7.2 Development of Lowland Area around Proposed Regulating Ponds

The preparation of two regulating ponds, the Jatorabari and the Gandaria, which will be main drainage facilities, have been proposed. These ponds are located on existing lowlands in the C II and B III area which are either government or privately owned. The proposed ponds are to be the minimum sizes required, occupying approximately 57 and 49 percent, respectively, of the existing undeveloped lowlands.

After completion of the project, these lowland areas, including the proposed ponds will be protected from external flooding by the proposed dikes. The H.W.L. during the rainy season will be always maintained at a lower level than prior to the project completion, thereby increasing the potential for development in these areas.

Accordingly, adequate land use arrangements or regulations for these areas shall be required by the government in order to secure the proposed ponds areas.

In this section, hydraulic problems due to confused or sprawling development in these areas are described by the comparative study of the following cases:

Case 1: With no anticipated development, the existing storage capacities of the two ponds will be maintained until the target year 2000.

Case 2: Due to development progression, the storage capacities of the two ponds will decrease until the proposed plan in the year 2000 becomes effective.

Case 3(a): Jatorabari pond will be the same as for case 2, but the Gandaria pond will be completely developed in 2000.

Case 3(b): The improvement plan of Case 3(a) will be maintained under similar drainage conitions as for Case 2.

Case 4(a): Development in Case 3(a) will have progressed further in 2000, while in the Jatorabari pond area it will decrease to almost half of that for Case 3(a).

Case 4(b): Improvement plan of Case 4(a) will be maintained under similar drainage conditions as for Case 2.

Table I.9 presents the detailed conditions of each calculation case.

Table I.9 Calculation Condition of Sensitive Analysis

Case No.	Regulating Cap. of Jatorabari Pond (x 10^6 m^3)	Regulating Cap. of Gandaria Pond (x 10^6 m^3)	Pump Capacity (m^3/sec)	Khal Improvement		
				Segun-bagicha	Dholai	Gondaria
1	3.00	0.80	18.8	execute	execute	no execute
2	1.75	0.40	18.8	do	do	do
3(a)	1.75	0	18.8	do	do	do
3(b)	1.75	0	38.0	do	do	execute
4(a)	1.15	0	18.0	do	do	no execute
4(b)	1.15	0	67.0	do	do	execute

The hydraulic calculation method is used in the same manner as for the unsteady flow as previously mentioned. The similar model for each case is illustrated in Fig. I.29. Calculation results (the H.W.L. and peak discharge at main points) for each case are illustrated in Fig. I.30. Hydraulic information is as follows:

Case 1: The H.W.L. of the three ponds, including the existing pond at the Narinda pumping station, will be 10 to 20 cm lower in comparison to the proposed plan, Case 2; however, the H.W.L. upstream of Segunbagicha Khal will not vary. Accordingly, drainage cnditions of the sub-drainage area in the B II, B III, C II areas and in half of the C I area will be better than for Case 2.

Case 2: To be omitted because of the proposed plan.

Case 3(a): Because of land development for the Gandaria pond, all of the B III area will experience internal flooding as peak discharges increase to almost 28 m^3/sec. The H.W.L. of the Jatorabari and Narinda ponds will be up almost 30 cm as compared with Case 2. Even the water level at the Narinda site at the time of the peak occurrence from the B II area will be 4.50 m G.T.S. (0.5 m higher than that of Case 2). Accordingly, drainage conditions at the B II upstream area will become critical.

Case 3(b): Drainage conditions of the B II and B III areas will be improved, being the same as for Case 2, by increasing the pump capacity of the Narinda pumping station (38 m^3/sec), and by accomplishing the Gandaria Khal improvements (i = 1:2000, Q = 28 m^3/sec, Width B = 7.0 m, Depth H = 5.5 m, Length L = 2.0 km).

Case 4(a) : Internal flood damage to the B II and B III areas will become more serious than for Case 3(a). Moreover, the C I upstream area, along the boundary of the B II and C I areas, will experience internal floding because the water level at the WAPDA building of the Segunbagicha Khal at the time of peak occurrence from the sub-drainage area will increase to more than 35 cm as compared to Case 2.

Case 4(b) : In order to improve the drainage conditions of the B II, B III and C I areas so as to be the same as for Case 2, increasing the pump capacity of the Narinda pumping station (67 m^3/sec) and accomplishing the Gandaria Khal improvements, so as to be the same as for Case 3(b), are required.

As described above, if the proposed ponds areas are subjected to rapid, confused and sprawled land development by the private sector, a heavy investment for the drainage improvement work will be required. Accordingly, it is reiterated that adequate land use arrangements or regulations encompassing the lowlands neighboring the proposed ponds are, at any cost, required.

Table I.10 Runoff Coefficient of Sub-Drainage Areas

B ZONE RUN-OFF COEFFICIENT

BLOCK	AREA	RUN-OFF COEFFICIENT	LAND USE (%)							
			Residential			Commercial	Industrial	Institutional	Open Space/ Agricultural	Waterbodies
			High Density	Medium Density	Low Density					
No.	km2	f	0.50	0.50	0.30	0.65	0.55	0.30	0.20	1.00
B1	0.64	0.39	35	3		5		57		
B2	0.39	0.54	52			40		8		
B3	0.22	0.52	85			15				
B4-1	0.32	0.52	90			10				
B4-2	0.51	0.56	57			43				
B5	0.49	0.46	30			50		20		
B6	0.70	0.51	48	27		16		9		
B7	0.41	0.45	49	18		11			22	
B8	1.09	0.53	50	15		3	27	2		3
B9	0.60	0.55		84		3		3		10
B10	0.51	0.52		90		10				
B11	0.14	0.56		40		30	30			
B12	0.12	0.55		50		25	25			
B13	0.33	0.50	65			15			15	5
B14	0.21	0.52	90			10				

C ZONE RUN-OFF COEFFICIENT

BLOCK	AREA	RUN-OFF COEFFICIENT	LAND USE (%)							
			Residential			Commercial	Industrial	Institutional	Open Space/ Agricultural	Waterbodies
			High Density	Medium Density	Low Density					
No.	km2	f	0.50	0.50	0.30	0.65	0.55	0.30	0.20	1.00
C1	0.79	0.28			30	4		30	35	1
C2	0.60	0.23						30	70	
C3	0.58	0.55		20		60		15	5	
C4-1	0.47	0.35			85	15				
C4-2	0.38	0.42		25	30	20		25		
C4-3	0.15	0.45		35		23		42		
C5-1	0.26	0.40		50	50					
C5-2	0.32	0.58		35	5	60				
C5-3	0.07	0.50		95		5				
C6	0.39	0.55		10		70		10	10	
C7-1	0.23	0.50		80		10		10		
C7-2	0.05	0.50		95		5				
C8	0.18	0.55		60		40				
C9	0.60	0.45		60		10		30		
C10	0.37	0.32				5		80	13	2
C11	0.15	0.61				90			10	
C12	0.24	0.52				70			30	
C13	0.39	0.35		35		5		20	40	
C14	0.28	0.53		10		60		30		
C15	0.11	0.50		50		30		20		
C16	0.44	0.49		50		30			20	
C17	0.20	0.52		90		10				
C18	0.84	0.59		65		5		10		20
C19	1.71	0.49		25		5			50	20
C20	1.14	0.54		70		10			10	10

F ZONE RUN-OFF COEFFICIENT

BLOCK	ARSA	RUN-OFF COEFFICIENT	LAND USE (%)							
			Residential			Commercial	Industrial	Institutional	Open Space/ Agricultural	Waterbodies
			High Density	Medium Density	Low Density					
No.	km2	f	0.50	0.50	0.30	0.65	0.55	0.30	0.20	1.00
F1	0.84	0.35		35		10		35	20	
F2	0.45	0.30						100		
F3	0.10	0.30						100		
F4	0.51	0.30						100		
F5	0.47	0.55		15		62		23		
F6	0.32	0.50		55		25		20		
F7	0.39	0.35		20	55	5		10	10	
F8	0.11	0.64		10		90				
F9	0.71	0.41		45	25	5		25		
F10	0.65	0.56			50				20	30
F11	0.35	0.38		20	70	10				
F12	0.98	0.34		30				50	20	
F13	0.67	0.53		60	5	30		5		
F14	0.42	0.40		20		40			20	
F15	0.18	0.52		70		25				5
F16	0.84	0.39		25		25			50	
F17	0.87	0.43					55	40	5	
F18	1.00	0.42		10	50	30		5	5	
F19	0.61	0.52		90		10				
F20	3.63	0.62		27		2	25	3	13	30

Table I.11 Design Discharge (No 1)

B ZONE (OLD DHAKA) : DRAINAGE PIPE : MAIN,DIVERSION,AND BRANCH

Conditions: Inlet Time; 20 min

Block No.	Drainage Area Individual a (ha)	Drainage Area Accumlated A (ha)	Run-off Coefficient Individual f	Run-off Coefficient Accumlated F	Length Individual l (m)	Length Accumlated L (m)	Velocity v (m/s)	Time of Concentration t (min)	Rainfall Intensity 2 y. Freq. r2 (mm/hr)	Rainfall Intensity 5 y. Freq. r5 (mm/hr)	Run-off 2y. Freq. Q2 (m3/s)	Run-off 5y. Freq. Q5 (m3/s)
(Diversion)												
B1	64.00		0.39		1400.00							
		64.00		0.39		1400.00	1.00	44.00	76.01	95.80	5.27	6.64
B2	39.00		0.54		700.00							
		103.00		0.45		2660.00	1.40	52.00	69.68	88.28	8.97	11.37
(Main)												
B3	22.00		0.52		750.00							
		22.00		0.52		750.00	1.40	29.00	91.63	113.99	2.91	3.62
B4	83.00		0.56		1250.00							
		105.00		0.55		1250.00	1.40	35.00	84.67	105.94	13.58	16.99
B5	49.00		0.46		450.00							
		154.00		0.52		1700.00	1.40	41.00	78.69	98.96	17.51	22.01
B6	70.00		0.51		650.00							
		224.00		0.50		2350.00	1.40	48.00	72.71	91.89	22.62	28.59
B7	41.00		0.45		300.00							
		265.00		0.49		2650.00	1.40	52.00	69.68	88.28	25.13	31.84
(Branch)												
B7*	36.00		0.44		280.00		1.00					
					500.00		1.40					
		36.00		0.44		780.00	1.40	29.10	91.50	113.84	4.03	5.01

C ZONE (SEGUNBAGICHA) : DRAINAGE PIPE (D-6) : C4 BLOCK

Conditions: Inlet Time; 20 min

Block No.	Drainage Area Individual a (ha)	Drainage Area Accumlated A (ha)	Run-off Coefficient Individual f	Run-off Coefficient Accumlated F	Length Individual l (m)	Length Accumlated L (m)	Velocity v (m/s)	Time of Concentration t (min)	Rainfall Intensity 2 y. Freq. r2 (mm/hr)	Rainfall Intensity 5 y. Freq. r5 (mm/hr)	Run-off 2y. Freq. Q2 (m3/s)	Run-off 5y. Freq. Q5 (m3/s)
C4-1	47.00		0.35		400.00		1.00					
					520.00		1.40					
		47.00		0.35		1080.00	1.40	32.65	87.03	108.68	3.98	4.97
C4-2	36.00		0.42		530.00							
		83.00		0.38		1610.00	1.40	39.17	80.43	100.99	7.05	8.85

C ZONE (SEGUNBAGICHA) : DRAINAGE PIPE (D-5) : C5 BLOCK

Conditions: Inlet Time; 20 min

Block No.	Drainage Area Individual a (ha)	Drainage Area Accumlated A (ha)	Run-off Coefficient Individual f	Run-off Coefficient Accumlated F	Length Individual l (m)	Length Accumlated L (m)	Velocity v (m/s)	Time of Concentration t (min)	Rainfall Intensity 2 y. Freq. r2 (mm/hr)	Rainfall Intensity 5 y. Freq. r5 (mm/hr)	Run-off 2y. Freq. Q2 (m3/s)	Run-off 5y. Freq. Q5 (m3/s)
C5-1	26.00		0.40		300.00		1.00					
					240.00		1.40					
		26.00		0.40		560.00	1.40	27.86	93.09	115.68	2.69	3.34
C5-2	32.00		0.58		480.00							
		58.00		0.50		1140.00	1.40	33.57	86.23	107.75	6.95	8.68

C ZONE (SEGUNBAGICHA) : DRAINAGE PIPE (D-4) : C7 BLOCK

Conditions: Inlet Time; 20 min

Block No.	Drainage Area Individual a (ha)	Drainage Area Accumlated A (ha)	Run-off Coefficient Individual f	Run-off Coefficient Accumlated F	Length Individual l (m)	Length Accumlated L (m)	Velocity v (m/s)	Time of Concentration t (min)	Rainfall Intensity 2 y. Freq. r2 (mm/hr)	Rainfall Intensity 5 y. Freq. r5 (mm/hr)	Run-off 2y. Freq. Q2 (m3/s)	Run-off 5y. Freq. Q5 (m3/s)
C7-1	23.00		0.50		250.00		1.00					
					640.00		1.40					
		23.00		0.50		890.00	1.40	30.60	89.67	111.73	2.86	3.57

Table I.12 Design Discharge (No 2)

C ZONE : SEGUNBAGICHA KHAL

Conditions: Inlet Time; 20 min

Block No.	Drainage Area Individual a (ha)	Drainage Area Accumulated A (ha)	Run-off Coefficient Individual f	Run-off Coefficient Accumulated F	Length Individual l (m)	Length Accumulated L (m)	Velocity v (m/s)	Time of Concentration t (min)	Rainfall Intensity 2 y. Freq. r2 (mm/hr)	Rainfall Intensity 5 y. Freq. r5 (mm/hr)	Run-off 2y. Freq. Q2 (m3/s)	Run-off 5y. Freq. Q5 (m3/s)
C1	79.00		0.26									
C2	60.00		0.23		1180.00							
		139.00		0.26		1180.00	1.00	39.67	79.95	100.43	8.03	10.08
C3	58.00		0.55		730.00							
C4	98.00		0.39									
		295.00		0.36		1910.00	1.00	51.83	69.80	88.43	20.59	26.09
C5	65.00		0.50		600.00							
C6	39.00		0.55									
		399.00		0.40		2510.00	1.00	61.83	63.20	80.52	28.02	35.70
C7	28.00		0.50		570.00							
C8	18.00		0.55									
		445.00		0.41		3080.00	1.00	71.33	58.00	74.22	29.55	37.83
C9	60.00		0.45		400.00							
		505.00		0.42		3480.00	1.00	78.00	54.83	70.35	32.30	41.45
C10-14	143.00		0.43		150.00							
		648.00		0.42		3630.00	1.00	80.50	53.73	69.00	40.62	52.17
C15	11.00		0.50		370.00							
		659.00		0.42		4000.00	1.00	86.67	51.19	65.89	39.36	50.66

F ZONE : BEGUNBARI KHAL

Conditions: Inlet Time; 20 min

Block No.	Drainage Area Individual a (ha)	Drainage Area Accumulated A (ha)	Run-off Coefficient Individual f	Run-off Coefficient Accumulated F	Length Individual l (m)	Length Accumulated L (m)	Velocity v (m/s)	Time of Concentration t (min)	Rainfall Intensity 2 y. Freq. r2 (mm/hr)	Rainfall Intensity 5 y. Freq. r5 (mm/hr)	Run-off 2y. Freq. Q2 (m3/s)	Run-off 5y. Freq. Q5 (m3/s)	
F1-5	217.00		0.36		2180.00								
F6	32.00		0.50										
F7	39.00		0.35										
		288.00		0.37		2180.00	1.00	56.33	66.67	84.69	19.73	25.07	
F8	11.00		0.64		600.00								
		299.00		0.38		2780.00	1.00	66.33	60.63	77.41	19.13	24.43	
F10	(DAIMOND LAKE BLOCK) MAX. DISCHARGE FROM THE LAKE REGULATED BY WEIR												2.70
F9	71.00		0.41		1200.00								
F11	35.00		0.38										
		106.00		0.40		1200.00	1.00	40.00	79.63	100.06	9.38	11.78	14.48
F12	98.00		0.34		1050.00								
F13	67.00		0.53										
		271.00		0.41		2250.00	1.00	57.50	65.90	83.77	20.36	25.88	28.58
F14	42.00		0.40		800.00								
F15	18.00		0.52										
		331.00		0.41		3050.00	1.00	70.83	58.25	74.52	21.96	28.09	30.79
		630.00		0.40		3050.00	1.00	70.83	58.25	74.52	40.77	52.17	54.87
F16	64.00		0.39		710.00								
		694.00		0.40		3760.00	1.00	82.67	52.81	67.88	40.72	52.34	55.04
F17	87.00		0.43		310.00								
F18	100.00		0.42										
		881.00		0.40		4070.00	1.00	87.83	50.74	65.33	49.67	63.95	66.65

Table I.13 Design Discharge (No 3)

C ZONE (SEGUNBAGICHA) : DRAINAGE PIPE (D-3) : C11 TO C14 BLOCK

Conditions: Inlet Time; 20 min

Block No.	Drainage Area Individual a (ha)	Drainage Area Accumlated A (ha)	Run-off Coefficient Individual f	Run-off Coefficient Accumlated F	Length Individual l (m)	Length Accumlated L (m)	Velocity v (m/s)	Time of Concentration t (min)	Rainfall Intensity 2 y. Freq. r2 (mm/hr)	Rainfall Intensity 5 y. Freq. r5 (mm/hr)	Run-off 2y. Freq. Q2 (m3/s)	Run-off 5y. Freq. Q5 (m3/s)
C10	37.00		0.32		350.00		1.00					
					500.00		1.40					
		37.00		0.32		990.00	1.40	31.79	88.26	110.10	2.90	3.62
C11	15.00		0.61		650.00							
		52.00		0.40		1640.00	1.40	39.52	80.08	100.59	4.67	5.86
C12	24.00		0.52		0.00							
		76.00		0.44		1640.00	1.40	39.52	80.08	100.59	7.45	9.35
C13	39.00		0.35		650.00							
		115.00		0.41		2290.00	1.40	47.26	73.29	92.59	9.59	12.12
C14	28.00		0.53		700.00							
		143.00		0.43		2990.00	1.40	55.60	67.16	85.28	11.47	14.57

F ZONE (BEGUNBARI) : DRAINAGE PIPE (D-9) : F1 TO F5 BLOCK

Conditions: Inlet Time; 20 min

Block No.	Drainage Area Individual a (ha)	Drainage Area Accumlated A (ha)	Run-off Coefficient Individual f	Run-off Coefficient Accumlated F	Length Individual l (m)	Length Accumlated L (m)	Velocity v (m/s)	Time of Concentration t (min)	Rainfall Intensity 2 y. Freq. r2 (mm/hr)	Rainfall Intensity 5 y. Freq. r5 (mm/hr)	Run-off 2y. Freq. Q2 (m3/s)	Run-off 5y. Freq. Q5 (m3/s)
F1	64.00		0.35		450.00		1.00					
					550.00		1.40					
		64.00		0.35		1180.00	1.40	34.05	85.70	107.14	5.33	6.67
F2	45.00		0.30		560.00							
(Branch)		45.00		0.30		560.00	1.40	26.67	94.66	117.46	3.55	4.40
		109.00		0.33		1180.00	1.40	34.05	85.70	107.14	8.56	10.71
F3	10.00		0.30		450.00							
		119.00		0.33		1630.00	1.40	39.40	80.20	100.72	8.75	10.99
F4	51.00		0.30									
		170.00		0.32		1630.00	1.40	39.40	80.20	100.72	12.12	15.22
F5	47.00		0.55		330.00							
		217.00		0.36		1960.00	1.40	43.33	76.59	96.48	16.62	20.94

F ZONE (BEGUNBARI) : DRAINAGE PIPE (D-8) : F15 BLOCK

Conditions: Inlet Time; 20 min

Block No.	Drainage Area Individual a (ha)	Drainage Area Accumlated A (ha)	Run-off Coefficient Individual f	Run-off Coefficient Accumlated F	Length Individual l (m)	Length Accumlated L (m)	Velocity v (m/s)	Time of Concentration t (min)	Rainfall Intensity 2 y. Freq. r2 (mm/hr)	Rainfall Intensity 5 y. Freq. r5 (mm/hr)	Run-off 2y. Freq. Q2 (m3/s)	Run-off 5y. Freq. Q5 (m3/s)
F15	18.00		0.52		450.00							
		18.00		0.52		450.00	1.40	25.36	96.44	119.50	2.51	3.11

F ZONE (BEGUNBARI) : DRAINAGE PIPE (D-7) : F19 BLOCK

Conditions: Inlet Time; 20 min

Block No.	Drainage Area Individual a (ha)	Drainage Area Accumlated A (ha)	Run-off Coefficient Individual f	Run-off Coefficient Accumlated F	Length Individual l (m)	Length Accumlated L (m)	Velocity v (m/s)	Time of Concentration t (min)	Rainfall Intensity 2 y. Freq. r2 (mm/hr)	Rainfall Intensity 5 y. Freq. r5 (mm/hr)	Run-off 2y. Freq. Q2 (m3/s)	Run-off 5y. Freq. Q5 (m3/s)
F19-1	36.00		0.52		550.00							
		36.00		0.52		550.00	1.40	26.55	94.81	117.64	4.93	6.12
F19-2	25.00		0.52		550.00							
		61.00		0.52		1100.00	1.40	33.10	86.76	108.37	7.64	9.55

Table I.14 Proposed Hydraulic Cross Section of Khal Improvements

(SEGUNBAGICHA KHAL)

Accumulated Distance	Side Slope	Bed Elevation	Bed Width	Ground Elevation	Top Width	Shape
m		m	m	m	m	
0	1 . 1	0.00	6.0	6.0	18.0	Trapezoidal
200	1 . 1	0.10	6.0	6.1	18.0	do.
300	1 . 1	0.15	6.0	6.1	17.9	do.
400	1 . 1	0.20	6.0	6.0	17.8	do.
500	1 . 1	0.25	5.0	6.0	16.5	do.
600	1 . 1	0.30	4.0	6.0	15.4	do.
800	1 . 1	0.40	4.0	6.0	15.2	do.
1000	1 . 1	0.50	4.0	6.0	15.0	do.
1200	1 . 1	0.60	3.5	6.0	14.3	do.
1300	1 . 1	0.65	3.5	6.0	14.2	do.
1400	1 . 1	0.70	3.5	6.0	14.0	do.
1500	-	0.75	7.5	6.0	7.5	Rectangular
1600	-	0.80	7.5	6.0	7.5	do.
1800	-	0.90	7.0	6.3	7.0	do.
2000	-	1.00	7.0	6.3	7.0	do.
2200	-	1.10	7.0	6.0	7.0	do.
2400	-	1.20	6.0	6.3	6.0	do.
2600	-	1.30	6.0	6.0	6.0	do.
2800	1 . 1	1.40	2.0	6.0	11.4	Trapezoidal
3000	1 . 1	1.50	2.0	6.3	11.6	do.

(SEGUNBARI KHAL)

Accumulated Distance	Side Slope	Bed Elevation	Bed Width	Ground Elevation	Top Width	Shape
m		m	m	m	m	
0	-	1.00	12.7	7.3	12.7	Rectangular
200	1 : 2	1.00	5.5	5.4	23.0	Trapezoidal
400	-	1.00	14.0	6.0	14.0	Rectangular
500	1 : 2	1.10	5.5	5.5	23.0	Trapezoidal
900	1 : 2	1.20	5.5	5.6	23.0	do.
1000	-	1.40	13.1	7.0	13.1	Rectangular
1100	-	1.30	12.5	5.6	12.5	do.
1450	1 : 2	1.70	4.0	6.5	20.8	Trapezoidal
1800	-	1.50	7.0	6.5	7.0	Rectangular
1850	1 : 2	1.50	2.0	6.5	21.6	Trapezoidal
2800	1 : 2	1.80	2.0	6.5	21.6	do.

(GANDARIA KHAL)

Accumulated Distance	Side Slope	Bed Elevation	Bed Width	Ground Elevation	Top Width	Shape
m		m	m	m	m	
0	1 : 1	1.00	2.0	5.5	13.0	Trapezoidal
200	1 : 1	1.10	2.0	5.5	13.0	do.
400	1 : 1	1.20	2.0	5.5	13.0	do.
600	1 : 1	1.30	2.0	5.5	13.0	do.
800	1 : 1	1.40	2.0	5.5	13.0	do.
1000	1 : 1	1.50	2.0	5.5	13.0	do.
1200	1 : 1	1.60	2.0	5.5	13.0	do.

(DHOLAI KHAL)

Accumulated Distance	Side Slope	Bed Elevation	Bed Width	Ground Elevation	Top Width	Shape
m		m	m	m	m	
0	1 : 2	0.00	5.0	5.0	26.0	Trapezoidal
1000	1 : 2	0.00	5.0	5.0	26.0	do.
1200	1 : 2	0.00	5.0	4.9	24.6	do.
1400	1 : 2	0.00	5.0	5.0	25.0	do.
1600	1 : 2	0.00	3.5	4.5	22.0	do.
1800	1 : 2	0.00	3.0	5.1	21.0	do.
2000	1 : 2	0.00	3.0	5.1	21.0	do.
2200	1 : 1.5	0.00	5.0	5.2	21.0	do.
2400	1 : 1.5	0.00	4.0	5.4	19.0	do.
2600	1 : 1.5	0.00	5.0	5.7	24.0	do.
2800	1 : 1.5	0.00	5.0	5.7	24.0	do.
3000	1 : 1.5	0.00	5.0	5.7	24.0	do.

(PARIBAGH KHAL)

Accumulated Distance	Side Slope	Bed Elevation	Bed Width	Ground Elevation	Top Width	Shape
m		m	m	m	m	
0	-	1.50	6.0	5.5	6.0	Rectangular
200	-	1.60	6.0	5.6	6.0	do.
400	-	1.70	6.0	5.7	6.0	do.
600	-	1.80	6.0	5.8	6.0	do.
800	-	1.90	6.0	5.9	6.0	do.
1000	-	2.00	6.0	6.0	6.0	do.

