C Pond 1.0 m x 1.0 m , ø 0.5 m

8.4.5 Bridges

Almost all the bridges crossing the Sg. Pinang and Sg. Keluang systems are to be reconstructed due to river improvement works by widening and deepening of river channel.

In the Sg. Pinang system, thirty five (35) bridges including 19 wooden bridges are to be reconstructed.

In the Sg. Keluang system, two (2) wooden bridges are to be reconstructed to R.C.T Girder bridges.

New one bridge is also to be constructed across the Relau Diversion Channel.

All the bridges to be reconstructed for urgent projects are summarized in Table 8-3.

Tables

TABLE 8-1 FEATURES OF PROPOSED RIVER IMPROVEMENT

RIVER IMPROVEMENT

Sg. Pinang System

		CHAINAGE	DISTANCE (m)	RIVER BED SLOPE	RIVER BED WIDTH (m)	WIDTH (m)	WATER DEPTH (m)	DESIGN DISCHARGE (m3/s)
Sg. Pinang	P1	– 0.71 to 0.4	1,110	1/2000	36.50	44.460 ~ 44.304	3.380 ~ 3.302	210
	P2	0.4 to 1.9	1,500	1/2000	36.50	44.304 ~ 40.295	3.302 ~ 3.195	210
	P3	1.9 to 3.1	1,250	1/950	23.00	40.295 ~ 30.400	3.195 ~ 3.100	195
Sg. Air Ilam	I1	0.0 to 1.1	1,100	1/800	18.20	25.4	3.0	160
	I2	1.1 to 3.0	1,900	1/800	16.40	23.6	3.0	145
Sg. Jelutong	J1	0.0 to 1.306	1,330	1/1070	4.70	4.7	2.5	20
	J2	1.306 to 2.015	820	1/1070	2.00	2.0	2.5	6
Sg. Dondang	D1	0.014 to 2.302	2,100	1/680	8.30	14.5	2.5	60
	D2	2.302 to 3.732	1,210	1/680	6.00	12.5	2.5	45
	D3	3.732 to 4.854	1,010	1/190	2.30	8.5	2.5	40

Sg. Keluang System

		CHAINAGE	DISTANCE (m)	RIVER BED SLOPE	RIVER BED WIDTH (m)	WIDTH (m)	WATER DEPTH (m)	DESIGN DISCHARGE (m3/s)
Sg. Keluang	K1	-0.2 to 1.540	1,740	1/1190	13.90	54.3	3	125
Sg. Ara	A1	1.540 to 2.200	660	1/1190	12.20	50.6	3	110
	A2	2.200 to 2.950	750	1/1190	3.80	26.2	2.5	40
	A3	2.950to 3.410	460	1/450	2.80	22.4	1.8	40
Sg. Relau	R2	2.410to 4.045	1,640	1/360	9.70	14.9	2.6	6

DIVERSION CHANNEL

AIR TERJUN DIVERSION CHANNEL

1	DIVERTING POINT	CH3093 of Sg. Air Terjun
2	CATCHMENT AREA OF DIVERTING POINT	7.74 km2
3	DIVERSION LENGTH	1740 m
4	CONFLUENCE POINT	CH160 of Sg. Babi
5	DISCHARGE CAPACITY	65 m3/S

CROSS SECTION

C1 : Open Channel 7.4 m (W) x 2.6 m (D) S=1/250

C2 : Box Culvert 6.3 m (W) x 2.76 m (H) S=1/200

C3 : Box Culvert 5.5 m (W) x 3.22 m (H) S=1/200

RELAU DIVERSION CHANNEL

1	DIVERTING POINT	CH2410 of Sg. Relau
2	CATCHMENT AREA OF DIVERTING POINT	10.5 km2
3	DIVERSION LENGTH	1530 m
4	CONFLUENCE POINT	CH2200 of Sg. Ara
5	DESIGN DISCHARGE	70 m3/S

CROSS SECTION

C1 : Open Channel 10.9 m (W) x 2.6 m (D) S=1/400

Table 8-2 CHARACTERISTICS OF DONDANG RETENTION PONDS

	Area (m2)	Ground Level (El. m)	Design High Water Level (El. m)	Design Pond Bed Level (El. m)	Water Depth (m)	Pond Depth (m)	Storage Volume (m3)	Inflow (m3/s)	Cut Q (m3/s)	Outflow (m3/s)
Pond A	30,500	21.50	20.28	17.26	3.02	4.24	79,013	40.627	9.500	31.127
Pond B	32,700	15.60	14.00	11.42	2.58	4.18	72,839	37.639	6.000	31.639
Pond C	21,200	13.50	11.47	8.73	2.74	4.77	46,410	43.399	4.500	38.899
Total	84,400						198,262		20.000	

TABLE 8-3-1 BRIDGES TO BE RECONSTRUCTED FOR URGENT PROJECT

Sg. Pinang

NO.	CHR. (m)	EXISTING LENGTH (m)	EXISTING WIDTH (m)	EXISTING AREA (sq.m)	EXISTING TYPE	EXISTING PIER NO.	PROPOSED LENGTH (m)	PROPOSED WIDTH (m)	PROPOSED AREA (sq.m)	PROPOSED TYPE	PROPOSED PIER NO.	REMARKS
1	405	33.0	10.0	330	STEEL TRUSS	0	47.0	10.0	470	R.C. T-GIDER	2	Jalan Jelutong
2	915	20.0	6 (1.5 x 0.9)	120	R.C.I-GIRDER	0	43.0	6.0	258	R.C. T-GIDER	1	Jalan Sungai
3	1,265	25.0	10.0	250	R.C. T-GIRDER	0	43.0	10.0	430	R.C. T-GIDER	1	Jalan Patani
4	2,122	18.0	15.0	270	R.C. T-GIRDER	0	33.0	15.0	495	R.C. T-GIDER	1	Jalan Perak
5	2,470	23.0	3.0	69	WOOD	0	33.0	3.0	99	R.C. T-GIDER	1	
6	2,928	12.0	3.0	36	WOOD	0	33.0	3.0	99	R.C. T-GIDER	1	
7	3,128	18.0	16.0	288	R.C.T-GIRDER	0	33.0	16.0	528	R.C. T-GIDER	1	Jalan Ayer Itam

Sg. Air Itam

NO.	CHR. (m)	EXISTING LENGTH (m)	EXISTING WIDTH (m)	EXISTING AREA (sq.m)	EXISTING TYPE	EXISTING PIER NO.	PROPOSED LENGTH (m)	PROPOSED WIDTH (m)	PROPOSED AREA (sq.m)	PROPOSED TYPE	PROPOSED PIER NO.	REMARKS
1	1,062	13.0	33.0	429	T-GIRDER	0	28.0	33.0	924	R.C. T-GIDER	1	Jalan Scotland
2	1,493	18.0	25.0	450	R.C.I-GIRDER	0	16.0	25.0	400	R.C. T-GIDER	0	Jalan Air Itam
3	1,940	21.8	8.0	174.4	T-GIRDER	2	16.0	8.0	128	R.C. T-GIDER	0	Lorong Batu Lancang

Sg. Dondang

NO.	CHR. (m)	EXISTING LENGTH (m)	EXISTING WIDTH (m)	EXISTING AREA (sq.m)	EXISTING TYPE	EXISTING PIER NO.	PROPOSED LENGTH (m)	PROPOSED WIDTH (m)	PROPOSED AREA (sq.m)	PROPOSED TYPE	PROPOSED PIER NO.	REMARKS
1	510	9.0	4.0	36	T-GIRDER	0	16.0	4.0	64	R.C. T-GIDER	0	Taman Thean
2	523	9.0	5.0	45	T-GIRDER	0	16.0	5.0	80	R.C. T-GIDER	0	Taman Thean
3	800	7.0	11.0	77	T-GIRDER	0	16.0	11.0	176	R.C. T-GIDER	0	Jalan Thean Teik Dua
4	1,403	6.0	3.0	18	WOOD	0	16.0	3.0	48	R.C. T-GIDER	0	
5	1,649	9.0	3.0	27	WOOD	0	11.0	3.0	33	R.C. SLAB	0	
6	1,863	7.0	5.0	35	T-GIRDER	0	11.0	5.0	55	R.C. SLAB	0	Jalan Thean TEIK
7	2,591	7.5	3.0	22.5	WOOD	0	11.0	3.0	33	R.C. SLAB	0	
8	2,865	9.0	3.0	27	WOOD	0	11.0	3.0	33	R.C. SLAB	0	

TABLE 8-3-2 BRIDGES TO BE RECONSTRUCTED FOR URGENT PROJECT

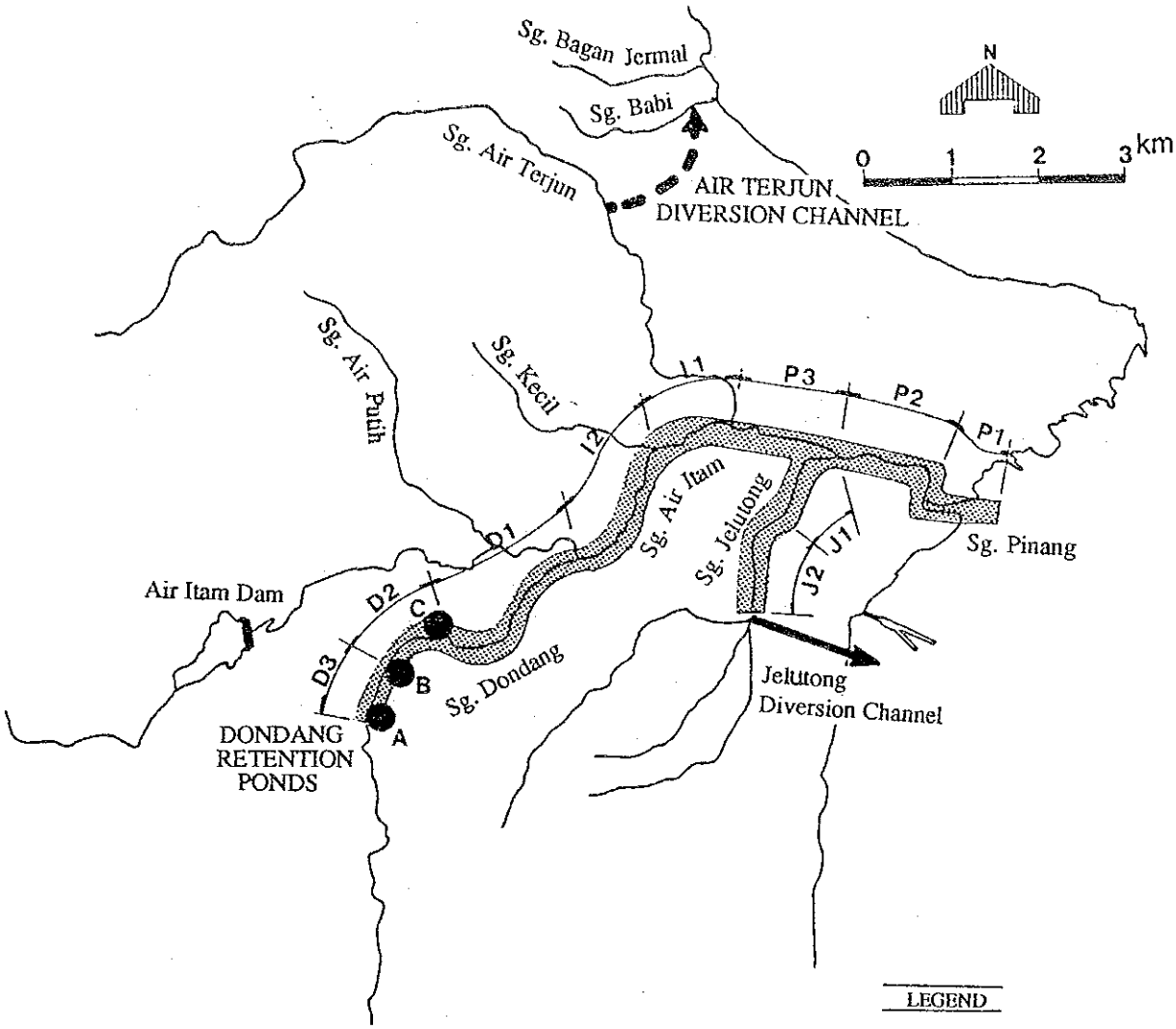
Sg. JELUTONG

NO.	CHR. (m)	EXISTING					PROPOSED					REMARKS
		LENGTH (m)	WIDTH (m)	AREA (sq.m)	TYPE	PIER NO.	LENGTH (m)	WIDTH (m)	AREA (sq.m)	TYPE	PIER NO.	
1	632	5.0	1.5	7.5	IRON	0	7.0	1.5	10.5	R.C. SLAB	0	JALAN ISMAIL CIK MATT
2	1,509	5.0	1.5	7.5	WOOD	0	7.0	1.5	10.5	R.C. SLAB	0	
3	1,554	5.0	1.5	7.5	WOOD	0	7.0	1.5	10.5	R.C. SLAB	0	
4	1,583	5.0	1.5	7.5	IRON	0	7.0	1.5	10.5	R.C. SLAB	0	
5	1,656	6.0	4.0	24	WOOD	0	7.0	4.0	28	R.C. SLAB	0	
6	1,664	3.1	1.0	3.1	WOOD	0	8.0	1.0	8	R.C. SLAB	0	
7	1,684	3.2	1.5	4.8	WOOD	0	5.0	1.5	7.5	R.C. SLAB	0	
8	1,690	3.2	3.0	9.6	WOOD	0	5.0	3.0	15	R.C. SLAB	0	
9	1,709	3.2	2.0	120	WOOD	0	5.0	2.0	10	R.C. SLAB	0	
10	1,739	3.3	2.5	8.25	WOOD	0	5.0	2.5	12.5	R.C. SLAB	0	
11	1,745	3.3	2.0	6.6	WOOD	0	5.0	2.0	10	R.C. SLAB	0	
12	1,751	3.0	2.0	6	WOOD	0	5.0	2.0	10	R.C. SLAB	0	
13	1,771	3.0	2.0	6	WOOD	0	5.0	2.0	10	R.C. SLAB	0	
14	1,843	5.0	4.0	20	R.C.T-GIRDE	0	5.0	4.0	20	R.C. SLAB	0	JALAN VAN PRAAGH
15	1,854	4.0	4.0	16	R.C.T-GIRDE	0	7.0	4.0	28	R.C. SLAB	0	JALAN VAN PRAAGH
16	1,935	3.0	1.5	120	WOOD	0	6.0	1.5	9	R.C. SLAB	0	
17	2,070	3.4	1.0	3.4	WOOD	0	5.0	1.0	5	R.C. SLAB	0	

Sg.Keluang

NO.	CHR. (m)	EXISTING					PROPOSED					REMARKS
		LENGTH (m)	WIDTH (m)	AREA (sq.m)	TYPE	PIER NO.	LENGTH (m)	WIDTH (m)	AREA (sq.m)	TYPE	PIER NO.	
1	2,070	22.0	3.0	66	WOOD	0	53.0	3.0	159	R.C. T-GIDER	2	Sg. Ara
2	3,143	16.0	3.0	48	WOOD	0	27.0	3.0	81	R.C. T-GIDER	1	Sg. Ara
3	1,290						17.6	20.0	352	R.C. T-GIDER	1	Relau Diversion

Figures



LEGEND

- Dam Completed
- Retention Pond
- Diversion Channel Completed
- Diversion Cannel
- River Improvement

RIVER IMPROVEMENT

PART	CHAINAGE	DISTANCE (m)	RIVER BED SLOPE	RIVER BED WIDTH (m)	WIDTH (m)	WATER DEPTH (m)	DESIGN DISCHARGE (m3/s)
P1	-0.71 to 0.4	1,110	1/2000	36.50	44.460 ~ 44.904	3.380 ~ 3.302	210
P2	0.4 to 1.9	1,500	1/2000	36.50	44.304 ~ 40.295	3.302 ~ 3.195	210
P3	1.9to 3.1	1,250	1/950	23.00	40.295 ~ 30.400	3.195 ~ 3.100	195
I1	0.0 to 1.1	1,100	1/800	18.20	25.4	3.0	160
I2	1.1 to 3.0	1,900	1/800	15.40	23.6	3.0	145
J1	0.0to 1.306	1,330	1/1070	4.70	4.7	2.5	20
J2	1.306 to 2.015	810	1/1070	2.00	2.0	2.5	6
D1	0.014 to 2.302	2,100	1/680	8.30	14.5	2.5	60
D2	2.302 to 3.732	1,210	1/680	6.00	12.5	2.5	45
D3	3.732 to4.854	1,010	1/190	2.30	8.5	2.5	40

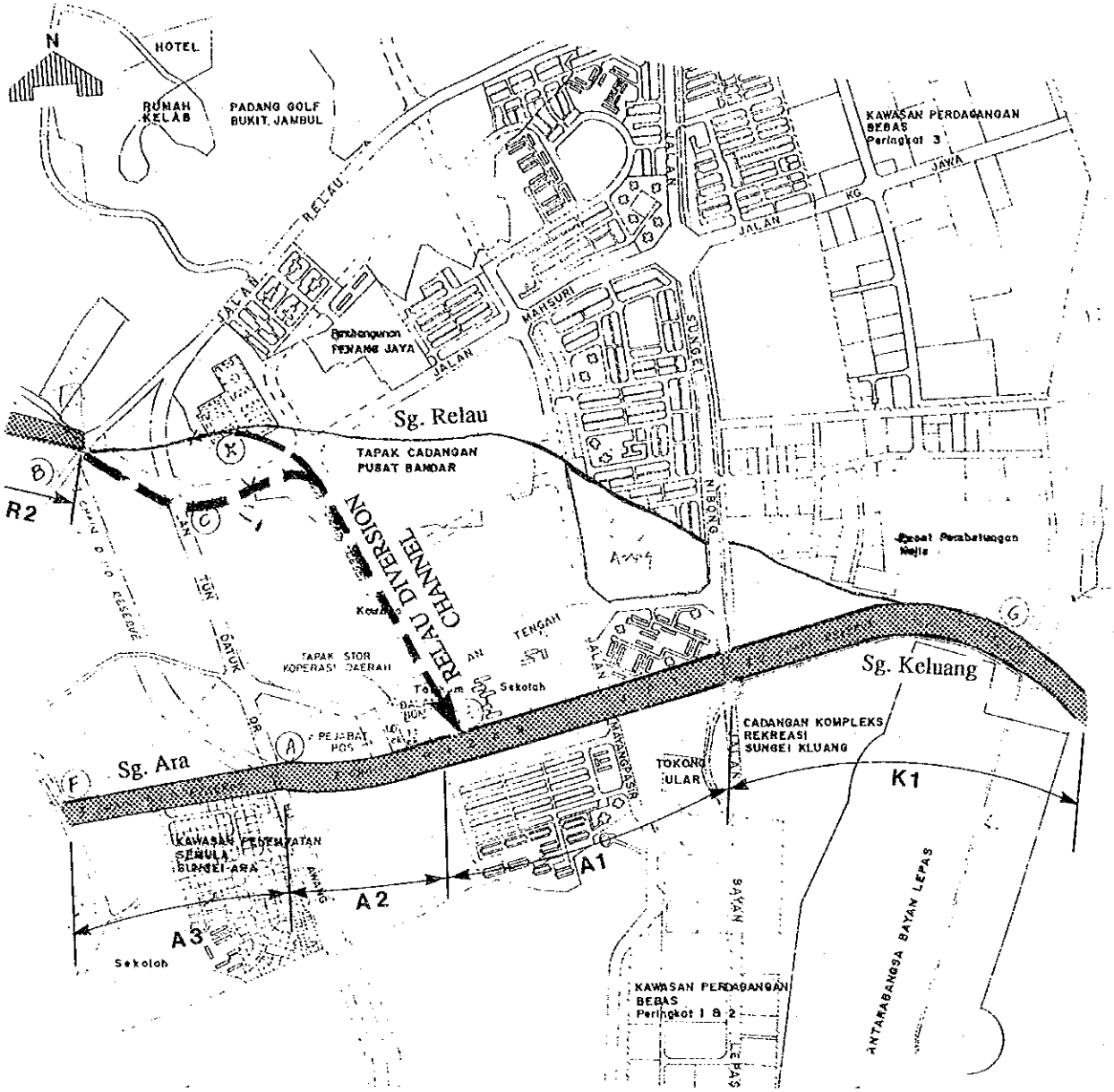
DONDANG RETENTION PONDS

	Area (m2)	Pond Depth (m)	Storage Volume (m3)	Cut O (m3/s)
Pond A	30,500	4.24	79,013	9.500
Pond B	32,700	4.18	72,839	6.000
Pond C	21,200	4.77	46,410	4.500
Total	84,400		198,262	20.000

AIR TERJUN DIVERSION CHANNEL

1	DIVERTING POINT	CH3093 of Sg. Air Terjun
2	CATCHMENT AREA OF DIVERTING POINT	7.74 km2
3	DIVERSION LENGTH	1740 m
4	CONFLUENCE POINT	CH160 of Sg. Babi
5	DISCHARGE CAPACITY	65 m3/S

FIG. 8-1 FLOOD MITIGATION FACILITIES OF SG. PINANG SYSTEM FOR URGENT PROJECT



RIVER IMPROVEMENT

PART	CHAINAGE	DISTANCE (m)	RIVER BED SLOPE	RIVER BED WIDTH (m)	WIDTH (m)	WATER DEPTH (m)	DESIGN DISCHARGE (m3/s)
K1	-0.2 to 1.540	1,740	1/1190	13.90	54.3	3	125
A1	1.540 to 2.200	660	1/1190	12.20	50.6	3	110
A2	2.200 to 2.950	750	1/1190	3.80	26.2	2.5	40
A3	2.950 to 3.410	460	1/450	2.80	22.4	1.8	40
R2	2.410 to 4.045	1,640	1/360	9.70	14.9	2.6	6

RELAU DIVERSION CHANNEL

1	DIVERTING POINT	CH2410 of Sg. Relau
2	CATCHMENT AREA OF DIVERTING POINT	10.5 km2
3	DIVERSION LENGTH	1530 m
4	CONFLUENCE POINT	CH2200 of Sg. Ara
5	DESIGN DISCHARGE	70 m3/S

