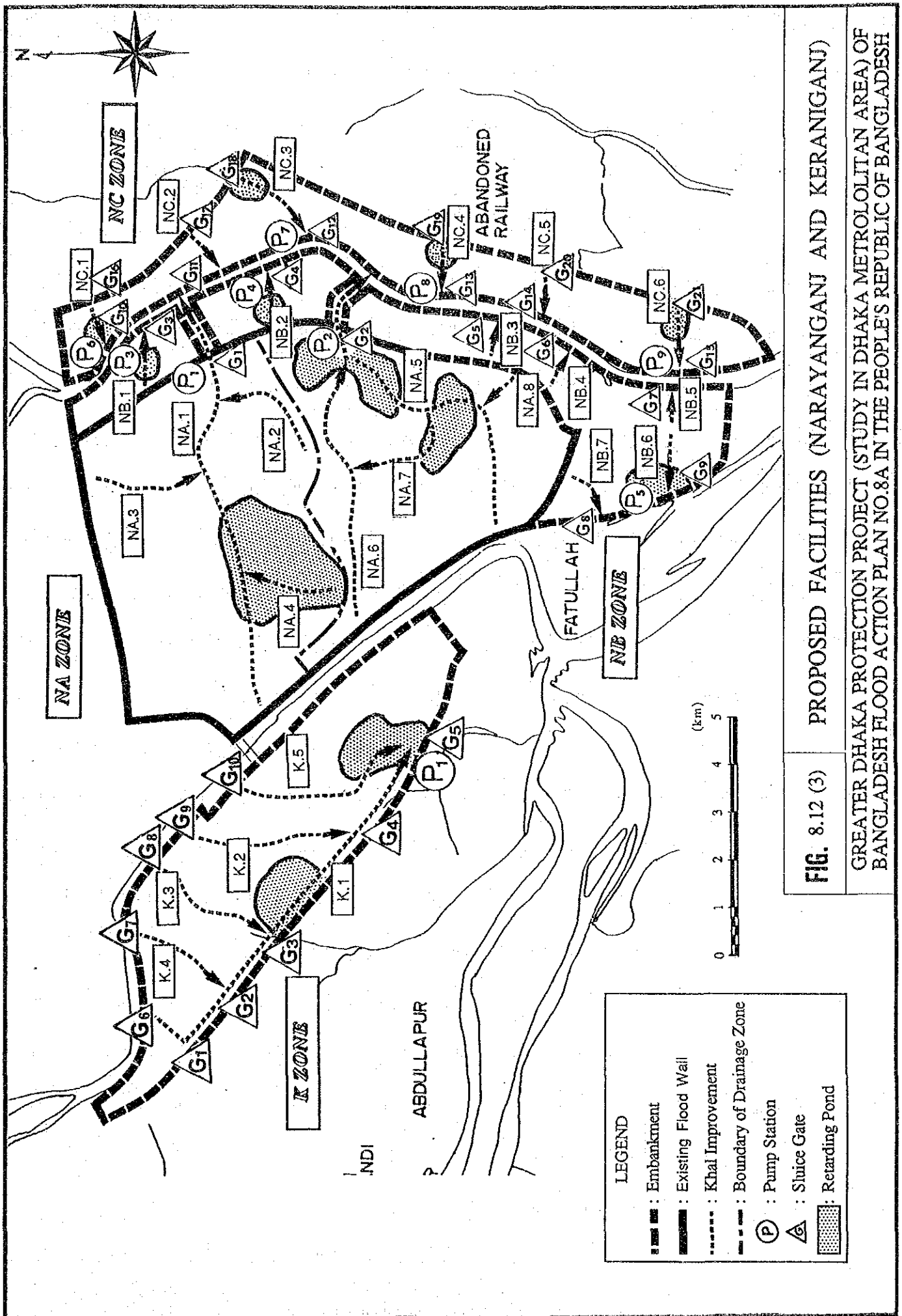


FIG. 8.12 (3) PROPOSED FACILITIES (NARAYANGANJ AND KERANIGANJ)
 GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF
 BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



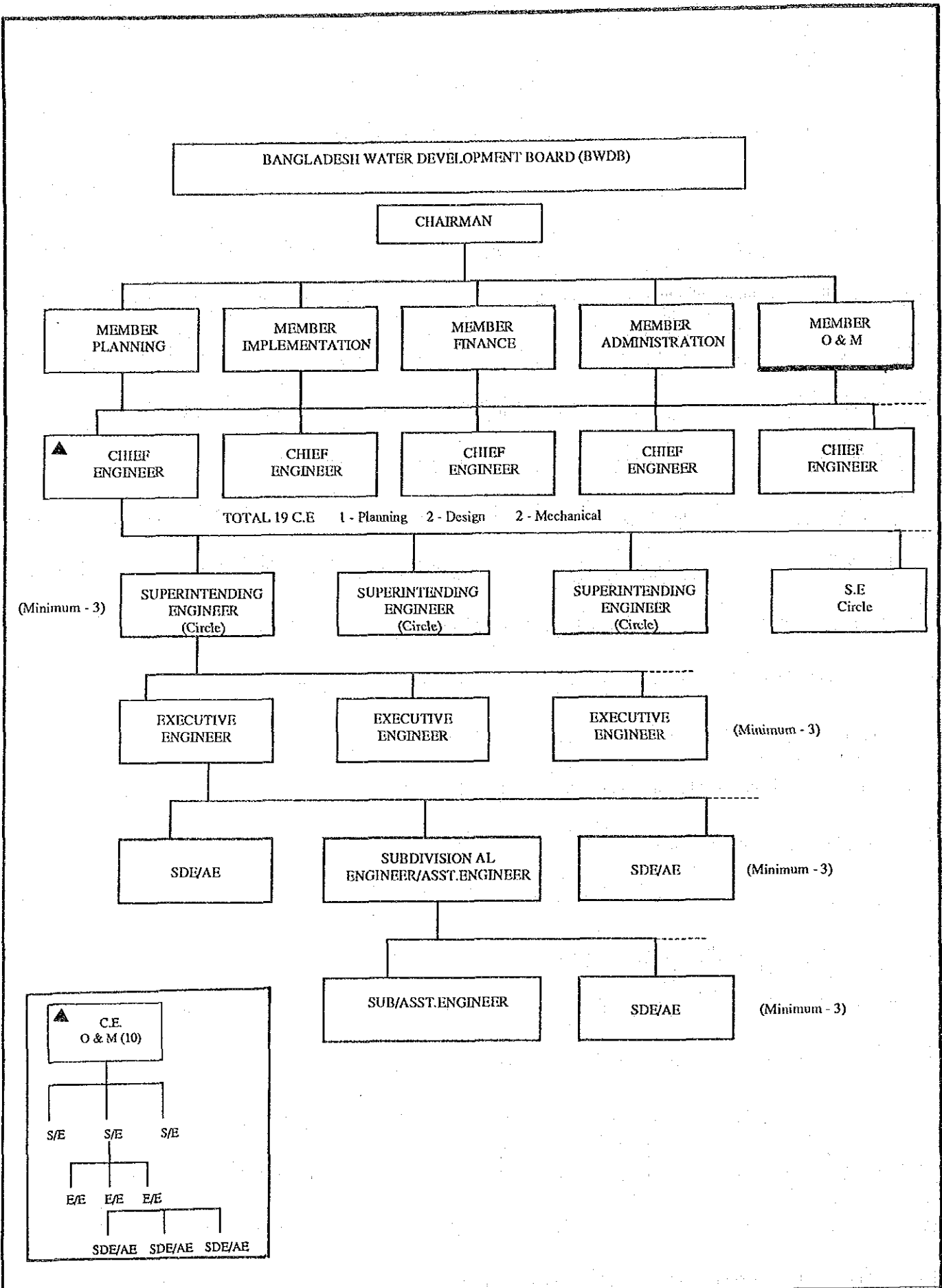


FIG. 8.13

ORGANIZATION CHART OF BWDB

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

Project Director	
Superintendent Engineer	1
Head Assistant	1
Estimator	1
Draftsman	1
Accounting Assistant	1
Steno/Typist	2
Driver/Mlss.	3
	<u>10 persons</u>

Executive Engineer	
Executive Engineer	1
Head Assistant	1
Estimator	1
Draftsman	1
Accounting Assistant	1
Typist/Cashier	2
Driver/Mlss.	3
	<u>10 persons</u>

Sub-Divisional Engineer	
Sub-Div. Engineer	1
Head Assistant	1
Accounting Assistant	1
Work Assistant	4
Typist	1
Driver	1
Pump Operator	3
Ass. Pump Operator	3
Cleaner/Mlss.	8
	<u>23</u>

