3.4.2 Simulation of the 1988 Flood

Simulation of the 1988 flood is conducted to evaluate the hydraulic effect with and without the project.
The basic concept and the river network of the hydraulic simulation model for the study area are shown in Figs. 3.7 and 3.8.

During the 1988 flood, the study area was divided into three zones, the main stream zone, the dead water zone and the flood free zone. The main stream zone is the zone with high velocity of flood water, while the dead water zone is the zone with low velocity of flood water in the flood plains.

The main stream zone during the 1988 flood was estimated by interpretation of the Spot Image (February and March 1989). River cross sections surveyed by BWDB and the JICA Study Team along the main stream zone are used for the simulation model (refer Fig. 3.2).

The sub-catchments of the simulation model, and their storm run-off during the 1988 flood, were estimated by rational formula, as shown in Figs. 3.9 and 3.10 respectively.

The Manning's roughness coefficient of river channel is studied by using the rating curves of BWDB at Nayarhat (Sta. 14.5), Demra (Sta. 179) and Mirpur (Sta. 302). The results are shown in Fig. 3.11. Manning's roughness coefficients for the rivers in the study area are set as follows :

Manning's Roughness Coefficient

River	Main Stream Zone	Dead Water Zone
Dhaleswari River	0.025	0.100
Bansi River	0.030	0.100
Buriganga River	0.030	0.100
Turag River	0.030	0.100
Lakhya River	0.030	0.100
Balu River	0.030	0.100
Tongi Khal	0.030	0.100
Karnatali River	0.030	0.100

The hydraulic boundary condition of the model is obtained by the daily discharge from outside the study area through the Bansi River, the Turag River, the Balu River, the Lakhya River and the Kaliganga River, and the daily maximum water level / discharge at Kalagachia.

Boundary discharge from the Bansi River and the Lakhya River are obtained by using the daily maximum water level and the rating curve of BWDB at Nayarhat (Sta. 14.5) and Demra (Sta. 179) respectively. The daily maximum water level of Demra (Sta.179) is estimated from the daily maximum water level at Demra (Sta.7.5) by using their correlation. Boundary discharges from the Turag River, the Balu River and the Kaliganga River are estimated by trial and error while conducting calibration of the simulation. The boundary water level at Kaligachia is obtained from the recorded maximum water level as shown in Fig.3.12.

According to the calibration results, daily maximum water levels at all gauging stations are simulated as almost the same as observed water levels, as shown in Fig. 3.12.

Variations of simulated daily maximum discharges of each river, and their peak discharge distributions during the 1998 floods, are shown in Fig. 3.13.

Table 3.1 List of Rainfall Gauging Stations and Available Data

STATION NAME	AGENCY	STAION NO.	LOCATION		DATE OF ESTAB-LISHMENT	MEASUREMENT	DATA	REMARKS
1) DHAKA	B.M.D.	-	Latitude : Longitude :	23 deg. 46.0 min. N 90 deg. 23.0 min. E	1949	Manual Auto	1953 - 1990	Auto recorder(1957 - 1983)
2) NARAYANGANJ	B.M.D.	-	Latitude : Longitude :	23 deg. 37.0 min. N 90 deg. 30 .0min. E	1867	Manual	1948 - 1979	Closed in 1979
3) DHAKA	BWDB	9	Latitude : Longitude :	23 deg. 47.2 min. N 90 deg. 24.2 min. E	08. 07. 1960	Manual Auto	1957 - 1990	Involved in Dhaka(B.M.D.) in 1985
4) JOYDEBPUR	BWDB	17	Latitude : Longitude :	24 deg. 00.0 min. N 90 deg. 25.0 min. E	11. 03. 1961	Manual	1961 - 1990	
5) SAVAR	BWDB	31	Latitude : Longitude :	24 deg. 01.0 min. N 90 deg. 11.0 min. E	23. 11. 1961	Manual	1962 - 1990	
6) NARSINDI	BWDB	76	Latitude : Longitude :	23 deg. 57.3 min. N 90 deg. 44.5 min. E	06. 03. 1961	Manual	1961 - 1990	
7) BANCHARAMPUR	BWDB	351	Latitude : Longitude :	23 deg. 44.5 min. N 90 deg. 45.7 min. E	02. 03. 1961	Manual	1961 - 1990	
8) DAUDKANDI	BWDB	357	Latitude : Longitude :	23 deg. 32.0 min. N 90 deg. 43.0 min. E	27. 06. 1961	Manual	1983 - 1990	
9) MUNSHIGANJ	BWDB	365	Latitude : Longitude :	23 deg. 33.1 min. N 90 deg. 32.2 min. E	25. 11. 1960	Manual	1963 - 1990	
10) NARAYANGANJ	BWDB	368	Latitude : Longitude :	23 deg. 36.8 min. N 90 deg. 30.2 min. E	-	Manual	1961 - 1977	Closed in 1977
11) NAWABGANJ	BWDB	412	Latitude : Longitude :	23 deg. 39.5 min. N 90 deg. 10.0 min. E	13. 03. 1961	Manual	1965 - 1990	

Table 3.2 List of Water Level Gauging Stations and Available Data

STATION NAME	AGENCY	STAION NO.	RIVER	LOCATION	DATE OF ESTAB-LISHMENT	MEASUREMENT	DATA OF WATER LEVEL	DATA OF DISCHARGE	DATA OF RATING CURVE
1) PUBAIL	BWDB	7	Balu	Latitude : 23 deg. 56.5 min. N Longitude : 90 deg. 29.8 min. E	26. 6. 1945	Manual	1945 - 1990	-	-
2) DEMRA	BWDB	7.5	Balu	Latitude : 23 deg. 44.0 min. N Longitude : 90 deg. 30.0 min. E	21. 10. 1964	Manual	1962 - 1990	1979 - 1989	1979 - 1987
3) NAYARHAT	BWDB	14.5	Bansi	Latitude : 23 deg. 54.7 min. N Longitude : 90 deg. 14.0 min. E	11. 06. 1963	Manual	1964 - 1988	1979 - 1989	1977 - 1989
4) MILL BARAK	BWDB	42	Buriganga	Latitude : 23 deg. 41.9 min. N Longitude : 90 deg. 25.3 min. E	10. 10. 1906	Manual Auto	1945 - 1990	-	-
5) HARIHARPARA	BWDB	43	Buriganga	Latitude : 23 deg. 38.0 min. N Longitude : 90 deg. 28.5 min. E	04. 06. 1945	Manual	1945 - 1990	-	-
6) SAVAR	BWDB	69	Dhaleswari	Latitude : 24 deg. 01.0 min. N Longitude : 90 deg. 11.o min. E	13. 07. 1945	Manual	1945 - 1990	-	-
7) KALATIA	BWDB	70	Dhaleswari	Latitude : 23 deg. 42.9 min. N Longitude : 90 deg. 15.9 min. E	01. 10. 1958	Manual	1968 - 1990	-	-
8) KALAGACHIA	BWDB	71	Dhaleswari	Latitude : 23 deg. 34.7 min. N Longitude : 90 deg. 32.7 min. E	15. 06. 1945	Manual	1977 - 1990	-	-
9) REKABI BAZAR	BWDB	71A	Dhaleswari	Latitude : 23 deg. 34.4 min. N Longitude : 90 deg. 29.7 min. E	16. 12. 1965	Manual	1968 - 1990	-	-
10) DEMRA	BWDB	179	Lakhya	Latitude : 23 deg. 44.0 min. N Longitude : 90 deg. 31.5 min. E	18. 06. 1945	Manual	1952 - 1990	-	1977 - 1989
11) MEGHNA FERRY GHAT	BWDB	275.5	Surma-Meghna	Latitude : 23 deg. 36.2 min. N Longitude : 90 deg. 37.5 min. E	25. 09. 1965	Manual	1968 - 1990	-	-
12) TONGI	BWDB	299	Tongi Khal	Latitude : 23 deg. 52.8 min. N Longitude : 90 deg. 24.2 min. E	25. 03. 1960	Manual	1960 - 1990	-	-
13) MIRPUR	BWDB	302	Turag	Latitude : 23 deg. 47.3 min. N Longitude : 90 deg. 20.3 min. E	-	Manual	1953 - 1990	1983 - 1989	1977 - 1989

Table 3.3 Probable Storm Rainfall

(Unit : mm)

DURATION	RAIN STATION	RETURN PERIOD (YEAR)					
		2	5	10	20	50	100
1 day	Dhaka (B.M.D.)	137	184	215	244	283	311
	Savar (BWDB Sta.31)	133	171	196	220	251	274
	Joydebpur (BWDB Sta. 17)	133	167	190	211	239	260
	Narayanganj (B.M.D.)	142	184	212	239	273	299
2 day	Dhaka (B.M.D.)	184	239	276	311	357	391
	Savar (BWDB Sta.31)	177	231	267	301	346	379
	Joydebpur (BWDB Sta. 17)	189	240	275	308	350	382
	Narayanganj (B.M.D.)	191	239	270	301	340	369
5 day	Dhaka (B.M.D.)	251	324	372	418	478	523
	Savar (BWDB Sta.31)	240	316	367	416	479	527
	Joydebpur (BWDB Sta. 17)	274	351	402	451	514	561
	Narayanganj (B.M.D.)	253	314	355	394	444	482
1 month	Dhaka (B.M.D.)	514	636	716	793	892	967
	Savar (BWDB Sta.31)	486	573	630	686	757	811
	Joydebpur (BWDB Sta. 17)	515	619	687	753	838	901
	Narayanganj (B.M.D.)	437	558	620	679	757	814

Table 3.4 Probable Flood Water Level

(Unit : PWD in m)

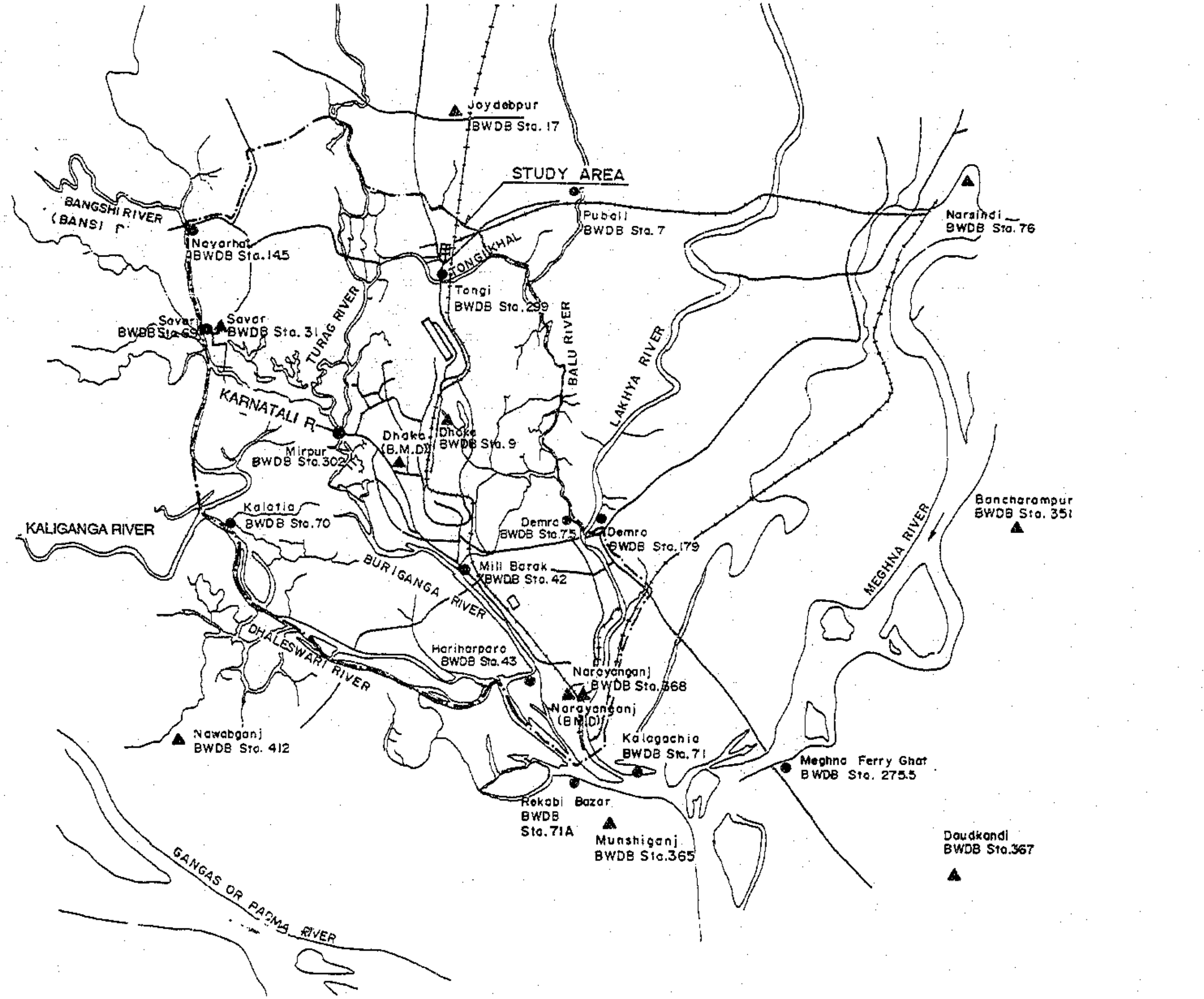
WATER LEVEL STATION	RETURN PERIOD (YEAR)												1988	1987	1974
	2	3	5	10	20	30	50	100	200	300	400	500	Flood	Flood	Flood
1) Pubail (BWDB Sta. 7)	6.15	6.34	6.55	6.83	7.09	7.24	7.43	7.67	7.93	8.08	8.17	8.26	7.29	6.90	6.95
2) Demra (BWDB Sta. 7.5)	5.89	6.07	6.27	6.53	6.77	6.91	7.09	7.32	7.56	7.70	7.79	7.87	7.10	6.46	6.58
3) Nayarhat (BWDB Sta. 14.5)	7.49	7.80	8.14	8.56	8.98	9.21	9.51	9.91	10.31	10.54	10.71	10.84	9.90	8.74	8.44
4) Mill Barak (BWDB Sta. 42)	5.78 (5.82)	6.03 (6.04)	6.30 (6.29)	6.65 (6.59)	6.98 (6.89)	7.17 (7.09)	7.40 (7.27)	7.72 (7.56)	8.04	8.23	8.36	8.46	7.54	6.60	6.57
5) Hariharpara (BWDB Sta. 43)	5.45	5.66	5.89	6.19	6.47	6.63	6.82	7.10	7.37	7.53	7.64	7.72	7.17	6.23	6.34
6) Savar (BWDB Sta. 69)	7.17	7.45	7.76	8.14	8.52	8.73	9.00	9.36	9.72	9.93	10.08	10.20	9.68	8.30	7.80
7) Kalatia (BWDB Sta. 70)	6.58	6.83	7.09	7.42	7.75	7.94	8.17	8.48	8.79	8.98	9.11	9.21	8.91	7.53	7.12
8) Kalagachia (BWDB Sta. 71)	5.33	5.46	5.61	5.81	5.99	6.09	6.23	6.40	6.58	6.69	6.75	6.81	5.97	5.92	-
9) Rakabi Bazar (BWDB Sta. 71A)	5.46	5.61	5.78	6.00	6.20	6.31	6.46	6.65	6.85	6.97	7.05	7.11	6.43	6.02	6.07
10) Demra (BWDB Sta. 179)	5.82	5.99	6.18	6.42	6.65	6.78	6.95	7.17	7.40	7.53	7.61	7.69	-	6.38	6.60
11) Tongi (BWDB Sta. 299)	6.28 (6.46)	6.54 (6.70)	6.82 (6.97)	7.18 (7.33)	7.53 (7.67)	7.72 (7.86)	7.96 (8.11)	8.30 (8.43)	8.63	8.83	8.96	9.07	7.96	7.02	7.10
12) Mirpur (BWDB Sta. 302)	6.30 (6.42)	6.59 (6.64)	6.90 (6.91)	7.30 (7.25)	7.68 (7.58)	7.90 (7.76)	8.17 (8.00)	8.53 (8.31)	8.90	9.12	9.27	9.39	8.39	7.30	7.09

Notes : 1) The results of the check survey for the water level gauging stations of Mill Barak, Mirpur, Tongi and Demra(Sta. 7.5) conducted by JICA STUDY are reflected.