LEGEND

Diversion Cannel

River Improvement

FIG. 8-2 FLOOD MITIGATION FACILITIES OF SG. KELUANG SYSTEM FOR URGENT PROJECT

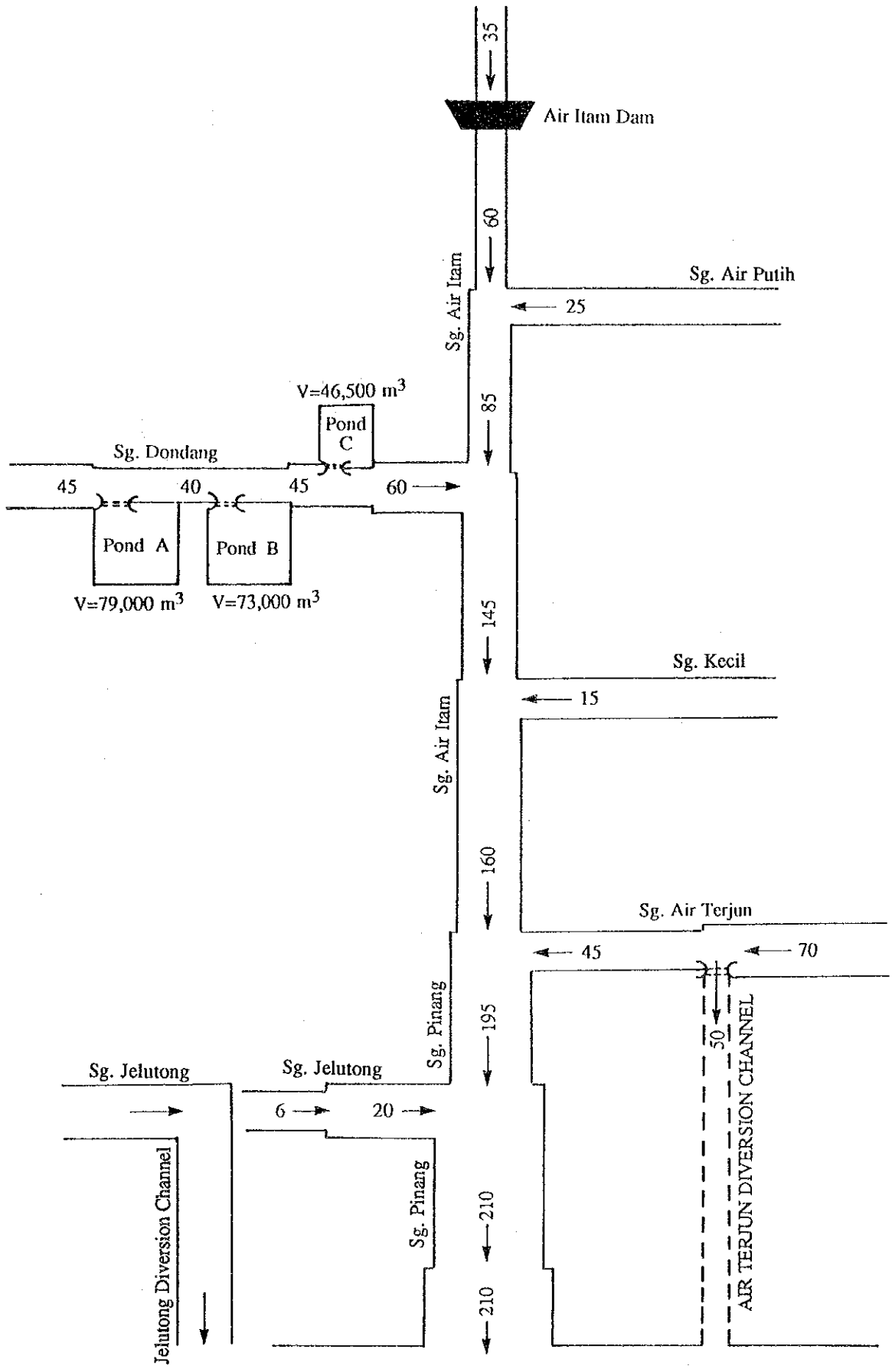


FIG. 8-3	DESIGN FLOOD DISCHARGE DISTRIBUTION OF SG. PINANG SYSTEM

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

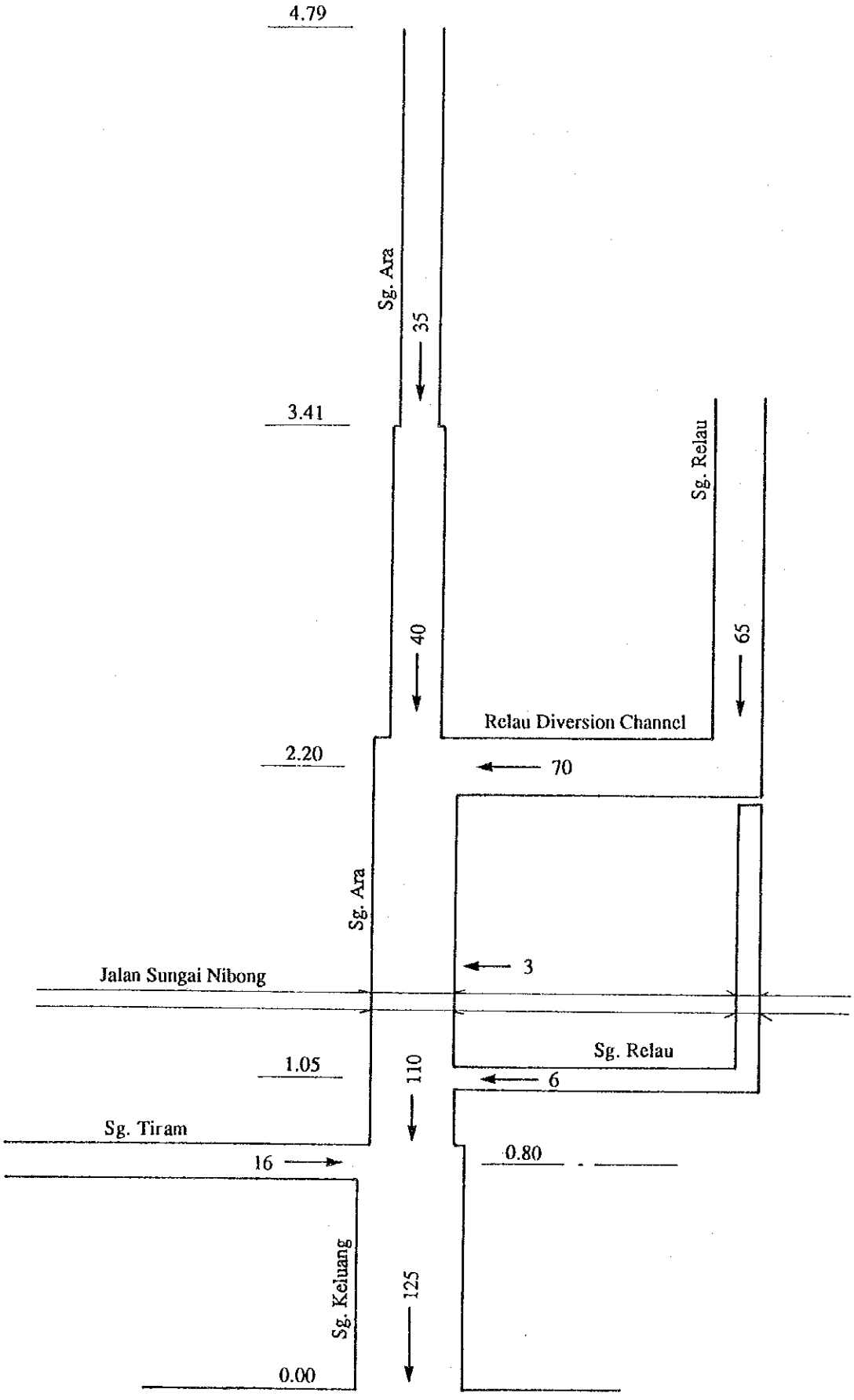
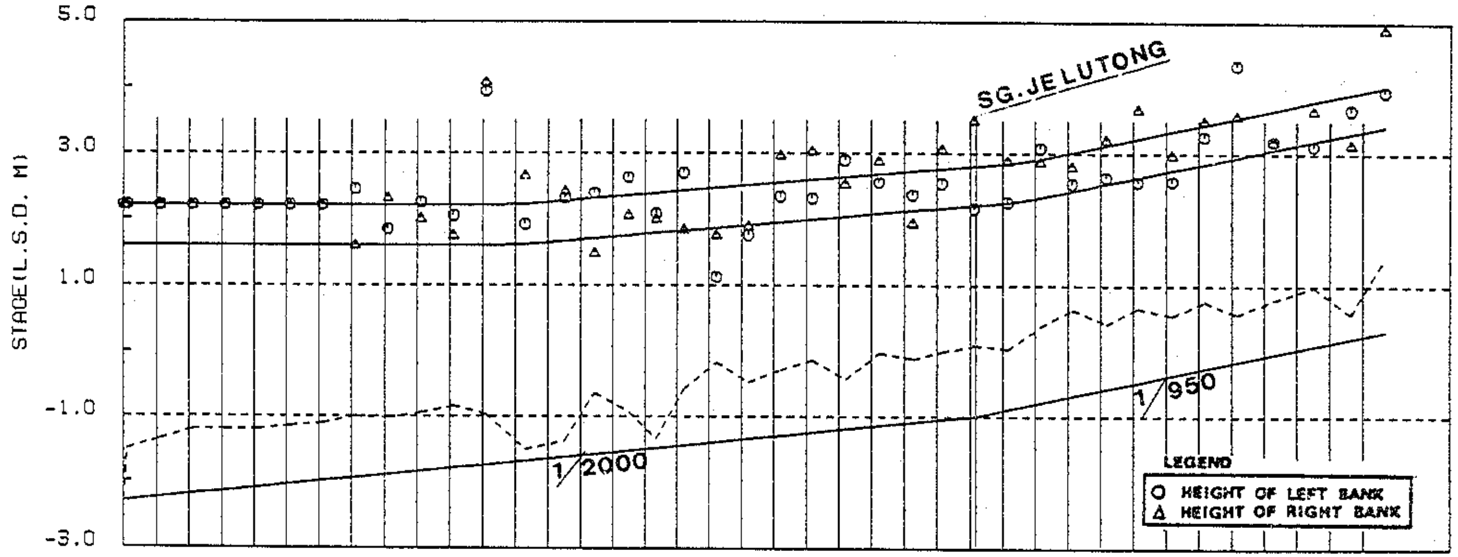


FIG. 8-4 DESIGN DISCHARGE DISTRIBUTION OF SG. KELUANG SYSTEM

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



PROPOSED BED LEVEL	-2.30	-2.286	-2.245	-2.195	-2.145	-2.095	-2.045	-1.995	-1.945	-1.895	-1.845	-1.795	-1.745
DESIGN H.W.L.	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600
PROPOSED BANK LEVEL	2.200	2.200	2.200	2.200	2.200	2.200	2.200	2.200	2.200	2.200	2.200	2.200	2.200
DISTANCE	0.0	10.0	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
CHAINAGE	-710.0	-700.0	-600.000	-500.000	-400.000	-300.000	-200.000	-100.000	0.000	100.000	200.000	300.000	400.000

PROPOSED BED LEVEL	-1.686	-1.625	-1.579	-1.526	-1.483	-1.440	-1.389	-1.340	-1.290	-1.241	-1.191	-1.139	-1.088
DESIGN H.W.L.	1.607	1.659	1.699	1.744	1.782	1.819	1.862	1.904	1.947	1.989	2.032	2.078	2.121
PROPOSED BANK LEVEL	2.207	2.259	2.299	2.344	2.382	2.419	2.462	2.504	2.547	2.589	2.632	2.678	2.721
DISTANCE	119.000	122.000	92.000	105.000	87.000	86.000	101.000	99.000	99.000	98.000	100.000	105.000	102.000
CHAINAGE	500.000	600.000	700.000	800.000	900.000	1000.000	1100.000	1200.000	1300.000	1400.000	1500.000	1600.000	1700.000

PROPOSED BED LEVEL	-1.043	-0.994	-0.887	-0.779	-0.676	-0.569	-0.467	-0.356	-0.253	-0.149	-0.030	0.098	0.218	0.325
DESIGN H.W.L.	2.159	2.201	2.245	2.321	2.424	2.531	2.633	2.744	2.847	2.951	3.070	3.198	3.318	3.425
PROPOSED BANK LEVEL	2.759	2.801	2.845	2.921	3.024	3.131	3.233	3.344	3.447	3.551	3.670	3.798	3.918	4.025
DISTANCE	89.000	98.000	102.000	102.000	98.000	102.000	97.000	105.000	98.000	99.000	113.000	121.000	114.000	102.000
CHAINAGE	1800.000	1900.000	2000.000	2100.000	2200.000	2300.000	2400.000	2500.000	2600.000	2700.000	2800.000	2900.000	3000.000	3100.000

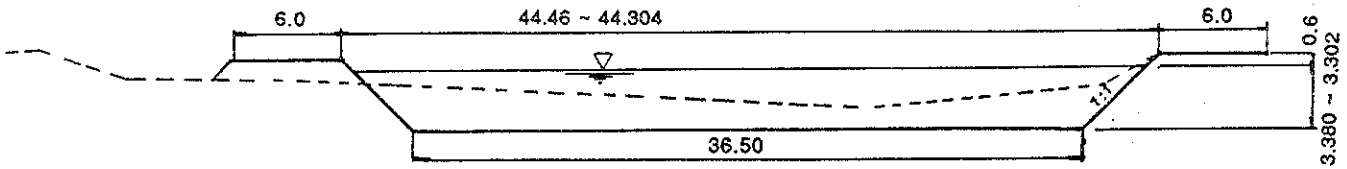
Q = 210 m³/s (chainage -710.0 to 1900.000)

Q = 195 m³/s (chainage 1900.000 to 3100.000)

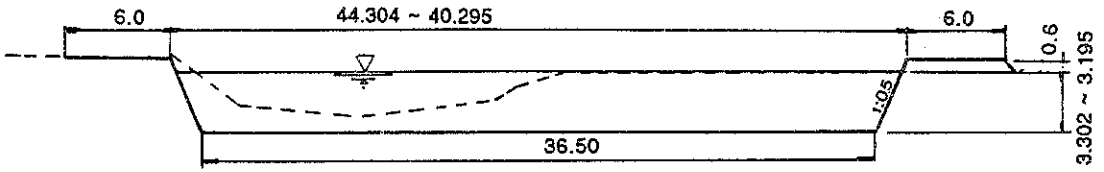
FIG. 8-5 LONGITUDINAL PROFILE OF SG. PINANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

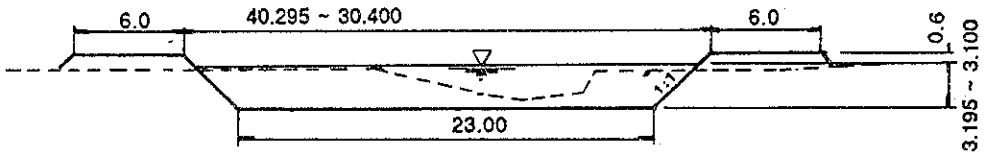
JICA



CH -710 ~ CH 400



CH 400 ~ CH 1900



CH 1900 ~ CH 3100

FIG. 8-6	PROPOSED CROSS SECTIONS OF SG. PINANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

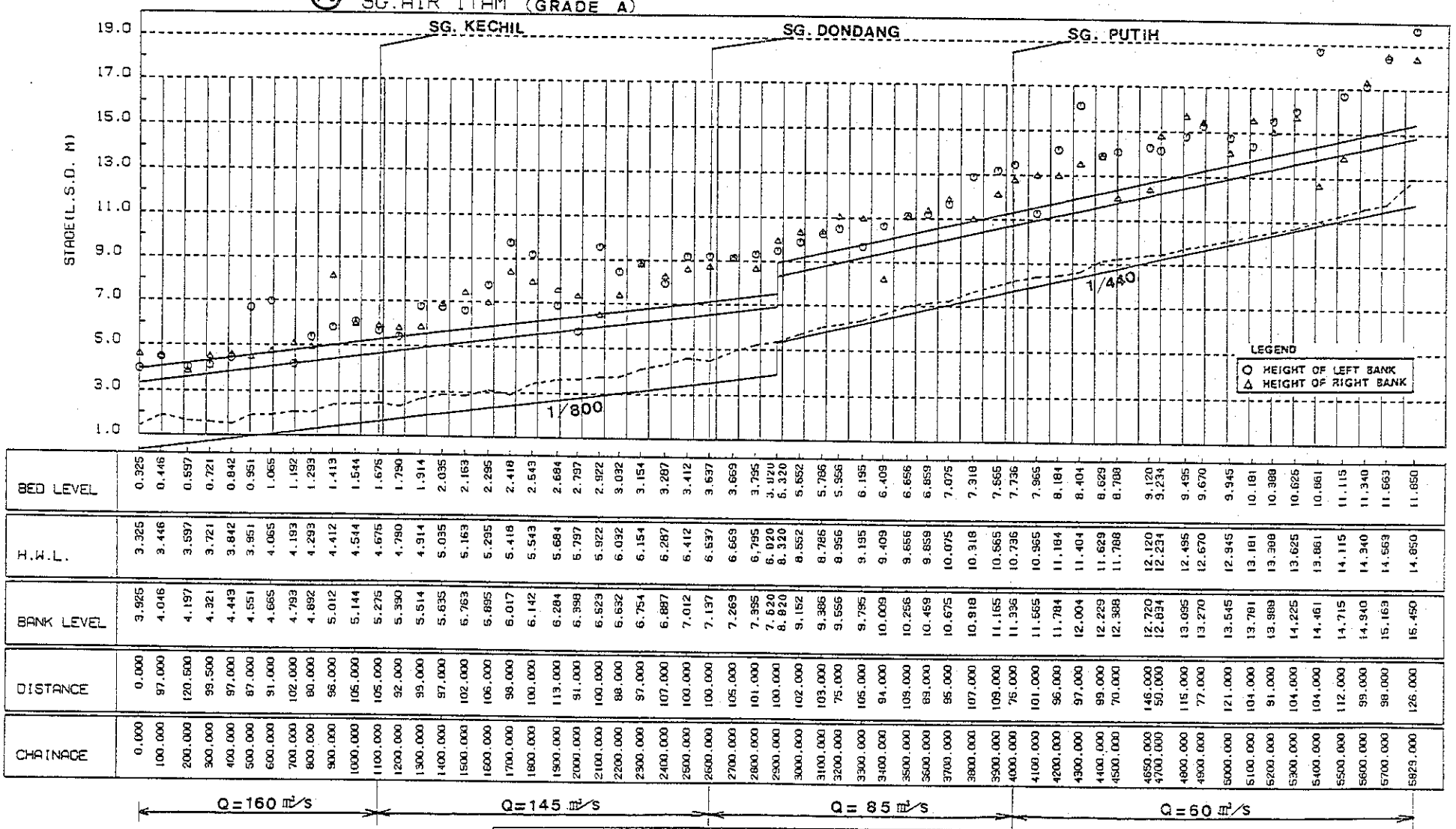


FIG. 8-7 LONGITUDINAL PROFILE OF SG. AIR ITAM

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

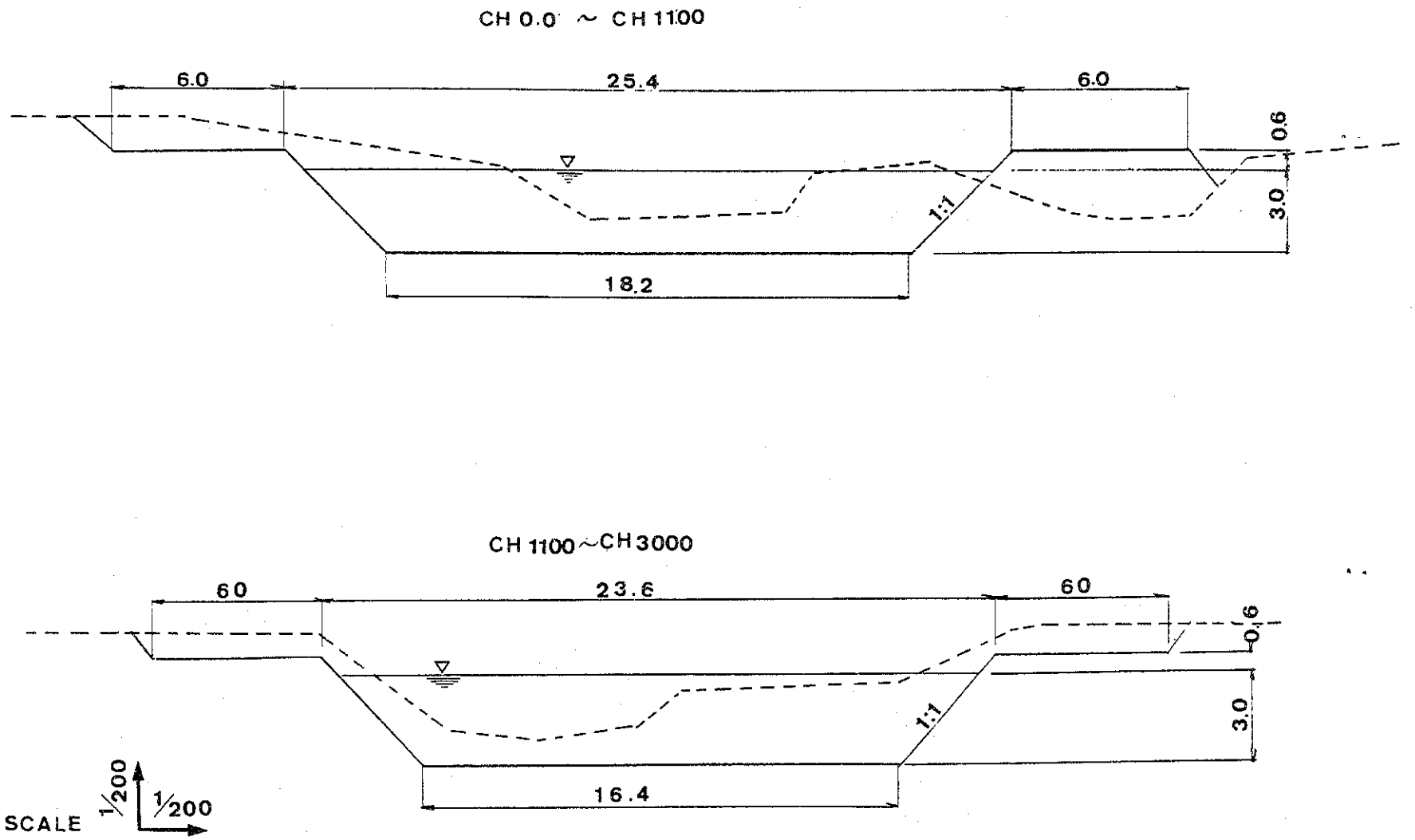
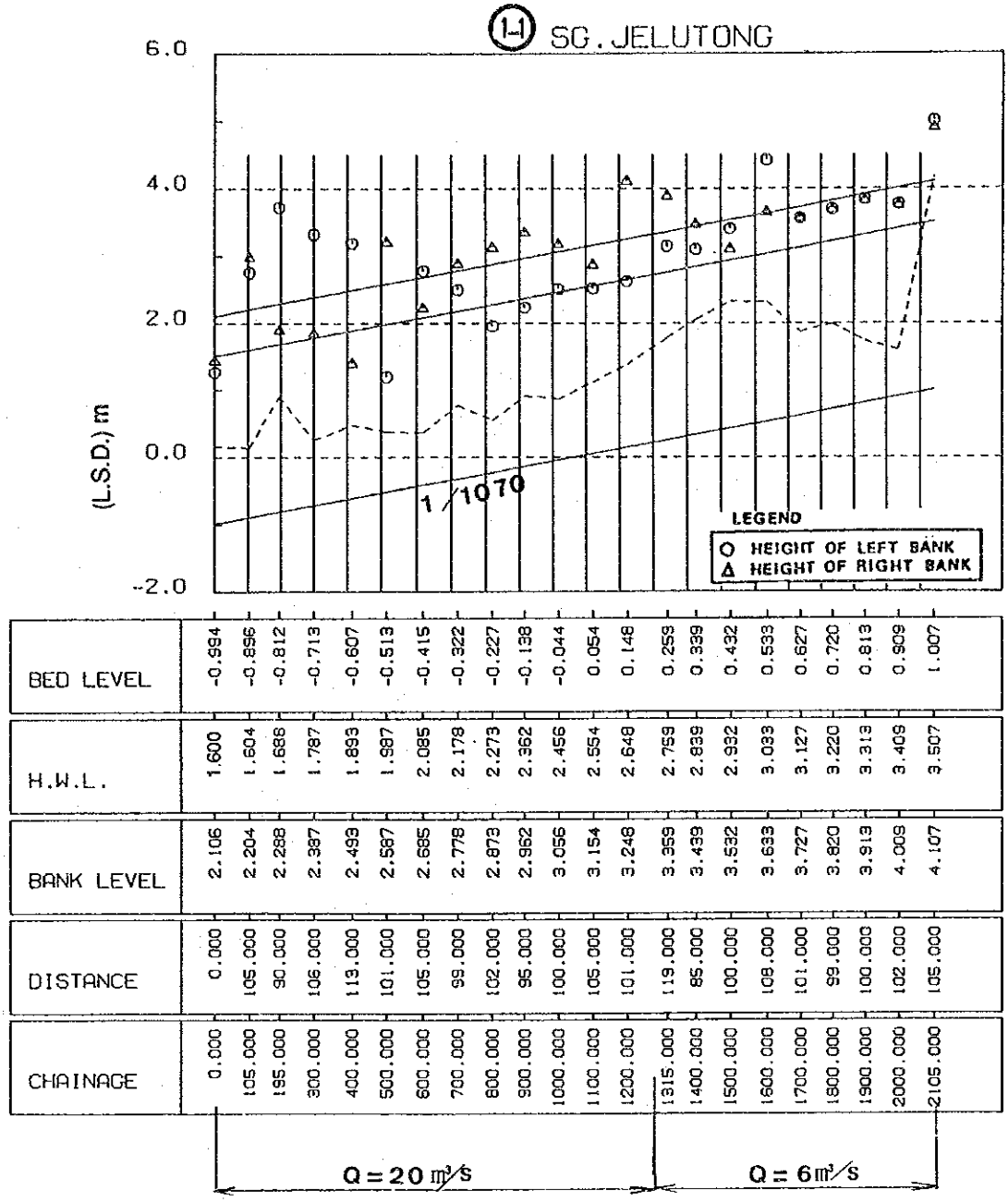


FIG. 8-8 PROPOSED CROSS SECTIONS OF SG. AIR ITAM

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



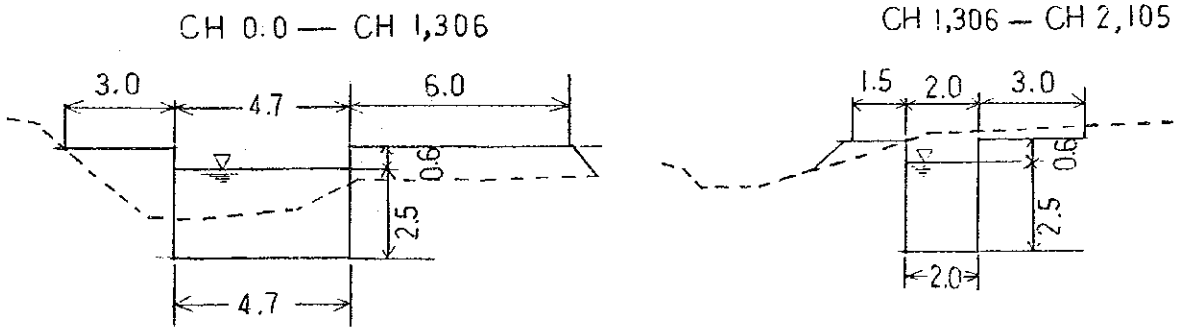


FIG. 8-9 LONGITUDINAL PROFILE AND PROPOSED CROSS SECTIONS OF SG. JELUTONG

CHAINAGE	DISTANCE	BANK LEVEL	H.W.L.	BED LEVEL
0.014	13.000	7.542	6.942	4.442
0.092	78.000	7.572	7.012	4.572
0.203	111.000	7.857	7.257	4.757
0.335	103.000	8.028	7.428	4.928
0.435	95.000	8.187	7.587	5.087
0.527	100.000	8.353	7.753	5.253
0.620	89.000	8.502	7.902	5.402
0.757	110.000	8.685	8.085	5.585
0.852	100.000	8.852	8.252	5.752
1.059	102.000	9.022	8.422	5.922
1.160	103.000	9.193	8.593	6.093
1.286	110.000	9.377	8.777	6.277
1.413	68.000	9.490	8.890	6.390
1.547	133.000	9.712	9.112	6.612
1.636	85.000	9.857	9.257	6.775
1.731	99.000	10.040	9.440	6.940
1.827	100.000	10.207	9.607	7.107
1.887	59.000	10.372	9.772	7.272
1.887	31.000	10.728	9.828	7.328
2.159	155.000	12.257	11.457	9.157
2.233	113.000	12.423	11.623	9.323
2.302	100.000	12.570	11.970	9.470
2.400	97.000	12.713	12.113	9.613
2.549	103.000	12.864	12.264	9.764
2.636	90.000	12.997	12.397	9.897
2.736	90.000	13.129	12.629	10.029
2.825	89.000	13.272	10.572	10.172
2.917	42.000	13.333	10.733	10.233
3.033	78.000	13.443	12.843	10.343
3.173	80.000	14.781	14.083	11.683
3.269	115.000	14.950	14.350	11.650
3.415	111.000	15.113	14.513	12.013
3.509	95.000	15.253	14.653	12.153
3.695	76.000	15.363	14.763	12.263
3.732	133.000	15.559	14.959	12.459
3.841	107.000	16.122	15.522	13.022
3.963	90.000	16.596	15.996	13.496
4.013	100.000	17.122	16.522	14.022
4.215	68.000	17.585	16.985	14.465
4.356	129.000	18.264	17.664	15.164
4.449	93.000	18.753	18.153	15.653
4.559	109.000	19.308 20.601	18.708 20.001	16.208 17.501
4.660	109.000	20.888	20.288	17.788
4.736	77.000	21.090	20.490	17.990
4.854	109.000	21.577	20.777	18.277
5.002	69.000	21.612	21.012	18.512
5.155	108.000	21.896	21.256	18.796
5.294	116.000	22.506	21.906	19.406
5.397	86.000	22.959	22.359	19.859
5.514	91.000	23.438	22.838	20.338
5.617	100.000	23.964	23.364	20.864
5.782	118.000	24.585	23.985	21.485
5.883	82.000	25.017	24.417	21.917
5.993	100.000	25.543	24.943	22.443
6.094	102.000	26.080	25.480	22.980

FIG. 8-10 LONGITUDINAL PROFILE OF SG. DONDANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

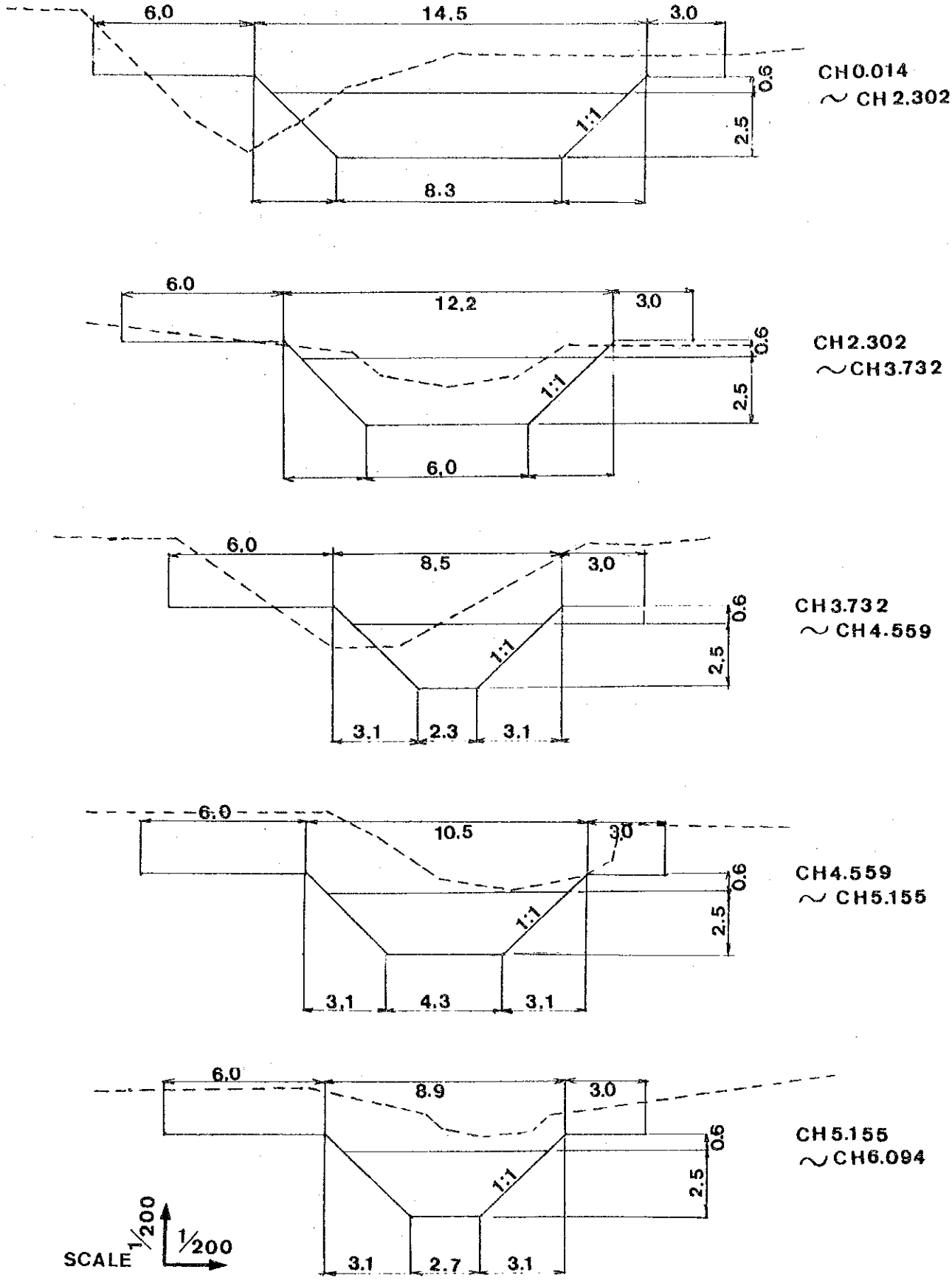


FIG. 8-11 PROPOSED CROSS SECTIONS OF SG. DONDANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