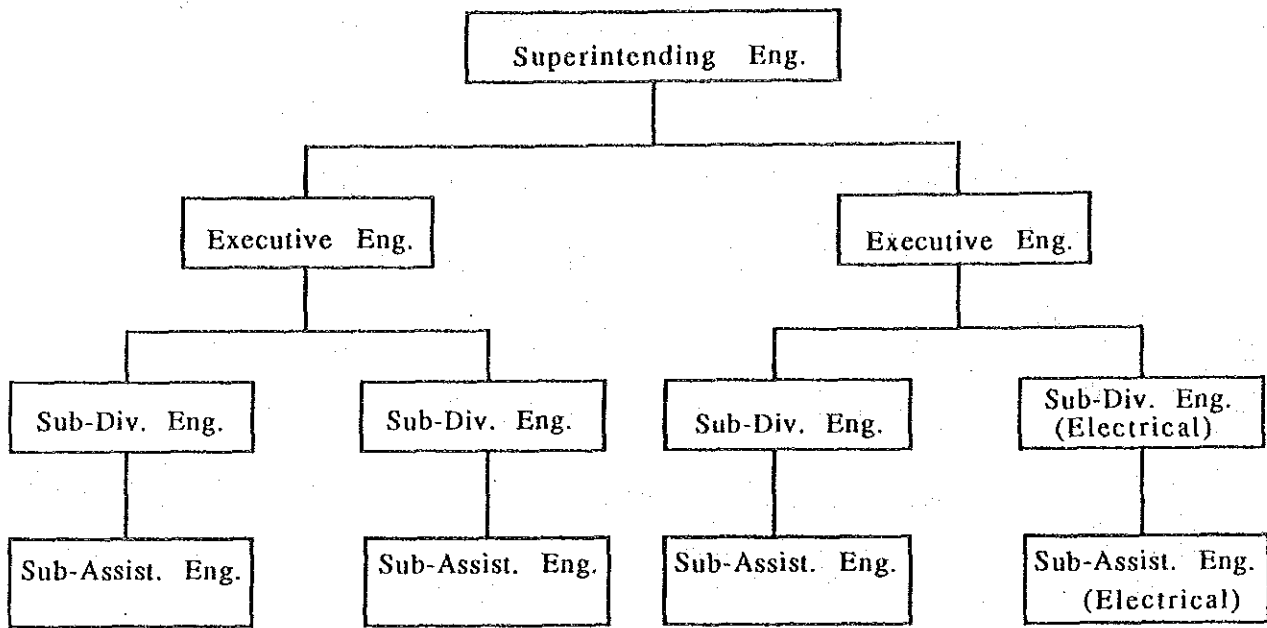
Sub-Divisional Engineer	
Sub-Div. Engineer	1
Head Assistant	1
Accounting Assistant	1
Work Assistant	5
Typist	1
Driver	1
Pump Operator	3
Ass. Pump Operator	3
Cleaner/Mlss.	10
	<u>26 persons</u>

FIG. 8.14

PRESENT ORGANIZATION OF DWASA DRAINAGE CIRCLE

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

1) PROPOSED ORGANIZATION FOR CONSTRUCTION



2) PROPOSED ORGANIZATION FOR OPERATION AND MAINTENANCE

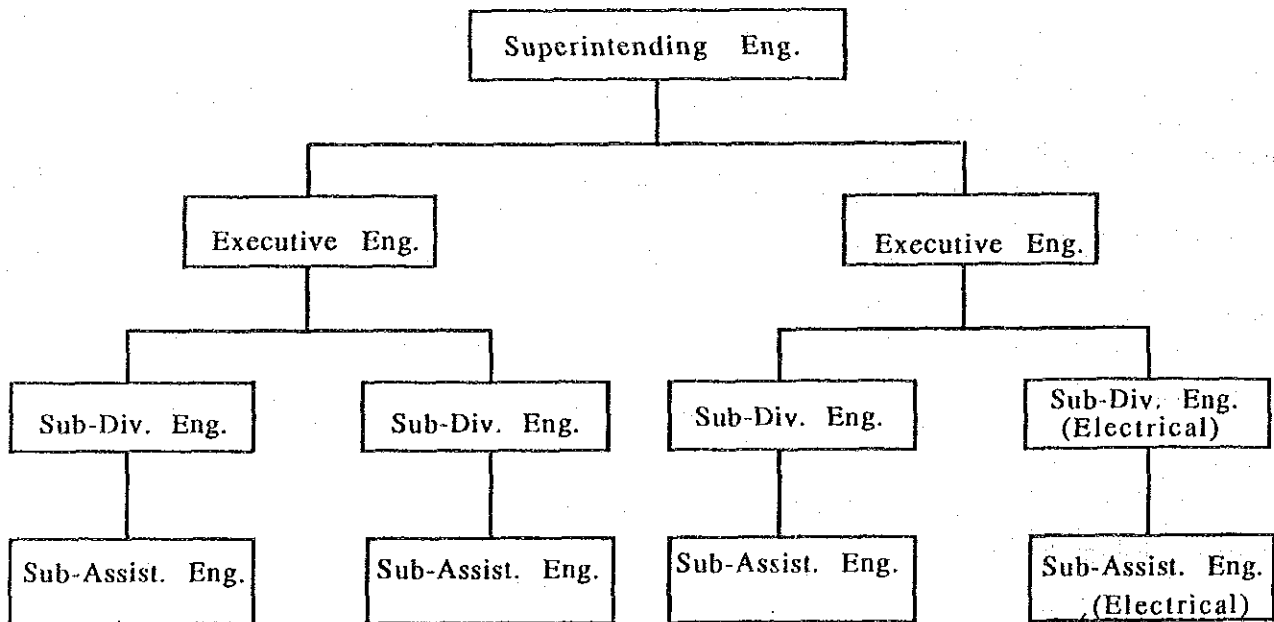


FIG. 8.15

PROPOSED ORGANIZATION FOR CONSTRUCTION,
OPERATION AND MAINTENANCE

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

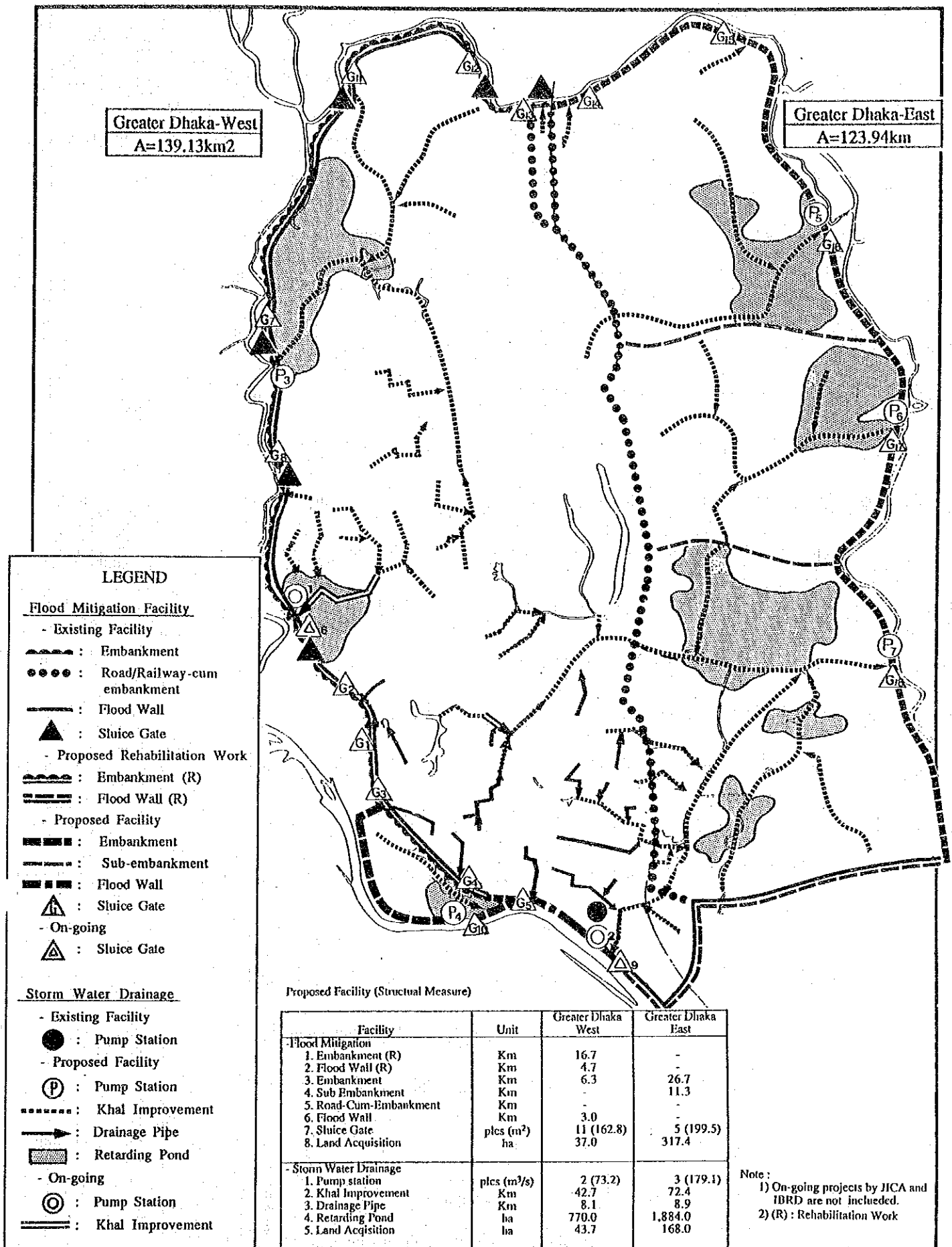


FIG. 8.16 (1)