2) Probable flood water levels of Mill Barak, Demra(Sta. 7.5) and Savar are caluculated by Gumbel-Chow's method.

3) Probable flood water levels of other stations except above three stations of Mill Barak, Demra(Sta. 7.5) and Savar are caluculated using the correlation with these three stations (refer to Fig. D.16).

4) Water levels in the parentheses are probable water levels of 1987 JICA STUDY.



LEGEND

▲ Rainfall gauging station

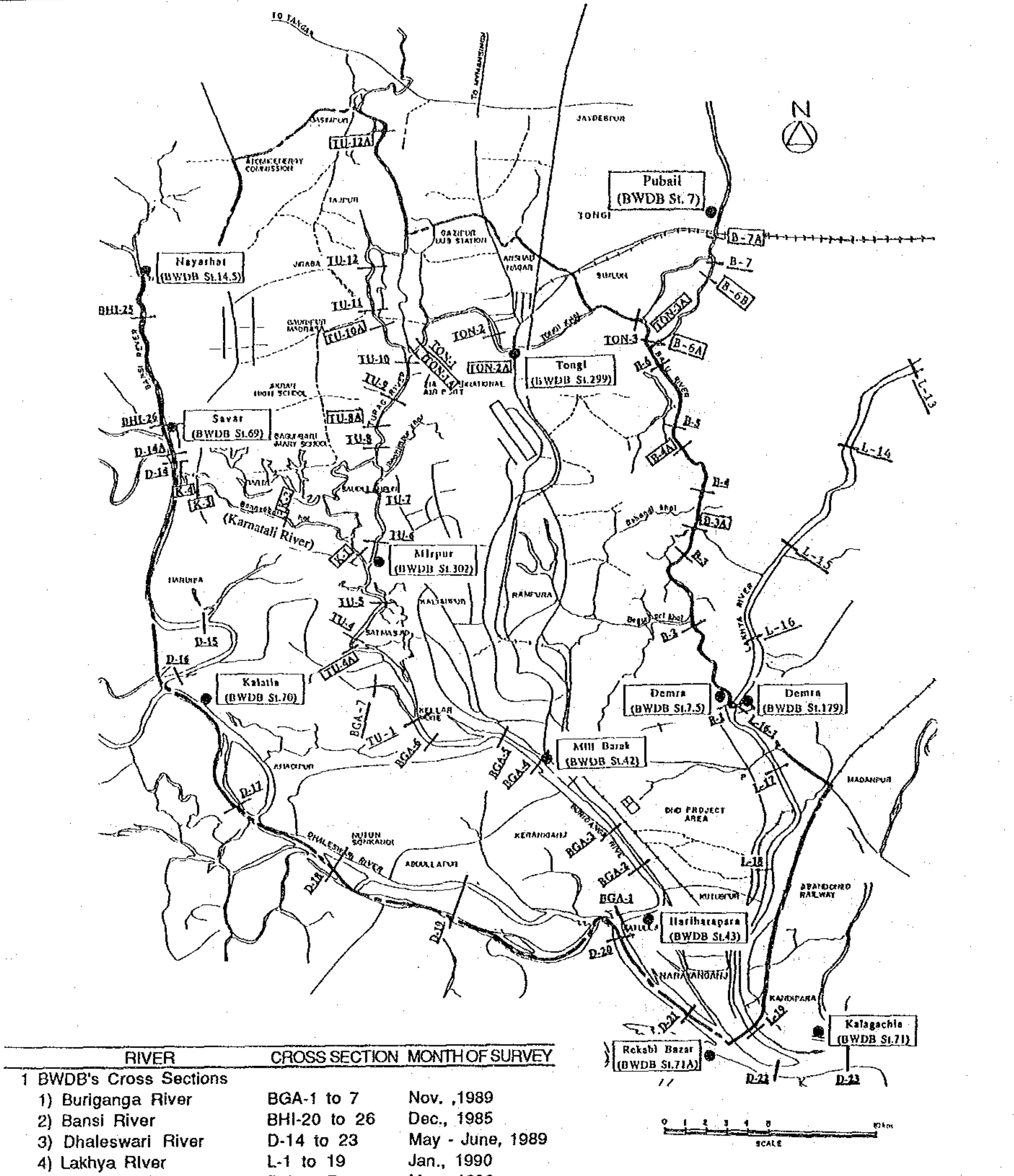
● Water level gauging station

Notes :

1) Narayangang Rainfall Station (B.M.D.) was closed in 1979.

FIG. 3.1	RIVER SYSTEM AND GAUGING STATIONS IN AND AROUND THE STUDY AREA

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



RIVER	CROSS SECTION	MONTH OF SURVEY
1 BWDB's Cross Sections		
1) Buriganga River	BGA-1 to 7	Nov. ,1989
2) Bansi River	BHI-20 to 26	Dec., 1985
3) Dhaleswari River	D-14 to 23	May - June, 1989
4) Lakhya River	L-1 to 19	Jan., 1990
5) Balu River	B-1 to 7	Mar., 1990
6) Turag River	TUR-1 to 9	Feb. - Mar., 1990
7) Tongi Khal	TON-1 to 3	Feb., 1990
2 JICA TEAM's Cross Sections		
1) Balu River	B-3A to 7A	Feb. - Mar., 1991
2) Turag River	TU-4A to 12A	Feb. - Mar., 1991
3) Tongi Khal	TON-1A to 3A	Feb. - Mar., 1991
4) Karnatali River	K-1 to 4	Feb. - Mar., 1991

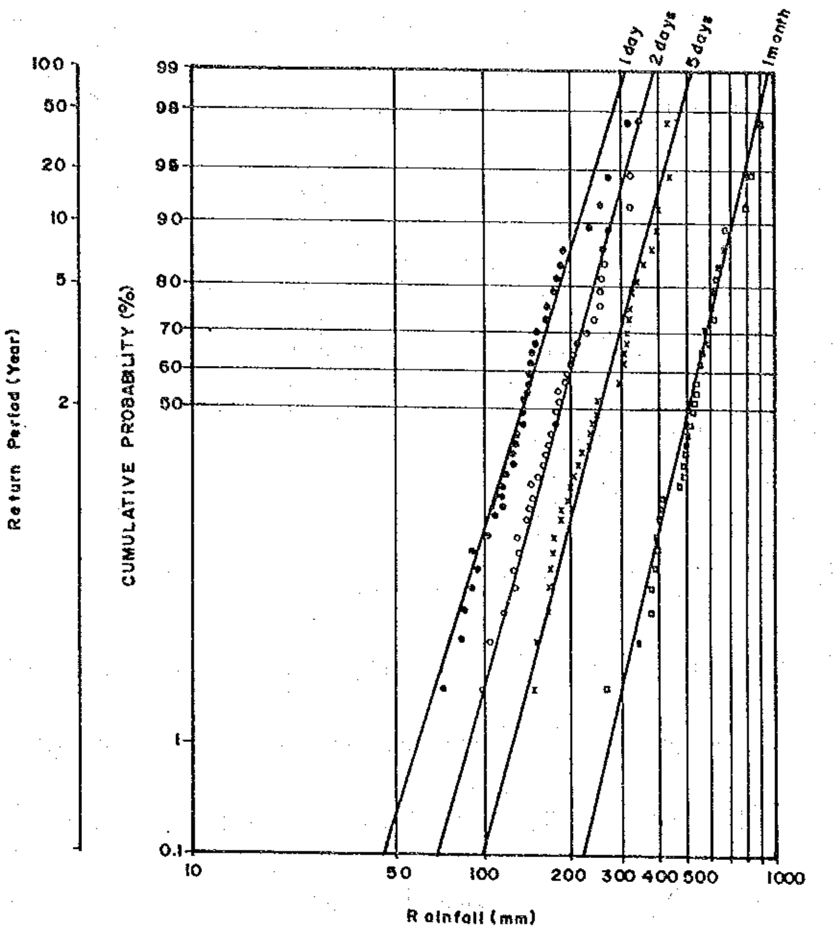
LEGEND :

BGA-3	Cross Section of BWDB
TU-4A	Cross Section of JICA TEAM
●	Water Level Gauging Station

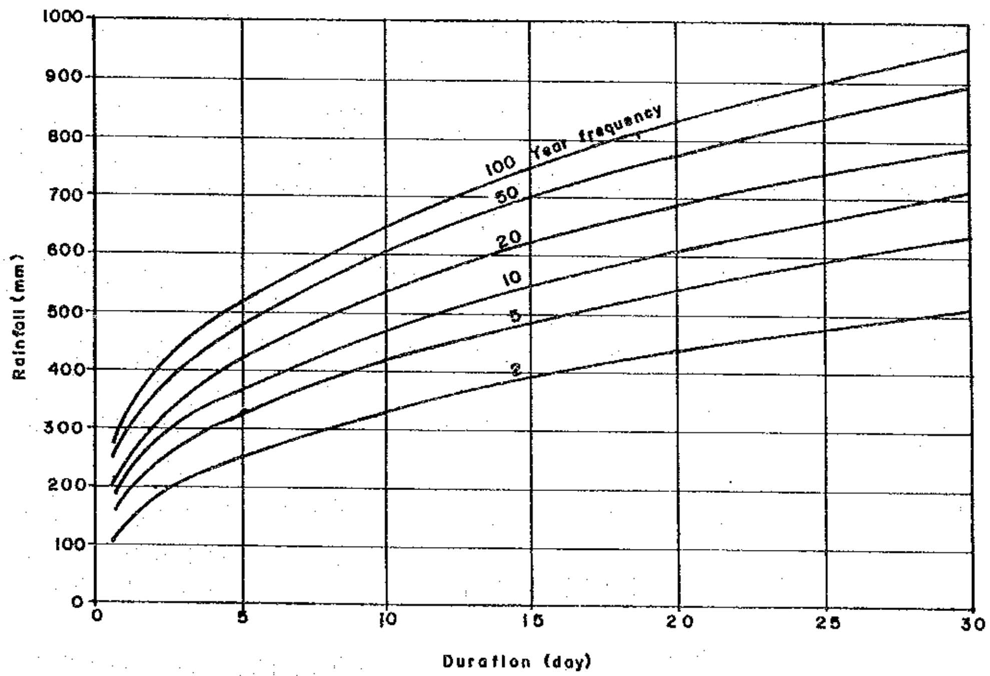
FIG. 3.2 AVAILABLE RIVER CROSS SECTION DATA

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

JICA



PROBABLE STORM RAINFALL AT DHAKA (B.M.D)



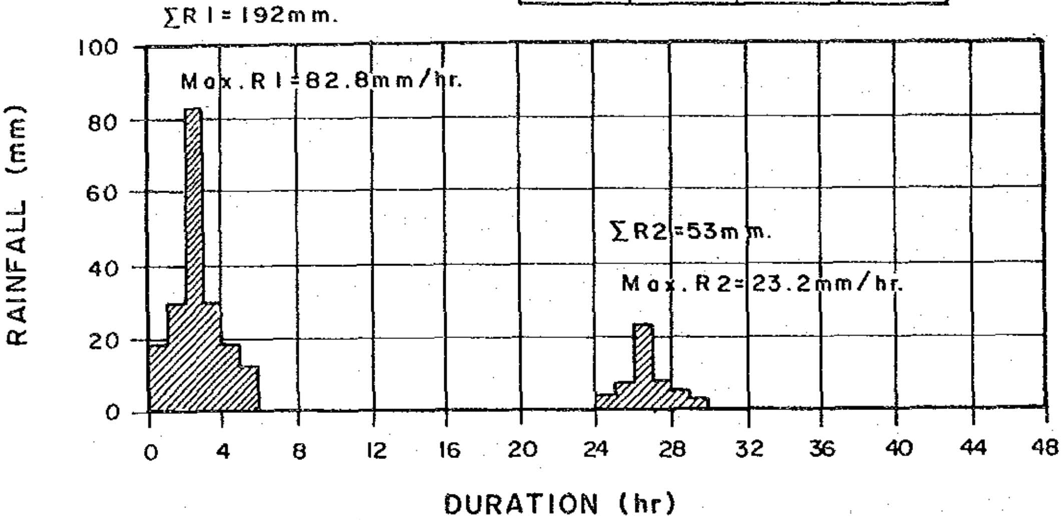
CONSECUTIVE RAINFALL-DURATION CURVE AT DHAKA (B.M.D)