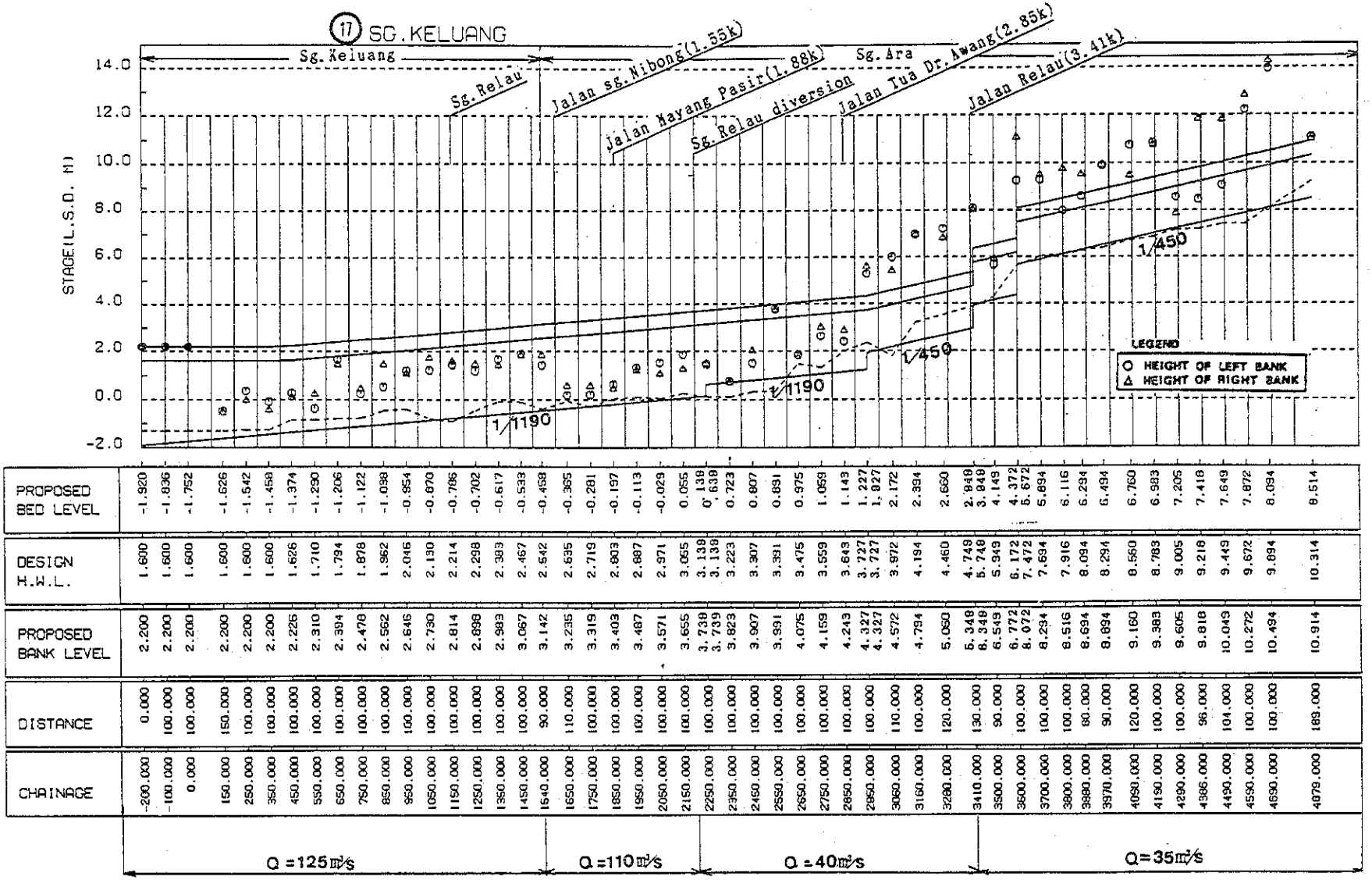


FIG. 8-12 LONGITUDINAL PROFILE OF SG. KELUANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

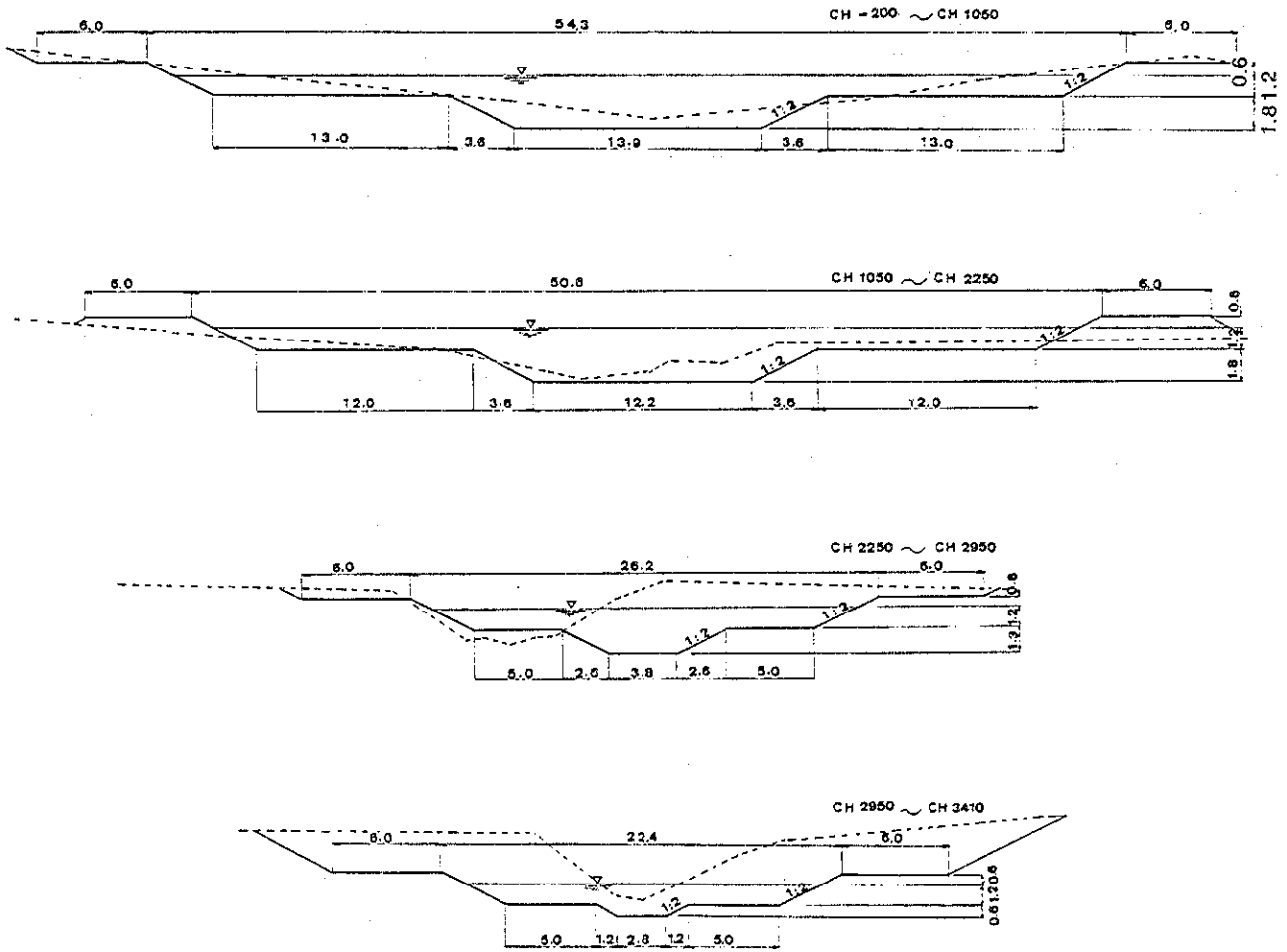


FIG. 8-13	PROPOSED CROSS SECTIONS OF SG. KELUANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

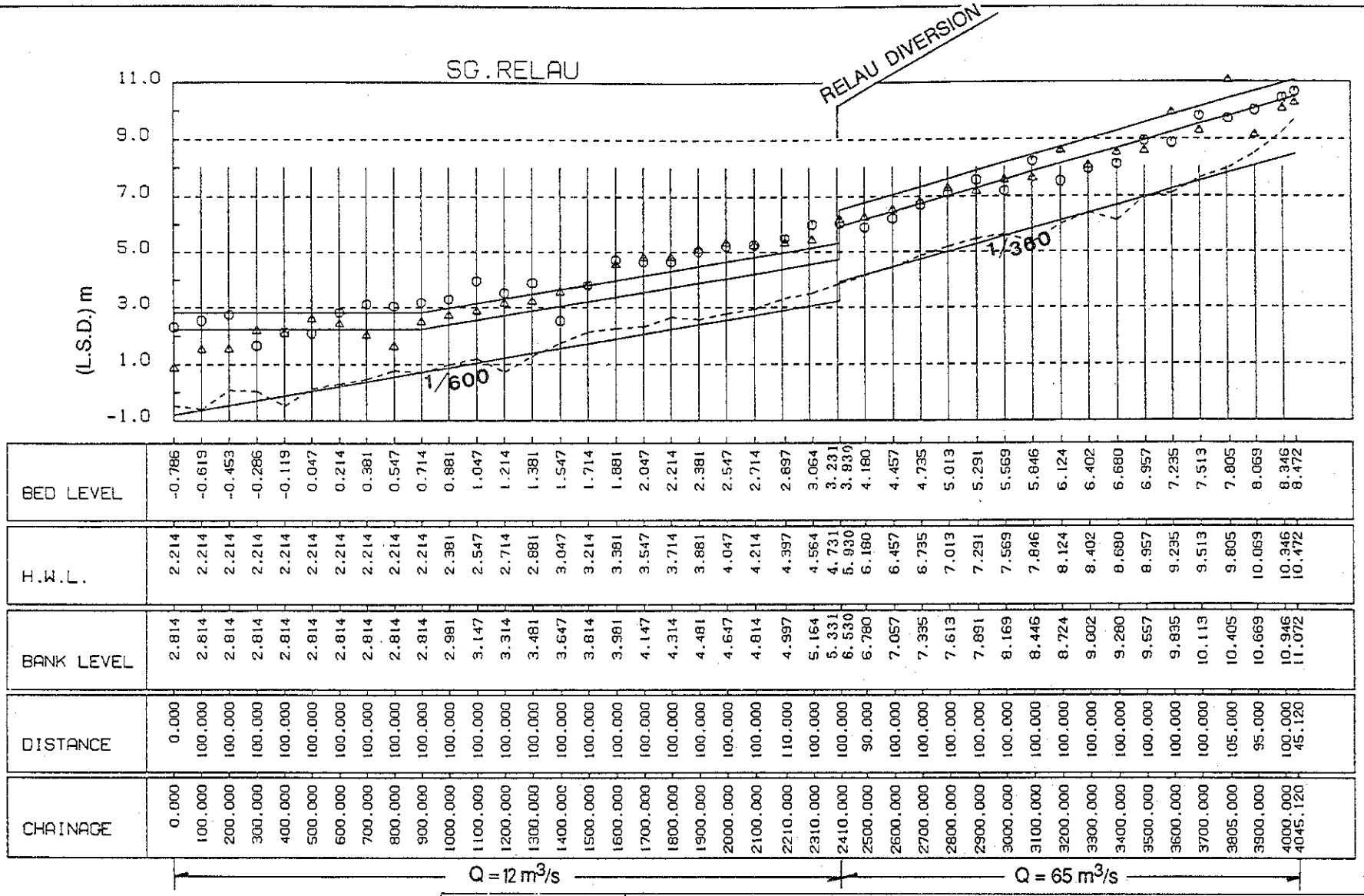


FIG. 8-14 LONGITUDINAL PROFILE OF SG. RELAU

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

Typical Cross Section of SG. RELAU

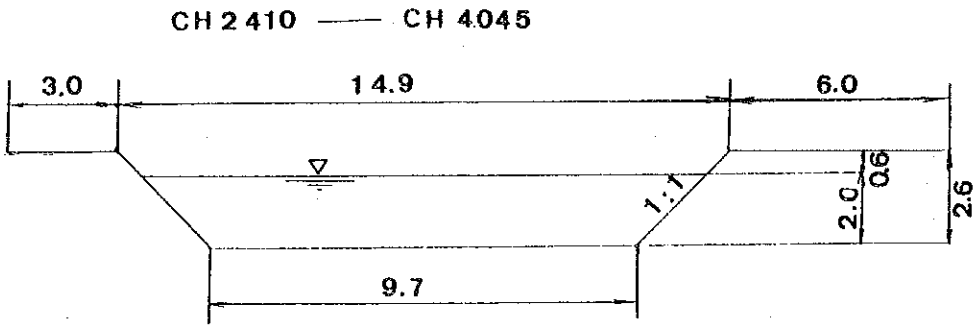


FIG. 8-15	PROPOSED CROSS SECTIONS OF SG. RELAU

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

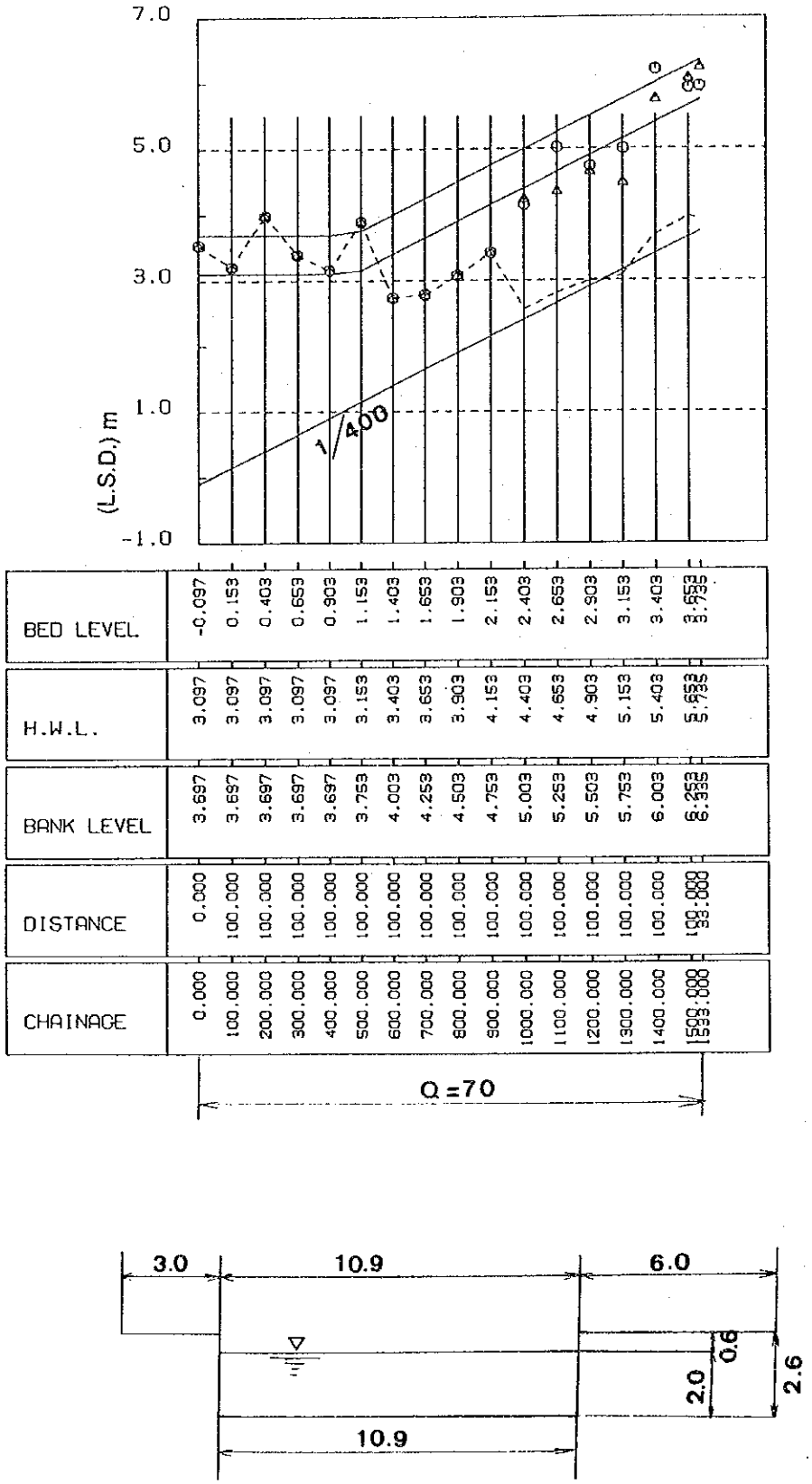
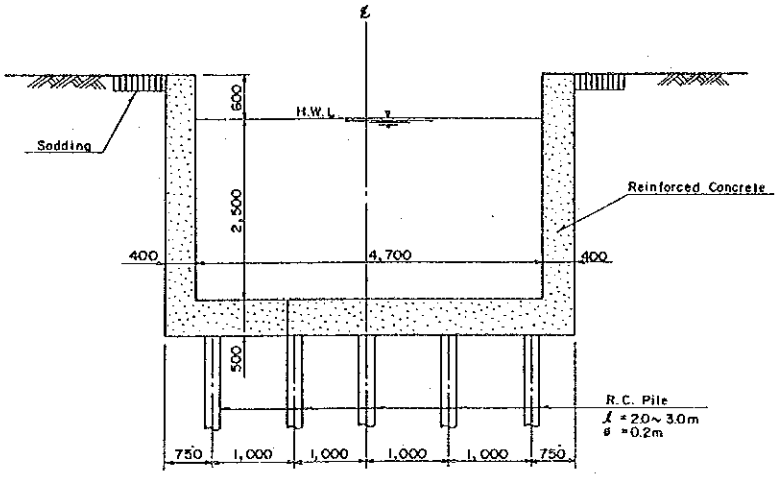
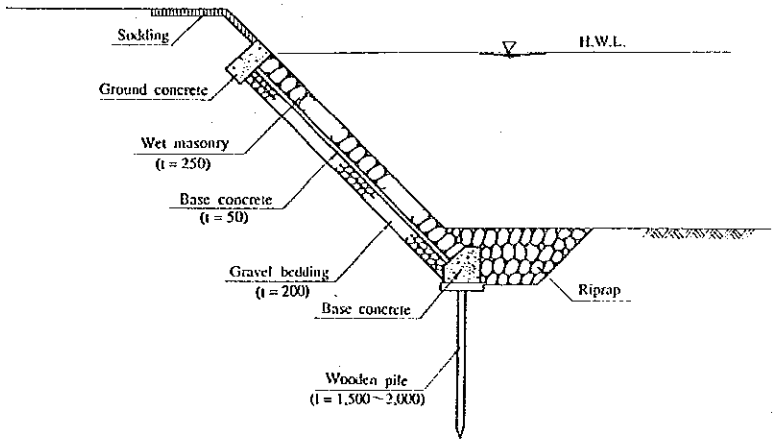


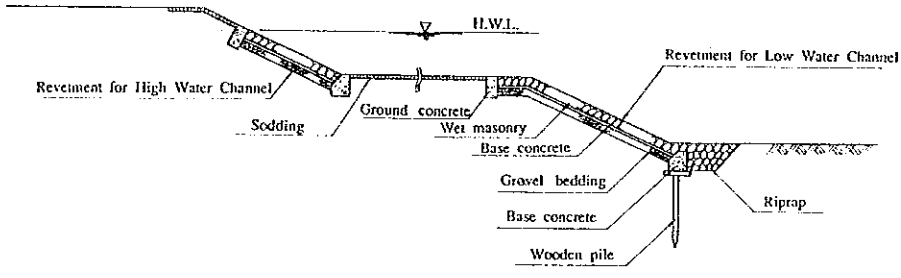
Fig. 8-16 LONGITUDINAL PROFILE AND PROPOSED CROSS SECTION OF SG. RELAU DIVERSION CHANNEL



Typical Cross Section of Revetment (Concrete Section)

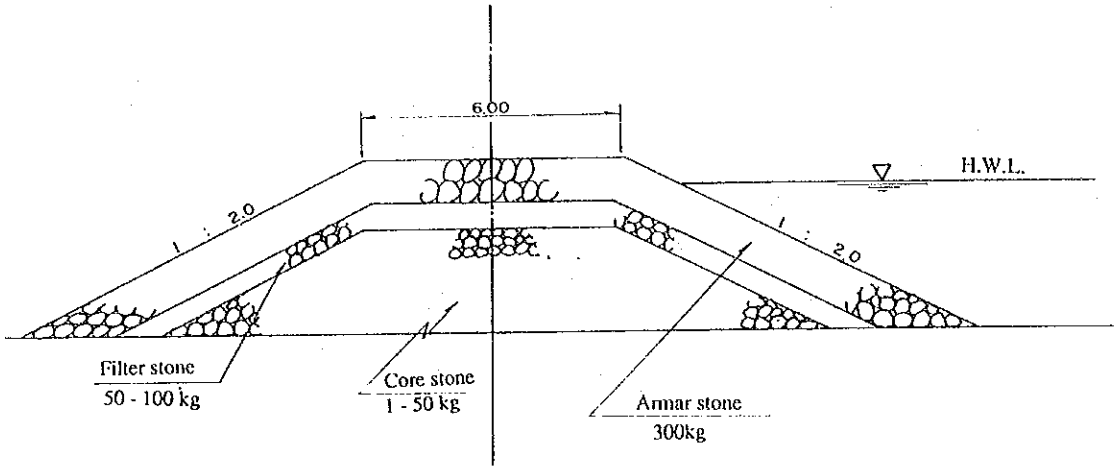


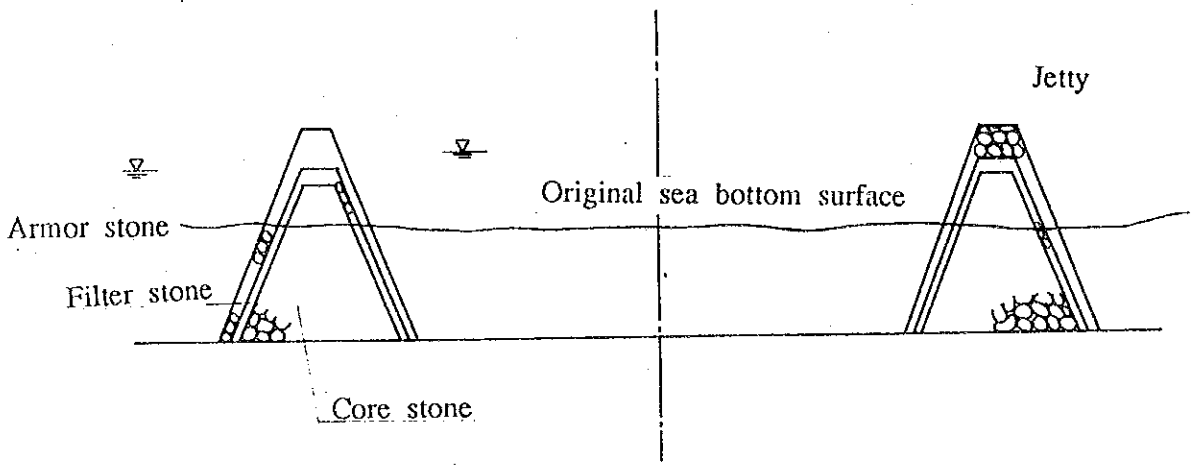
Typical Cross Section of Revetment (Single Section)



Typical Cross Section of Revetment (Compound Section)

FIG. 8-17	TYPICAL CROSS SECTION OF RIVER IMPROVEMENT

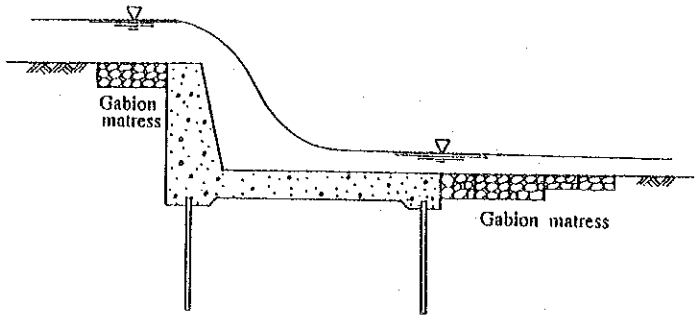




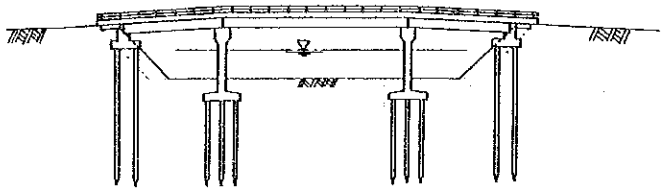
Typical Cross Section of Jetty

FIG. 8-18	TYPICAL CROSS SECTIONS OF JETTY AT SG. PINANG MOUTH

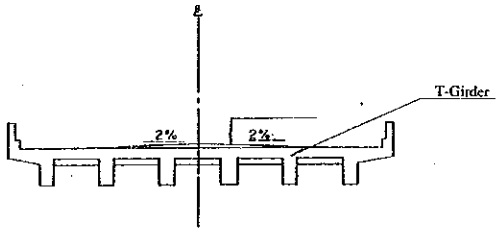
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



Typical Section of Drop Structure

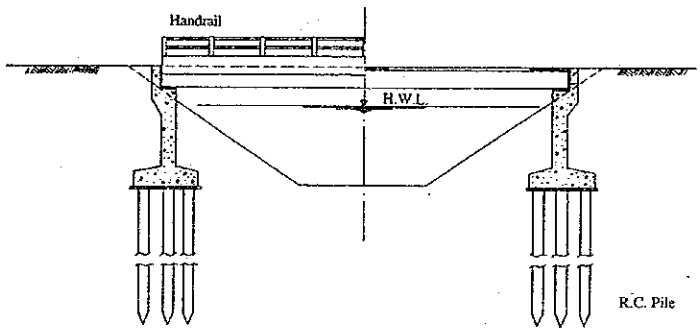


Longitudinal Section of T-Girder Bridge (1)