Table I.15 Hydraulic Design of Drainage Pipes (No 1)

B ZONE (OLD DHAKA) : DRAINAGE PIPE : MAIN,DIVERSION,AND BRANCH

Section No.	Area Individual ha	Area Accumlated ha	Runoff m3/s	Exist.Pipe Capacity m3/s	Design Runoff m3/s	Conduit Data Shape	Size m	Length m	Slope W.Head o/oo	Slope Pipe o/oo	Velocity m/s	Discharge m3/s	Invert Elevation Upper End m	Invert Elevation Lower End m	Ground Elev. m	Overburden Depth m
(Diversion)																
	64.00	64.00	6.64													
D-2	39.00	103.00	11.37	-	11.37	Rectangular	2.20*2.86	1480.00	1.0	0.5	2.07	11.50	1.90	1.15	7.00 - 6.00	1.95 - 1.70
(Main)																
D-1-5	22.00	22.00	3.62	-	3.62	Circular	1.90	750.00	1.0	0.5	1.28	3.64	2.50	2.15	6.80 - 6.30	1.85
D-1-4	83.00	105.00	16.99	9.30	7.69	do.	2.60	350.00	1.0	0.5	1.58	8.40	1.45	1.25	6.30	1.95
D-1-3	49.00	154.00	22.01	12.30	9.71	do.	2.60	450.00	1.0	0.5	1.66	10.23	1.05	0.85	6.30	2.15
D-1-2	70.00	224.00	28.59	12.30	16.29	Square	2.90	650.00	1.0	0.5	2.35	17.37	0.75	0.45	6.30 - 6.60	2.35 - 3.15
D-1-1	41.00	265.00	31.64	12.30	19.54	do.	3.10	100.00	1.0	0.5	2.46	20.76	0.25	0.20	6.60 - 6.00	3.15 - 2.50
(Branch)																
D-1-6	36.00	36.00	5.01	-	5.01	Circular	2.20	500.00	1.0	0.5	1.42	5.38	2.00	2.25	6.00 - 6.50	1.30

C ZONE (SEGUNBAGICHA) : DRAINAGE PIPE (D-4) : C7 BLOCK

Section No.	Area Individual ha	Area Accumlated ha	Runoff m3/s	Exist.Pipe Capacity m3/s	Design Runoff m3/s	Conduit Data Shape	Size m	Length m	Slope W.Head o/oo	Slope Pipe o/oo	Velocity m/s	Discharge m3/s	Invert Elevation Upper End m	Invert Elevation Lower End m	Ground Elev. m	Overburden Depth m
D-4	23.00	23.00	3.57	1.94	1.63	Circular	1.50	540.00	1.0	0.5	1.10	1.94	2.90	2.60	6.00 - 5.60	1.00

C ZONE (SEGUNBAGICHA) : DRAINAGE PIPE (D-3) : C11 TO C14 BLOCK

Section No.	Area Individual ha	Area Accumlated ha	Runoff m3/s	Exist.Pipe Capacity m3/s	Design Runoff m3/s	Conduit Data Shape	Size m	Length m	Slope W.Head o/oo	Slope Pipe o/oo	Velocity m/s	Discharge m3/s	Invert Elevation Upper End m	Invert Elevation Lower End m	Ground Elev. m	Overburden Depth m
	37.00															
D-3-4		37.00	3.62	-	3.62	Circular	1.90	500.00	1.0	0.5	1.28	3.64	3.60	3.35	7.20 - 7.30	1.20 - 1.55
	15.00															
D-3-3		52.00	5.66	-	5.66	do.	2.30	650.00	1.0	0.5	1.46	6.06	2.95	2.60	7.30 - 7.50	1.55 - 2.10
	24.00															
		76.00	9.35	-	9.35			0.00								
	39.00															
D-3-2		115.00	12.12	-	12.12	do.	3.00	650.00	1.0	0.5	1.74	12.30	2.00	1.65	7.50 - 7.10	2.10 - 1.95
	28.00															
D-3-1		143.00	14.57	-	14.57	Rectangular	2.6*3.0	700.00	1.0	0.5	1.91	14.90	1.65	1.30	7.10 - 5.00	2.15 - 0.40

Table I.16 Hydraulic Design of Drainage Pipes (No 2)

C ZONE (SEGUNBAGICHA) : DRAINAGE PIPE (D-6) : C4 BLOCK

Section No.	Area Individual ha	Area Accumulated ha	Runoff m3/s	Exist.Pipe Capacity m3/s	Design Runoff m3/s	Conduit Data Shape	Size m	Length m	Slope W.Head o/oo	Slope Pipe o/oo	Velocity m/s	Discharge m3/s	Invert Elevation Upper End m	Invert Elevation Lower End m	Ground Elev. m	Overburden Depth m
D-6-2	47.00	47.00	4.97	0.27	4.70	Circular	2.20	520.00	0.8	0.5	1.27	4.81	2.30	2.00	6.10 - 6.40	1.10 - 1.70
D-6-1	36.00	83.00	8.85	0.95	7.90	do.	2.70	530.00	0.8	0.5	1.45	8.31	1.50	1.20	6.40 - 5.00	1.70 - 0.60

C ZONE (SEGUNBAGICHA) : DRAINAGE PIPE (D-5) : C5 BLOCK

Section No.	Area Individual ha	Area Accumulated ha	Runoff m3/s	Exist.Pipe Capacity m3/s	Design Runoff m3/s	Conduit Data Shape	Size m	Length m	Slope W.Head o/oo	Slope Pipe o/oo	Velocity m/s	Discharge m3/s	Invert Elevation Upper End m	Invert Elevation Lower End m	Ground Elev. m	Overburden Depth m
D-5-2	26.00	26.00	3.34	-	3.34	Circular	1.90	240.00	1.0	0.5	1.28	3.64	2.65	2.50	6.10 - 6.20	1.05 - 1.30
D-5-1	32.00	58.00	8.86	-	8.86	do.	2.70	480.00	1.0	0.5	1.62	9.29	1.75	1.50	6.20 - 5.90	1.30 - 1.20

F ZONE (BEGUNBARI) : DRAINAGE PIPE (D-7) : F19 BLOCK

Section No.	Area Individual ha	Area Accumulated ha	Runoff m3/s	Exist.Pipe Capacity m3/s	Design Runoff m3/s	Conduit Data Shape	Size m	Length m	Slope W.Head o/oo	Slope Pipe o/oo	Velocity m/s	Discharge m3/s	Invert Elevation Upper End m	Invert Elevation Lower End m	Ground Elev. m	Overburden Depth m
D-7-2	36.00	36.00	6.12	-	6.12	Circular	2.40	550.00	1.0	0.5	1.50	6.78	2.70	2.45	6.70 - 6.60	1.10 - 1.25
D-7-1	25.00	61.00	9.55	-	9.55	do.	2.80	550.00	1.0	0.5	1.66	10.23	2.05	1.75	6.60 - 6.00	1.25 - 0.95

F ZONE (BEGUNBARI) : DRAINAGE PIPE (D-9) : F1 TO F5 BLOCK

Section No.	Area Individual ha	Area Accumulated ha	Runoff m3/s	Exist.Pipe Capacity m3/s	Design Runoff m3/s	Conduit Data Shape	Size m	Length m	Slope W.Head o/oo	Slope Pipe o/oo	Velocity m/s	Discharge m3/s	Invert Elevation Upper End m	Invert Elevation Lower End m	Ground Elev. m	Overburden Depth m
D-9-3	64.00	64.00	6.67	-	6.67	Circular	2.40	550.00	1.0	0.5	1.50	6.78	4.10	3.80	8.00	1.00 - 1.30
D-9-2	45.00		4.40	-	4.40	do.	2.10	560.00	1.0	0.5	1.37	4.75	4.40	4.10	8.00	1.00 - 1.30
		109.00	10.71	-	10.71											
D-9-4 (Branch)	10.00	119.00	10.99	-	10.99	do.	2.90	450.00	1.0	0.5	1.70	11.24	3.30	3.10	8.00	1.30 - 1.50
	51.00	170.00	15.22	-	15.22											
D-9-1	47.00	217.00	20.94	-	20.94	do.	3.70	300.00	1.0	0.5	2.00	21.52	2.30	2.15	8.00	1.50 - 1.65

F ZONE (BEGUNBARI) : DRAINAGE PIPE (D-8) : F15 BLOCK

Section No.	Area Individual ha	Area Accumulated ha	Runoff m3/s	Exist.Pipe Capacity m3/s	Design Runoff m3/s	Conduit Data Shape	Size m	Length m	Slope W.Head o/oo	Slope Pipe o/oo	Velocity m/s	Discharge m3/s	Invert Elevation Upper End m	Invert Elevation Lower End m	Ground Elev. m	Overburden Depth m
D-8	18.00	18.00	3.11	-	3.11	Circular	1.80	450.00	1.0	1.0	1.24	3.15	3.75	3.30	7.50 - 6.50	1.45 - 0.90

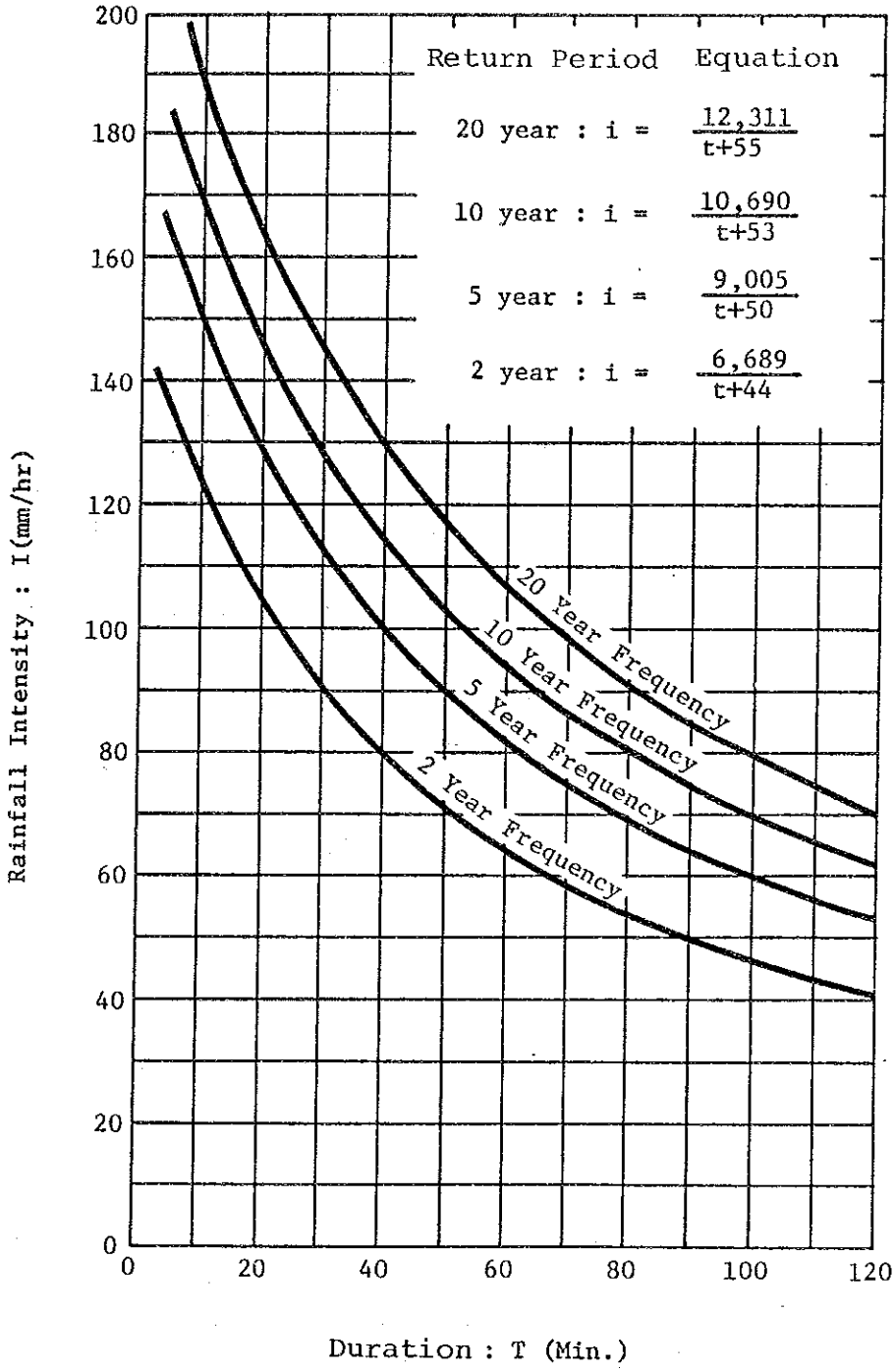
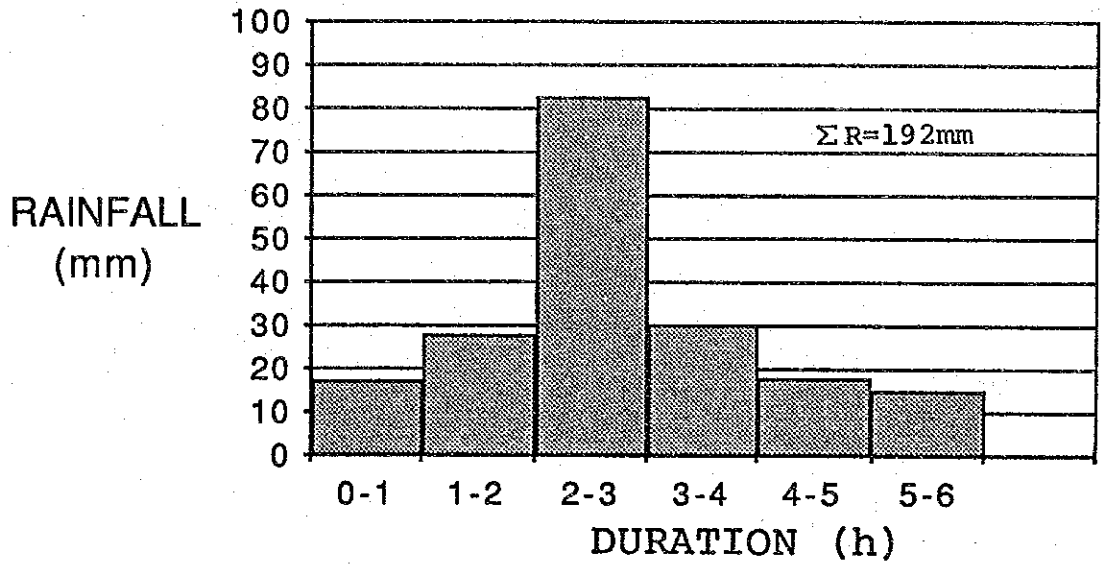


FIG. I.1 RAINFALL INTENSITY-DURATION CURVE

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

DESIGN RAINFALL DISTRIBUTION
(FIRST DAY)



DESIGN RAINFALL DISTRIBUTION
(SECOND DAY)

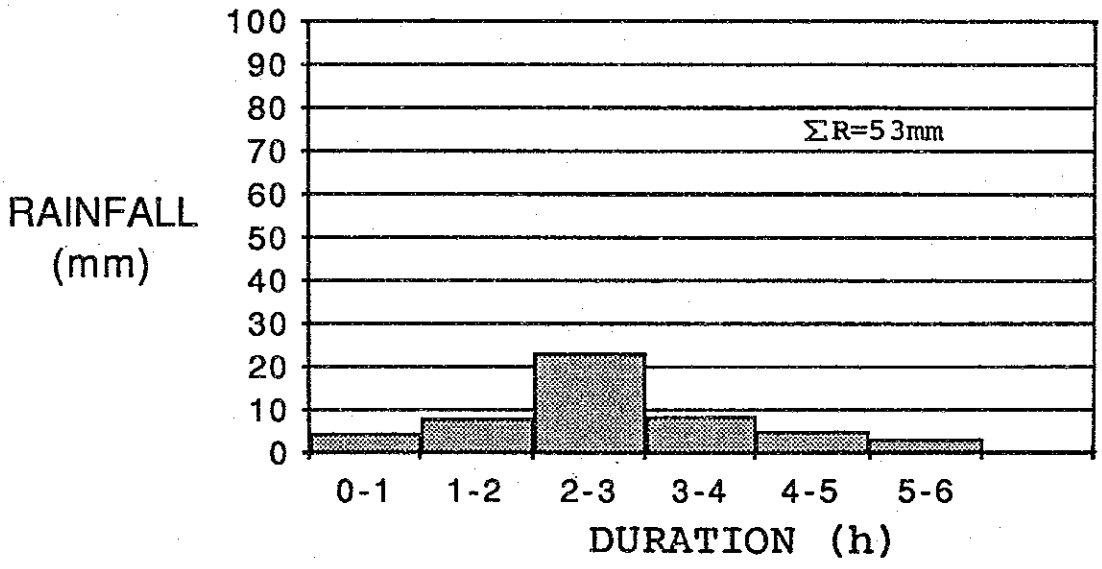
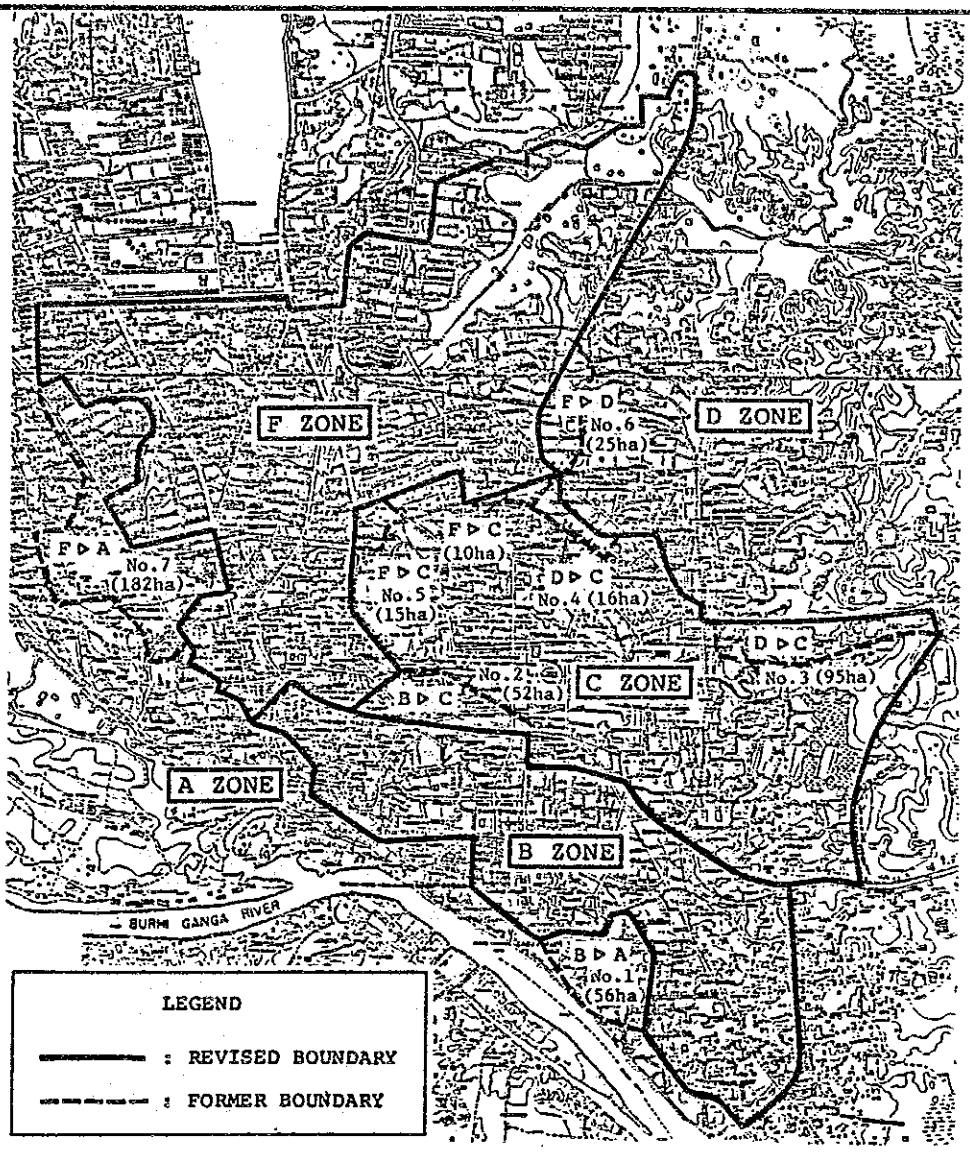


FIG. I.2 DESIGN TWO DAYS CONSECUTIVE RAINFALL

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

JICA 1987A.D



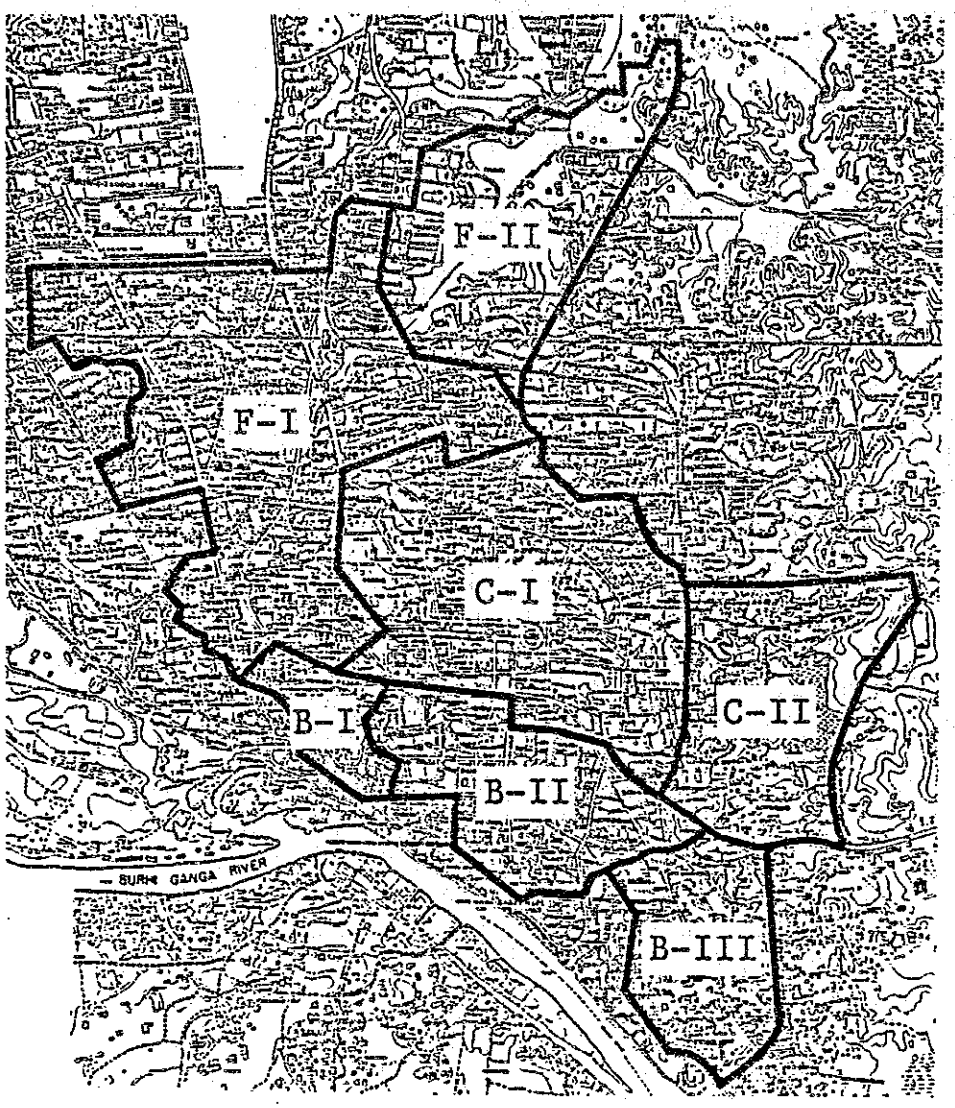
AREA OF DIVIDED DRAINAGE ZONES

Unit : km2

	DRAINAGE ZONE	FORMER	REVISED	REMARKS
A	BURIGANGA RIVER ZONE	12.85	15.23	0.56 from B Zone, 1.82 from F Zone
B	DHOLAI KHAL ZONE	7.76	6.68	0.52 to C Zone, 0.56 to A Zone
C	SEGUNBAGICHA KHAL ZONE	9.04	10.92	0.25 from F Zone, 1.11 from D Zone, 0.52 from B Zone
D	BASHABO ZONE	8.32	7.46	0.25 from F Zone, 1.11 to C Zone
E	NORTH-EAST EDGE ZONE	13.93	13.93	
F	BEGUNBARI KHAL ZONE	16.02	13.70	1.82 to A Zone, 0.25 to C Zone, 0.25 to D Zone
G	GULSHAN-BANI ZONE	17.64	17.64	
H	KALLYANPUR ZONE	12.78	12.78	
I	NORTH ZONE	31.42	31.42	
J	TURAG RIVER BANK ZONE	7.69	7.69	
	TOTAL DRAINAGE AREA	137.45	137.45	

FIG. I.3 REVISION OF DRAINAGE ZONE BOUNDARY

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



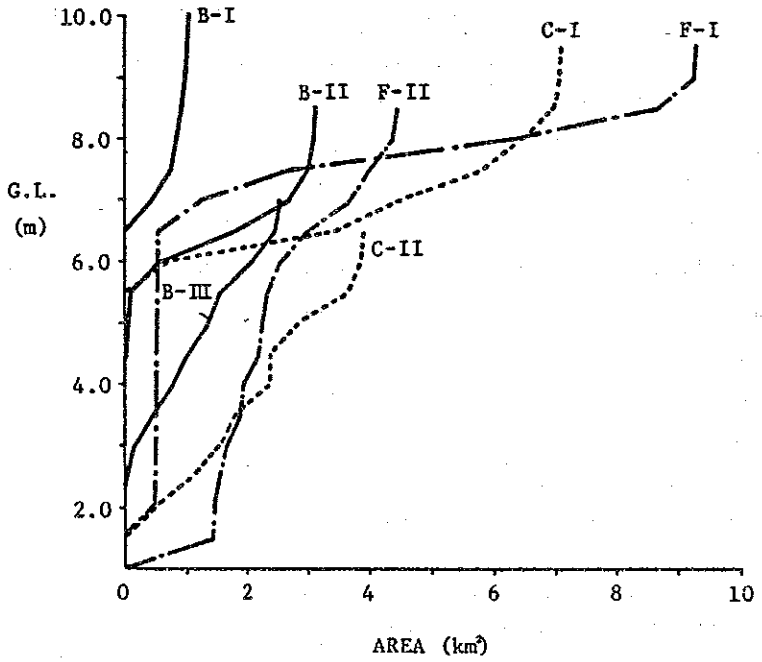


FIG. I.4 GROUND ELEVATION AND AREA CURVE FOR SUB-DIVIDED AREA

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

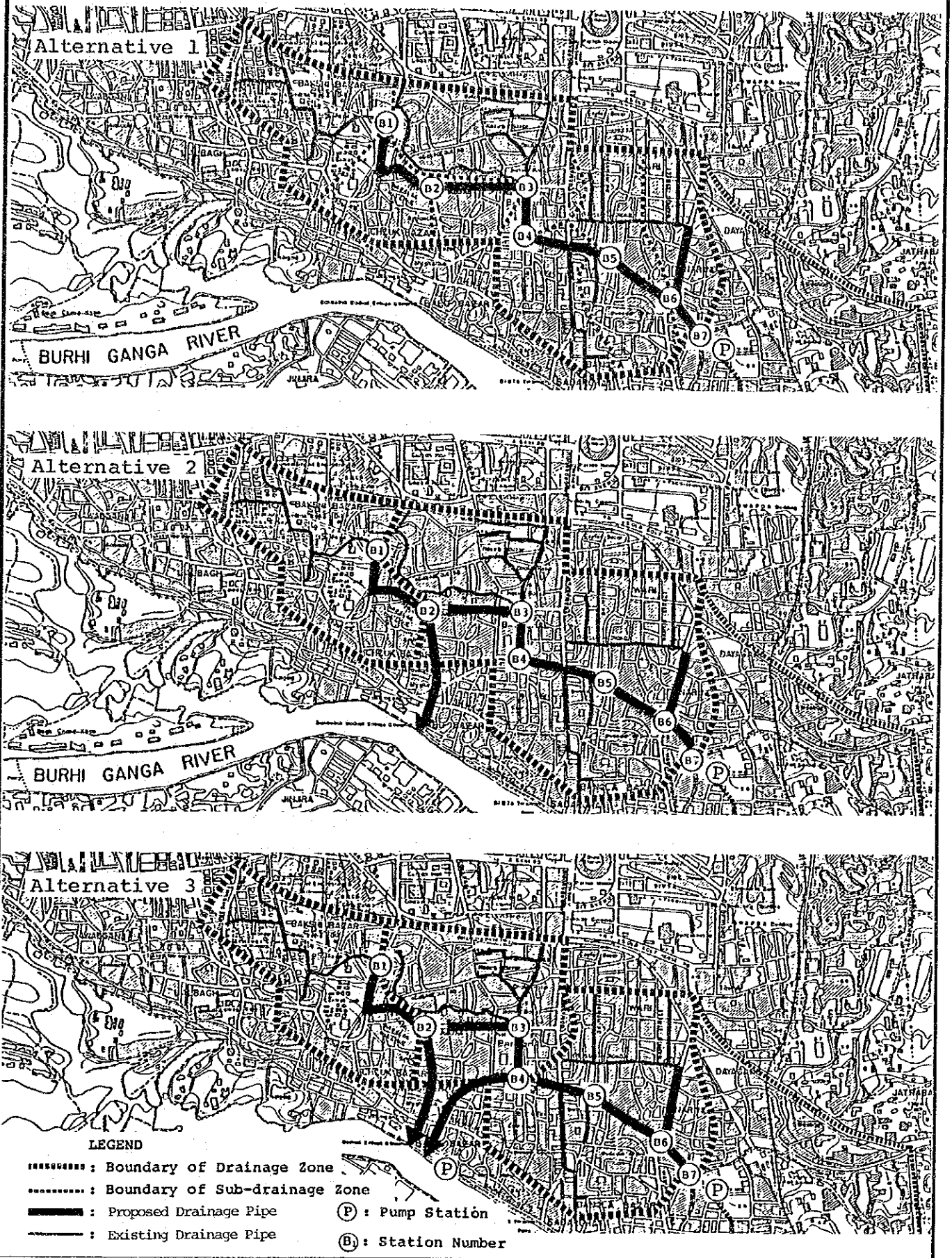
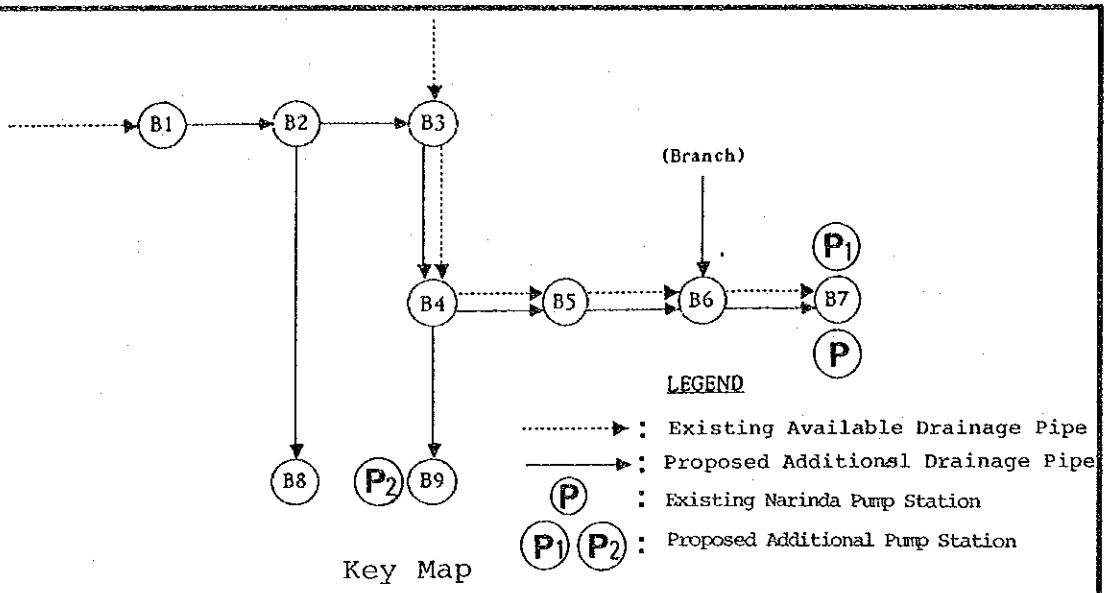