FIG. 3.3	PROBABLE STORM RAINFALL AND CONSECUTIVE RAINFALL- DURATION CURVE AT DHAKA (B.M.D)

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

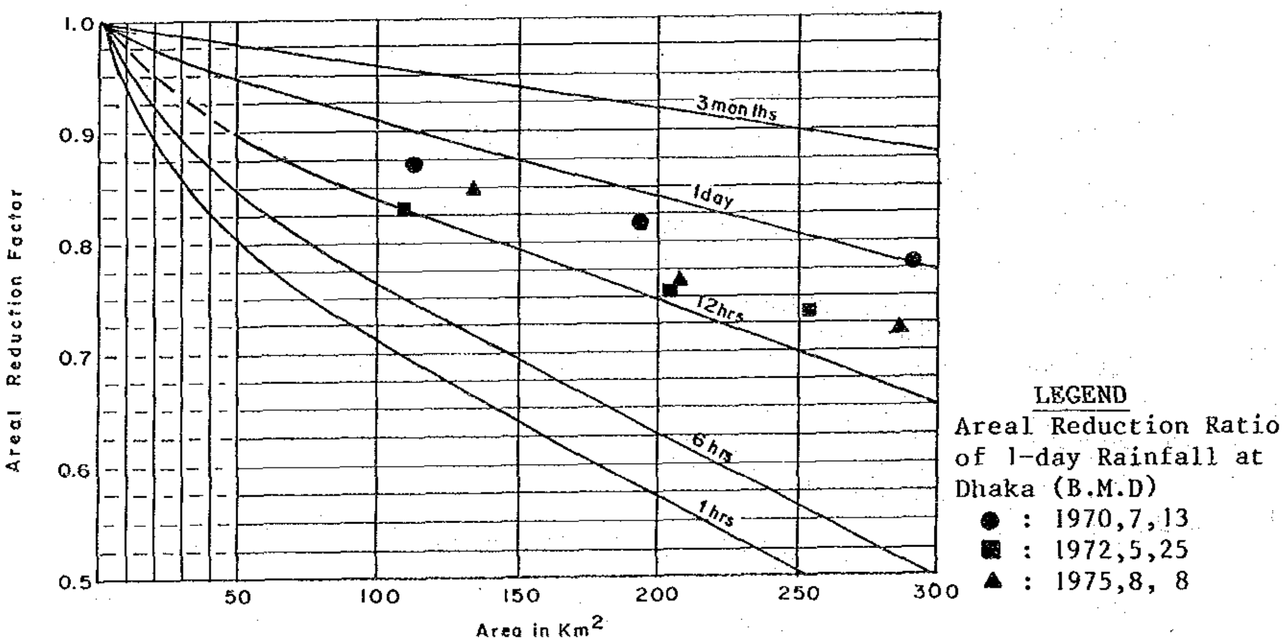
HOURLY DISTRIBUTION

hr	%	R1	R2
1	9	17.4	4.8
2	15	28.5	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



PROPOSED DESIGN HYETOGRAPH FOR PUMP DRAINAGE PLAN

Source: JICA;Study on Storm Water Drainage Improvement Project in Dhaka City,1987

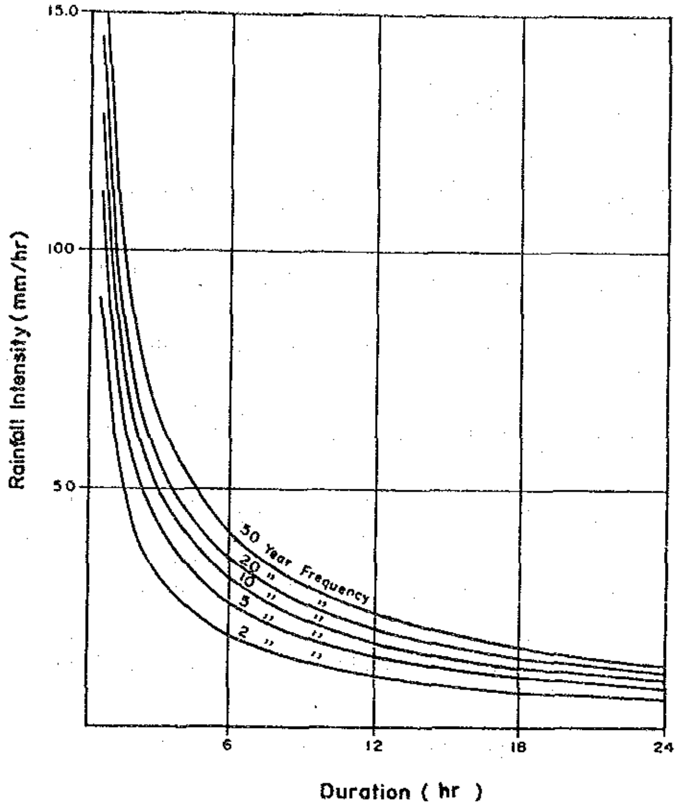


AREAL REDUCTION CURVES FOR POINT RAINFALL

Source: NEDECO;Master Plan for Drainage and Flood Control of Jakarta,1970

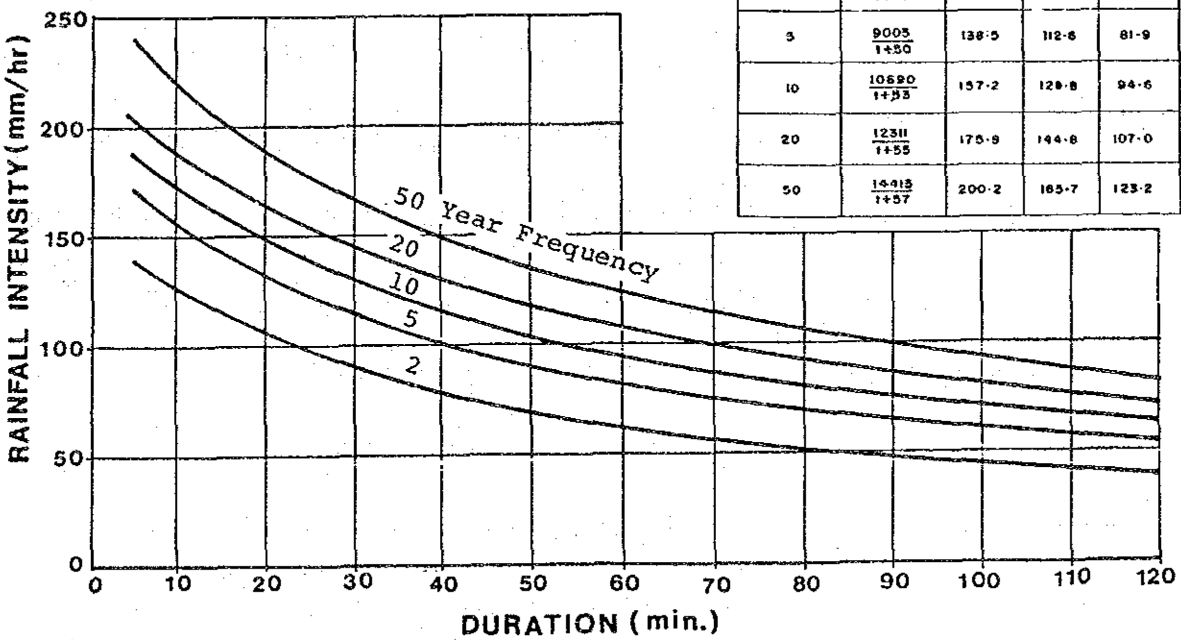
FIG. 3.4	PROPOSED DESIGN HYETOGRAPH FOR PUMP DRAINAGE PLAN AND AREAL REDUCTION CURVE FOR POINT RAINFALL

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN 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	$\frac{5689}{t+44}$	113·4	90·4	64·3	40·9
3	$\frac{7674}{t+47}$	123·8	99·7	71·7	46·0
5	$\frac{9005}{t+50}$	138·5	112·6	81·9	53·0
10	$\frac{10690}{t+53}$	157·2	128·8	94·6	61·8
20	$\frac{12311}{t+55}$	175·9	144·8	107·0	70·3
50	$\frac{14415}{t+57}$	200·2	165·7	123·2	81·4



Source :

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

FIG. 3.5 RAINFALL INTENSITY AND DURATION RELATIONSHIP

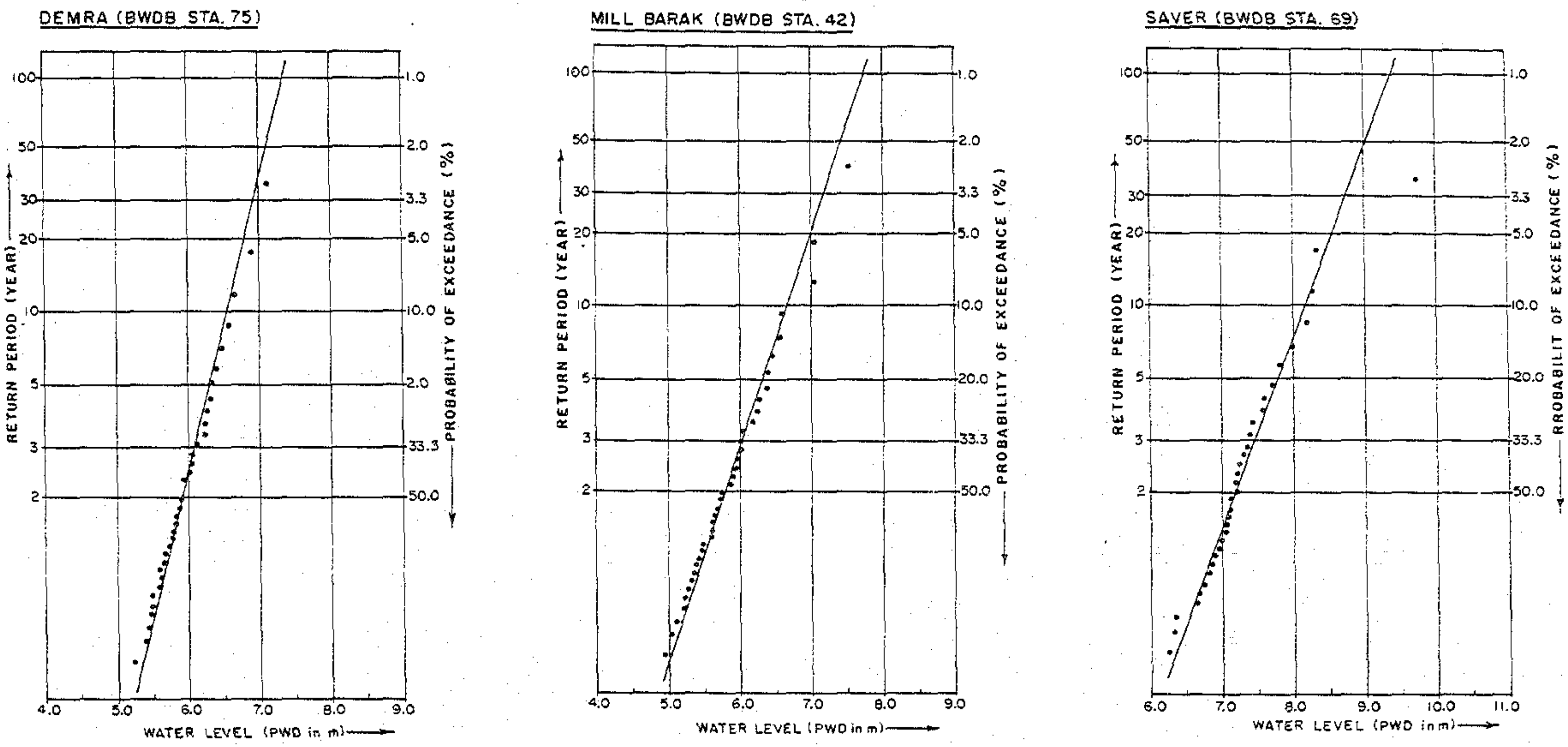
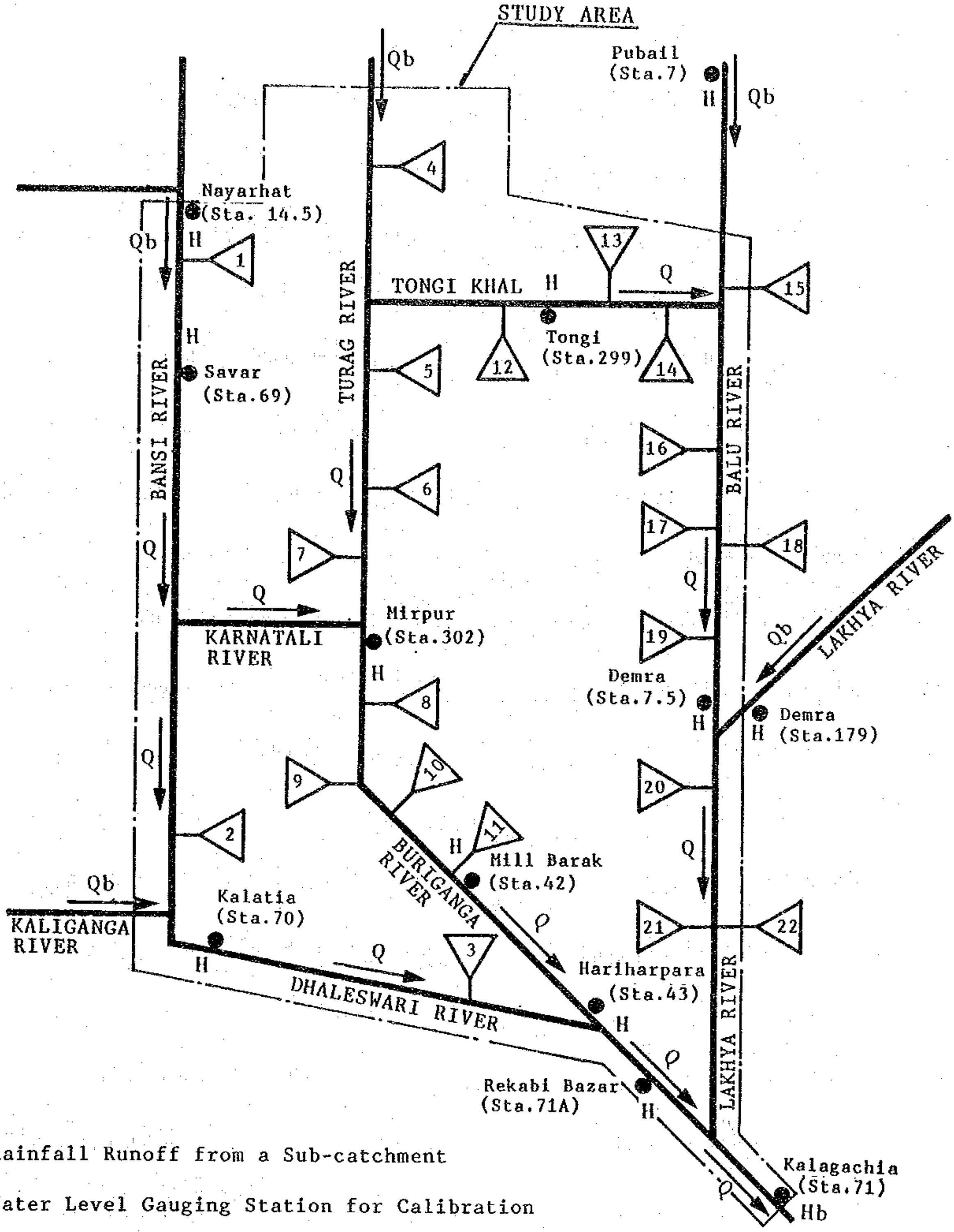