PROJECT AREAS WITH PROPOSED FACILITIES - GREATER DHAKA - WEST AND EAST

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

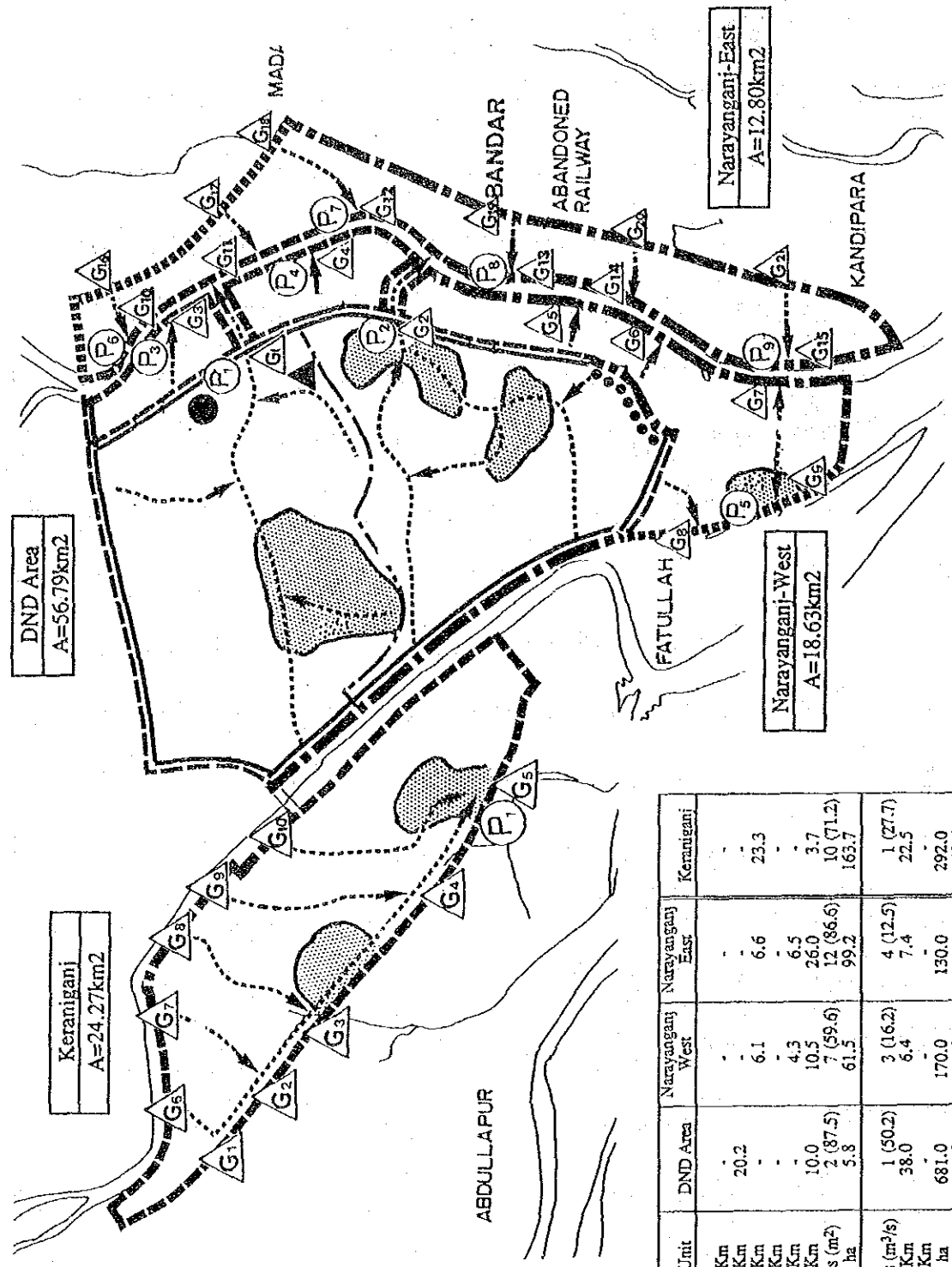
LEGEND

Flood Mitigation Facility

- Existing Facility
 - Flood Wall
 - Road/Railway-cum embankment
 - ▲ Sluice Gate
- Proposed Rehabilitation Work
 - Flood Wall (R)
- Proposed Facility
 - ▬ Embankment
 - ▬▬▬ Road-cum-embankment
 - ▬▬▬ Flood Wall
 - ▲ Sluice Gate

Storm Water Drainage

- Existing Facility
 - Pump Station
- Proposed Facility
 - Pump Station
 - Khal Improvement
 - ▬ Retarding Pond



Proposed Facility (Structural Measure)

Facility	Unit	DND Area	Narayanganj West	Narayanganj East	Keraniganj
- Flood Mitigation					
1. Embankment (R)	Km	20.2	-	-	-
2. Flood Wall (R)	Km	-	6.1	6.6	23.3
3. Embankment	Km	-	-	6.5	-
4. Sub Embankment	Km	10.0	4.3	26.0	3.7
5. Road-Cum-Embankment	Km	2 (37.5)	7 (59.6)	12 (86.6)	10 (71.2)
6. Flood Wall	pieces (m ²)	5.8	61.5	99.2	163.7
7. Sluice Gate	pieces (m ²)	1 (50.2)	3 (16.2)	4 (12.5)	1 (27.7)
8. Land Acquisition	pieces (m ²)	38.0	6.4	7.4	22.5
- Storm Water Drainage					
1. Pump station	Km	681.0	170.0	130.0	292.0
2. Khal Improvement	ha	90.8	12.2	14.1	50.6
3. Drainage Pipe					
4. Retarding Pond					
5. Land Acquisition					

Note: 1) On-going projects by JICA and IBRD are not included.
2) (R) : Rehabilitation Work