FIG. I.5 ALTERNATIVE DRAINAGE SYSTEM FOR OLD DHAKA AREA

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



Proposed Additional Pump Capacities

Pump Station	Alternative 1	Alternative 2	Alternative 3
P1 (m^3/sec)	25.3	23.5	10.3
P2 (m^3/sec)	-	-	17.4
Total	25.3	23.5	27.7

Existing and Proposed Drainage Pipes

	ITEM	(B1)-(B2)	(B2)-(B3)	(B3)-(B4)	(B4)-(B5)	(B5)-(B6)	(B6)-(B7)	(B2)-(B8)	(B4)-(B9)
	Length (m)	700.00	750.00	350.00	450.00	650.00	100.00	780.00	920.00
	Existing Available Drainage Pipe Dimension/Capacity	-	-	Ø 2700 I=1.0 o/oo Q=9.29	Ø 3000 I=1.0o/oo Q=12.30	Ø 3000 I=1.0o/oo Q=12.30	Ø 3000 I=1.0o/oo Q=12.30	-	-
Alternative 1	Design Runoff (m3/s)	11.37	12.96	22.62	26.03	31.95	34.17	-	-
Alternative 1	Proposed Additional Drainage Pipe	Box Culvert 2.2 x 2.86 I=1.0 o/oo v=2.07 Q=11.50	Box Culvert 2.6 x 2.6 I=1.0 o/oo v=2.19 Q=12.99	Box Culvert 2.7 x 2.7 I=1.0 o/oo v=2.24 Q=14.36	Box Culvert 2.7 x 2.7 I=1.0 o/oo v=2.24 Q=14.36	Box Culvert 3.1 x 3.1 I=1.0 o/oo v=2.46 Q=20.76	Box Culvert 3.2 x 3.2 I=1.0 o/oo v=2.51 Q=22.59	-	-
Alternative 2	Design Runoff (m3/s)	11.37	3.62	16.99	22.01	28.59	31.84	11.37	-
Alternative 2	Proposed Additional Drainage Pipe	Box Culvert 2.2 x 2.86 I=1.0 o/oo v=2.07 Q=11.50	Circular Pipe Ø 1900 I=1.0 o/oo v=1.28 Q=3.64	Circular Pipe Ø 2600 I=1.0 o/oo v=1.53 Q=8.40	Circular Pipe Ø 2800 I=1.0 o/oo v=1.66 Q=10.23	Box Culvert 2.9 x 2.9 I=1.0 o/oo v=2.35 Q=17.37	Box Culvert 3.1 x 3.1 I=1.0 o/oo v=2.46 Q=20.76	Box Culvert 2.2 x 2.86 I=1.0 o/oo v=2.07 Q=11.50	-
Alternative 3	Design Runoff (m3/s)	11.37	3.62	16.99	6.96	15.52	19.60	11.37	16.99
Alternative 3	Proposed Additional Drainage Pipe	Box Culvert 2.2 x 2.86 I=1.0 o/oo v=2.07 Q=11.50	Circular Pipe Ø 1900 I=1.0 o/oo v=1.28 Q=3.64	Circular Pipe Ø 2600 I=1.0 o/oo v=1.53 Q=8.40	Existing Drainage Pipe	Circular Pipe Ø 1900 I=1.0 o/oo v=1.28 Q=3.64	Circular Pipe Ø 2500 I=1.0 o/oo v=1.54 Q=7.56	Box Culvert 2.2 x 2.86 I=1.0 o/oo v=2.07 Q=11.50	Box Culvert 2.9 x 2.9 I=1.0 o/oo v=2.35 Q=17.37

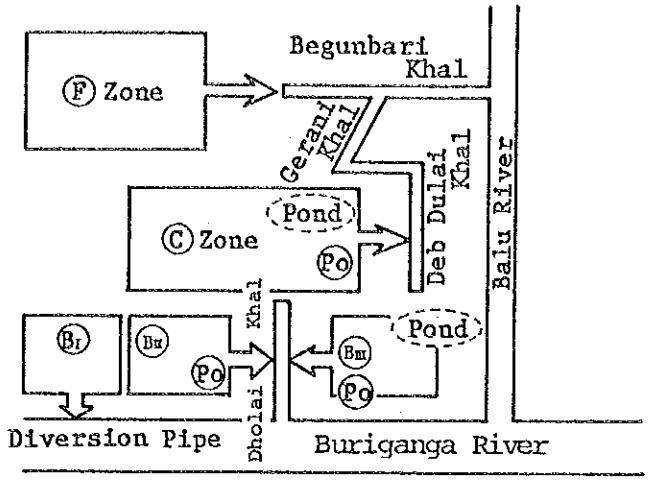
FIG. I.6 PROPOSED DRAINAGE FACILITIES OF ALTERNATIVES OF OLD DHAKA AREA

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

Alternative 1

Drainage Area

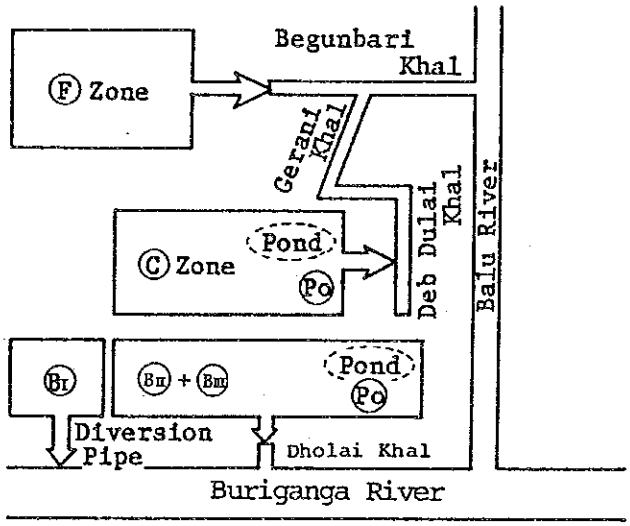
B I Area : 1.03 km^2
B II Area : 3.11 km^2
B III Area : 2.59 km^2
C Zone : 10.92 km^2
F Zone : 13.70 km^2



Alternative 2

Drainage Area

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



Alternative 3

Drainage Area

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

LEGEND

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

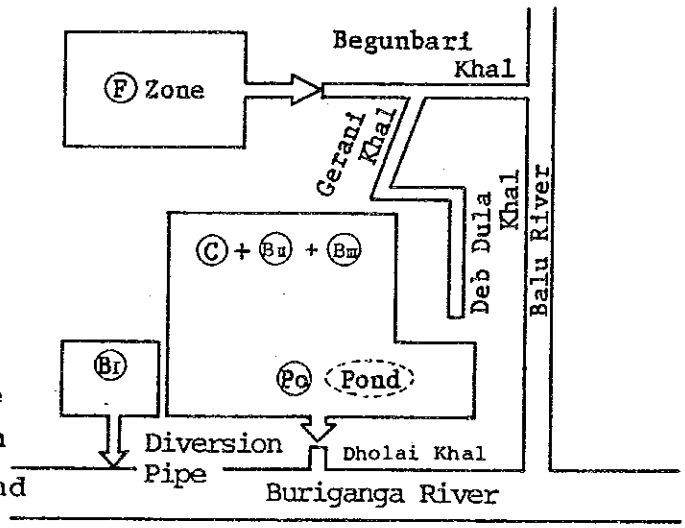


FIG. I.7 ALTERNATIVE PUMP DRAINAGE SYSTEM

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

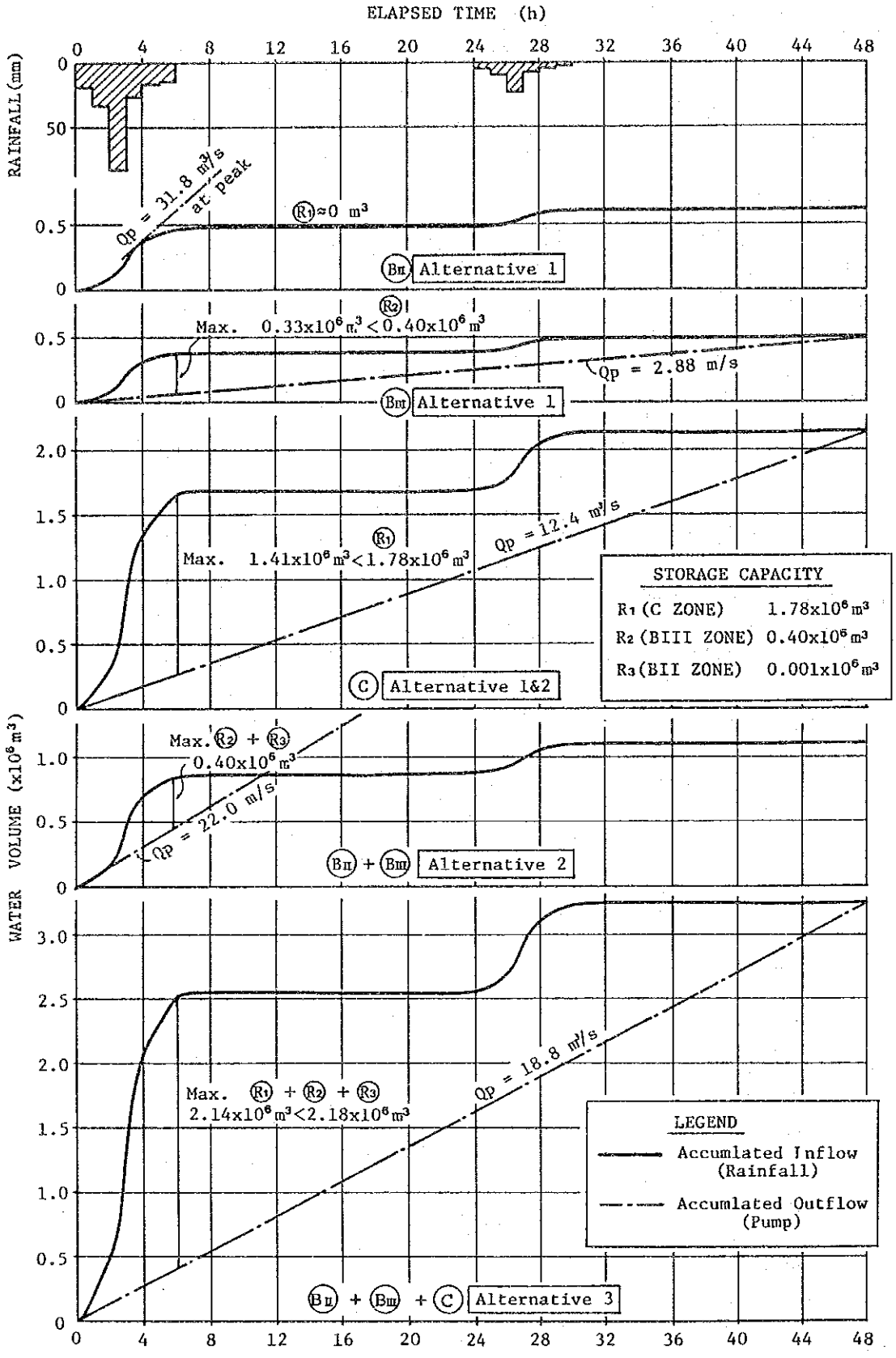
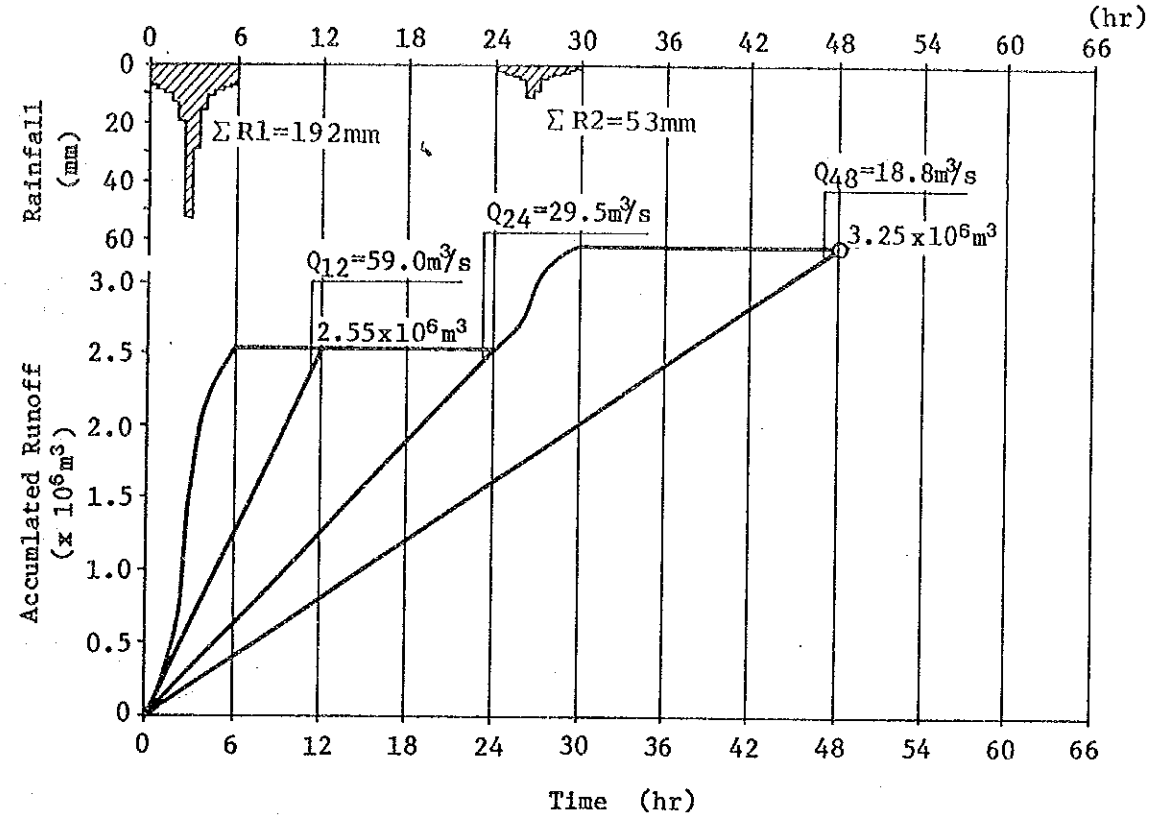


FIG. I.8 REQUIRED PUMP AND REGULATING POND CAPACITIES OF PUMP DRAINAGE ALTERNATIVES

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



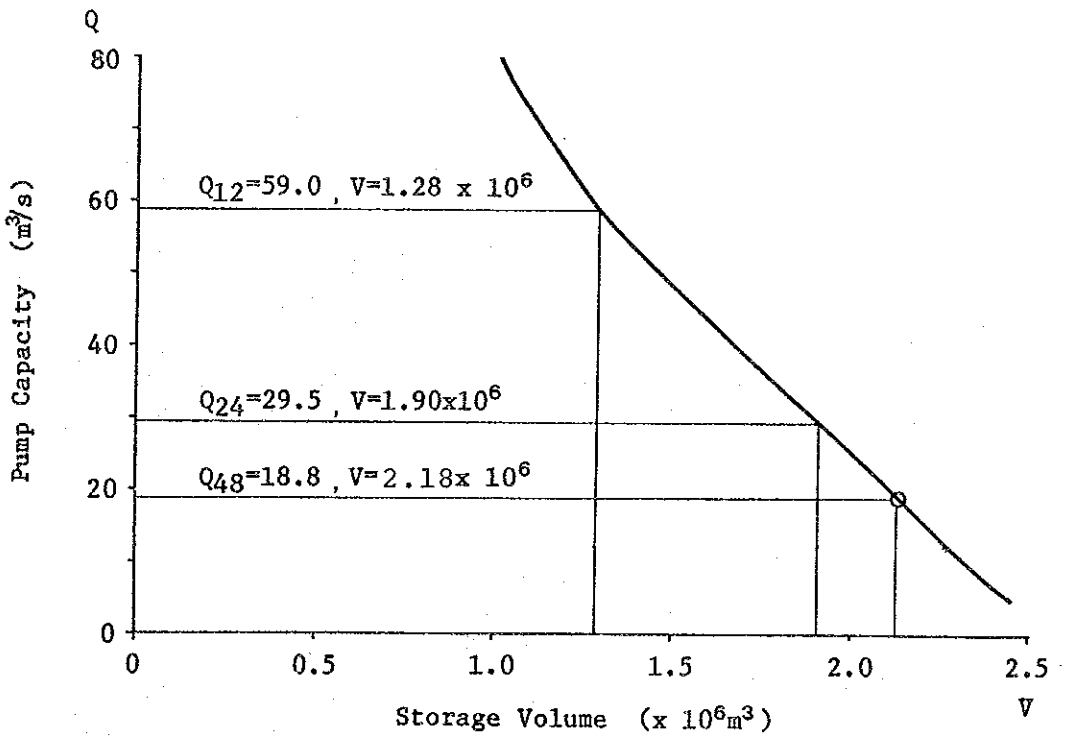
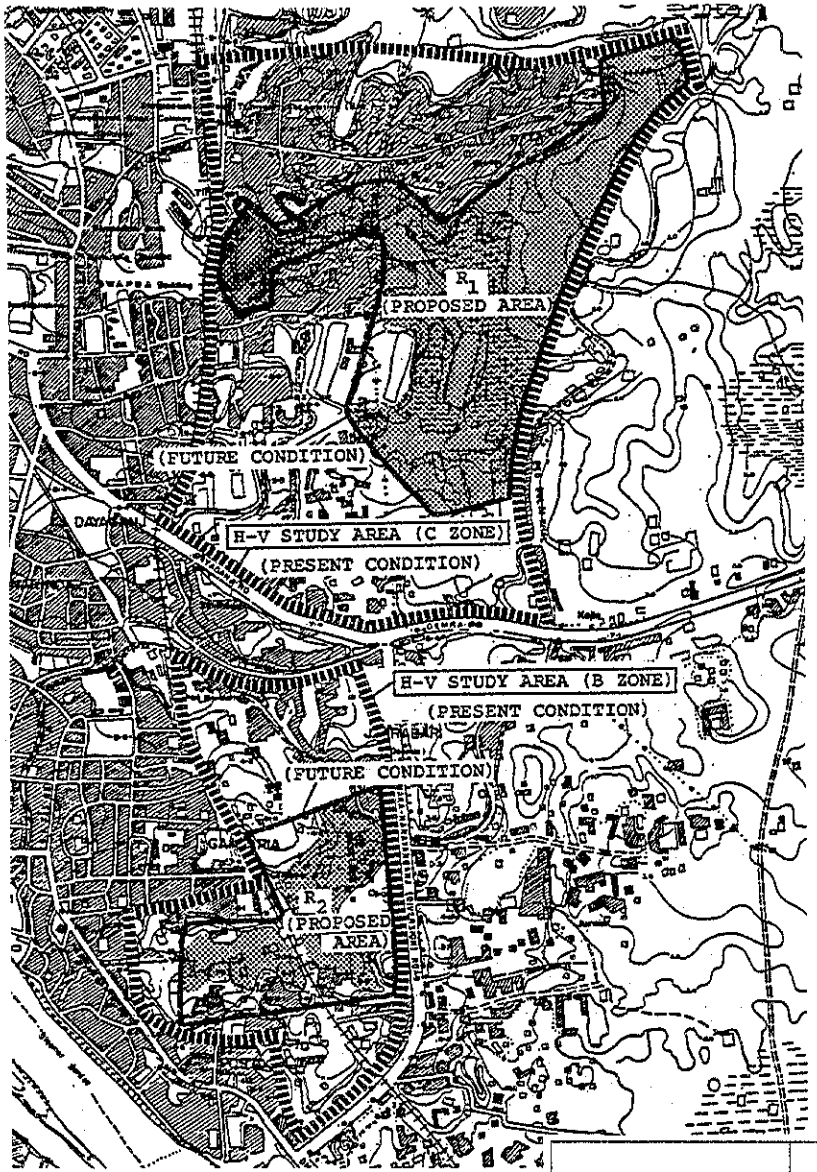
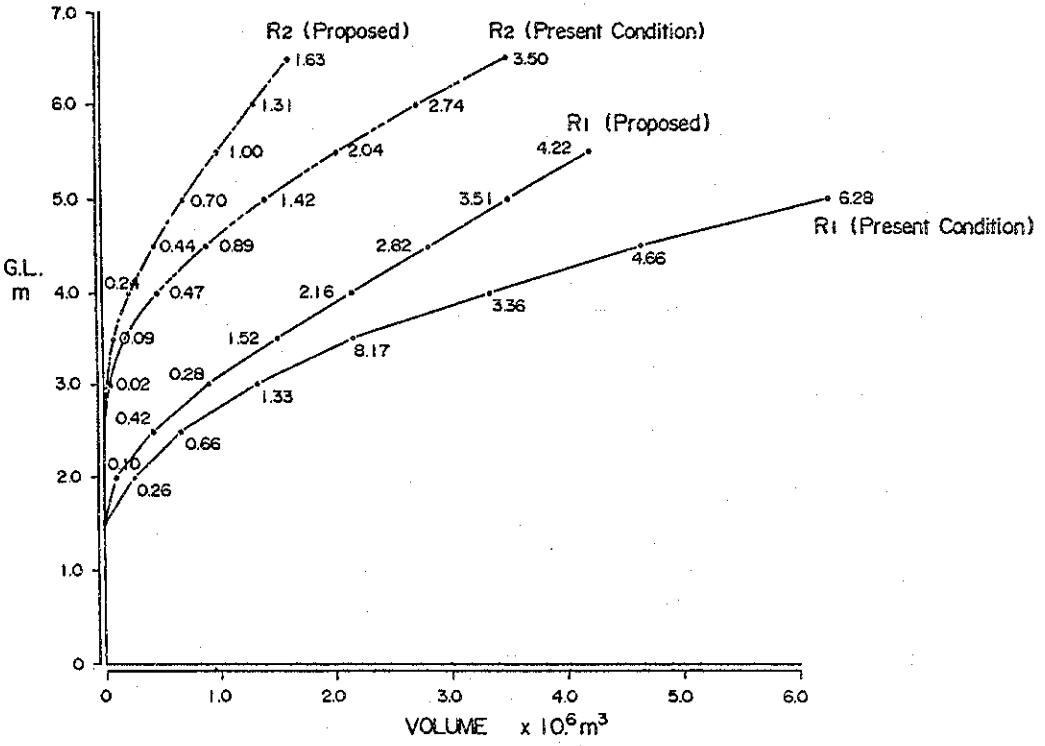


FIG. I.9 MASS CURVE FOR PUMP DRAINAGE

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



LOCATION



H - V CURVE

FIG. I.10 LOCATION AND H-V CURVE OF PROPOSED REGULATING PONDS

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

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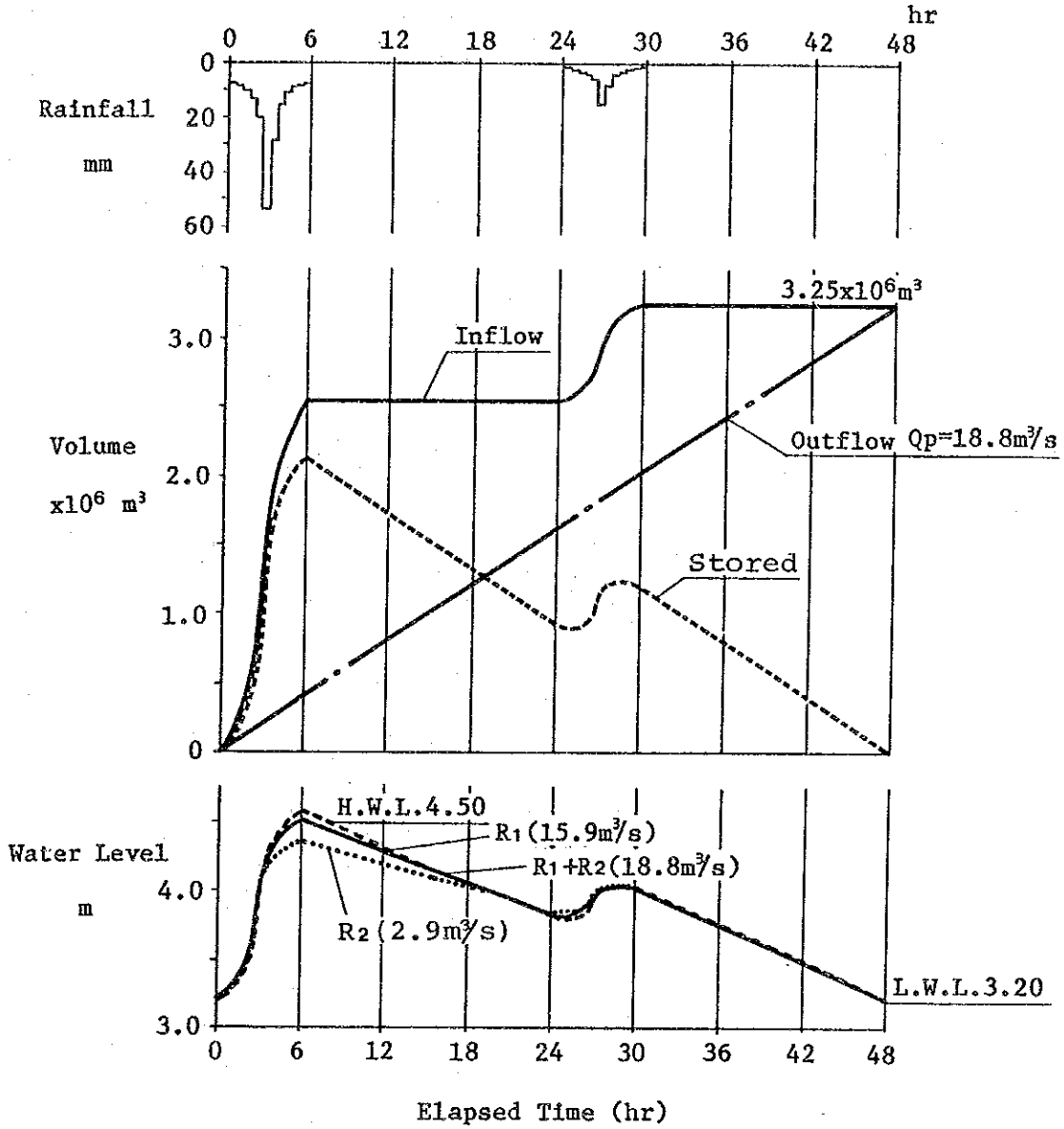

