

THE PEOPLE'S REPUBLIC OF BANGLADESH
DHAKA WATER SUPPLY AND SEWERAGE AUTHORITY
MINISTRY OF LOCAL GOVERNMENT, RURAL DEVELOPMENT
AND COOPERATION AND LOCAL GOVERNMENT DIVISION

UPDATING STUDY ON
STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT
IN DHAKA CITY

SUPPORTING REPORT

FEBRUARY 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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**THE PEOPLE'S REPUBLIC OF BANGLADESH
DHAKA WATER SUPPLY AND SEWERAGE AUTHORITY**

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AND COOPERATIVES, LOCAL GOVERNMENT DIVISION**

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SUPPORTING REPORT

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ABBREVIATIONS

1. Government, International and Private Organizations

ADB	Asian Development Bank
BWDB	Bangladesh Water Development Board
BIWTA	Bangladesh Inland Water Transport Authority
BKH B.V.	Bongaerts, Kuyper and Huiswaard B.V.
BUET	Bangladesh University of Engineering and Technology
DMC	Dhaka Municipal Corporation
DPHE	Department of Public Health Engineering
DWASA	Dhaka Water Supply and Sewerage Authority
ERD	External Resources Division
GDFCD	Greater Dhaka Flood Control and Drainage Project
GOB	Government of the People's Republic of Bangladesh
GOJ	Government of Japan
HDA	Hokkaido Development Authority,
IDA	International Development Aid
JICA	Japan International Cooperation Agency
MLGRDC	Ministry of Local Government, Rural Development and Cooperatives, GOB
MOC	Ministry of Construction, GOJ
RAJUK	Rajdhani Unnayan Kartripakkhya
RHD	Roads and Highways Department
PCI	Pacific Consultants International
PWD	Public Works Department
SKK	Sangyo Kaihatsu K.K.
UNDP	United Nations Development Programme
UNCHS	United Nations Centre for Human Settlement

2. Others

BM	Bench Mark
GTS	Geographical Survey Datum of Bangladesh : GTS=PWD-0.45m (Example GTS+9.55m=PWD+10.00m)
PWD	Survey Datum of Public Works Department
Khal	A term Commonly used in Bangladesh for "Canal"
HHWL	Highest High Water Level
HWL	High Water Level
LWL	Low Water Level
LLWL	Lowest Low Water Level
Tk	Taka (Bangladesh Currency), 1 US Dollar = approx. Tk 32.2 =4.38 Japanese Yen
Fig.	Figure
mm	millimeter
cm	centimeter
m	meter
km	kilometer
m ²	square meter
m ³	cubic meter
m ³ /s	cubic meter per second
m ³ /m	cubic meter per minutes
m ³ /h	cubic meter per hour
ha	hectare (10,000 m ²)
hr	hour

SUPPORTING REPORT - A -

1988 FLOOD

SUPPORTING REPORT A
1988 FLOOD

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SUPPORTING REPORT A 1988 FLOOD

1. GENERAL

During the later part of August and early part of September 1988, Bangladesh was devastated by the most disastrous flood that has ever been experienced. Reportedly, this flood was caused by an unprecedented flood flow of the Brahmaputra that was synchronised with very high flows of the Ganges and Meghna. An approximately 80 thousand km² (56% of the total area of Bangladesh) and 47 million people (49% of the total population of Bangladesh) were adversely affected by the flood. Dhaka city also been experienced its worst flood and suffered extensive flood damage.

In this chapter, flooding conditions of the 1988 flood in and around the Study Area will be discussed based on the hydrological records and the result of the JICA Study Team's flood survey. Where in more than 1,000 inhabitants were interviewed.

2. AVAILABLE DATA AND INFORMATION

The available hydrological data and information collected concerning the 1988 flood are as listed below :

- (1) Text book of the Seminar on "Floods in Bangladesh" held at the Institution of Engineers, Dhaka on 7 November 1988,
- (2) The 1987 and 1988 flood news by the Bangladesh Observer,
- (3) Water level records in 1987 and 1988 at four Stations (Mill Barack, Mirpur, Tongi and Demra).
- (4) Daily rainfall records for 1987 and 1988 at Dhaka station.

3. HYDROLOGICAL PARAMETERS

3.1 Rainfall

According to the isohyets of the 10 day maximum rainfall for the later part of August, 1988 shown in Fig. A.1, it can be seen that the rainfall within the country was not a big factor for the most serious 1988 flood. The rainfall pattern in the north and north-eastern zone is indicative of a very high rainfall in the upper catchment area in India.

Monthly rainfalls for August and September 1988 at the Dhaka station were 169 mm and 196 mm respectively and were almost one half of the normal amount. Daily rainfall between April and March 1988 is presented in Table A.1.

3.2 Flood Water Level

At four (4) water level stations (Mill Barack, Mirpur, Tongi and Demra) that encircle the Study Area, the 1988 flood water levels were recorded as shown in Fig. A.2. The flood water levels at each station started to rise rapidly from 29 August onward. The sharpest rise was at Mirpur. During five (5) consecutive days of rising, the daily change in water level was 39 cm at Mirpur and 30 cm at Mill Barack. The major flood of the city continued for 18 days between 30 August and 16 September and, during this period, the flood water level at Mirpur and Mill Barack were above 6.5 m and 6.0 m in GTS respectively. The frequency of 1988 flood at the each station is estimated between 40 and 100-year return period as listed below :

Maximum Water Level and Its Occurrence

<u>Station</u>	<u>Observed H.W.L. (m in PWD)</u>	<u>Modified H.W.L. (m in GTS)</u>	<u>Date</u>	<u>Frequency</u>
Mirpur	8.35	7.93	4 Sep. '88	1/100-years
Tongi	7.84	7.51	4 Sep. '88	1/40-years
Mill Barack	7.55	7.08	4 Sep. '88	1/100-years
Demra	7.09	6.64	6 Sep. '88	-

Note : Above figures of HWL (m in GTS) are the modified values of the observed records (m in PWD) based on the check survey conducted in the previous JICA study (Refer to previous JICA Supporting Report B, page B-23).

The probability of flood water level at Mill Barack is illustrated in Fig. A.3.

Table A.2 shows the water level records (m in PWD) at the four (4) above named gauging stations between August and September in 1988.

4. 1988 FLOOD CONDITIONS IN THE STUDY AREA

4.1 1988 Floods Survey

In order to yield the necessary data and information needed for reviewing of the previous JICA study, the 1988 flood survey was conducted by local surveyors employed and supervised by the JICA Study Team between 19 August and 27 August 1989.

More than 1,000 survey points were selected on the preliminary flood map having a scale of 1:10,000 provided by the JICA Study Team based on the hydrological data collected, and a rough flood map obtained from the Greater Dhaka Flood Control Implementation Coordination Committee. The number of survey points in each drainage zone is shown below :

Number of 1988 Flood Survey Points

<u>Zone</u>	<u>Number of Survey Points</u>	<u>Zone</u>	<u>Number of Survey Points</u>
A	73	F	104
B	78	G	146
C	177	H	175
D	106	I	102
E	52	J	55
		Total	1,068

Survey method was one that involved interviewing the inhabitants using the interview sheet shown in Table A.3.

4.2 Flood Area

According to a flood area map drawn using the data collected (Fig. A.4), it is estimated that almost 58% of the Study Area (Approx. 79 km²) was inundated during 1988

flood. Of the drainage zones A to J, zone I had the maximum flood area of 20.6 km²; zone A had the minimum one of 2.5 km². Drainage zones having flood area rates higher than the average one of 58% were D, E, H, I and J. Zone D had the highest rate of 98%. Details of flood area are shown in Table A.4 and Fig. A.5.

4.3 Flood Depth

Observed flood depths varied from 0.3 m for relatively high land to 4.3 m for a low land. The Study Area's average flood depth was estimated as being approximately 1.2 m. The drainage areas averaging more than 1.2 m were zones B, E, H, I, and J. Zone H had the greatest figure in average flood depth. Details of the flood depths are shown in Table A.4 and Fig. A.5.

4.4 Flood Duration

Flood durations for relatively highland and lowland areas ranges from 3 to 15 days and from 15 to 60 days respectively. From the interviews, it was learned that although there are some inland city areas of zones C, D, and F having relatively high ground elevations and a drainage khals, they nevertheless had long flood durations. This means that most of the khals are choked by encroachment, earth filling, deposition of city garbage, etc. and require improvement to be able to maintain satisfactory drainage conditions. Details of the 1988 flood durations are shown in Table A.4 and Fig. A.5.

4.5 Flood Vulnerable Population

The total population of the Study Area in 1988 is estimated as being $3,267 \times 10^3$. The figure is based on the 1986 population growth rate given in the previous study. $1,823 \times 10^3$ (55.8%) people were estimated to have been affected by the 1988 flood. This population will increase to $2,709 \times 10^3$ by the year 2000. The flood vulnerable population in 1988 and 2000 are shown in Table A.4 by drainage zone.

4.6 Specific Characteristics of the 1988 Flood

Specific characteristics of the 1988 flood to be considered for the Updating Study are summarized below:

- The 1988 flood in Dhaka city was caused by external flooding coming from the northwest upper catchment areas and its occurrence was a very low frequency.

- Flood conditions of the north or northwest parts of the Study Area were worse in comparison to those in the central parts of the Dhaka city.
- The poor discharge capacities of the existing khals caused the long flood durations in inland areas and aggravated the flood damage.

Table A.1 Daily Rainfall at Dhaka Station between April 1988 and March 1989

BANGLADESH WATER DEVELOPMENT BOARD
Surface Water Hydrology

Daily Rainfall in mm												
Station : 9 Dhaka sub div : DA Year : 1988-89												
Date	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	0	0	8.0	0	2.0	0	0	0	2.0	0	0	0
2	0	0	0	2.0	0	0	6.0	0	1.0	0	0	0
3	0	0	8.0	4.0	1.0	20.0	3.0	0	0	0	0	0
4	0	1.0	37.0	16.0	6.0	11.0	4.0	0	0	0	0	0
5	0	0	0	14.0	3.0	0	17.0	0	0	0	0	0
6	0	0	0	23.0	4.0	42.0	2.0	0	0	0	0	0
7	0	4.0	51.0	40.0	0	1.0	8.0	0	0	0	0	0
8	0	1.0	53.0	18.0	0	0	0	0	0	0	0	0
9	0	51.0	0	24.0	1.0	18.0	0	0	0	0	0	0
10	0	5.0	4.0	4.0	0	15.0	0	0	0	0	0	0
11	0	1.0	15.0	9.0	6.0	29.0	0	0	0	0	0	0
12	3.0	0	7.0	26.0	34.0	0	0	0	0	0	0	0
13	0	1.0	78.0	2.0	2.0	1.0	45.0	0	0	0	0	0
14	0	5.0	64.0	3.0	10.0	0	4.0	0	0	0	0	0
15	26.0	0	18.0	14.0	2.0	1.0	0	0	0	0	6.0	0
16	122.0	21.0	11.0	6.0	0	6.0	0	0	0	0	0	0
17	1.0	5.0	28.0	2.0	3.0	17.0	0	0	0	0	0	0
18	0	0	56.0	0	0	0	0	0	0	0	0	0
19	0	2.0	0	2.0	0	2.0	35.0	0	0	0	25.0	0
20	0	4.0	0	1.0	2.0	11.0	129.0	0	0	0	1.0	0
21	14.0	59.0	0	0	3.0	0	0	1.0	0	0	0	0
22	64.0	82.0	6.0	10.0	22.0	0	0	0	0	0	0	0
23	0	93.0	2.0	7.0	20.0	0	0	0	0	0	0	0
24	0	35.0	23.0	2.0	3.0	0	0	0	0	0	0	0
25	0	32.0	48.0	0	4.0	13.0	0	0	0	0	0	0
26	23.0	21.0	17.0	16.0	0	0	0	0	0	0	0	0
27	0	0	37.0	6.0	0	0	0	0	0	0	0	0
28	0	0	6.0	3.0	0	0	0	0	0	0	0	0
29	28.0	6.0	2.0	0	40.0	1.0	0	17.0	0	0	-	0
30	1.0	84.0	0	0	1.0	8.0	0	135.0	0	0	-	0
31	-	2.0	-	1.0	0	-	0	-	0	0	-	0
Ten Daily Total												
Td1	0	62.0	161.0	145.0	17.0	107.0	40.0	0	3.0	0	0	0
Td2	152.0	39.0	277.0	65.0	59.0	67.0	213.0	0	0	0	32.0	0
Td3	130.0	416.0	141.0	45.0	93.0	22.0	0	153.0	0	0	0	0
Monthly Total												
Mtot	282.0	517.0	579.0	255.0	169.0	196.0	253.0	153.0	3.0	0	32.0	0
Rday	9.0	21.0	22.0	25.0	20.0	16.0	10.0	3.0	2.0	0	3.0	0
Depth Duration Data												
Dday	1	2	3	5	7	10	15	20	30.0	60.0	90.0	120.0
Rmax	135.0	175.0	234.0	301.0	326.0	414.0	469.0	577.0	858.0	1212.0	1557.0	1697.0

Annual rainfall : 2439

Annual rainy days : 131

Table A.2 Water Level at Four Stations (Aug. to Sep. 1988)