FIG. 3.6 PROBABLE FLOOD WATER LEVEL

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

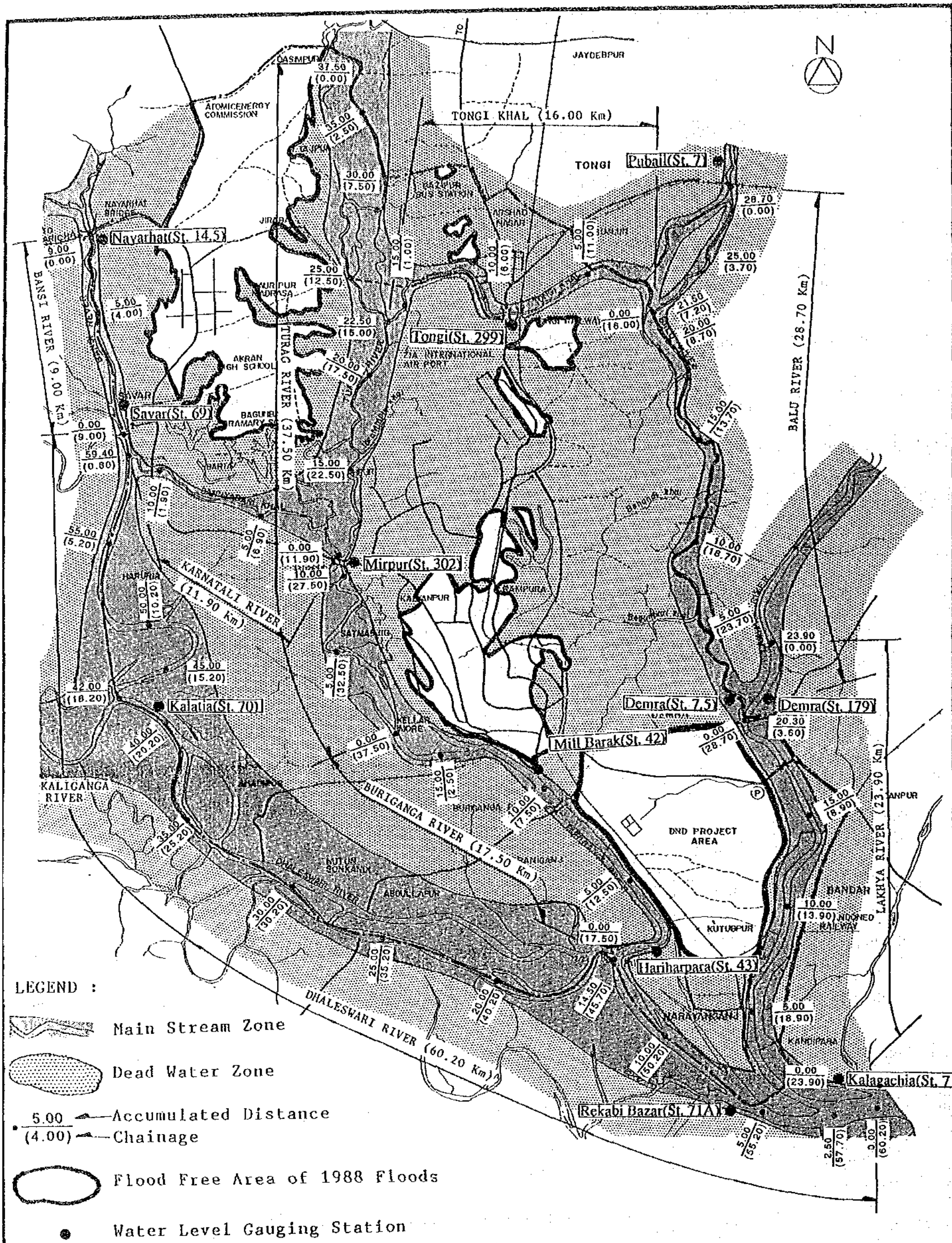


LEGEND :

(triangle symbol)	Rainfall Runoff from a Sub-catchment
●	Water Level Gauging Station for Calibration
Qb	Boundary Discharge to be inputed
Hb	Boundary Water Level to be inputed
H	Water Level to be simulated
Q	Discharge to be simulated

FIG. 3.7 PROPOSED SIMULATION MODEL

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



Note : Main Stream Zone and Dead Water Zone are estimated by using the satellite colored image (SPOT IMAGE :taken between Feb. - Mar., 1989).

FIG. 3.8 RIVER NETWORK OF THE SIMULATION MODEL

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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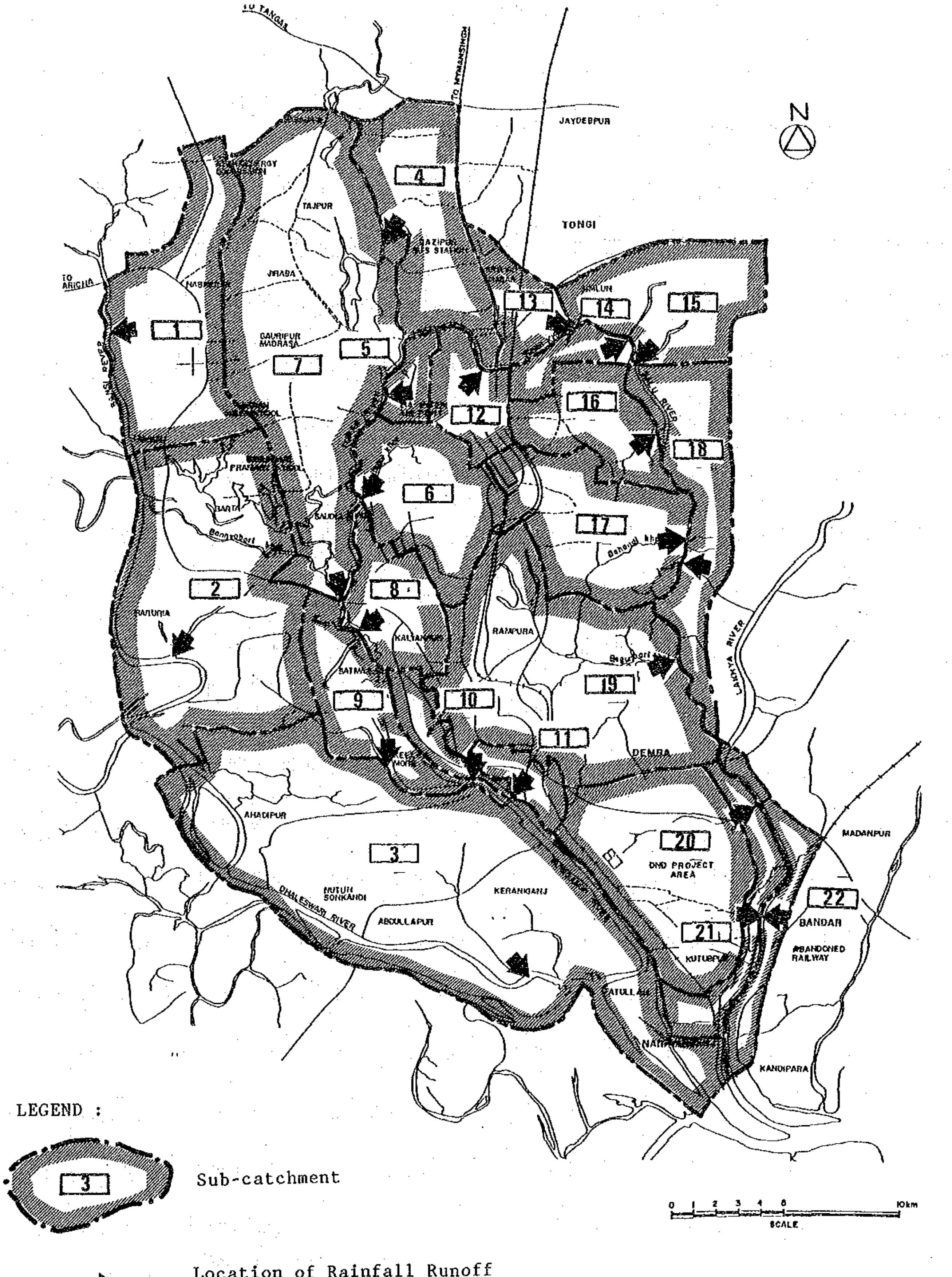


LEGEND :

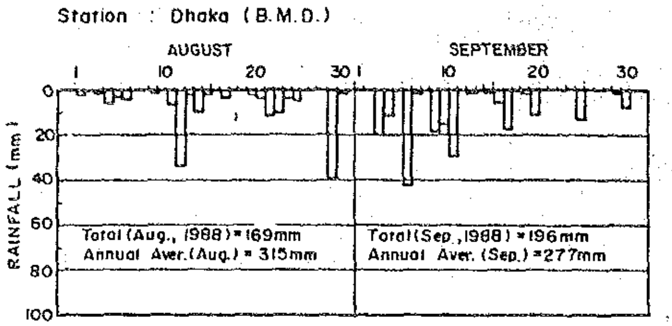
Sub-catchment

Location of Rainfall Runoff into the River

FIG. 3.9 SUB-CATCHMENT OF THE SIMULATION MODEL

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

RAINFALL (AUG. - SEP., 1988)



RUNOFF (AUG. - SEP., 1988)