FIG. I.11 VARIATION CURVE OF WATER LEVEL OF PROPOSED REGULATING PONDS

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

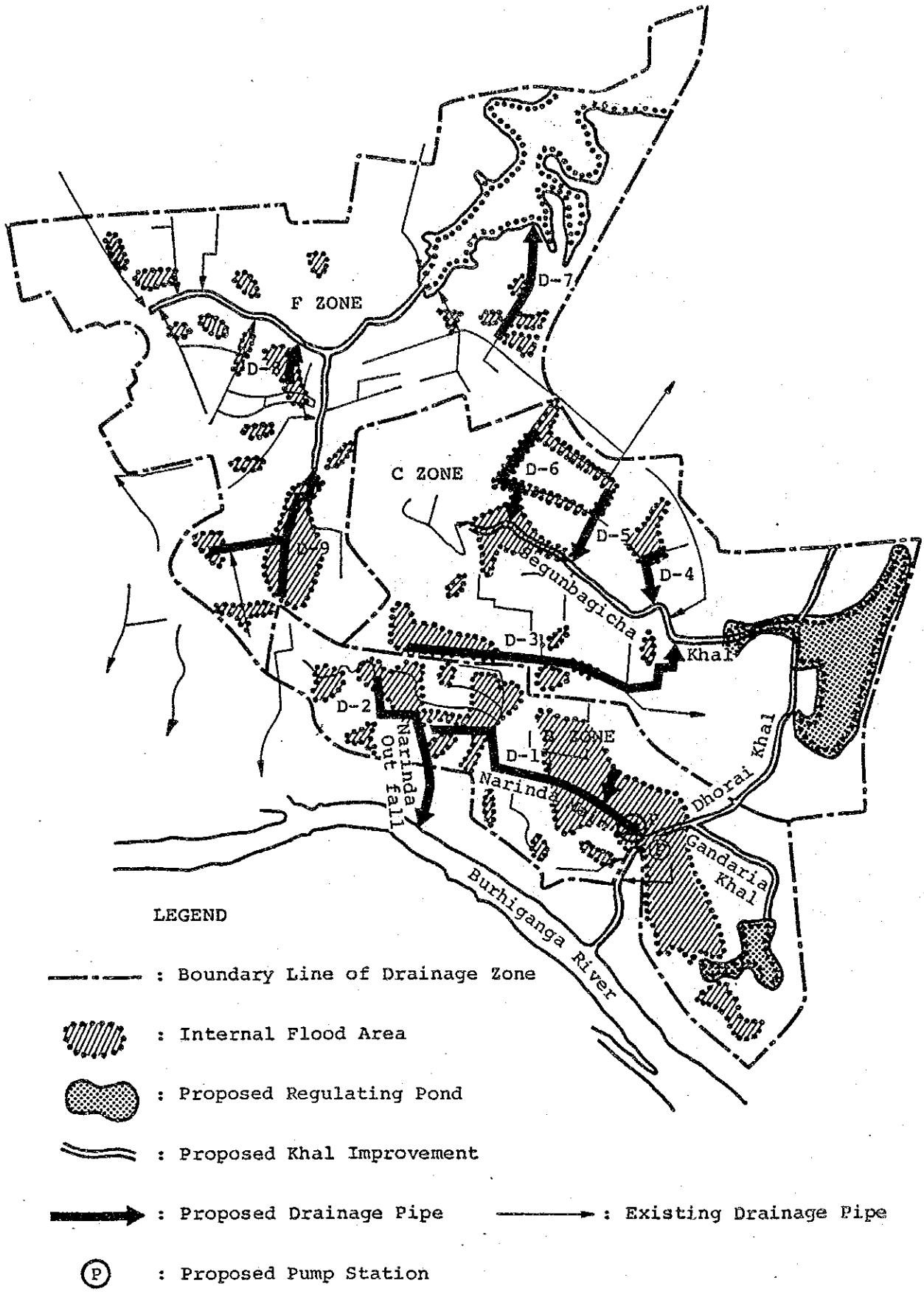

FIG. I.12 PROPOSED DRAINAGE NETWORKS

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

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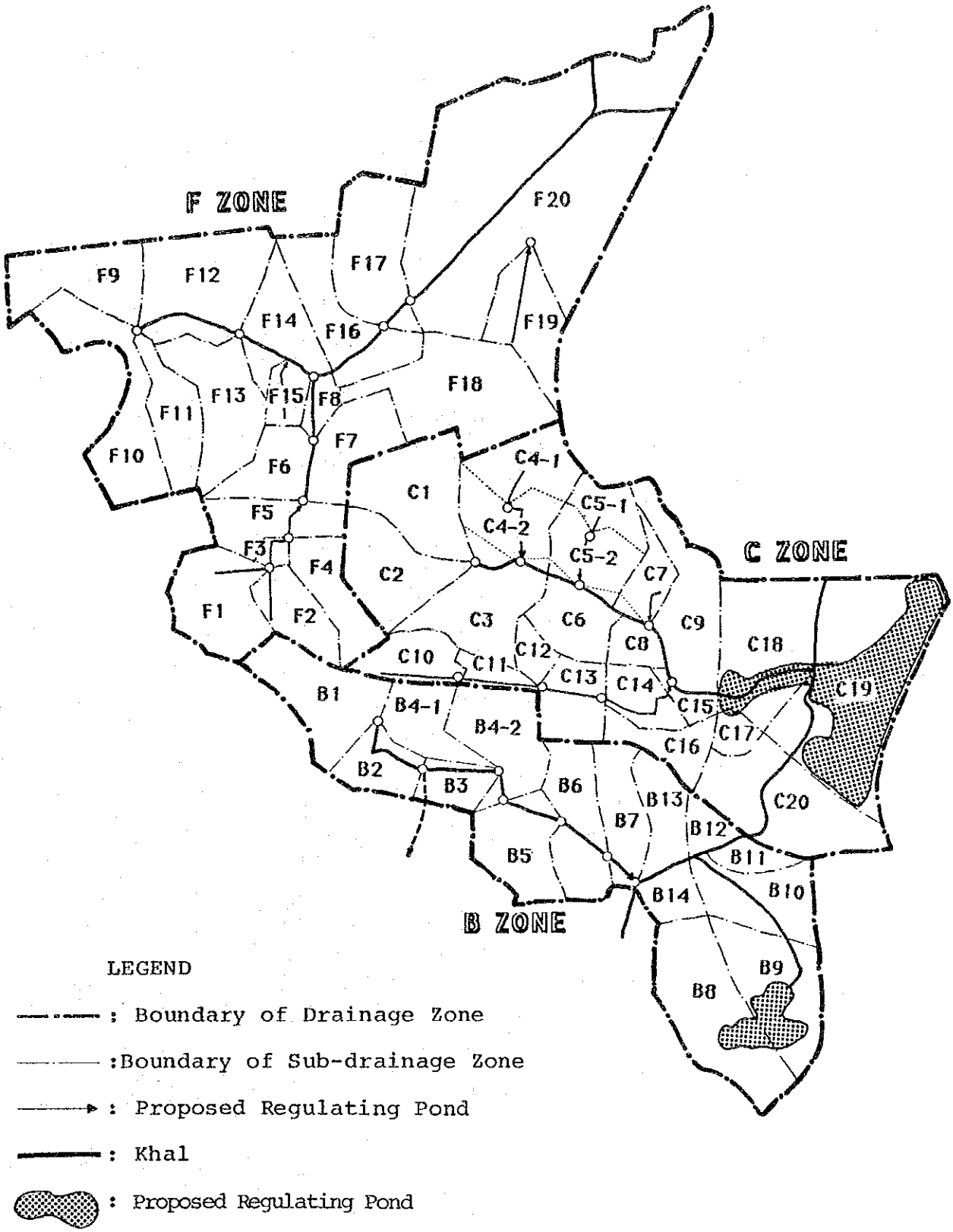

FIG. I.13 SUB-DIVIDED DRAINAGE AREA

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

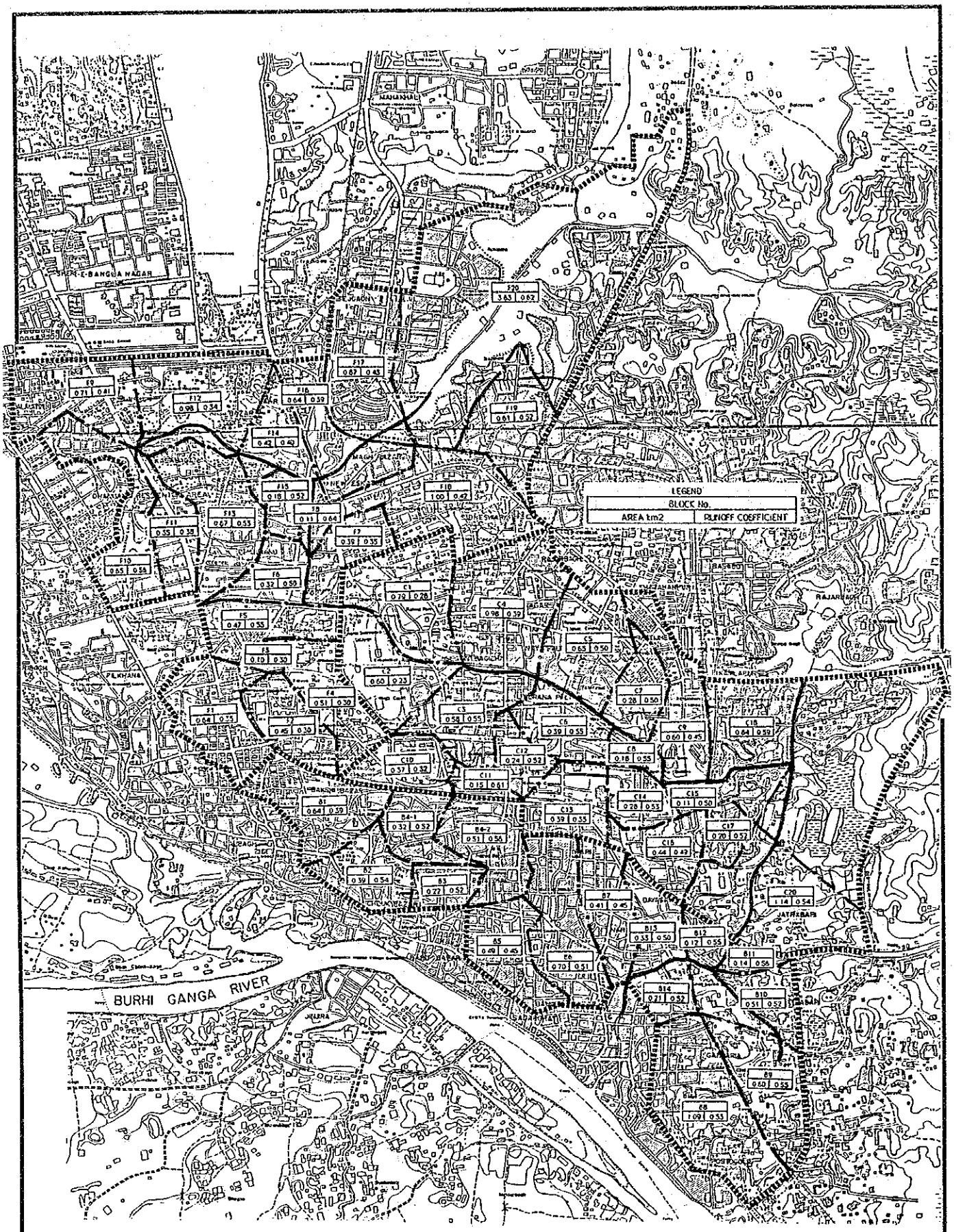

FIG. I.14 AREA AND RUNOFF COEFFICIENT OF SUB-DRAINAGE AREA

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

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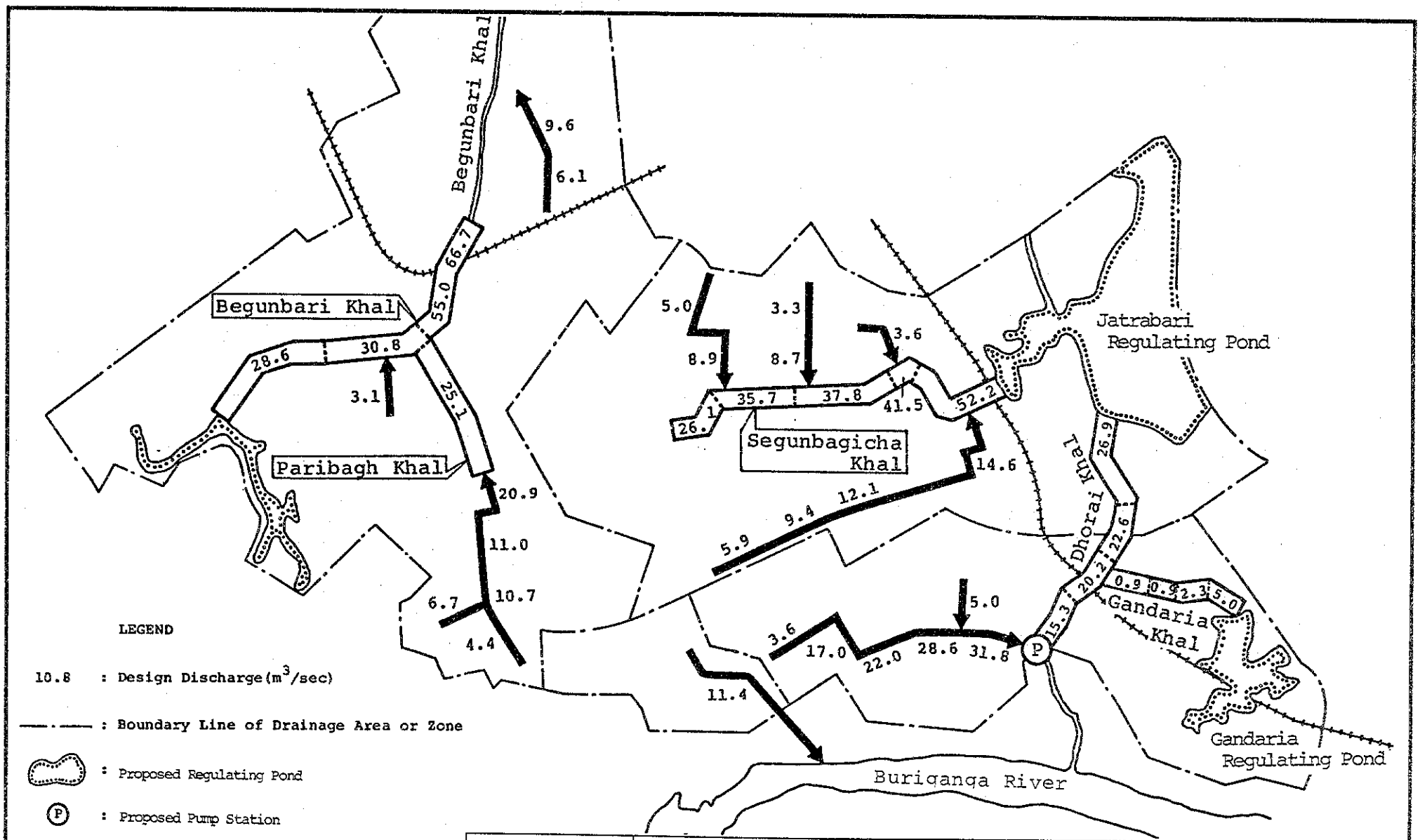

FIG. I.15 DESIGN DISCHARGE OF KHAL IMPROVEMENT AND DRAINAGE PIPE

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

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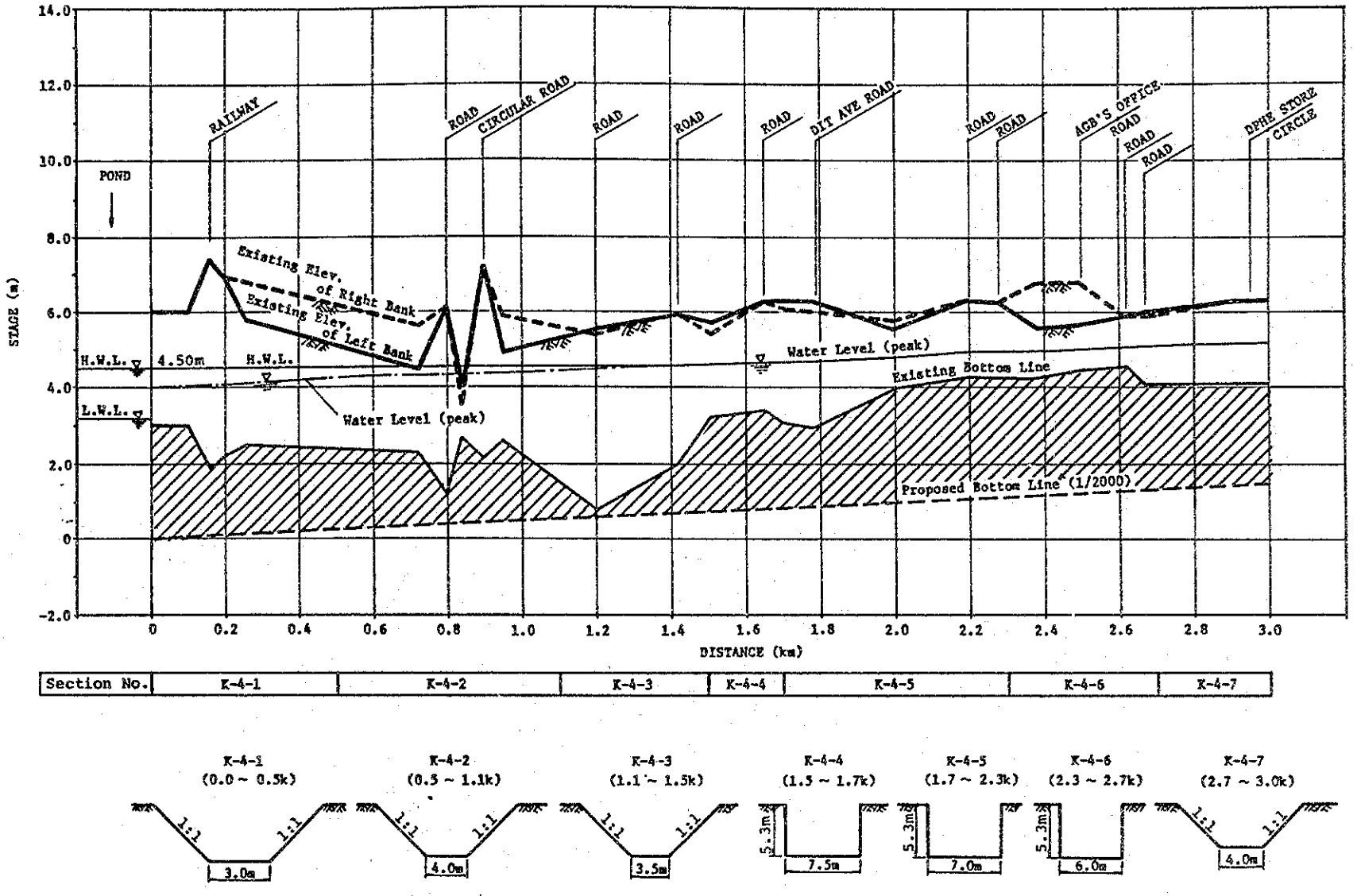

FIG. I.16 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF SEGUNBAGICHA KHAL

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

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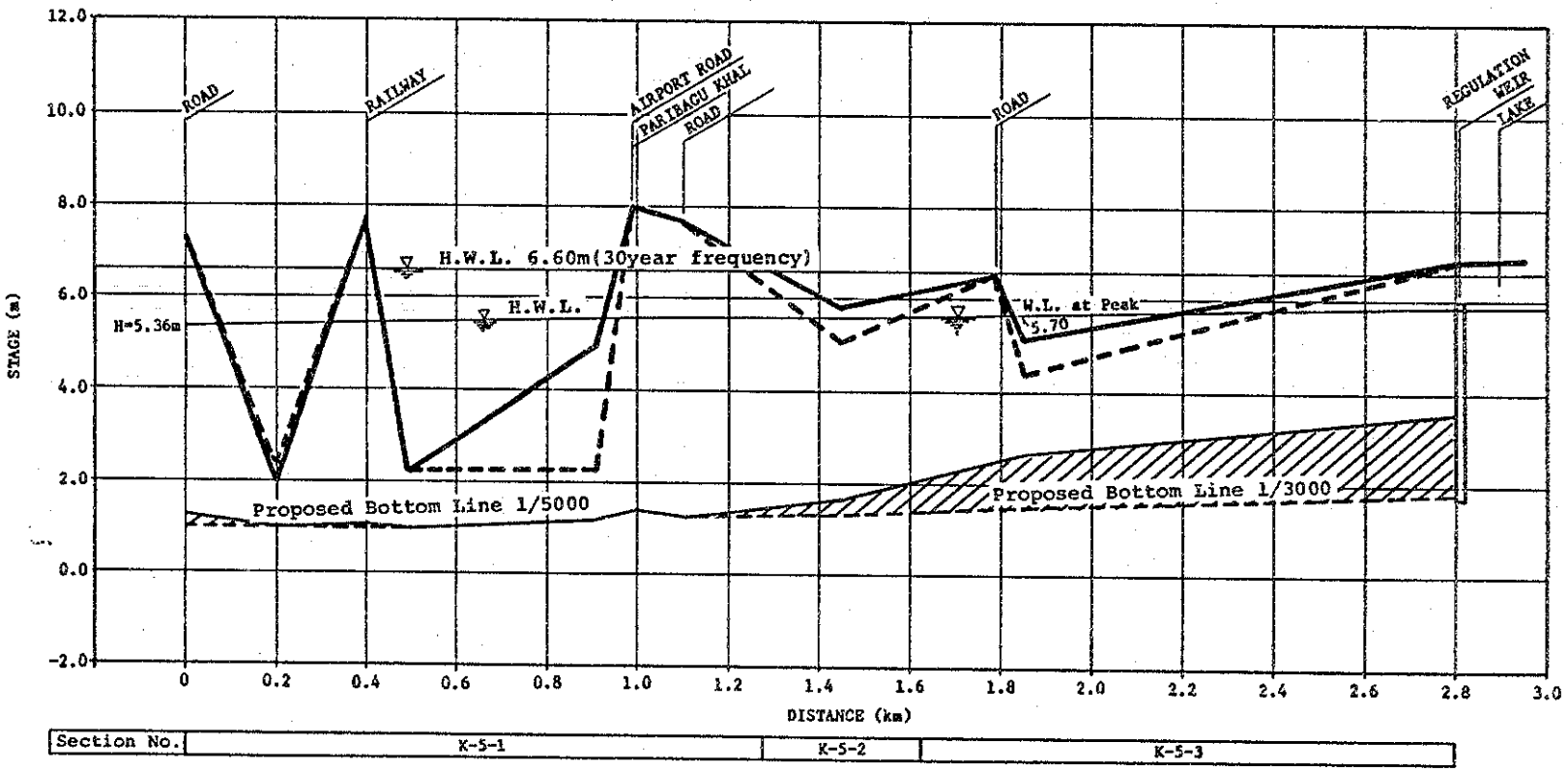

FIG. I.17 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF BEGUNBARI KHAL

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

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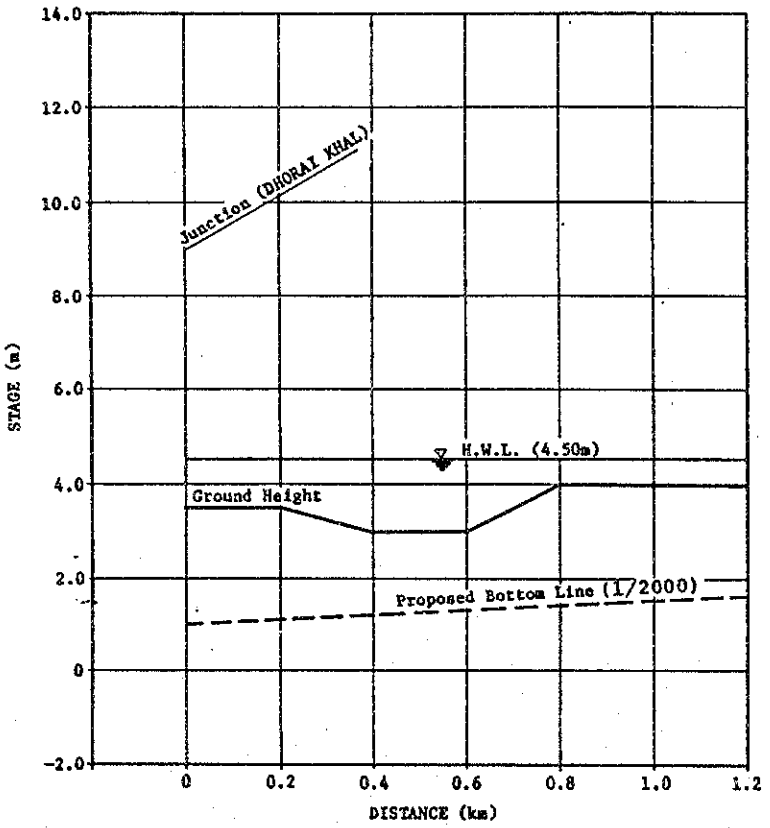
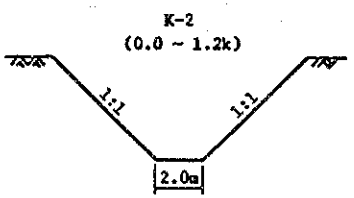
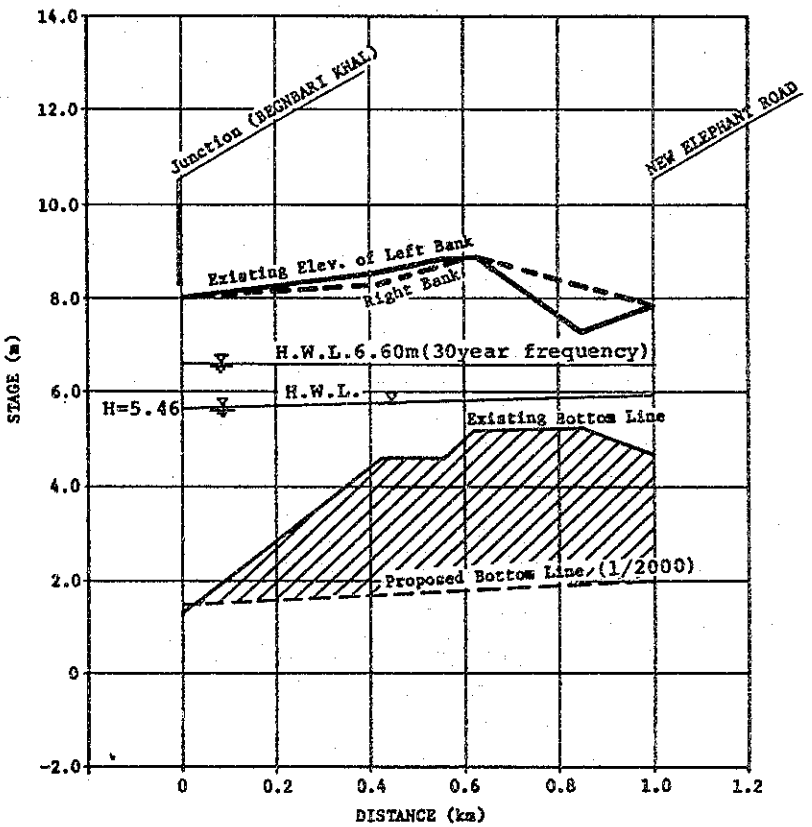
(GANDARIA)



Section No.	K-2



(PARIBAGH)



Section No.	K-6

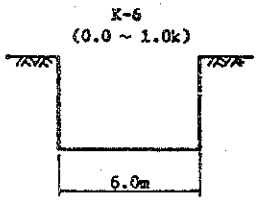


FIG. I.18 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF PARIBAGH AND GANDARIA KHALS