Date	Mill Barrack				Mirpur				Tongi				Demra			
	August		September		August		September		August		September		August		September	
	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL
1	5.420	5.380	7.340	0.150	5.680	5.680	7.880	5.580	5.580	7.280	5.670	5.620	6.820	6.400		
2	5.490	5.420	7.510	7.430	5.720	5.700	8.160	5.610	5.590	7.630	5.680	5.650	6.920	6.860		
3	5.530	5.490	7.570	7.540	5.750	5.750	8.300	5.640	5.640	7.780	5.730	5.670	6.990	6.950		
4	5.450	5.420	7.580	7.550	5.750	5.720	8.300	5.630	5.620	7.800	5.690	5.660	7.040	7.010		
5	5.410	5.360	7.510	7.490	5.700	5.680	8.150	5.610	5.590	7.730	5.640	5.600	7.080	7.060		
6	5.320	5.270	7.460	7.410	5.640	5.620	8.100	5.570	5.550	7.650	5.570	5.520	7.090	7.070		
7	5.240	5.190	7.360	7.300	5.600	5.550	7.750	5.530	5.500	7.540	5.480	5.450	7.070	7.050		
8	5.160	5.150	7.240	7.200	5.530	5.500	7.730	5.470	5.440	7.530	5.460	5.400	7.020	7.000		
9	5.160	5.130	7.160	7.130	5.490	5.460	7.720	5.410	5.400	7.370	5.450	5.360	7.010	6.990		
10	5.150	5.130	7.100	7.070	5.460	5.450	7.600	5.380	5.360	7.320	5.400	5.340	7.020	7.010		
11	5.160	5.130	7.030	6.980	5.480	5.460	7.500	5.430	5.400	7.230	5.410	5.360	6.980	6.950		
12	5.160	5.130	6.940	6.900	5.490	5.480	7.420	5.470	5.450	7.150	5.400	5.350	6.940	6.910		
13	5.180	5.150	6.850	6.800	5.490	5.480	7.340	5.480	5.470	7.070	5.430	5.360	6.900	6.880		
14	5.210	5.190	6.760	6.740	5.530	5.510	7.200	5.480	5.480	6.980	5.480	5.440	6.840	6.810		
15	5.270	5.230	6.670	6.610	5.580	5.550	7.100	5.490	5.480	6.870	5.540	5.470	6.770	6.720		
16	5.330	5.290	6.560	6.510	5.620	5.590	6.900	5.500	5.490	6.820	5.580	5.500	6.700	6.670		
17	5.380	5.330	6.450	6.390	5.650	5.630	6.800	5.530	5.510	6.700	5.620	5.550	6.620	6.570		
18	5.450	5.410	6.290	6.220	5.710	5.680	6.620	5.570	5.560	6.580	5.680	5.630	6.500	6.480		
19	5.490	5.450	6.110	6.020	5.740	5.730	6.600	5.600	5.590	6.450	5.710	5.670	6.390	6.350		
20	5.530	5.490	5.940	5.870	5.780	5.760	6.440	5.630	5.610	6.370	5.720	5.690	6.290	6.250		
21	5.550	5.520	5.760	5.700	5.790	5.780	6.340	5.660	5.640	6.260	5.720	5.700	6.170	6.090		
22	5.560	5.550	5.630	5.580	5.840	5.820	6.180	5.690	5.650	6.200	5.730	5.710	6.030	5.980		
23	5.590	5.580	5.500	5.440	5.900	5.850	6.020	5.730	5.710	5.980	5.760	5.720	5.920	5.850		
24	5.620	5.590	5.380	5.290	5.980	5.940	5.880	5.750	5.730	5.880	5.780	5.740	5.770	5.700		
25	5.670	5.640	5.250	5.150	5.990	5.980	5.710	5.790	5.780	5.700	5.820	5.790	5.650	5.560		
26	5.760	5.710	5.140	5.040	6.060	6.000	5.560	5.840	5.820	5.580	5.900	5.850	5.540	5.390		
27	5.840	5.820	5.030	4.940	6.180	6.100	5.430	5.930	5.890	5.460	6.000	5.950	5.400	5.300		
28	6.020	5.850	4.920	4.840	6.440	6.280	5.330	6.130	6.030	5.350	6.150	6.070	5.270	5.150		
29	6.380	6.190	4.300	4.740	6.780	6.620	5.200	6.400	6.280	5.160	6.350	6.250	5.160	5.050		
30	6.720	6.540	4.690	4.630	7.300	7.030	5.080	6.770	6.580	5.090	6.530	6.450	5.040	4.950		
31	7.030	6.890	-	-	7.700	7.460	-	7.130	7.000	-	6.680	6.620	-	-		

Note: Above figures indicate the water levels in meters in PWD.

TABLE A.3 1988 FLOOD SURVEY SHEET

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

FLOOD SURVEY INTERVIEW SHEET

Subject: Flood Survey in Dhaka City
বিষয় : ঢাকা মহানগরীতে বন্যার জরিপ।
Execution Agency: JICA STUDY TEAM in
cooperation with DWASA

Date	Aug.	1989
Name of Interviewer		
(ID No.)		

A. Survey Point
জরিপ স্থান

Address	ঠিকানা
Ward No.	এলাকা নং
Point No.	

Note: Interviewer should mark each survey point and its number down on the map.
সাক্ষরকারী অবশ্যই জরিপ স্থান চিহ্নিত এবং মাল চিত্রে প্রদর্শন করবেন।

B. Questionnaire
প্রশ্নমালা

- What sort of land is this spot?
এই স্থানটি কোন প্রকারের?
 - High Land Area or উচ্চ এলাকা
 - Low Land Area or নিচ এলাকা
 - Very Low Land Area or অতি নিচ এলাকা
- How flooded is this spot?
এই এলাকায় কেমন বন্যা হয়?
 - Completely free from flood?
(ক) বন্যা হতে সম্পূর্ণ মুক্ত?
 - Flooded in every rainy season?
(খ) প্রতি বর্ষায় প্রায়ই হয় কিনা?
 - Flooded very seriously in rainy season only?
(গ) কেবলমাত্র অতি বন্যায় ভেঙ্গে যায় কি?

3. If you chose (b) or (c) above, please answer the following questions:
উপরে (খ) বা (গ) অনুসারে নীচের প্রশ্ন দুটির উত্তর দিন

3-1. What was the maximum depth of flood in 1988?
১৯৮৮ সনের বন্যায় সবচেয়ে বেশী কত পানি জমেছিল?

- Less than 1 foot. এক ফুটের নিচে
- Less than 2 feet. দুই ফুটের নিচে
- Less than 3 feet. তিন ফুটের নিচে
- Less than 4 feet. চার ফুটের নিচে
- Less than 5 feet. পাঁচ ফুটের নিচে
- More than 5 feet. Then how deep was it?feet.
পাঁচ ফুটের বেশী হলে পানির গভীরত কত ছিল? ফুট

3-2. How long was the duration of the flood in 1988?
১৯৮৮ সনের বন্যা কত দিন স্থায়ী ছিল?

..... day(s). month(s)
দিন মাস

3-3. When did the flood start and finish in 1988?
১৯৮৮ সনের বন্যা কখন শুরু এবং
কখন শেষ হয়েছিল?

Beginning Date.....	Ending Date.....
আরম্ভের তারিখ.....	কমানোর তারিখ.....

TABLE A.4 1988 FLOOD CONDITIONS

Drainage Zone	Area (km ²)	Population (Density per ha)		Number of Survey Points in Flood Area	1988 Flood			Flood Vulnerable People	
		1988	2000		Area (km ²) (% of Area)	Depth (m) min. ~ max. (Avg.)	Duration (days) min. ~ max. (Avg.)	Year 1988	Year 2000
A	7.25	259900 359	321800 444	49 * 73	2.50 (34.5)	0.30~2.13 (1.16)	7~42 (25.43)	89600	111000
B	7.24	565000 780	606100 837	77 * 78	3.38 (46.7)	0.30~2.44 (1.21)	15~60 (30.09)	263800	283000
C	10.92	385000 353	469200 430	163 * 177	5.72 (52.4)	0.30~1.75 (1.08)	3~64 (30.02)	201700	245800
D	7.46	332000 445	552000 740	106 * 106	7.32 (98.1)	0.30~2.13 (1.05)	7~60 (31.27)	325800	541600
E	13.93	93000 67	244000 175	51 * 52	9.93 (71.3)	0.30~3.05 (1.32)	14~48 (29.23)	66300	173900
F	13.70	429500 313	540300 394	83 * 104	3.57 (26.1)	0.30~4.27 (1.05)	14~50 (26.18)	111900	140800
G	17.64	243500 138	337000 191	115 * 146	7.90 (44.8)	0.30~1.83 (0.85)	7~60 (23.10)	109000	150900
H	17.60	435700 248	669500 380	150 * 175	12.34 (70.1)	0.30~3.35 (1.45)	13~47 (28.58)	305500	469400
I	31.42	382300 122	613300 195	93 * 102	20.58 (65.5)	0.30~3.66 (1.36)	13~52 (24.91)	250400	401700
J	7.69	141100 184	271700 353	43 * 55	5.42 (70.5)	0.30~2.44 (1.39)	12~45 (29.28)	99400	191500
SUMMATION	134.85	3267000 242	4624900 343	930 * 1068	78.66 (58.3)	0.30~4.27 (1.18)	3~64 (27.91)	1823400	2709600

Note : The figure marked with * means number of total survey points

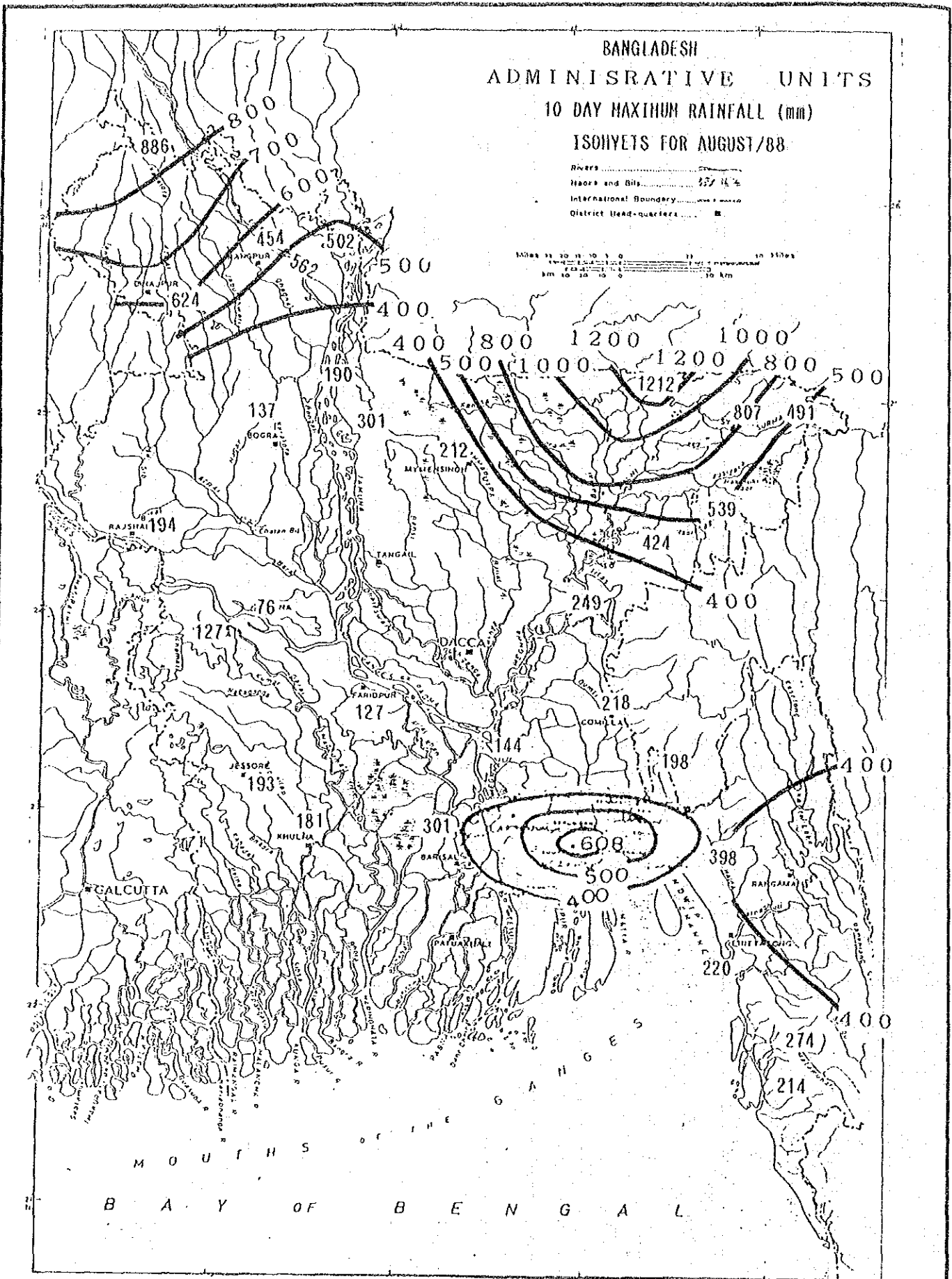
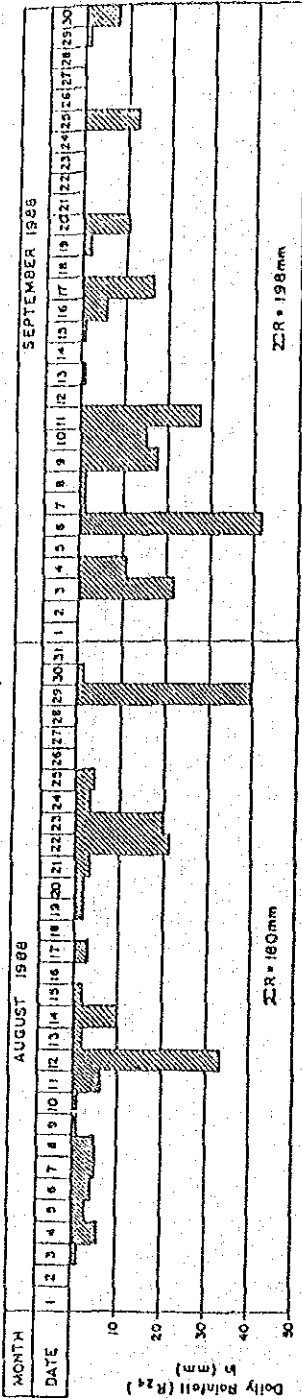