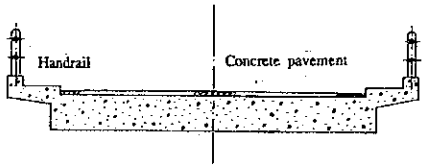


Cross Section

Typical Section of Bridge (I)



Longitudinal Section of R.C. Slab Bridge (2)



Cross Section

Typical Section of Bridge (II)

FIG. 8-19 TYPICAL SECTION OF DROP STRUCTURE AND BRIDGE

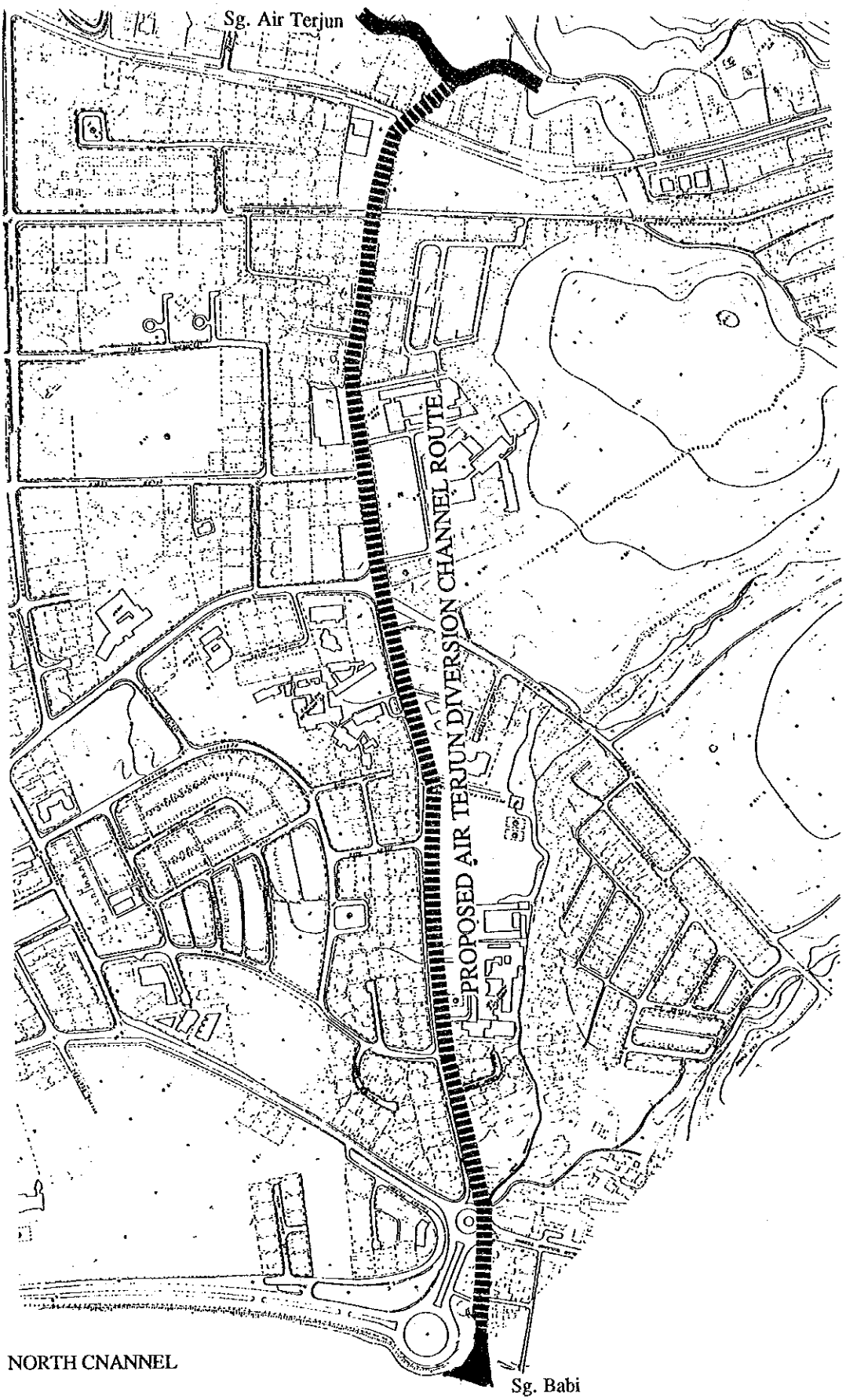
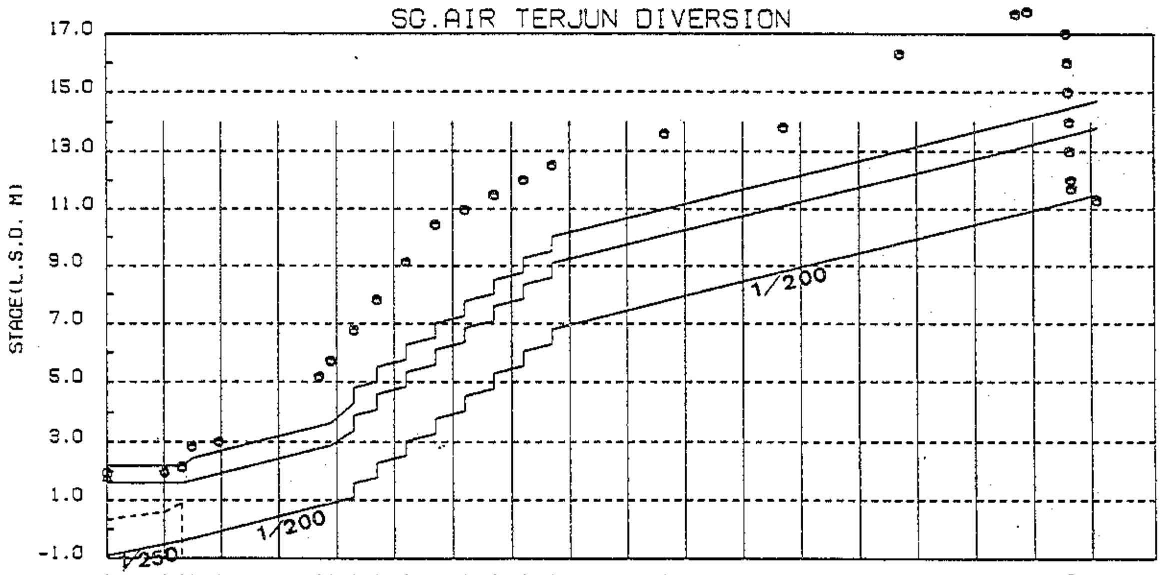


FIG. 8-20	PLAN OF PROPOSED AIR TERJUN DIVERSION CHANNEL ROUTE

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

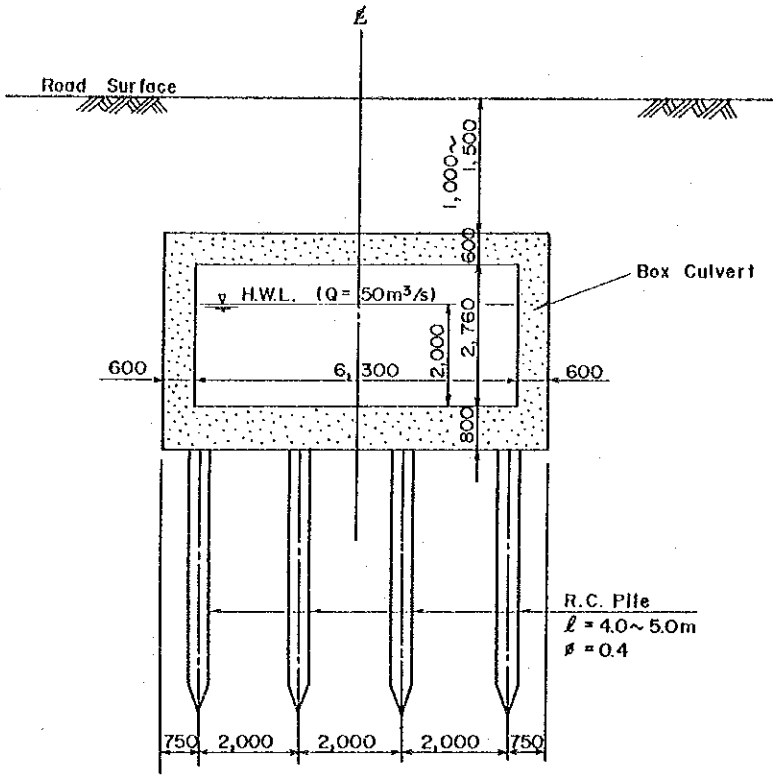


CHAINAGE	DISTANCE	EXISTING GROUND LEVEL	PROPOSED INVERT LEVEL	PROPOSED H.W.L.	PROPOSED COPING LEVEL
0.000	0.000	1.940	-0.920	1.600	2.200
100.000	100.000	1.880	-0.520	1.600	2.200
160.000	30.000	2.150	-0.400	1.600	2.200
178.000	18.000	2.660	-0.310	1.690	2.450
225.000	47.000	3.010	-0.075	1.925	2.685
400.000	175.000	5.180	0.800	2.800	3.560
420.000	20.000	5.710	0.900	2.900	3.660
460.000	40.000	6.760	1.600	3.800	4.820
500.000	40.000	7.810	2.600	4.600	5.820
550.000	50.000	9.130	2.850	5.850	6.270
600.000	50.000	10.440	3.800	6.600	6.820
650.000	50.000	10.960	4.850	6.850	7.270
700.000	50.000	11.480	5.800	7.600	8.820
750.000	50.000	12.000	6.650	8.850	8.270
800.000	50.000	12.520	6.800	8.600	18.620
994.000	194.000	13.600	7.770	10.070	10.990
1200.000	206.000	13.600	8.800	11.100	12.020
1400.000	200.000	16.300	9.800	12.100	13.020
1600.000	200.000	17.670	10.800	13.100	14.020
1620.000	20.000	17.750	10.900	13.200	14.120
1740.000	44.000	11.300	11.500	13.800	14.720