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

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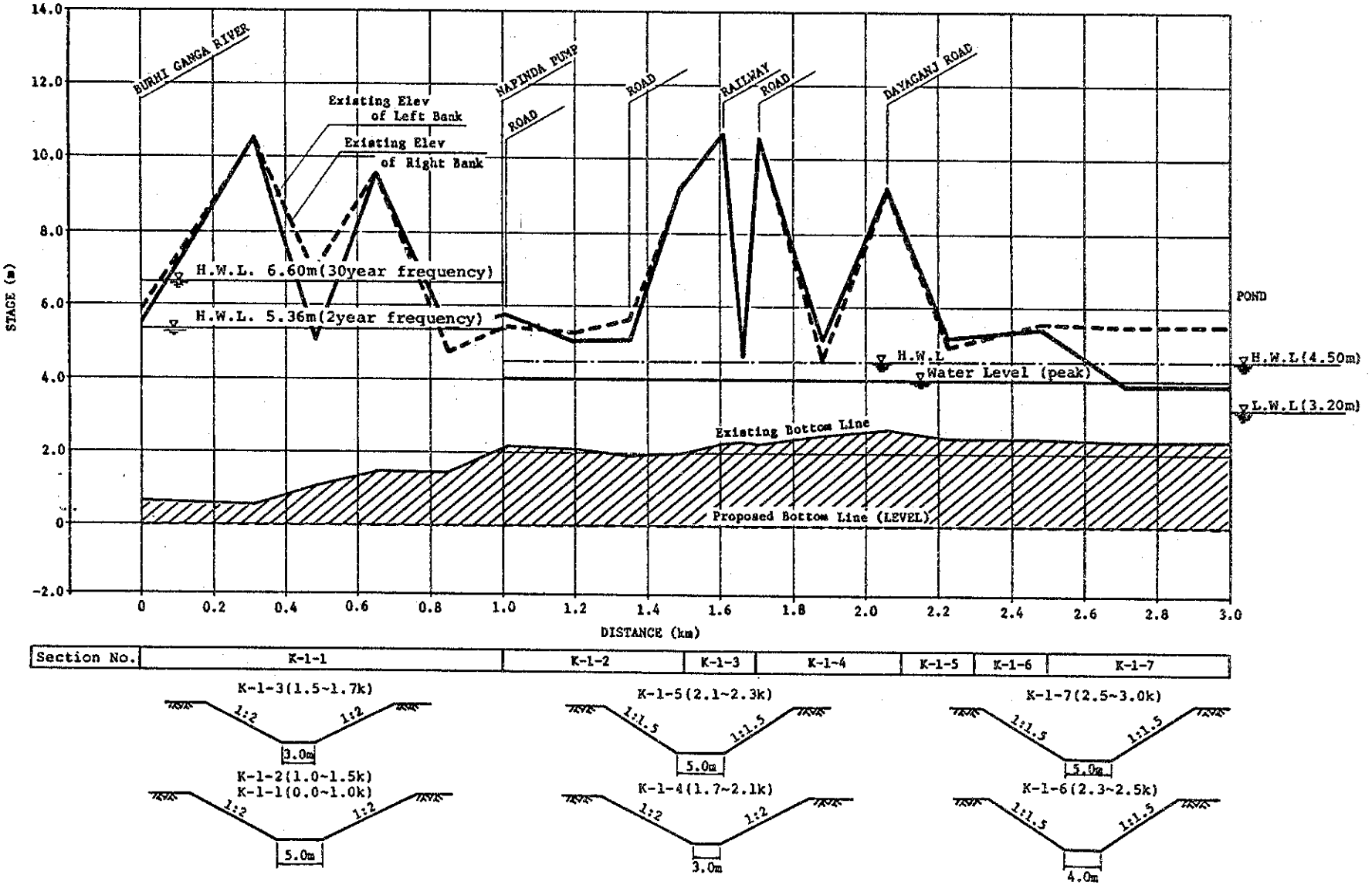

FIG. I.19 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF DHOLAI KHAL

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

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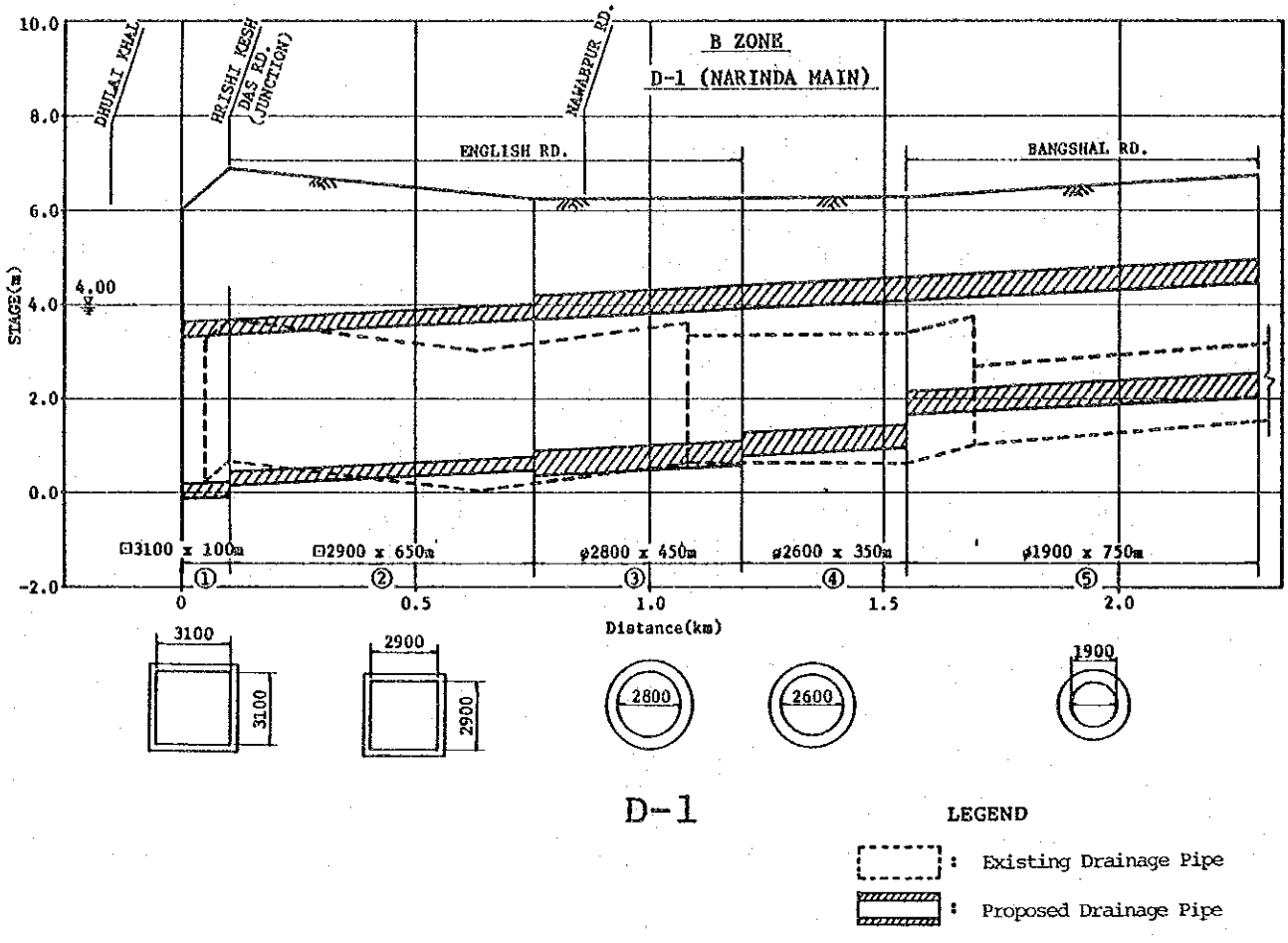
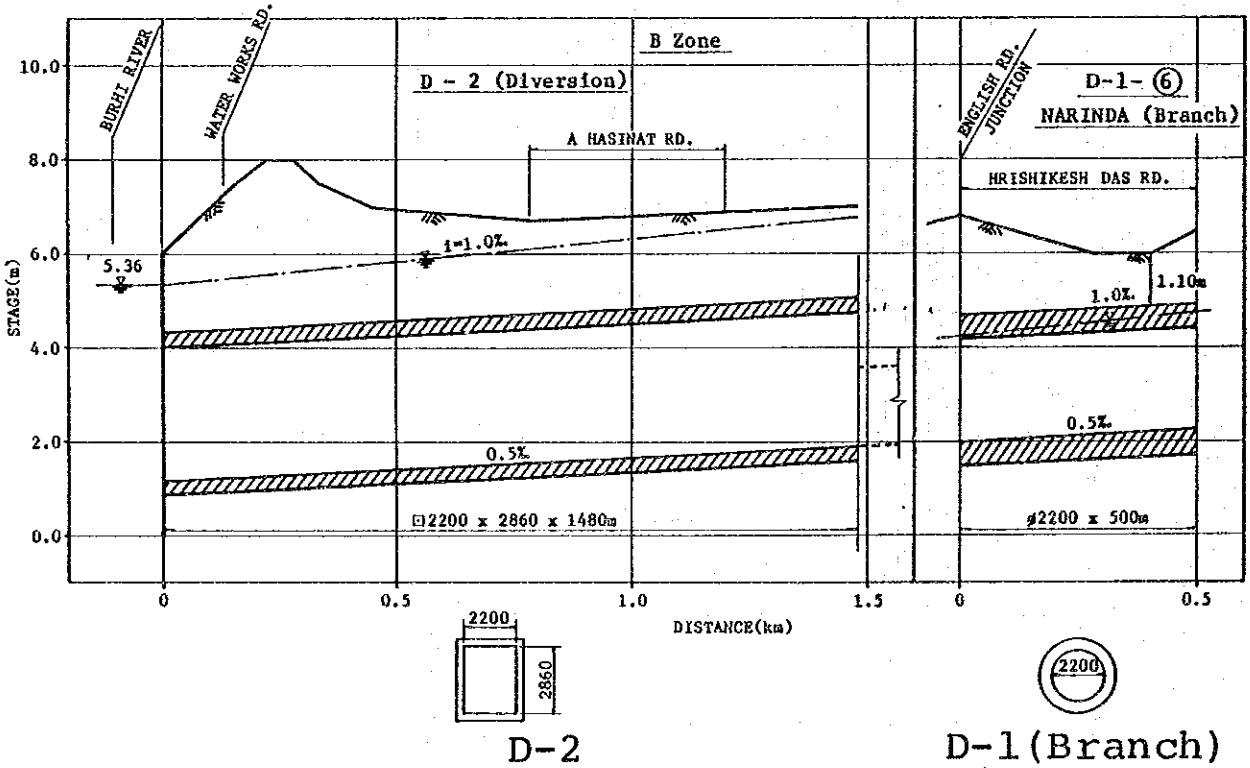


D-1

LEGEND

: Existing Drainage Pipe

: Proposed Drainage Pipe

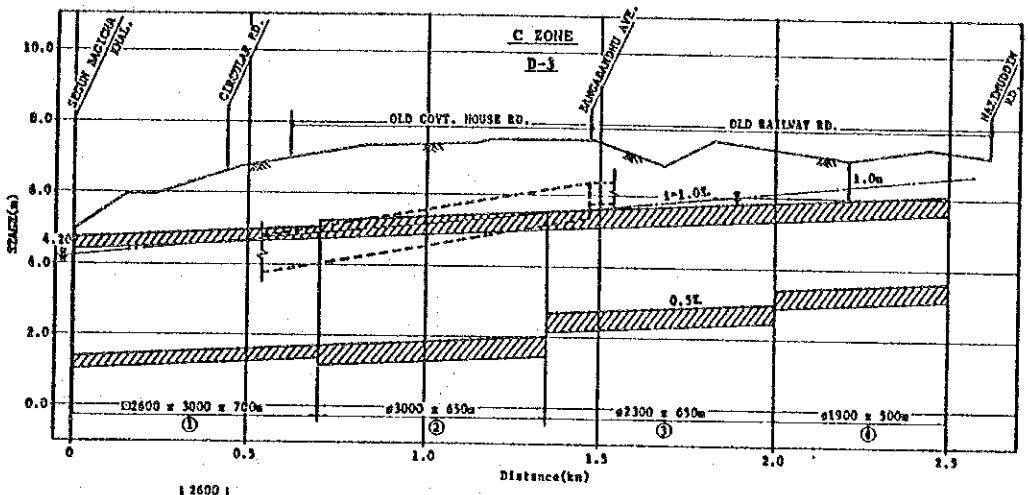


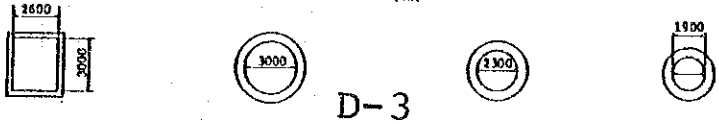
D-2

D-1(Branch)

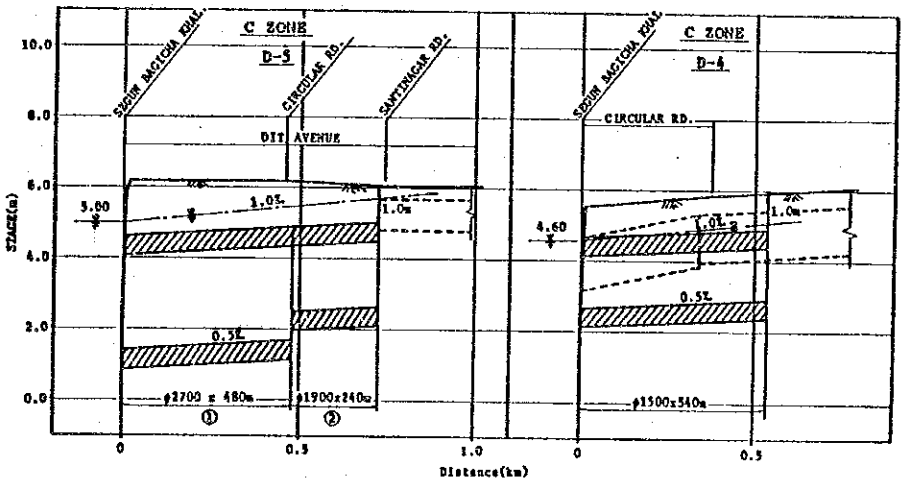
FIG. I.20 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF DRAINAGE PIPE (B ZONE)

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

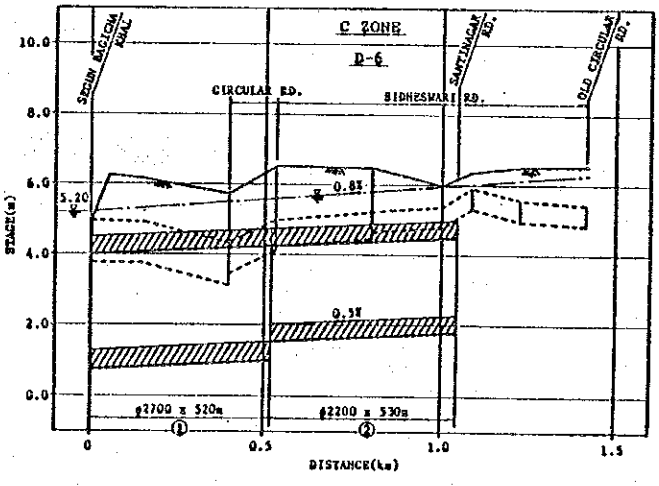




D-3



D-5 D-4



D-6

LEGEND

: Existing Drainage Pipe

: Proposed Drainage Pipe

FIG. I.21 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF DRAINAGE PIPE (C ZONE)

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

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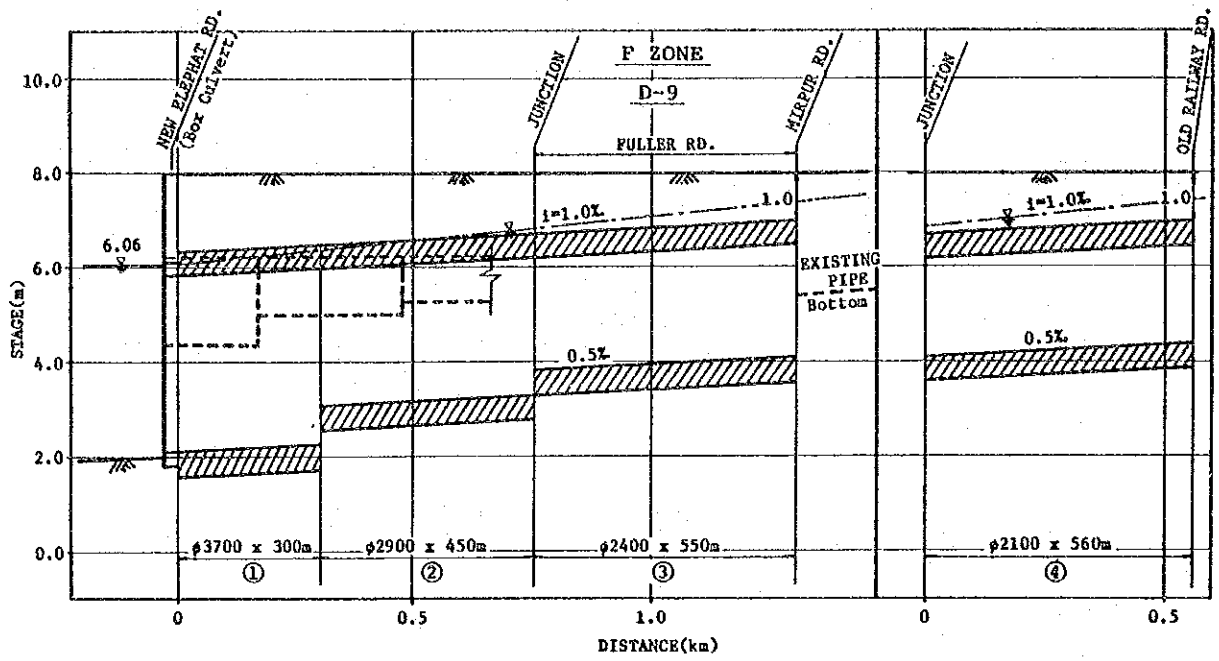
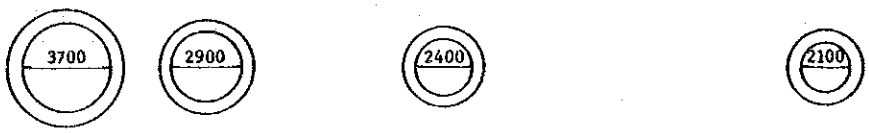


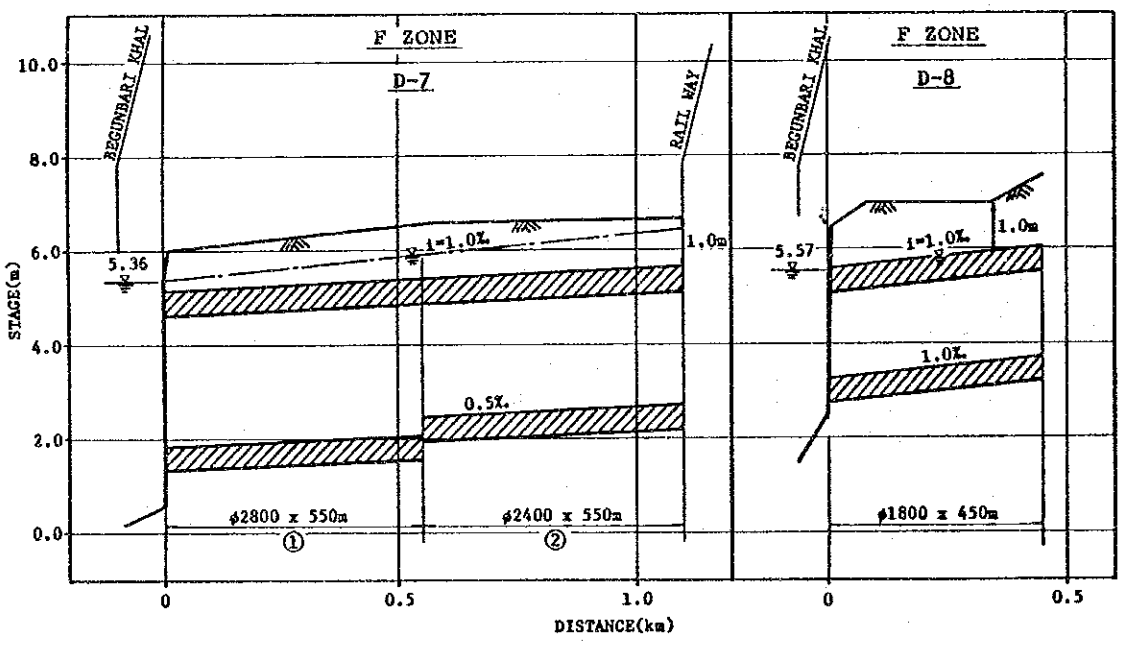


D-9

LEGEND

: Existing Drainage Pipe

: Proposed Drainage Pipe



D-7 D-8

FIG. I.22 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF DRAINAGE PIPE (F ZONE)

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

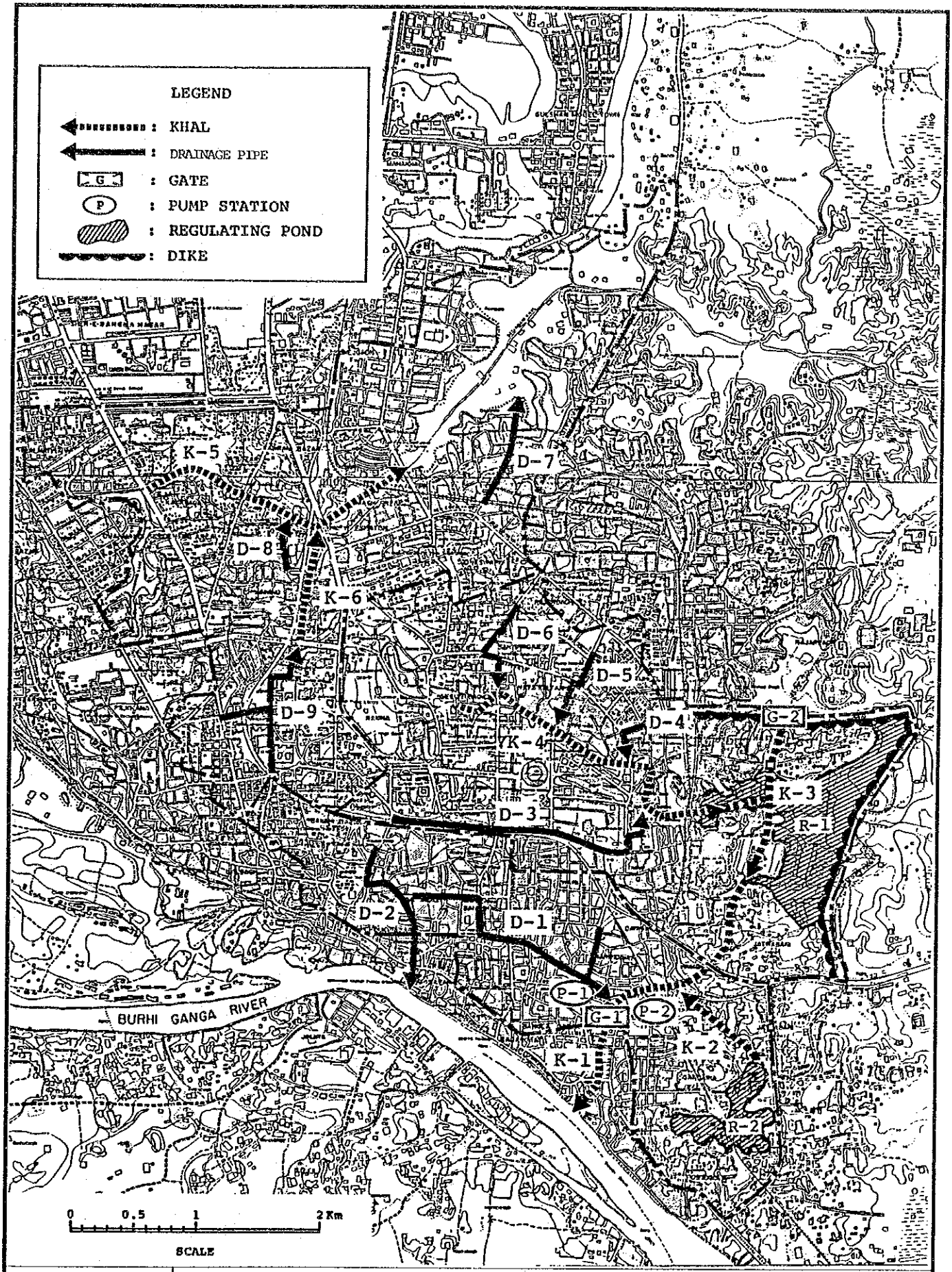


FIG. I.23 LOCATION OF PROPOSED FLOOD PROTECTION AND DRAINAGE FACILITIES

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

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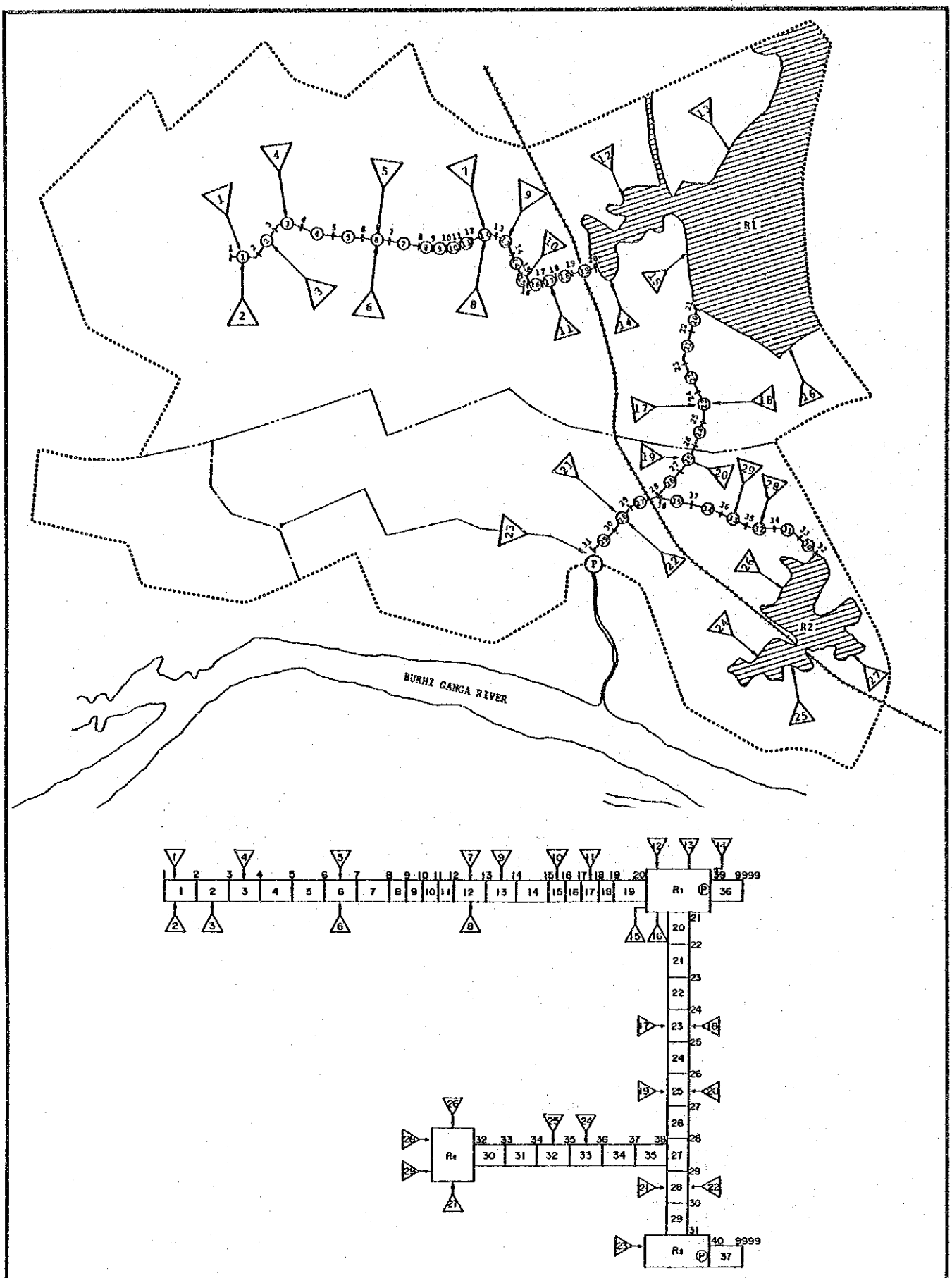
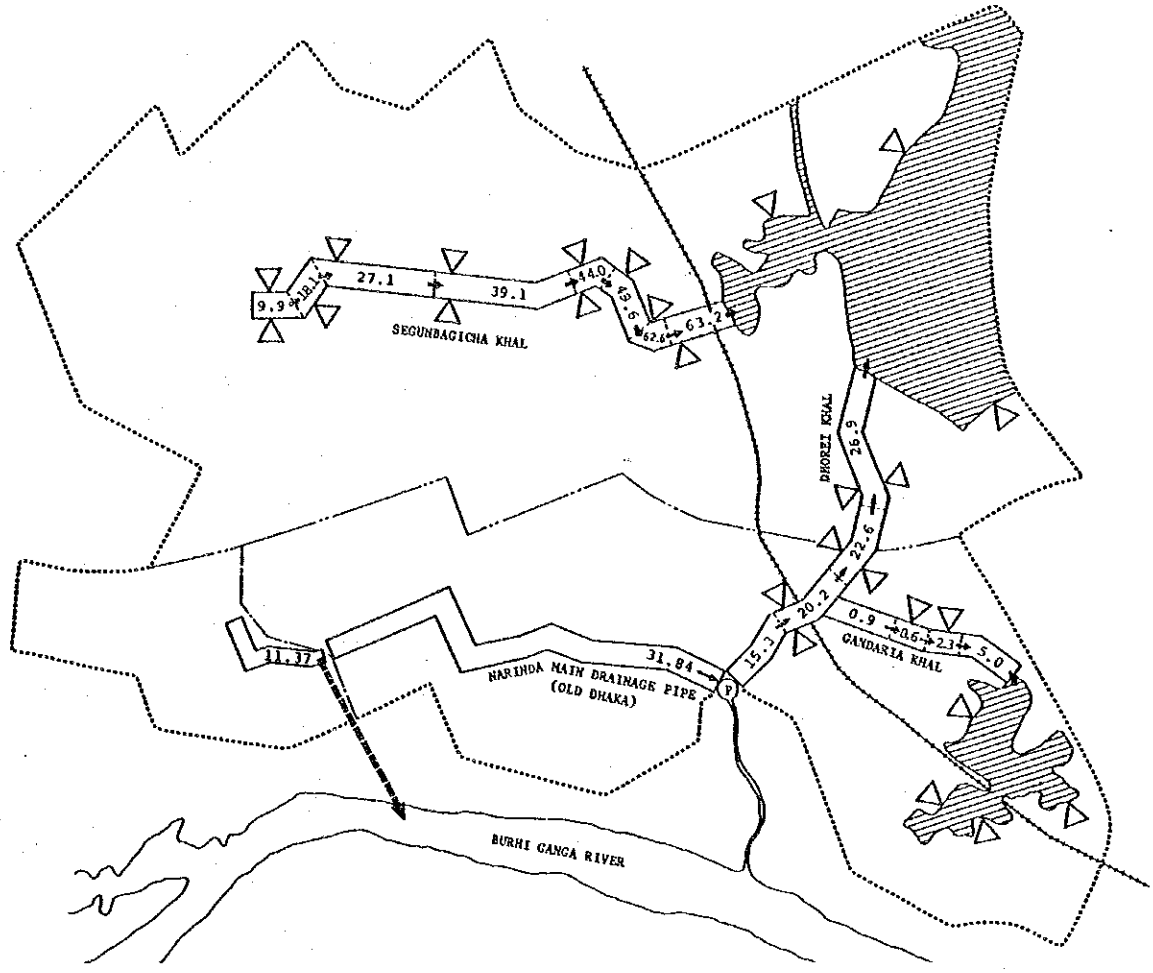