FIG. A. 1

10 DAY MAXIMUM RAINFALL DURING AUGUST 1988

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY



LOCATION OF EXISTING STATIONS

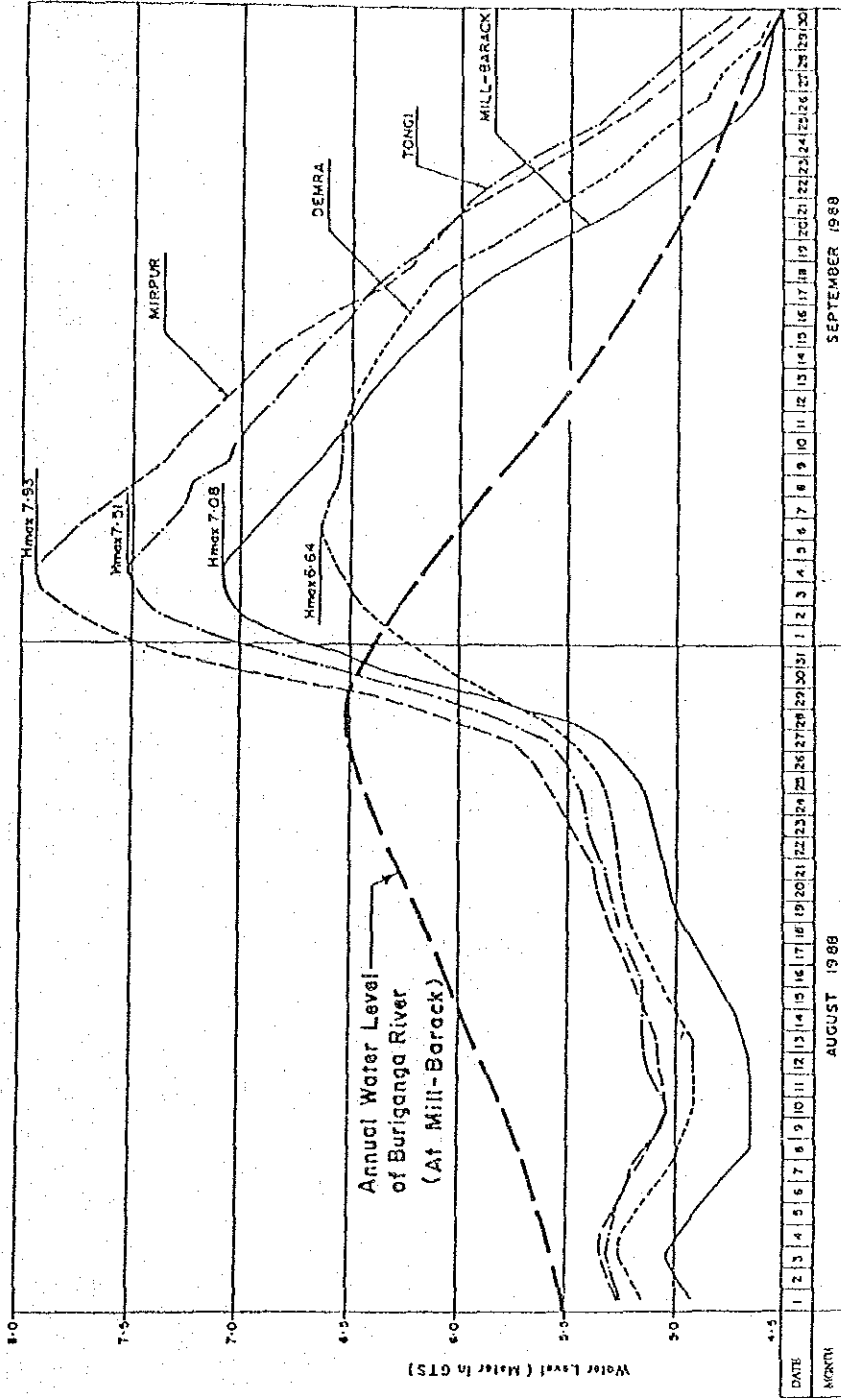
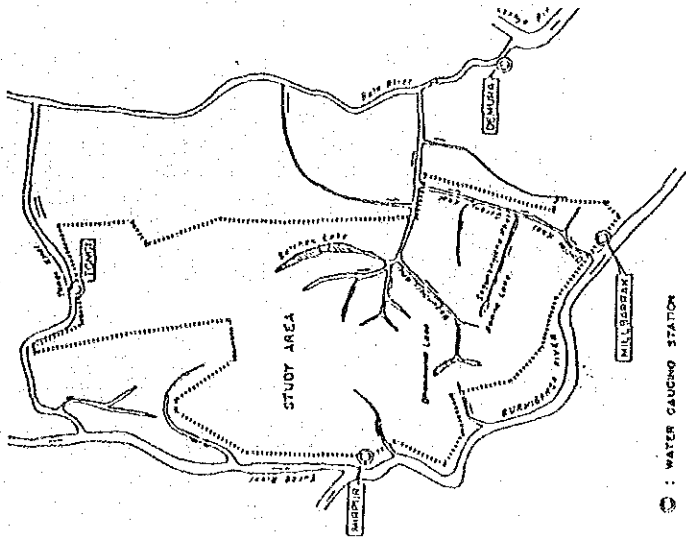
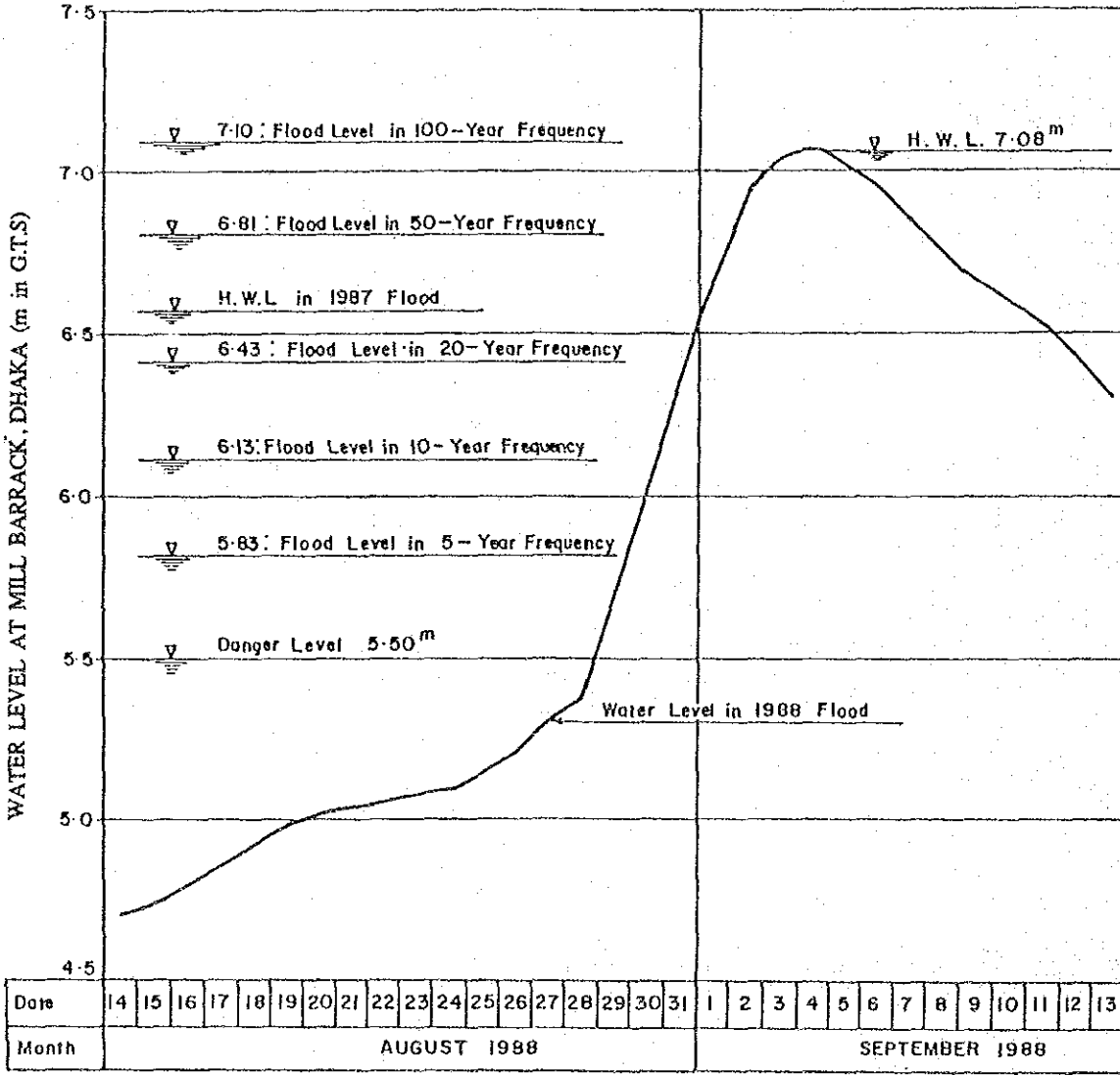
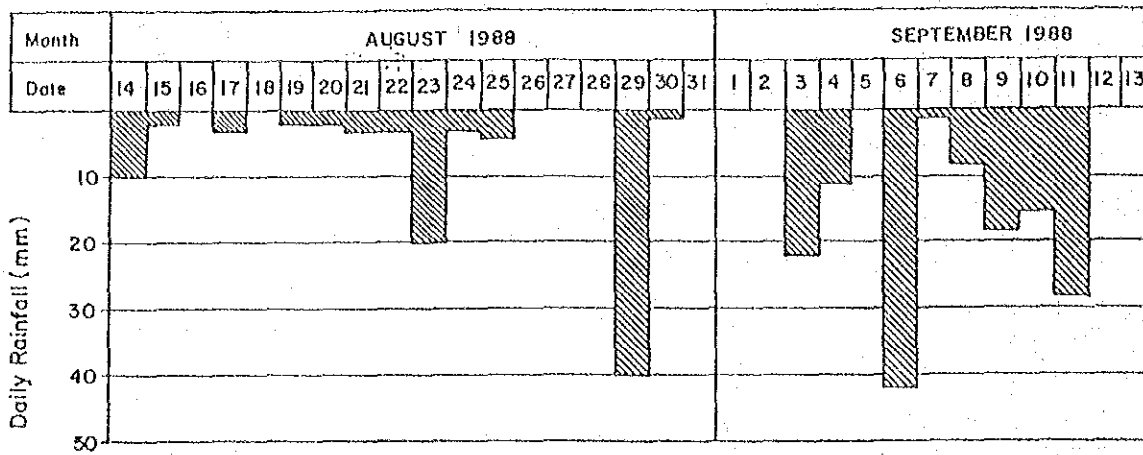