FIG. 8.16 (2) PROJECT AREAS WITH PROPOSED FACILITIES - NARAYANGANJ DND AREA, NARAYANGANJ - WEST, EAST AND KERANIGANJ

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



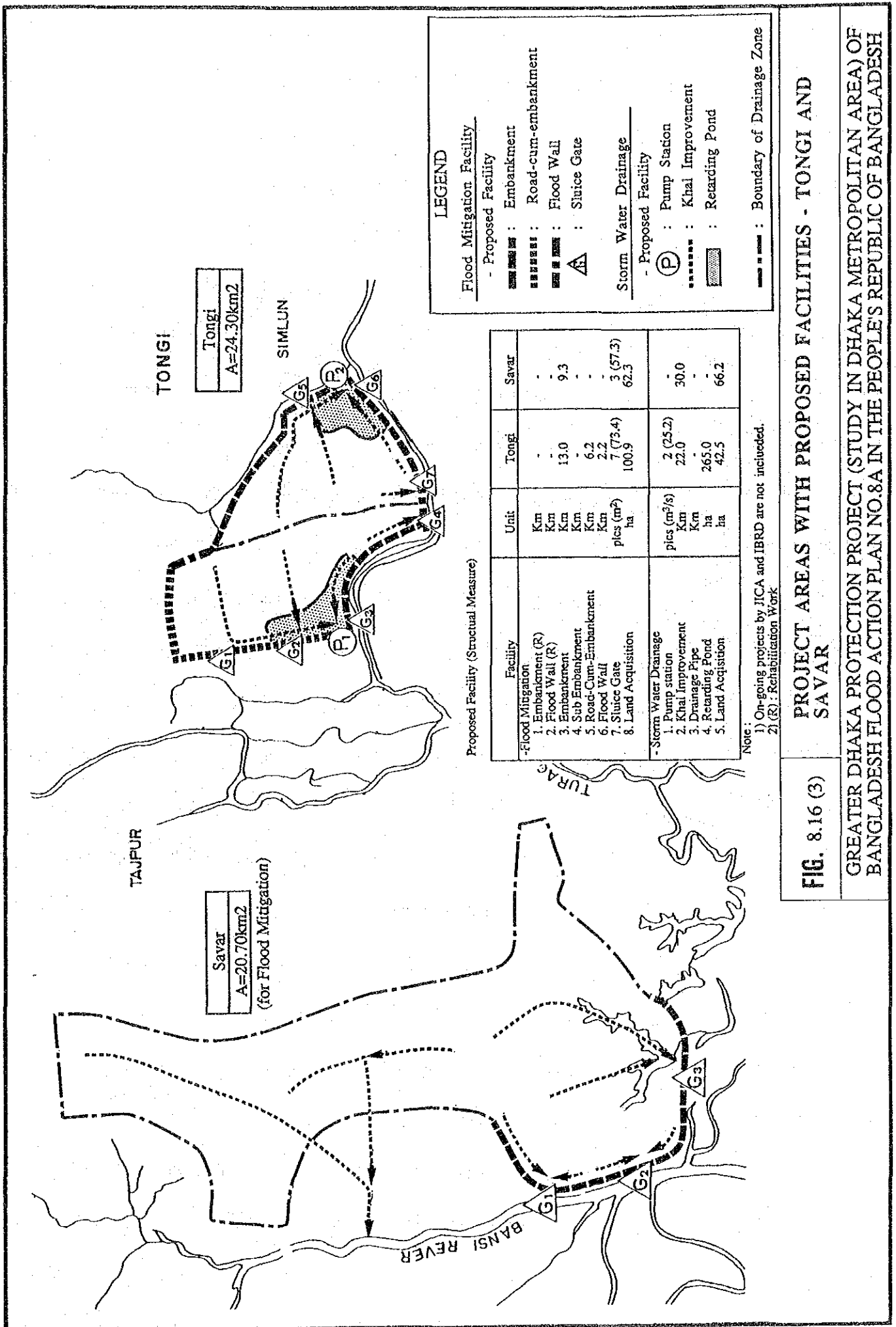
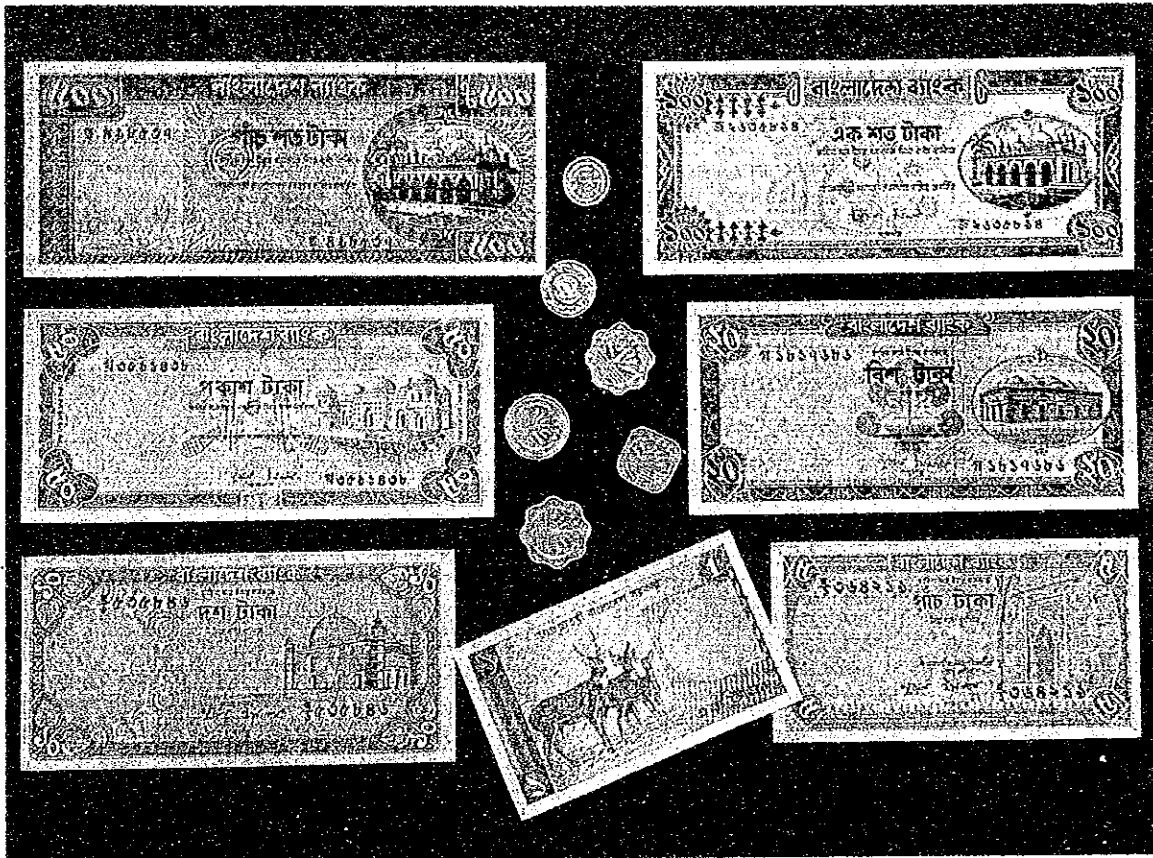


FIG. 8.16 (3)

PROJECT AREAS WITH PROPOSED FACILITIES - TONGI AND SAVAR

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





Local Currency : Taka

CHAPTER 9 PROJECT EVALUATION

GCHAPTER 9 PROJECT EVALUATION

9.1 General

The flood protection and storm water drainage project is implemented primarily to protect properties such as houses, shops, factories, roads and bridges from damage due to inundation. That is, there will be a reduction in flood damage by implementing such a project. This is the tangible benefit of the project.

On the other hand, implementation of the project entails the construction/installation of various facilities and equipment such as embankments, sluice gates, flood walls and pump stations, which have capital costs. After project implementation, these facilities and equipment have to be operated/maintained on a regular or ad hoc basis, thus incurring recurrent costs.

The project is evaluated by comparing the costs with the benefits.

In making an economic analysis, one has to convert costs and benefits into economic terms.

The period of project life is assumed to be 30 years. The opportunity cost of capital is assumed as 12%.

9.2 Economic Evaluation

9.2.1 Estimation of Benefits

Major benefits will derive from the reduction of direct flood damages to properties such as houses, shops, factories and institutions, the reduction of income losses due to inability to engage in economic activities in time of floods and the reduction of direct flood damages to agricultural crops.

The reduction of direct flood damages to infrastructure such as roads, bridges, power supply, gas supply, water supply, telecommunication and transportation facilities can also be expected. In addition, there will be a reduction of flood damage to traffic in the form of high oil consumption from taking of roundabout routes and slowing down of vehicle speeds.

The methodology for the estimation of flood damages is described in Supporting Report E. In that report, average annual flood damages for 1990 and 2010 are calculated on the assumption that the maximum return period is a hundred years. These flood damages are expected in the "without project" situation. In the "with project" situation, that is to say, in the situation where the flood protection and drainage project is implemented with the facility design based on the return period of a hundred years, the exact amount of those flood damages turns into benefits.

Thus, flood damages and project benefits are two ways of expressing the same thing.

Under Flood Action Plan 8A, the JICA Study Team proposes eight major projects, dividing the study area into the same number of areas. Those projects or areas are :

Greater Dhaka West, Greater Dhaka East, Narayanganj DND, Narayanganj West, Narayanganj East, Keraniganj, Savar and Tongi

The expected detailed benefits by item by scale of floods by Project for the present and the target year are shown in Tables 9.1(1) and (2)

Tables 9.2(1) and (2) presents summarized and more comprehensive benefits by major item by scale of floods by Project for 1990 and 2010.

In the Greater Dhaka West Project, the expected benefits in 1990 work out at Tk 897.4 million. In the target year of 2010 they will grow 2.64 times to Tk 2,366.4 million. In the Greater Dhaka East Project the expected benefits in 1990 work out at Tk 697.5 million, which will grow 2.87 times to Tk 2,000.7 million in 2010.

In the same way, in the Narayanganj DND Project, the expected benefits in 1990 and 2010 work out at Tk 206.7 million and Tk 549.0 million, respectively. In the Narayanganj West Project, the expected benefits are calculated at Tk 73.4 million for 1990 and Tk 288.4 million for 2010, while in the Narayanganj East Project the expected benefits in 1990 amount to Tk 61.0 million and in 2010 will rise to Tk 166.3 million.

In the Keraniganj Project, benefits amounting to Tk 169.4 million were expected in 1990, and in 2010, benefits are expected to reach Tk 430.3 million. In the Savar Project, the expected benefits were Tk 12.5 million as of 1990, which will increase to Tk 43.1 million in the target year. In the Tongi Project the average annual benefits for

the present are calculated at Tk 55.2 million, while in 20 years they will grow to Tk 311.2 million.