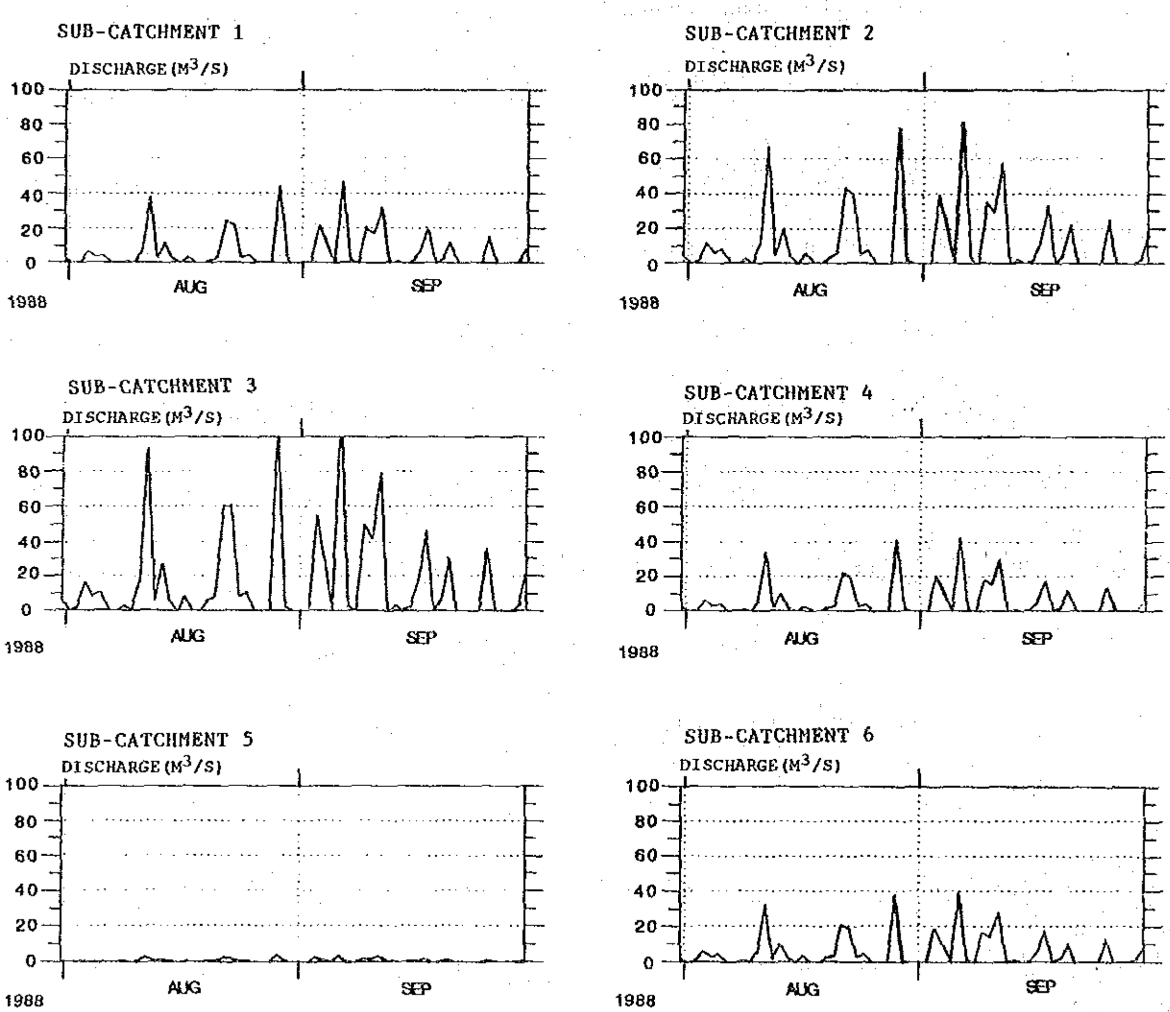
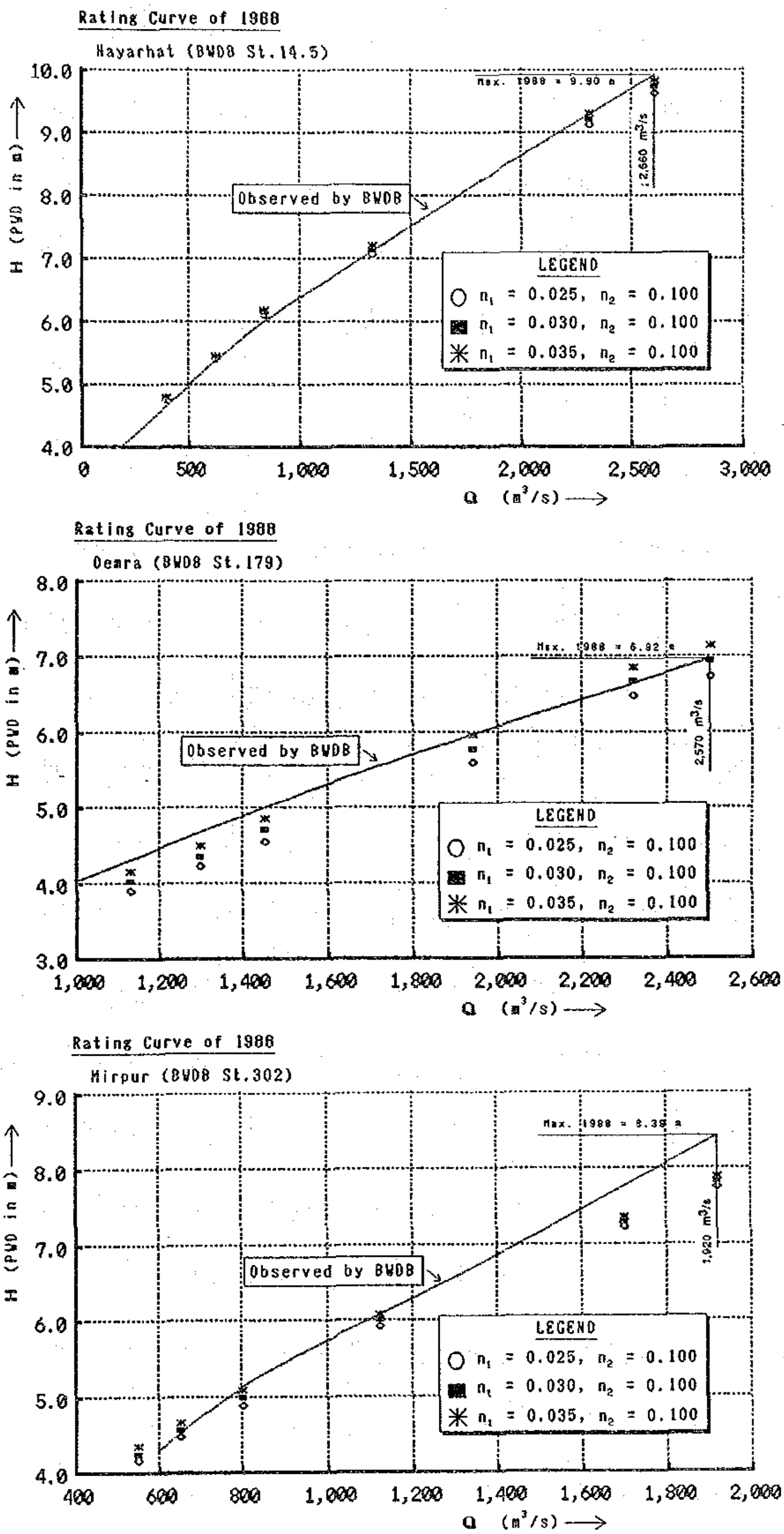


FIG. 3.10 RAINFALL RUNOFF OF THE SUB-CATCHMENT



Notes :

1) n1 is a manning's roughness coefficient of river channel.
2) n2 is a manning's roughness coefficient of flood plain.

FIG. 3.11 COMPARISON OF MANNING'S ROUGHNESS COEFFICIENTS

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

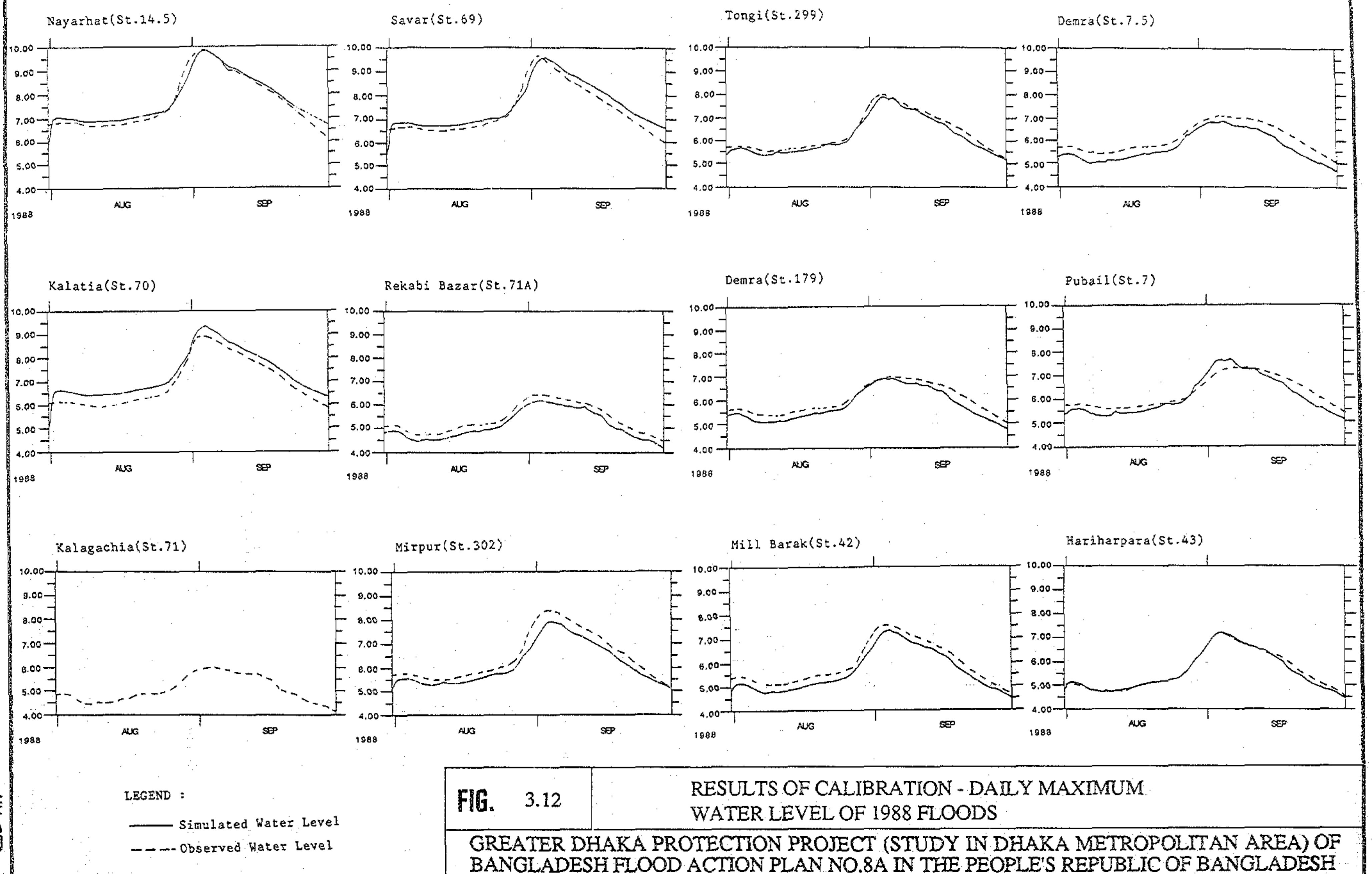


FIG. 3.12	RESULTS OF CALIBRATION - DAILY MAXIMUM WATER LEVEL OF 1988 FLOODS

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

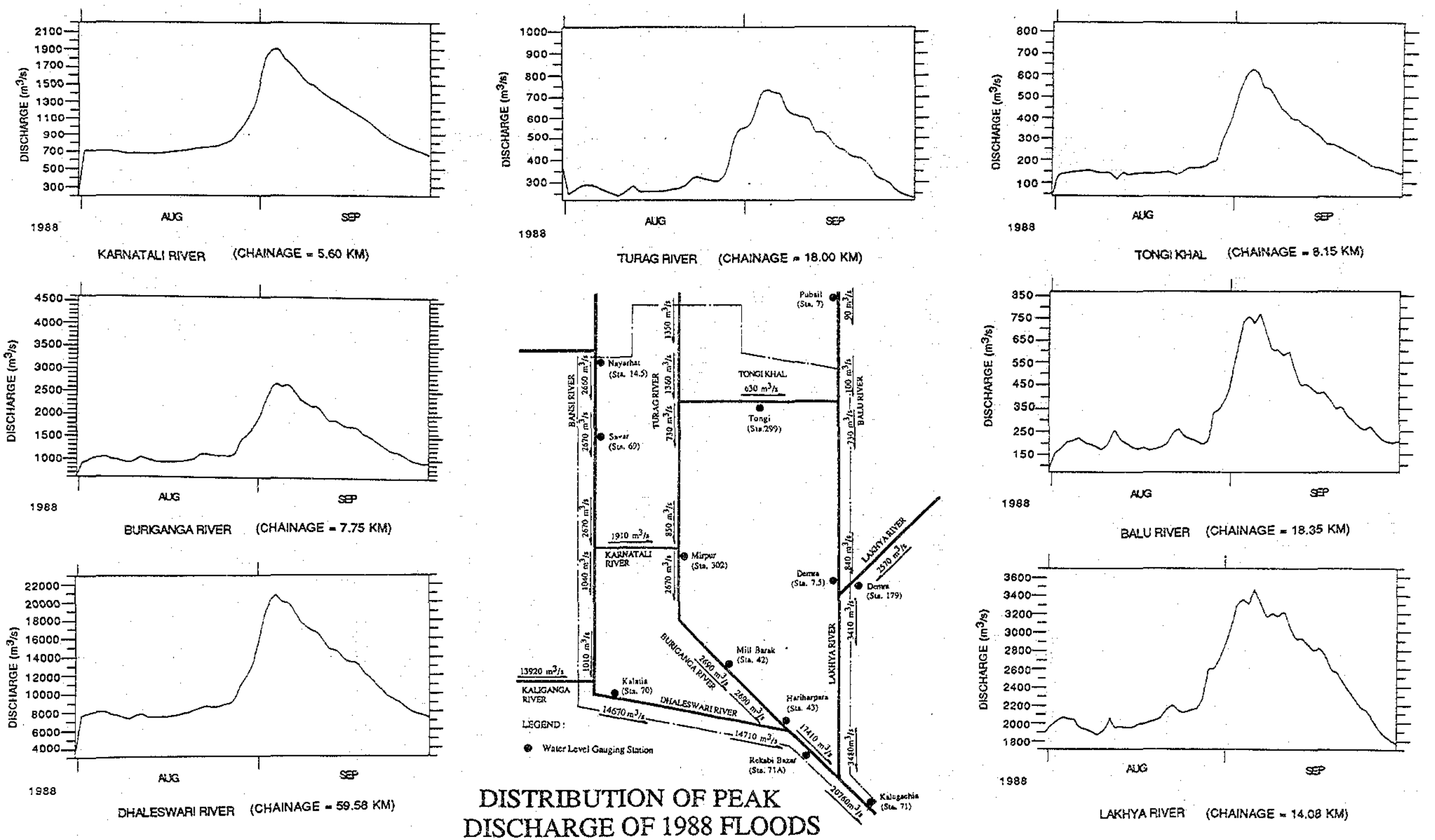
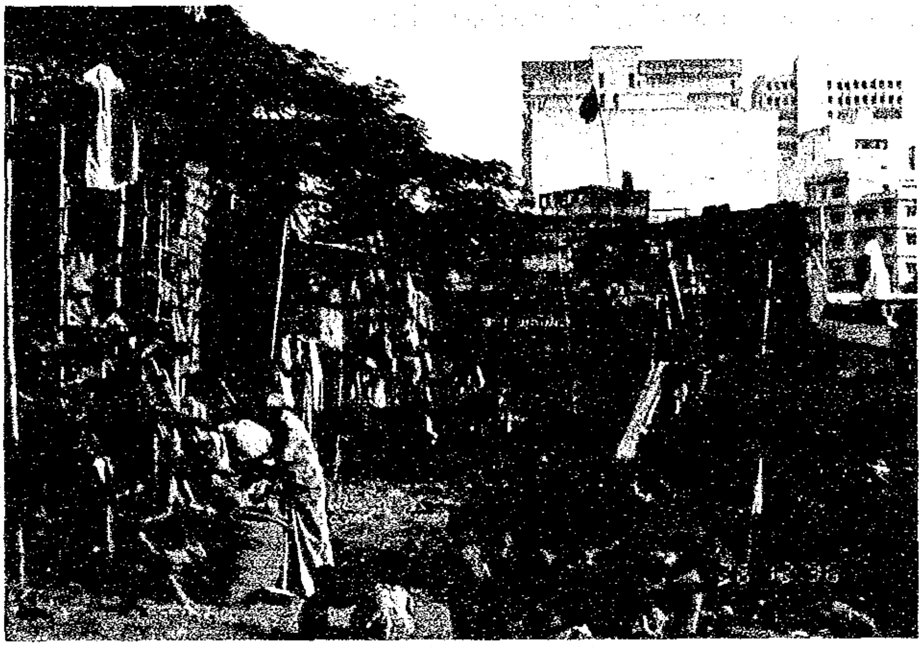


FIG. 3.13	RESULTS OF CALIBRATION - VARIATION OF DAILY MAXIMUM DISCHARGE AND DISTRIBUTION OF PEAK DISCHARGE OF 1988 FLOODS -

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

High Income Residential Area : Gulshan Model Town



Slum Area : Purana Paltan

CHAPTER 4

LAND USE AND URBAN PLANNING

CHAPTER 4 LAND USE AND URBAN PLANNING

The study of existing land use in the Dhaka metropolitan area, and the forecasts of population growth and distribution to the year 2010, provide the basis for determining which areas can most justifiably be considered for flood protection.