FIG. I.24 KHAL NETWORKS AND SIMULATION MODEL

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



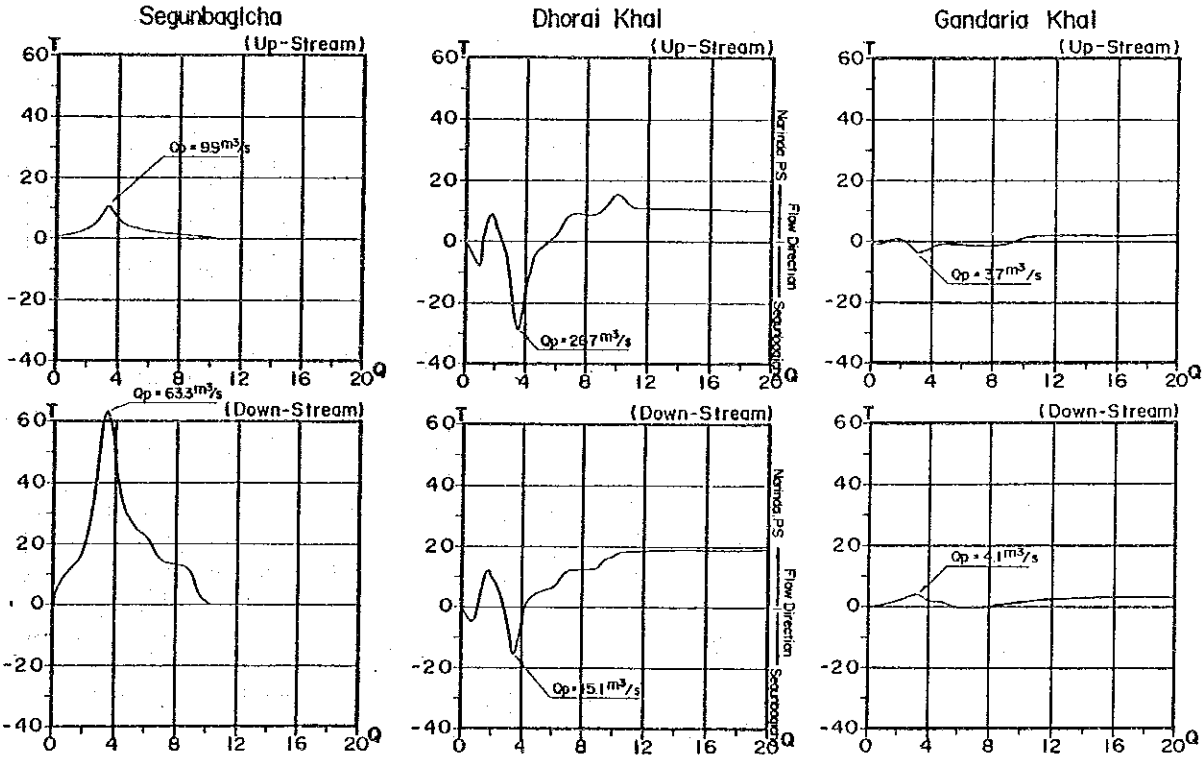
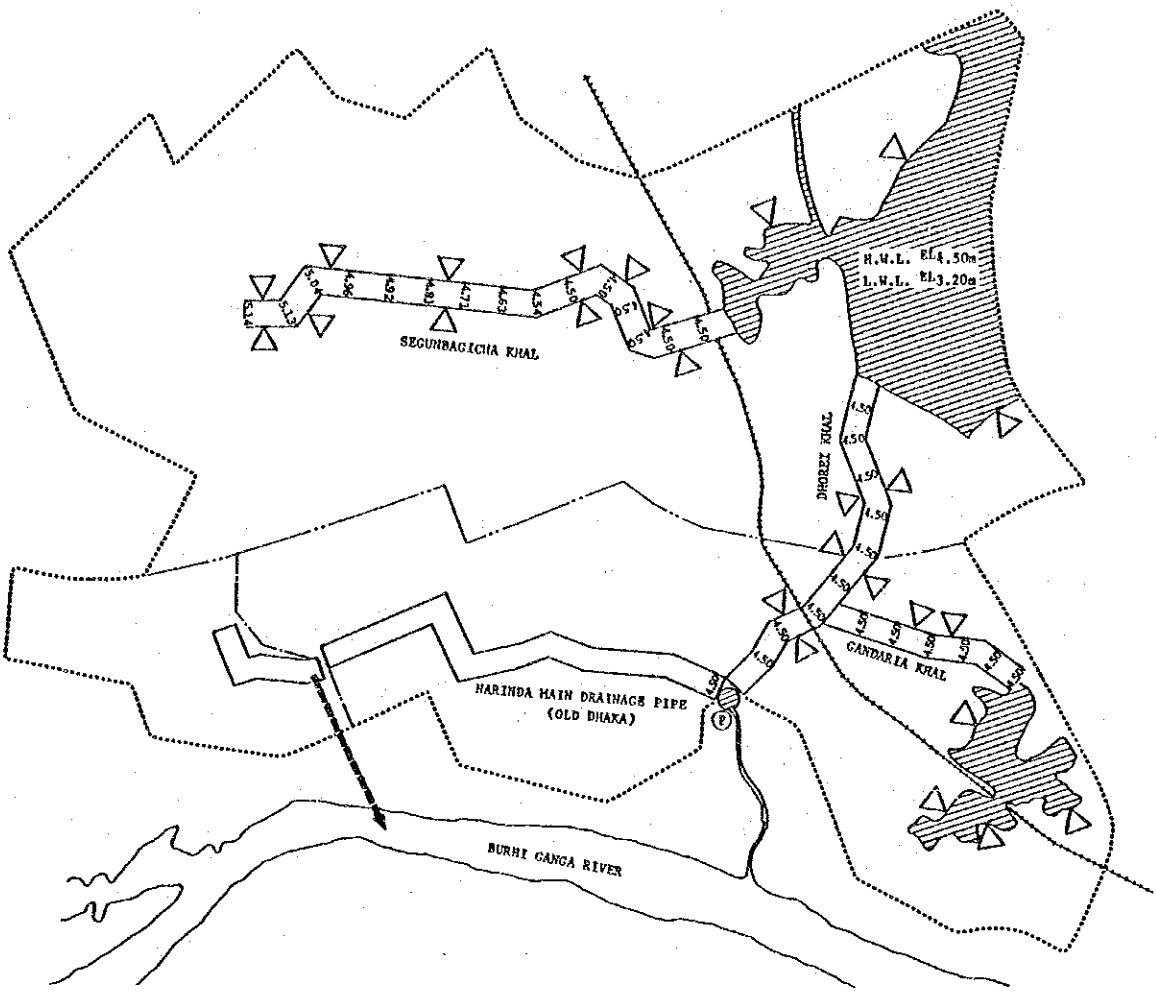


FIG. I.25 VARIATION OF DISCHARGE

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



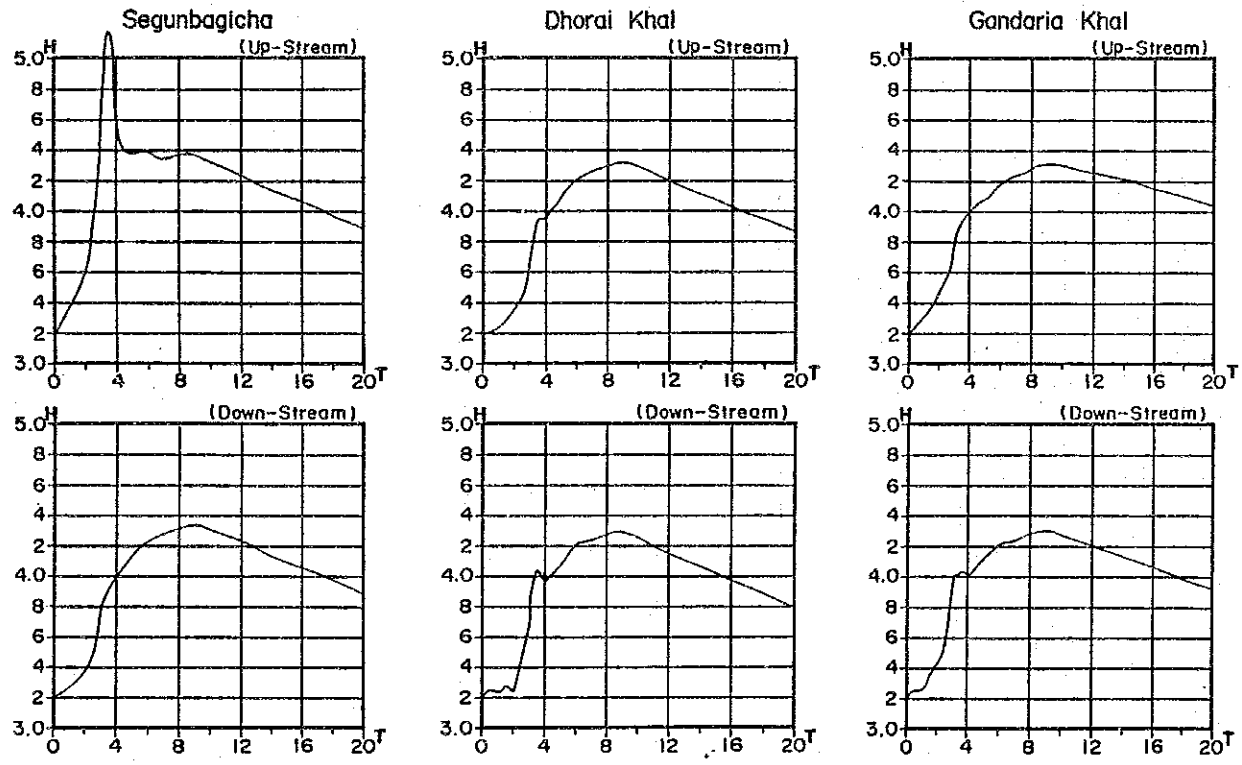
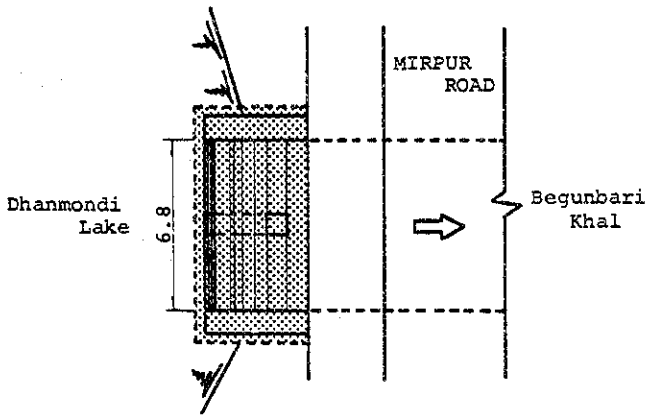
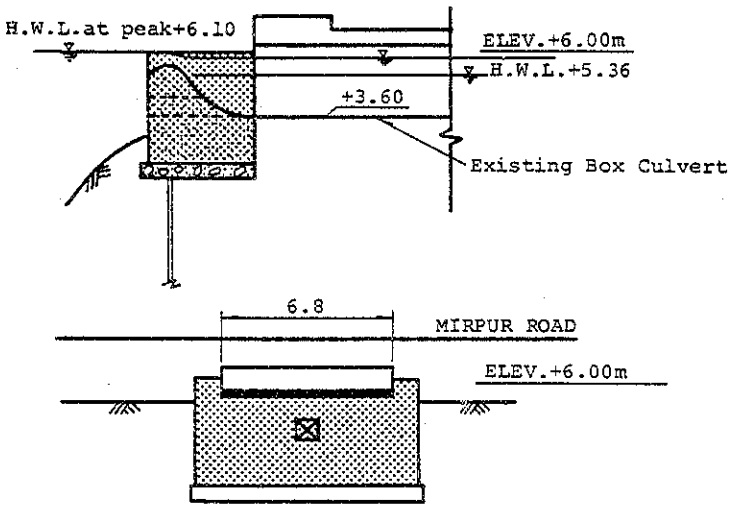


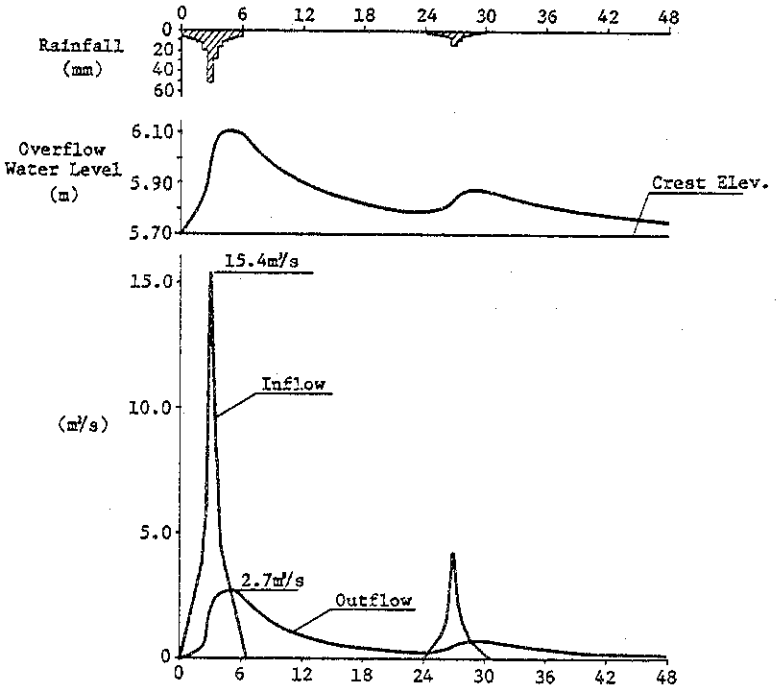
FIG. I.26 VARIATION OF WATER LEVEL

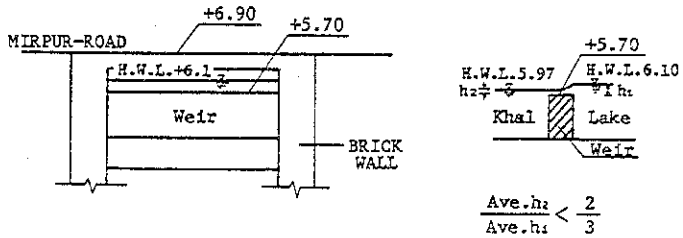
STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY, THE PEOPLE'S REPUBLIC OF BANGLADESH





Regulation Weir of DHANMONDI LAKE





Design of Regulation Weir
DHANMONDI LAKE

$Q = 0.35\ B\ h_1\sqrt{2gh_1}$ m³/s

where B : Width of Weir (=6.8) m

h : Overflow depth m

g : 9.8 m/s²

FIG. I.27 PROPOSED SMALL CONCRETE DAM AND ITS HYDRAULIC EFFECT

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

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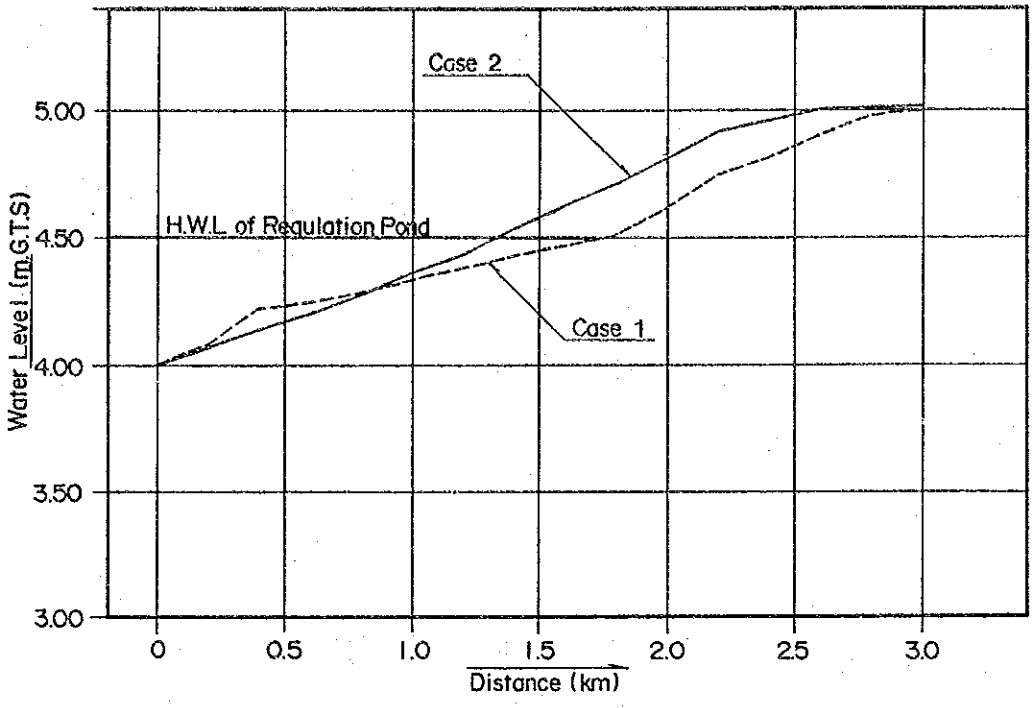
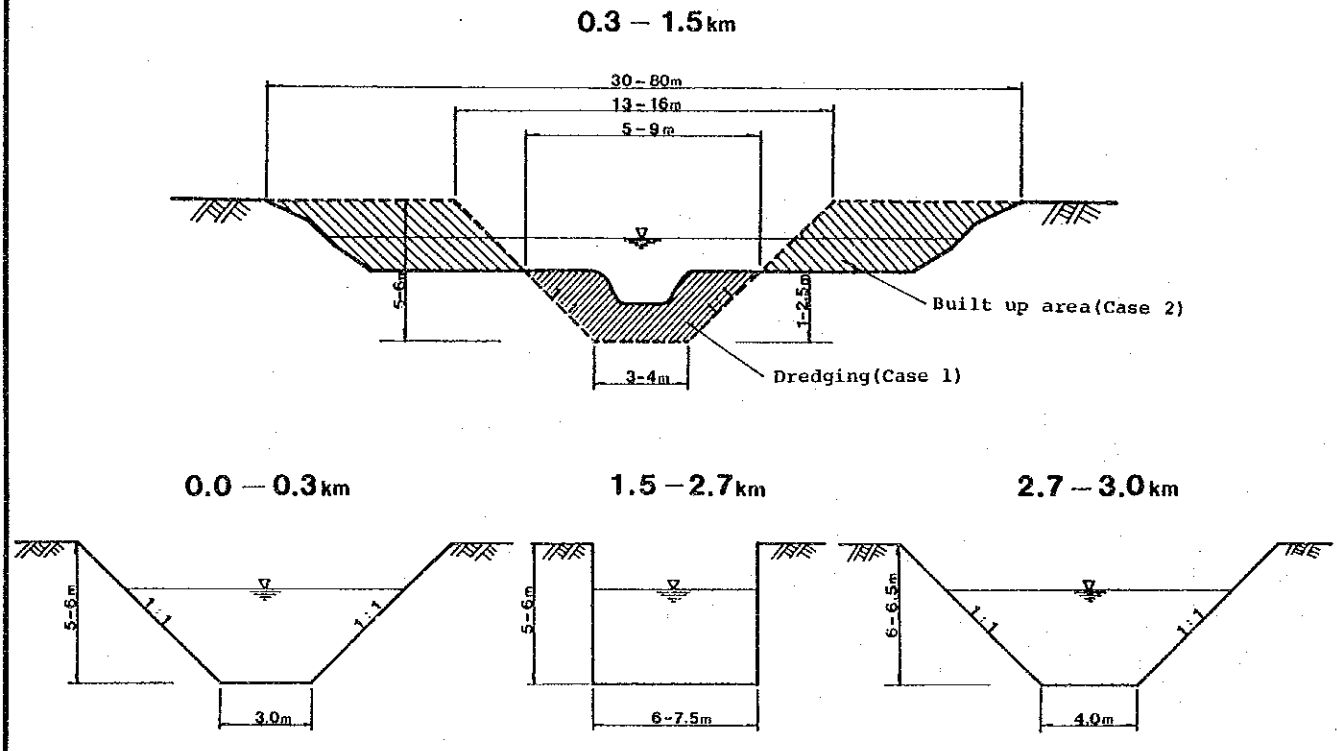


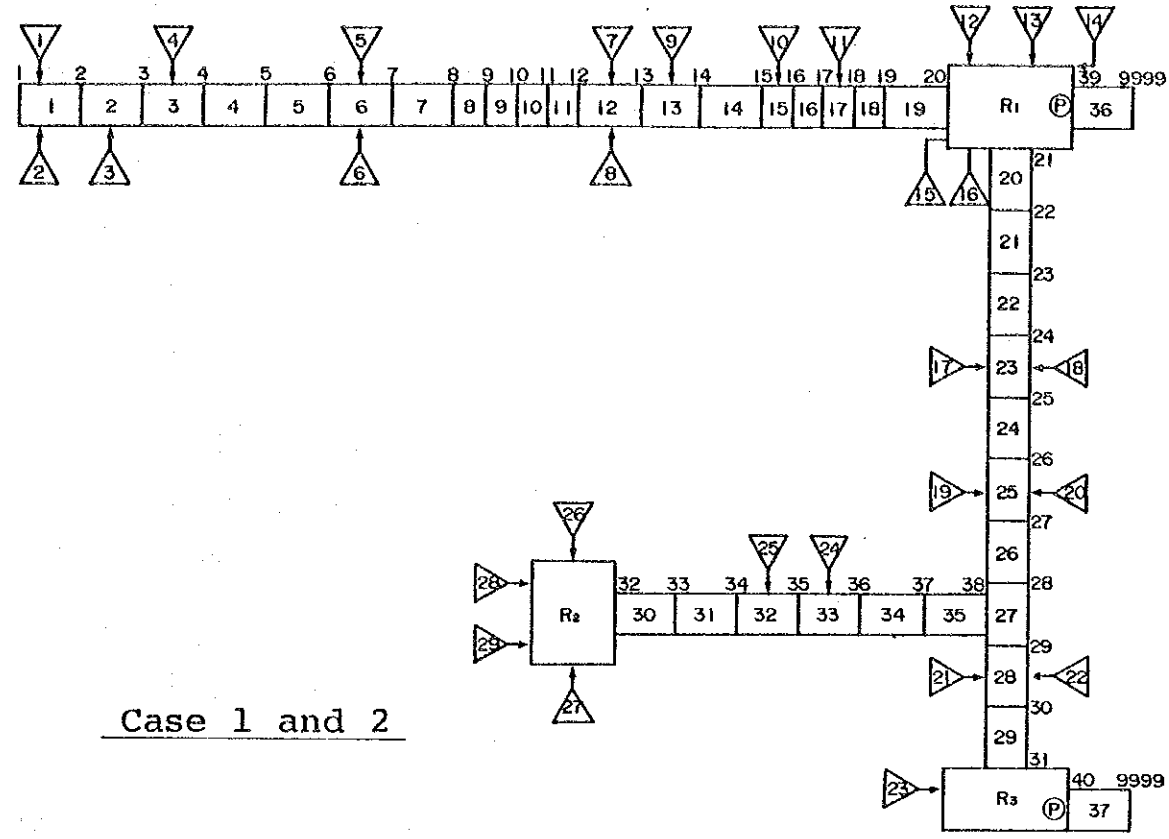
Profile of Water Level of Segunbagicha Khal