Summing up, the total benefits across the eight Projects that were expected in 1990 work out at Tk 2,173.1 million. In the target year of 2010 the total expected benefits are estimated to multiply by 2.83 times to Tk 6,155.4 million.

9.2.2 Estimation of Costs

In performing economic analysis, costs have to be converted into economic costs. To convert capital cost into economic cost, a conversion factor is employed for a specific type of works.

The employed conversion factors are 89.8% for embankment, 85.2% for flood wall, 97.2% for sluice gate, 95.1% for pump station and 88.0% for khal improvement.

Regarding land acquisition cost, it is valued as a stream of annual net benefits of production foregone in conformity to the "FAP : Guidelines on Economic (Micro) Analysis".

O/M cost is assumed to be 0.5% of capital cost excluding land acquisition cost.

Besides the above-mentioned capital and O/M costs, one has to take into consideration the cost of resettlement of people living along rivers who will not be protected by embankments.

Economic capital cost of the Greater Dhaka West Project works out at Tk 9,222.3 million, amounting to 23.7% of the total capital cost combining the eight Projects, while that of the Greater Dhaka East Project amounts to Tk 14,430.0 million, accounting for 37.1%. (Refer to Table 9.3.)

The cost related to the Greater Dhaka West embankments and Narayanganj DND flood walls which are already constructed is included in the above cost.

Capital cost for the Narayanganj DND, West and East Projects comes to Tk 3,232.1 million, Tk 1,550.0 million and Tk 2,102.0 million, accounting for 8.3%, 4.0% and 5.4%, respectively.

Capital cost of the Keraniganj Project is calculated at Tk 4,086.6 million (10.5%). Likewise, that of the Savar and Tongi Projects is calculated at Tk 1,700.7 million (4.4%) and Tk 2,589.2 million (6.7%), respectively.

The above eight economic capital cost totals Tk 38,912.9 million.

The cost of land acquisition in each Project was annualized in the form of net benefits of production foregone. Such annual cost at 1991 prices adds up to Tk 63.6 million for the eight Projects.

The cost of resettlement combining the eight Projects is estimated at Tk 413.3 million at 1991 prices based on 1990 population. Annual O/M cost of the eight Projects combined is estimated to come to Tk 194.6 million.

9.2.3 Economic Evaluation

1) Calculation of NPV, B/C and EIRR

Cost benefit streams were prepared for each of the eight Projects as well as for the combined total area covering the whole structural master plan area. Those of the combined total are shown in Table 9.4. Based on them economic analysis was conducted. The results are presented in Table 9.5.

According to Table 9.5 the Greater Dhaka West Project has the highest economic internal rate of return (EIRR) of 18.3% among the eight Projects. This EIRR is 6.3% higher than the OCC of 12%.

The second highest EIRR belongs to the Narayanganj DND Project with 14.2%. The Narayanganj West Project is placed third with 13.7%. The Greater Dhaka East Project is placed fourth with 12.3%. It is to be noted that all these four Projects have the EIRR's surpassing OCC.

The Greater Dhaka West Project has the greatest NPV reaching Tk. 4,433 million along with the highest B/C of 1.52. NPV of the Narayanganj DND, Narayanganj West and Greater Dhaka East Projects is calculated at Tk. 363 million, Tk. 177 million and Tk. 149 million, respectively, and their respective B/C's come to 1.16 and 1.14 and 1.02.

When the two Greater Dhaka Projects are combined, the EIRR is 15.3%, the NPV is Tk. 4,570 million and the B/C is 1.27. Likewise, when the three Narayanganj

Projects are bundled together, EIRR, NPV and B/C are 13.5%, Tk. 456 million and 1.11, respectively.

The Tongi, Keraniganj and Narayanganj East Projects have an EIRR of 11.8%, 10.0% and 7.4%, respectively. EIRR could not be computed for the Savar Project.

The EIRR of the eight Projects combined works out at 14.3%, which is 2.3 points above the assumed OCC. The combined NPV and B/C work out at Tk. 4,388 million and 1.18, respectively.

2) Conclusions

It follows from the above that all Projects except Narayanganj East and Savar, are positioned on or above the border line of economic feasibility. The Savar Project is judged to be not feasible, at least in economic terms.

The eight Projects envisioned under the Flood Action Plan No. 8A are intertwined in administrative, geographical, demographical and economic terms: no Project can be separated out and treated independently. Thus, the eight Projects will have to be dealt with as a single system or package. Fortunately, the eight Projects, when treated as one entity, turn out to have a sufficiently viable economic feasibility because of the dominance of the Greater Dhaka Projects.

Many more benefits than the ones incorporated in the economic analysis can be expected in the event that the Projects are implemented. There will also arise costs or negative benefits that were excluded from the quantitative evaluation.

Among these others, such benefits will include the reduction of the breakout of communicable diseases, creation of employment opportunities during and after project implementation, the releasing of psychological burdens ushering in greater socio-economic activities, and the urbanization of land or upgrading of land use leading to the greater economic values of land within the flood protected areas. On the cost side, one of the major concerns will be over some negative or disturbing impacts/effects on the ecological system and other natural conditions.

However, we conclude that the above cited unquantified benefits are significantly more real, stronger and more direct than the costs.

Further, the fundamental question is if Dhaka, the capital of Bangladesh, with a population expected to surpass thirteen million before the end of the project period, can be left open to recurrent attacks of natural calamity by debilitating floods. Flood protection of settlements is a basic need which should, and can only, be addressed by Government.

9.3 Social Impacts

The flood mitigation and storm water drainage facilities are to be executed as basic infrastructure in the urban areas to improve the existing urban environmental conditions and to enhance development potential.

Accordingly the proposed measures for the master plan will give mainly positive impacts, and the direct adverse effects by the project will be highly localized, short term and insignificant in comparison to the necessity and benefit of the project.

The likely social impacts of the project are as follows :

- (1) The forecast urban areas of 450 km² in 2010: Greater Dhaka, Narayanganj, Tongi, Savar, and Keraniganj will be safe from the flood of a 100 - years frequency or the 1988 flood by the proposed flood mitigation measures.
- (2) The forecast urban area will be improved and be less prone to uncertainty and disruption by implementation of the project.
- (3) The development potential of the urban area will be enhanced by the project. Approximately 169 km² of habitual flood prone area will become flood free urban area.
- (4) Employment opportunity will be expected to increase during the implementation stage of the project.
- (5) Enhancement of the technical competence of local engineers will be expected through on the job training during the implementation of the project.

9.4 Project Evaluation

The project evaluation is based on effectiveness in economic, social and environmental terms. However, the environmental adverse impacts will not be significant and may be non-existent.

The results of evaluation as shown in Table 9.7 are as follows :

- (1) According to the economic evaluation, all the project except Narayanganj East project and Savar project, will be feasible from flood mitigation and drainage related benefits, though the EIRR values of Tongi project and Keraniganj project at 11.8% and 10.0% respectively seem marginal compared to the high discount rate of 12%.
- (2) All the projects will have strong impacts and beneficial effects in social and environmental terms.
- (2) Based on the economic efficiency and the likely social impacts in 1990 and in 2010, the priority of each project will be as follows :

1st Priority area:

- Greater Dhaka West
- Greater Dhaka East
- DND
- Narayanganj West

2 nd Priority area:

- Tongi
- Keraniganj

3rd Priority area :

- Narayanganj East
- Savar

Table 9.1 (1) Benefits by Type of Properties by Project - 1990

Bd = Building (s), H. E = Household Effects, Ic = Income, E & I = Equipment and Inventories, Pf = Profit, Cp = Crops