4.1 Population Forecasts

The Dhaka population forecast has been made for the period 1981 to 2010. It is for the 'pull' area which is expected to attract migrants and accommodate urban development up to 2010. (See Fig. 4.1).

Quite small changes in growth rates can affect the population forecast for a particular year. While a range of forecasts would more accurately reflect level of confidence, such a range over the long term could become too wide to be useful. A preferred forecast is thus adopted early, after looking at the alternatives. We have predicted continuing high in-migration and do not forecast a dramatic decline in natural growth over the next decade. Even after 2000, when improved national economic performance may lead to less migration, and a fall in natural increase may continue, continuing overall high rates of growth are predicted. This is summarized below :

Period	Population	Increase
1981	3.98 m	
1981 - 90		+ 2.34 m
1990	6.32 m	
1990 - 2000		+ 3.54 m
2000	9.86 m	
2000 - 2010		+ 3.62 m
2010	13.48 m	

4.2 Existing Land Use

The first comprehensive land use survey of the metropolitan area has been undertaken during the study. This classifies seven residential types, commercial, industrial, institutional, recreational, transport use and water bodies. A 1988 survey of slum and squatter settlements and a 1983/4 aerial photo has been used to supplemented this. Major land use features are :

- the preponderance of mixed uses

- the low proportion of non-residential uses.

- the scatter of very poor slum and squatter areas, housing a third of the population within small areas. In contrast, large areas are used for upper income groups.

- high densities, especially in the inner city and slum/squatter settlements.

The features reflect an intensity of land use caused by increasing population pressure, limited alternative development areas, and the lack of a transportation system which would allow more extensive development.

4.3 Basis for Distributing Forecast Growth

The 1981 census is the basis for all subsequent distributions. This is done on the basis of the following findings :

- the unfairness of urban land allocation between rich and poor. The poor 70% majority has access to only 20% of the city's land.

- almost all planned development is for the relatively rich. The poor are crowded into small, unplanned areas. This will not change significantly before 2000.

- population increase between 1981 and 1990 was 59%. The increase in the amount of land developed (as from the comparison of the 1983-4 aerial photo and the 1999-91 land use) was less than 20%. This must therefore have led to higher densities in exiting areas.

- densities will continue to become higher in existing and new areas, reflecting urbanization pressures and lack of supply of new, serviced land for urban purposes.

- densities will not, nowever, become uniformly higher. There may be a limit to population absorption capacity in the most highly developed areas but it will be higher than existing density.

- more new development land for the relatively rich means that density increases in existing rich areas should be lower than in poor areas. Only when substantial quantities of land are made available for the poor will densities in poor areas stop increasing.

- the need to live near to work is important. Densities will thus continue to increase in most inner city zones. Relatively flood-free land close to the city will also be rapidly developed. Both factors will determine the development pattern, though provision of mass transit would increase the attraction of higher, more distant areas.

However, long range planning requires some degree of optimism. Further, any flood prevention plan has to be based on the maximum rather than the minimum distribution of urban uses. It is assumed therefore that measures will be taken in the nineties which will make available significant amounts of serviced land for urban growth, including accommodating the poor, after the end of the century.

4.4 Future Development

4.4.1 Development between 1981 and 1990

A total population increase of 2.34 million was forecast. In its distribution, a distinction is made between rich and poor, existing areas and new areas. As population increase was much greater than land increase, much of the growth must have been in existing areas.

a) The increase in the relatively rich was some 700,000, 30% of total increase. As we could find the location and extent of major new planned areas, we could make a reasonable assessment of how many people were accommodated there, as follows :

Baridhara	15,000
Uttara (50% developed)	47,000
Savar	10000
DND Triangle (over 50% for the relatively rich)	104,000
Mirpur	15,000
Senparaparbata	20,000
Goran/Khilgaon	15,000
Cantonment	10,000
Total relatively rich in new planned areas	236,000

b) The remaining increase in numbers of the rich (466,000) will have been housed at higher densities in existing better areas, distributed on the basis of the best housing categories in the 1981 census.

c) The increase in the poor was 1.64 million, most being housed in existing areas (as there was little new land). The natural increase element of growth (625,000) is distributed as higher density in the lower 70% of the census housing categories.

d) The map of slum and squatter settlements is the basis of our distribution of the very poor. As 30% of the population lives ins such settlements, 30% of total increase (709,000) has been distributed in them.

e) The residual 304,000 poor has been distributed in the new (1981-90) unplanned areas, which we have identified :

Western periphery :	42,000
Eastern periphery : from Badda south to Gandaria	19,000
DND Triangle	95,000
Linear development E of Katchpur Bridge	7,000
Kamrangir Char	35,000
Mirpur area	16,000
Tongi-Uttara : linear development north of the Airport	38,000
Uttara East area	23,000
Scattered smaller areas	29,000
Total	304,000

Fig.4.2 shows the new areas developed (for rich and poor) in this period. Distribution is summarized in Fig. 4.7.

4.4.2 Development between 1990 and 2000

Total growth has been forecast at 3.54 million. The distribution of this increase is slightly more difficult than estimating what has already happened. It is done on the basis of the factors already noted, largely assuming that known commitments will go ahead and that current locational development trends will continue. Again, a differentiation is made between rich and poor, and between new development and higher densities in existing areas.

a) The total increase in the relatively rich (assuming they will remain as 30% of the total) is estimated at 1.06 million. But capacities of proposed new 'rich' areas may be over three times as high as in 1981-90. There should then be less pressure for higher densities and it is assumed that only half the natural increase in the relatively rich will remain 'in-zone'. This equals 196000 people, distributed proportionately in 1990 better-off areas.

b) The major planned new areas should accommodate the remainder of this growth. This has been estimated as follows :

Panchibati (RAJUK development)	44,000
Katchpur (RAJUK)	49,000
Baridhara/Badda/Basundhara (RAJUK plus private)	68,000
Uttara East (half completed)	36,000
Savar Phase I (RAJUK plan)	100,000
Senparaparbata (RAJUK densification plan)	65,000
DND Triangle (mostly northern part)	224,000
Uttara centre (remaining half)	47,000
Mirpur	30,000
Goran (private development	49,000
Tongi (private)	8,000
Rayer Bazar (reclaimed land)	60,000
Mirpur - Turag (low laying reclaimed)	56,000
Total	866,000

c) By the year 2000, an additional 2.5 million poor people will be living in Dhaka, most at even higher densities in existing and new unplanned areas. Its natural increase is estimated at 916,000. It is assumed that all will stay as higher density in existing poorer areas. However, in the most heavily populated zones, an allowance is made for the existing high density levels.

d) a continuing 30% of total population growth (1.062 million) will be in slum/squatter areas. As new areas will develop, all over the city, distribution is made proportional to total 1990 population per zone.

e) the remainder (501,000), is distributed in unplanned peripheral areas, 56,000 in each. These areas are :

- DND Triangle
- Tongi - Joydepbur, linear growth
- E. of Katchpur Bridge, linear growth
- Turag - Mirpur, new flood protected area
- Eastern expansion, peripheral development
- Kamrangir Char
- Western periphery, on and beyond embankment
- Uttara East, continuation of existing trend development

A further 50,000 will be housed in the planned low income development at Mirpur.

The new areas are shown on Fig.4.3. Distribution between different areas is summarized in Fig.4.7

4.4.3 Development after 2000

A population increase of 3.62 million is forecast. It is assumed that more efficient land acquisition and servicing mechanisms will be operational by the year 2000, with substantial areas now being made available for all income groups. Availability of such land should reduce the pressures which cause even higher densities. More of the population increase will now take place in new areas.

a) for the top 30%, a distinction is made between areas developed before and after 1990. In the former, a 5% increase (96,000) is distributed proportional to the 2000 rich population, but not in inner city zones where a density ceiling is assumed. In the latter, newer, areas, a greater increase in density is likely. An increase in density of the same magnitude as took place between 1981 and 1990 is assumed. Population increase in these newer, better, areas would, on this basis, amount to 320,000.

b) the increase in the poor is forecast at 2.53 million. As we have made more favourable assumptions or land availability post -2000, we can now make a more favourable assumption on increasing densities : that only 620,000, half the natural increase in the bottom 70%, will stay in -zone.

c) potential new development areas are shown on Fig. 4.4. Their potential capacity is vast and not all need to be developed. The more likely areas (with two exceptions) have a capacity of 1.61 million compared with 2.58 million who will need new land.

-	Tejgaon Airport	development assumed	50,000
-	Uttara East	completion assumed	36,000
-	DND Triangle	completion assumed	467,000
-	Mirpur - Turag	part developed, say 50%	195,000
-	Savar III	limited upper income development, say	50,000
-	Eastern Expansion	all of s. part, 50% of rest	786,000
-	E of Katchpur	trends continue	28,000
	Total		1,612,000

970,000 will need new land outside these seven areas. They can be distributed in Keraniganj, and/or Tongi-Joydebpur. Capacity of a maximum Keraniganj reclamation is over 1 million, while that of Tongi-Joydebpur is 1.3 million. Both locations have advantages and disadvantages. The decision on which area to develop should be based on a comparison, but sufficient data is unavailable. A transportation study and a metropolitan planning study, starting this year, should consider these issues, amongst others, and provide a framework for future development.

A poldering decision on Keraniganj could therefore await the completion of these studies. Thus, any embankment decision, at earliest, would be after 1992. But, as development is post - 2000, a decision could justifiably be postponed. No decision would be needed on flood-protection for Tongi-Joydebpur, which is largely flood-free.

The protection of Jinjira may however have priority. Three alternative embankment alignments were considered, protecting Jinjira and additional development land. The larger scheme appears more cost-effective but affects a large area of flood plain and may divert flood water, with serious implications for Dhaka. The recommended middle-size alignment is smaller, protects existing built-up area and also includes the proposed container depot, where further development is anticipated. This alternative has a capacity of 333,000.

We assume that Keraniganj, because of its central location, would be more attractive to development, with the residual going into Tongi-Joydebpur. Thus, 333,000 are distributed in Keraniganj and 637,000 in the northern strategy area.

Fig.4.5 shows the likely development areas post-2000. Distribution of the 2000-2010 total population increment is summarized in Fig.4.7.

4.5 Future Land Use

Fig.4.6 shows the area most likely to be urban by 2010. It is based on the increments to city growth already outlined and taking into account the nature and distribution of major flood protection elements. This forecast of the extent of the city by 2010 is the basis for deciding for which areas structural flood protection measures are justified. The future urban area will measure some 45,000 hectares, divided between five of the present administrative districts.

A considerable change of land use from rural to urban will take place within the study area, though some rural uses would still continue, particularly in the dry season, in the substantial areas of retention ponds which are proposed.

Four urban zones have been delineated :

- environmental improvement zone, including old Dhaka, with a forecast population of 2.7 million. Environmental improvements of all kinds will have priority here.

- densification zone, with a forecast population of 6.2 million, where major urban facilities will be needed.

- new development zone, with a 2010 population forecast at 3.6 million. This is currently agricultural and consists of a highland sub zone, where urban development will not require land reclamation, and a low land sub zone, where reclamation is needed beforehand. New infrastructure will be needed in this zone, and development (in lower lying areas) guided in conformity with flood protection requirements.

- green and open space zone, which will remain rural, and be frequently inundated.

Outside these zones, but still within the study area, are rural settlements where non-structural flood protection management would needed.

4.6 Control and Management of Urban Development

The availability of land required for flood protection purposes has to be ensured. Such land will have to be delineated, safeguarded, in some cases acquired and in others controlled. It will be necessary to

- control/prevent urban development

- acquire land for structures, ponds and resettlement.

- prevent encroachment onto government land

- guide development in an equitable fashion while safeguarding flood protection needs

- ensure flood protection by enforcing height standards, and by safeguarding drainage and flood flow channels.

Current methods are slow, fragmentary, inefficient, badly and often little used. Failure to improve control and acquisition mechanisms will mean that implementation of flood protection measures will be impossible, as land will become scarce and more expensive.

New, revised, legislation is needed if the government is to obtain a share of the profit from land development, so as to enable it to continue an efficient land acquisition and servicing programme. The forthcoming metropolitan development plan should provide the legal zoning basis for land use control in the capital, while the adoption of the 1985 Draft Physical Planning and Development Control Ordinance would allow control and enforcement on the lines required. Streamlining of acquisition procedures is also desirable as is revised legislation allowing public development agencies to recoup costs, profit from development activities, and permit further investment.

RAJUK should remain to be the agency responsible for land purchase, land holding, and development for urban needs. In consultation with the involved sectoral agencies, this function should include safeguarding, controlling, and acquiring land for flood control purposes. Immediate action is needed if further land price increases are to be avoided and further urban growth in areas which should remain rural is to be prevented. A lack of such action would prevent the implementation of sound flood prevention and control.