FIG. A. 2 RAINFALL AND FLOOD WATER LEVEL VARIATIONS AT DHAKA DURING 1989 FLOOD

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY

Daily Rainfall in Dhaka Station

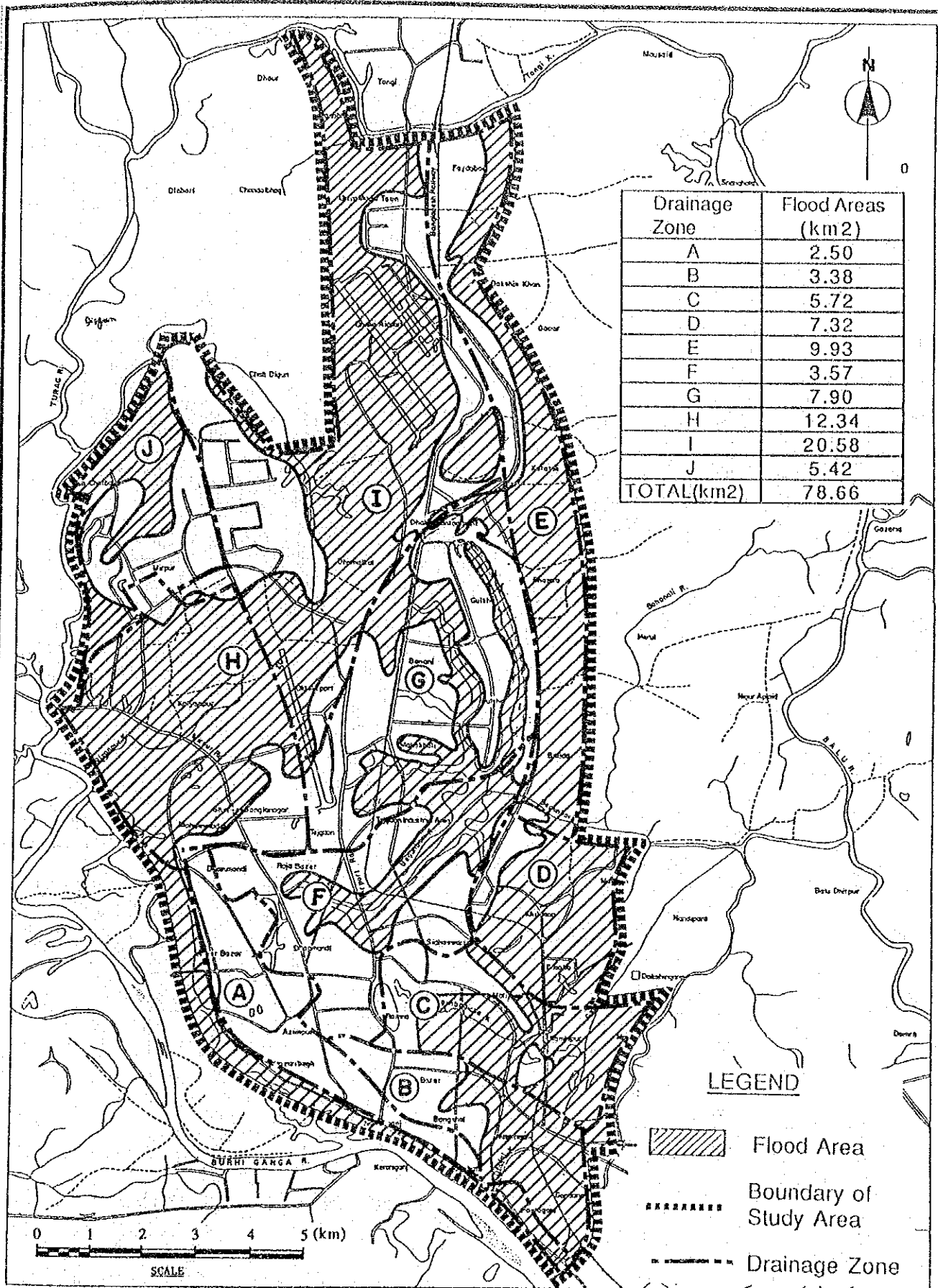


WATER LEVEL AT MILL BARACK DHAKA CITY

Source : EWDB

FIG. A. 3

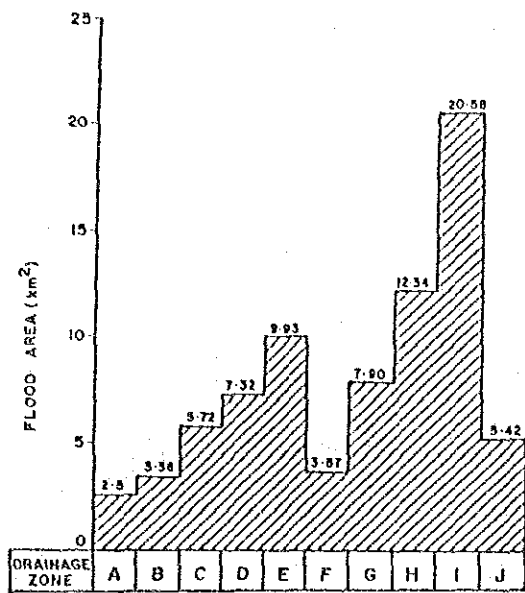
PROBABILITY OF FLOOD WATER LEVEL AT MILL BARACK



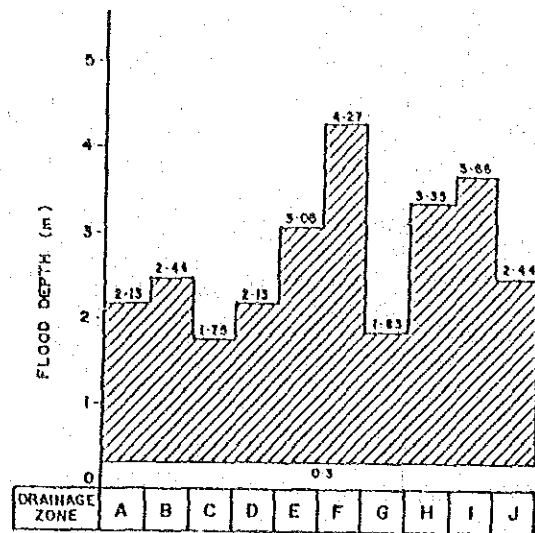
Source: Surveyed by JICA Study Team

FIG. A. 4 1988 FLOOD AREA BY DRAINAGE ZONE

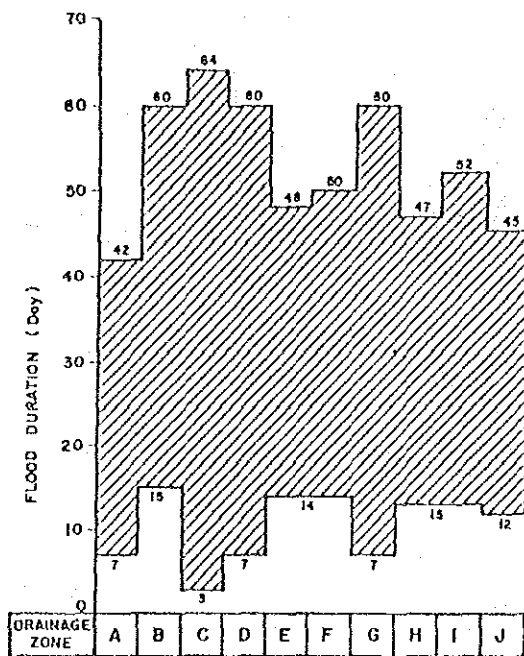
UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY



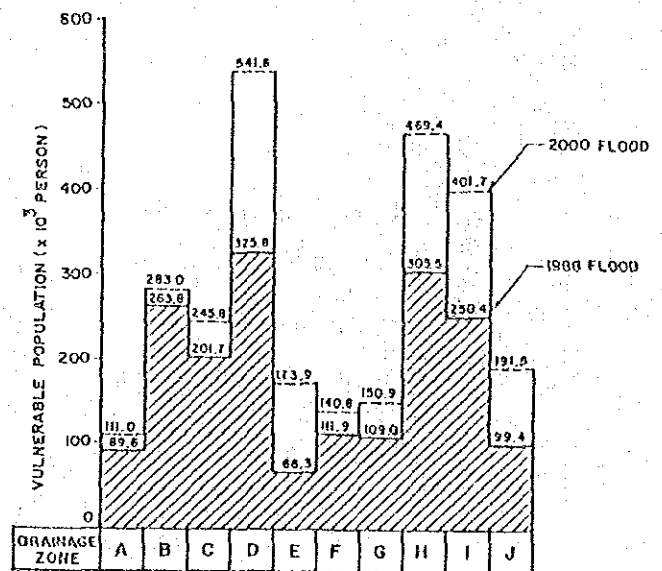
FLOOD AREA



FLOOD DEPTH



FLOOD DURATION



VULNERABLE POPULATION

Source: JICA Study Team

FIG. A. 5 1988 FLOOD CONDITIONS BY DRAINAGE ZONE

SUPPORTING REPORT - B -

RELATED ONGOING PROJECTS

SUPPORTING REPORT B
RELATED ONGOING PROJECTS

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SUPPORTING REPORT B RELATED ONGOING PROJECTS

1 GENERAL

In the previous JICA study, the following related Studies and Projects were reviewed.

- Master Plan and Feasibility Study in 1968
- Dhaka Metropolitan Area Integrated Urban Development Project
- Ongoing Project by DPHE

In this Chapter, the following three projects will be discussed as the related ongoing projects to correlate with the updating JICA study.

- Dholai Khal Rehabilitation and Area Development Project
- Greater Dhaka Flood Control and Drainage Project
- Drainage Improvement Projects

2 DHOLAI KHAL REHABILITATION AND AREA DEVELOPMENT PROJECT

2.1 Scope of the Project

In October 1986, BKH B.V. submitted to UNDP/UNCHS the Final Feasibility Report on the Dholai Khal Rehabilitation and Area Development Study, Housing Development Project Sub-contract A, in cooperation with Dhaka Municipal Corporation (DMC), the execution agency of the Government of Bangladesh. The Study Area is 6.40 km² as illustrated in Fig. B.1.

The Housing Development Project, the so-called World Bank Project, which includes the Dholai Khal rehabilitation, has been accepted by the Government of Bangladesh. Negotiations with the World Bank have been made and a Loan Agreement was signed in July 1988 between the IDA and the Government of Bangladesh.

The purposes of the World Bank Project are :

- (1) Improvement of the drainage system of the old part of Dhaka city

- (2) Improvement of the communication facilities in the old area as previously made in other parts of Dholai Khal
- (3) Provision of new commercial activity along the side of the improved Dholai Khal
- (4) Provision of improved health and sanitation conditions.

For the above project purpose (1), the consultant proposed rehabilitation measures consisting of three major components:

- (1) Ensuring the discharge of the storm water during high water levels periods in the river by closing off the Dholai Khal from the river and installing a combined sluice/pump station,
- (2) Rehabilitation of the Debdulai and Gerani khals by resectioning and lining the profile, and
- (3) Rehabilitation of the section from the Dayaganji railway bridge to the confluence with the Buriganga River.

As rehabilitation alternatives for the Dholai Khal improvement works, the following three options were developed and investigated:

- Option 1 : A lined open canal over the full length of the Dholai Khal.
- Option 2 : A culvert section from the Sutrapur Iron Bridge to Narinda and further onwards to the existing Dholai khal road, and a lined open canal from Narinda to Dayagonji Railway Bridge.
- Option 3 : A culvert section from the Sutrapur Iron Bridge to the Dayagonji Railway Bridge and from Narinda junction to the existing Dholai khal road, and a lined open canal in the remaining parts.

With each of the three options, the Gerani and Debdulai khals will be lined open canals and the installation of a combined sluice/pump station will be required at the confluence of the khal with the Buriganga River.

Fig. B.2 illustrates the Dholai Khal rehabilitation alternatives.

As the result of a feasibility study of the above alternatives, Option 1 is most feasible for the purpose of making drainage system improvement only. The Consultant, considering other three purposes of the project mentioned before, recommended that Option 3 is the best choice for developing the Dholai Khal..

2.2 Proposed Storm Water Drainage Works

The proposed storm water drainage works are as follows :

- (1) Improvement of Dholai Khal by covered types (box culvert) from Dayagonji Railway Bridge up to Sutrapur Iron Bridge (length : approx. 0.75 km)
- (2) Improvement of Dholai Khal by open lined section from Sutrapur Iron Bridge up to Buriganga River (length : approx. 0.35 km)
- (3) Improvement of Gerani and Debdulai khals by open lined section from the confluence with both khals up to their uppermost points (length : approx. 1.4 and 1.25 km respectively)
- (4) Construction of a new pumping station having a capacity of 80,000 m³/h at the confluence with the Buriganga River
- (5) Construction of one reservoir with an area of 2.4 ha, a depth of 8.25 m and an effective storage capacity of 155,000 m³ at the existing Narinda pumping station, and two deep reservoirs with a total area of 1.8 ha, a depth of 3.75 m and a total effective storage capacity of 50,000 m³ at Dayaganj/Jatrabari
- (6) Removal of the existing Narinda pumping station

The proposed drainage plan and facilities are illustrated in Fig. B.3 and Fig. B.4.

2.3 Project Cost

The capital cost of the World Bank Project was estimated to be US\$ 11.43 million (1989 prices). The breakdown are presented below :

CAPITAL COST

<u>Item</u>	<u>Cost (Thousand US\$)</u>
A. Khal rehabilitation	
1. Open canal sections	730
2. Culvert sections	2,270
Subtotal A	----- 3,000
B. Pumping stations	4,551
C. Storage basins	
1. Narinda	317
2. Doyaganj/Jatrabari	123
Subtotal B	----- 440
D. Road & reconstruction	699
E. Relocation programme	205
F. Land acquisition	895

Total A - F	9,790
Contingency	1,640
Grand Total	----- 11,430

2.4 Correlation with Related Ongoing Projects

A detailed design was started in October 1989 by the foreign consultant, BKH V.B. with financial assistance from UNDP/UNCHS finance. During the detailed design stage, the following items may be reviewed in order to correlate the Greater Dhaka Flood Control and Drainage Project with the JICA Project, and to revise, if necessary.

- (1) Drainage Zone Boundary: The drainage zone boundary of the Dholai khal, including Debdulai and Gerani khals, shall be adjusted with both projects, the World Bank and JICA projects.
- (2) Design Rainfall: Design rainfalls adopted for the storm water drainage in the World Bank and JICA projects

are 10-year and 5-year frequency rainfalls respectively.

(3) Design/Flood Water Level: The design flood water level for a flood protection dike and sluice gate of the World Bank Project shall be correlated with that of the GDFCD Project.

(4) Culvert and Pump Station: Invert elevation of the culvert proposed in the World Bank Project shall be planned below zero (0) meter in GTS to connect the existing drainage pipe of 3.0 m dia at the existing Narinda pumping station. Considering the improvement of drainage condition around Bakshi Bazar area (flood depth : 0.4-1.0 m, duration : 5-150 hr.) it would be desirable to have the HWL of Dholai khal at the existing Narinda pump station be 4.0 meter in G.T.S.

3 GREATER DHAKA FLOOD CONTROL AND DRAINAGE PROJECT (GDFCD PROJECT)

3.1 Committee for Flood Control and Drainage of Greater Dhaka

In the wake of the most disastrous 1988 flood, on October 24, 1988, the President, organized a Committee for "Flood Control and Drainage of Greater Dhaka" comprised of thirteen members of the related government offices and agencies with the Minister of Planning as the Chairman. The terms of reference of the Committee are as follows :

- (1) To prepare a flood control plan for Greater Dhaka Metropolitan area, Mirpur, Tongi and Narayanganj
- (2) The committee will also consider the following :
 - (a) Establishing link roads around Dhaka-Narayanganj, Tongi-Savar-Mirpur and neighbouring industrial areas
 - (b) Formation of lakes within Dhaka City to facilitate drainage

(c) Modernization of Dhaka's sewerage system

Organization of the Committee is shown in Table 3.1.

The Committee has held a series of meetings with not only its members but also with experts from BUET, Diploma Engineers Institute, BIWTA, Surveyor's General Office etc. and also Dutch Consultant, Mr. T.G.H. Jansen, in order to take a high level policy decision for Flood Control and Drainage of Greater Dhaka.

3.2 Recommendation by a Dutch Expert

In response to the request by the Government of Bangladesh, the Government of the Netherlands sent the expert Mr. T.G.H. Jansen to Dhaka to assist the Committee in analysing the possibilities for protecting Greater Dhaka city from serious inundation by the November 1988 floods.

The Dutch expert joined by two local consultants studied for five (5) working days and then submitted a report to the Committee on 17 November 1988.

The report consists of (1) the hydrological conditions in Dhaka city, (2) 1988 flood and flood damages faced, (3) the relevant studies carried out in the past and existing plans, (4) considerations of how to solve flooding problems in Dhaka city, and (5) recommendations of actions to be taken.

As a result of economic, technical and social considerations on long term planning, Mr. Jansen proposed protecting Greater Dhaka city by constructing a flood protection dike along the Buriganga, Turag and Balu rivers, and the Tongi khal in three (3) phases. This idea, as shown in Fig. B.5, is almost the same as that of Halcrow's who was consulted in 1972.

The proposed plan which will cost almost Tk 4,500 million (1988 prices) covers:

- 66 km of peripheral embankment
- 44 km of inner (secondary) embankment
- 4 km of flood protection wall along the Buriganga River
- 5 pumping stations
- sluices and other structures.

He suggested that the proposed plan be implemented through a policy decision made at an appropriate higher level for the solution of Greater Dhaka city's flood problems.