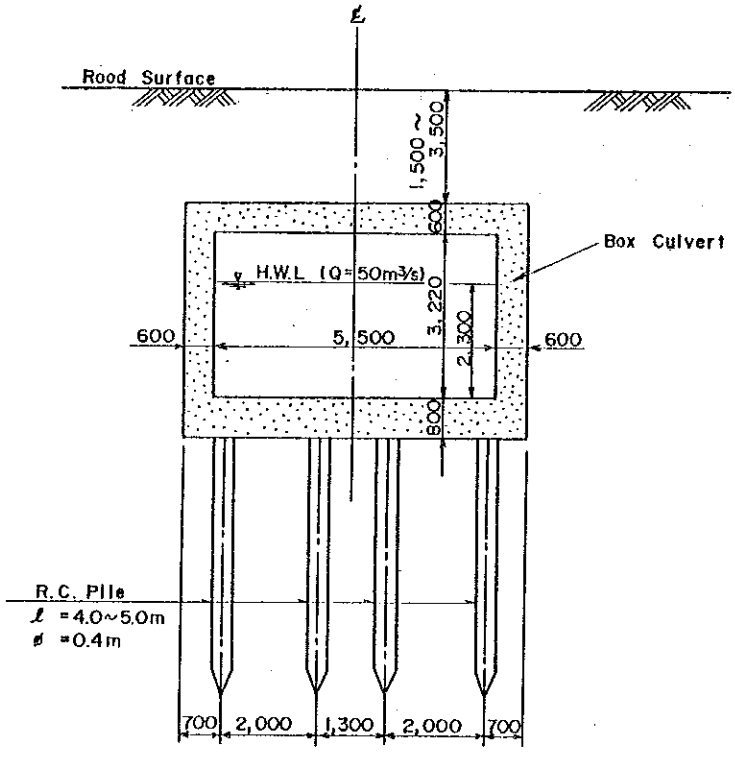
FIG. 8-21 PROPOSED LONGITUDINAL PROFILE OF AIR TERJUN DIVERSION CHANNEL

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

JICA



CH 160 ∼ CH 420



CH 420 ∼ CH 1690

Cross Section of Air Terjun Diversion Channel

FIG. 8-22	TYPICAL CROSS SECTION OF AIR TERJUN DIVERSION CHANNEL

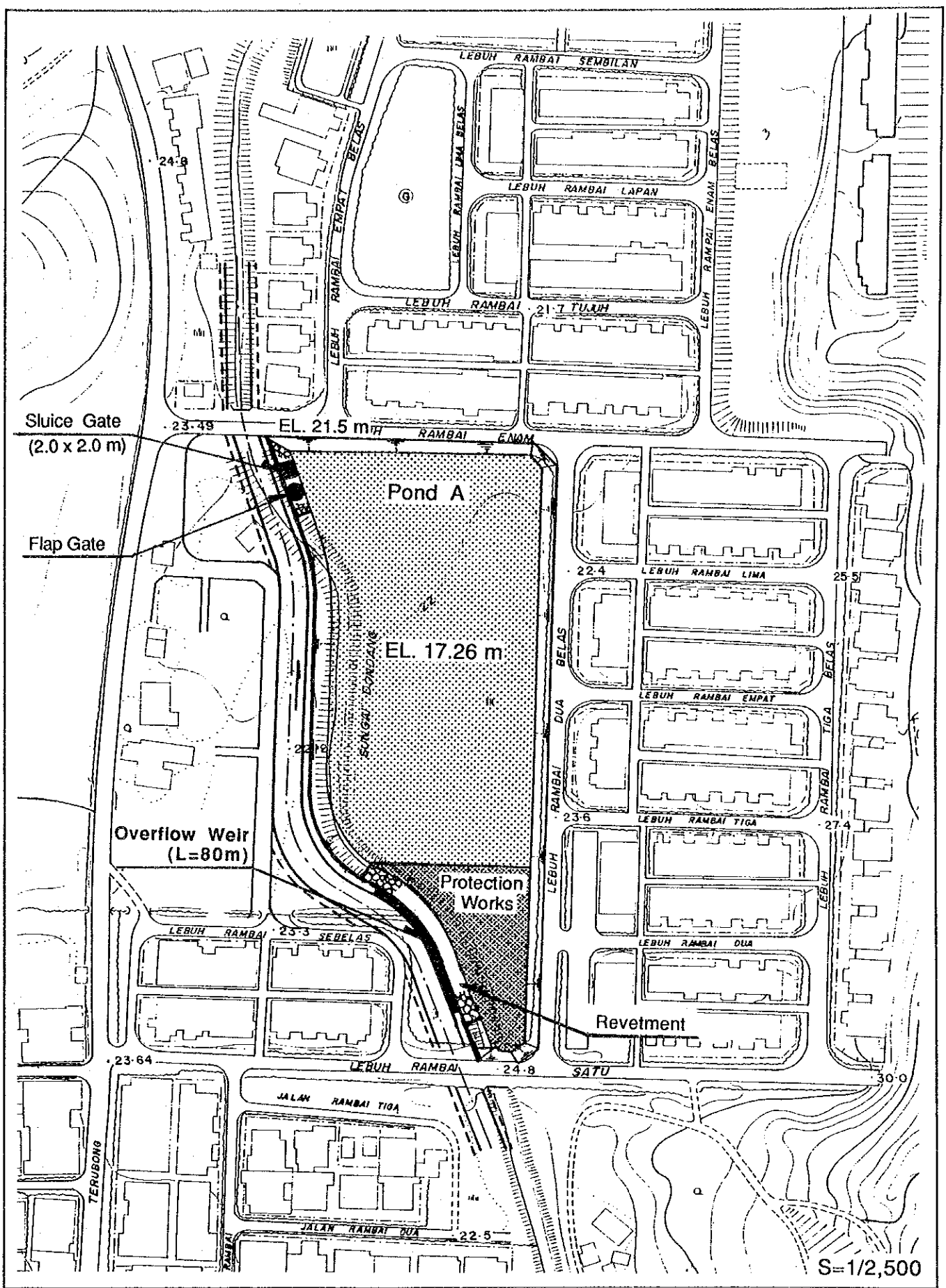


FIG. 8-23 GENERAL PLAN OF RETENTION POND A

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

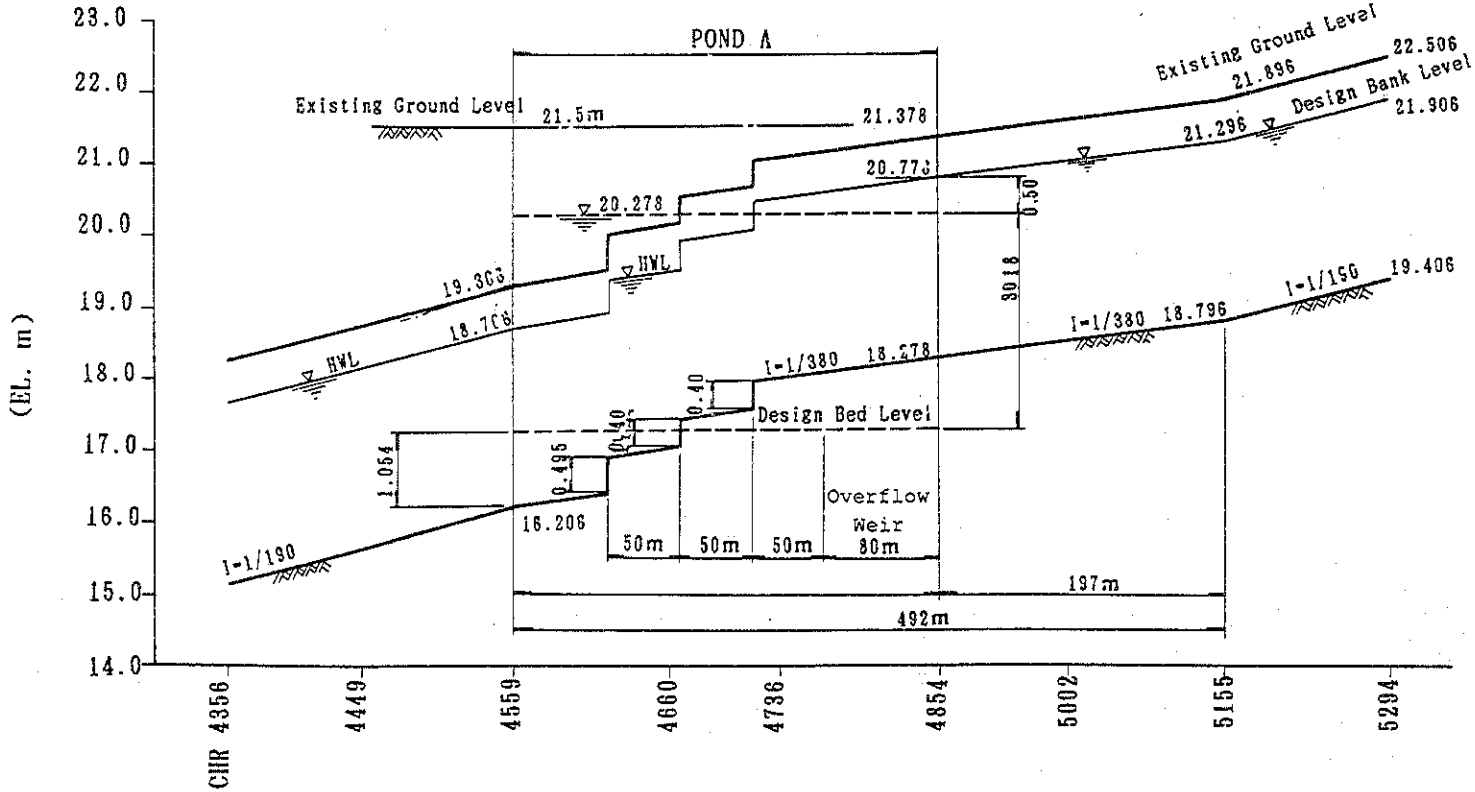


FIG. 8-24	LONGITUDINAL SECTION OF RETENTION POND A

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

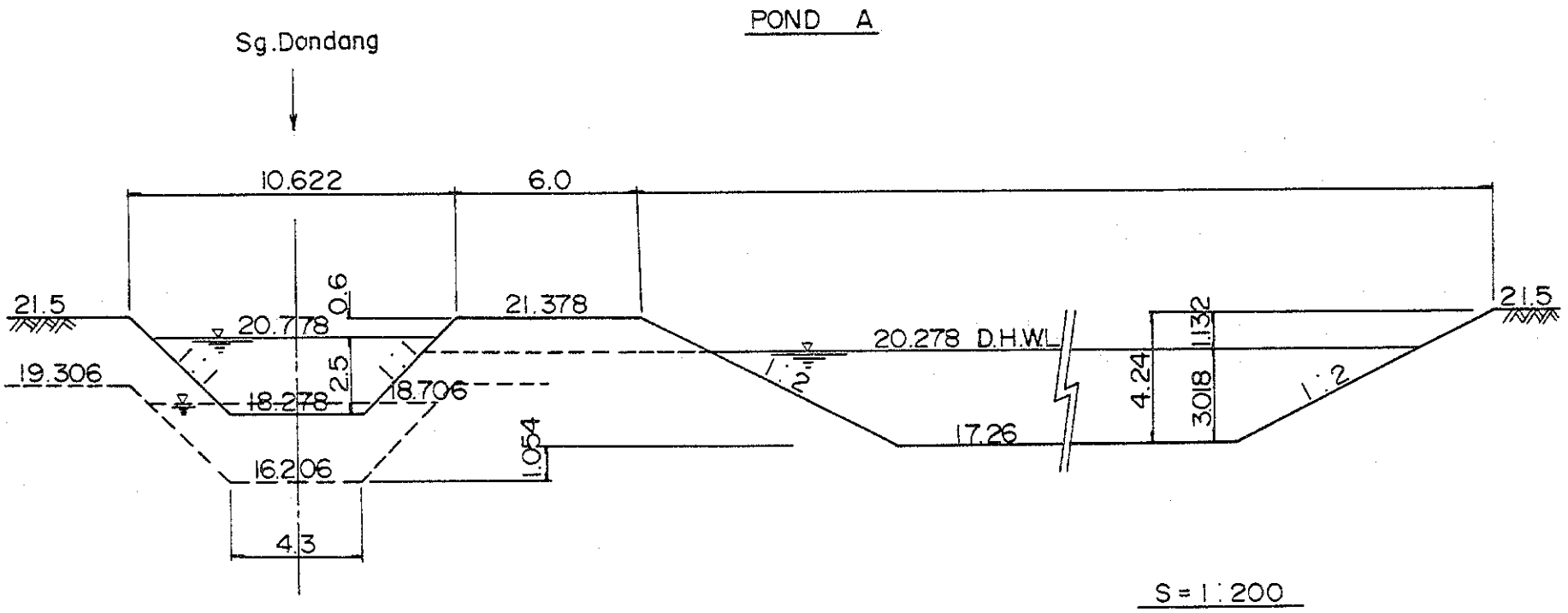


FIG. 8-25	TYPICAL CROSS SECTION OF RETENTION POND A

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

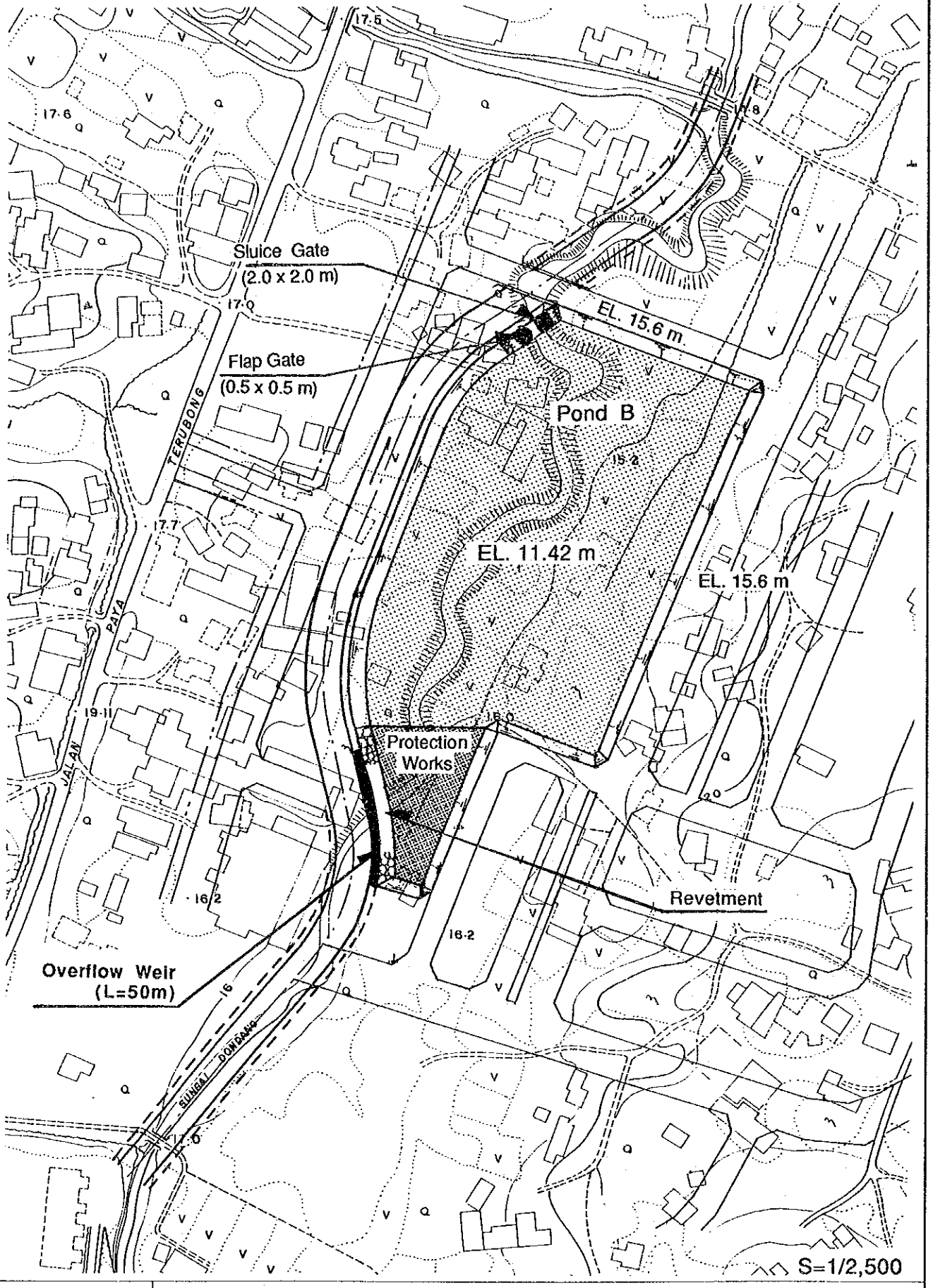


FIG. 8-26 GENERAL PLAN OF RETENTION POND B

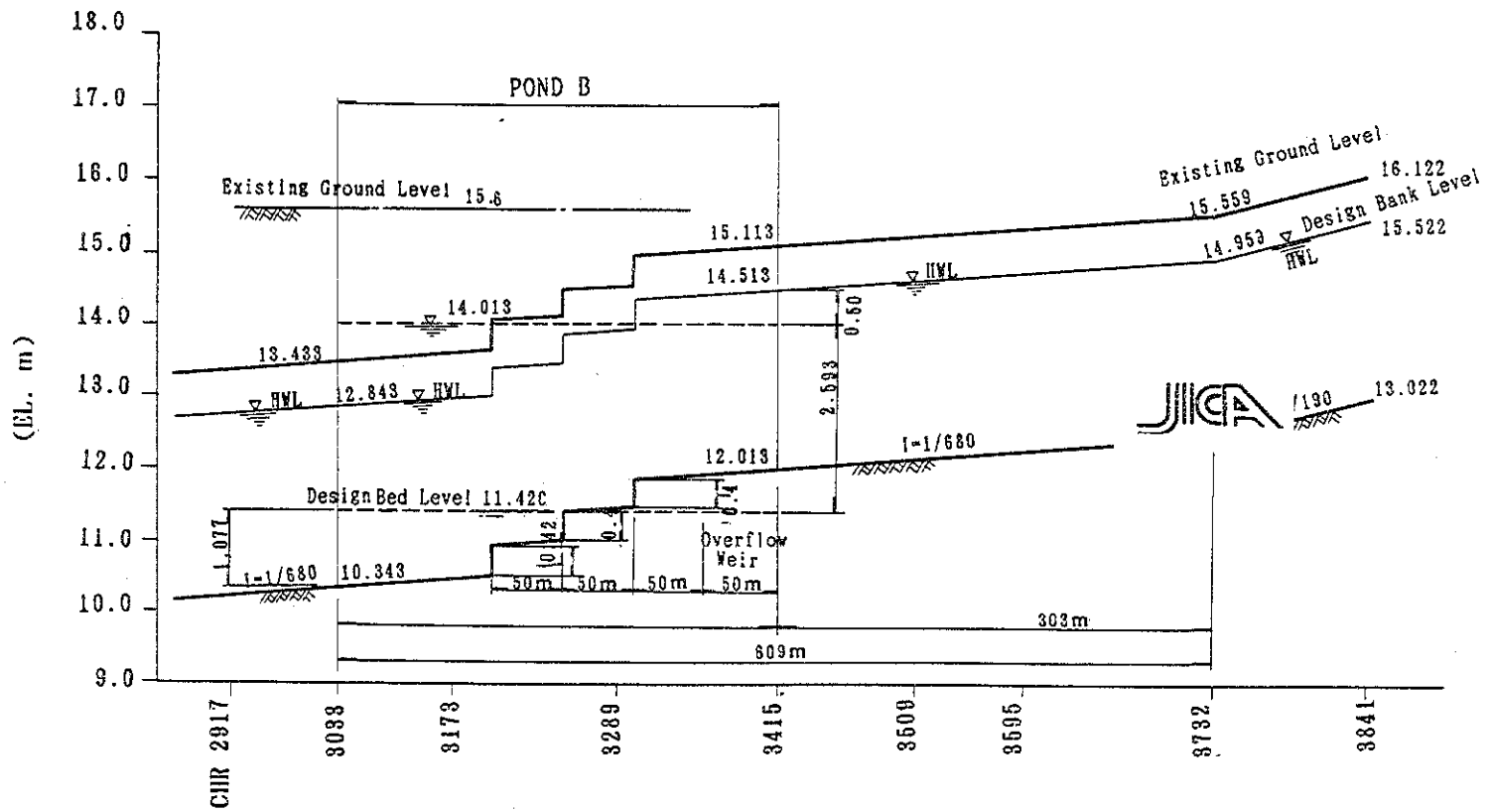


FIG. 8-27	LONGITUDINAL SECTION OF RETENTION POND B

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

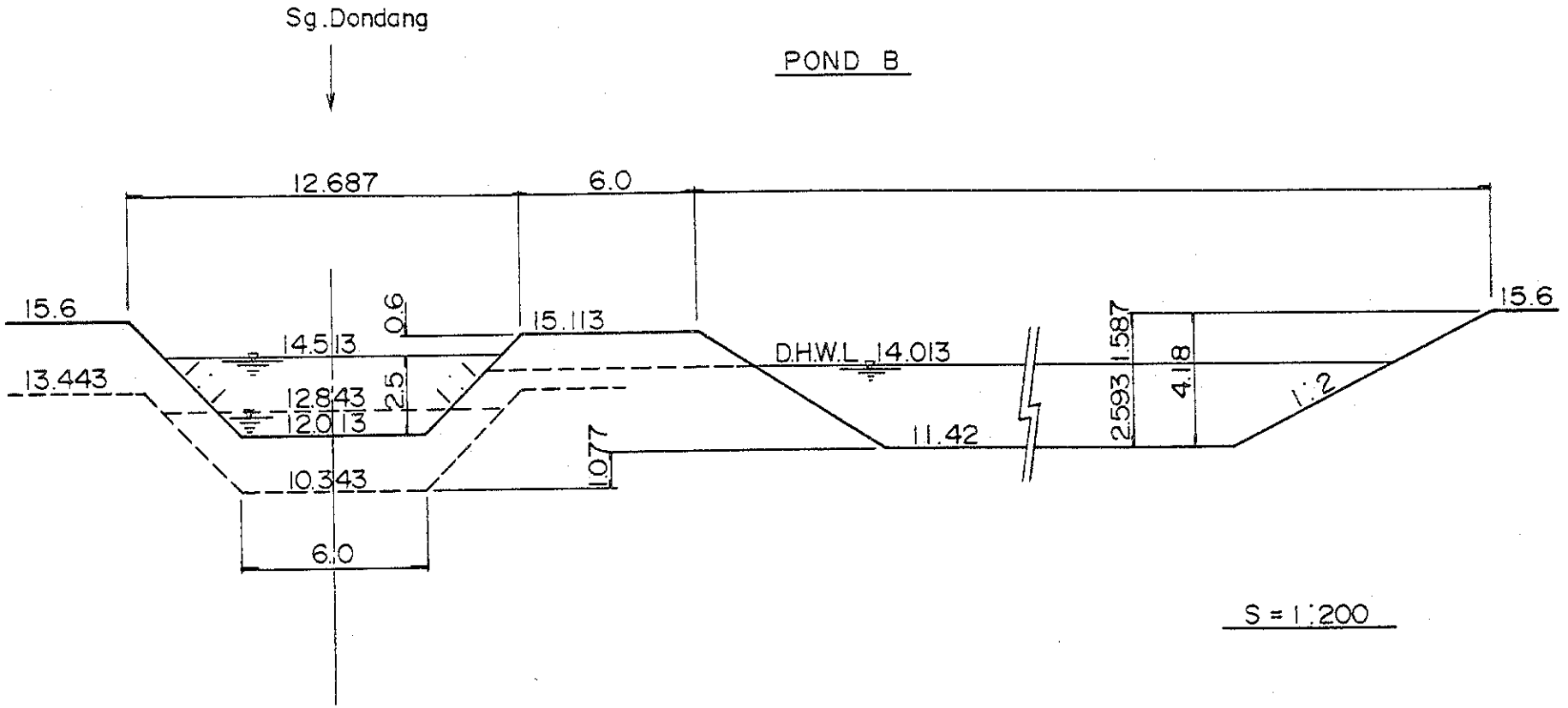


FIG. 8-28 TYPICAL CROSS SECTION OF RETENTION POND B

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

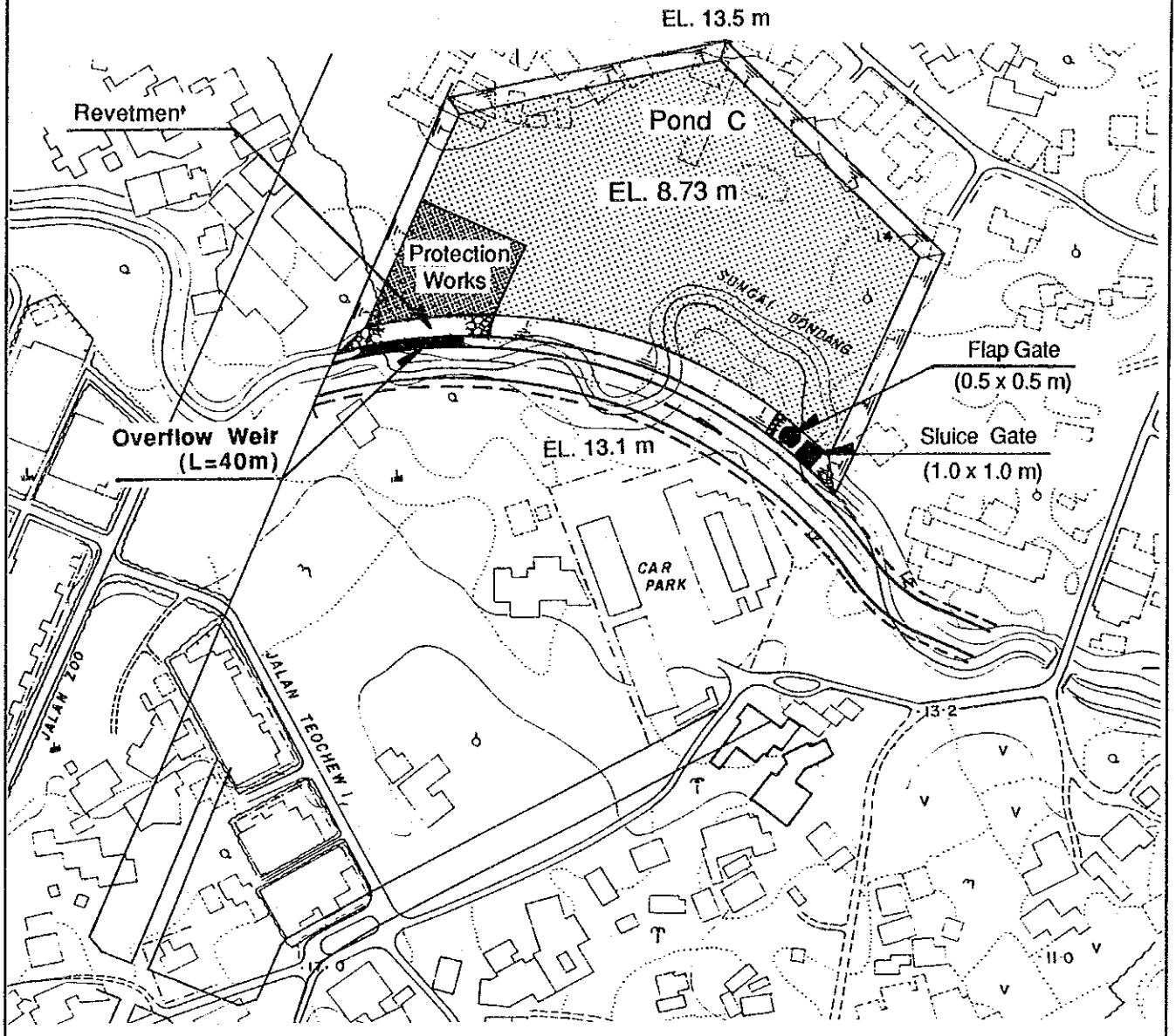


FIG. 8-29 GENERAL PLAN OF RETENTION POND C

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

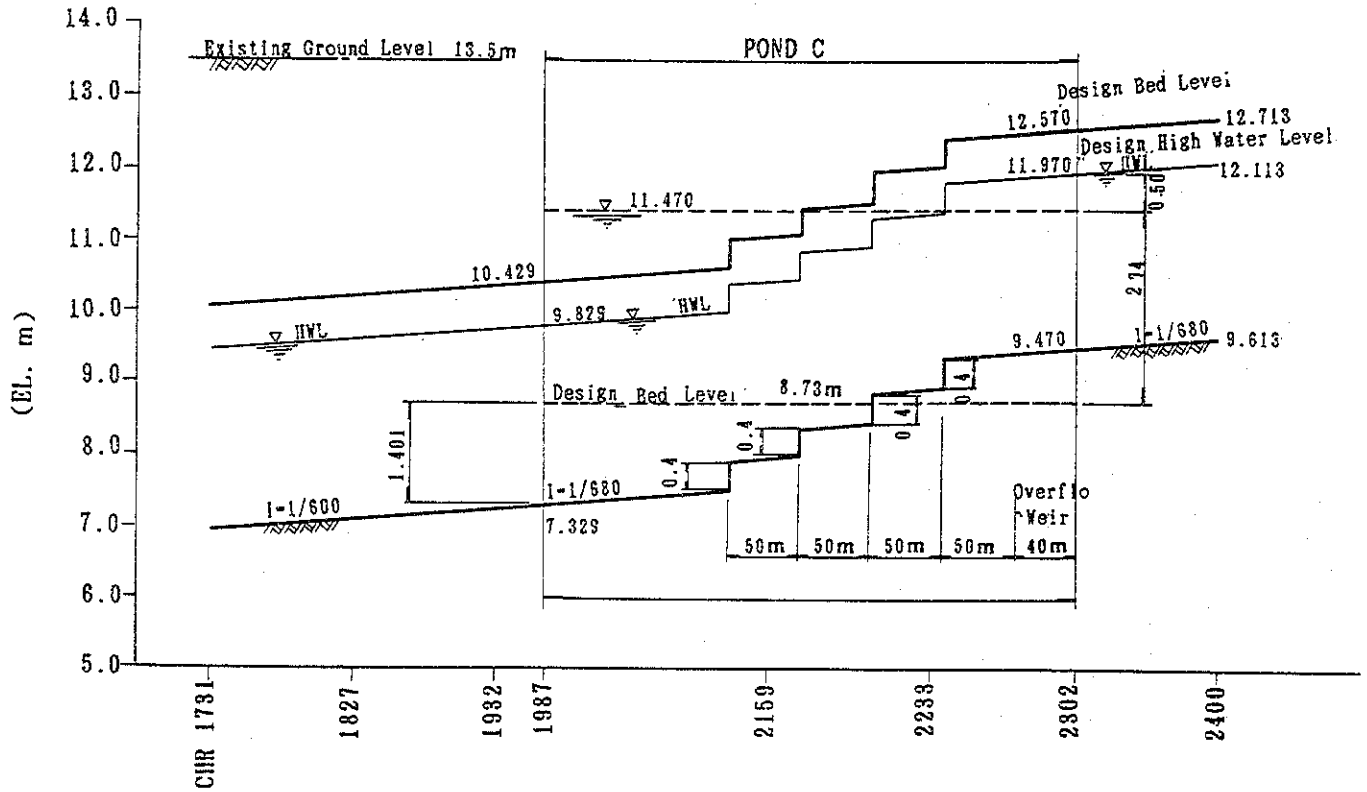


FIG.	LONGITUDINAL SECTION OF RETENTION POND C

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

JICA

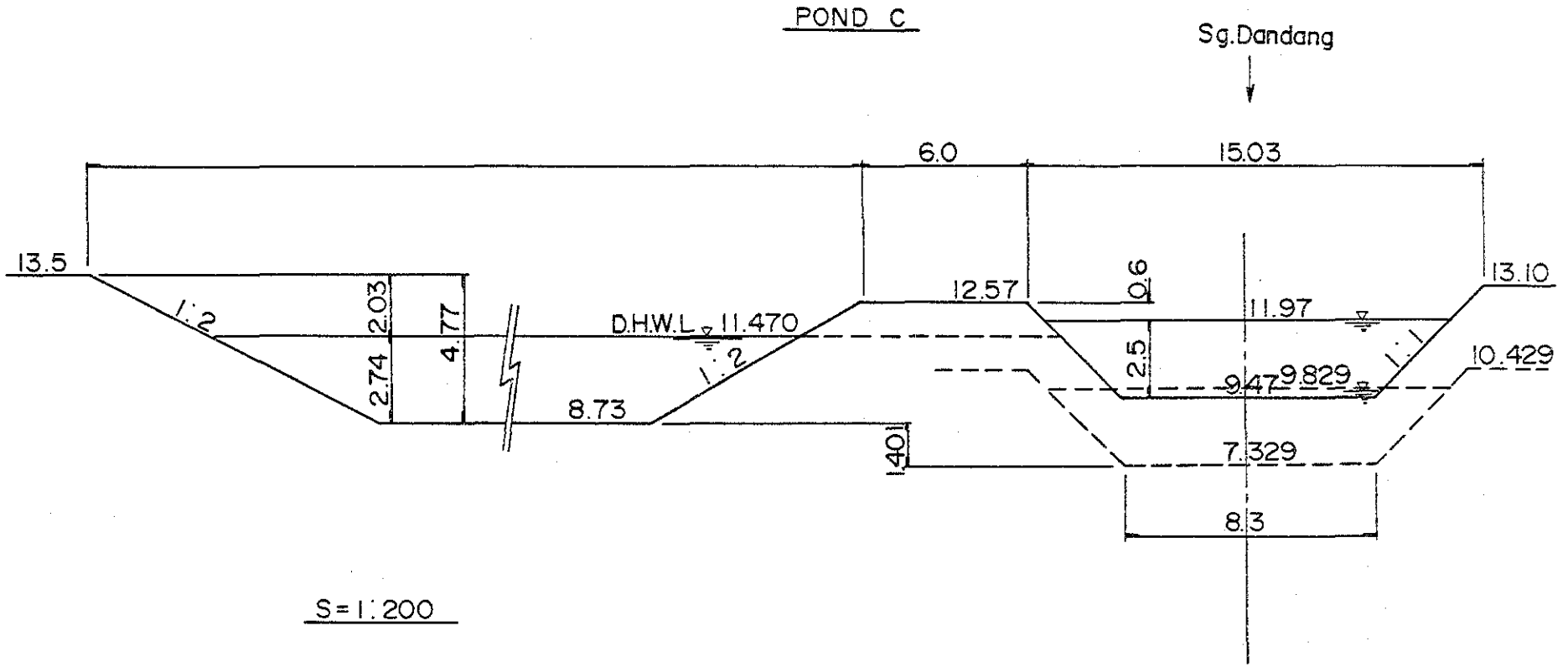
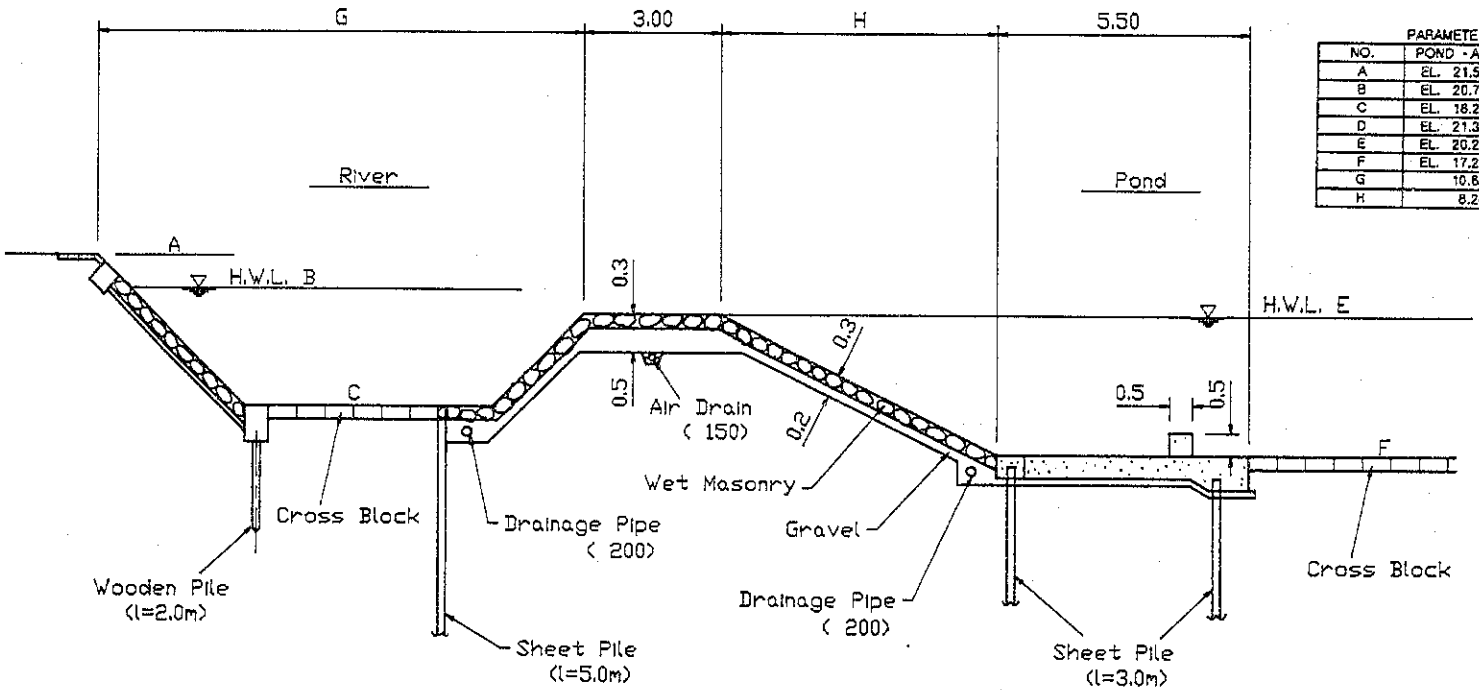


FIG. 8-31 TYPICAL CROSS SECTION OF RETENTION POND C

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

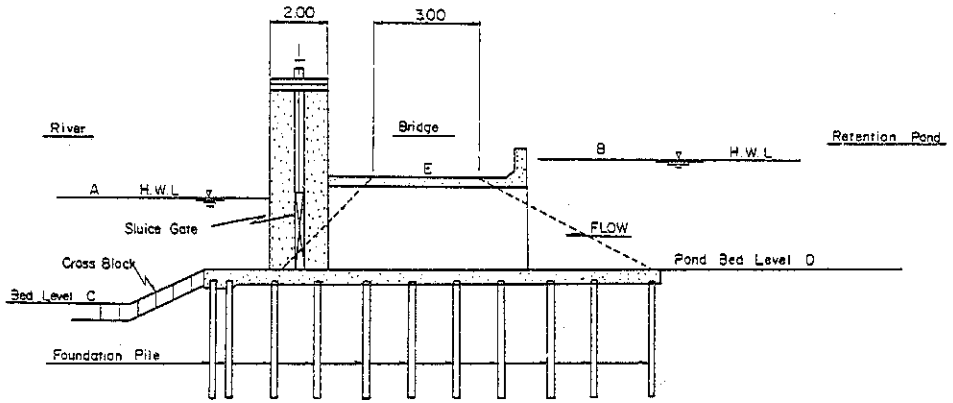


PARAMETER TABLE (m)

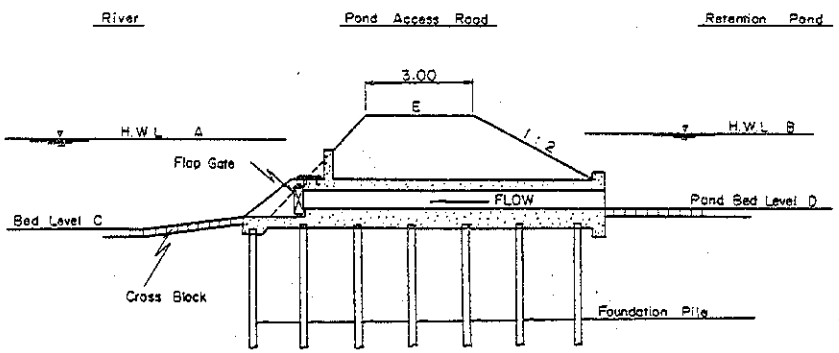
NO.	POND - A	POND - B	POND - C
A	EL. 21.50	EL. 15.80	EL. 13.10
B	EL. 20.78	EL. 14.51	EL. 11.90
C	EL. 18.28	EL. 12.01	EL. 9.47
D	EL. 21.38	EL. 15.11	EL. 12.57
E	EL. 20.28	EL. 14.01	EL. 11.47
F	EL. 17.28	EL. 11.42	EL. 8.73
G	10.82	12.69	15.03
H	8.24	7.39	7.68

FIG. 8-32 LONGITUDINAL SECTION OF OVERFLOW WEIR

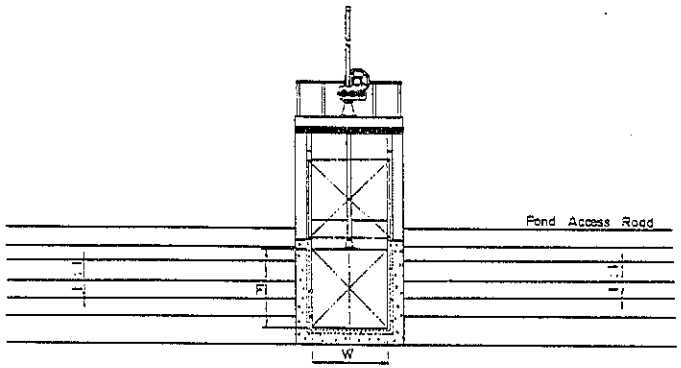
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



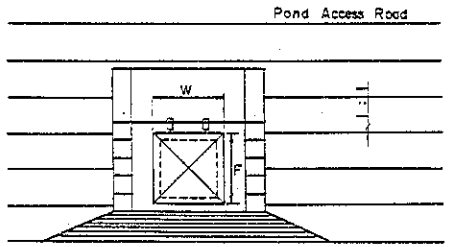
Profile of Sluice Way



Profile of Flap Gate



Front View of Sluice Gate



Front View of Flap Gate

PARAMETER TABLE (m)

NO.	POND-A	POND-B	POND-C
A	EL. 18.71	EL. 12.84	EL. 9.83
B	EL. 20.28	EL. 14.01	EL. 11.47
C	EL. 16.21	EL. 10.34	EL. 7.33
D	EL. 17.26	EL. 11.42	EL. 8.73
E	EL. 19.31	EL. 13.44	EL. 10.43
F	2.00	2.00	1.00
W	2.00	2.00	1.00

PARAMETER TABLE (m)

NO.	POND-A	POND-B	POND-C
A	EL. 18.71	EL. 12.84	EL. 9.83
B	EL. 20.28	EL. 14.01	EL. 11.47
C	EL. 16.21	EL. 10.34	EL. 7.33
D	EL. 17.26	EL. 11.42	EL. 8.73
E	EL. 19.31	EL. 12.44	EL. 10.43
F	0.50	0.50	0.50
W	0.50	0.50	0.50

FIG. 8-33 LONGITUDINAL AND CROSS SECTIONS OF OUTLET GATE OF RETENTION POND

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

Chapter 9 URGENT DRAINAGE PLAN

CHAPTER 9 URGENT DRAINAGE PLAN

9.1 INTRODUCTION

The center of Georgetown suffers from recurrent floods and needs the immediate implementation of flood mitigation works. After completion of urgent flood mitigation works for Sg. Pinang, all drainage areas in Georgetown will be released from flooding problems due to overflow from the river. However, many drains still have flooding problems due to poor drainage system.

These problems are very serious especially in the large drainage basins in lowlying areas.

The feasibility study for the Drainage Plan was carried out for such priority areas.

9.2 SELECTION OF PRIORITY AREAS FOR THE FEASIBILITY STUDY

For the priority areas of Urgent Drainage Projects, three major drainage basins in Georgetown were selected. They are S-10 (Prangin Road), S-18 (Macalister Road), and N-12 (Jalan Pangkor). Fig.9-1 shows the study areas for Urgent Drainage Projects. The reasons for selection are as follows:

i S-10 and S-18 basins have lowlying areas which are affected by high tides and become inundated without any rainfall.

ii In S-10 and S-18 basins, drainage by gravity is impossible during high tides. Drainage by pumping is required

iii S-10 and S-18 basins are located in the central part of Georgetown, and have a high priority for solving rainage problems.

iv In S-12 basin , there is a lowlying area which is commonly inundated due to the inadequate flow capacity of the drain.

9.3 DESIGN CONCEPT AND CONDITIONS FOR DRAINAGE PLAN

9.3.1 Flood Protection Level

For the Urgent Drainage Plan, the design flood protection level of 10-year return period was adopted.

Because stagewise construction of these types of facilities is extremely difficult and costly, especially in built-up urban areas.

9.3.2 Determination of Pump Capacity and Storage Capacity of Retention Pond

For the optimum combination of drainage pump and retention pond, simulation studies on the relationship between given run-off hydrograph, pump capacity and pond volume were carried out.