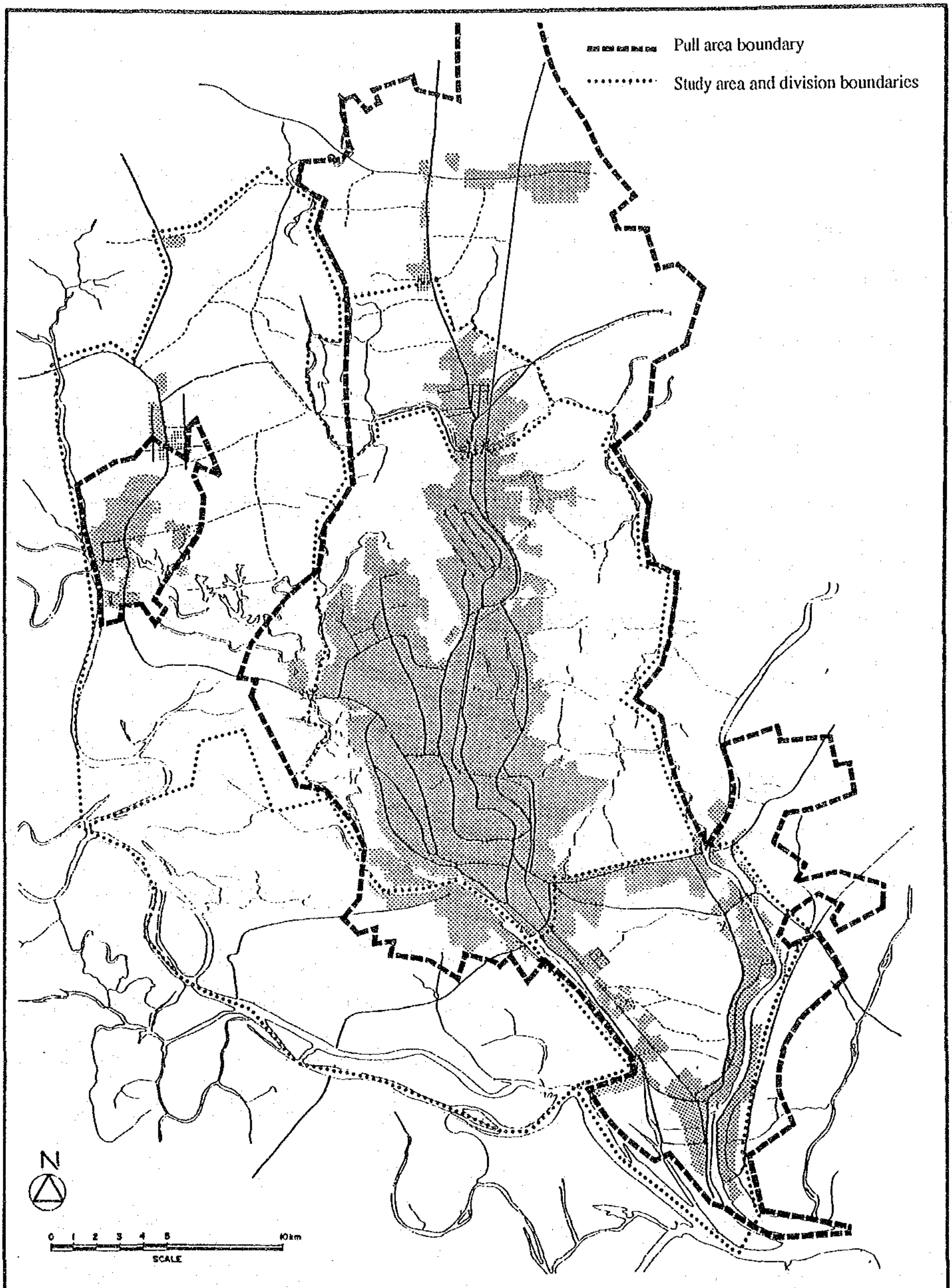


FIG. 4.1 PULL AREA STUDY AREA AND DIVISION BOUNDARIES

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

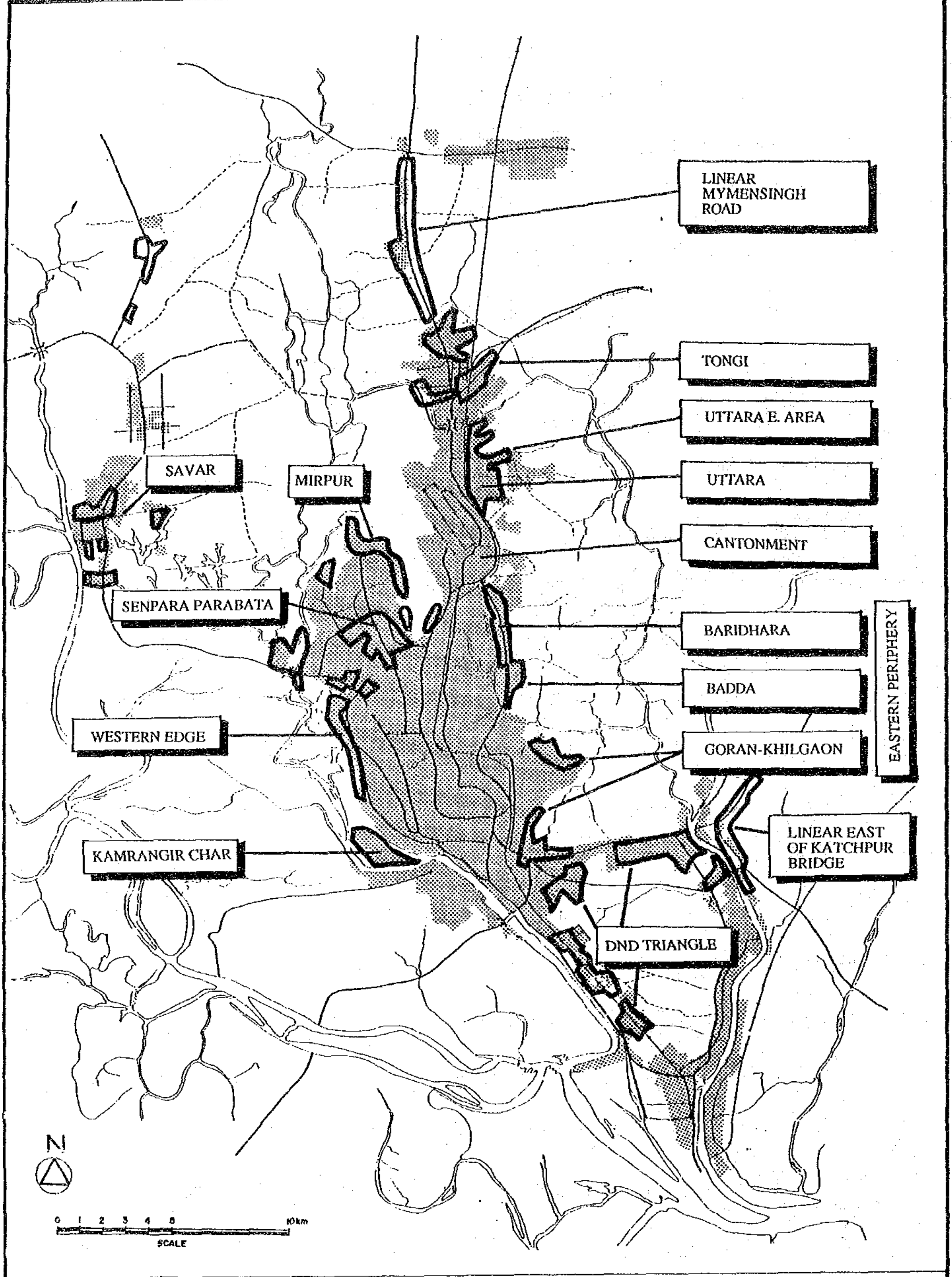


FIG. 4.2 MAJOR DEVELOPMENT AREAS, 1981 - 1990

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

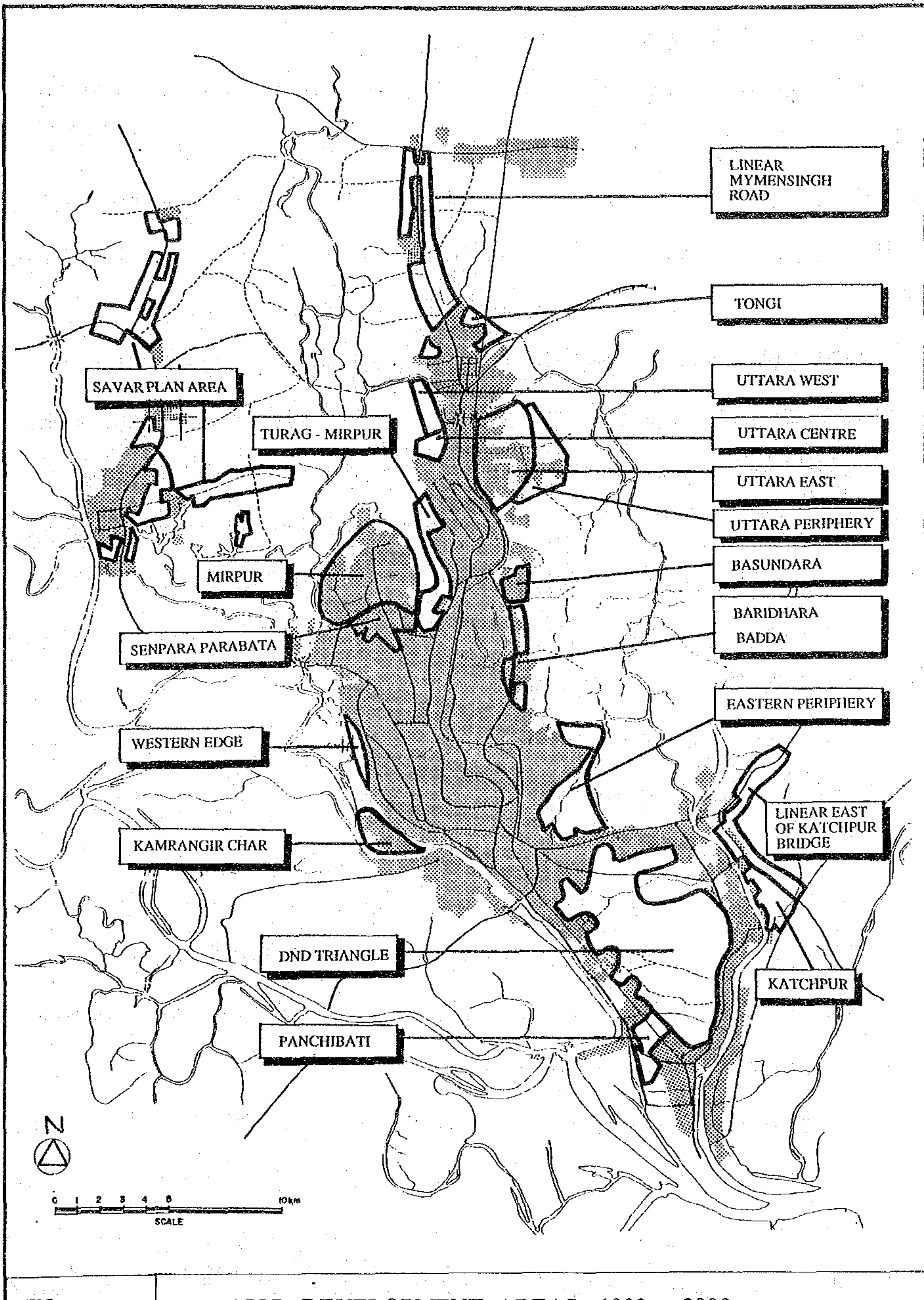


FIG. 4.3 MAJOR DEVELOPMENT AREAS, 1990 - 2000

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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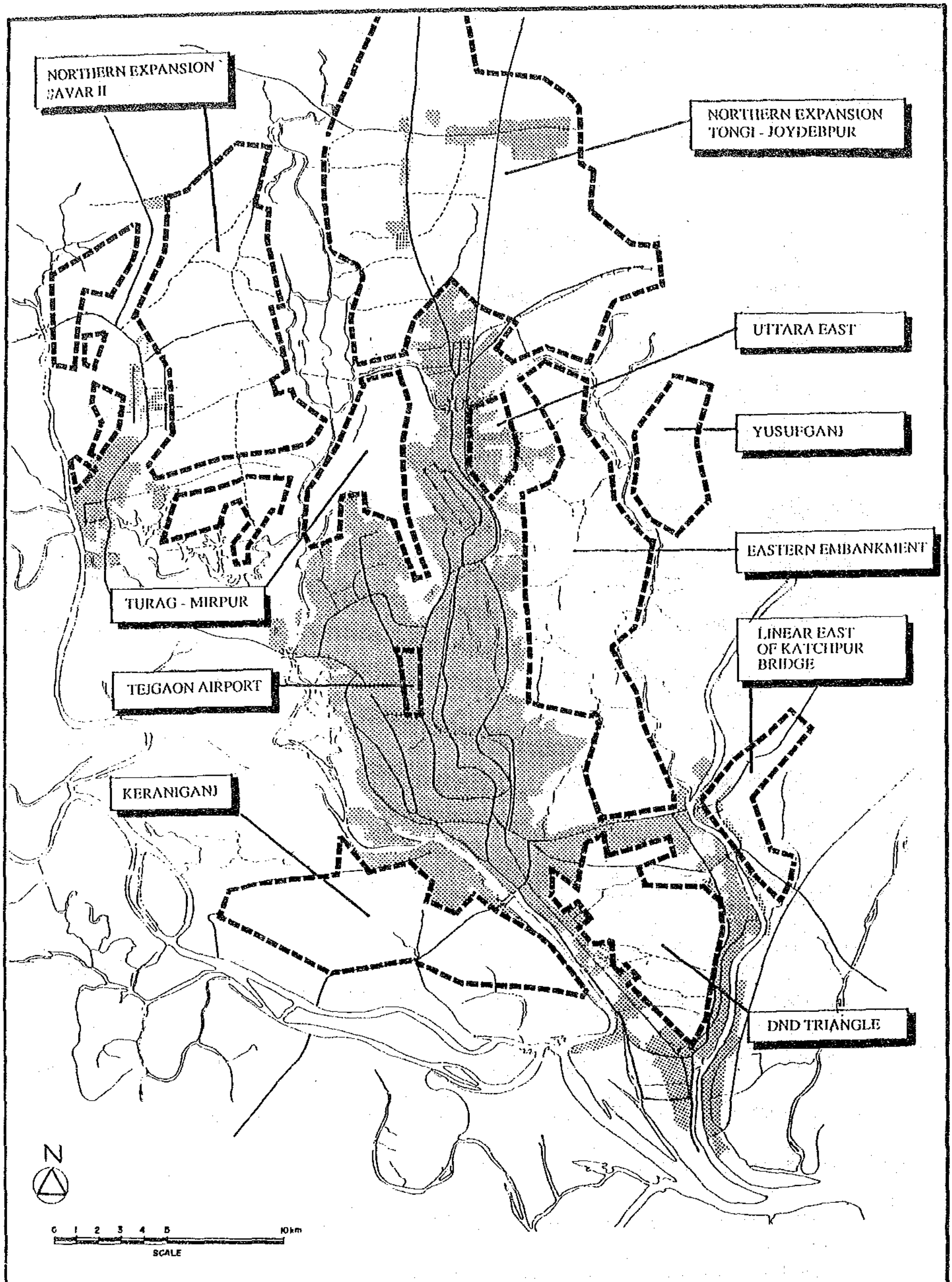