1) Year 1990

Project	(Unit :Tk Million)																
	Residential			Commercial			External Flood			Industrial			Institutional		Agricultural		Internal Flood
	Bd	H. E	Ic	Bd	E & I	Pf	Bd	E & I	Pf	Bd	E & I	Pf	Bd	Bd	Cp		
(1) 1987 - Scale Flood																	(1) Annual Flood
G. Dhaka West	1,083	85	190	0	0	3	0	0	0	0	0	0	0	0	172	86	
G. Dhaka East	413	21	122	0	0	1	0	0	0	0	0	0	0	0	212	226	
Nara. DND	288	27	35	0	0	0	0	0	0	0	0	0	0	0	70	-	
Nara. West	71	3	24	0	0	0	0	0	0	0	0	0	0	0	18	-	
Nara. East	67	2	21	0	0	0	0	0	0	0	0	0	0	0	22	-	
Keraniganj	253	9	56	0	0	0	0	0	0	0	0	0	0	0	10	-	
Savar	8	0	2	0	0	0	0	0	0	0	0	0	0	0	8	-	
Tongi	58	2	13	0	0	0	0	0	0	0	0	0	0	0	12	-	
TOTAL	2,241	149	463	0	0	4	0	0	0	0	0	0	0	0	524	312	
(2) 1988- Scale Flood																	(2) Water Flood
G. Dhaka West	2,550	1,042	308	60	143	13	26	85	14	205	204	196					
G. Dhaka East	1,590	773	238	39	87	8	22	75	12	233	250	468					
Nara.DND	450	170	49	8	20	2	16	52	8	78	79	-					
Nara. West	403	181	55	14	32	3	21	72	10	29	21	-					
Nara. East	202	100	31	2	3	0	20	66	9	18	26	-					
Keraniganj	605	219	63	15	36	3	9	28	5	14	12	-					
Savar	75	32	8	1	1	0	7	21	4	13	10	-					
Tongi	195	93	25	8	22	2	54	182	30	51	14	-					
TOTAL	6,070	2,610	777	147	344	31	175	581	92	641	616	664					

Source: JICA

Table 9.1 (2) Benefits by Type of Properties by Project - 2010

Bd = Building (s), H. E = Household Effects, Ic = Income, E & I = Equipment and Inventories, Pf = Profit, Cp = Crops

2) Year 2010

(Unit: Tk. Million)

Project	External Flood														Internal Flood		
	Residential				Commercial				Industrial				Institutional			Agricultural	
	Bd	H. E	Ic		Bd	E & I	Pf		Bd	E & I	Pf		Bd			Cp	
(1) 1987 - Scale Flood																	(1) Annual Flood
G. Dhaka West	3,408	260	568	0	0	8	0	0	0	0	0	0	0	0	21	155	
G. Dhaka East	2,028	73	551	0	0	5	0	0	0	0	0	0	0	0	39	445	
Nara. DND	883	82	108	0	0	1	0	0	0	0	0	0	0	0	28	-	
Nara. West	394	18	99	0	0	1	0	0	0	0	0	0	0	2	2	-	
Nara. East	210	5	67	0	0	0	0	0	0	0	0	0	0	2	2	-	
Keraniganj	660	22	148	0	0	2	0	0	0	0	0	0	0	1	1	-	
Savar	37	1	9	0	0	0	0	0	0	0	0	0	0	1	1	-	
Tongi	360	14	80	0	0	2	0	0	0	0	0	0	0	0	0	-	
TOTAL	7,980	475	1,630	0	0	19	0	0	0	0	0	0	0	94	600		
(2) 1988- Scale Flood																(2) Water Flood	
G. Dhaka West	7,318	2,886	859	152	353	32	62	201	33	547	25	317					
G. Dhaka East	5,826	2,772	862	114	254	24	47	159	25	746	46	922					
Nara.DND	1,431	529	153	24	57	5	54	169	27	234	31	-					
Nara. West	1,229	545	165	32	71	7	58	194	28	80	3	-					
Nara. East	687	347	109	4	9	1	75	255	35	60	2	-					
Keraniganj	1,591	580	168	32	74	7	25	76	13	37	1	-					
Savar	368	158	40	3	7	1	32	105	18	64	1	-					
Tongi	1,222	580	154	52	135	11	338	1,136	186	320	0	-					
TOTAL	19,672	8,397	2,510	413	960	88	691	2,295	365	2,088	109	1,239					

Source : JICA

Table 9.2 (1) Summary of Benefits by Project

RCII = Residential, Commercial, Industrial and Institutional Properties, AC = Agricultural Crops, Ot = Others

(Unit :Tk Million)

Project	External						Flood						Internal Flood			
	1987 - Scale			1988 - Scale			RCII	AC	Ot	Total	RCII	AC	Ot	Total	Annual	Worst
	RCII	AC	Ot	RCII	AC	Ot										
(1) Year 1990																
G. Dhaka West	1,361.1	172.2	306.7	1,839.9	4,445.7	204.0	929.9	5,579.6	86.0	195.5						
G. Dhaka East	557.9	211.6	153.9	923.4	3,077.7	250.0	665.5	3,993.2	226.4	468.4						
Nara. DND	351.3	69.7	84.2	505.2	852.8	79.2	186.4	1,118.4	-	-						
Nara. West	98.6	17.5	23.2	139.3	821.5	20.9	168.5	1,010.9	-	-						
Nara. East	89.0	21.9	22.2	133.1	452.0	25.9	95.6	573.5	-	-						
Keraniganj	318.7	10.2	65.8	394.7	998.0	12.0	202.0	1,212.0	-	-						
Savar	9.6	8.3	3.6	21.5	162.9	9.7	34.5	207.1	-	-						
Tongi	72.8	11.9	16.9	101.6	660.6	13.9	134.9	809.4	-	-						
TOTAL	2,859.0	523.2	676.5	4,058.7	11,471.2	615.6	2,417.3	14,504.1	312.4	663.9						
(2) Year 2010																
G. Dhaka West	4,244.1	21.2	853.1	5,118.4	12,442.4	25.0	2,493.5	14,960.9	155.5	317.0						
G. Dhaka East	2,656.9	39.0	539.2	3,235.1	10,828.9	46.0	2,175.0	13,049.9	444.6	922.4						
Nara.DND	1,074.7	27.6	220.5	1,322.8	2,683.3	31.1	542.9	3,257.3	-	-						
Nara. West	512.1	2.4	102.9	617.4	2,408.9	2.9	482.4	2,894.2	-	-						
Nara. East	282.2	1.7	56.8	340.7	1,582.9	2.0	317.0	1,901.9	-	-						
Keraniganj	832.1	0.6	166.5	999.2	2,604.2	0.7	521.0	3,125.9	-	-						
Savar	47.1	1.2	9.7	58.0	796.7	1.5	159.6	957.8	-	-						
Tongi	455.2	0.0	91.0	546.2	4,133.1	0.0	826.6	4,959.7	-	-						
TOTAL	10,104.4	93.7	2,039.7	12,237.8	37,480.4	109.2	7,518.0	45,107.6	600.1	1,239.4						

Source : JICA

Table 9.2 (2) Summary of Benefits by Project

Project	Unit : TK Million		
	Average External	Annual Internal	Flood Total
(1) Year 1990			
G. Dhaka West	788.2	109.2	897.4
G. Dhaka East	423.4	274.1	697.5
Nara. DND	206.7	-	206.7
Nara. West	73.4	-	73.4
Nara. East	61.0	-	61.0
Keraniganj	169.4	-	169.4
Savar	12.5	-	12.5
Tongi	55.2	-	55.2
TOTAL	1,789.8	383.3	2,173.1
(2) Year 2010			
G. Dhaka West	2,179.5	186.9	2,366.4
G. Dhaka East	1,461.5	539.2	2,000.7
Nara.DND	549.0	-	549.0
Nara. West	288.4	-	288.4
Nara. East	166.3	-	166.3
Keraniganj	430.3	-	430.3
Savar	43.1	-	43.1
Tongi	311.2	-	311.2
TOTAL	5,429.3	726.1	6,155.4

Source : JICA

Table 9.3 Economic Capital Cost by Project

(Unit : Tk Million)

Project	Embankment	Flood Wall	Sluice Way	Others	Sub-Total
G. Dhaka West	2,386.4	262.5	621.1	497.3	3,767.3
G. Dhaka East	3,216.3	-	541.6	1,289.7	5,047.6
Narayanganj DND	-	330.5	278.5	167.0	776.0
Narayanganj West	249.4	111.9	277.4	216.4	855.1
Narayanganj East	364.0	357.5	409.0	388.2	1,518.7
Keraniganj	1,523.9	110.7	361.2	685.1	2,680.9
Savar	570.5	-	229.8	271.6	1,071.9
Tongi	646.2	21.6	332.1	338.6	1,338.5
TOTAL	8,956.7	1,194.7	3,050.7	3,853.9	17,056.0

(Unit : Tk Million)

Project	Pump Station	Khal Improvement	Others	Sub-Total	Total
G. Dhaka West	2,269.3	1,875.6	1,310.1	5,455.0	9,222.3
G. Dhaka East	3,925.1	3,093.3	2,364.0	9,382.4	14,430.0
Narayanganj DND	1,155.5	680.9	619.7	2,456.1	3,232.1
Narayanganj West	437.3	84.4	173.2	694.9	1,550.0
Narayanganj East	343.7	93.8	145.8	583.3	2,102.0
Keraniganj	674.5	376.8	354.4	1,405.7	4,086.6
Savar	-	464.4	164.4	628.8	1,700.7
Tongi	653.7	282.7	314.3	1,250.7	2,589.2
TOTAL	9,459.1	6,951.9	5,445.9	21,856.9	38,912.9

Note : 1. "Others" includes physical contingencies, engineering fees, administration costs, etc.