Typical Cross Section of Case 1,2

FIG. I.28	HYDRAULIC EFFECT DUE TO RECLAMATION OF LOWLAND ALONG SEGUNBAGICHA KHAL

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



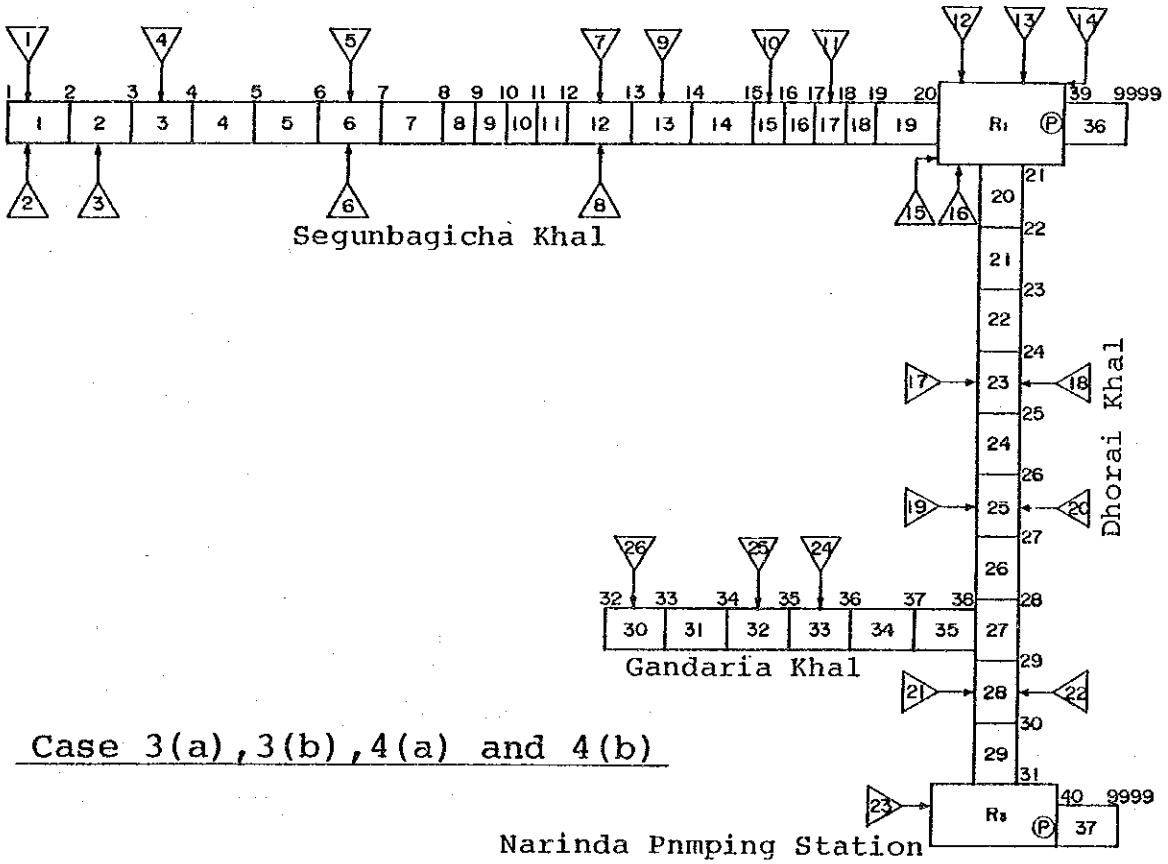
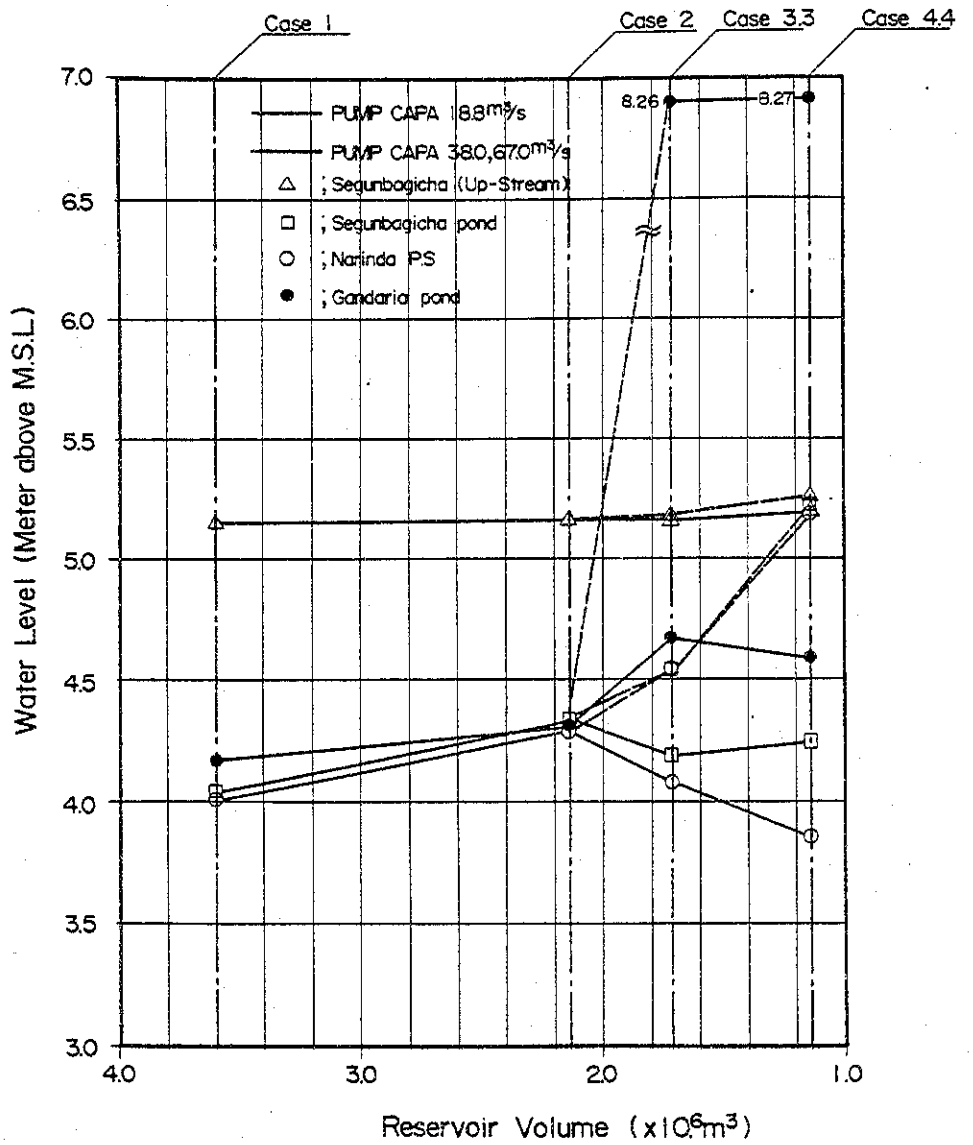


FIG. I.29 SIMULATION MODEL FOR SENSITIVE ANALYSIS

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



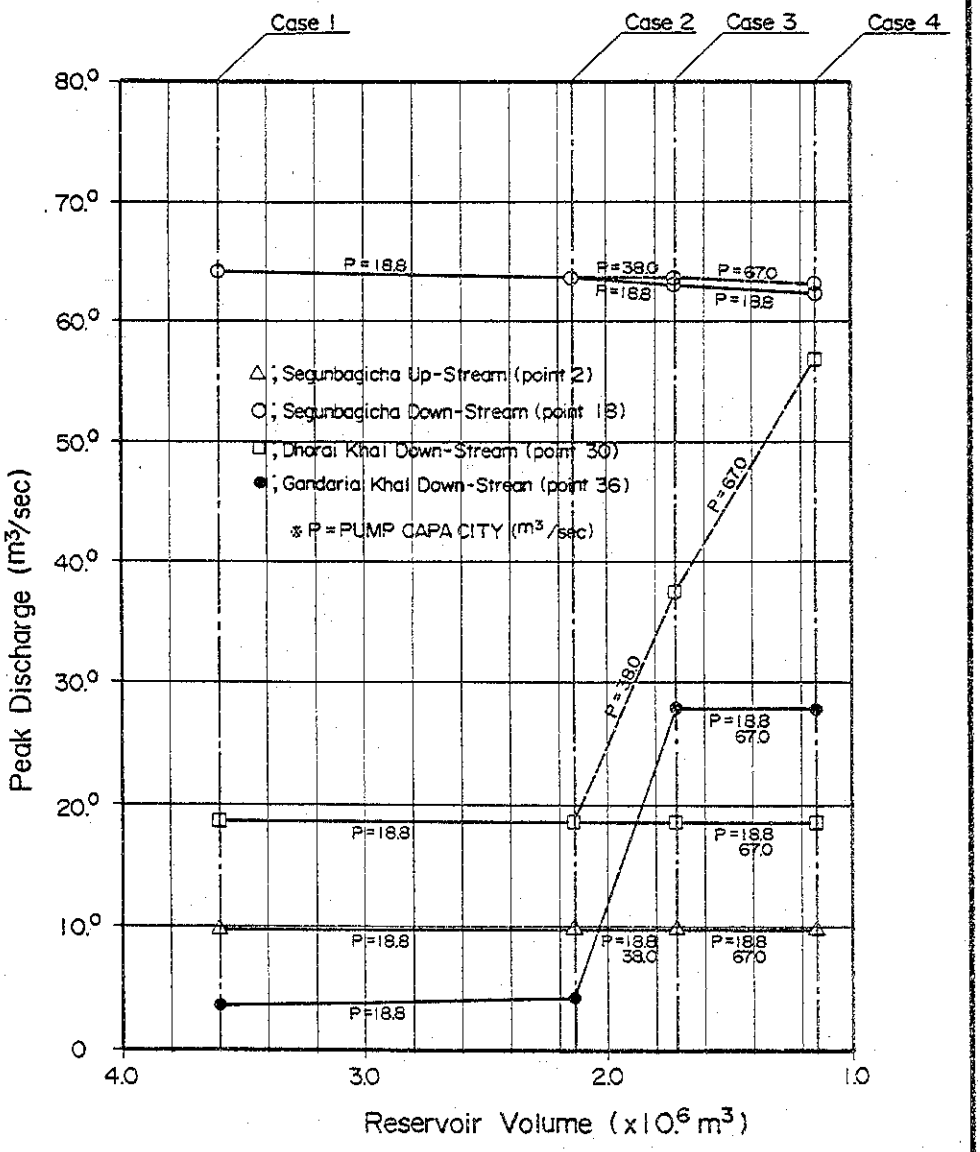


FIG. I.30 HYDRAULIC EFFECT DUE TO RECLAMATION OF LOWLAND AROUND REGULATING PONDS

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

JICA 1987 A.D

SUPPORTING REPORT J

PRELIMINARY DESIGN OF DRAINAGE FACILITIES

SUPPORTING REPORT J PRELIMINARY DESIGN OF DRAINAGE FACILITIES

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SUPPORTING REPORT J PRELIMINARY DESIGN OF DRAINAGE FACILITIES

1. Introduction

Two(2) types of work are proposed to alleviate the flood problems experienced in Dhaka: flood protection work and internal drainage improvement work.

The flood protection work consists of construction of the dikes and control gates. The internal drainage improvement works are composed of rehabilitation of the existing pump station, installation of additional pump stations, khal improvements and construction of trunk drainage pipes.

The khal improvement works include dredging, sodding, brick protection, and construction of retaining walls, bridges, and box culverts.

The trunk drainage pipes consist of brick drain pipes and box culverts.

The proposed works are summarized in Table J.1. The locations of the proposed facilities are illustrated in Fig. J.1.

2. Flood Protection Dike

The 4.8 km of flood protection dikes is proposed along the eastern and northern boundaries of the Segunbagicha Khal drainage zone (C zone). The alignment runs northward along the Deb Dholai Khal from the Dhaka-Demura Road to Manda and then turns westward until it reaches the Bangladesh Railway (See Fig. J.2).

The area is not urbanized and used for rice fields and remains swampy.

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

The Longitudinal section of the proposed dike is illustrated in Fig. J.2.

The following three(3) typical types are considered as structural alternatives for the dike (See Fig. J.3):

Alternative-1: Embankment type with sodding protection
Alternative-2: Embankment type with brick protection
Alternative-3: Double concrete wall type

After comparison, Alternative-1 is recommended in terms of structural reliability, construction cost, operation and maintenance, required land acquisition area, and procurement of construction materials. Construction cost including land acquisition of Alternative-1 is 1/1.2 of Alternative-2 and 1/2.5 of Alternative-3.

The typical design of the dike is illustrated in Fig. J.4. Side slope of 1:2 is proposed for stability of the embankment. Grassing is provided to avoid erosion of the slope.

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

The embankment materials are obtained by dredging the inside areas along the dike. The borrow pits are used as channels for drainage, irrigation, and other water uses (See Fig. J.4).

3. Gate

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

The proposed structural type and dimensions of the gates are shown in Table J.2.

Main features considered are as follows:

(1) Of the types of gates considered (roller, slide, flap, miter, and rubber) the use of the roller gate is proposed taking into account its ease of operation and maintenance. For the lift, the pin-jack type is recommended.

(2) Bearing capacity of the subsoils in the Project area is assumed to be 8-10 tons/m2 (Refer to 2.1). Since the gate structure has a unit load per square meters of 10-15 tons/m2, it is supported by pile foundation. The bearing piles shall be driven to the fine sand layer, having more than 30 of N-value, at about 20 m below ground surface.

(3) To protect the gate structure from seepage, a cutoff wall made of steel sheet piles will be provided beneath and at the sides of the gate.

The typical design of the gate are illustrated in Fig. J.5.

4. Pump Station

The proposed works are rehabilitation of the existing Narinda pump station with a 9.6 m3/S capacity, and the installation of the additional Narinda pump station with a 9.2 m3/S capacity.

The basic hydraulic requirements of both pump stations are shown in Table J.3.

The pump stations are designed to meet the above-mentioned hydraulic requirements.

The main features of the proposed rehabilitation and additional installation of the pump stations are shown in Table J.4.

The locations and layouts of the existing and new pump stations are illustrated in Fig. J.6 to Fig. J.7.

4.1 Rehabilitation of Existing Pump Station

The existing Narinda pump station suffers from the following problems as described in Supporting Report E.

(1) Overloading of the pump shaft's horsepower rating created by operations requiring large pump-up heads exceeding that for which it was designed.

(2) Hydraulic head loss generated by trash collected at the screen.

(3) Difficulty in procurement of spare parts for the motors.

(4) Lack of pump supporting parts: bolts, nuts, base plates, etc.

(5) Damaged gate
(The existing gates are to be demolished after completion of the proposed additional pump station).

(6) Shortage in the capacity of electric equipment.
(This problem may have been solved since some electric equipment were replaced by DPHE in late 1986).

A rehabilitation plan, taking into consideration of the following two(2) steps, is proposed in order to solve the above-mentioned problems.

Step 1:

(1) Reconstruction of discharge pipes
The requirement of the maximum pump-up head is attributed to the high elevation of the top point (8.699 m G.T.S.) and outlet point (6.600 m G.T.S.) of the existing discharge pipes (See Fig. J.8). No siphonage is available in this discharge system.

The existing outlets of the discharge pipes are extended downward to reduce the required pump-up head by siphonage.

(2) Installation of Automatic Trash Rankes

Automatic trash rakes [Four (4) sets] are to be installed for quick removal of collected garbage (See Fig. J.8).

Setp 2:

The existing pumps are to be replaced with new ones in order to obtain higher pump efficiency. The replacement is expected when the life of the existing pump is at its end.
The existing motors are to be replaced to meet the specifications of the replaced pumps.

4.2 Additional Pump Station (New Narinda Pump Station)

(1) Pump Type

Based on the conditions of the total pump head of approx. 3.8 m and a total flow of 9.2 m^3/S, the following three(3) alternatives are considered:

Alternative 1: Vertical axial flow pump
Alternative 2: Horizontal mixed flow pump
Alternative 3: Submersible motor pump

Alternative 1: The vertical axial flow pump is proposed through comparison of the advantages and disadvantages of each pump type described below:

Alternative 1: Vertical axial flow pump

Advantage:
- It can be operated at high reliability over a wide range of flows with easy operation and maintenance.

Disadvantage:

- Compared to the horizontal mixed flow type, this type saves about 10% in costs for mechanical equipment, but requires additional costs for civil works. As a result, the total construction cost is larger.

Alternative 2: Horizontal mixed flow pump

Advantage:

- Dismantling of the pump for inspection and repair is simple.
- Only a small vertical clearance is required inside the pump house for dismantiling and removing the pump.

- Total construction cost, including costs for equipment and civil works, is less than for vertical axial flow type.

Disadvantage:

- There are many pre-operation requirements to be dealt with, prior to start of pump operation. These are:

  (a) To start vacuum pump
  (b) To confirm full supply of water in intake casing
  (c) To switch on main pump
  (d) To start discharge valve opening
  (e) Full opening of discharge valve
  (f) To stop vaccum pump operation

  Due to these complicated pre-operational requirements, operation reliability of this type is lower than for that of the vertical axial flow type.
- A more detailed inspection of the many pieces of auxiliary equipment is required as compared to the vertical axial flow type.

Alternative 3: Submersible motor pump

Advantage:

- Total construction cost is lower: approximately half of the costs of the other two(2) alternatives.

Disadvantage:

- Life is very short: assumed to be 5-7 years, approximately one-third of the other two(2) Alternatives.
- Frequent maintenance work is required.

(2) Number of Pump Units

In view of operational trouble of the pumps, one pump station is usually provided with three(3) to five(5) pump units. Provision of a large number of pump units will lower the risk of pump operation trouble and reduce the operating period of each pump unit. On the other hand, installation of a small number of pump units will lower the construction cost.

The provision of four(4) pump units is proposed through a comparative study of the use of three(3) to five(5) pump units.

(3) Power Source of Pump Operation

As alternatives for the pump power source, the electrical motor driven type and the diesel engine driven type were studied. Comparing the two types, the electrical motor driven type was adopted taking into account its ease of operation and maintenance and the availability of electricity in Dhaka. A backup electric power source will be provided to handle such emergencies as power failures.

(4) Other Equipment

Other equipment, including travelling overhead crane, facilities for minor in-station repairs, water level recorder, and automatic trash rakes are to be provided.

(5) Civil Works

Bearing capacity of the subsoils in the site is assumed to be 8-10 tons/m^2.
Pile foundation is required to support the pump facilities.
The piles shall be driven to the sand bearing layer, about 20 m below ground surface.
Cutoff wall is to be provided against seepage.

5. Khal Improvement

The proposed typical cross sections of the khal improvement are:

- Trapezoidal shape with 1:1.5-1:2.0 slope protected by sodding
- Trapezoidal shape with 1:1 slope protected by brick

The proposed khal improvement works consist of dredging, sodding protection, brick protection, construction of retaining walls, bridges, and box culverts and are summarized in Table J.5.

(1) Cross Section Type and Protection Works

Trapezoidal Shape is applied for the khal sections where comparatively easy land acquisition is expected. A slope of 1:1.5-1:2.0 is provided with sodding protection and slope of 1:1 is protected by brick.

Selection of the slope types is made based on land acquisition conditions.

Typical sections are illustrated in Fig. J.9.

A rectangular shape is proposed for the khal sections where land acquisition is difficult. The rectangular shape is supported by retaining walls.

Of the alternative retaining walls (concrete panel wall type, sheet pile wall type, and gravity type) as shown in Fig. J.9, the concrete panel wall type with bracing beam (B-2 type) is recommended, comparing construction costs, stability and reliability of structures and requirements for land acquisition.

The typical section of the proposed retaining wall is as illustrated in Fig. J.10.

(2) Box Culvert and Bridge

Reconstruction of existing box culverts and bridge is proposed for the crossing sections of the roads and railway. The proposed box culverts are made of reinforced concrete. A girder type bridge is proposed when reconstructing the existing railway bridge because of the necessity to perform first and safe construction under conditions requiring the frequent passing of trains.

The typical designs of the proposed box culverts and bridge are as illustrated in Fig. J.11 and Fig. J.12.

(3) Fence

Guard fences are provided for both banks of the khals in the developed areas for protection against garbage dumping and encroachment by squatters.

6. Drainage Pipe

The existing structural types of drainage pipe employed by DPHE are as shown in Table J.6.

Structural damages to the existing drainage pipes have been rarely reported in the past. Bricks can be sufficiently supplied at low cost. Moreover, many skilled masons are available for this work.

Considering the above, it is recommended that brick type pipes with diameters of 1.5 - 3.7 m be used.

For drainage pipes having diameters of more than 3.0 meters and are being used under heavy load conditions, the reinforced concrete box culvert type is recommended. Under light load conditions, the brick type, having four (4) layers of arched brick, are to be used.

The proposed types of drainage pipe structure are shown in Table J.7.

The typical design of the proposed drains are illustrated in Fig. J.11.

The proposed drainage pipe work is shown in Table J.8.

Table J.1 Summary of Proposed Works

Item	Description	Unit	Zone			Total	Remarks
			B	C	F		
A. Dike	H = 6.0 m	m		4800		4800	
B. Pump station	9.2 & 9.6 m3/s	place (m3/s)	2 18.8			18.8	Rehabilitation and New
C. Gate	6.0 m x 6.0 m	place	1	1		2	
D. Khal Improvement Works		m	4200	5100	3800	13100	
1. Dredging		1000 m3	106.9	154.6	33.7	295.2	
2. Sodding		1000 m2	54	25	53	132	
3. Brick Protection		m	400	1180	700	2280	
4. Retaining Wall	Concrete Panel	m		480	280	760	
5. Box Culvert	B 4-7 m x H 4-6 m	m	25 (1 place)	192 (12 places)	147 (8 places)	364 (21 places)	
6. Railway Bridge	L = 12 m X 3	place		1		1	
E. Drainage Pipe		m	4280	4810	3410	12500	
1. Brick Pipe	D=1.5 - 3.7 m	m	2050	4110	3410	9570	
2. Box Culvert	av. 3 m x 3 m	m	2230	700		2930	

Table J.2 Main Features of Gate

Location	No. of Gate Leaf	Width x Height of Gate Leaf	Type	Remarks
Narinda	1	6 m x 6 m	Roller Gate	At Pump Station
Rajarbagh	1	6 m x 6 m	Roller Gate	

Table J.3 Basic Hydraulic Requirements of Pump Station

Item	Additional Pump Station	Existing Pump Station to be Rehabilitated	Remarks
Pump capacity	9.2 m3/s	9.6 m3/s	
L.W.L (Inner Side)	+3.2 m	+3.2 m	
H.W.L (Inner Side)	+4.5 m	+4.5 m	
H.W.L (Outer Side)	+5.4 m	+5.4 m	2-year Frequency
H.W.L (Outer Side)	+6.6 m	+6.6 m	30-year Frequency
Design Total Head	≈ 3.8 m	-	

Table J.4 Main Features of Rehabilitation and Additional Installation of Pump Stations

Item	Rehabilitation of Existing P.S.	Additional Installation of P.S.	Remarks
A. Main Pump			
1. Total Capacity	9.6 m3/s	9.2 m3/s	
2. Type	Vertical Axial Flow Pump	Vertical Axial Flow Pump	
3. Diameter	Ø 1,000 mm	Ø 1,000 mm	
4. Capacity x Unit	2.4 m3/s x 4 sets	2.3 m3/s x 4 sets	
B. Main Electric Motor	140 kw x 4 sets	132 kw x 4 sets	
C. Electric Panel	*	11 sets	
D. Automatic Trash Rake	4 sets	4 sets	
E. Overhead Crane	*	1 set	
F. Other Auxiliary Equip.	1 set	1 set	

Note: Items shown with * are utilizing the existing equipment.

Table J.5 (a) KHAL IMPROVEMENT WORKS (1) --- PROTECTION / DREDGING

Khal	Section No.	Section Length m	Improvement Length, Section Shape & Protection Type				Khal Dredging m3	Land Acquisition m2
			Trapezoidal (Non-Protection) m	Trapezoidal (Sodding) m	Trapezoidal (Brick) m	Rectagular (Retaining Wall) m		
K-1 DHOLAI	1	1,000	1,000	-	-	-	12,600	-
	2	500	-	500	-	-	10,400	-
	3	200	-	200	-	-	4,200	-
	4	400	-	400	-	-	11,800	4,810
	5	200	-	200	-	-	6,400	3,800
	6	200	-	200	-	-	9,800	4,200
	7	500	-	500	-	-	25,000	11,000
	SUBTOTAL	3,000	1,000	2,000	0	0	80,200	23,810
K-2 GANDARIA		1,200	-	800	400	-	27,000	10,800
	SUBTOTAL	1,200	0	800	400	0	27,000	10,800
K-3 GERANI	1	1,400	1,000	400	-	-	56,600	20,000
	2	700	400	300	-	-	16,900	5,040
	SUBTOTAL	2,100	1,400	700	0	0	73,500	25,040
K-4 SEGUNBAGICHA	1	500	300	200	-	-	12,600	2,600
	2	600	300	300	-	-	11,900	2,550
	3	400	-	-	400	-	11,000	3,040
	4	200	-	-	100	100	5,200	1,265
	5	600	-	-	300	300	16,800	3,570
	6	400	-	-	200	200	8,000	1,850
	7	300	-	100	200	-	8,000	3,300
	SUBTOTAL	3,000	600	600	1,200	600	73,500	18,175
K-5 BEGUNBARI	1	1,270	1,270	-	-	-	3,200	21,060
	2	350	-	350	-	-	1,800	4,800
	3	1,180	-	1,180	-	-	8,500	17,110
	SUBTOTAL	2,800	1,270	1,530	0	0	13,500	42,970
K-6 PARIBAGH		1,000	-	-	700	300	24,600	4,830
	SUBTOTAL	1,000	0	0	700	300	24,600	4,830
TOTAL		13,100	4,270	5,630	2,300	900	292,300	125,625

Table J.5 (b) KHAL IMPROVEMENT WORKS (2) --- BRIDGES / BOX CULVERTS

Khal	No.	Existing		Required	Proposed			Remarks
		(Type)	(Size)* m x m	(Size)* m x m	(Type)	(Size)* m x m	(Length) m	
DHOLAI		Bridge	36.0 x 9.0	-	-	-	-	Utilizing Exist.
		do.	18.0 x 8.0	-	-	-	-	Utilizing Exist.
		Box Culvert	16.0 x 7.0	16.0 x 5.0	-	-	-	Utilizing Exist.
		Railway Bridge	39.0 x 7.0	16.0 x 5.0	-	-	-	Utilizing Exist.
		do.	45.0 x 8.0	15.0 x 5.0	-	-	-	Utilizing Exist.
	B-1	Box Culvert	10.0 x 6.0	15.0 x 5.0	Box Culvert	7.5 x 5.0 X 2	25.0	Reconstruction
GERANI		Box Culvert	6.0 x 5.0	6.0 x 5.0	-	-	-	
SEGUNBAGICHA	B-2	Box Culvert	9.5 x 5.5	12.0 x 5.0	Box Culvert	6.0 x 5.0 x 2	17.0	Reconstruction
	B-3	do.	5.5 x 4.0	12.0 x 5.0	Bridge	12.0 x 5.0	19.0	do. (Railway)
	B-4	do.	9.5 x 3.0	10.0 x 4.5	Box Culvert	5.0 x 4.5 x 2	15.0	Reconstruction
	B-5	do.	10.5 x 4.0	10.0 x 4.5	Box Culvert	5.0 x 4.5 x 2	17.0	Reconstruction
	B-6	Pipe	3.0	9.0 x 4.5	Box Culvert	4.5 x 4.5 x 2	7.0	Reconstruction
	B-7	Box Culvert	4.0 x 4.0	7.5 x 4.5	Box Culvert	4.5 x 4.5 x 2	9.0	Reconstruction
	B-8	do.	4.0 x 3.0	7.5 x 4.5	Box Culvert	7.5 x 4.5	11.0	Reconstruction
	B-9	Pipe	1.6	7.0 x 4.5	Box Culvert	7.0 x 4.5	37.0	Reconstruction
	B-10	Box Culvert	2.5 x 1.5	7.0 x 4.5	Box Culvert	7.0 x 4.5	11.0	Reconstruction
	B-11	do.	3.0 x 2.5	7.0 x 4.5	Box Culvert	7.0 x 4.5	10.0	Reconstruction
	B-12	Pipe	0.8 x 2	6.0 x 4.5	Box Culvert	6.0 x 4.5	36.0	Reconstruction
	B-13	Box Culvert	3.0 x 1.0	6.0 x 4.0	Box Culvert	6.0 x 4.0	12.0	Reconstruction
	B-14	do.	1.5 x 2.0	6.0 x 4.0	Box Culvert	6.0 x 4.0	10.0	Reconstruction
BEGUNBARI	B-15	Box Culvert	5.7 x 5.6	13.0 x 6.0	Box Culvert	7.0 x 6.0	25.0	Additional
	B-16	do.	6.8 x 5.8	13.0 x 6.0	Box Culvert	7.0 x 6.0	14.0	Additional
	B-17	do.	6.1 x 5.5	13.0 x 6.0	Box Culvert	7.0 x 6.0	30.0	Additional
		do.	6.0 x 4.3 x 2	12.0 x 5.0	-	-	-	Utilizing Exist.
	B-18	do.	6.0 x 3.5	7.0 x 4.5	Box Culvert	7.0 x 4.5	24.0	Reconstruction
	B-19	do.	6.8 x 2.5	-	-	-	-	Regulation Weir
PARIBAGH	B-20	Box Culvert	2.8 x 3.5	6.0 x 4.0	Box Culvert	6.0 x 4.0	11.0	Reconstruction
	B-21	do.	2.6 x 3.4	6.0 x 4.0	Box Culvert	6.0 x 4.0	13.0	Reconstruction
	B-20	Pipe	1.5	3.7 x 3.7	Box Culvert	3.7 x 3.7	30.0	Reconstruction
						Total Length	383.0	m
						Box Culvert	[364.0]	
						Bridge	[19.0]	