More details of the simulation studies are described in APPENDIX K.

The relationship between the required retention pond volume and pump capacity is shown in Fig.9-5.

Alternative cost comparison for S-10 and S-18 drainage areas was carried out and is shown in Table 9-1.

The combined construction cost of pump and retention pond is almost the same for each case.

Finally, for the S-10 drainage basin, the pump capacity of 6 m^3/s, which is similar to the existing one, was selected, while, for the S-18 drainage basin, the pump capacity of 2 m^3/s was selected considering maintenance problems and cost.

9.4 PROPOSED DRAINAGE FACILITIES

The major construction works of Urgent Drainage Projects consists of the improvement of main drains of about 3.6 km stretchs, the construction of two pump stations and two retention ponds.

9.4.1 Main Drain

The objective main drains for each catchment flow along the main road in the city and consist of concrete open channels or box culverts.

(1) S-10

The lowest ground level in this catchment is 1.4 m above M.S.W.L. To protect this lowlying area, the D.H.W.L. of the channel was decided upon below the lowest ground level. The water level in this channel will not be affected by high tides after the installation of the tidal gates which will be closed during high tides.

The type of the channel section will be either concrete open channel or box culvert according to the use conditions of the land nearby.

The existing inadequate section of the channel was planned to be improved by widening and deepening.

The plan of proposed S-10 drains is shown in Fig.9-2.

(2) S-18

The outfall of this drain was extended up to S-18 retention pond. For this stretch, two routes were compared. Route 1 flows along LEBOH SANDILANDS and has a shorter length as compared to Route 2. Route 2 is located along the Sg. Pinang and needs land acquisition. Considering the construction cost and hydraulic condition, Route 1 was selected. The existing flow capacity of the S-18 main drain is extremely small; the channel should be improved over the entire stretch. Fig.9-3 shows the plan of the proposed S-18 drains.

(3) N-12

As shown in Fig.9-4, the N-12 drainage system consists of two main drains along Jln. PERAK and LEBOH RAYA PEEL, and a trunk drain of about 250 m in length along Jln. PANGKOR.

The outfall of this drain is planned to be extended 36 m considering the proposed future Ring Road.

These two drains are of concrete box culvert type and are to be constructed under the existing road or footpath.

The existing ground level of these routes is between 3.1 to 4.5 m and, basically, is not affected by high tides.

9.4.2 Retention Pond

The retention pond will be planned to store the run-off discharge from the catchment during high tides. Under normal condition without any rainfall this run-off discharge is small and it is possible to store all of it in the retention pond remaining enough capacity without pumping. However, when rainfall intensity exceeds a certain degree, the pump will be operated to drain inner water.

The location of the retention ponds for the S-10 and S-18 drainage basins was selected considering the following conditions:

(i) Availability of land for retention pond and land acquisition cost.

(ii) Environmental impacts on the surrounding areas

(iii) Location of the areas to be protected.

(iv) Future Land Use Plan for the Coastal Area.

The S-18 Retention Pond is located outside the proposed Coastal Road. This site presents no major

environmental problems either during or after construction, and no land acquisition costs are required. However, it will be necessary to construct the dyke for the retention pond.

As for the S-10 Retention Pond Site, the area outside the proposed Coastal Road was also selected.

The general plans for the S-10 and S-18 Retention Ponds are shown in Fig.9-6 and Fig.9-7.

The design high water level of the pond will be decided by referring to the lowest ground level to be protected in the catchment and the hydraulic gradient. The lowest ground level in the S-10 and S-18 basins is +1.4 m.

The H.W.L. in the pond was set at 1.20 m.

The design low water level of the pond was set at -0.80 m by referring to M.L.W.S (Mean Low Water Spring).

The bottom level of the pond was set at about 30 cm lower than the design L.W.L. for the purpose of retaining the free storage capacity for sediment.

The effective depth of the pond is 2.0 m for both the S-10 and S-18 ponds.

By closing the sea about 4.3 ha by considering a 720 m dyke outside the proposed Coastal Road, it is planned to create storage capacity required for drainage purpose.

Each retention pond is surrounded by this closing dyke and the proposed Coastal Road.

The closing dyke consists of earth embankment with a rubble revetment and cut off sheet piles.

The dyke is about 3.4 m high and its formation level is 2.2 m having a 60 cm freeboard above the E.H.W.S.

The top of the dyke is paved and serves as a maintenance road. The inner surrounding of the retention pond is planned to have a twenty meter wide green belt for screening and preventing odor problems.

Fig.9-8 shows a typical cross section of the dyke.

9.4.3 Pump Station

1) Pump Facilities

The major facilities of each pump station consists of pumps, a tidal gate, pump house, box culvert, outlet tank and screen. The S-18 pump station is planned to have two horizontal axial flow pumps with a capacity of 1 m^3/s each.

While the S-10 pump station has three pumps of the same type with a capacity of 2 m^3/s.

The general plan and longitudinal section of the S-10 and S-18 pump stations are shown in Fig.9-9 and 9-10.

2) Tidal Gate

The sluice gate will be installed near the outlet tank to prevent the inflow of sea water during high tides.

Two 3.0 m x 3.1 m maintenance gates are to be installed at each outlet of sluice way.

Under normal conditions at low tide, these gates are to be kept open. They will only be operated during high tide.

Tables

TABLE 9-1 ALTERNATIVE COST COMPARISON OF RETENTION POND AND PUMP STATION

S-18

CASE NO.	PUMP CAPACITY (m^3 /sec.)	RETENTION POND (1000 M$)	PUMP STATION (1000 M$)	TOTAL COST (1000 M$)
1	2.0	2,477	3,242	5,719
2	4.0	1,930	3,742	5,672
3	6.0	1,512	4,092	5,604
4	8.0	1,291	4,732	6,023

S-10

CASE NO.	PUMP CAPACITY (m^3 /sec.)	RETENTION POND (1000 M$)	PUMP STATION (1000 M$)	TOTAL COST (1000 M$)
1	2.0	2,528	3,242	5,770
2	4.0	2,296	3,742	6,038
3	6.0	2,144	4,092	6,236
4	8.0	1,871	4,732	6,603

Figures

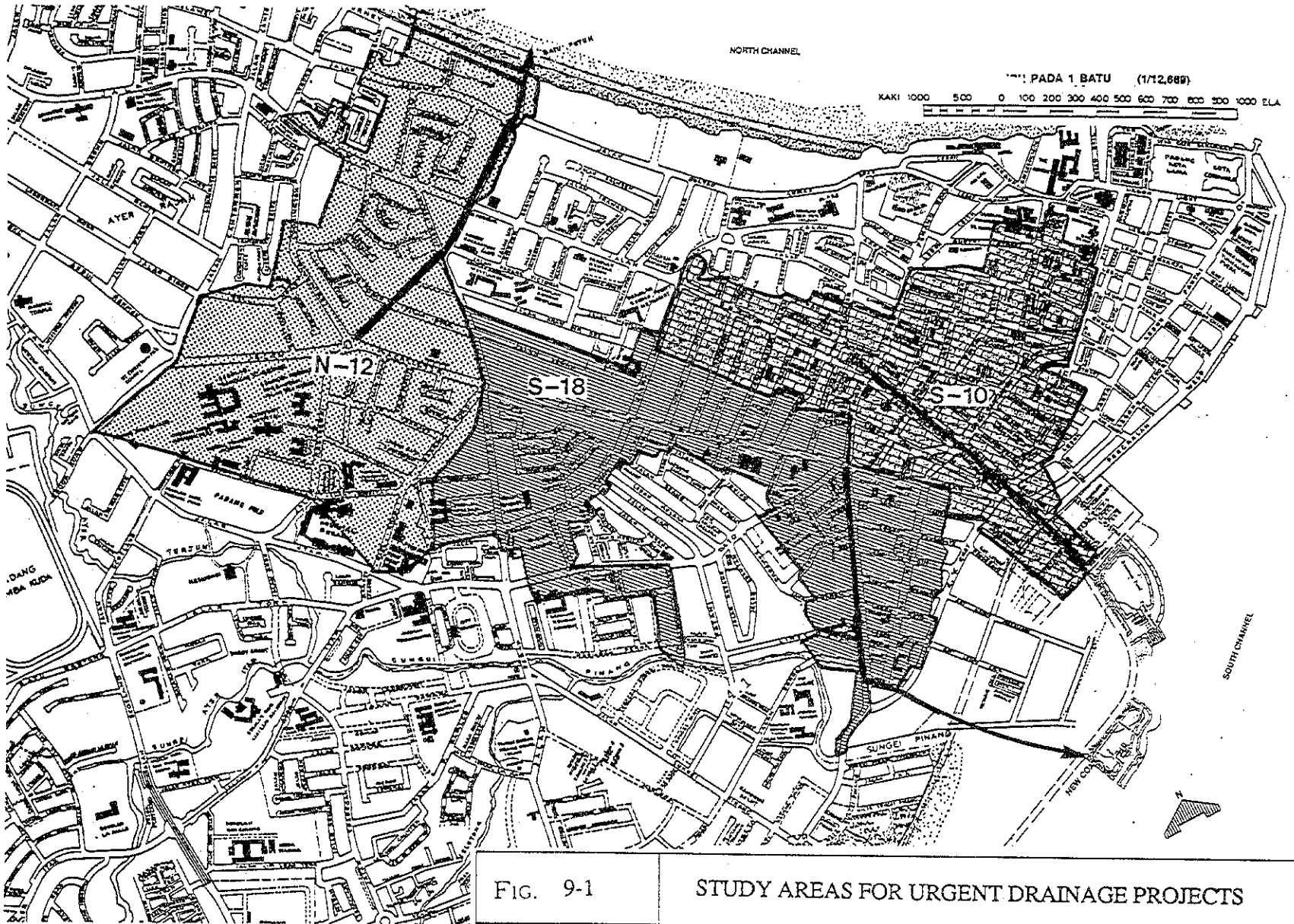
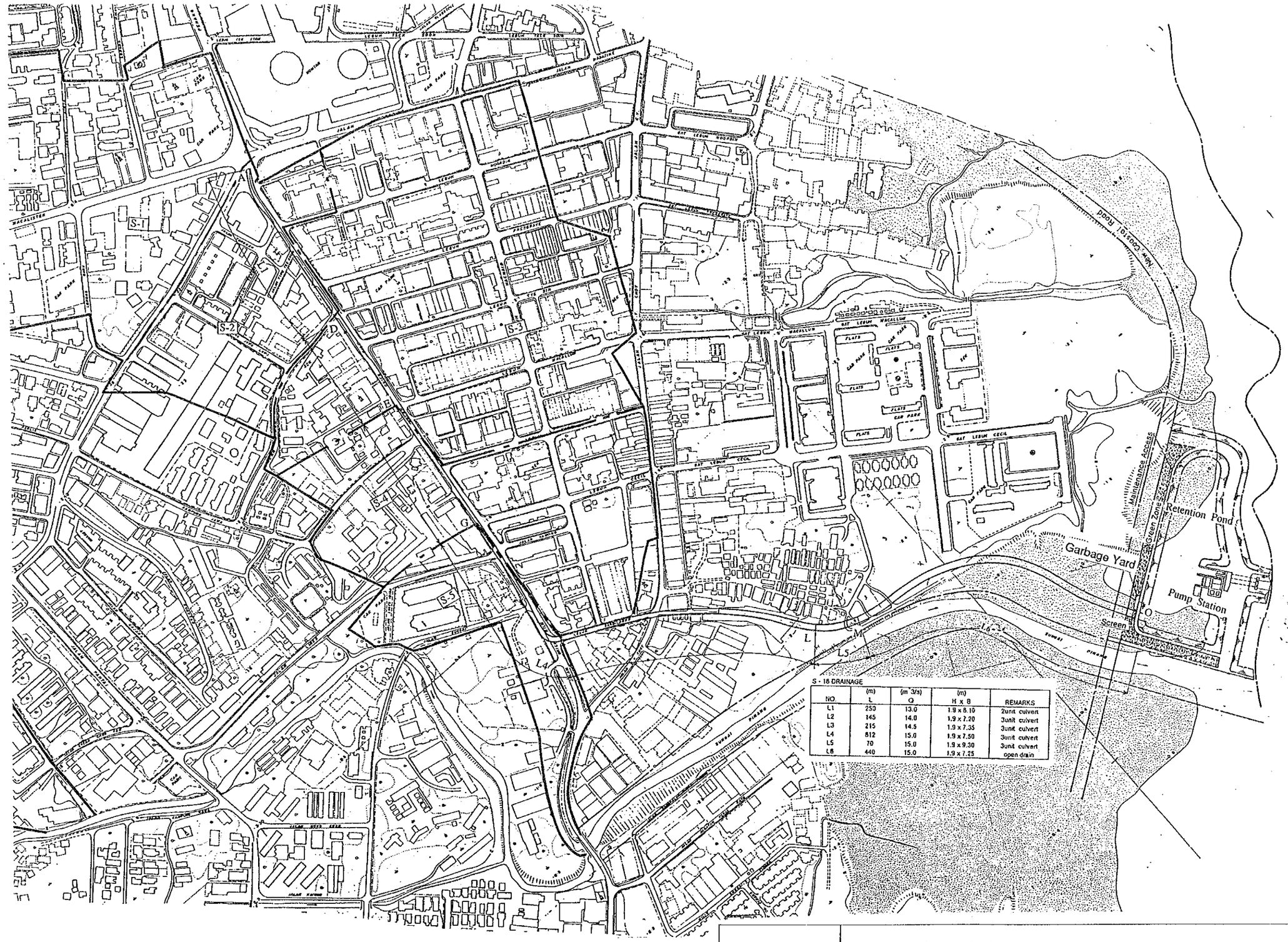


FIG. 9-1 STUDY AREAS FOR URGENT DRAINAGE PROJECTS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

FIG. 9-2 PLAN OF PROPOSED S-10 DRAINS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



S - 18 DRAINAGE

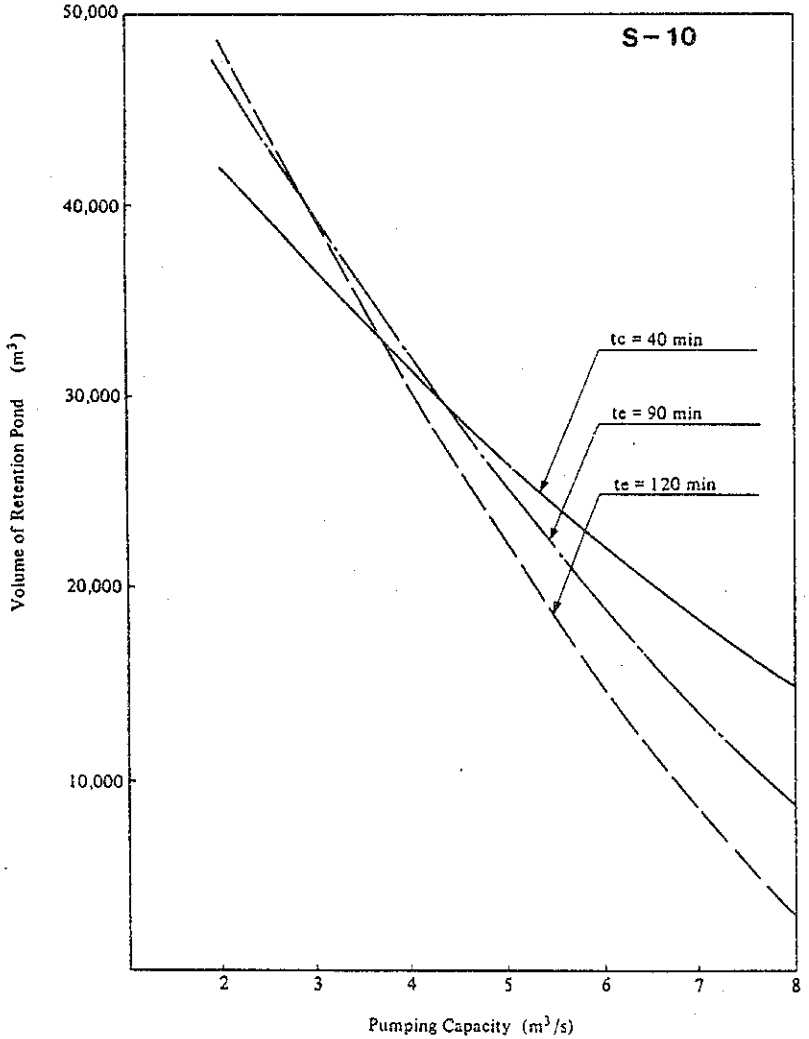
NO	(m) L	(m³/s) Q	(m) H x B	REMARKS
L1	250	13.0	1.9 x 6.10	2unit culvert
L2	145	14.0	1.9 x 7.20	3unit culvert
L3	215	14.5	1.9 x 7.35	3unit culvert
L4	512	15.0	1.9 x 7.50	3unit culvert
L5	70	15.0	1.9 x 9.30	3unit culvert
L6	440	15.0	1.9 x 7.25	open drain

FIG. 9-3 PLAN OF PROPOSED S-18 DRAINS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

FIG. 9-4	PLAN OF PROPOSED N-12 DRAINS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



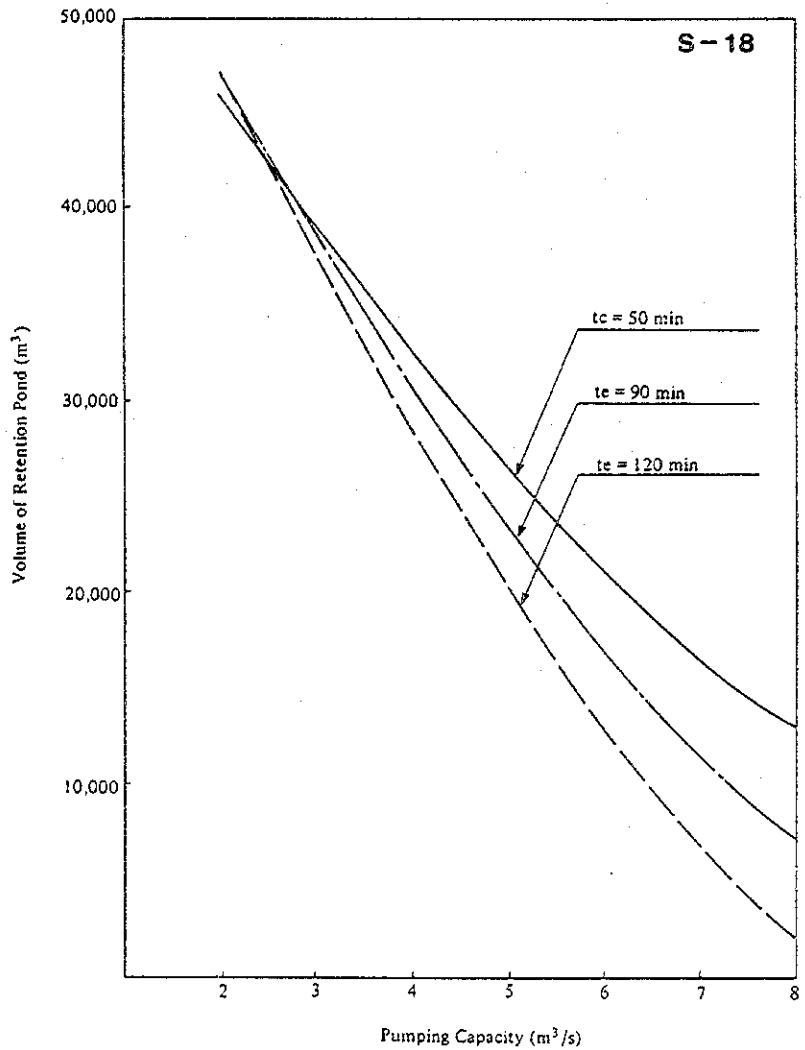


FIG. 9-5 RELATIONSHIP BETWEEN POND VOLUME AND PUMP CAPACITY

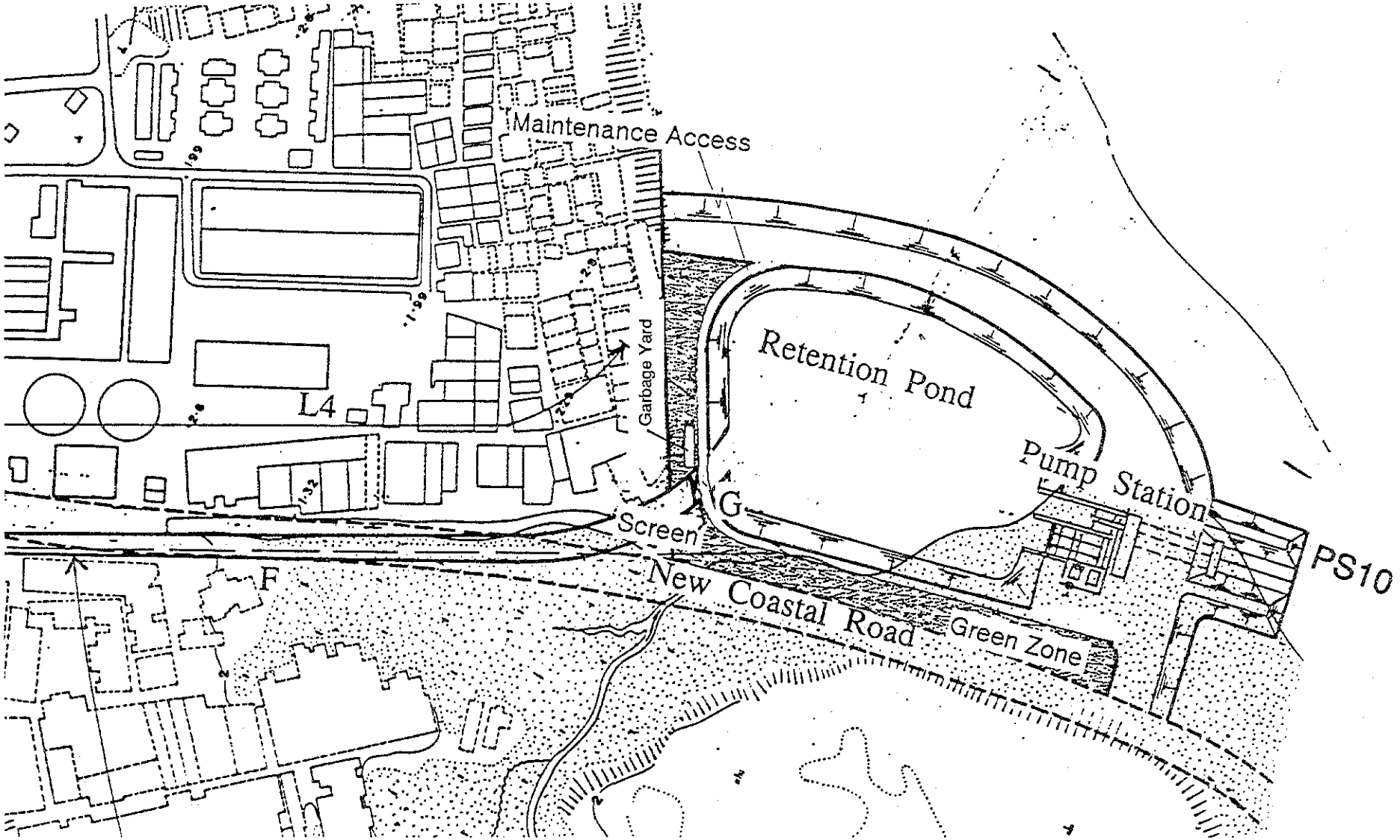


FIG. 9-6 GENERAL PLAN OF S-10 RETENTION POND

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

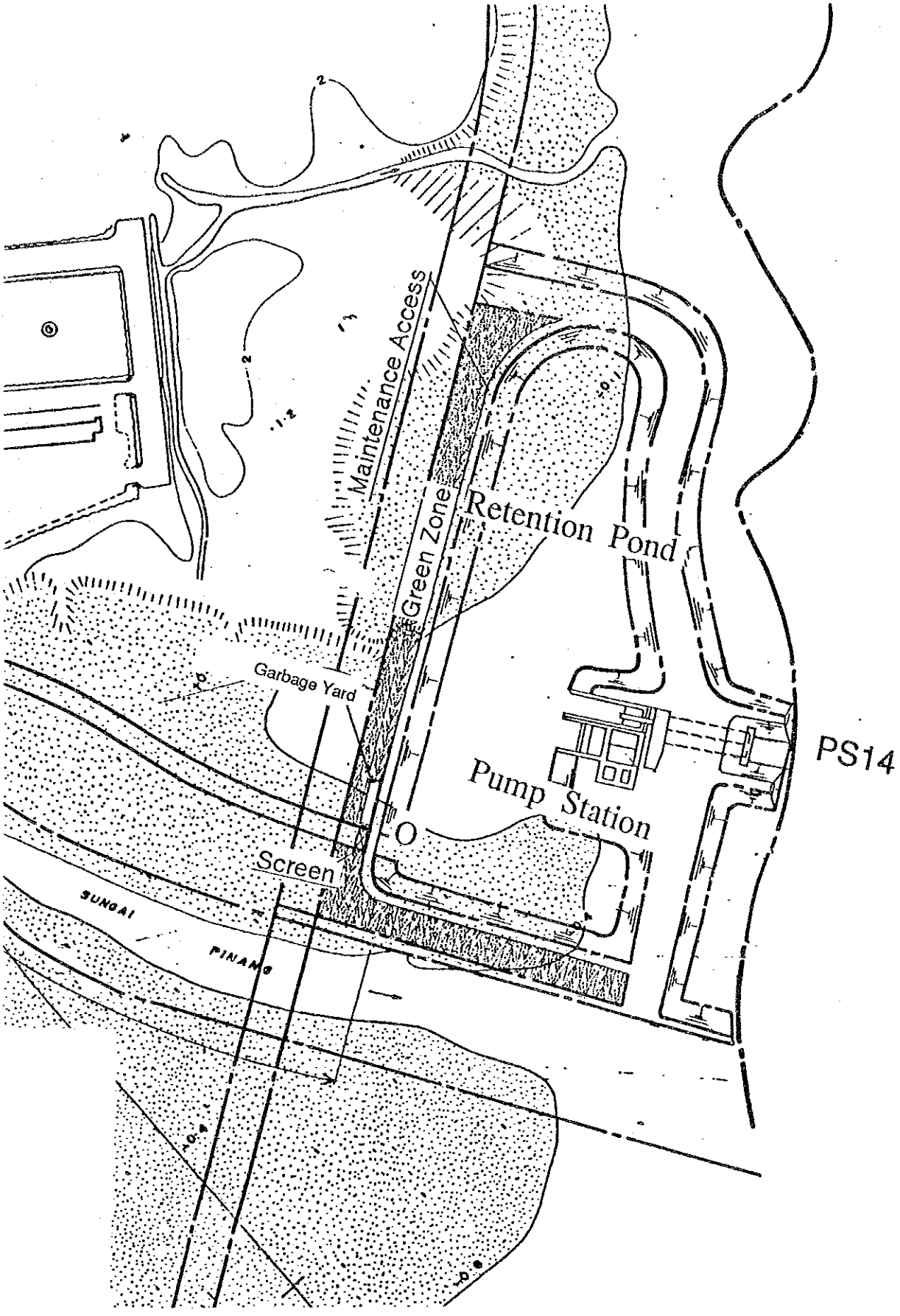
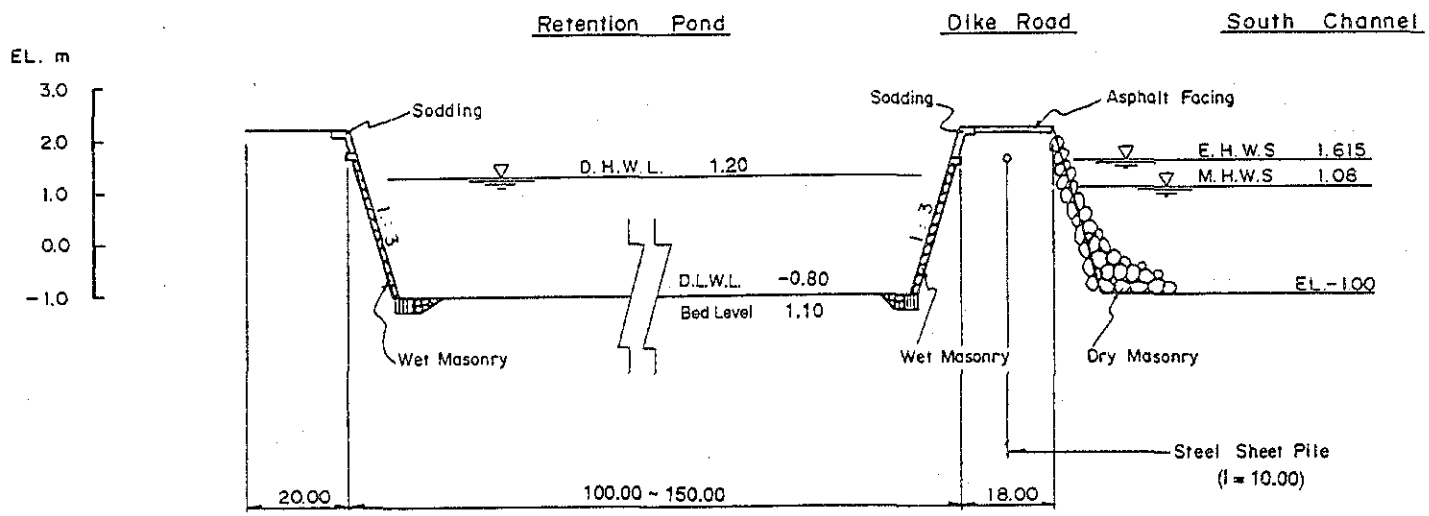