FIG. 4.4 POTENTIAL URBAN DEVELOPMENT AREAS, POST 2000

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

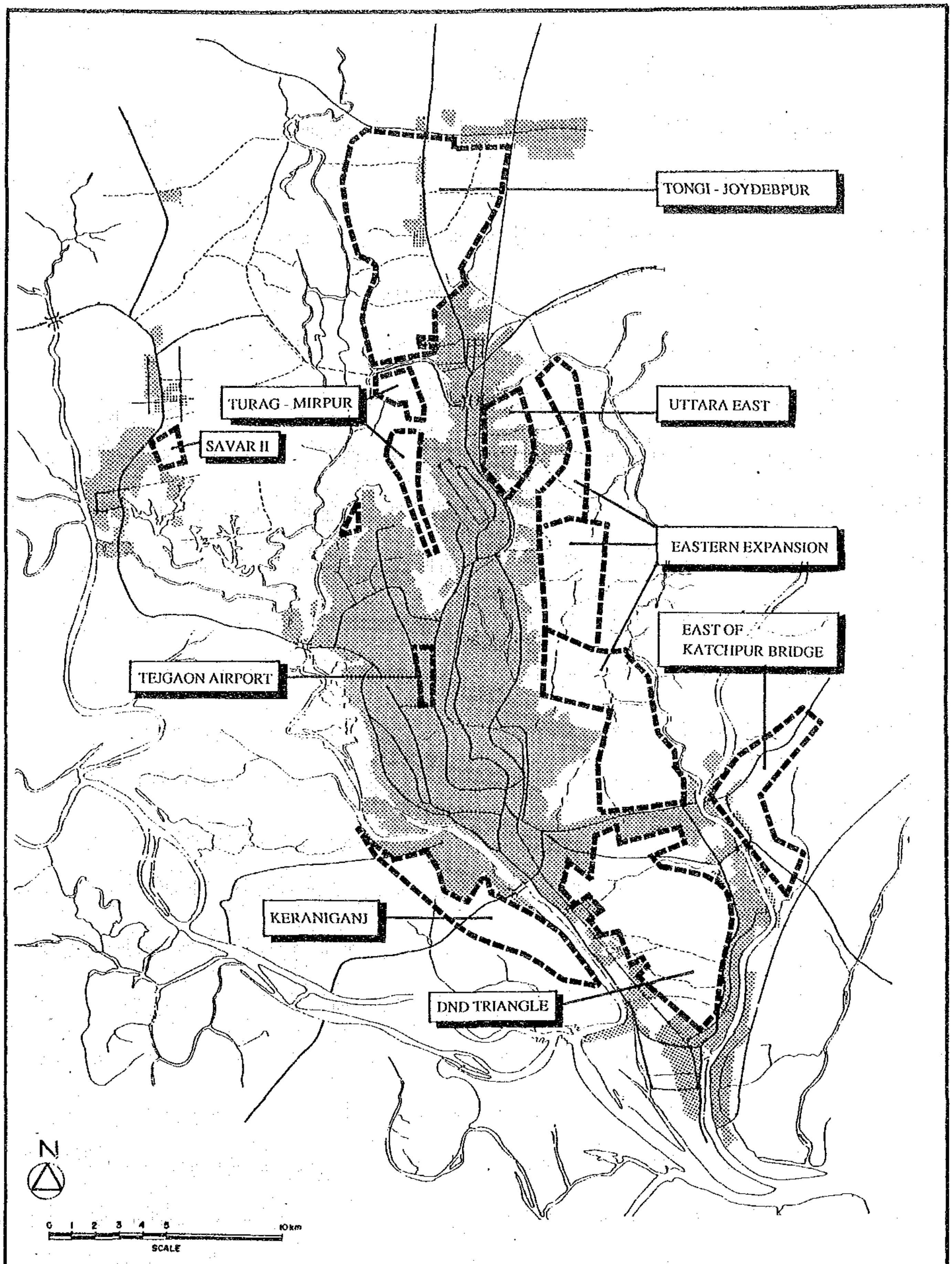

FIG. 4.5 PROBABLE DEVELOPMENT AREAS, 2000 - 2010

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

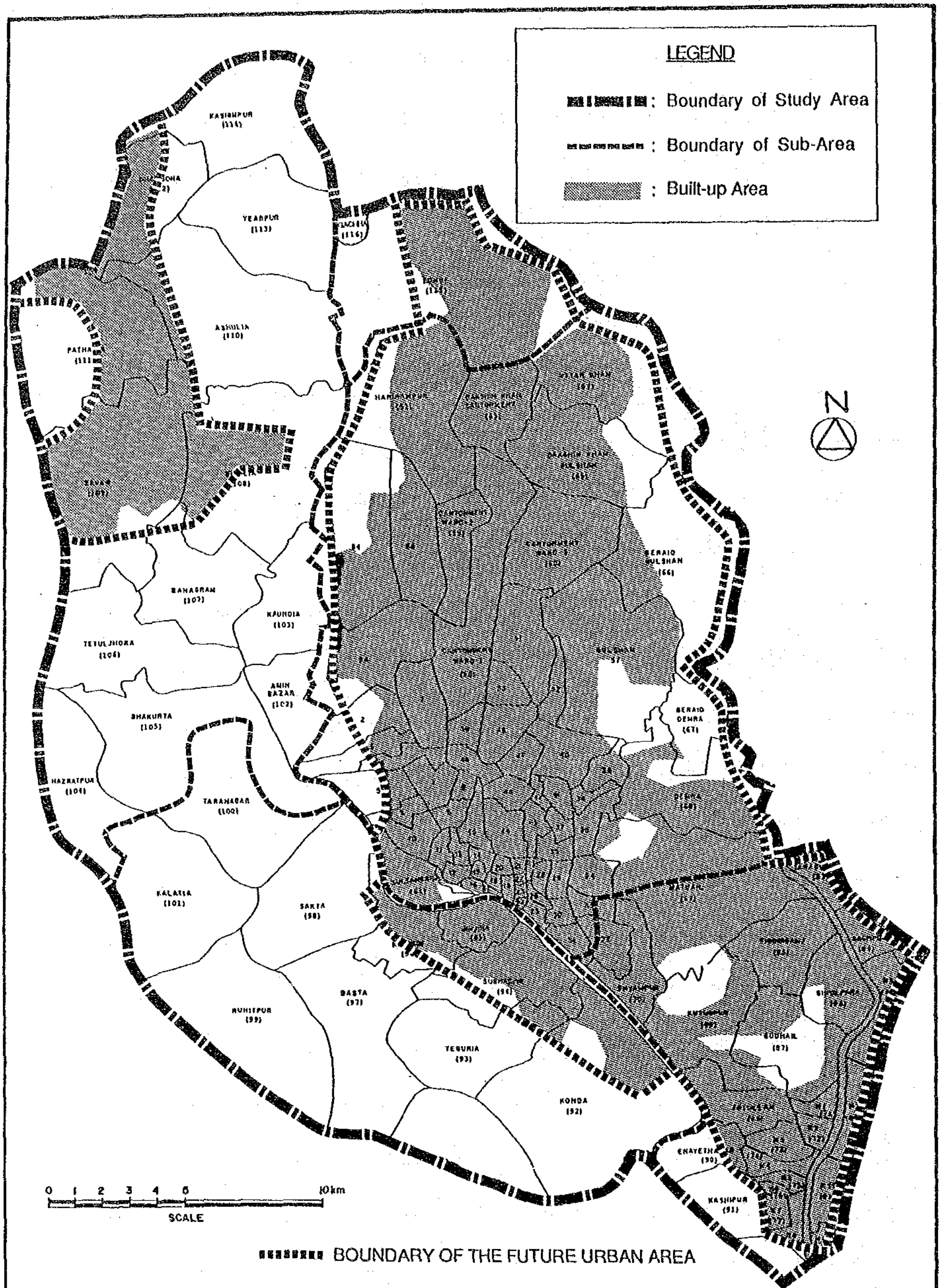

FIG. 4.6 BUILT-UP AREA, 2010

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

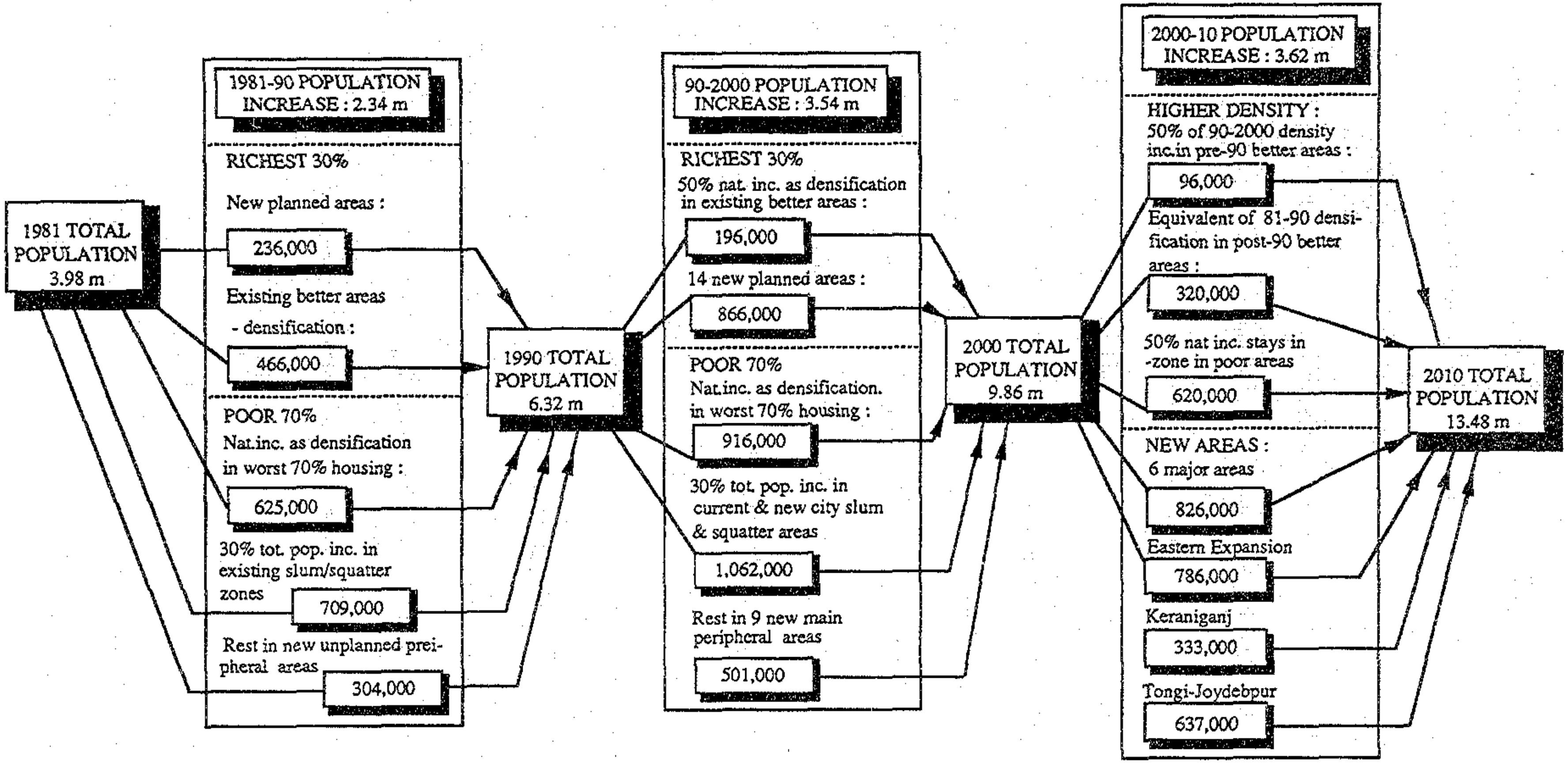

FIG. 4.7 DHAKA METROPOLITAN 'PULL' AREA : DISTRIBUTION OF POPULATION GROWTH

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

1988 Flood in Motijheel Commercial Area

1988 Flood Along Airport Road

CHAPTER 5

FLOOD AND FLOOD DAMAGE

CHAPTER 5 FLOOD AND FLOOD DAMAGE

5.1 General

There are two types of floods, external and internal, in the study area. External floods are caused by overflow of surrounding rivers, while internal floods are caused by stormwater flooding due to insufficient drainage facilities in built-up areas. The major floods have been derived from the surrounding rivers.

In order to get a clear idea of flood conditions and damage, a questionnaire survey in the study area has been carried out by the Study Team, about flood depth/duration and damage both by external and internal floods. The flood area survey covers all the major land uses of the built-up area and farm land, while the flood depth/duration survey covers only those of built-up areas. The survey on external floods has been executed for the last three floods.

They are :

- 1987 flood : one of the middle scale floods with approximately a 10-year return period
- 1988 flood : the largest flood on record, estimated to be a 70-year return period
- 1989 flood : One of the annual floods.

The internal flood survey has concentrated on the annual flood and the worst flood which occurred in the past 10 years.

5.2 Flood Conditions

5.2.1 External Flood

1) Annual Flood (1989)

The total flood area during the annual flood was 397.4 km^2, which is 48.0% of the Study Area (Fig. 5.1). However, almost no built-up areas were inundated.

2) 1987 Flood

The total flood area in the 1987 flood is calculated at 492.0 km^2 which is 59.5% of the Study Area (Fig. 5.2). The maximum inundation depth and duration over the whole built-up area were 1.65 m and 32 days. Likewise, the average depth and duration were 0.42 m and 10.5 days respectively.

3) 1988 Flood

The total flood area is estimated at 620.5 km^2 or 75.0% of the Study Area (See Fig.5.3). The maximum inundation depth and duration across the entire built-up area were 3.2 m and 65.0 days respectively. The average depth and duration were 1.03 m and 22.1 days respectively.

5.2.2 Internal Flood

1) Annual Flood

The total flood area during an annual flood is calculated at 19.8 km^2, corresponding to 9.9% of the built-up area in Dhaka, Narayanganj and Tongi, are shown in Fig. 5.4. The maximum and average inundation depth and duration are 0.61 m, 4 days, and 0.38 m, 0.5 day respectively.

2) Worst Flood

The total area of the worst internal flood is calculated at 20.1 km^2, which is almost the same value as that of annual flood.The maximum and average inundation depth and duration reach 0.91 m, 7 days, and 0.55 m, 1.5 days respectively.

5.3 Flood Damage

5.3.1 Flood Damage Records

Data and information on flood damage to various properties in the Study Area in the 1987 and 1988 floods were collected from the agencies concerned. They are summarized below :