2. The capital costs of the already implemental and on-going projects are included.

Table 9.4 Cost Benefit Streams of Eight Projects Combined

CC = Capital Costs; OM = O/M Costs; CS = Costs; BF= Benefits
 CF = Cash Flow (=BF - CS)

(Unit : Tk Million)

NO.	YEAR	CC	OM	CS	BF	CF
1	1995	7934	31	7965	724	-7241
2	1996	2807	45	2852	1046	-1806
3	1997	2807	60	2867	1401	-1466
4	1998	2588	73	2661	1765	-896
5	1999	2420	84	2504	2137	-367
6	2000	3231	97	3328	2532	-796
7	2001	2967	114	3081	2957	-124
8	2002	2967	128	3095	3406	311
9	2003	2967	142	3109	3890	781
10	2004	2632	155	2787	4367	1580
11	2005	2098	163	2261	4668	2407
12	2006	1784	172	1956	4980	3024
13	2007	1784	181	1965	5300	3335
14	2008	1426	187	1613	5625	4012
15	2009	1426	195	1621	5957	4336
16	2010	1778	195	1973	6154	4181
17	2011	64	195	259	6355	6096
18	2012	64	195	259	6553	6294
19	2013	64	195	259	6753	6494
20	2014	64	195	259	6949	6690
21	2015	1680	195	1875	7152	5277
22	2016	64	195	259	7351	7092
23	2017	64	195	259	7551	7292
24	2018	64	195	259	7748	7489
25	2019	64	195	259	7947	7688
26	2020	1029	195	1224	8146	6922
27	2021	64	195	259	8345	8086
28	2022	64	195	259	8544	8285
29	2023	64	195	259	8744	8485
30	2024	64	195	259	8944	8685
31	2025	1778	195	1973	9142	7169
32	2026	64	195	259	9342	9083
33	2027	64	195	259	9540	9281
34	2028	64	195	259	9740	9481
35	2029	64	195	259	9938	9679
36	2030	1178	195	1373	10037	8664
37	2031	64	195	259	10134	9875
38	2032	64	195	259	10232	9973
39	2033	64	195	259	10329	10070
40	2034	64	195	259	10427	10168

Table 9.5 Summary of Results of Economic analysis

Project	EIRR (%)	NPV (Tk. Million)	B/C
Greater Dhaka West	18.3	4,433	1.52
Greater Dhaka East	12.3	149	1.02
Greater Dhaka Combined	15.3	4,570	1.27
Narayanganj DND	14.2	363	1.16
Narayanganj West	13.7	177	1.14
Narayanganj East	7.4	-176	0.69
Narayanganj Combined	13.5	456	1.11
Keraniganj	10.0	-263	0.85
Savar	-	-351	0.23
Tongi	11.8	-24	0.98
TOTAL	14.3	4,388	1.18

SOURCE : JICA

Note : 1) OCC is assumed as 12%

Table 9.6 Built-up Area and Population in 1990 and 2010 in Master Plan Area

ZONE	AREA (ha)	1990		2010	
		Built-up area (ha)	Population	Built-up area (ha)	Population
Greater Dhaka					
Buriganga River Left Bank Zone (DA)	3,433	2,855	1,829,107	3,715	2,989,701
Turag River Left Bank Zone (DB)	6,084	2,200	435,000	4,326	1,095,444
Balu River Right Bank Zone (DC)	16,725	6,859	2,177,887	13,005	4,502,091
Northern Area (DC-1)	4,586	1,050	334,000	3,880	1,375,932
Central Area (DC-2)	3,065	549	174,263	1,497	512,861
Southern Area (DC-3)	9,074	5,260	1,669,624	7,628	2,613,298
Total	26,242	11,914	4,441,994	21,046	8,587,236
Tongi					
Tongi West Zone (TA)	1,324	619	96,737	1,166	391,748
Tongi East Zone (TB)	1,106	413	41,459	778	261,166
Total	2,430	1,032	138,196	1,944	652,914
Savar	5,652	2,058	131,496	4,503	410,268
Narayanganj					
DND Project Zone (NA)	5,679	2,174	448,590	4,270	1,313,749
Narayanganj West Zone (NB)	1,863	1,312	470,449	1,720	926,820
Narayanganj East Zone (NC)	1,280	746	130,571	1,148	266,204
Total	8,821	4,232	1,049,610	7,138	2,506,773
Keraniganj	2,427	735	220,878	2,000	457,252
Grand Total	45,572	19,971	5,982,174	36,631	12,614,443

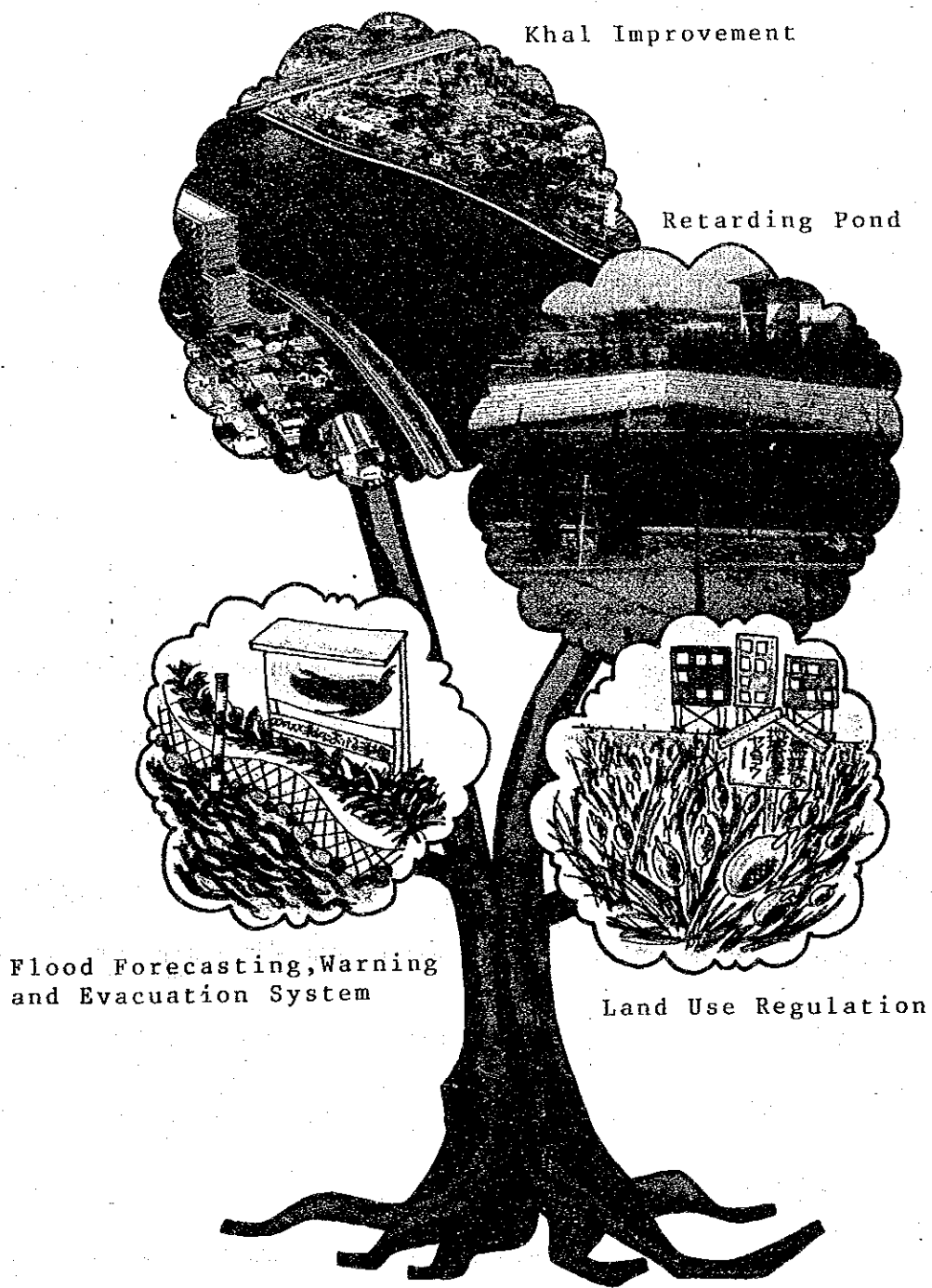
Table 9.7 Project Evaluation

	Greater Dhaka		Narayanganj			Keraniganj	Savar	Tongi
	West 1/	East 2/	DND	West	East			
EIRR (%)	18.3	12.3	14.2	13.7	7.4	10.0	-	11.8
	15.3		13.5					
NPV (Tk. Million)	4,433	149	363	177	-176	-263	-351	-24
	4,570		456					
B/C	1.52	1.02	1.16	1.14	0.69	0.85	0.23	0.98
	1.27		1.11					
Study Area (km ²)	95.1	167.3	56.8	18.6	12.8	24.3	50.5	24.3
Social impact on Built-up Area (km ²) in 1990	50.6	68.6	21.7	13.1	7.5	7.4	20.6	10.3
Population in 1990	2,264,000	2,178,000	449,000	470,000	131,000	221,000	131,000	138,009
Population Density at Build-up area (Pop./ha)	447	317	207	359	175	298	63	134
Likely social impact on New Develop Area (km ²)	29.8	61.5	21.0	4.1	4.0	12.7	24.5	9.1
Population in 2010	4,085,000	4,502,000	1,314,000	927,000	266,000	457,000	410,000	652,000
Population Density	508	346	307	539	232	228	91	235
Environmental Adverse impact	not significant	not sig.	not sig.	not sig.	not sig.	not sig.	not sig.	not sig.
Evaluation 3/								
Economic Efficiency	A	A	A	A	C	B	C	B
Present Social Impact	A	A	B	A	C	B	C	B
Future Social Impact	A	A	A	B	C	B	C	B
Area Priority	A	A	A	A	C	B	C	B