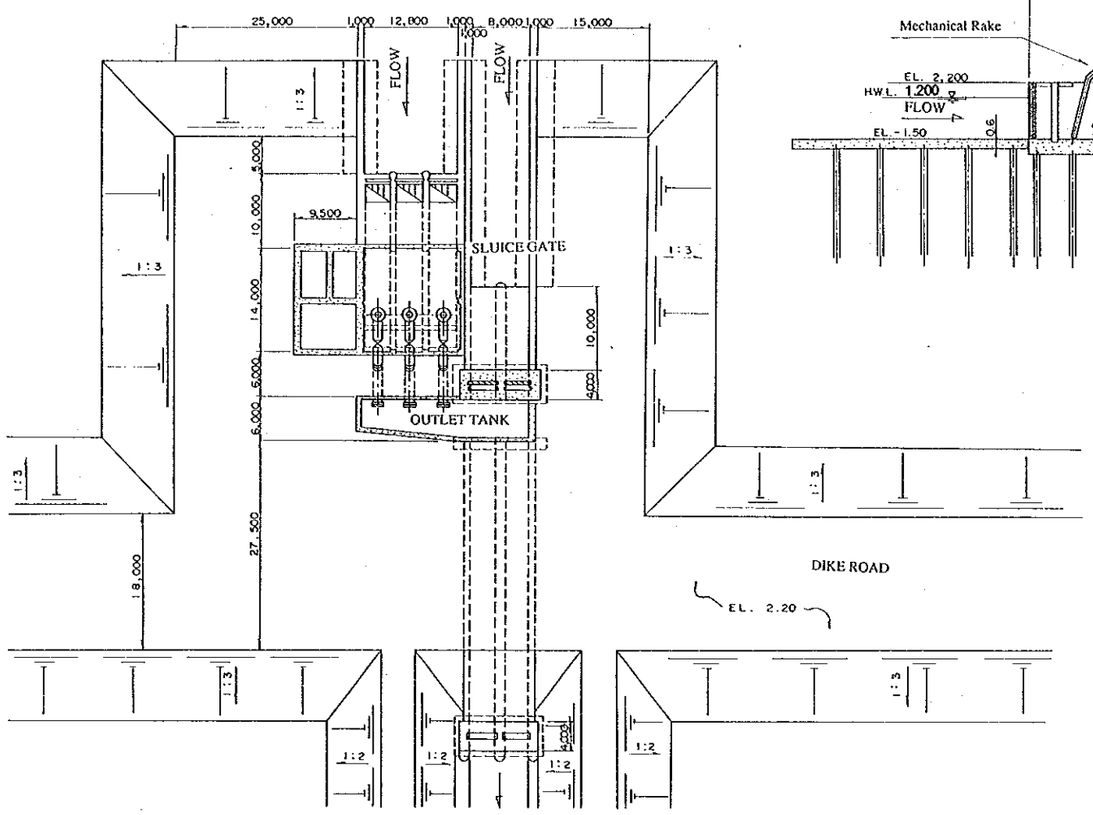
FIG. 9-7	GENERAL PLAN OF S-18 RETENTION POND



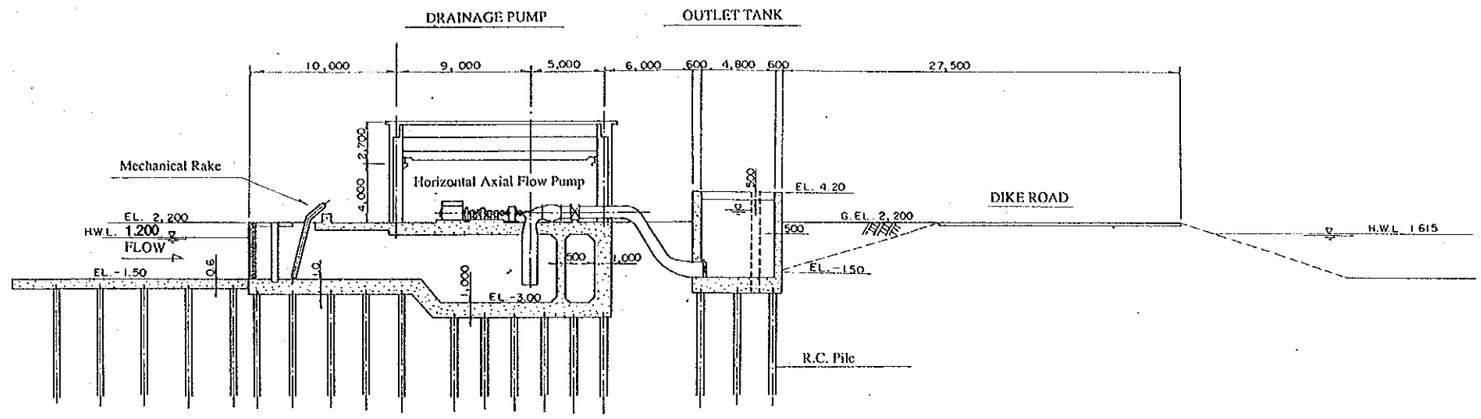
SCALE V 1 : 100
H 1 : 1000

Typical Cross Section of Retention Pond

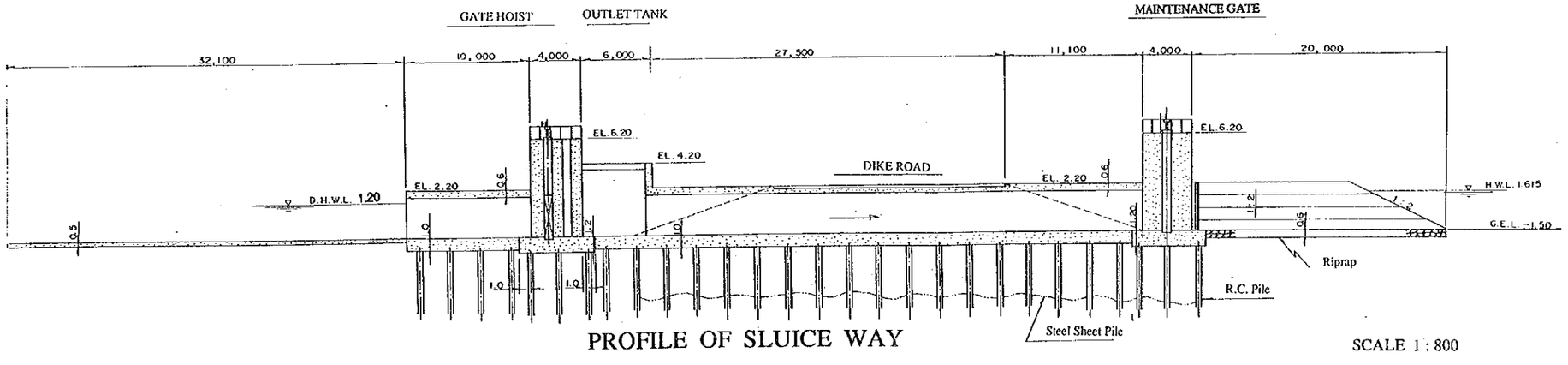
FIG. 9-8	TYPICAL CROSS SECTION OF RETENTION POND
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND	



GENERAL PLAN SCALE 1 : 400



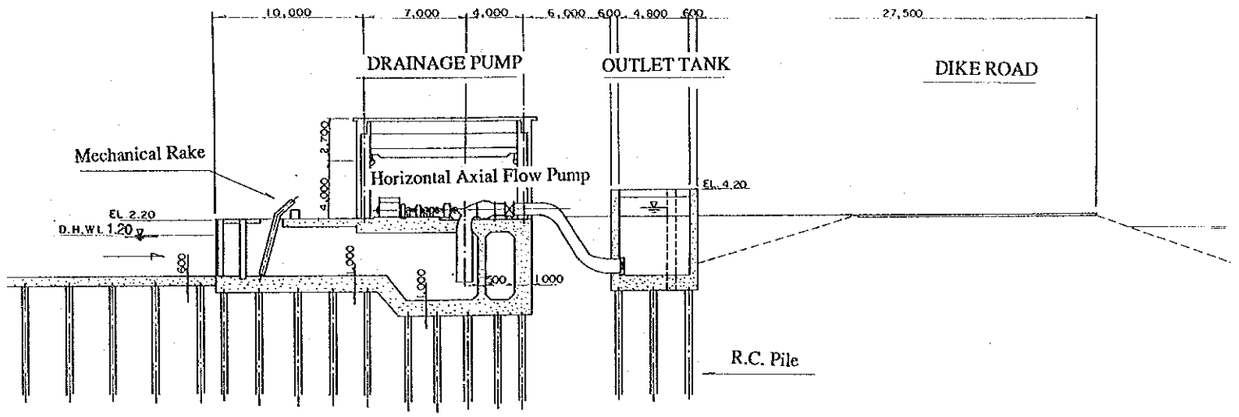
PROFILE OF DRAINAGE PUMP



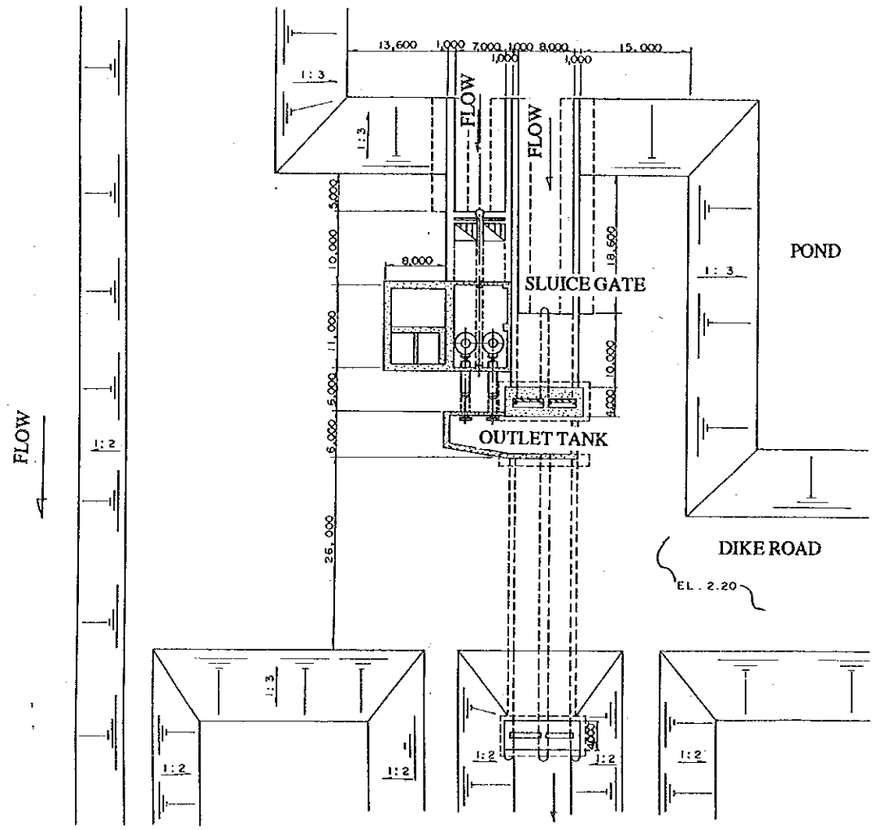
PROFILE OF SLUICE WAY SCALE 1 : 800

FIG. 9-9 PLAN, LONGITUDINAL AND CROSS SECTIONS OF S-10 PUMP STATION

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

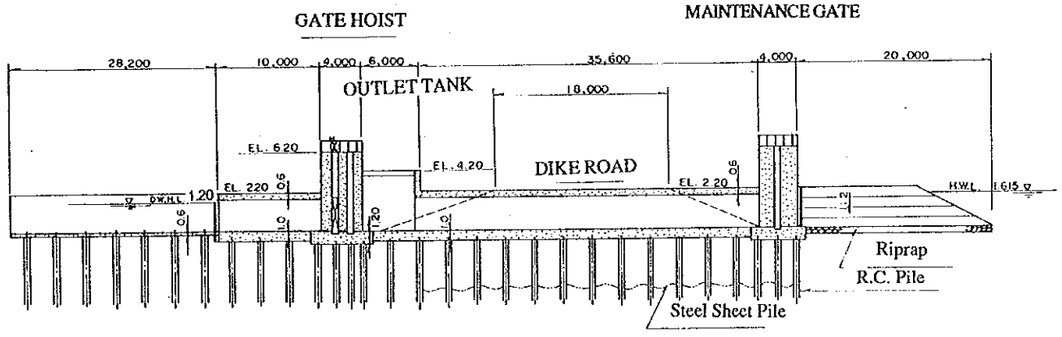


PROFILE OF DRAINAGE PUMP SCALE 1 : 600



GENERAL PLAN SCALE 1 : 400

CASE－1
(q = 1m³/sec)
SCALE 1 : 800



PROFILE OF SLUICE WAY

FIG. 9-10	PLAN, LONGITUDINAL AND CROSS SECTIONS OF S-18 PUMP STATION
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND	

Chapter 10 CONSTRUCTION PLAN AND COST ESTIMATE FOR URGENT PROJECT

CHAPTER 10 CONSTRUCTION PLAN AND COST ESTIMATE FOR URGENT PROJECTS

10.1 INTRODUCTION

The urgent projects for the construction stage (Phase I) have the following two schemes:

i) Improvement of two major river systems (Sg. Pinang and Sg. Keluang), including some stretches of Sg. Gelugor and Sg. Dua Besar.

ii) Improvement of three major drainage systems in Georgetown (S-10, S-18 and N-12 drainage basins).

The Five-year Construction Plan is adopted for executing these urgent projects.

10.2 CONSTRUCTION WORK FOR URGENT PROJECTS

The construction work for the Urgent Flood Mitigation and Drainage Projects consist mainly of excavation, embankment and bank protection for channel improvement, the construction of retention ponds, the construction of structures, such as concrete diversion channels, gates, culverts, bridges and drop structures, the construction of drainage pump stationss, and the improvement of trunk drains.

The required major construction works are as follows:

- Improvement of Sg. Pinang (13.3 km), Sg. Keluang (5.25 km), downstream stretches (0.5 km and 2.1 km of the Sg. Gelugor and Sg. Dua Besar respectively).

- Construction of Air Terjun (1.74 km) and Relau (1.5 km) Diversion Channels.

- Construction of Dondang Retention Ponds at three (3) locations. They will have a total capacity of 8.4 ha.

- Construction of river related structures, mainly the renewal of existing bridges.

- Improvement of trunk drains N-12, S-10 and S-18 (about 4.5 km in total length).

- Construction of a retention pond (1.9 ha) and pumping station (6.0 m^3/s) for the S-10 drainage area.

- Construction of a retention pond (2.4 ha) and pumping station (2.0 m^3/s) for the S-18 drainage area.

10.3 CONSTRUCTION PLAN

10.3.1 Basic Considerations for Planning

The construction plan for executing the projects is formulated by taking into account the following:

a. The construction work is to be conducted in Penang Island and its central areas which are mainly international tourist resorts. Therefore, it is obliged that maintenance of environmental aspects, protection of existing public infrastructures and other relevant works will be required.

b. Considering the degree of urgency and importance and the 6th Malaysia Plan (1991 - 1995), it is planned that the urgent project construction work is to be implemented within three (3) years stating at the beginning of 1993. Pre-construction works (detailed design, tendering, financial arrangement and others) are scheduled to be carried out within a two (2) year period (1991 to 1992).

c. The river improvement and drainage works will proceed simultaneously and will be completed within a three (3) year period.

d. Major work items for the river improvement include channel widening and deepening by excavation or dredging, revetment by wet masonry or concrete and levee embankment. Medium to small class equipment will be planned to be utilized considering the site conditions, such as urbanized area, the dense area of buildings, traffic and other restricted conditions. Excavated soil will be planned to be utilized effectively as material for the levee embankment, land reclamation of CDD 21, and others.

e. A phased and rapid construction system will be applied for the Air Terjun Diversion Channel. Traffic, so far as practicable, will not be obstructed.

10.3.2 Construction Schedule

The proposed implementation schedule and construction time schedule for the urgent projects are given in Fig.10-1 and 10.2 respectively.

10.4 CONSTRUCTION COST FOR THE PROJECT

10.4.1 Conditions and Assumptions for Cost Estimate

The construction cost consists of these required for civil works, land acquisition and building compensation, engineering and administration costs, and contingencies.

The following conditions were applied for arriving at the financial cost estimate.

- The price level prevailing in August 1990 was applied. That was the time when the survey and investigation work was conducted at the site.

- The following foreign exchange rate was adopted for conversion purposes.

  One (1) US$ = M$ 2.70 = Yen 140.0

1) Composition of financial cost

The financial cost of the urgent projects consists of the following items:

- Direct construction cost
- Land acquisition and building compensation cost
- Administration cost
- Engineering services cost for the detailed design including hydraulic model test and construction supervision.
- Physical and price contingencies

2) Currency of estimate

The estimated costs are indicated by the Malaysian Dollar both for the foreign currency portion and local currency portion.

3) Disbursement of investment cost

It is assumed that the investment cost will be disbursed according to the proposed implementation schedule starting at the detailed design stage.

10.4.2 Estimate of Construction Cost

1) Direct Construction Cost

The direct construction cost for civil works is estimated by multiplying the unit cost of each work item by the corresponding work quantity. The unit cost of

respective work item consists of the cost for materials, labourers, equipment, and contractor's indirect costs for site expenses, overhead and profit. Required preparatory works such as access roads, construction roads, temporary buildings and others are estimated on a lump sum basis and are incorporated as the general items. The replacement costs for public utilities are estimated on a lump sum basis and treated as the provisional sum cost items incorporating the general items.

2) Land Acquisition and Building Compensation Cost

These costs are estimated based on the unit cost which were established by following the data obtained from the State Valuation Department. The costs are incorporated into the local currency component.

3) Administrative Cost

The cost for the project's administration, management and supervision for the implementation of the urgent projects was estimated in proportion to the direct construction cost. An allowance of about 5 % of the total direct construction cost was provided for the cost and incorporated in the local currency component.

4) Engineering Services Cost

The cost was also estimated in propotion to the direct construction cost to cover the detailed design, hydraulic model tests and construction supervision by consultants. The engineering services cost was estimated to be about 10% of the total direct construction cost and its 80% was incorporated into the foreign currency component and 20% into the local currency component.

5) Contingencies

Physical contingency

The physical contingency was provided to cope with the unpredictable physical conditions during implementation of the urgent projects amounting to approximately 15% of the total direct cost.

Price contingency

The price contingency was provided for the reflection of the inflational effect against the implementation of the urgent projects. The price contingency for the financial cost was estimated assuming the inflational rate to be 3% per annum for foreign currency and 3.2% for local currency portions by referring the inflational rate (3.2%) for the whole country of Malaysia in 1990.

10.4.3 Financial Cost of Urgent Projects

The financial cost for the urgent projects is summarized as follows.

Unit : Million M$

Project	Amount (M$)	Equivalent US$
- Sg. Pinang System	135.5	(50.2)
- Sg. Keluang System	40.2	(14.9)
- Georgetown Drainage	37.9	(14.0)
Total	213.6	(79.1)

The breakdown of the financial cost for each urgent project is shown in Table 10-1 to 10-4.

10.4.4 Annual Disbursement Schedule

The annual disbursement of investment costs was allocated on the basis of the implementation schedule and is summarized as follows.

Annual Disbursement Schedule for Financial Cost of Urgent Project

Unit : Million M$

Year/Projcet	Sg.Pinang		Sg.Keluang		Drainage		Total	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
1991	0.6		0.2		0.4		1.2	
	2.5	0.6		0.2		0.5		1.3
1992	0.6		0.2		0.5		1.3	
	62.9	47.1		13.6		0.9		61.6
1993	10.0		3.2		9.1		22.3	
	95.5	52.9		15.4		4.9		73.2
1994	7.8		2.5		7.1		17.4	
	26.1	3.9		1.2		3.6		8.7
1995	8.0		2.5		7.2		17.7	
	26.6	4.0		1.2		3.7		8.9
	27.0	108.5	8.6	31.6	24.3	13.6	59.9	153.7
Total 213.6	135.5		40.2		37.9			

The annual disbursement schedule for each project is shown in Table L-6 in APPENDIX L.

10.4.5 Operation and Maintenance Cost

The annual operation and maintenance (O & M) costs for the urgent projects were estimated for the said works as shown in Table L-13 in APPENDIX L. The O & M costs include the salary of operation and maintenance staffs, materials, labours and equipment costs for O & M works required for the project's facilities. Thus, the annual O & M cost for the urgent projects was estimated to be M$ 0.3 million in total.

Unit : 1,000M$

Category	O & M Costs
- Flood mitigation facilities (rivers/retention ponds)	100
- Drainage facilities (pumps/retention ponds)	200
Total	300

10.4.6 Replacement Cost

Some of the project's facilities, especially mechanical and electrical equipment have, a shorter useful life than the concrete or earthing structures, and require replacement at a certain time during their project service life. The yearly replacement costs were estimated to be about M$0.1 million for flood mitigation facilities every 20 years and about M$3.0 million for drainage facilities.

Tables

TABLE 10 -1 SUMMARY OF FINANCIAL COST FOR THE URGENT PROJECTS

(10^3 M$)

Cost Items	Costs		
	F.C.	L.C.	Amount
1. Direct Construction Cost	42,200	19,320	61,520
2. Land acquisition & house evacuation cost	-	98,490	98,490
3. Administration expenses<1	-	3,100	3,100
4. Engineering services cost<2	4,220	1,930	6,150
Sub total (1 - 4)	46,420	122,840	169,260
5. Contingency			
(1) Physical contingency<3	6,960	18,430	25,390
(2) Price contingency<4	6,380	12,620	19,000
Sub total	13,340	31,050	44,390
Total (1 - 5)	59,760	153,890	213,650

Notes :

* F.C. : Foreign currency component
* L.C. : Local currency component

<1 : 5% of (1) approximately

<2 : 10% of (1) approximately for detailed design and of direct cost and construction supervision

<3 : 15% approximately of base cost(1 - 4)

<4 : 3% for F.C. and 3.2% for L.C. per annum (1991 - 1995)

TABLE 10 -2 SUMMARY OF FINANCIAL COST FOR THE URGENT PROJECT
SG.Pinang System

(10^3 M$)

Cost Items	Costs		
	F.C.	L.C.	Amount
1. Direct Construction Cost	19,040	8,630	27,670
2. Land acquisition & house evacuation cost	-	75,950	75,950
3. Administration expenses<1	-	1,380	1,380
4. Engineering services cost<2	1,900	860	2,760
Sub total (1 - 4)	20,940	86,820	107,760
5. Contingency			
(1) Physical contingency<3	3,140	13,020	16,160
(2) Price contingency<4	2,880	8,650	11,530
Sub total	6,020	21,670	27,690
Total (1 - 5)	26,960	108,490	135,450

Notes :

* F.C. : Foreign currency component
* L.C. : Local currency component

<1 : 5% of(1) approximately

<2 : 10% of(1)approximately for detailed design and of direct cost and construction supervision including hydraulic model test

<3 : 15% approximately of base cost(1 - 4)

<4 : 3% for F.C. and 3.2% for L.C. per annum (1991 - 1995)

<5 : Sg.Pinang System contains Sg.Pinang, Sg.Air Itam Sg. Dondang,Sg.Jelutong,Terjun Diversion

TABLE 10 -3 I SUMMARY OF FINANCIAL COST FOR THE URGENT PROJECT
SG.Keluang System

(10^3 M$)

Cost Items	Costs		
	F.C.	L.C.	Amount
1. Direct Construction Cost	6,070	2,700	8,770
2. Land acquisition & house evacuation cost	-	21,910	21,910
3. Administration expenses<1	-	440	440
4. Engineering services cost<2	610	270	880
Sub total (1 - 4)	6,680	25,320	32,000
5. Contingency			
(1) Physical contingency<3	1,000	3,800	4,800
(2) Price contingency<4	910	2,520	3,430
Sub total	1,910	6,320	8,230
Total (1 - 5)	8,590	31,640	40,230

Notes :

* F.C. : Foreign currency component
* L.C. : Local currency component

<1 : 5% of (1) approximately

<2 : 10% of (1) approximately for detailed design and of direct cost and construction supervision

<3 : 15% approximately of base cost(1 - 4)

<4 : 3% for F.C. and 3.2% for L.C. per annum (1991 - 1995)

<5 : Sg.Keluang System contains Sg.Keluang, Sg.Ara Sg.Gelugor, Sg. Dua Besar

TABLE 10 -4 SUMMARY OF FINANCIAL COST FOR THE URGENT PROJECT URBAN DRAINAGE WORKS

(10^3 M$)

Cost Items	Costs		
	F.C.	L.C.	Amount
1. Direct Construction Cost	17,090	7,990	25,080
2. Land acquisition & house evacuation cost	-	630	630
3. Administration expenses<1	-	1,260	1,260
4. Engineering services cost<2	1,710	800	2,510
Sub total (1 - 4)	18,800	10,680	29,480
5. Contingency			
(1) Physical contingency<3	2,820	1,600	4,420
(2) Price contingency<4	2,600	1,440	4,040
Sub total	5,420	3,040	8,460
Total (1 - 5)	24,220	13,720	37,940

Notes :