Note : (Size)* = Width x Height x Units

Table J.6 Existing Structural Types of Drainage Pipe (by DPHE)

Structure Type	Diameter (m)	Condition	Remarks
(1) Reinforced concrete pipe	0.30 - 0.76	Under Road	
(2) Brick pipe with 2 layers	1.06 - 1.50	Under Road	
(3) Brick pipe with 3 layers	1.67 - 3.00	Under Road	

Table J.7 Proposed Structural Types of Drainage Pipe

Structure Type	Diameter (m)	Condition	Remarks
(1) Brick pipe with 3 layers	$D \leq 3$ m	Under High Load	
(2) Brick pipe with 4 layers	$3 \text{ m} < D < 4 \text{ m}$	Under Light Load	
(3) Box culvert	$3 \text{ m} < D$	Under High Load	

Table J.8 Drainage Pipes (Brick Pipe & Box Culvert)

Route	Section No.	Length m	Existing Size(Dia.) m	Proposed Drains Type	Proposed Drains Size m	Remarks
D-1 NARINDA(Main)	1	100	3.0	R.C. Box Culvert	3.1	Additional Construction
	2	650	3.0	R.C. Box Culvert	2.9	Additional Construction
	3	450	3.0	Brick Pipe	2.8	Additional Construction
	4	350	2.7	Brick Pipe	2.6	Additional Construction
	5	750	-	Brick Pipe	1.9	
(Branch)	6	500	-	Brick Pipe	2.2	
	Subtotal	2,800				
D-2 NARINDA(Diversion)		1,480	-	R.C. Box Culvert	2.2 x 2.86	
	Subtotal	1,480				
D-3 Old Railway Rd. & Old Govt. House Rd.	1	700	-	R.C. Box Culvert	2.6 x 3.0	
	2	650	-	Brick Pipe	3.0	
	3	650	-	Brick Pipe	2.3	
	4	500	-	Brick Pipe	1.9	
	Subtotal	2,500				
D-4 Circular Rd.		540	1.5	Brick Pipe	1.5	Additional Construction
	Subtotal	540				
D-5 DIT Av.	1	480	-	Brick Pipe	2.7	
	2	240	-	Brick Pipe	1.9	
	Subtotal	720				
D-6 SANTINAGAR	1	530	1.2	Brick Pipe	2.7	Additional Construction
	2	520	0.8	Brick Pipe	2.2	Additional Construction
	Subtotal	1,050				
D-7 NAYATARA	1	550	0.9	Brick Pipe	2.4	Reconstruction
	2	550	0.6	Brick Pipe	2.8	Reconstruction
	Subtotal	1,100				
D-8 DHANMANDI		450	-	Brick Pipe	1.8	
	Subtotal	450				
D-9 DHAKA Univ. (Main)	1	300	-	Brick Pipe	3.7	
	2	450	-	Brick Pipe	2.9	
	3	550	-	Brick Pipe	2.4	
	4	560	-	Brick Pipe	2.1	
(Branch)	Subtotal	1,860				
TOTAL		12,500				
	Brick Pipe	[9,570]				
	R.C. Box Culvert	[2,930]				

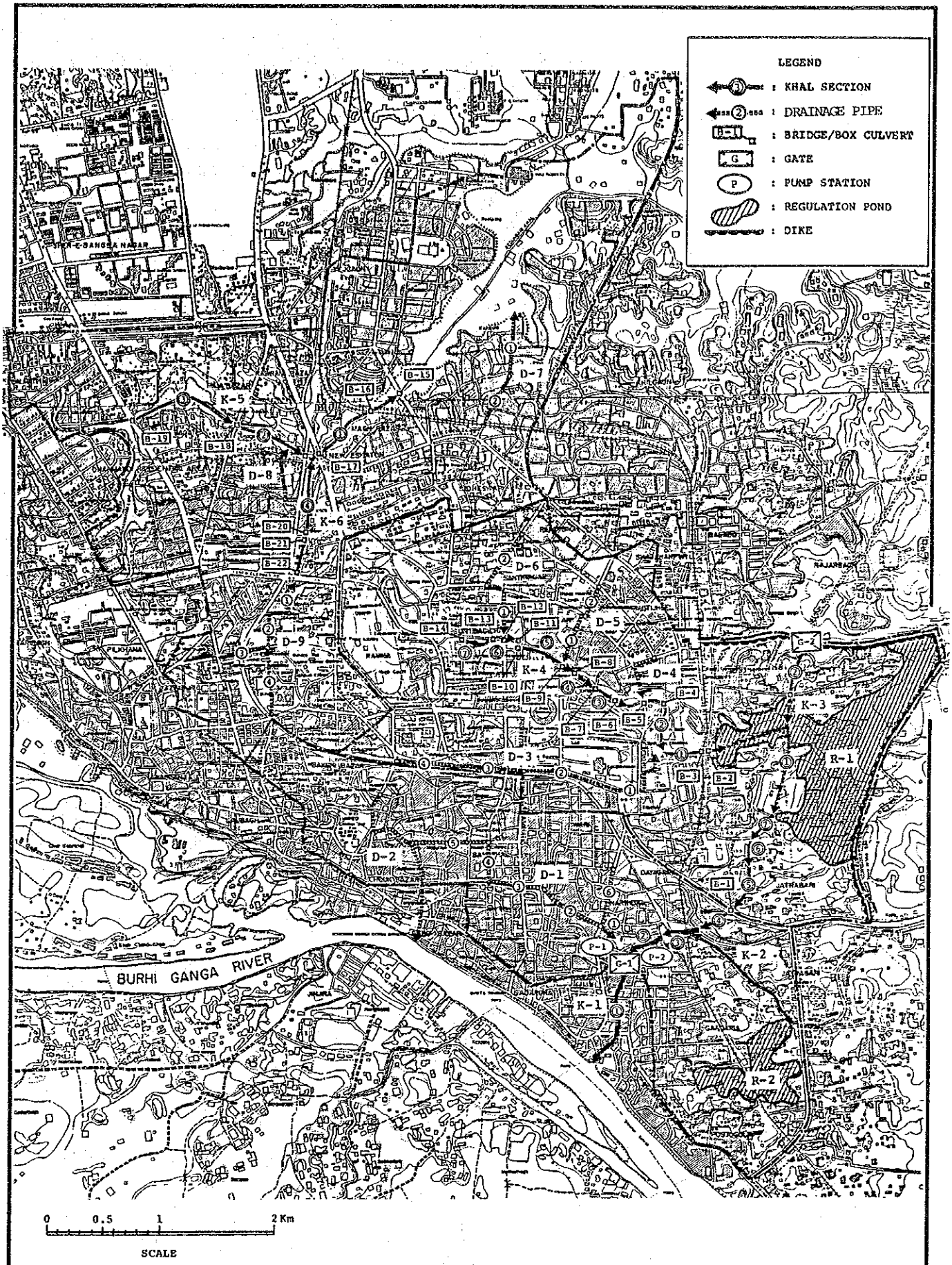
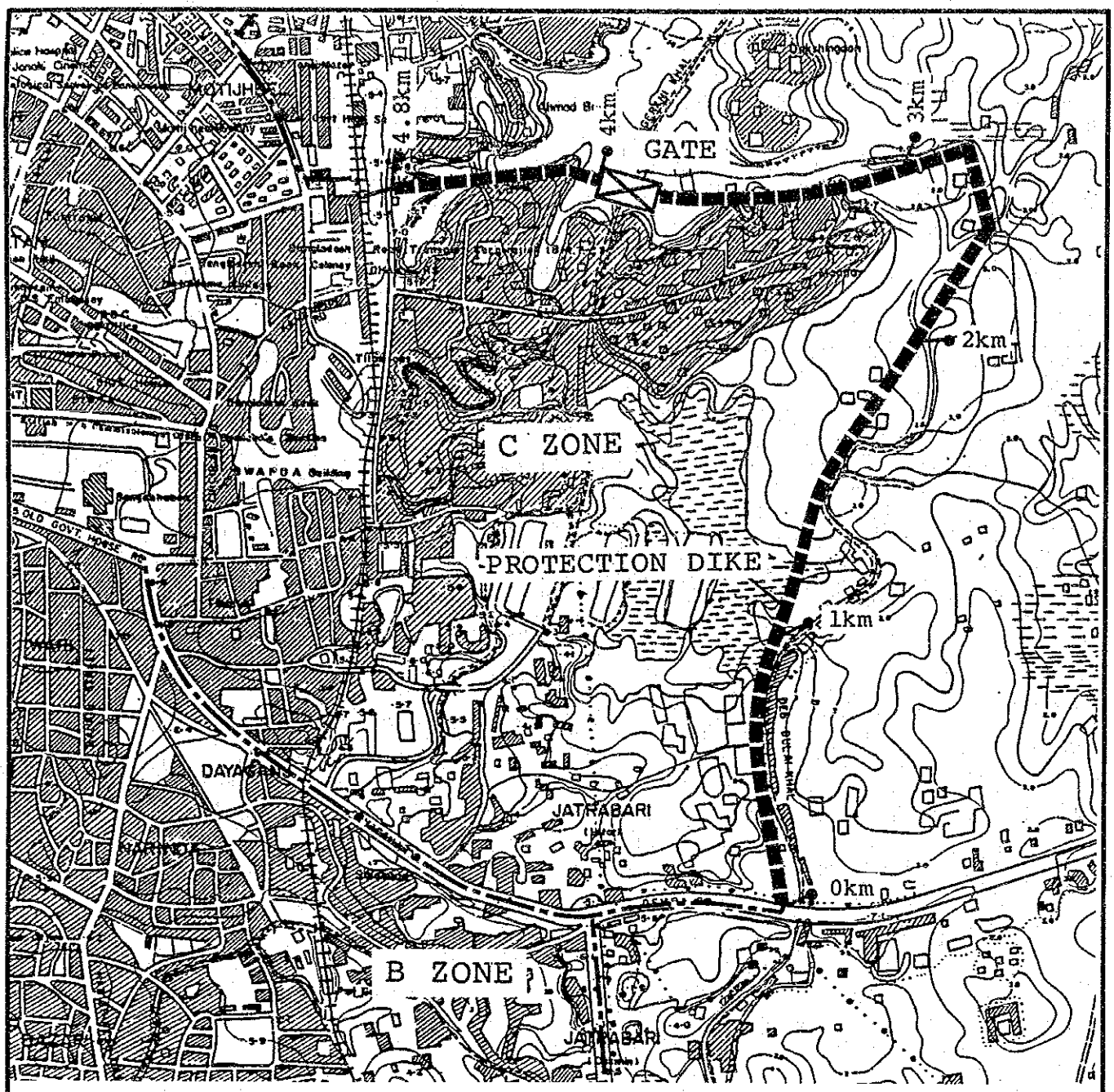
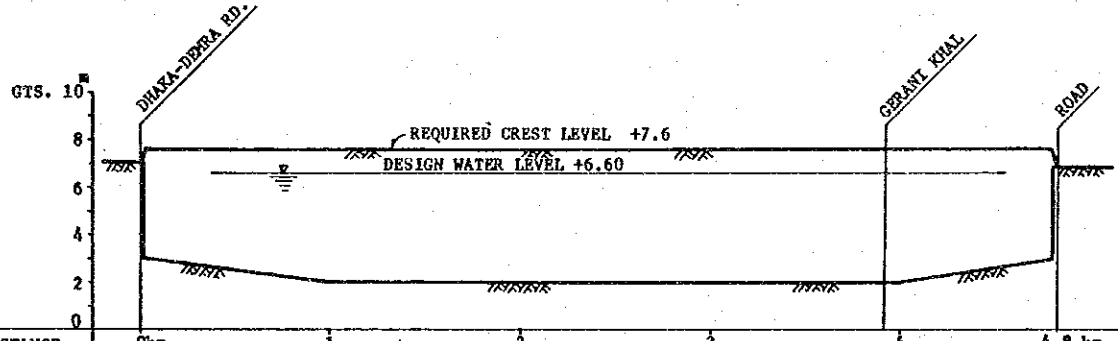


FIG. J.1 LOCATION OF PROPOSED FACILITIES

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





ACCUMLATED DISTANCE	0km	1	2	3	4	4.8 km
REQUIRED CREST LEVEL	+7.60m					
DESIGN WATER LEVEL	+6.60m					
GROUND LEVEL	3.0m 7.0	2.0m	2.0	2.0	2.0	3.0 m 6.8 m

FIG. J.2 DIKE ALIGNMENT

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

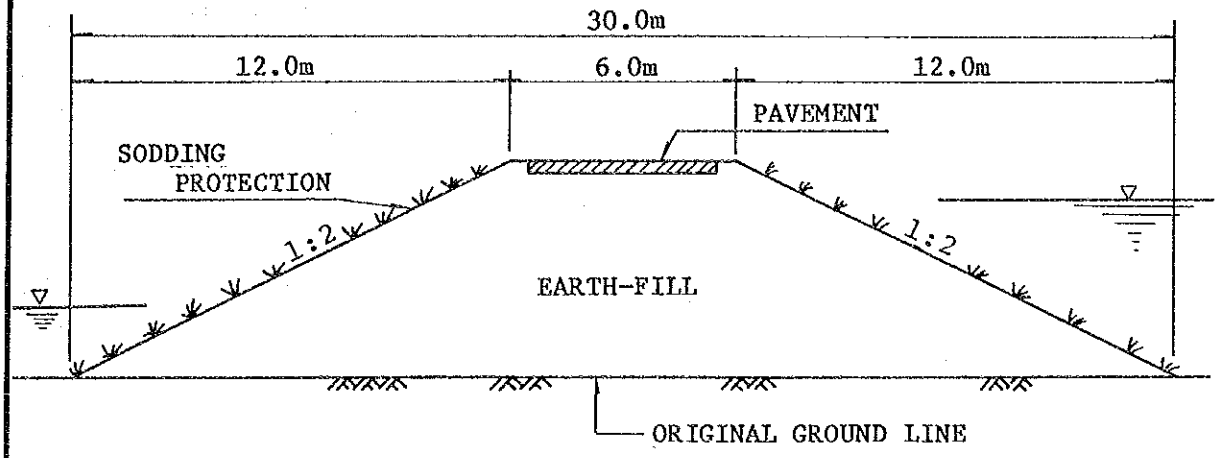
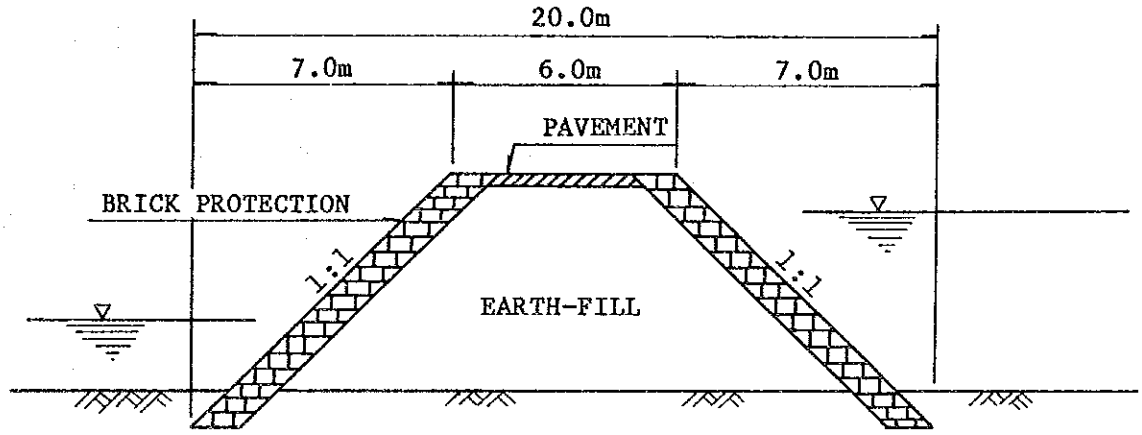
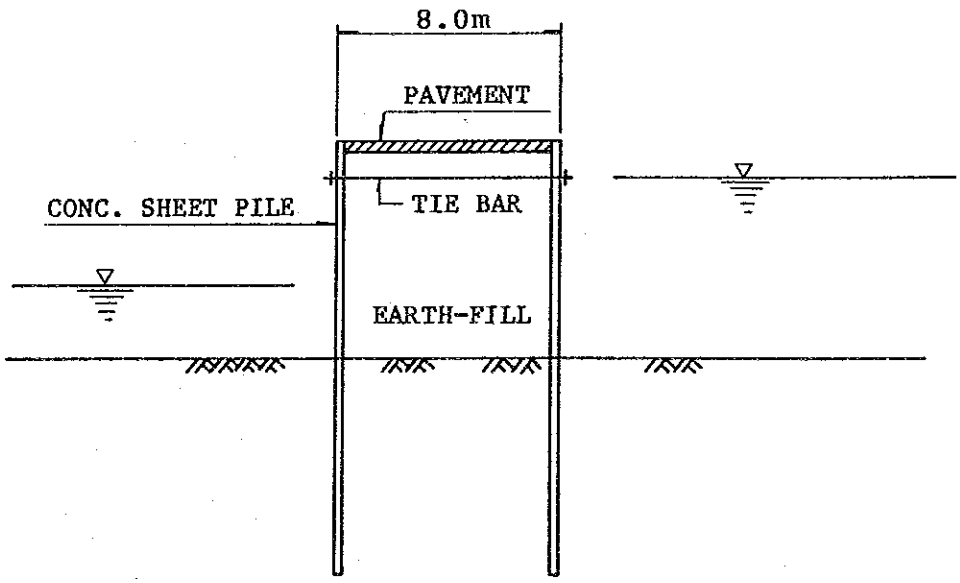
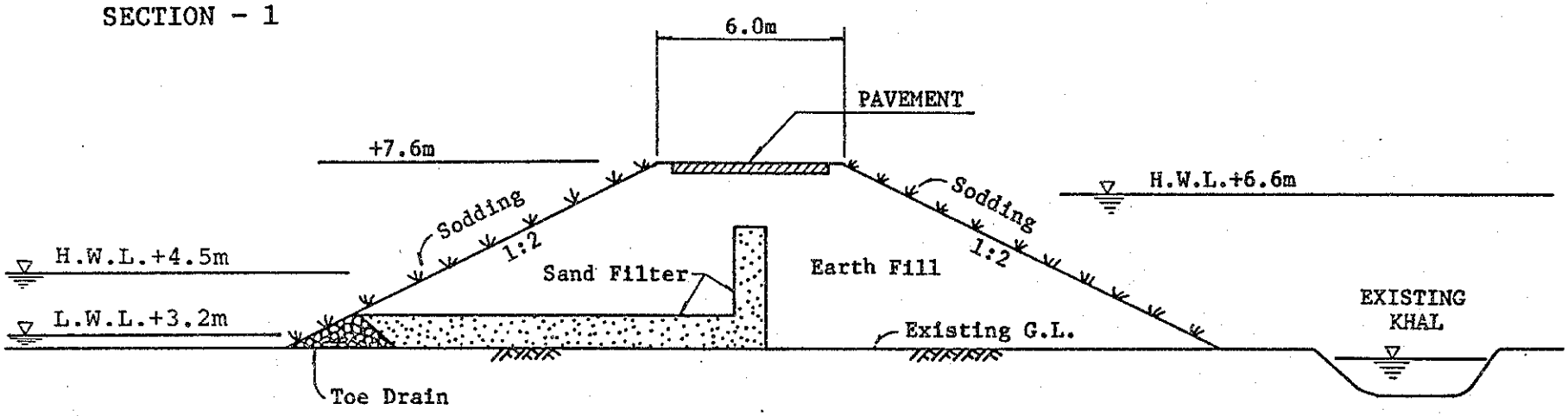
	COST RATIO
ALTERNATIVE-1, EMBANKMENT WITH SODDING PROTECTION  	(1.0) Recommended
ALTERNATIVE-2, EMBANKMENT TYPE WITH BRICK PROTECTION  	(1.2)
ALTERNATIVE-3, DOUBLE CONCRETE WALL TYPE  	(2.5)

FIG. J.3 ALTERNATIVES FOR STRUCTURAL TYPE OF DIKE

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

SECTION - 1



SECTION - 2

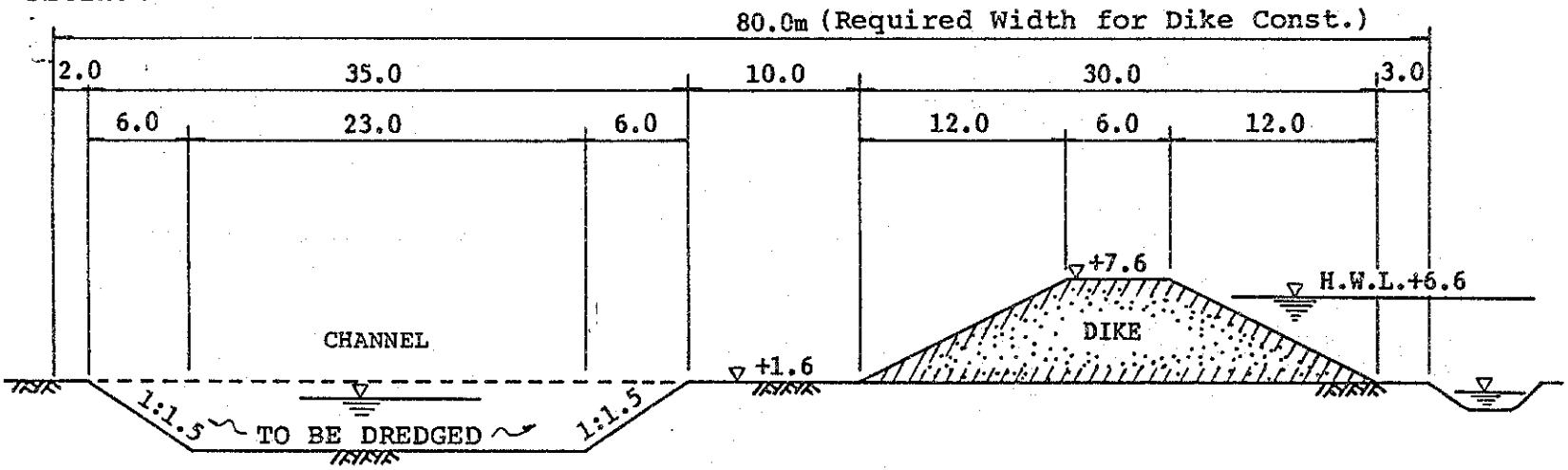
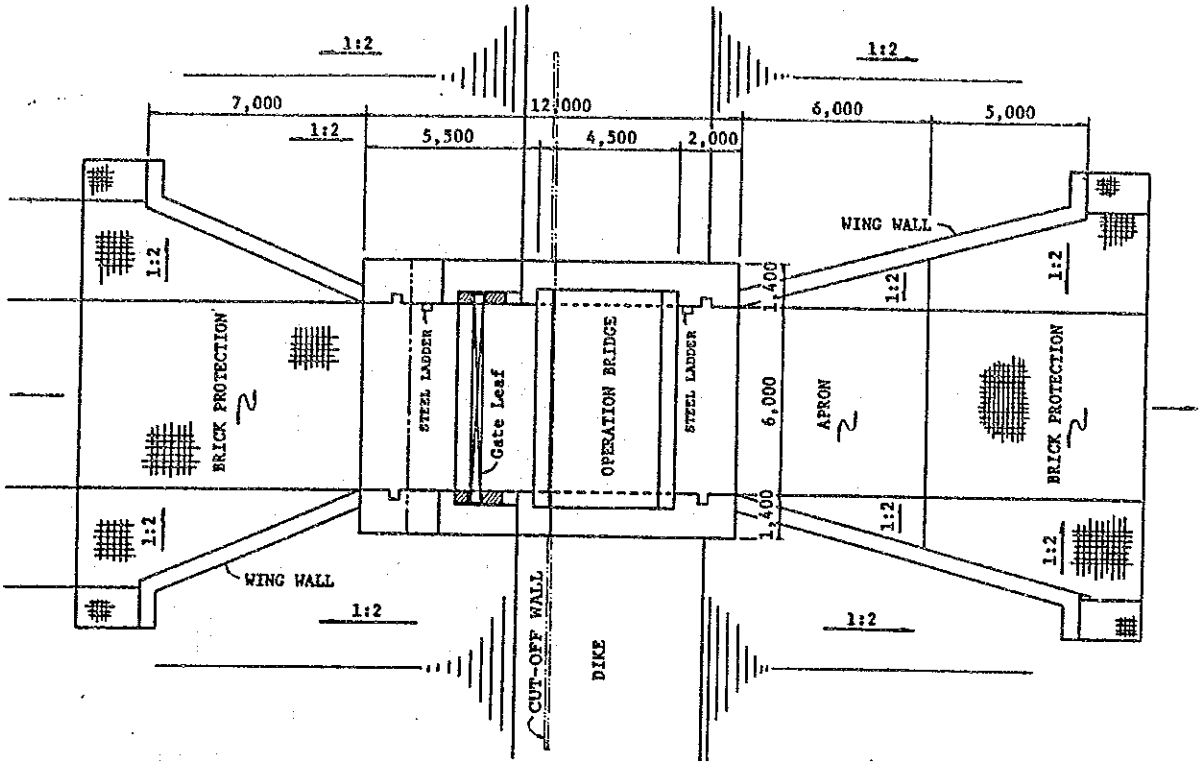


FIG. J.4 TYPICAL DESIGN OF DIKE

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



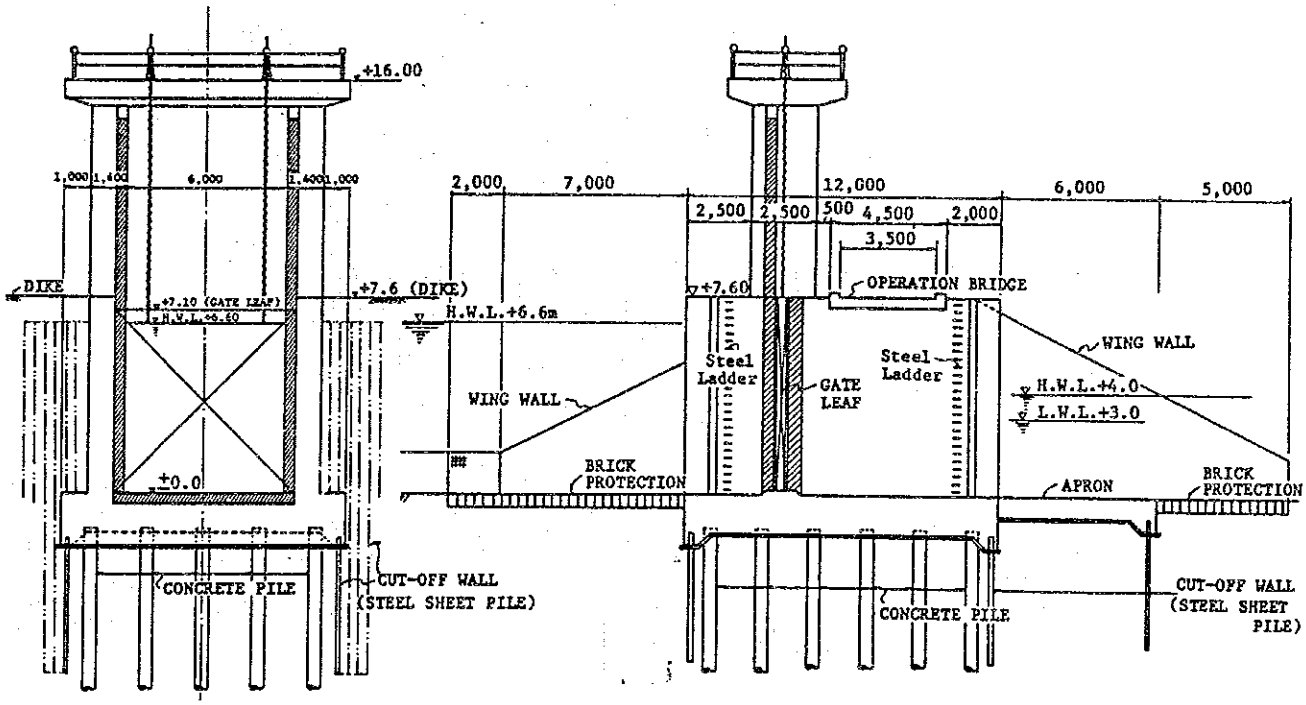


FIG. J.5 TYPICAL DESIGN OF GATE

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