Note : 1) Greater Dhaka-West : Buriganga River/Turag River left bank zones

2) Greater Dhaka-East : Balu River left bank zone

3) Evaluation : High Low
A B C



CHAPTER 10
**GUIDELINES FOR FLOOD
PLAIN MANAGEMENT AND
URBAN DEVELOPMENT**

CHAPTER 10 GUIDELINES FOR FLOOD PLAIN MANAGEMENT AND URBAN DEVELOPMENT.

10.1 General

The study area of 850 km² is divided into two categories from the flood plain management aspect, the flood prone area and the flood free area,

The urban areas such as Dhaka, Tongi, Narayanganj, Savar and Keraniganj, have been developed partly on the elevated flood free areas. However, the areas are already densely populated, and expansion now is towards surrounding flood hazard low lying areas.

The flood prone low lying areas are mostly in agricultural use. There are also a large number of rural settlements, where some 580,000 people suffered during the 1988 flood.

For effective management of land use and proper development of the future urban area, proper guidelines for flood plain management and low-lying area development will be required from the flood mitigation and drainage improvement aspects.

For effective management and proper development of the flood plain areas, the following aspects should be considered :

- Flood forecasting and warning systems will be incorporated with FAP 10, to strengthen BWDB's "Flood Forecasting and Early Warning System" by improving telemetry, radar coverage, radio links, data management and flood modelling.
- For evacuation purposes, people in flood plain should be provided with evacuation road networks and evacuation shelters. The elevation of road surfaces should be higher than the flood stages of a 10 to 20 year flood frequency or be about 0.6m higher than the ground level of the rural settlement areas in flood plains.
- The forthcoming UNDP assisted studies will provide the necessary Structure Plans and Transport Plan for Dhaka city which will be the essential tools for the long term planned development of Dhaka city.
- From the flood control and storm water drainage improvement aspects, the provision of optimum scale of trunk drains, retarding ponds, park and open space is very important.

- Based on the inventory, appropriate Government policies and strategies for rationalization of the use of vacant and underutilized lands for effective use shall be adopted.
- Land management and development of flood plain areas shall consider features of flood flows from the hydraulic aspects.

10.2 Flood Prone Area and Population

Out of the study area of 850 km², high lands of 200 km² are free from flood and selected low-lying areas of 299 km² will be protected by the proposed flood mitigation facilities to a safety level of a 100-year flood frequency. However, the remaining low-lying areas of 328 km² will be left unprotected as before, while major river areas of 23 km² are not included in the flood plain area. Such unprotected flood plains are as follows .

1) Buriganga/Dhaleswari River Flood Plain	:	152 km ²
2) Turag River Flood Plain	:	100 km ²
3) Savar South Flood Plain	:	44 km ²
4) Savar North Flood Plain	:	16 km ²
5) Buriganga Lower Left Bank Flood Plain	:	11 km ²
Total	:	328 km ²

The above flood plains were consecutively damaged by severe floods in 1987 and 1988. The affected population in the respective flood plains are estimated as follows :

		(population)	
		<u>1987 Flood</u>	<u>1988 Flood</u>
1)	Buriganga/Dhaleswari	280,000	292,000
2)	Turag	55,000	63,000
3)	Savar South	123,000	178,000
4)	Savar North	5,000	21,000
5)	Buriganga Lower Left	27,000	30,000
	Total	490,000	584,000

10.3 Proposed Organization

Flood plain management involves the activities of flood forecasting and warning, flood evacuation and relief, and land use regulation.

Presently such activities are carried out by various organizations. Flood forecasting and warning has been carried out by BWDB. Evacuation and relief activities have involved the municipal bodies, the Ministry of Relief and Rehabilitation, the President's Flood Monitoring Center, the Army, etc. Land development has been undertaken by RAJUK, the Ministry of Local Government and the municipal body.

For the smooth and effective implementation of flood plain management, the establishment of a committee is recommended.

This committee should be composed of members of the following organizations : BWDB, SPARRSO, BUET, BMD, DWASA, MOLG, MORR, DDC, Army, the respective Municipal bodies, and other related authorities.

10.4 Flood Forecasting and Warning System

Flood forecasting and warning has been carried out by the Flood Forecasting and Warning Center of Hydrology-2, BWDB, in cooperation with MPO, SPARRSO and other concerned agencies.

The existing flood forecasting mechanism is limited to a few water level monitoring stations along the Ganges, the Brahmaputra River, the Buriganga and the Lakhya River, due to lack of hydrological observation equipment, telecommunication equipment and trained personnel.

There are only two river stage monitoring stations located within the study area.

These two stations are inadequate for forecasting flood water levels considering the vast expanse of the flood plains.

Though FAP 10 will propose necessary measures to improve the BWDB's flood warning systems, the following strengthening measures to the existing flood forecasting and warning system are proposed in order to realize a more practical flood forecasting and warning system.

- (1) Establishment of water level gauging stations in the flood plain area. The proposed locations are Abdullahpur in the Buriganga/Dhaleswari flood plain and Qusimpur in the Turag flood plain.

- (2) Establishment of telecommunication/wireless link between the major water level monitoring stations and the Flood Forecasting and Warning Center. The monitoring stations are proposed for the upazila offices of Savar, Tongi, Keraniganj and Narayanganj.
- (3) Upgrading of the regional flood forecast model for detailed regional forecasting, in cooperation with the authorities/agencies concerned.
- (4) Improvement of the flood warning system up to the Upazila level by establishing/strengthening the flood warning section in the Upazila Offices of the flood plain area.

In addition, bilateral cooperation with the concerned flood forecasting/warning agencies across the border in India in the upstream reaches, for the exchange of information, is necessary.

10.5 Flood Evacuation System

During the 1988 flood, flood levels at Dhaka and Narayanganj were announced on radio and television. However, no evacuation order was issued by the authorities concerned.

People in the flood plain evacuated themselves only after the depth of inundation was already too high.

In order to evacuate people effectively from floods, the following measures are required;

- (1) For the rural settlements which are located more than 2 km away from the neighboring flood free land, a flood evacuation and relief section in the Upazila Office should be equipped with necessary telecommunication facilities to enable communication with the Evacuation & Relief Center.
- (2) It is important to inform the people of water levels before giving evacuation orders in the respective flood plains.

The danger water levels are recommended to be set about 0.3 m lower than the existing mean residential ground level for the respective water monitoring station in due consideration to the rise in flood level of 0.3m in one day during the 1988 floods. The residential ground level in the flood plain is assessed to be 3 to 5 years flood frequency.

The danger water levels are proposed and shown in Table.10.1 and Fig.10.1.

- (3) Provision of evacuation shelters are recommended in order to avoid flood casualties. The shelters are only proposed for the flood plains of Keraniganj and Savar, considering the distance from the neighboring flood free lands.

The location of the shelters must take into consideration the flood risk map, flood streams, trunk road and distribution of the population.

- (4) The evacuation roads shall link the evacuation centers and the rural settlements in the flood plain.

The minimum road requirement are proposed as follows :

- (a) The minimum top elevation of the evacuation road is recommended to correspond to a 10 to 20 year return period floods which is essentially 0.6 m above the average ground elevation of the existing house base. This will take into account the time needed for evacuation.
- (b) The road width should be more than 2 lanes.
- (c) The road should be strong enough even in submerged condition.
- (d) The road should have guide posts in order to identify its location even when submerged.

The proposed locations of evacuation roads and shelters are shown in Figs.10.2(1) and 10.2(2).