He also suggested that

- (1) The Zia International Airport should be protected by an embankment as soon as possible.
- (2) The construction of the water regulating structure at the outfall of Dholai Khal (the World Bank Project) fits as a short term solution in the long term strategy and seems well justified.
- (3) The plan allows phase wise development. The pump capacity could be expanded gradually when the habitation expands into the lowlands and the storage of water in the lowlands is decreasing.
- (4) When a decision is made to go for a permanent solution, a feasibility study should be made.

3.3 Recommendation by the Committee

The Committee proposed the Phased Programme of Flood Control and Drainage for Greater Dhaka City (hereinafter referred as to "GDFCD Project"), after considering the existing conditions of the Greater Dhaka area, previous studies and projects, ongoing projects and existing plans, and the recommendation by the Dutch expert.

As shown in Fig. B.6, the Phase I Programme was proposed as the flood control and drainage measures for most of the existing urbanized areas and the western part of the Greater Dhaka city, which is surrounded by the Buriganga River, Turag River, Tongi Khal, National Railway, D.I.T. Road, etc. The remaining eastern part of the Greater Dhaka city will be protected by the Phase II Programme.

The proposed 13 projects for the Phase I Programme and three (3) projects for the Phase II Programme are listed in Tables B.2 and B.3, and illustrated in Fig. B.7. The typical design of flood protection embankment and wall are given in Fig.B.8.

The Committee also recommended the following :

- 1) The proposed programme for the Greater Dhaka city is to be accepted for implementation in the immediate phase.
- 2) If the required land is acquired, it will be handed over to the executing agencies who will complete all the preparatory actions (survey, design, tender etc.) and will make the required funds available. If a serious effort is made on an emergency basis, it will be possible to protect the Greater Dhaka city from another serious flood even if it occurs during the next flood season.
- 3) Coordination of activities of all concerned agencies, e.g., RHD, DMC, BWDB, RAJUK, DPHE, WASA, Airport Development Authority, etc. will be a gigantic task. Either a Committee consisting of all agencies concerned is constituted with requisite power or, perhaps, a better alternative would be to establish a statutory authority having all the necessary legal and administrative powers.

The proposed Phase I Programme is now under construction by the agencies concerned. The Government of Bangladesh reported that almost 70% of the urgent work was completed by the beginning of September 1989.

4 DRAINAGE IMPROVEMENT PROJECTS

4.1 Khal Improvement Project

There are three (3) groups of major drainage khals in the city: (1) Digun-Ibrahimpur-Kallyanpur khals; (2) Gulshan-Banani-Begunbari-Dhanmondi khal; and (3) Dholai-Gerani-Segunbagicha khal.

During the previous JICA study, an observation was made that many portions of these khals were occupied by encroachment without proper sanction, earth filling, deposition of city garbage, and buildings and roads. It is clear that this is one of the major causes of floods in Dhaka city. JICA has strongly recommended the enforcement of controls to prevent any reduction of the minimum khal area.

The GDFCD Committee also recommended implementing the khal cleaning work. DPHE proposed the Khal Reexcavation Project to MLGRDC at the beginning of January 1989. MLGRDC decided that the project was to be executed by DWASA and seventy six officials of DPHE were transferred to DWASA on 20 March 1989 in order to implement the project satisfactorily. The Project (preliminary emergency work),

having a Tk 7 million budget, was implemented from the beginning of March until the end of June 1989. Progress of each khal reexcavation is shown in Table B.4.

The above project is, however, for the urgent khal cleaning work only. For the Drainage Circle, DWASA is now preparing a project for the demarcation of land acquisition, eviction or resettlement of unauthorized houses or structures, and the reexcavation of thirteen khals that are immediately required. This is accordance with the khal improvement plan of the previous JICA study. DWASA has already taken up the matter of land acquisition with the District administration and in some cases with RAJUK.

Locations of the proposed thirteen khal improvements is illustrated in Fig. B.9.

4.2 Additional Drainage Facilities

Major drainage facilities in the Study Area constructed before 1985 were investigated and evaluated hydraulically and structurally in the previous study. In this Section, the additional drainage facilities constructed since 1986 and those that will be constructed by the related agencies (DPHE, DWASA, DMC and RAJUK) in the near future were investigated.

(1) DPHE

During the 1986-88 fiscal years, DPHE installed 3,428 m of 0.45-2.60 diameter pipes to improve the drainage conditions around Dhanmondi and Cantonment areas. This project was executed as a link in the chain of "Revised Crash Programme for Construction of Storm Water Drainage in Waterlogged Areas of Dhaka Metropolis," which was described in the previous study (refer to Main Report, page 5-2).

(2) DWASA

In March 1989, based on a decision made by the MLGRDC, the Government of Bangladesh, DPHE turned over the administrative responsibility for solving the drainage problems in Dhaka city to DWASA.

In response of the request of the President, the Begunbari khal improvement that entails installing a 600 m long RC-Culvert between the Airport Road and the

Railway crossing will be implemented from November 1989 by the special presidential budget. 7,300 m of drainage pipes having diameters of from 0.45-2.05 m will be constructed during fiscal year 1989.

Moreover, the Paribagh khal improvement work that entails installing a RC-Culvert that is 4000 mm in width, 3,900 mm in height, and 1,000 m in length will be implemented by DWASA in near future.

(3) RAJUK

In 1987, RAJUK executed an area development project near the Sonargaon Hotel. In this project, Begunbari and Paribagh khal improvements were conducted by installing a 83 m long RC-culvert and a 213 m long brick sewer.

The Begunbari khal improvement work by the installation of RC-culvert type between the Mirpur Road and Green Road (l = 1,000 m) proposed by JICA will be started during 1989 in order to construct a new road along the Begunbari khal. RAJUK has already submitted a proposal to the Ministry of Works.

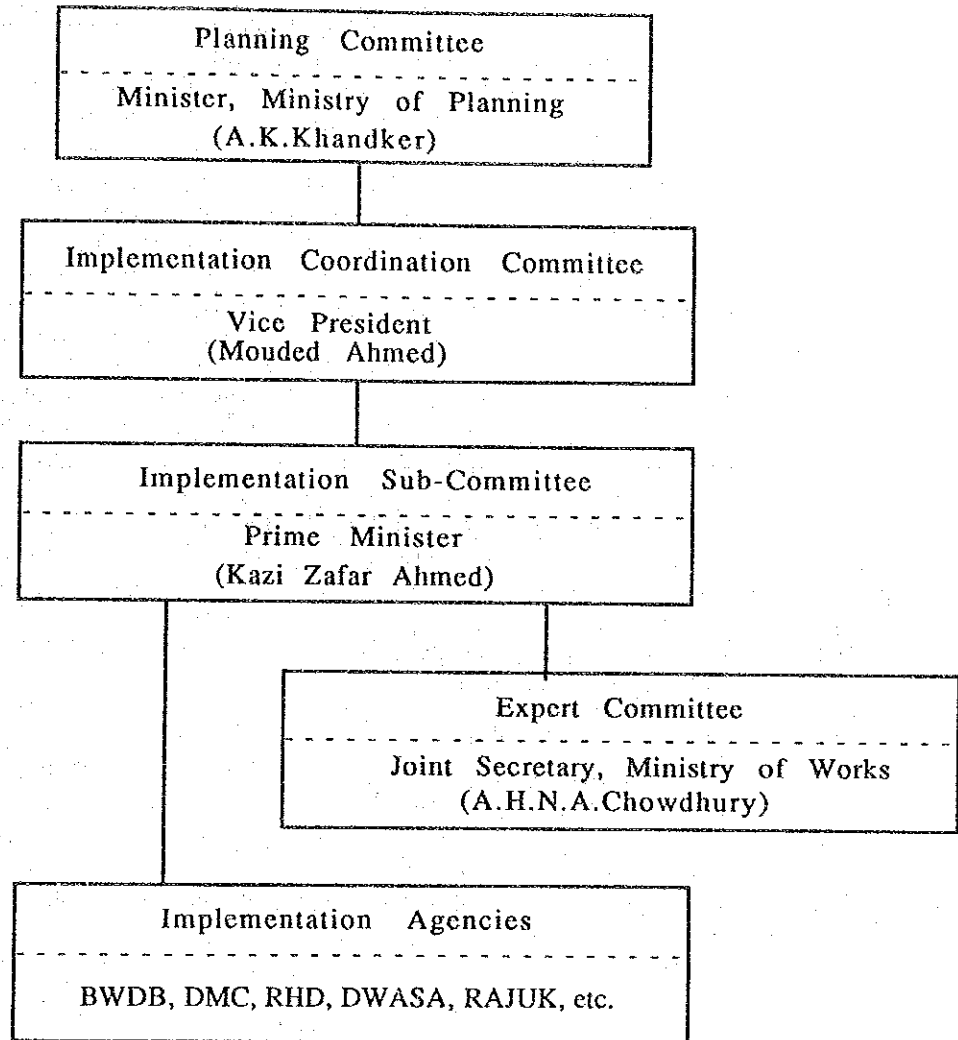
(4) DMC

In fiscal year 1986, DMC planned the Paribagh khal improvement work by installing a 1,000 m long brick sewer pipe having a diameter of 3,050 mm. The 128 m middle section of the pipe was constructed by DMC in 1987. The cross section planned by DMC does not meet the mark for the JICA proposal.

Through the discussion with DMC officials, it is clear that DMC has no near future plans for khal improvement or major drainage pipe work.

Details of the existing drainage facilities that were constructed during 1986-1989 and the drainage facilities proposed to be constructed during 1989-1990 by the agencies concerned are shown in Tables B.5 and B.6 respectively. These locations are illustrated in Fig. B.10.

TABLE B.1 ORGANIZATION CHART OF FLOOD CONTROL AND DRAINAGE OF GREATER DHAKA



- Note:
1. Planning Committee consisted of 14 members was established on 24 October 1988.
 2. Implementation Coordination Committee consisted of 22 members was established on 8 January 1989.
 3. Implementation Sub-Committee is consisted of 10 members and related agencies.
 4. Expert Committee is consisted of 14 members.
 5. National Committee on Flood Control Issues headed by the Prime Minister was established on 24, August 1989 in stead of teh ablove Committee. This new committee is consisted of 30 government officials and related agencies.

TABLE B.2 GREATER DHAKA FLOOD CONTROL AND DRAINAGE
PROJECT (PHASE I) PROPOSED BY THE COMMITTEE

Project	Agency	Cost (Million Tk)
(1) 17.62 km embankment from Tongi railway bridge up to Shirnir Tek with 5-sluice gates	BWDB	785.00
(2) 2.27 km embankment and flood protection wall from Shirnir Tek up to Mirpur Bridge	DMC	95.38
(3) 0.77 km road construction from Shirnir Tek up to Mirpur Mazar	RAJUK	47.50
(4) 4.25 km embankment from Mirpur Bridge up to Satmasjid Road	DMC	176.14
(5) 5.76 km embankment from Satmasjid Road up to Kellar Morh	DMC	341.11
(6) 7.20 km flood protection wall from Kellar Morh up to Friendship Bridge	DMC	
(7) 29.40 km flood protection wall around the Dhaka-Narayanganj-Demra Project	RHD	118.80
(8) 1.40 km new road construction from Kamlapur up to Saidabad Bus Terminal	RAJUK	107.44
(9) 2.5 km road raising of Rampura Road	DMC	22.97
(10) 6.0 km road raising of Pragati Sarani Road with Temporary gates	RAJUK	46.00
(11) Flood protection bund around Zia International Airport	CAAB	77.20
(12) Cleaning of 13 Khals/Canals in the city	DWASA	252.00
(13) Repair and restoration of the sewerage in Dhaka City	DWASA	16.80
Total		2,086.34

TABLE B.3 GREATER DHAKA FLOOD CONTROL AND DRAINAGE PROJECT (PHASE II) PROPOSED BY THE COMMITTEE

Project	Agency	Cost (approx.) (Million Tk)
(1) The proposed self-financing road from Demra DND to Tongi bridge should be realigned to follow the western bank of the Balu river. This should be a bypass road. In designing this bypass road/dam, the eastern part should be raised to prevent flooding. On the inside, at a lower level, a four lane road (minimum) should be built. Similarly, on the northwestern side of the city, from Tongi bridge to Shimir Tek, a similar design should be considered. Proper survey should be carried out and Technical aspects to be considered in designing the above work.		1,500.00
(2) A four lane road should be built along the inside part of the western flood embankment (from Tongi bridge to Shimir Tek)		100.00
(3) Installation of 5 pumping stations		2,000.00
Total		3,600.00

TABLE B.4 PROGRESS OF KHAL REEXCAVATION PROJECT (PRELIMINARY EMERGENCY WORKS) UPTO JULY, 1989 BY DWASA

No.	Name of Khal	Length of Khal (m)	Progress of Activity (m, %)	Remarks
K.1	Dholai Khal	4,959	3,743 (90%)	Temporary work stoppage
K.2	Gopibag Khal	386	120 (90%)	Privately owned khal
K.3	Segunbagicha Khal	4,162	3,580 (86%)	House resettlement is required
K.4	Paribag Khal	655	655 (97%)	-
K.5	Begunbari Khal	3,857	2,950 (75%)	Work stoppage due to pressure of water
K.6	Dhanmondi Khal	1,540	1,527 (9%)	Khal digging discontinued; land acquisition is required
K.7	Khatalbagan Khal	255	153 (60%)	Land acquisition is required
K.8	West Rajabazar Khal	129	129 (95%)	Land acquisition is required
K.9	Khilgaon-Basabo Khal	2,000	-	No proper boundary is marked. Proposal to acquire land is given
K.10	Mohakhali Khal	5,435	3,872 (90%)	Work stoppage due to pressure of water
K.11	Kalyanpur Khal	3,821	3,021 (90%)	Work stoppage due to hightide of water
K.12	Ibrahimpur Khal	1,296	-	Proposal for land acquisition given. No C.S. plan available
K.13	Mohakhali-Banani Khal	2,850	40 (2%)	Primarily it was a lake. Alternative scheme is to be taken for storm water from the side of the Banani graveyard.