* F.C. : Foreign currency component
* L.C. : Local currency component

<1 : 5% of(1) approximately

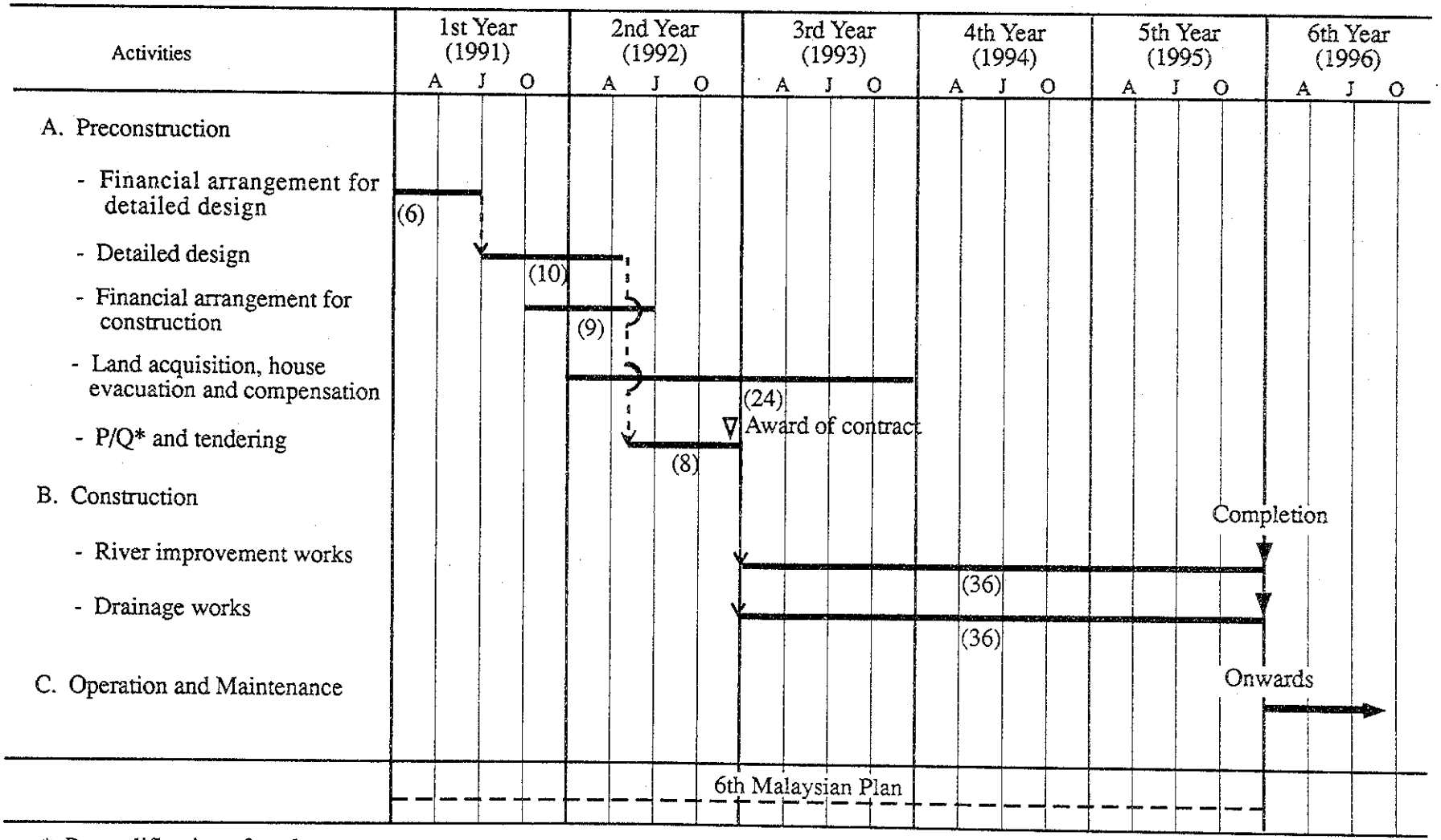
<2 : 10% of(1)approximately for detailed design and of direct cost and construction supervision

<3 : 15% approximately of base cost(1 - 4)

<4 : 3% for F.C. and 3.2% for L.C. per annum (1991 - 1995)

Figures

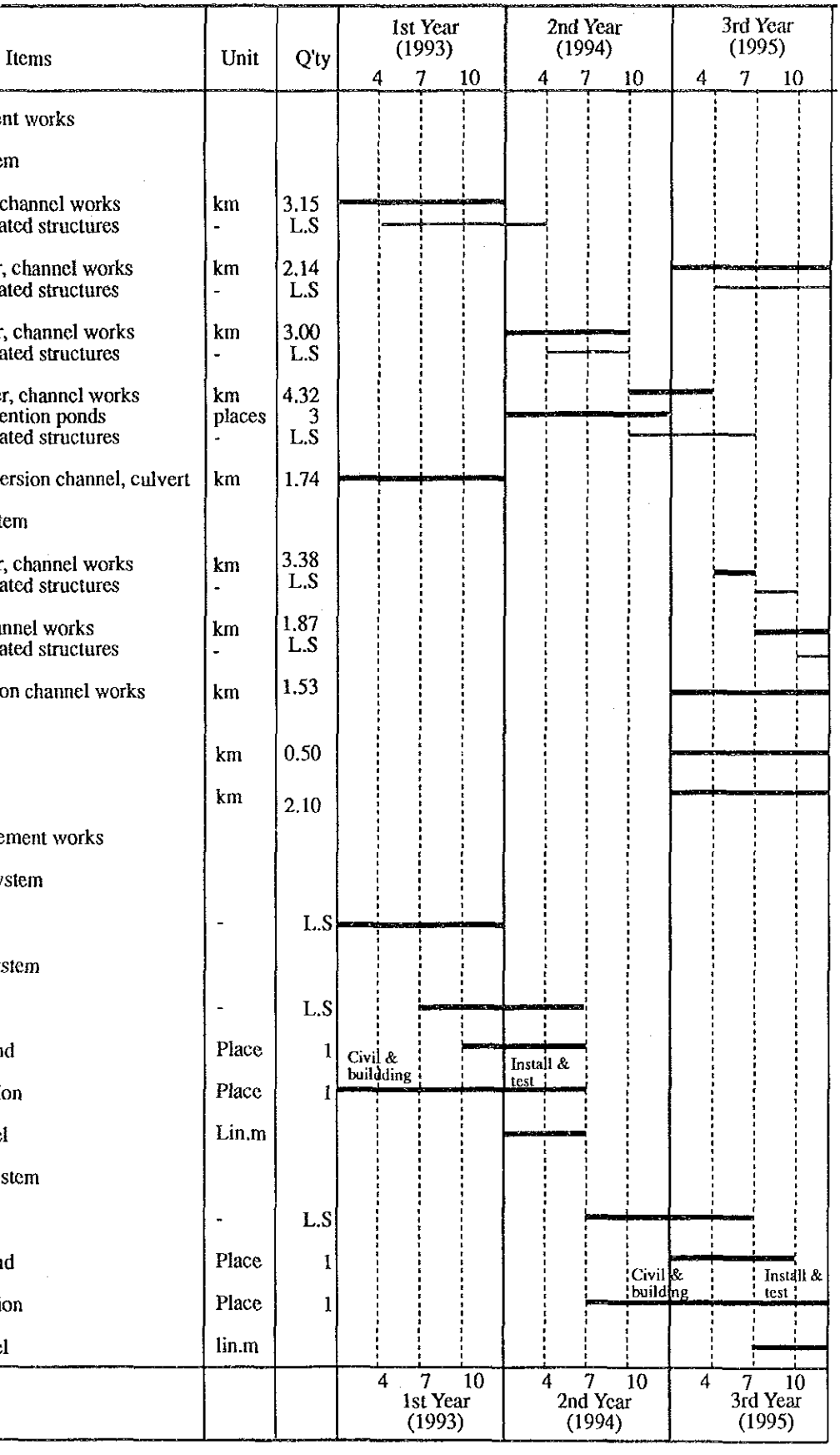
FIG. 10-1 IMPLEMENTATION SCHEDULE FOR THE URGENT PROJECTS



* Prequalification of tender

Fig. 10-2 CONSTRUCTION TIME SCHEDULE FOR THE URGENT PROJECTS

Work Items	Unit	Q'ty
A. River improvement works		
1. Sg. Pinang system		
(1) Pinang river, channel works	km	3.15
, related structures	-	L.S
(2) Jelutong river, channel works	km	2.14
, related structures	-	L.S
(3) Air Itam river, channel works	km	3.00
, related structures	-	L.S
(4) Dondang river, channel works	km	4.32
, retention ponds	places	3
, related structures	-	L.S
(5) A. Terjun diversion channel, culvert	km	1.74
2. Sg. Keluang system		
(1) Keluang river, channel works	km	3.38
, related structures	-	L.S
(2) Ara river, channel works	km	1.87
, related structures	-	L.S
(3) Relau diversion channel works	km	1.53
3. Sg. Gelugor	km	0.50
4. Sg. Dua Besar	km	2.10
B. Drainage improvement works		
1. N-12 drainage system		
(1) Trunk drains	-	L.S
2. S-10 drainage system		
(1) Trunk drains	-	L.S
(2) Retention pond	Place	1
(3) Pumping station	Place	1
(4) Outlet channel	Lin.m	
3. S-18 drainage system		
(1) Trunk drains	-	L.S
(2) Retention pond	Place	1
(3) Pumping station	Place	1
(4) Outlet channel	lin.m	



Chapter 11 OPERATION AND MAINTENANCE PLAN FOR URGENT PROJECT S

CHAPTER 11 OPERATION AND MAINTENANCE PLAN FOR URGENT PROJECTS

11.1 PRESENT STATUS OF OPERATION AND MAINTENANCE OF THE EXISTING FLOOD MITIGATION AND DRAINAGE FACILITIES

The activities of operation and maintenance (O/M) for the existing major facilities of flood mitigation and drainage are as follows:

Flood Mitigation

a) Periodical dredging in Sg. Pinang and other rivers.
b) Periodical removal of floating debris by screening.
c) Clearing of river banks and leveling of maintenance road surface.
d) O/M of flood forecasting and warning system.

Drainage

a) Periodical removal of sediments and floating debris by screening.
b) Maintenance of flap gates.
c) Removal of floating debris in Prangin Pump Station
d) O/M of Prangin Pump Station. (S-10 Drain)

These activities are conducted mainly by State DID and MPPP. However, due to budget constraints and the ambiguousness of the demarcation of river stretches among the agencies concerned, these flood control and drainage activities are still at a rather unsatisfactory level. Among these facilities, Prangin Pumping Station especially, has a problem of O/M. The present status of this pump station is summarized in Table N-1 in APPENDIX-N.

11.2 REQUIRED OPERATION AND MAINTENANCE WORKS

In the urgent projects, several new facilities for flood mitigation are to be constructed. They are the Dondang retention ponds, the diversion channels, water gates, tidal gates and pumping station. Hence, to ensure the expected beneficial effects of both the existing and proposed flood mitigation and drainage facilities, the following O/M works are strongly recommended to be undertaken by the relevant agencies:

River Channel

a) Periodical dredging
b) Removal of floating debris
c) Clearing of river banks and leveling of maintenance road surface.

Retention Ponds

d) O/M of outlet gates in the Dondang retention ponds
e) Desilting of the retention ponds when necessary
f) Clearing and removal of garbage after flooding

Pumping Stations and Retention Ponds

g) O/M of pumps in S-10 and S-18 pump stations
h) O/M of tidal gates in S-10 and S-18 retention ponds
i) Removal of floating debris by screening
j) Periodical dredging of the retention ponds when necessary

Operation and Maintenance of these flood control and drainage facilities require the provision of the following equipment:

a) Trucks for garbage transportation: 2 each
b) Supervision vehicles: 2 each

11.3 OPERATION AND MAINTENANCE OF GATES AND PUMPING STATIONS

11.3.1 Pumping Stations in the S-10 and S-18 Areas

The tidal gates at the S-10 and S-18 retention ponds will be constructed to protect the inland against high tides.

These gates are kept open under normal circumstances. When the tidal level is expected to rise beyond an elevation of 1.2 m, the operation of the tidal gates is necessary.

These gates shall be closed when the sea water level is about -0.8 m and remain closed until the tidal level peaks beyond 1.2 m and shall be opened when the level recedes below 1.2 m. In general, under no rainfall conditions, the pumps will not be operated because the retention pond has sufficient capacity to keep the water level low enough, even when normal dry weather flow enters the pond.

However, under rainfall conditions, once the runoff entering the pond exceeds a certain amount, the pumps will be operated.

The general guideline for operation of tidal gate and drainage pump is as follows:

i) Basic conditions

- Design High Water Level of the Pond; + 1.20m

- Design Low Water Level; - 0.80m

- Effective Depth of the Pond; 2.00m

- Lowest ground level in the catchment; + 1.40m

- Design discharge of trunk drain; S-10 1.85m^3/s
  S-18 15.0m^3/s

- Pump Capacity; S-10 6m^3/s
  S-18 2m^3/s

- Storage Capacity of Retention Pond; S-10 22,000m^3
  S-18 56,000m^3

ii) Operation of tidal gate

- Closing of gate; when the tidal level rises beyond an elevation of 1.20m.

- Timing of closing; when the tidal level lowers below an elevation of -0.80m (D.L.W.L. of the pond).

- Duration of closing; 6 - 7 hours.

- Timing of opening; when the tide level falls below an elevation of + 1.20m.

iii) Operation of Pump

The pump will be operated only when the floods in coincidence with high tide occurs.

- Timing of operation; when the rising speed of water level goes beyond 30 cm/h, or when the inflow to the pond increases beyond the design pump capacity.

- Duration of continuous operation; Maximum 6 -7 h.

These conditions should be examined in more details in the further stage.

11.3.2 Retention Ponds in Dondang Area

At the outlet of each retention pond, a flap gate and a sluice gate will be installed.

The flap gate will be used to release the inner water in the retention pond. The sluice gate will discharge water stored in the pond for flood mitigation of Sg. Dondang.

Under normal flooding conditions, only the discharge from the retention pond area will be released automatically through the flap gate.

When the scale of floods of Sg. Dondang exceeds the 30-year return period, discharge of Sg. Dondang enters into the retention pond overflowing the weir.

The release of water stored in the retention pond has to be regulated so that the river discharge will not exceed the allowable design discharge at each point near the outlet of each pond.

11.4 REQUIRED ORGANIZATION FOR CONSTRUCTION, OPERATION AND MAINTENANCE

The required organization for the construction of the proposed Urgent Flood Mitigation and Drainage Works is shown in Fig. 11-1.

Fig. 11-2 shows the required operation and maintenance organization.

Such an organization is recommended to be established by reorganizing the existing organizational structures of SDID and MPPP.

Moreover, the retention ponds in the Dondang area are planned for multipurpose usage. Works related to these ponds are to be coordinated between SDID and MPPP.

Tables

Fig. 11-1 ORGANIZATION CHART FOR CONSTRUCTION OF THE URGENT PROJECTS BY DID

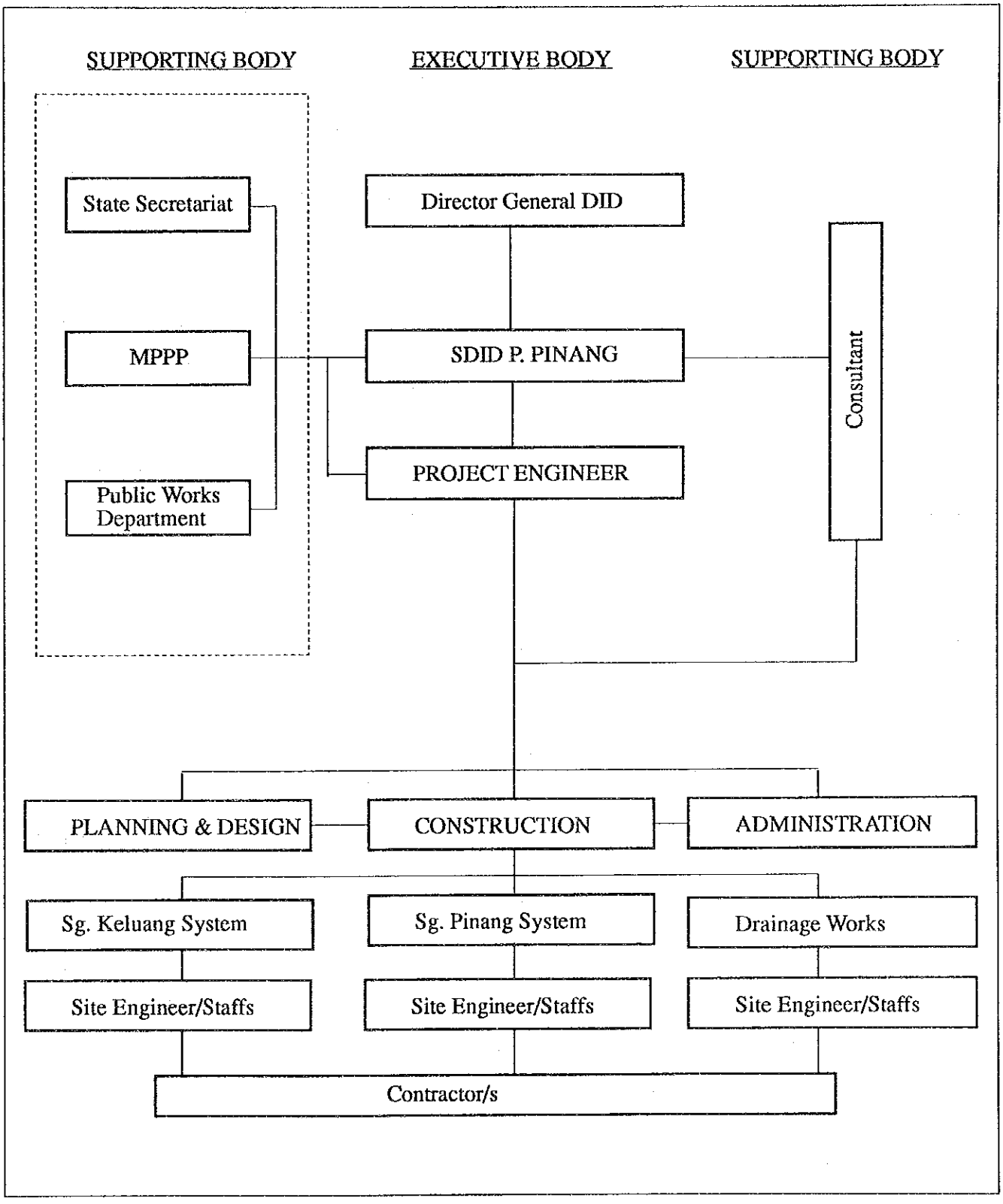
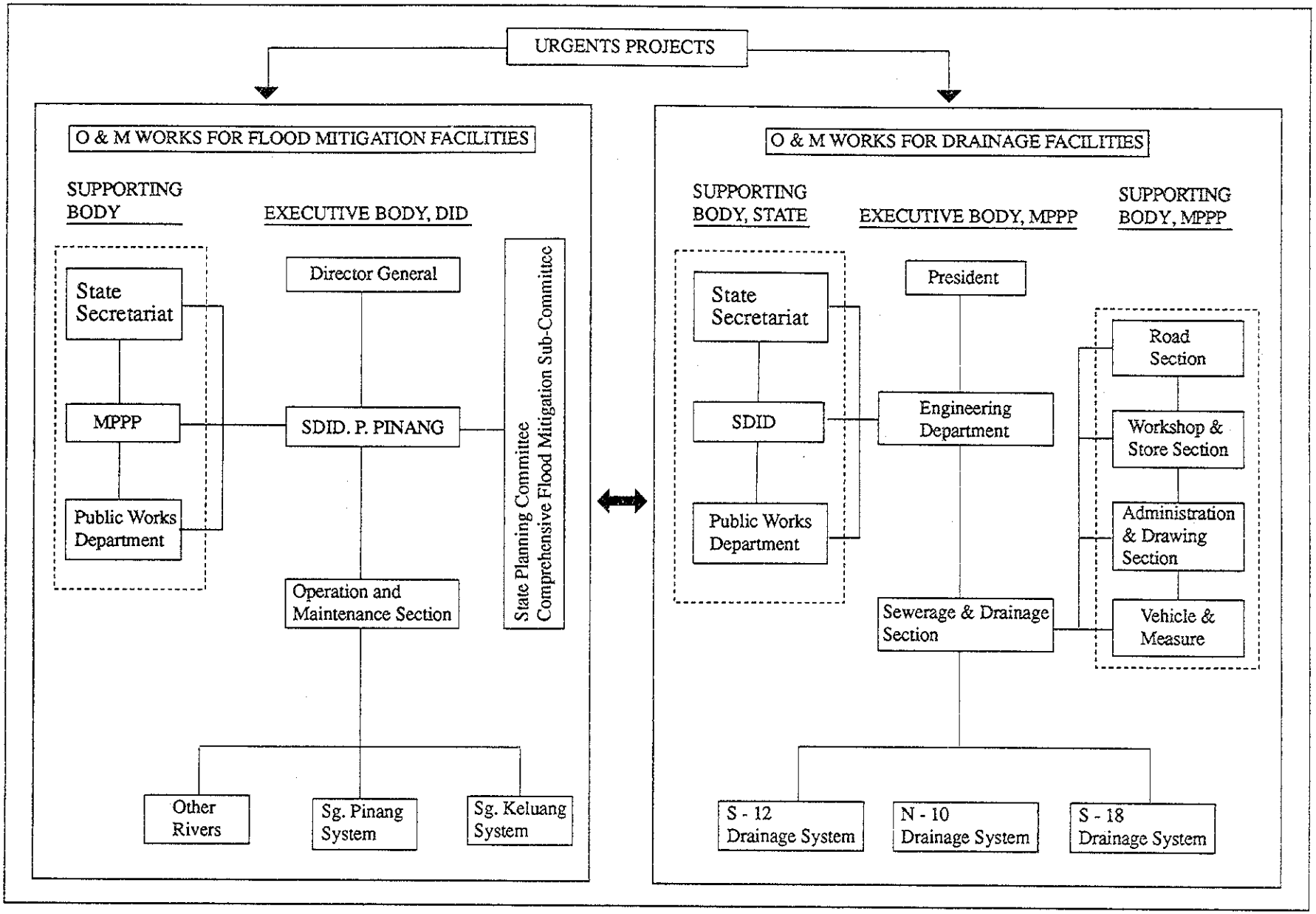


Fig. 11-2 ORGANIZATION CHART FOR OPERATION & MAITENANCE WORKS BY DID & MPPP



Chapter 12 ENVIRONMENTAL ASPECT S

CHAPTER 12 ENVIRONMENTAL ASPECTS

12.1 ENVIRONMENTAL FEATURES OF THE OBJECTIVE FEASIBILITY STUDY AREA

Regarding the environmental and landscape conditions of the objective riverside areas, they are in relatively bad shape as a result of water pollution, solid waste, natural grown sedges and vegetation on the banks. More frequent maintenance and care for the river reserves is highly expected, especially at focal points. Yet, it is recognized that a great potential for improving the landscape exists.

12.1.1 Sg. Pinang Area for River Improvement

All the river stretches of the improvement objectives, except Sg. Air Terjun, are heavily polluted. At this moment the rivers are not suitable for any meaningful beneficial uses.

The vegetation along the river in the upstream areas is shaded by wayside trees. However, the areas near the estuary and downstream are, to a great extent, exposed to the sun.

12.1.2 Sg. Dondang Retention Ponds and Park Areas

The three retention ponds will be constructed at the mid reaches of Sg. Dondang. The recent water quality survey conducted indicated the river water to be heavily polluted by organic matter.

The major waste being discharged into the river include raw and semi-treated domestic sewage and pig wastes. The poor water quality of Sg. Dondang has rendered it unsuitable for any meaningful beneficial usage.

In these areas, dense and diverse riparian vegetation is growing. Common grasses, palms, shrubs and bamboo inhabit the river banks. Waste and decaying organic matter can be seen along the river banks in the vicinity of the retention ponds. Housing development activities have caused odours and the deposition of eroded sediment.

A dense canopy of bamboo covers the river. Because of water pollution, there are but very few fish in the river.

12.1.3 Diversion Channel Route Area

In the vicinity where the proposed diversion channel is to divert into Jln. Gottlieb, there is a rather flat area having lush vegetation, such as grass, palm and banana trees, bamboo thickets, and tall wayside trees at its

riparian fringe. Fish fauna in this area includes species of the common guppy and others.

The area of the proposed diversion channel at Jln. Gottlieb is where most of the commercial activities take place (shops, hotels and hawkers). Hawker activities are increasing along the Jln. Gottlieb; their principal activities are primarily conducted at night. The area along Jln. Bagan Jermal is mostly for residential and institutional use.

A small portion of the diversion channel will be at Sg. Babi's downstream area. This is a relatively flat area. Kampong-style residential houses and some representative villages are situated along the river banks.

12.1.4 Area of Sg. Ara and Sg. Keluang

The objective area of Sg. Ara and Sg. Keluang is approximately 3.8 km in length from the new reclamation area at the estuary to a part of the upper reach of the river. Downstream of the river itself is undergoing reclamation work by PDC. In this area there is an airfield and an industrial zone. Wide expanded river reserve may have a high potential for establishing river front greenery landscape.

At the mid to upper stream, residential areas, government reserved areas, and Kampong-type residential areas are allocated with relatively low density along the widely expanded river reserve.

Most of the river banks are definetely wide enough to have gentle slopes and a good view of the amicable riverside scenery. At the upper reaches of the river, the banks become narrow and steep and are covered with bamboo thickets, trees and shrubs.

12.1.5 Area of Retention Ponds for Urban Drainage

The proposed area for the retention ponds for urban drainage is located at the reclamation area adjacent to the low cost high-rise residential development area near the Sg. Pinang estuary. The area is unused open space with flat expanded land facing the sea. This area is to be a part of the CDD 21 reclamation project area.

The proposed site is a muddy area near the shore. Patches of green and blue-green algal mats can be seen on the mud-flats along with garbage and other solid wastes. This matter has either been flushed out by the river flow or deposited by tidal affects.

Some aquaculture activities are presently ongoing near the coastal waters south of the proposed retention ponds.

Around of this area, high-rise housing flats are located in the reclamation land to the west of the

retention ponds site. Dense squatter settlements are located a short distance northwest of the proposed ponds site.

12.2 ENVIRONMENTAL APPROACH TO FLOOD MITIGATION

In this section, two conceptual approaches to mitigate flooding are proposed in conjunction with the flood mitigation and drainage study. One approach is to use some future park areas and open spaces as retention ponds into which the flood waters can be temporarily diverted. The other approach is to provide diversion channel to divert the flood water directly into the sea.

12.2.1 Retention Ponds and Multi-use Park Environment

Within the three future park areas, flood regulating functions (retention ponds) are to be formulated. The flood water is diverted into these temporary pond areas. The retention ponds may occasionally be combined as a temporary pond and only filled with diverted water at critical hours during floods having more than a 30-year return period, so that normally these are no water impounded in this portion of the pond areas.

The major portions of the retention pond areas are provided as spaces for diversified recreational activities. These retention pond areas are to be landscaped and used for multi-use recreational purposes.

Fig.12-1, Fig.12-2 show the temporary retention ponds and the sunken water front parks system at Sg. Dondang.

12.2.2 Retention Ponds of Urban Drainage

Two retention pond sites for urban drainage mitigation may be allocated near the estuary of Sg. Pinang in Georgetown's coastal reclamation zone. Each of these ponds has an area of 2 ha. In this vicinity there is a forested green belt for screening and preventing odour problems. The retention ponds face the sea allowing adequate ventilation.

Fig.12-3 shows a retention pond for urban drainage at the Sg. Pinang estuary.

12.2.3 Diversion Channel

The channel reserve area shall be provided with neat bank slopes and landscaped plantings on the flat tops of the berms. Or, in the case of limited reserve width, revetments and nearby riverside space should be provided with solid landscaping. Along the channel, some access ways to the waterfront for maintenance purposes and pedestrian use may be necessary.

A box culvert type of diversion channel shall be provided under the existing road area when there is not