TABLE B.5 EXISTING DRAINAGE FACILITIES CONSTRUCTED DURING 1986-1989

SL. NO	TYPE OF WORK	NAME OF ROAD/KHAL	DIA(mm)	LENGTH(m)	REMARKS
<u>A. DPHE</u>					
1.	Brick sewer	Satmosjid Road	2600	129.52m 628.48m	1986 1987
2.	Brick sewer	Satmosjid Road	2450	365.00	1986
3.	Brick sewer	Satmosjid Road	2200	242.00	1987
4.	Brick sewer	Satmosjid Road	2050	120.00m 214.00m	1987 1988
5.	Pipe drain	Kallyanpur	450	170.00	1988
6.	Pipe drain	Nakhalpara	450	145.00	1987
7.	Pipe drain	Lalmatia	900	308.00	1987
8.	Pipe drain	Lalmatia	750	160.00	1987
9.	Pipe drain	Satmosjid Road	750	250.00	1988
10.	Brick sewer	Cantonment Area	1550	122.00	1988
11.	Brick sewer	Cantonment Area	1400	200.00	1988
12.	Brick sewer	Cantonment Area	1700	198.00	1988
13.	Brick sewer	Cantonment Area	1850	168.00	1988
<u>B. RAJUK</u>					
1.	RC-Culvert	Begunbari Khal	W6500x H5100	83.00	1987
2.	Brick sewer	Paribagh Khal	4570	213.00	1987
<u>B. DMC</u>					
1.	Brick sewer	Paribagh Khal	3050	128.00	1987

Note: The figures in the Remarks column denotes the fisical year of construction.

TABLE B.6 EXISTING DRAINAGE FACILITIES TO BE CONSTRUCTED DURING 1989-1990

SL. NO	TYPE OF WORK	NAME OF ROAD/KHAL	DIA(mm)	LENGTH(m)	REMARKS
<u>A. DWASA</u>					
1.	Brick sewer	Satmosjid Road	2050	50.00	1989
2.	Brick sewer	Satmosjid Road	1850	500.00	1989
3.	Brick sewer	Satmosjid Road	1700	533.00	1989
4.	Brick sewer	Satmosjid Road	1550	540.00	1989
5.	Pipe drain	Dhanmondi Area	750	2781.00	1989
6.	Pipe drain	Dhanmondi Area	600	2186.00	1989
7.	Pipe drain (different connection drain)	Begunbari Khal	900	710.00	1989
8.	RC-Culvert	Begunbari Khal	2-W4500x H3800	600.00	1989
9.	RC-Culvert	Paribagh Khal	W4000x H3800	800.00	Near future
<u>B. RAJUK</u>					
1.	RC-Culvert	Begunbari Khal	W4500x H3800	1000.00	1989

Note: The figures in the Remarks column denotes the fisical year of construction.

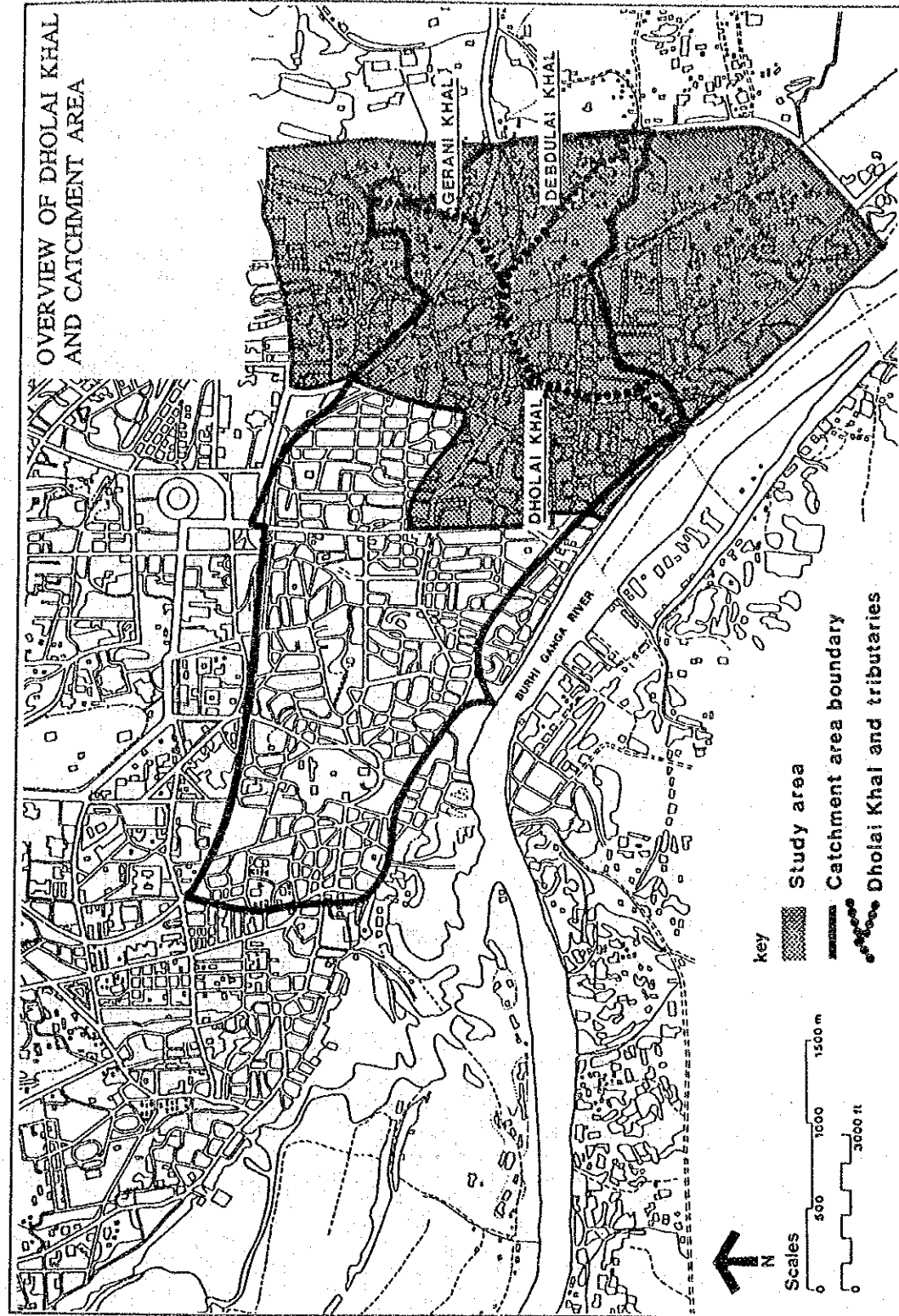
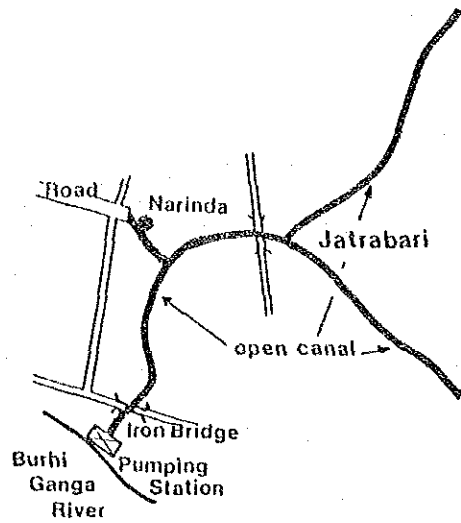
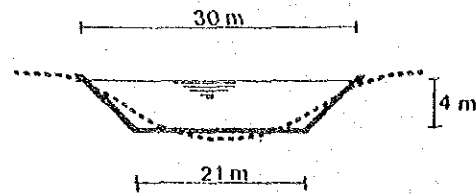


FIG. B. 1 STUDY AREA OF THE WORLD BANK PROJECT

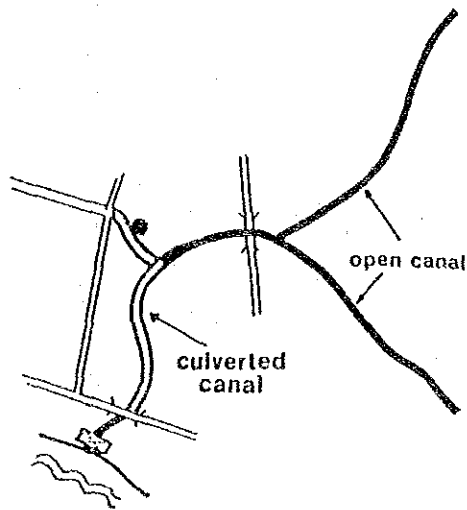
UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY



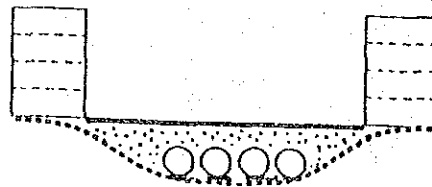
OPTION 1: OPEN CANAL



Dholai Khal and tributaries re-shaped and lined over the full length

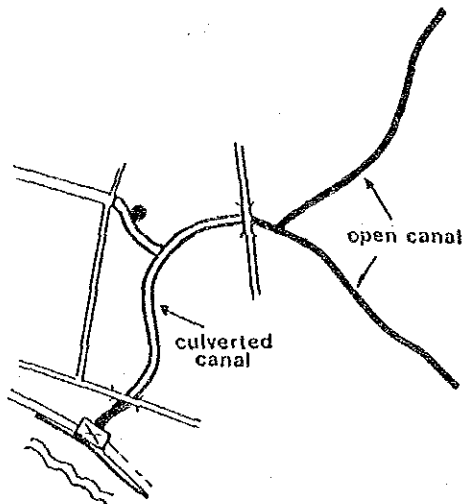


OPTION 2: PARTLY CULVERTING

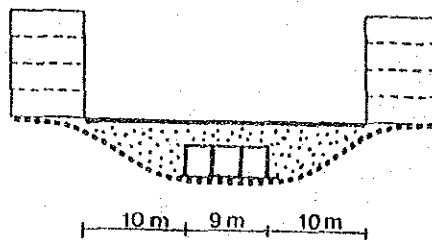


Dholai Khal culverted between Iron Bridge and Narinda

All other Khal sections and tributaries as open canals



OPTION 3: COMPLETE CULVERTING



Dholai Khal culverted between Iron Bridge and Jatrabari with major road on top

Tributaries as open canals

FIG. B. 2

DHOLAI KHAL REHABILITATION ALTERNATIVES

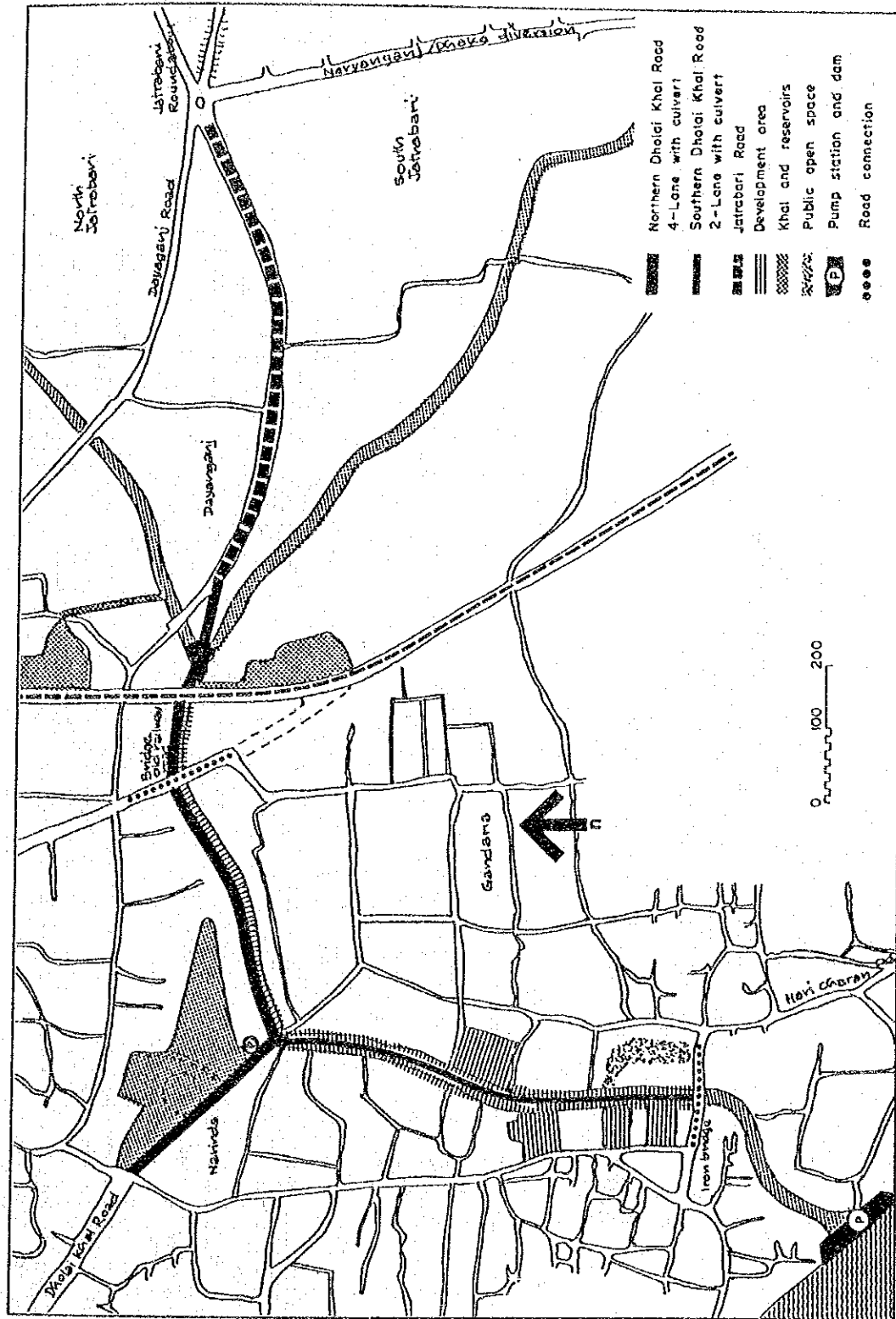


FIG. B. 3 PROPOSED DRAINAGE PLAN OF THE WORLD BANK PROJECT

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY

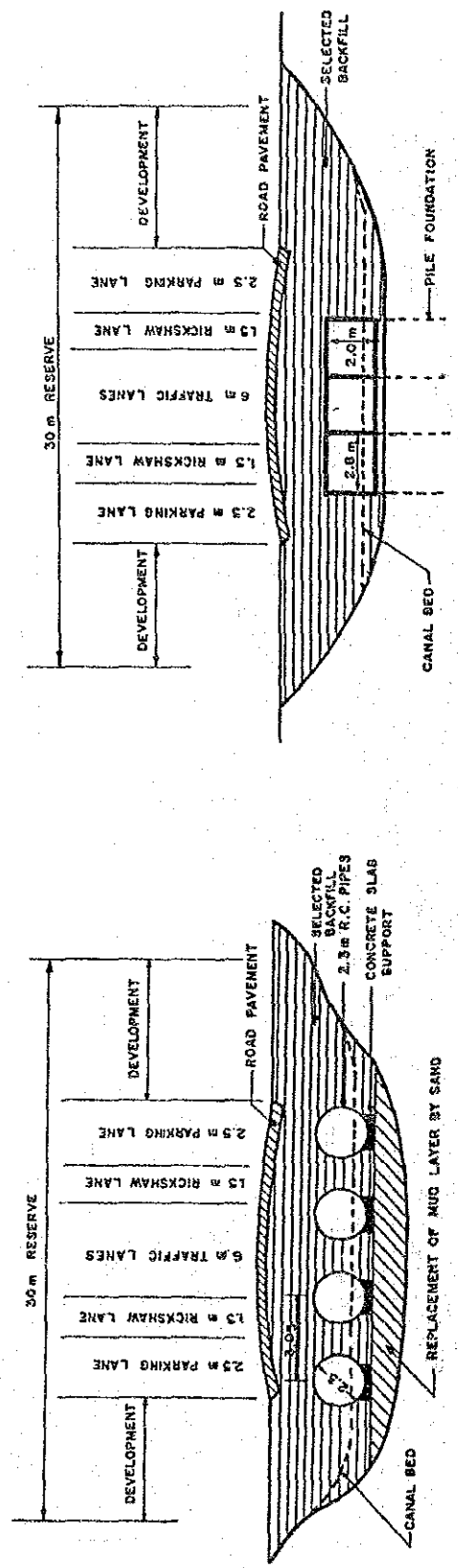
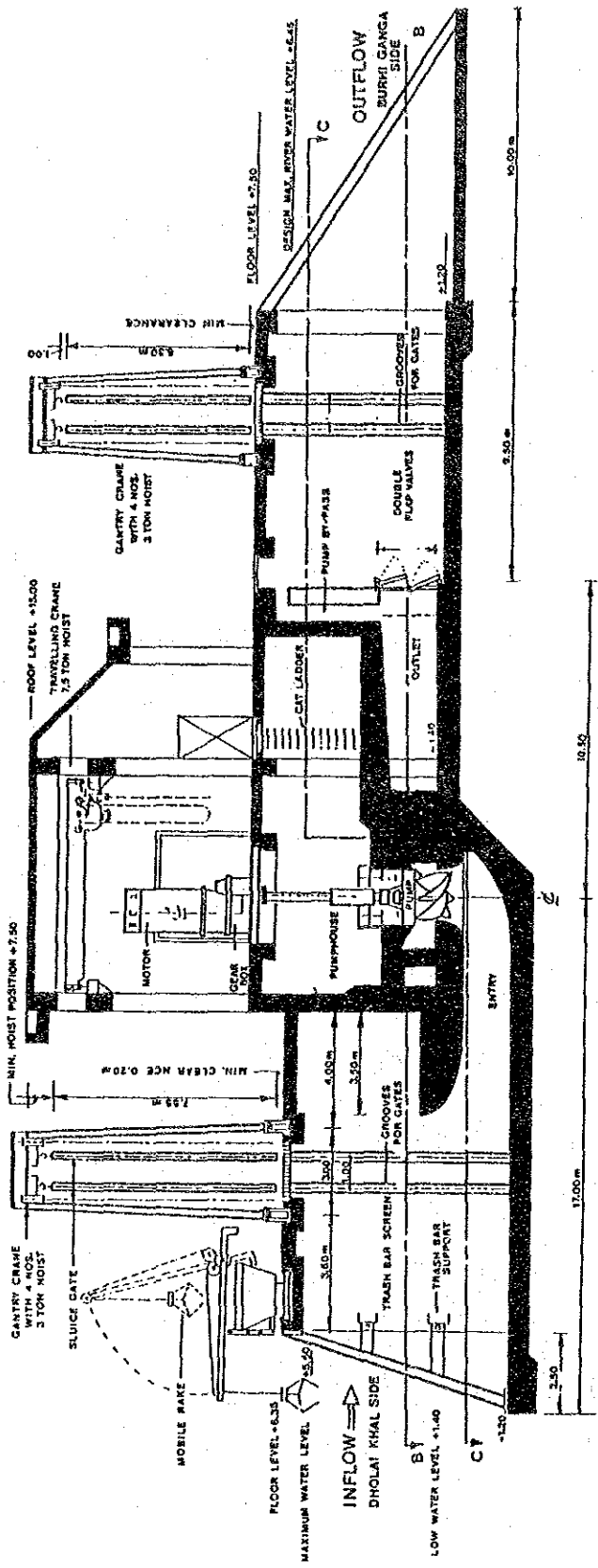
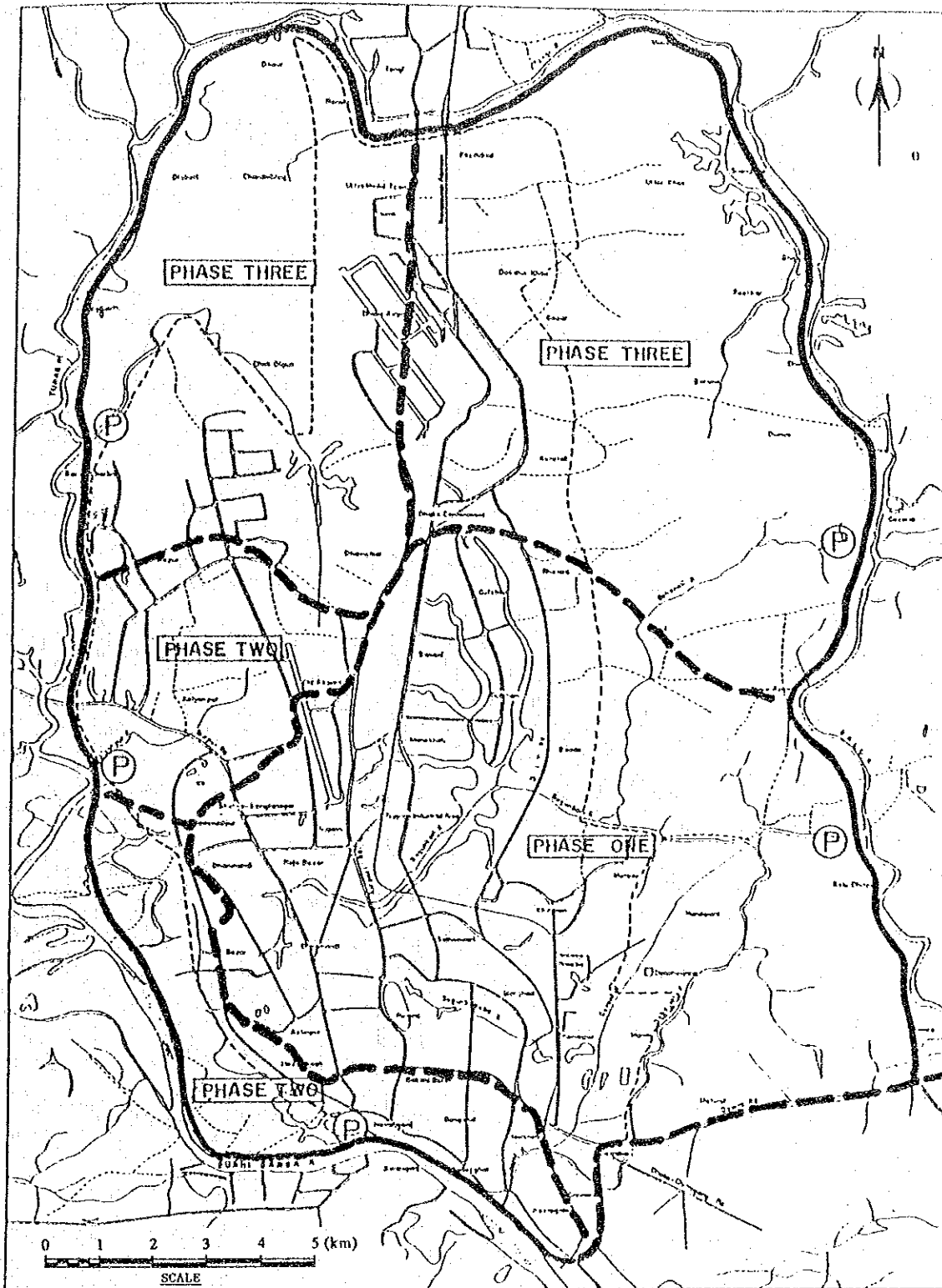


FIG. B. 4 TYPICAL DESIGN OF PUMP STATION AND CULVERTS PROPOSED IN THE WORLD BANK PROJECT

SOURCE : Final Report on Dholai Khal Rehabilitation and Area Development Study by B. K. H. B. V. in October 1989



LEGEND

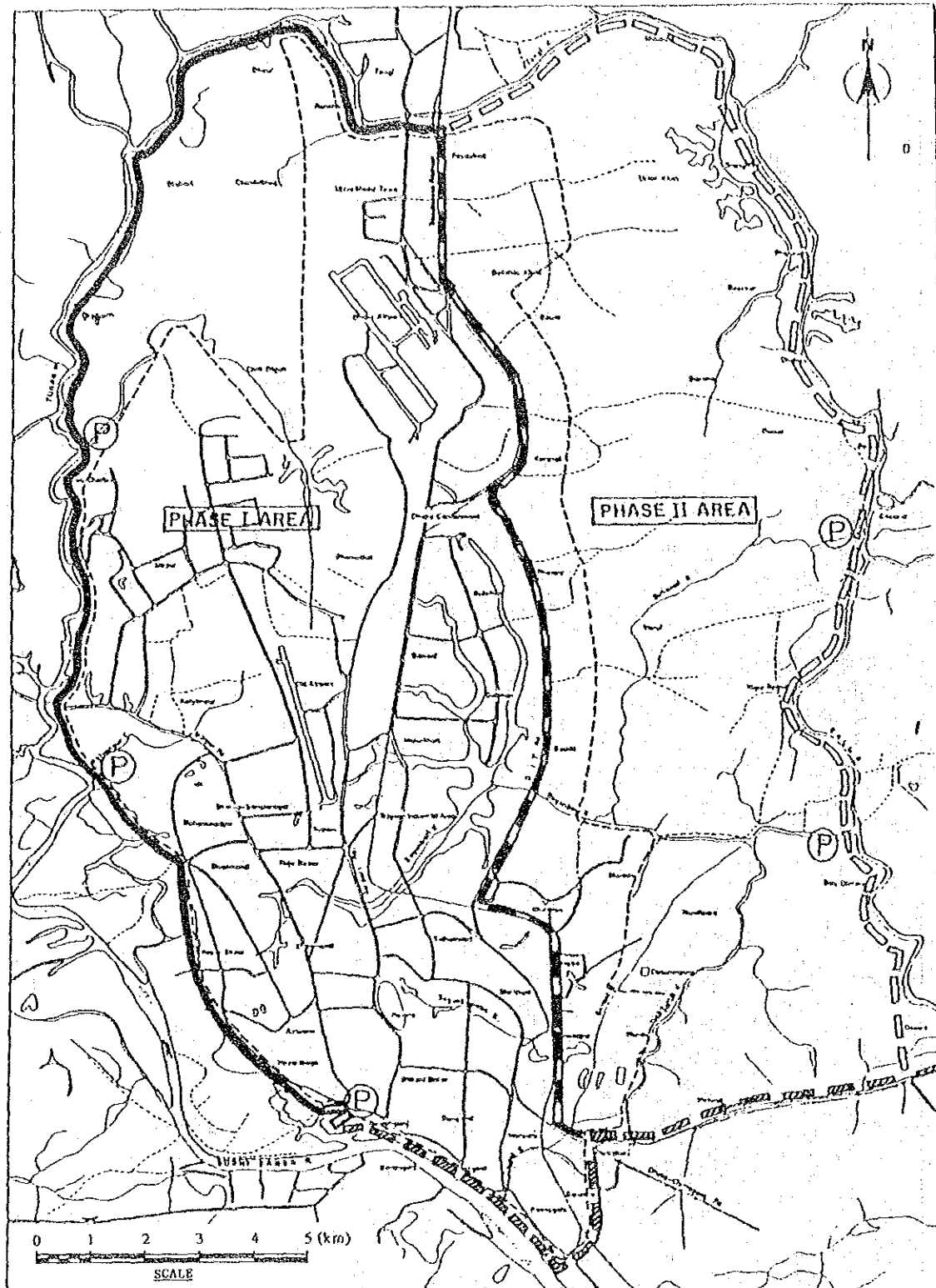
- | | | | |
|--|--------------------------------|--|-------------------------------------|
| | ROAD | | PROPOSED SECONDARY EMBANKMENT |
| | RIVER/KHAL | | PROPOSED PUMPING STATION-CUM SLUICE |
| | RAILWAY | | BOUNDARY OF JICA STUDY AREA |
| | PROPOSED PERIPHERAL EMBANKMENT | | |

Source: Recommendations to the Committee on Greater Dhaka Flood Control by T.G.H. Jansen in Nov. 1988


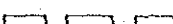
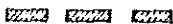



FIG. B. 5

FULL FLOOD PROTECTION SCHEME RECOMMENDED BY A DUTCH EXPERT

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY



LEGEND

- | | |
|--|---|
|  Embankment (Phase I) |  Embankment (Phase II) |
|  Flood Protection Wall (Phase I) |  Pumping Station (Phase II) |
|  Temporary Flood Protection Boundary with Interim Works (Phase I) |  Boundary of JICA Study Area |

Source Report on Flood Control and Drainage of Greater Dhaka by the Committee in Jan. 1989

FIG. B. 6

GREATER DHAKA FLOOD CONTROL AND DRAINAGE SCHEME PROPOSED BY THE COMMITTEE

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY

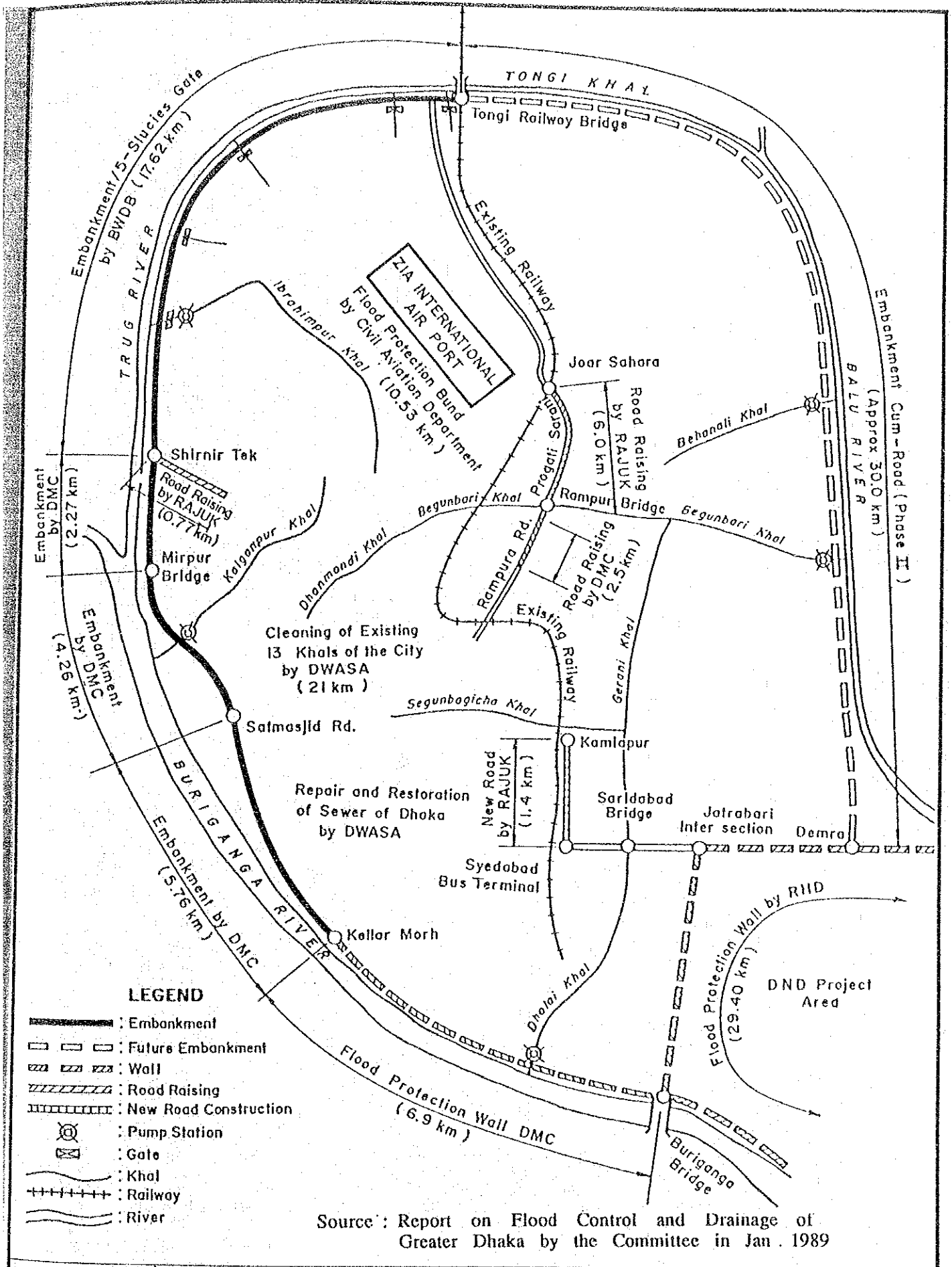
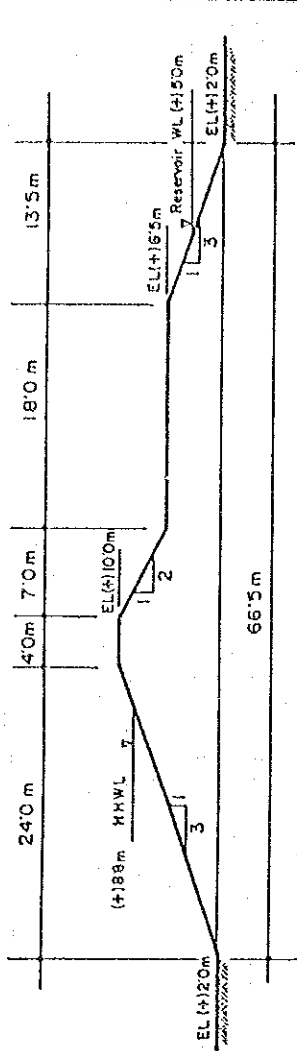
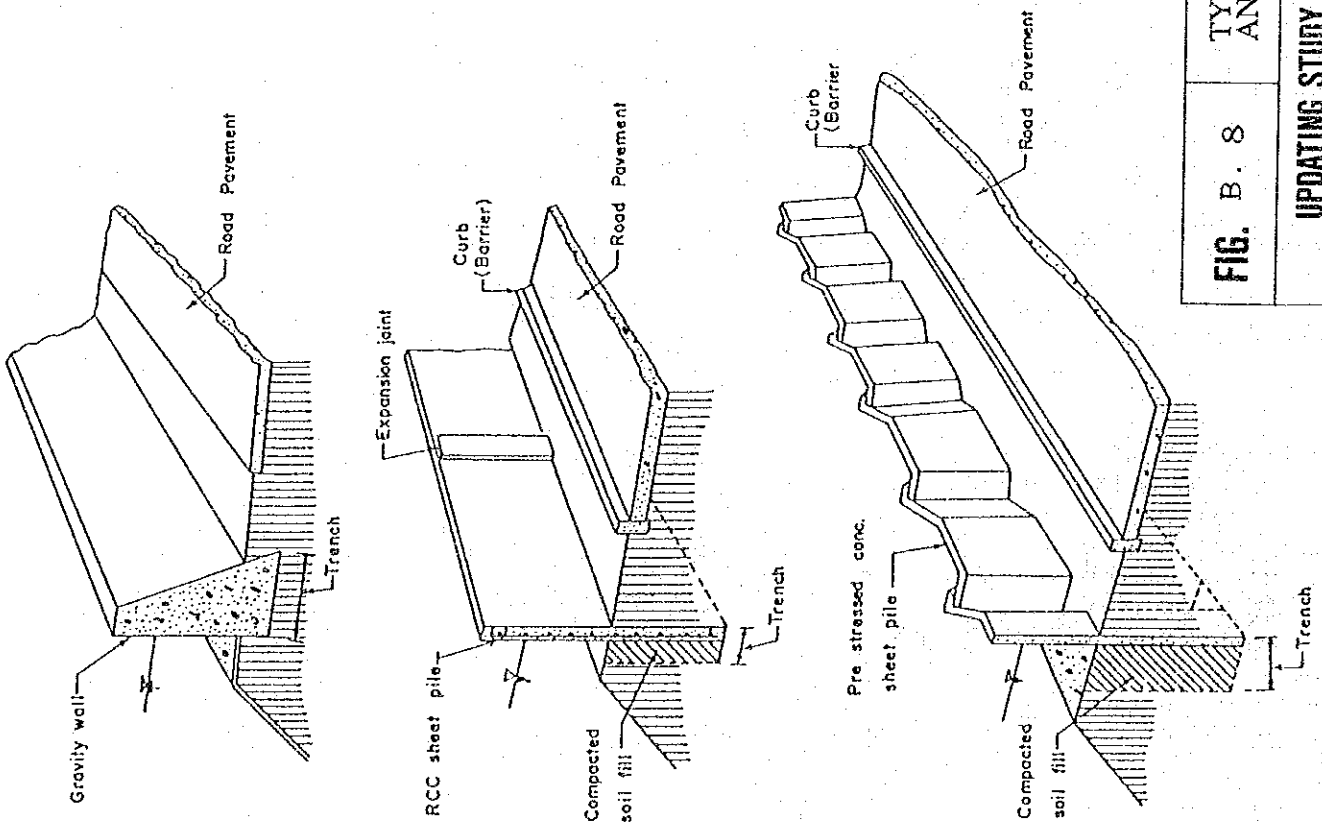


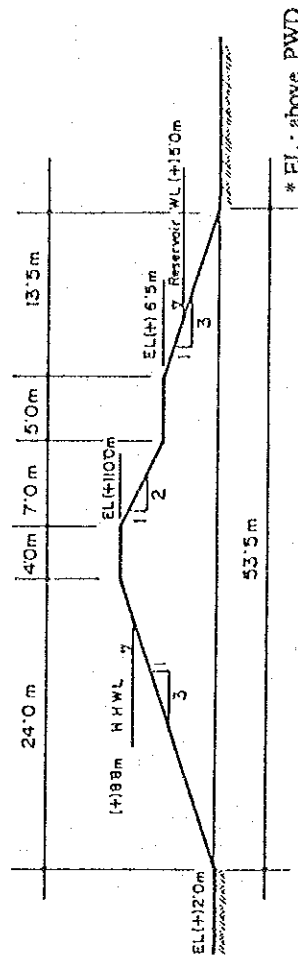
FIG. B. 7

PROPOSED PROJECTS IN GDFCD PROJECT

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY



TYPICAL SECTION (INCLUDING 4 LANE HIGHWAY)



TYPICAL SECTION (ONLY EMBANKMENT)

Source : Report on Flood Control and Drainage of Greater Dhaka by the Committee in Jan . 1989

FIG. B. 8 TYPICAL DESIGN OF FLOOD PROTECTION EMBANKMENT AND WALL OF GDFCD PROJECT

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY

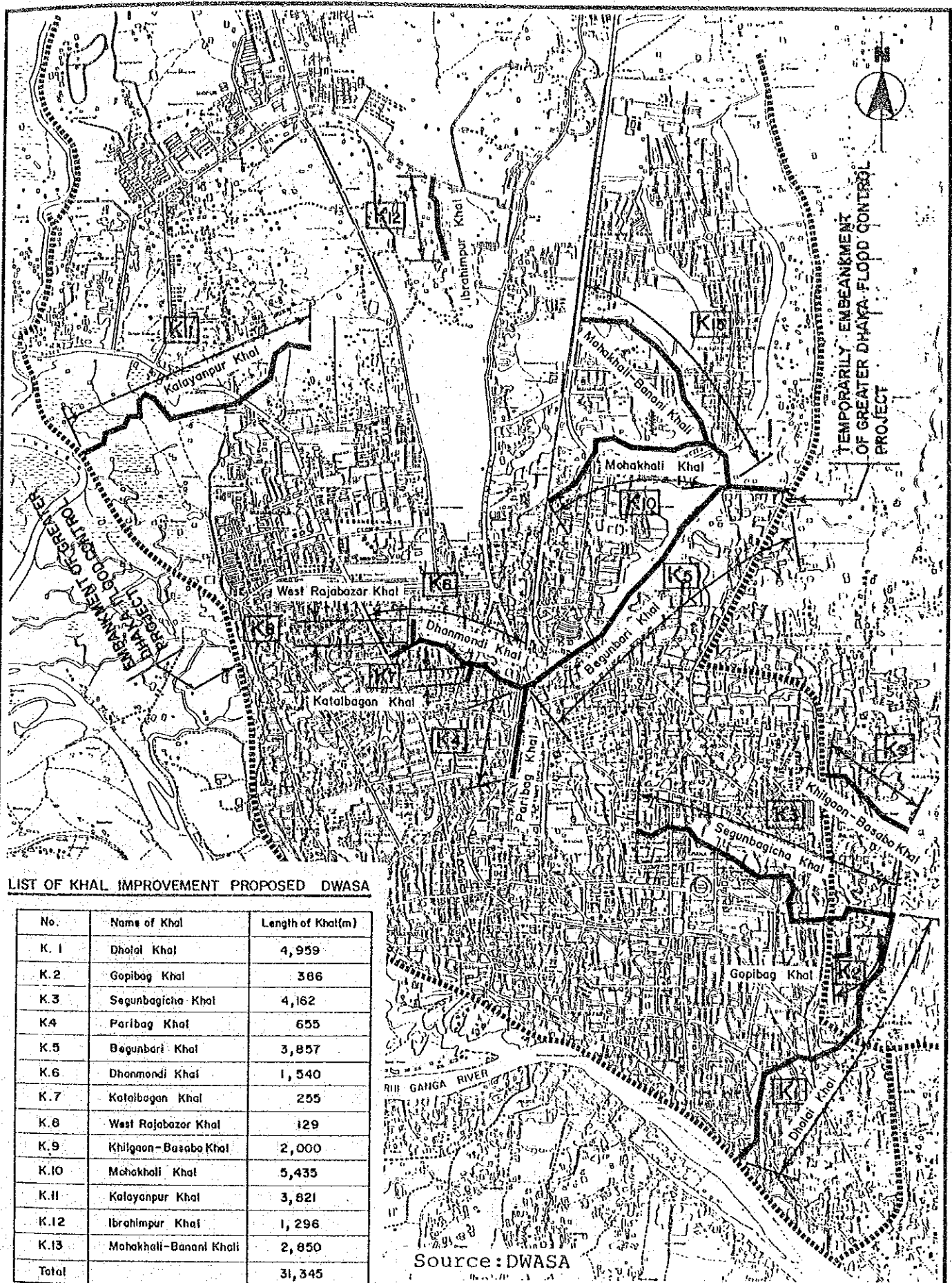


FIG. B. 9

LOCATION OF KHAL IMPROVEMENT PROJECT BY DWASA

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY