

FIG. J-29

PLAN OF PROPOSED RETENTION POND B

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

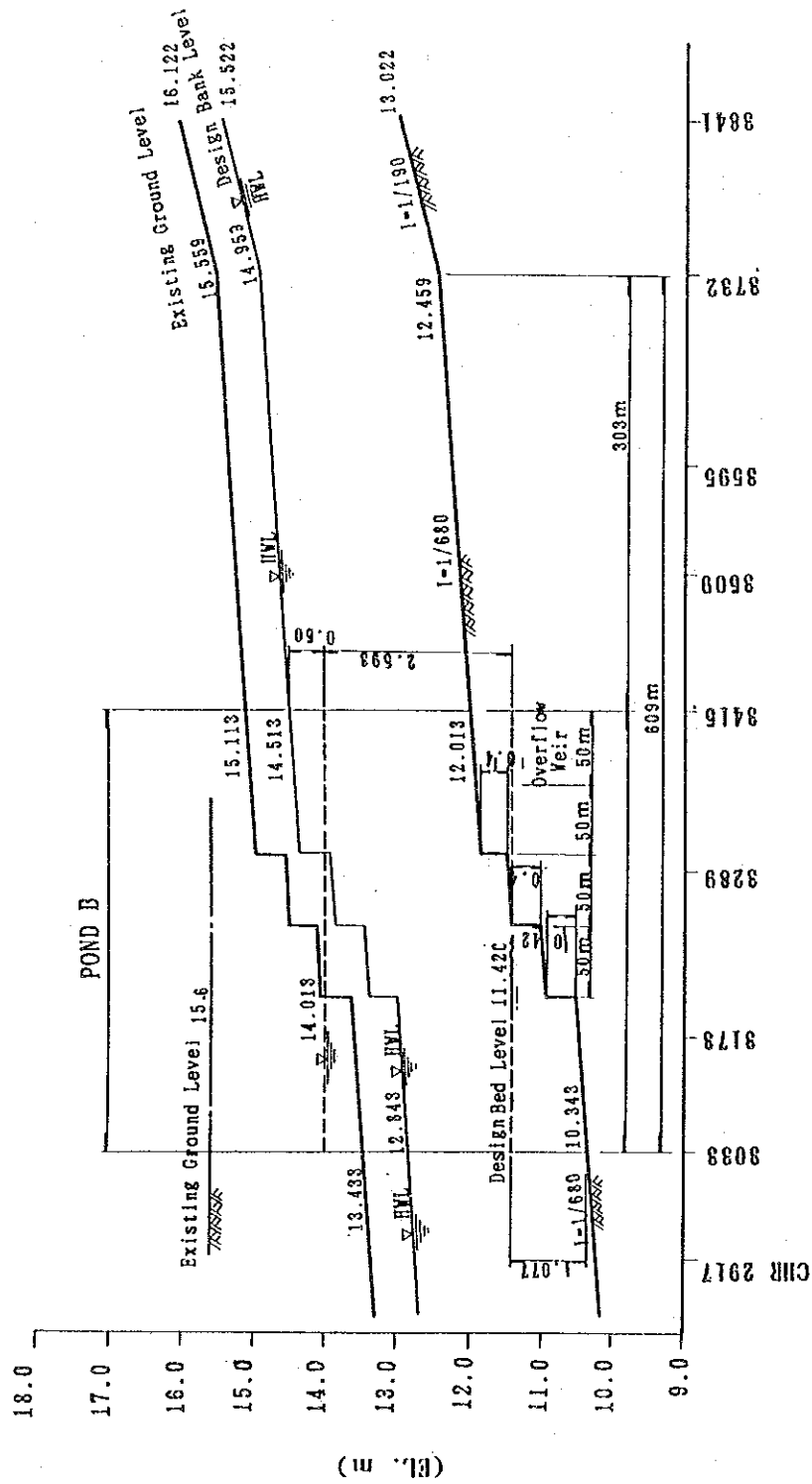


FIG. J-30 LONGITUDINAL PROFILE OF PROPOSED RETENTION POND B

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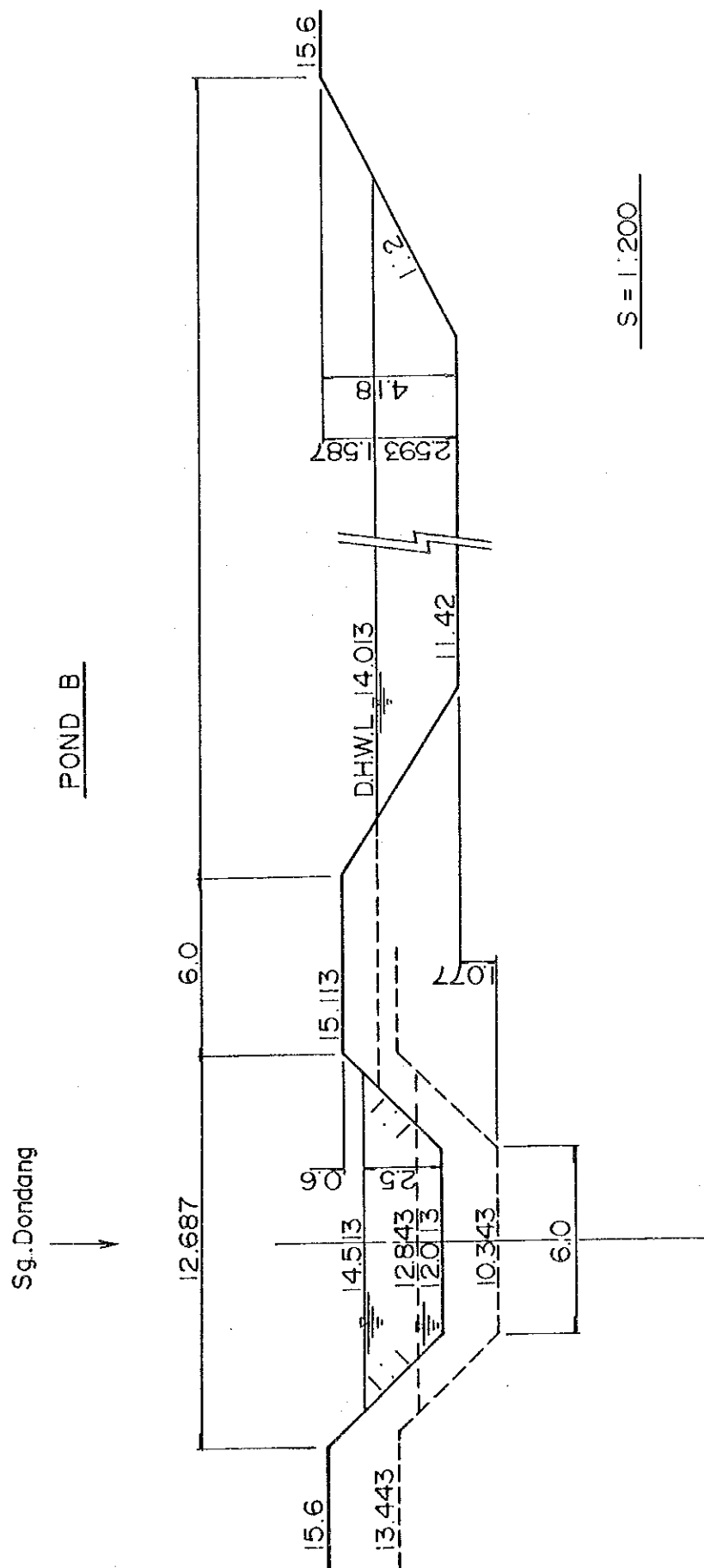


FIG. J-31 TYPICAL CROSS SECTION OF PROPOSED RETENTION POND B

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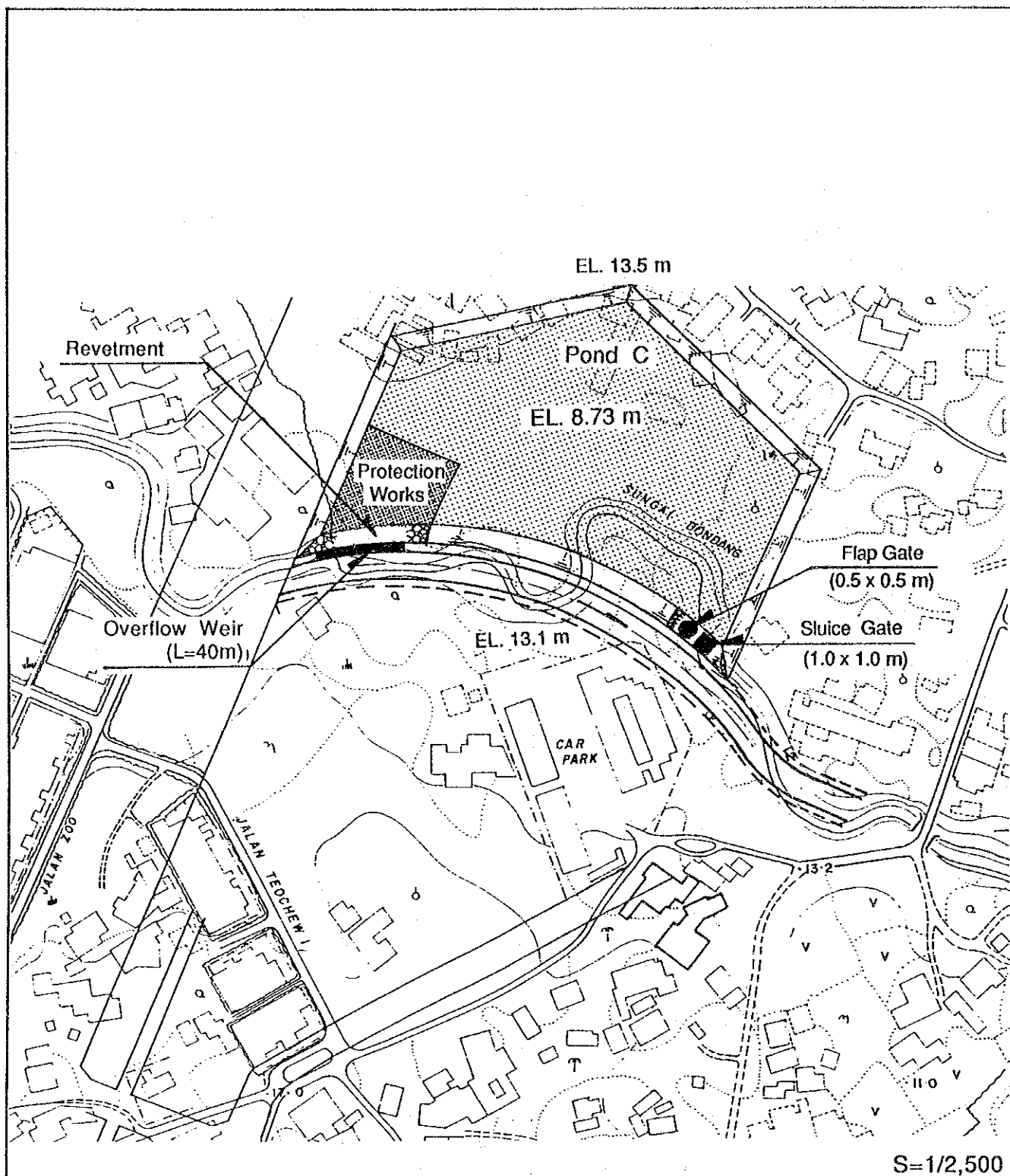
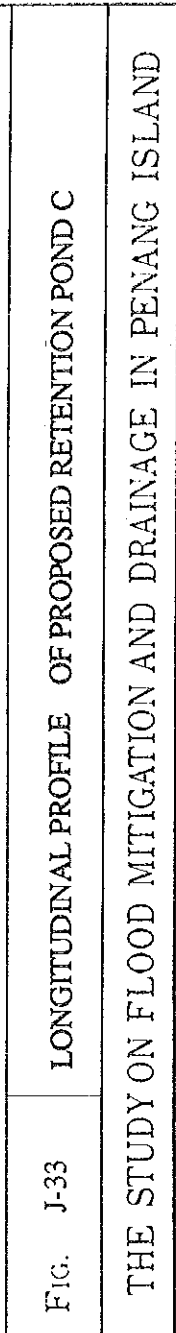


FIG. J-32

PLAN OF PROPOSED RETENTION POND C

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



POND C

Sg. Dongdang

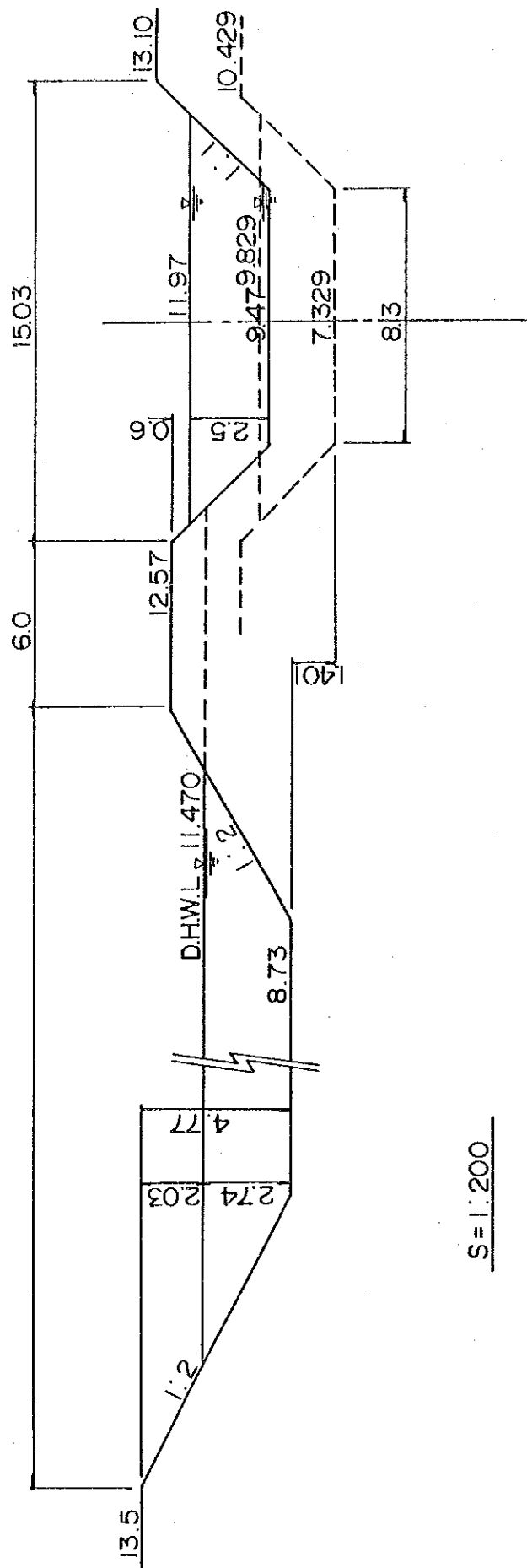


FIG. J-34 TYPICAL CROSS SECTION OF PROPOSED RETENTION POND C

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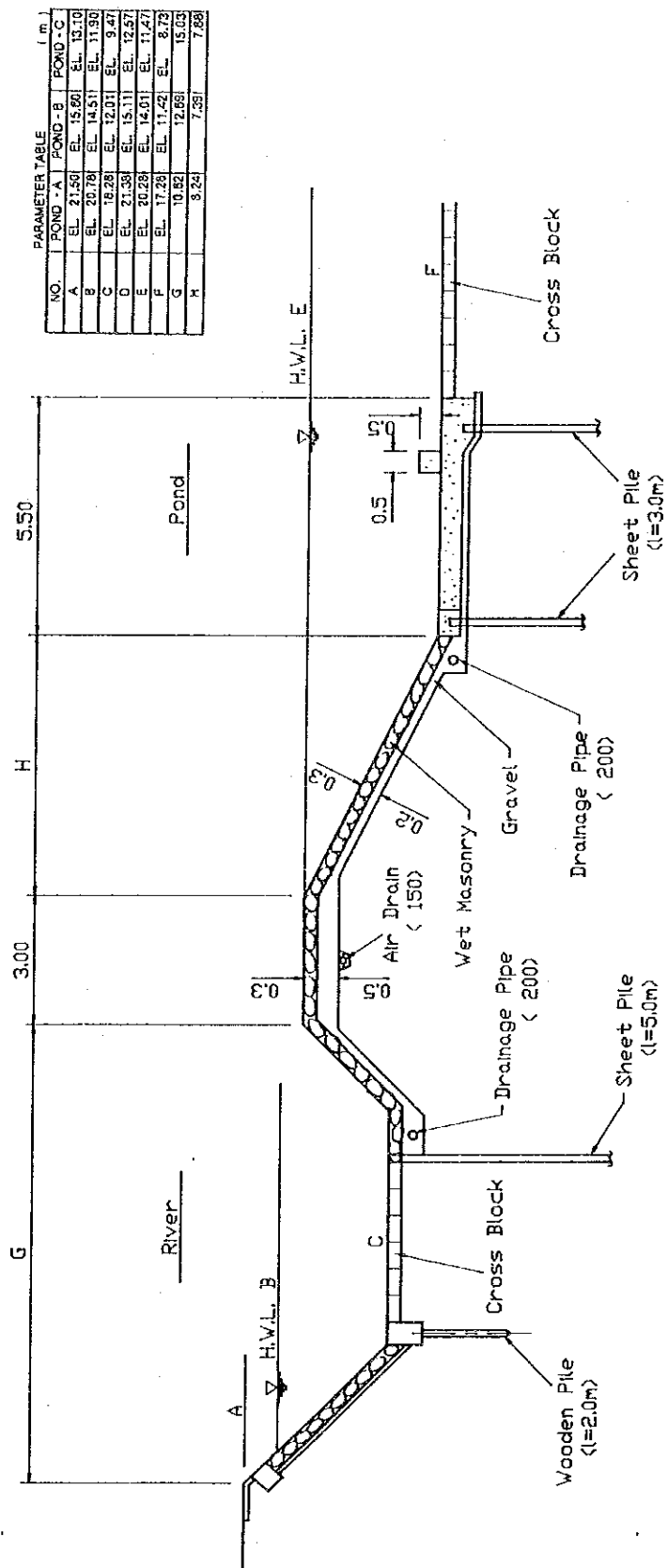
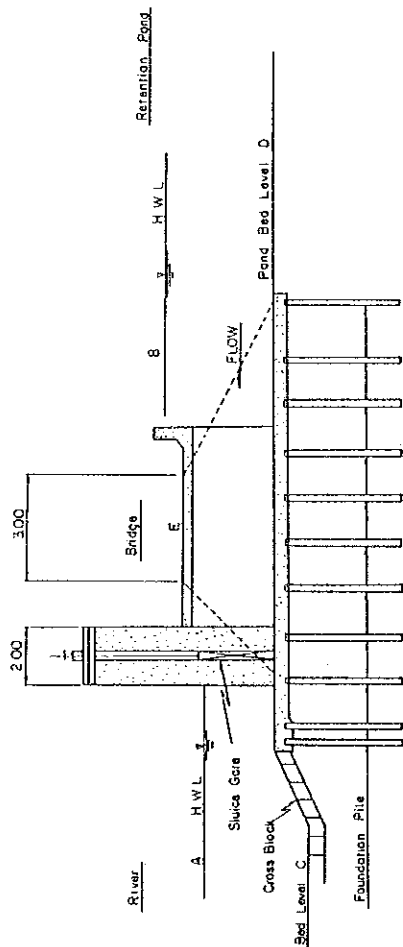
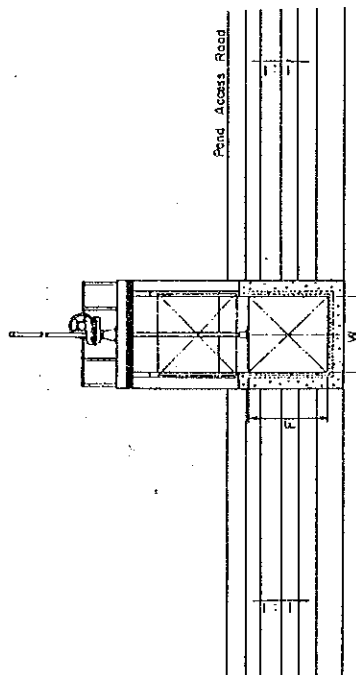


FIG. J-35 LONGITUDINAL SECTION OF OVERFLOW WEIR

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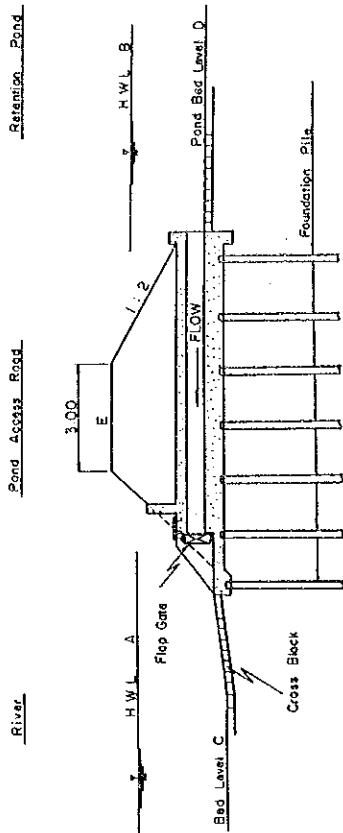


Profile of Sluice Way

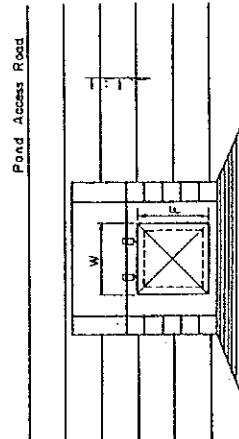


Front View of Sluice Gate

PARAMETER TABLE			
NO.	POND-A	POND-B	POND-C
A	EL. 1871	EL. 1284	EL. 989
B	EL. 2028	EL. 1401	EL. 1147
C	EL. 1621	EL. 1034	EL. 733
D	EL. 1728	EL. 1142	EL. 873
E	EL. 1931	EL. 1344	EL. 1043
F	200	200	100
W	200	200	100



Profile of Flap Gate



Front View of Flap Gate

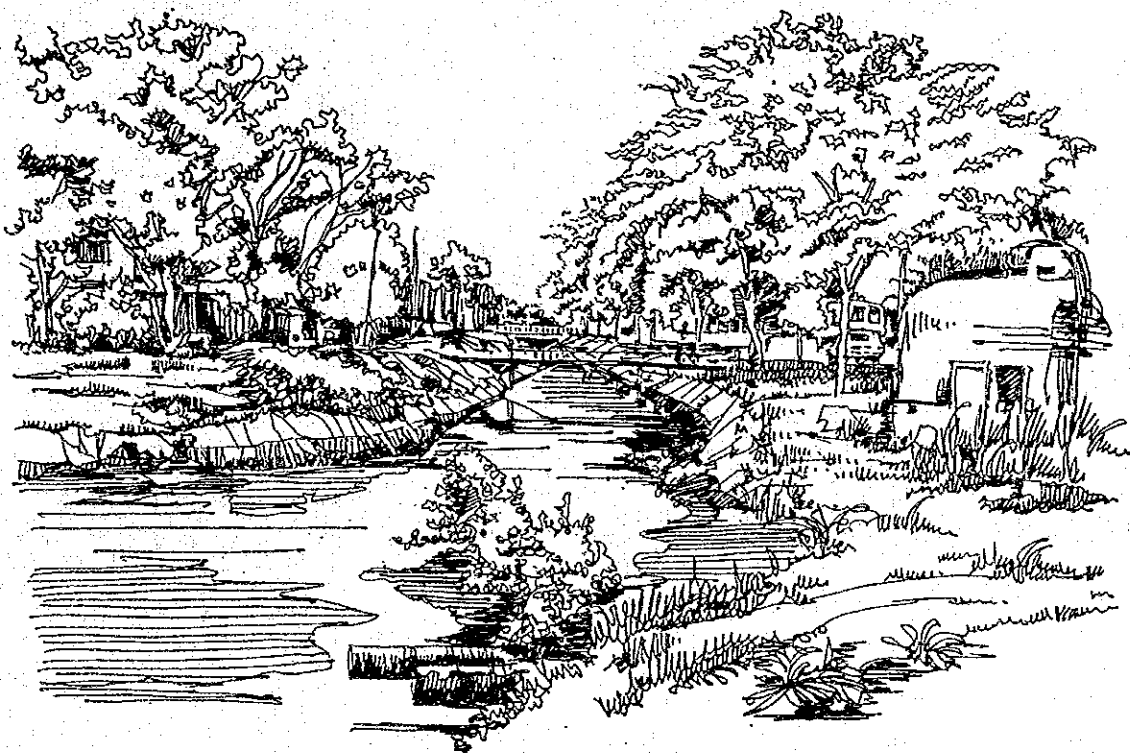
PARAMETER TABLE			
NO.	POND-A	POND-B	POND-C
A	EL. 1871	EL. 1284	EL. 989
B	EL. 2028	EL. 1401	EL. 1147
C	EL. 1621	EL. 1034	EL. 733
D	EL. 1728	EL. 1142	EL. 873
E	EL. 1931	EL. 1344	EL. 1043
F	0.93	0.93	0.93
W	0.93	0.93	0.93

FIG. J-36 PLAN AND TYPICAL CROSS SECTION OF OUTLET GATE

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

APPENDIX K

URGENT DRAINAGE PLAN



APPENDIX K URGENT DRAINAGE PLAN

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APPENDIX K URGENT DRAINAGE PLAN

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 basin with lowlying area.

The feasibility study for drainage plan was carried out for such priority areas.

2 PRIORITY AREAS SELECTED FOR FEASIBILITY STUDY

2.1 Selection of Priority Areas for Feasibility Study

AS a priority area for urgent drainage project, three major drainage basins in Georgetown were selected (see Fig.K-1). They are S-10 (Prangin Road), S-18 (Macalister Road) and N-12 (Jalan Pangkor). The reasons for selection are as follows;

- (i) S-10 and S-18 basins have lowlying areas which are affected by high tide and inundated without any rainfall.
- (ii) In S-10 and S-18 basins, drainage by gravity is impossible during high tides, and drainage by pumping is required
- (iii) In S-10 drains, there exist the old pump facilities. These facilities, however, have serious problem of operation and maintenance and do not well function.
- (iv) S-10 and S-18 basins are located in the central part of Georgetown, and have a high priority to solve these drainage problems.
- (v) S-18 drain flows into the Sg. Pinang at present and is affected by both high tides and backwater of Sg. Pinang.
- (vi) In S-12 basin , there exist a lowlying area which is commonly inundated due to inadequate flow capacity of drain.

2.2 Present and Future Landuse Conditions of Study Areas

(1) S-10 Drainage Basin

The existing S-10 catchment is 120 ha. However, in the future, S-11, S-12 and S-13 drains should be reorganized to connect with S-10 drains because of difficulty of discharge by gravity in the future reclaimed area. Total catchment area of new outfall of S-10 will be 126.3 ha. The existing catchment

has already densely populated part of the City and no major change in land use condition is expected in the future. The existing ground is about 1.35 m to 3.31 m in height and affected by high tides. The average slope of the ground is about 0.16 % and inclines slightly to the sea. Main drain of S-10 basin flows between Prangin Road and Maxwell Road, and has 900 m in length with 0.1 % of slope. The existing flow capacity of this drain is about 15.4 m³/s which is equivalent to 8-year return period. The required extension length in the future will be about 280 m. The alignment of this new drain is to be planned along the future Coastal Road.

(2) S-18 Drainage Basin

The existing S-18 catchment is 104 ha and consists of the densely populated part of the City like as S-10 catchment. No major change in land use condition is expected in the future.

The existing ground level is about 1.5 m to 4.4 m in height, and affected by both high tide and backwater of Sg. Pinang.

The average slope of the ground is about 0.1 % and inclines slightly to the sea. Main drain of S-18 basin, which is about 1,200 m long, flows along the Brick Kiln Road and directly into the Sg. Pinang.

The existing flow capacity of this drain is only about 3 m³/s.

In the Master Plan Study, the extension of about 910 m in length for the S-18 outfall was proposed.

The alignment of this new stretch is to be planned along the Sg. Pinang passing the existing and future reclaimed area.

(3) N-12 Drainage Basin

This outfall serves an approximate catchment area of 156.9 ha of mainly residential areas. It discharges to the sea at Gurney Drive via outfall N-12.

The average gradient of the existing ground of the basin is about 0.17 % with ground elevation of 2.4 m to 8.5 m.

In the upper portion of the catchment there exists a lowlying area where the lowest ground level is about 2.4 m, and flooding commonly occurs due to poor drainage system.

The existing drain and outfall serving Barrack Road / Perak Road / Pangkor Road are grossly undersized. The maximum flow capacity is only 6.2 m³/s. The outfall N-12 consists of double hume concrete pipe of 1.2 m diameter. This outfall is to be extended with about 36 m in length up to the outside new Outer Ring Road. This outfall N-12 will be reorganized to reduce the number of outfalls at Gurney Drive area.

3 DRAINAGE FACILITIES FOR FEASIBILITY STUDY

In the Master Plan Study, the flowing drainage facilities for S-10, S-18 and N-12 basin were proposed.

- (i) S-10 Drainage System
 Improvement of Trunk Drain (including the extension stretch)
 Retention Pond; Area
 Storage capacity
 Effective Depth
 Pump station; Pump capacity
 Tidal Gates
- $L = 1,660 \text{ m}$
 $L_e = 383 \text{ m}$
 $A = 1.9 \text{ ha}$
 $V = 22,000 \text{ m}^3$
 $H = 2.0 \text{ m}$
 $P = 6.0 \text{ m}^3/\text{s}$
 $3.0 \text{ m} \times 3.1 \text{ m}$
 (2 sets)

- (ii) S-18 Drainage System
 Improvement of existing drain
 Extension of drain
 Retention Pond; Area
 Storage capacity
 Effective depth
 Pump station; Pump capacity
 Tidal gates
- $L = 820 \text{ m}$
 $L_e = 910 \text{ m}$
 $A = 2.4 \text{ ha}$
 $56,000 \text{ m}^3$
 $H = 2.0 \text{ m}$
 $2.0 \text{ m}^3/\text{s}$
 $3.0 \text{ m} \times 3.1 \text{ m}$
 (2 sets)

- (iii) N-12 Drainage System

Improvement of existing drain $L = 2,660 \text{ m}$
 Extension of drain $L_e = 36 \text{ m}$

4 DESIGN CONCEPT AND CONDITIONS FOR DRAINAGE PLAN

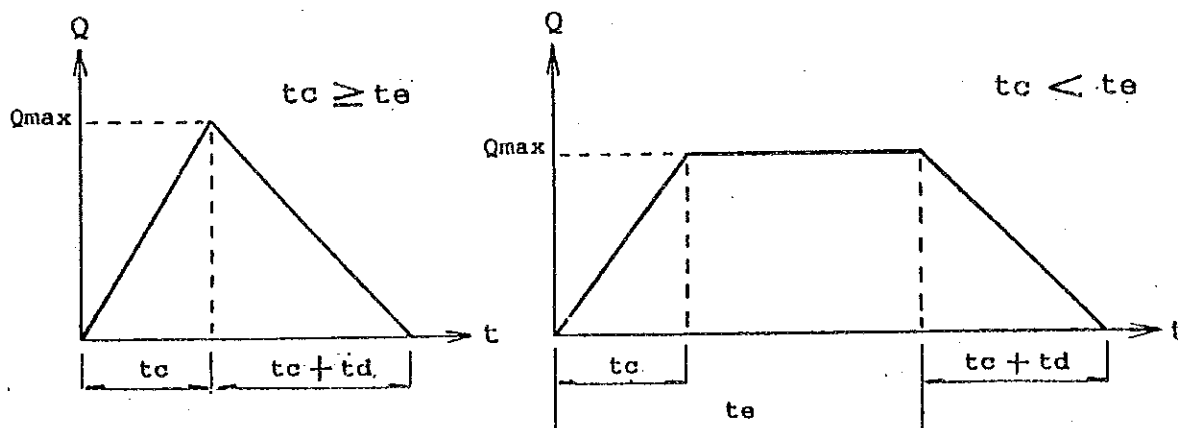
4.1 Flood Protection Level

For the urgent drainage plan, design flood protection level of 10-year return period as for master drainage plan was adopted.

4.2 Determination of Pump Capacity and Storage Capacity of Retention Pond

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

The peak discharge used for simulation study are calculated as follows;



where, t_c = Time of concentration
 t_e = Storm duration
(critical storm duration is determined
by trial and error)
 t_d = Time of flow in channel

Q_{max} is calculated by the modified Rational Method. For the S-10 Basin, Q_{max} for different flood durations are as follows;

$t_c = 40$ (min),	$Q_{max} = 18.3$ (m^3/s)
$t_e = 90$ (min),	$Q_{max} = 11.3$ (m^3/s)
$t_e = 120$ (min),	$Q_{max} = 9.4$ (m^3/s)

Also, for the S-18 Basin

$t_c = 50$ (min),	$Q_{max} = 14.7$ (m^3/s)
$t_e = 90$ (min),	$Q_{max} = 10.2$ (m^3/s)
$t_e = 120$ (min),	$Q_{max} = 8.4$ (m^3/s)

Flood hydrographs for S-10 and S-18 are shown in Fig.K-2.

The relationship between the required retention pond volume and pump capacity is shown in Fig.K-3

Four alternatives by pump capacity are considered and their cost are estimated as shown in Table K-1. Alternative cost curves for S-10 and S-18 drainage areas are shown in Fig.K-4.

As shown in Fig.K-4, the combination construction cost of pump and retention pond is almost same for each case.

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

The breakdown of construction cost of S-10 and S-18 drainage facilities is shown in Table K-2.

5 STRUCTURE PLAN OF DRAINAGE FACILITIES

5.1 Main Drain

The objective main drains of each catchment flow along the main road in the City and consist of concrete open channel or box culvert.

(1) S-10

The lowest ground level in this catchment is 1.4 m above M.S.W.L. In order to protect this lowlying area the D.H.W.L. of the channel was decided below the lowest ground level. The water level in this channel are not affected by high tides. Because tidal gates to be installed at the outfall will be closed during high tides.

The type of the section is of concrete channel or box culvert according to the land use conditions of the ground nearby.

Especially in the stretch to be extended along the proposed Coastal Road, the box culvert section was planned under future road.

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

The proposed S-10 drainage system, longitudinal profile and cross section are shown in Fig.K-5 and K-8.

(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 shorter length comparing with Route 2. Route 2 is located along the Sg. Pinang and needs land acquisition. Considering construction cost and hydraulic condition, Route 1 was selected. The existing flow capacity of S-18 main drain is extremely small and channel should be improved for the whole stretch.

The proposed S-18 drainage system, longitudinal profile and cross section are shown in Fig.K-6 and.K-9.

(3) N-12

As shown in Fig.K-7, N-12 drainage system consists of two main drains along Jln. Perak and Jln. Pangkor, and trunk drain of 1,290 m in length.

The outfall of this drain is planned to be extended with 36 m in length considering proposed Future Ring Road.

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

The existing ground level of these routes are about 3.1 to 4.5 m and basically not affected by high tides.

The proposed longitudinal profiles and cross sections of N-12 drains are shown in Fig. K-10-1 and K-10-2.

5.2 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 amount and it is possible to store all discharge in the retention pond remaining enough capacity without pumping up the storage water. However, when rainfall intensity exceeds some degree, the pump will be operated to drain inner water.

The retention ponds were planned considering the following conditions.

5.2.1 Location of Retention Pond

The location of the retention ponds for 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 for the surroundings.
- (iii) Location of the areas to be protected.
- (iv) Future land use plan in the coastal area.

AS for the retention pond site of S-18 basin, three sites were contemplated. They are the area along the Jln. Brick Kiln Road near to existing S-18 outfall (site A), the existing reclaimed area along the Sg. Pinang (site B) and the area outside proposed Coastal Road (site C).

The required area for retention pond will be about 2 ha for each.

In site A, land acquisition is practically impossible due to difficulty of relocation of houses and high cost. Furthermore, negative environmental impacts due to stagnation of polluted water in the pond is anticipated.

Accordingly, this site was rejected.

Site b is located in an open space leftside of the Sg. Pinang. This area has already been reclaimed and is alienated for housing. The surroundings of this site is residential area and the same negative environmental impacts as site A is anticipated. Hence, this site was also rejected.

Site c is located outside the proposed Coastal Road. This site has no major problem of environment both during and after construction.

This site needs no land acquisition cost. However, it is necessary to construct the dyke for retention pond.

Finally, site c was selected for S-18 retention pond.

As for S-10 Retention Pond Site, initially, the area inside the proposed Coastal Road was considered. However, this site is planned to be for whole sale market. Hence, the area outside the proposed Coastal Road was selected.

The general plans of S-10 and S-18 Retention Ponds are shown in Fig.K-11 and K-12.

5.2.2 Effective Depth

The effective depth of the pond is the difference of water levels between design high water level and design low water level. The design high water level of the pond will be decided referring the lowest ground level to be protected in the catchment and the hydraulic gradient.

Accordingly, the H.W.L. in the pond was set to 1.20 m.

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

The bottom level of the pond was set to be about 30cm lower the Design L.W.L. to keep the free storage capacity for sediments.

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

5.2.3 Closing Dyke

The 720 m dyke was planned outside proposed Coastal Road to obtain the required storage capacity for drainage purpose by closing the sea of about 4.3 ha.

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

A closing dyke consists of earth embankment with rubble revetment and cut off sheet pile.

The dyke will be constructed on the sea bed with weak foundation and has gentle bank slope. The height of dyke is about 3.4 m and formation level of this dyke is 2.2m having 60cm freeboard above E.H.W.S.

Top of dyke is paved and serves as maintenance road. The inner surrounding of the retention pond was planned to have green belt with twenty meter with for screening and preventing odour problem.

Fig.K-13 shows typical cross section of the dyke.

5.3 Pump Station

5.3.1 Pump Facilities

The major facilities of each pump station consists of pump, tidal gate, pump house, box culvert, outlet tank and screen. S-18 pump station is planned to have two horizontal axial flow pumps with a capacity of 1 m³/s each. While S-10 pump station has three pumps of the same type as S-18 type with a capacity of 2 m³/s.

The general plan and longitudinal section are shown in Fig.K-14 and Fig.K-15.

5.3.2 Tidal Gate

The sluice gate will be installed near the outlet tank to protect inflow of sea water during high tides. At each outlet of sluice way, the maintenance gate is to be installed. Under normal condition of low tides, these gates are kept open and closed only during high tides.

The dimensions of these gates are as follows;

S-10 two sets 3.0 x 3.1 m

S-18 two sets 3.0 x 3.1 m.

Tables

TABLE K-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

TABLE K-2 COST BREAKDOWN OF S-10 AND S-18 PUMP STATION AND RETENTION PONDS

S-10

CASE-3 (Q = 6 m³/sec.)

(1) Retention pond

Works Items	Unit	Qty	Total (M\$)
Embankment	cum	64,000	512,000
Steel sheet piling, type II, l = 10m	nos.	900	900,000
Revetment by dry masonry	sq.m	4,000	160,000
Revetment by wet masonry	sq.m	5,300	265,000
Asphalt pavement, levee top	sq.m	8,000	160,000
Landscaping works	L.S.	-	20,000
Miscellaneous works	L.S.	-	100,000
Amount of (1)			2,117,000

(2) Pumping house

Works Items	Unit	Qty	Total (M\$)
Excavation/hauling	cum	10,000	40,000
Foundation piling, R.C. type	nos.	164	164,000
Steel sheet piles, type II	nos.	423	846,000
Backfill	cum	4,800	14,400
Building, R.C. type	L.S.	4,750	997,500
Landscaping works	L.S.	-	30,000
Drainage pumps	set	3	600,000
Auxiliary facilities	L.S.	-	200,000
Gate and trashrack	ion	20	400,000
Garbage equipment	set	3	300,000
Erection cost, pump & others	L.S.	-	300,000
Miscellaneous works	L.S.	-	200,000
Amount of (2)			4,091,900

(3) Outlet channel

Works Items	Unit	Qty	Total (M\$)
Excavation/hauling	cum	150	600
Embankment	cum	1,800	14,400
Revetment by dry masonry	sq.m	250	10,000
Miscellaneous works	L.S.	-	1,500
Amount of (3)			27,000
Total of (1),(2),(3)			6,235,900

S-18

CASE-1 (Q = 2 m³/sec.)

(1) Retention pond

Works Items	Unit	Qty	Total (M\$)
Embankment	cum	76,000	608,000
Steel sheet piling, type II, l = 10m	nos.	1,000	1,000,000
Revetment by dry masonry	sq.m	4,300	172,000
Revetment by wet masonry	sq.m	7,500	375,000
Asphalt pavement, levee top	sq.m	8,600	172,000
Landscaping works	L.S.	-	23,000
Miscellaneous works	L.S.	-	100,000
Amount of (1)			2,450,000

(2) Pumping house

Works Items	Unit	Qty	Total (M\$)
Excavation/hauling	cum	5,600	22,400
Foundation piling, R.C. type	nos.	153	153,000
Steel sheet piles, type II	nos.	395	790,000
Backfill	cum	3,200	9,600
Building, R.C. type	L.S.	3,100	651,000
Landscaping works	L.S.	-	16,000
Drainage pumps	set	2	200,000
Auxiliary facilities	L.S.	-	200,000
Gate and trashrack	ion	20	400,000
Garbage equipment	set	3	300,000
Erection cost, pump & others	L.S.	-	300,000
Miscellaneous works	L.S.	-	200,000
Amount of (2)			3,242,000

(3) Outlet channel

Works Items	Unit	Qty	Total (M\$)
Excavation/hauling	cum	150	600
Embankment	cum	1,800	14,400
Revetment by dry masonry	sq.m	250	10,000
Miscellaneous works	L.S.	-	1,500
Amount of (3)			27,000
Total of (1),(2),(3)			5,719,000

Figures

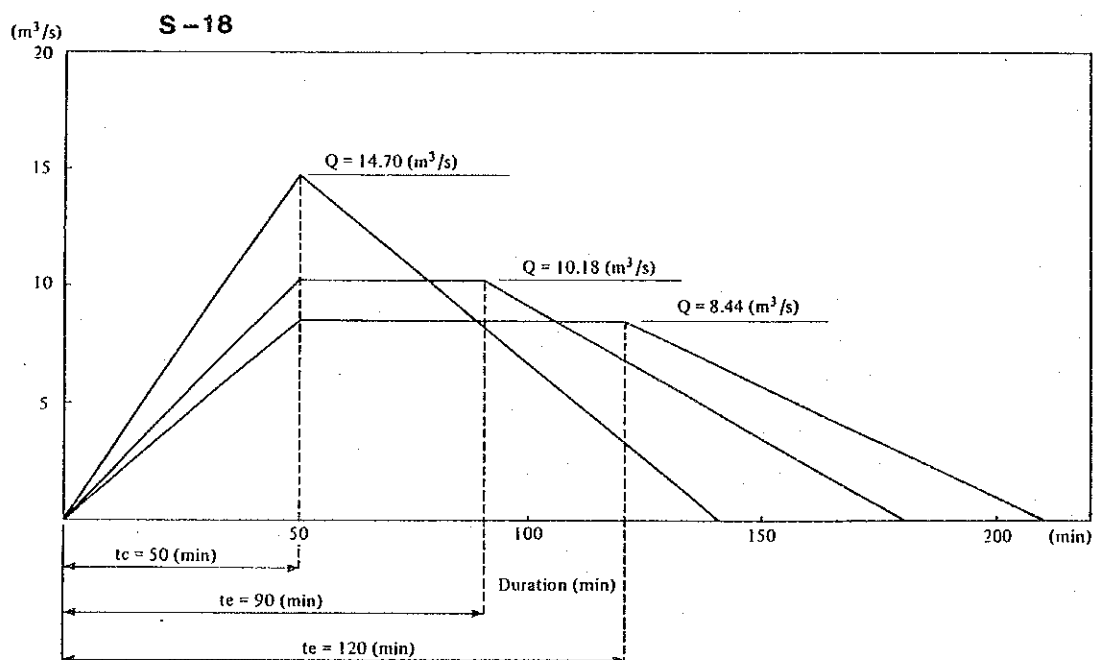
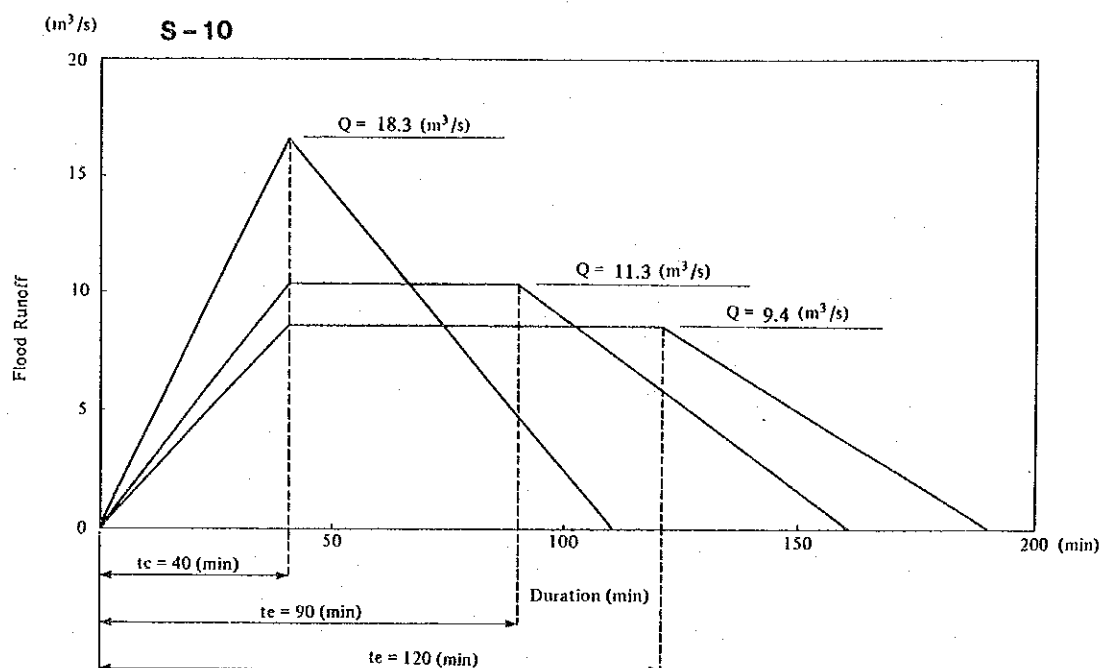


FIG. K-2

**FLOOD HYDROGRAPHS FOR S-10 AND S-18
DRAINAGE BASINS**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

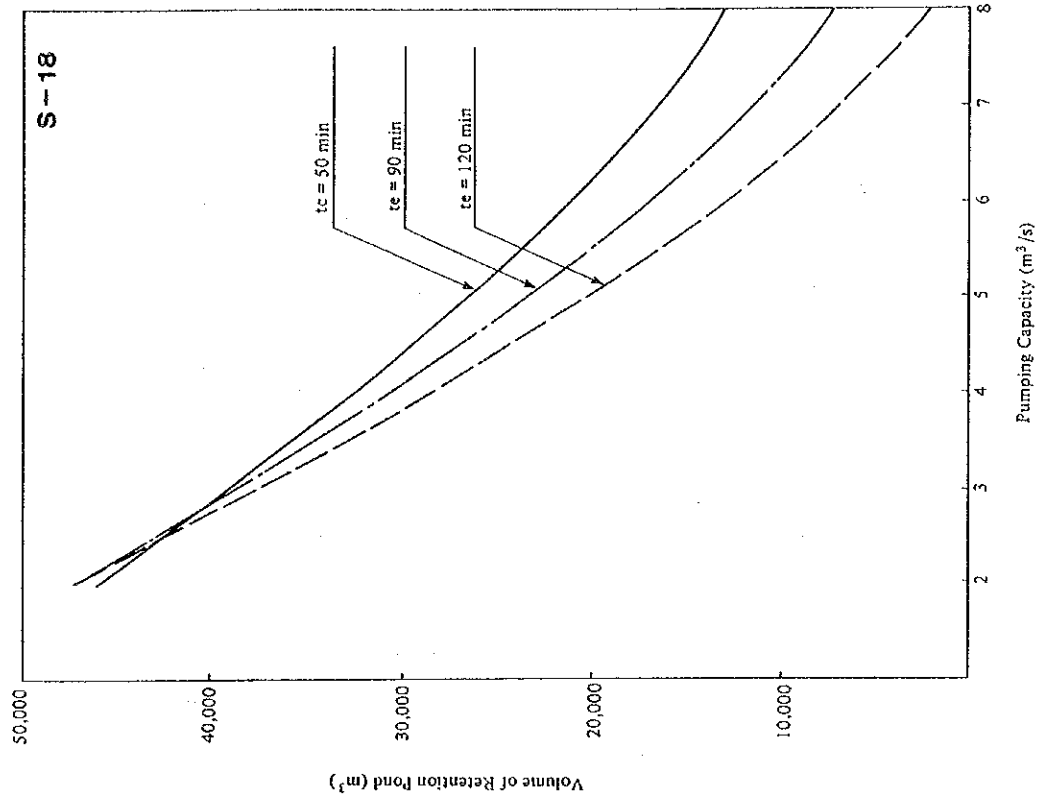
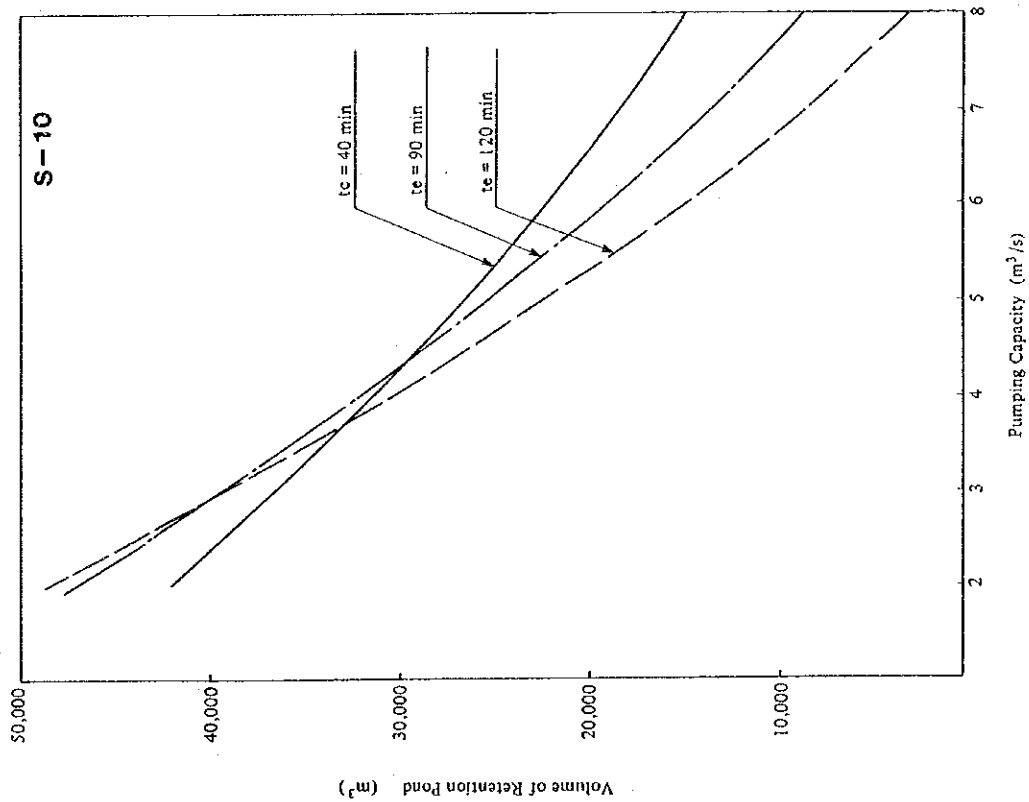


FIG. K-3 RELATIONSHIP BETWEEN POND VOLUME AND PUMP CAPACITY

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

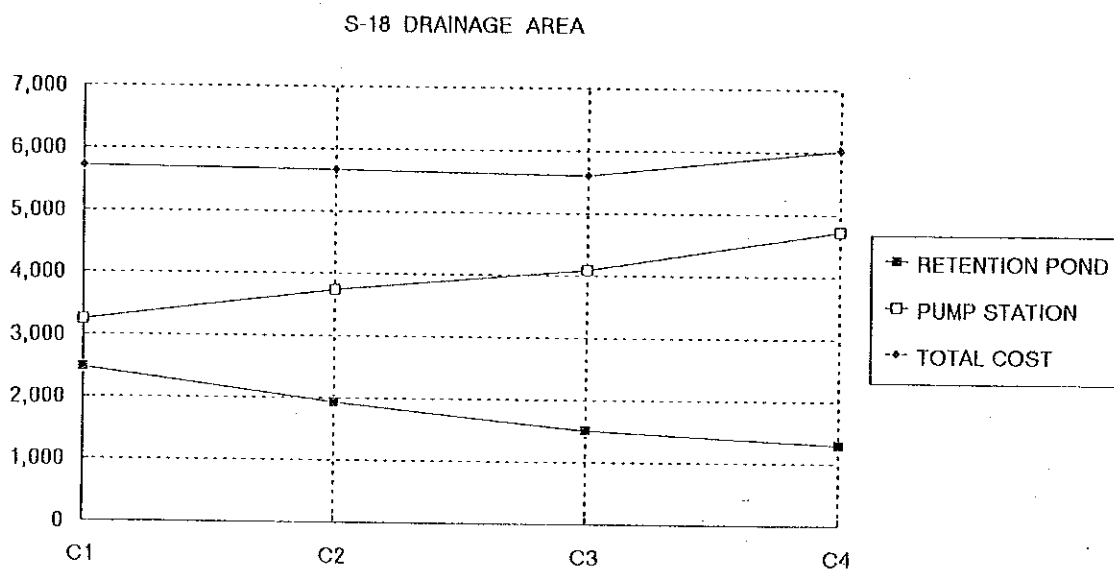
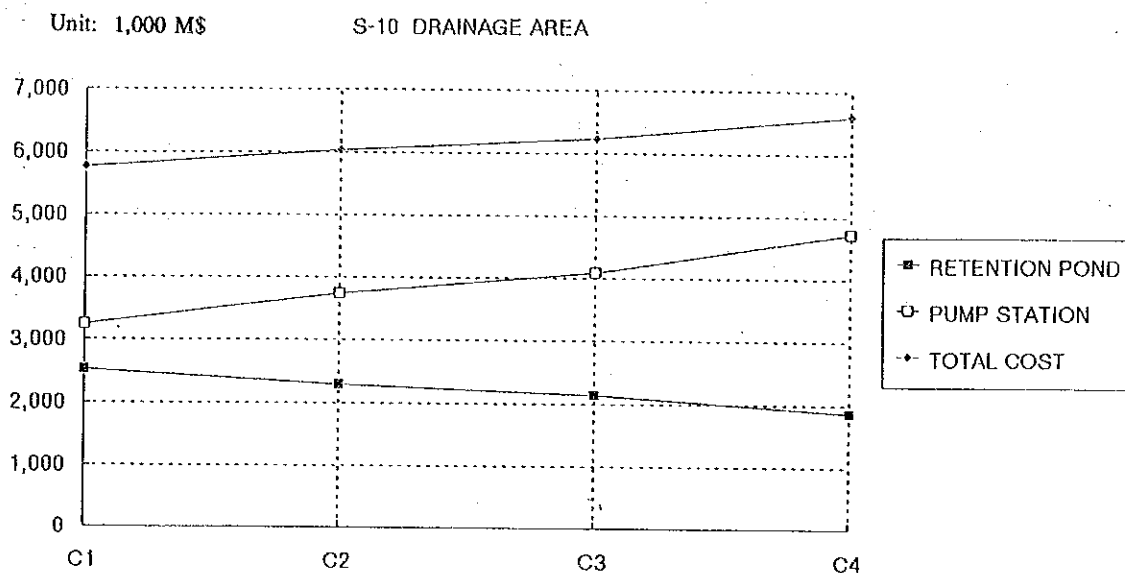


FIG. K-4

ALTERNATIVE COST COMPARISON OF PUMP STATION AND
RETENTION POND

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



FIG. K-5

PLAN OF PROPOSED S-10 DRAINS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

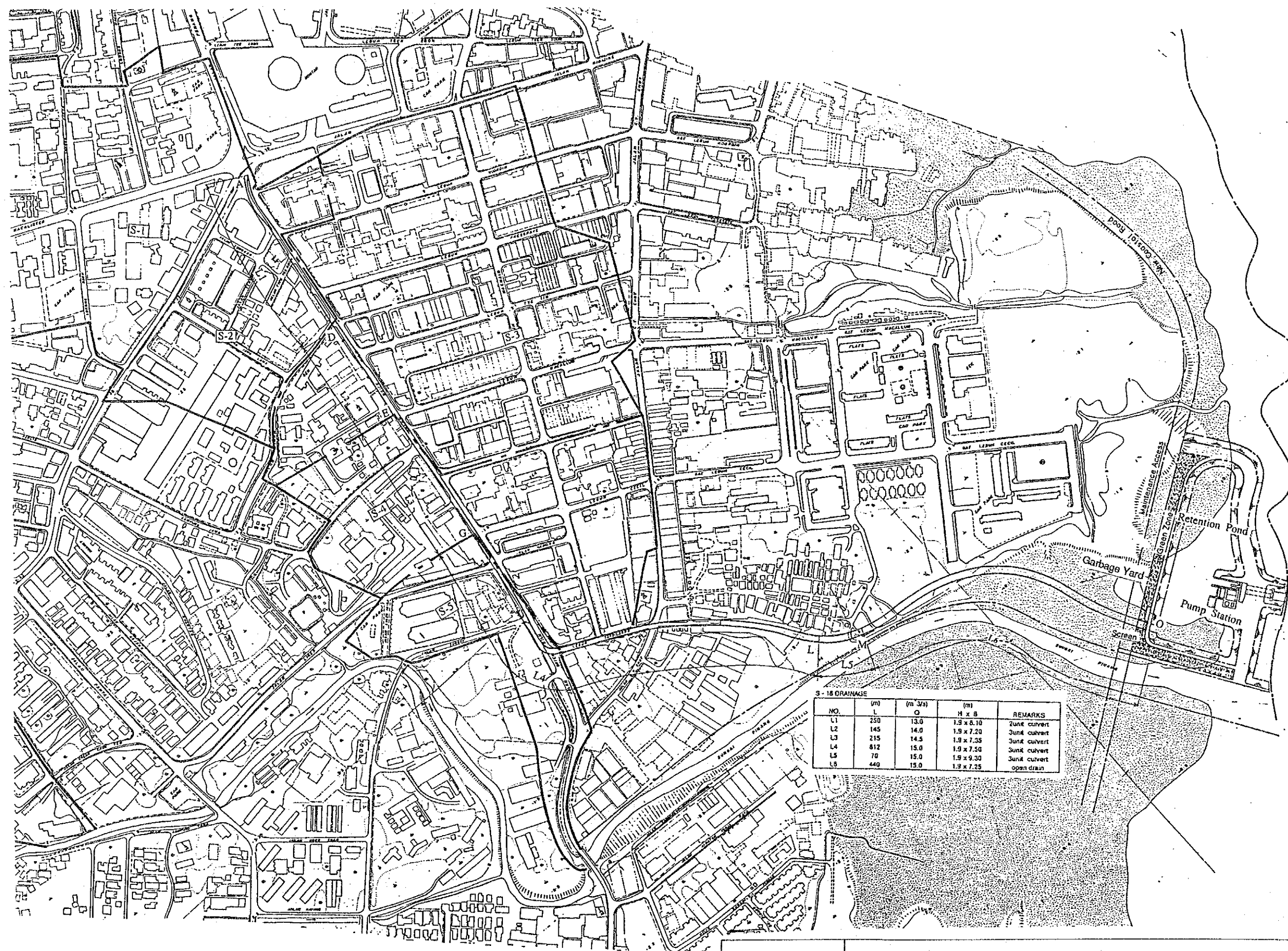


FIG. K-6

PLAN OF PROPOSED S-18 DRAINS



FIG. K-7

PLAN OF PROPOSED N-12 DRAINS

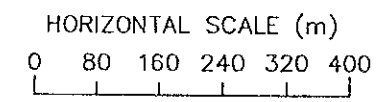
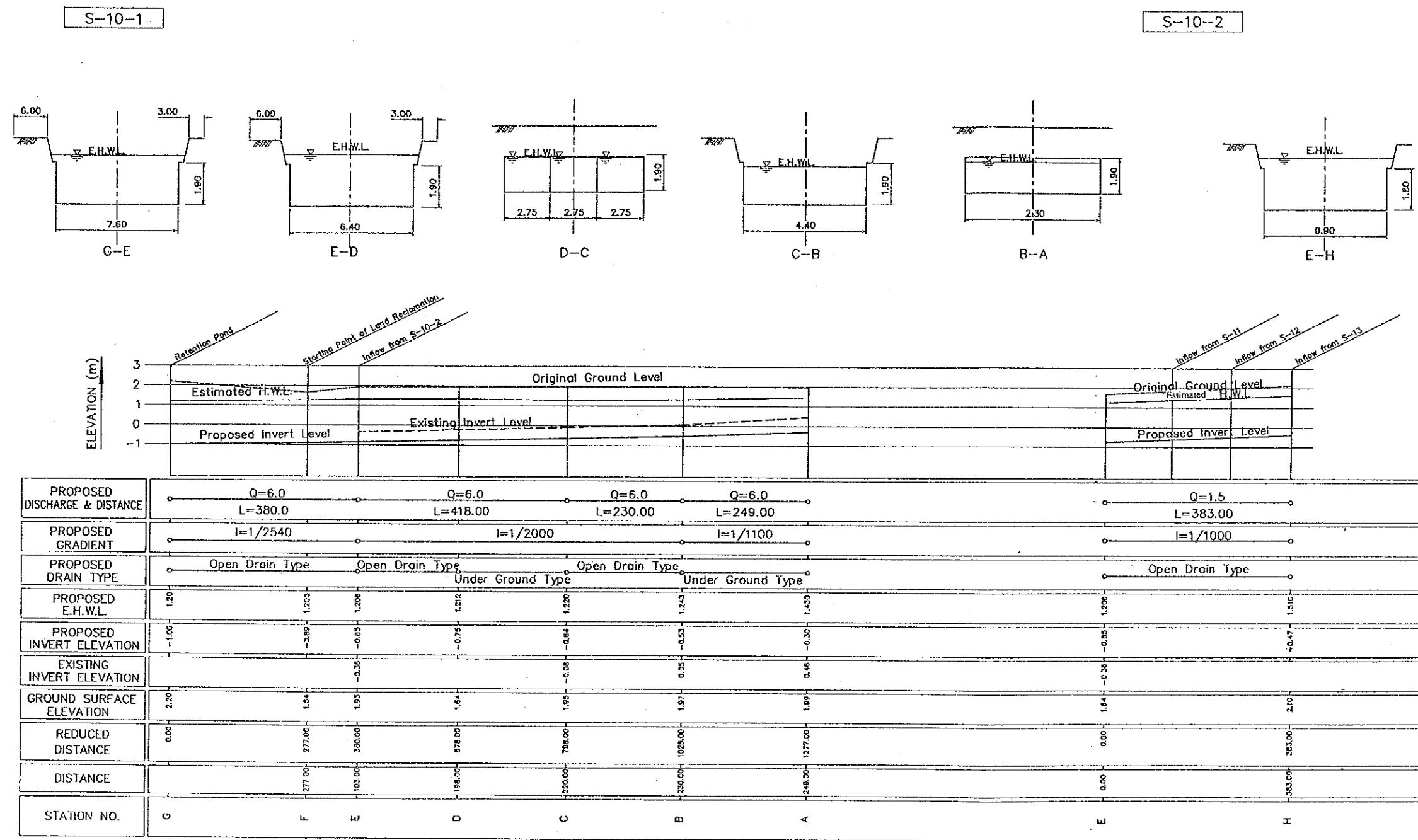


FIG. K-8

LONGITUDINAL PROFILE AND CROSS SECTION OF
S-10 DRAIN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

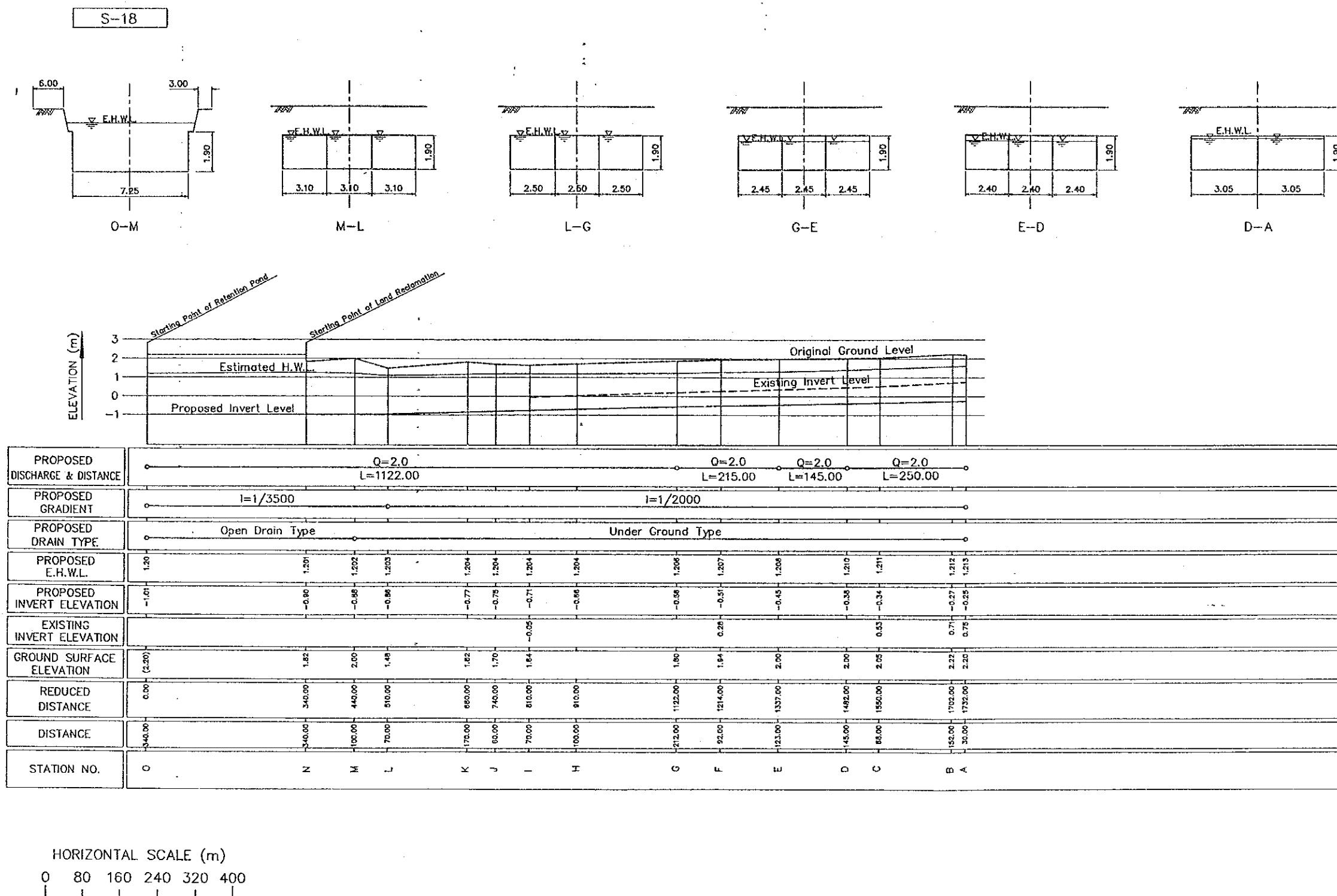
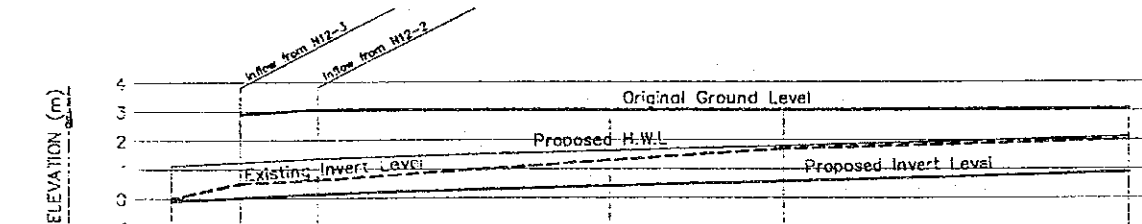
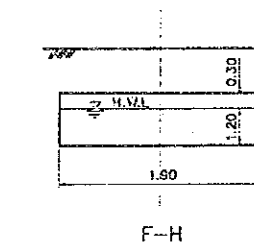
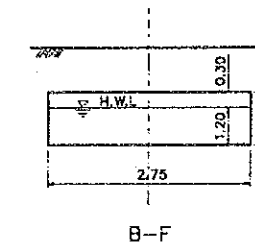
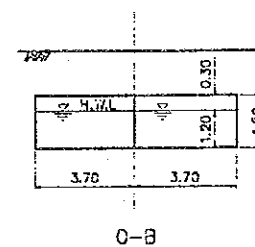


FIG. K-9

LONGITUDINAL PROFILE AND CROSS SECTION OF
S-18 DRAIN

N12-1



PROPOSED DISCHARGE & DISTANCE	Q=18.0 L=205.00		Q=3.5 L=400.00		Q=2.0 L=720.00	
PROPOSED GRADIENT	I=1/800		I=1/1500			
PROPOSED DRAIN TYPE	Under Ground Type					
PROPOSED H.W.L.	1.10	1.22	1.30	1.42	1.71	2.10
PROPOSED INVERT ELEVATION	-0.10	0.02	0.12	0.42	0.59	0.60
EXISTING INVERT ELEVATION	-0.08	0.31	0.63	1.30	1.70	2.00
GROUND SURFACE ELEVATION		2.90	3.06	3.00	3.00	3.00
REDUCED DISTANCE	0.00	05.00	205.00	400.00	610.00	1335.00
DISTANCE		05.00	110.00	400.00	600.00	1400.00
STATION NO.	0	A	B	F	G	H

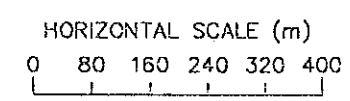


FIG. K-10-1

LONGITUDINAL PROFILE AND CROSS SECTION OF
N-12 DRAIN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

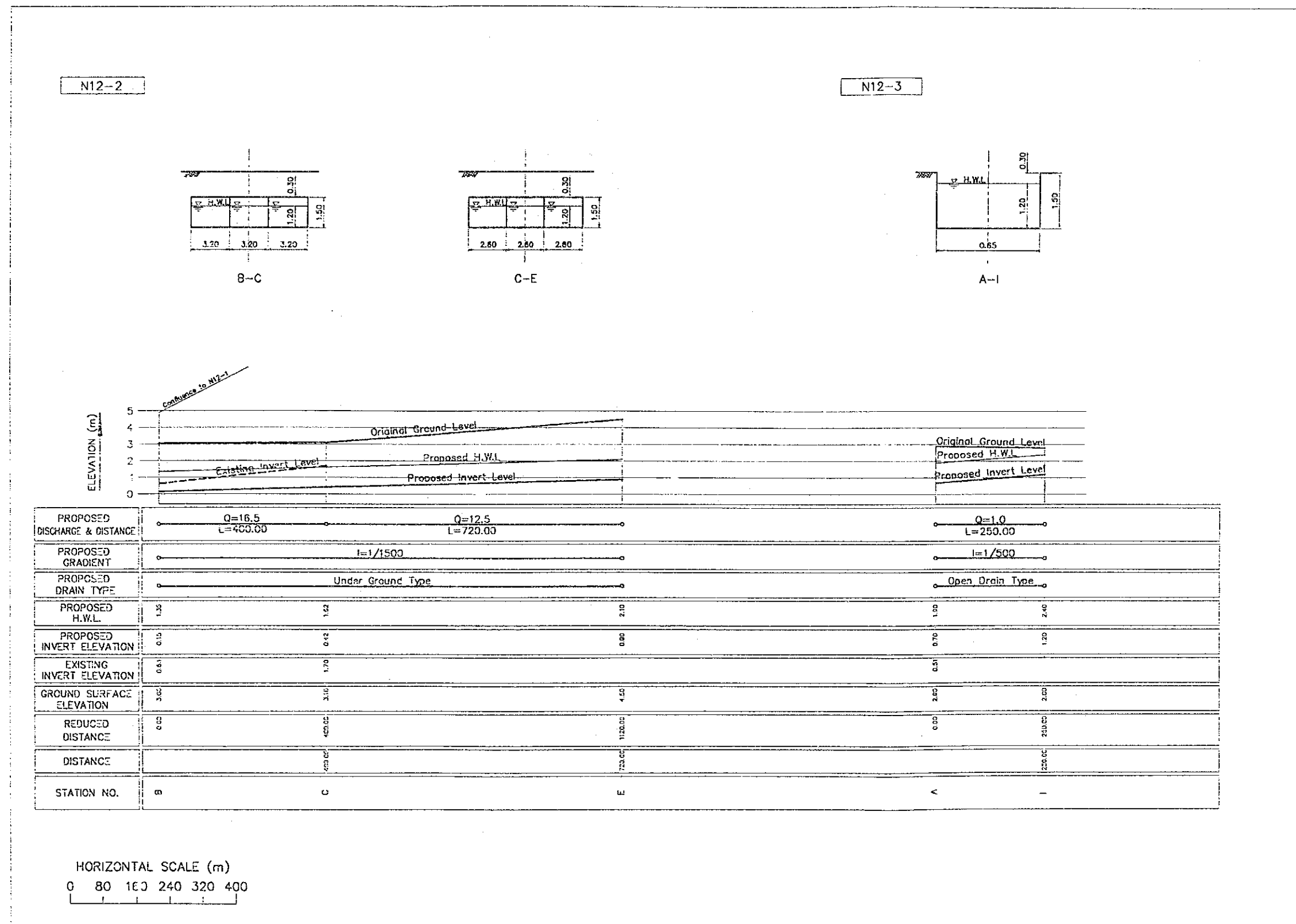


FIG. K-10-2

LONGITUDINAL PROFILE AND CROSS SECTION OF
N-12 DRAIN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

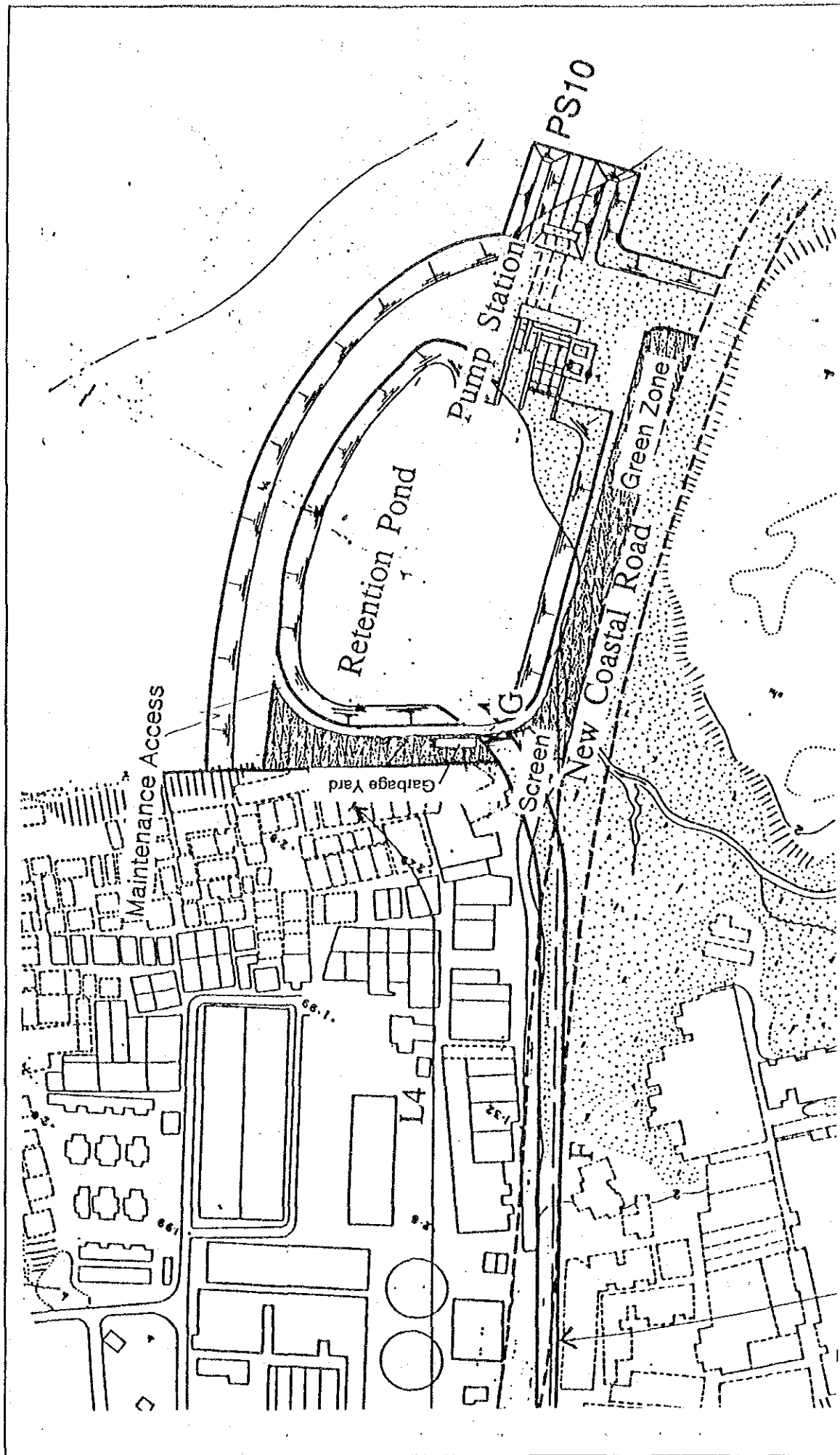


FIG. K-11 GENERAL PLAN OF S-10 RETENTION POND

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

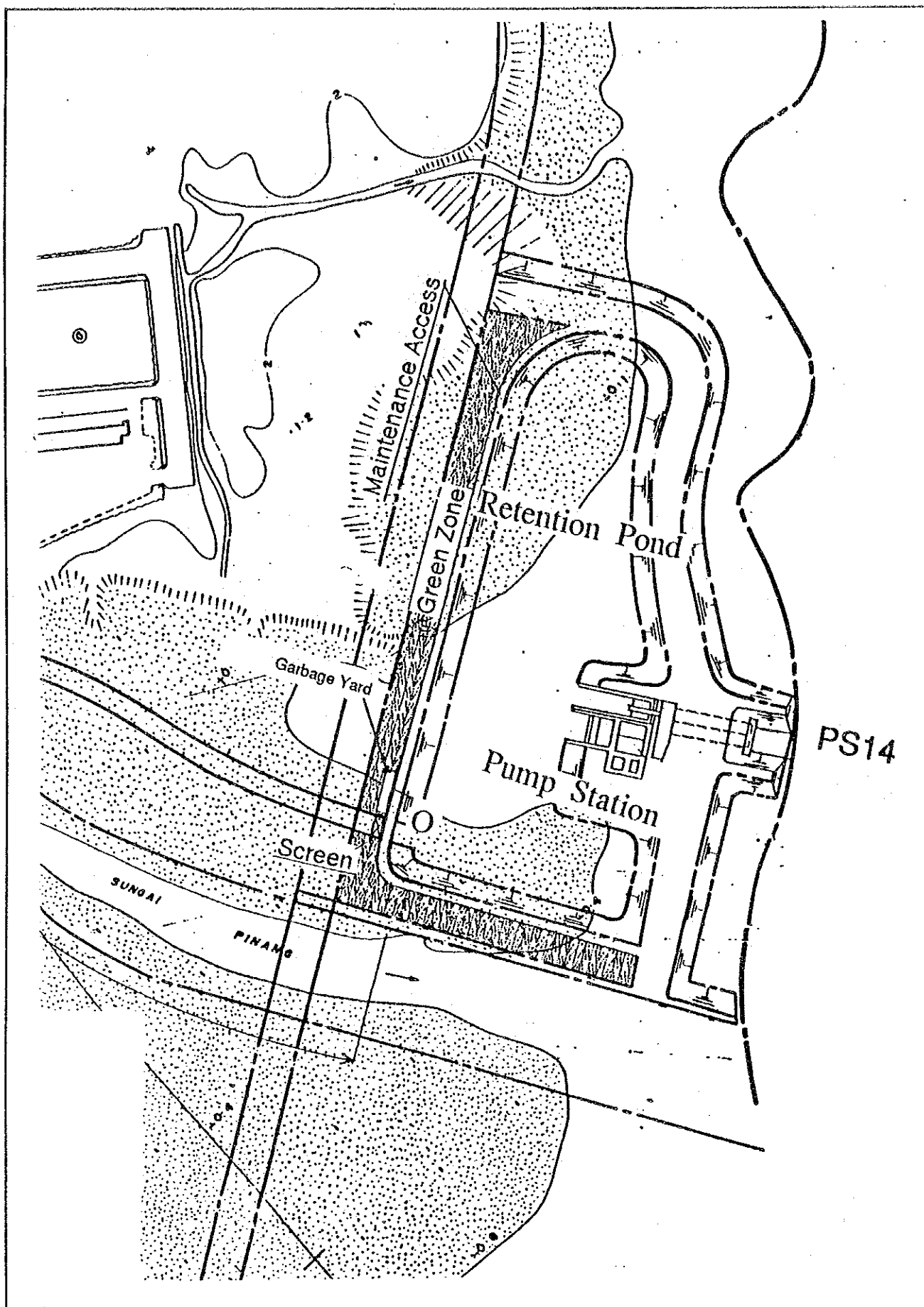
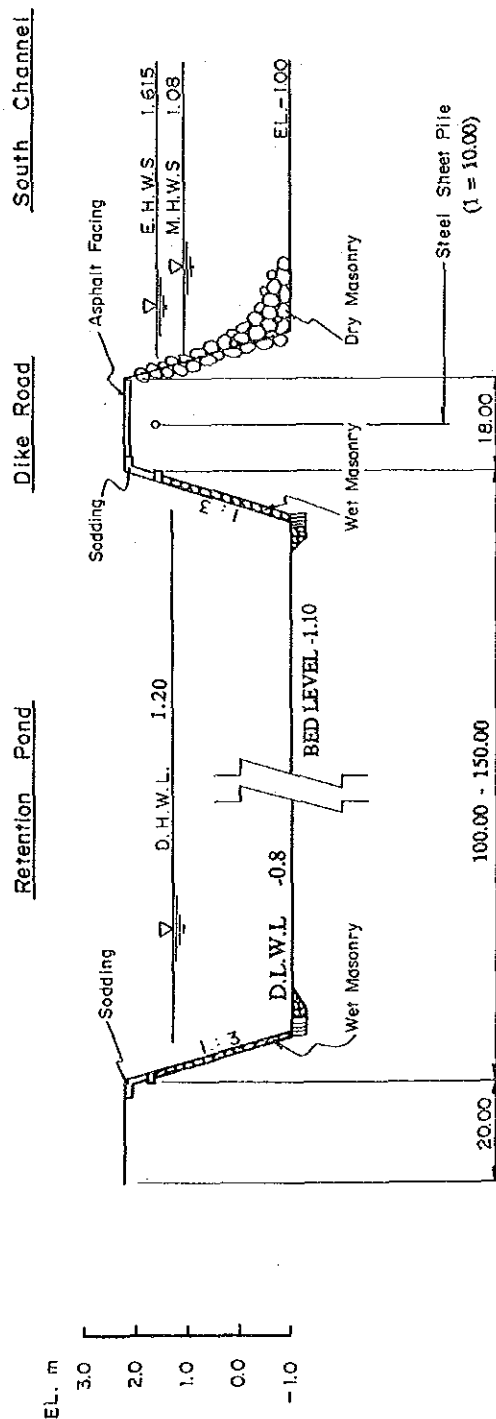


FIG. K-12

GENERAL PLAN OF S-18 RETENTION POND

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

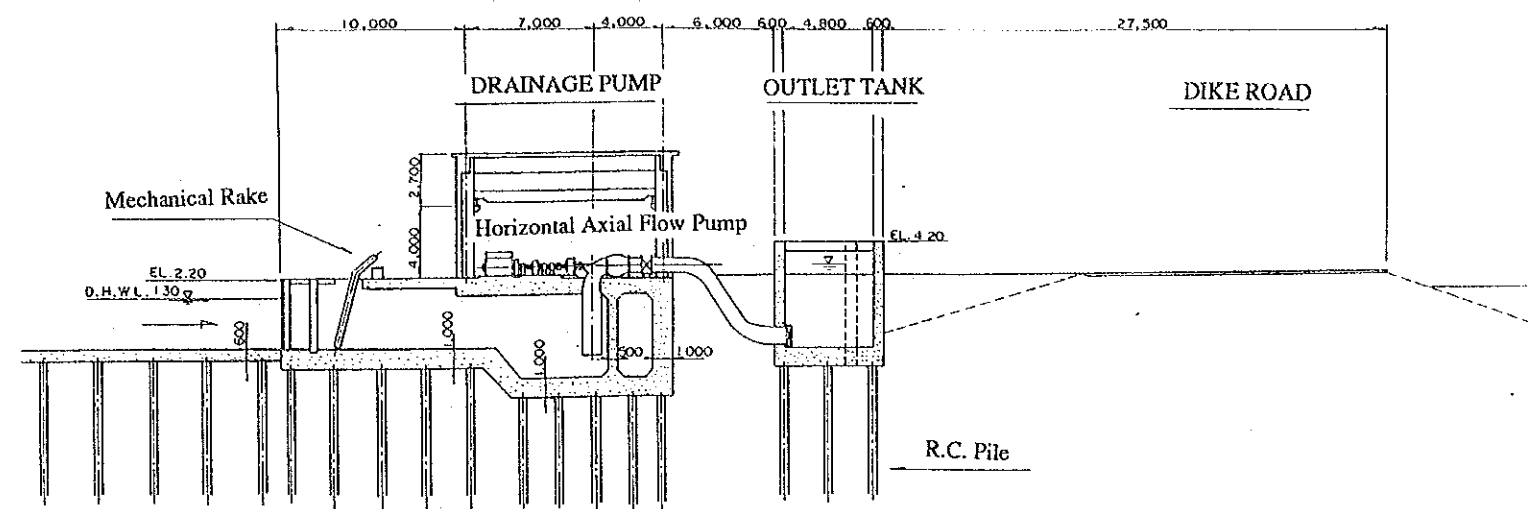


SCALE
V 1 : 100
H 1 : 1000

Typical Cross Section of Retention Pond

FIG. K-13 TYPICAL CROSS SECTION OF RETENTION POND

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



CASE - I
($q = 1 \text{ m}^3/\text{sec}$)
SCALE 1 : 800

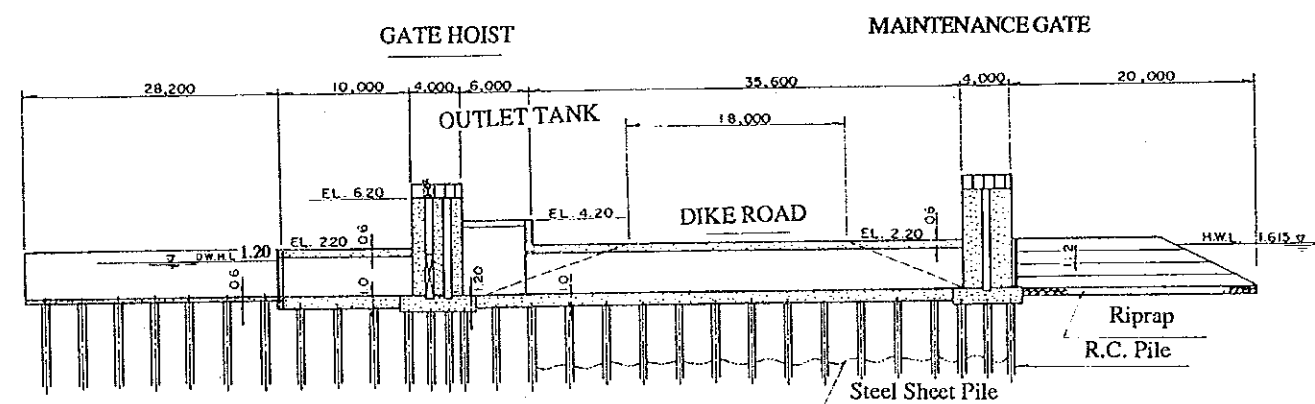
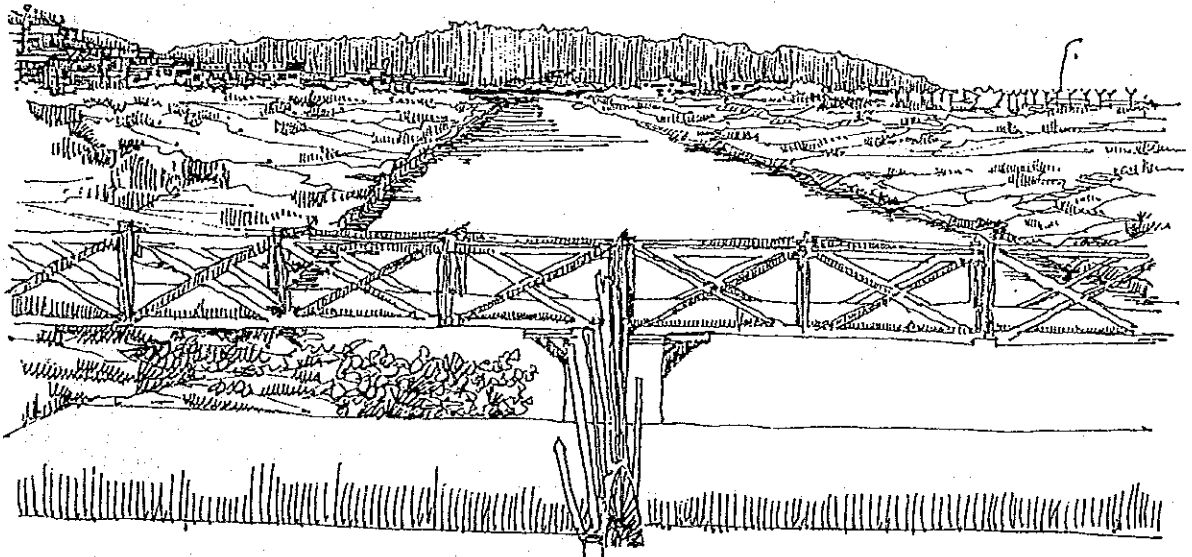


FIG. K-15	PLAN, LONGITUDINAL AND CROSS SECTIONS OF S-18 PUMP STATION
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND	

APPENDIX L

CONSTRUCTION PLAN AND COST ESTIMATE



APPENDIX L CONSTRUCTION PLAN AND COST ESTIMATE

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APPENDIX L CONSTRUCTION PLAN AND COST ESTIMATE

1. PREFACE

This chapter deals with a construction plan and financial cost estimate on the proposed urgent projects for the identified priority areas in the study of flood mitigation and drainage in Penang Island.

The project's financial cost is worked out in this chapter follows the proposed construction plan and schedule which are presented as a basic idea or guide for execution of required construction works of the rivers and drainage improvement on the urgent projects based on the site surveys results and collected data at the site. The protection level is 50-years and 10-years for flood mitigation and drainage respectively.

The urgent projects is planned by five (5) years implementation period considering the degree of urgency and 6th Malaysian Plan in 1991 to 1995, and started with the detailed design in 1991 on the selected priority areas as follows including beautification and landscaping works in the construction areas.

- Sg. Pinang system
- Sg. Keluang system
- Downstream stretch of Sg. Gelugor
- Downstream stretch of Sg. Dua Besar
- Drainage basin of N-12, S-10 and S-18

It is planned that the construction works of the urgent projects will be procured by the international contract basis.

2. CONSTRUCTION PLAN

2.1 General

Following to the feasibility design, a construction plan and schedule are presented herein for the required major construction works of the rivers improvement and drainage on the urgent projects as a basic idea or guide to understanding the project's construction works and to estimate the financial cost. The major construction works required for the urgent projects are 1) river improvement works, and 2) drainage works are summarized as follows:-

River improvement works of Sg. Pinang system

a. Sg. Pinang

- Deepening, widening and revetment of 3.15 km long river stretches

- Extension of river mouth with 710 m long
- Renewal of 7 sets bridges
- b. Sg. Jelutong
 - Deepening, widening and revetment of 2.14 km long river stretches
 - Construction of a drop structure
 - Renewal of 17 sets small bridges
- c. Sg. Dondang
 - Deepening, widening and revetment of 4.32 km long river stretches
 - Construction of a drop structure
 - Renewal of 8 sets bridges
- d. Sg. Air Itam
 - deepening, widening and revetment of 3.00 km long river stretches
 - Construction of a drop structure
 - Renewal of 3 sets bridges
- e. Construction of Air Terjun Diversion Channel of 1.74 km long in total
- f. Construction of Dondang Retention Ponds at 3 places with 8.4 ha in total
- g. Replacement of public and private utilities

River improvement works of Sg. Keluang

- a. Sg. Keluang and Sg. Relau
 - Deepening, widening and revetment of 3.18 km long river stretches
 - Extension of river course of 200 m
 - Renewal of 3 sets of bridges
- b. Deepening and widening of Sg. Ara with 1.87 km long river stretch
- c. Construction of 1.53 km long Relau Diversion Channel connecting Sg. Relau to Sg. Ara

Improvement for downstream stretch of Sg. Gelugor

- Deepening, widening and revetment of about 0.5 km long downstream stretches

Improvement for downstream stretch of Sg. Dua Besar

- Deepening, widening and revetment of about 2.1 km long downstream stretches

Drainage works

a. N-12 drainage system

- Reorganization and improvement of trunk drains covered with the basins of 157 ha

b. S-10 drainage system

- Improvement of trunk drain covered with the basins of 120 ha
- Construction of a retention pond with 1.9 ha of area
- Construction of a drainage pumping station having the capacity of 6.0 m³/s in total with outlet channel

c. S-18 drainage system

- Improvement of trunk drains covered with the basins of 104 ha
- Construction of a retention pond with 2.4 ha in area
- Construction of a drainage pumping station having the capacity of 2.0 m³/s in total with outlet channel

The following survey and study results are also comprise in this Appendix-L which will be affecting the implementation and construction of the urgent projects.

- Conditions for construction execution
- Implementation schedule and mode of construction
- Construction time schedule
- Basic considerations for planning

2.2 Conditions for Construction Execution

2.2.1 Site conditions

The Penang Island of 285 km² in total area is located at 3 km off Butterworth in west coast of Peninsular Malaysia. Topography of the Island can be broadly divided into the hill country and lowland area. The construction sites of the urgent project are located in east side of the Island, and urbanized and/or industrialized area mostly with elevations of less than

30 m, and slope is less than 5 in the project area. Sg. Pinang of about 2.4 km long stretches from the estuary are passing through dense area of houses and buildings in the central part of Georgetown with 1/950 to 1/2000 of river slopes approximately having 20 to 50 m of river width and 20 to 40 m³/s flow capacity. Sg. Air Terjun flows passing through the Botanical garden at upstream and housing area at downstream. Sg. Air Itam flows passing through dense housing area with 1/800 of river slope in an average having the river width varies 10 to 20 m. Sg. Keluang flows through the industrial areas having 13 to 20 m width and 10 to 30 m³/s with the river slope of about 1/1190. These rivers flows down to the south channel.

The project site, Penang Island, is equatorial climate which is quite uniform throughout the year. The annual average temperature is 27.8 degrees centigrade and annual mean relative humidity is 72 %. The annual mean rainfall in the construction sites is 2400 mm approximately. There are two monsoon seasons, northeast monsoon in November to January and southwest monsoon in April and May. Maximum amount of precipitation occurs in September and October.

The tidal level at the Kedah pier, MHWS and EHW are +1.08 (R.L, reduced level) and +1.615 (R.L) respectively. Penang Island is mainly composed of granite rocks. Top portion of the granite is weathered into residual soils. At low land areas and coastal plains, loose sandy soils and soft clayey soils including organic clay were deposited. The geotechnical conditions of the construction sites are summarized as follows.

- The coastal area is composed of soft alluvial deposits, sand and clay with N value of 0-5.
- Loose medium dense sand and silty sand with some gravel are composed at middle part of Georgetown. Stiff silty clay layers of medium dense sand layers exist below this strata. Foundation rock mass is estimated to exist at deep layer.
- Upstream area consists of granite rock, talus deposit, boulder deposit with gravel and sand.
- Thickness of the weathering granite rocks is more than 30 m undulating to flat areas relatively less in hilly areas to 10 to 20 m of depth.

2.2.2 Support Infrastructure/Public Utilities

Roadway

In the project area, existing public roads are available as access and construction roads for all of the work sites. Most of these roads have concrete paving, and maintenance conditions seems fair under the management by Municipal council for city roads and JKR for roads outside the city. The Island and the main land are linked by the Penang Bridge of about 13.5 km long which was completed in 1985. The charge is 7.0 M\$ per one unit of sedan type car for one time passage at present.

Railway

The Malaysian railway line, main line, runs north and south on the Peninsular Malaysia passing through Butterworth and connects with Thailand. The line has cargo handling service at the Butterworth station without unloading facility. The rail gauge is 1000 mm as well as the Thailand's railway, with 16 tons axle load at maximum. The driving system is diesel locomotive types of all at present. The bogie type wagon are also available for the handling of heavy cargoes, having about 30 tons payload capacity per unit. The cargo line operates in about 10 hours between Klang and Butterworth of about 400 km in distances.

Seaport

The port of Penang is located in the state of Penang and it offers efficient services to ships and cargo equipped with up-to-date and sophisticated equipment to facilitate the handling of containers, liquid bulk, dry bulk and break bulk cargo under management by Penang Port Commission. Facilities provided by the port are located on the Island as well as on the mainland. On the Island, facilities consist of Swettenham pier and the ferry terminal, which are located in the hub of the Georgetown city. Facilities on the mainland comprise Butterworth Wharves, bulk cargo terminal, Prai Wharf, private petroleum jetties and the ferry terminal. A 24 hours ferry services are available between the Penang port and Butterworth by 8 pairs of ferries which have a capacity of 30 to 40 units of sedan type cars with a charge of M\$ 6.4 per time per sedan type a car and the navigation time of about 20 to 30 minutes at present. The draught depth of the Penang port ranges 7 to 10 m.

Airport

The Penang international airport is located at Bayan Lepas in the southeast of the Island and about 16 km from Georgetown, and connects the region with all major overseas capitals.

Communication

The communication systems are well developed in the Island including the project area. These include cables, telex, telephone, postal, radio, TV, newspapers and other services.

Power supply

The electricity supply in Penang including the project area is provided via 2 high voltage of 132 KV submarine cables with a capacity of 180 MVA (162 MV) and 3 high voltage of 132 KV underground cable with a capacity of 300 MVA (270 MV) via Penang bridge. Supply to the sub-cable are from power station at Prai, whereas the underground cable via Penang bridge is supplied by National Grid via transmission sub-station Bukit Tengah. This is supported by Gelugor power station with a capacity of 20 MW. At present, maximum demand in Penang is 199 MW, and Penang district has 3 main intake sub-station of 132 KV with connecting capacity of 2 by 90 MVA that are :

- Gelugor main intake sub-station
- Bayan Baru main intake sub-station

- Sg. Pinang

The distribution system is 3 stages of 33 KV, 11 KV and low voltage lines. The future maximum demand is estimated at 370 MW in 1995 using a load factor of 65 % by NEB. The NEB has proposals to lay another 132 KV, 90 MVA cable from the mainland and 2 more 132 KV, 180 MVA cables by 1990. This will increase the supply capacity from the national grid to 450 MW by 1990 according to the structure plan of the Island.

Water supply

The Penang Water Authority manages the water supply in Penang Island including treatment and distribution. The sources are a number of water catchment areas in the northern hilly areas and the Sg. Muda scheme on the mainland. Of about 97 % of the population in the Island has access to piped water with meter service. The average daily water consumption in Penang Island was about 150 thousand cubic meters in 1986 according to the annual report of PWA.

2.2.3 Conditions Affecting Construction

Availability of constructional plant and equipment

In studying the contents of construction works, large scale of constructional plant will not be required. Middle to light class of construction equipment will mainly be utilized. Such equipment is available in the domestic market mostly. Granite rock quarries and ready-mixed concrete plants are commercially operated in the Island.

Construction materials

Table below shows the expected supply sources of major materials which will be required for the construction works.

Materials	Sources
Portland cement	: Perak State
Round and deformed bar	: Penang/Trengganu/Johor
Shaped steel	: Penang/Trengganu/Johor
Fuel and lubricants	: Penang/Butterworth
Concrete aggregates	: Penang Island
Rock materials	: Penang Island
Wooden materials	: Kedah/Perak
Explosives	: Kuala Lumpur

A brief explanation is given as follows based on the site survey and collected data.

(Cement)

Brands of cement popular in Penang are as follows which are produced in Peninsular Malaysia.

Brands	Location of factory
CAMEL	Perak State
LION	Perak State

TIGER Perak State
CROCODILE Perak State

(Steel material)

Round and deformed type of reinforced steel bars are produced at the native factories in the country while the shaped steel such as H-shaped steel, angles and so on are produced limitedly. But those materials are obtainable in the local market, Peninsular Malaysia, in most sizes of standard.

(Concrete aggregates)

The project involves much volume of concrete works. Granite type rock materials are commercially obtainable in Penang Island with sufficient volume and the hauling distance of about 20 km to the estuary of Sg. Pinang

(Ready mixed concrete)

In Penang Island, two (2) factories operate at present for the production of ready mixed concrete. The production capacity is 35 and 40 m³/h respectively, and 8 to 16 hours daily operation. The aggregates are granite rocks taken from the quarries and river deposit sand in the Island. Commercial base is site delivery basis by these factories having agitator trucks of 3 to 5 m³ capacity mostly. Distance is about 8.0 km between these factories and Sg. Pinang estuary.

Labour sources

Skilled and semi-skilled labourers would be recruited in Penang Island and Butterworth. Common labourers could be employed on Penang Island. These labourers would be available without seasonal variation. The SOCSO (Employee's social security scheme) should be followed for the execution of construction works.

General constructors

With regard to civil construction works for the public sector, the Government has a registration system of contractors classified in eight (8) ranking based on the value of the contract amount as follows.

<u>Class Financial limit (M\$)</u>		<u>Nos. of registration *</u>
A	4000001 or more	146
B	2000001 - 8000000	345
BX	1000001 - 4000000	435
C	750001 - 2000000	475
D	150001 - 750000	678
E	100001 - 350000	473
EX	50001 - 150000	380
F	100000 and below	-

* As of 1988

Source : Pusat Khidmat Kontraktor (Authority over the registration of all classes of contractors bidding for government job or project).

2.3 Implementation Schedule and Mode of Construction

It is essential to realize the rivers and drainage improvement plans as early as possible to protect the areas from recurrent flooding. It is proposed that the whole project be implemented over a twenty (20) years period dividing into three (3) phases as shown in Fig.L-1 and summarized as follows.

Phase	Duration	Period (Years)
- 1st phase for the urgent projects	1991 - 1995	5.0
- 2nd phase for mid-term plan	1996 - 2000	5.0
- 3rd phase for long-term plan	2001 - 2010	10.0

The urgent projects are scheduled to be conducted in five (5) years implementation period started with the detailed design in 1991 considering the degree of urgency and 6th Malaysian Plan in 1991 to 1995, as shown in Fig.L-2 and L-3 and summarized as follows.

Activities	Period (months)	Duration
- Detailed design:	10	1991-1992
- Financial arrangement for detailed design and construction works:	15 (6 & 9 months for D/D and construction respectively)	1991 & 1992
- Prequalification of tenderer and: tendering	8	1992
- Land acquisition and building compensation:	24	1992-1993
- Award of contract:	-	December, 1992
- Construction:	36	1993-1995
- Completion:	-	December, 1995

The construction works of the urgent projects will be procured on the basis of unit price contracts by means of international and/or local tenders, with a prequalification system to be established in the detailed design stage. The number of contract package will be decided in the successful detailed design stage.

The funds required for the implementation of the urgent projects will be allocated by the national government budget and a supporting loan from an international financing agency.

Throughout the implementation period, the project will be managed and administrated by DID in association with an international engineering consultant. Fig.L-4 shows a proposed organization chart for the construction execution of the urgent projects.

2.4 Main Civil Works

2.4.1 Basic considerations for Construction Planning

In studying the construction plan and schedule, the following basic conditions and assumptions are applied.

Construction method

Conventional methods and equipment are applied taking local conditions into consideration. Excavated materials at the rivers, retention ponds and others will be utilized effectively for land reclamation, embankment, and etc..

Construction plant, equipment and materials

Plant, equipment and materials required for the construction works will be procured locally as far as possible.

Work days

Annual work days are estimated based on the rainfall records in project site, station no. 5303001, considering Sundays and national holidays. Thus, annual working days are determined at 223 days when rainfall intensity is more than 10 mm per day as tabulated in Table L-1. A work day is normally 8 hours.

Hourly production rate of equipment

Hourly production rates of major equipment are estimated as shown in Table L-3 to meet with the site conditions using the following swelling and shrinkage factors of materials.

Material	Loose/Bank	Embank/Bank
- Common	1.25	0.88
- Coarse/Sand and gravel	1.15	1.02
- Rock	1.60	1.15

Environmental aspects

Special attention will be paid to the protection of environmental aspects in and around the construction area. Landscaping works will be carried out to meet with the urban view in Penang Island following to the required zones of the areas in the urgent projects.

Traffic

For the construction of bridges, Diversion Channel and other structures, due consideration should be given to the flow of traffic. Traffic obstruction will be minimized applying following plan or method during the construction period.

- to provide detour routes
- to adopt the phased construction works for respective structures
- to apply to carried out in night time works at the heavy traffic places such as the Air Terjun Diversion Channel route
- to apply 2 or 3 shifts works per day

Public utilities

There are many public utilities in the variety of the construction sites. The construction works should be conducted without any interference with the operation or functioning of these existing public or private utilities.

2.4.2 Construction Work Items and Its Quantity

The urgent project comprises the following major construction work items and quantities.

No.	Work items	Quantity
1.	General items	L.S.
2.	River improvement works	
2.1	Sg.Pinang system	
1)	Sg. Pinang, 3.15 km	
(1)	Channel excavation	275000 m ³
(2)	Levee embankment	15200 "
(3)	Jetty embankment, l=710 m	5000 "
(4)	Revetment, wet masonry	38000 m ²
(5)	Inspection road, right and left	7600 m
(6)	Renewal of bridges	7 sets
(7)	Landscaping works	L.S.
2)	Sg. Jelutong, 2.14 km	
(1)	Channel excavation	19700 m ³
(2)	Levee embankment	10000 "
(3)	Concrete	5200 m ³
(4)	Inspection road, right and left	4210 m
(5)	Renewal of small bridges	17 sets
(6)	Landscaping works	L.S.
3)	Sg. Air Itam, 3.0 km	
(1)	Channel excavation	235200 m ³
(2)	Levee embankment	8550 m ³
(3)	Revetment, wet masonry	30000 m ²
(4)	Inspection road, right and left	5800 m
(5)	Renewal of bridges	3 sets
(6)	Landscaping works	L.S.
4)	Sg. Dondang, 4.32 km	
(1)	Channel excavation	110000 m ³
(2)	Levee embankment	14900 m ³
(3)	Revetment, wet masonry	53300 m ²
(4)	Inspection road, right and left	7584 m
(5)	Renewal of bridges	8 sets
(6)	Landscaping works	L.S.
5)	Air Terjun Diversion Channel, 1,740 km	
(1)	Excavation	56220 m ³
(2)	Concrete box culvert (W5.5m*H3.22 m)	1530 m
(3)	Concrete open channel (W7.4 m*H2.60 m) (Improvement of Sg.Babi)	210 m
(4)	Revetment, wet masonry	900 m ²
(5)	Backfill	2000 m ³
(6)	Restoration of roads	L.S

(7) Landscaping works	L.S.
6) Dondang Retention Ponds, 8.4 ha, 3 sets	
(1) Ponds excavation	360000 m ³
(2) Revetment, wet masonry	1000 "
(3) Weir structure by stones	3 places
(4) Outlet structure	L.S.
(5) Sluice gates, 2 m*2 m & 1 m*1 m	3 sets
(6) Flap gates, 0.5 m * 0.5 m	3 sets
(7) Landscaping works	L.S.
2.2 Sg. Keluang system	
1) Sg. Keluang and Sg. Relau, 3.18 km	
(1) Channel excavation	29000 m ³
(2) Levee embankment	58000 "
(3) Revetment, low/high water channel	23400 m ²
(4) Inspection road, right and left	3100 m
(5) Landscaping works	L.S.
2) Sg. Ara, 1.87 km	
(1) Channel excavation	73000 m ³
(2) Levee embankment	23000 m ³
(3) Revetment, low/high water channel	22000 m ²
(4) Inspection road, right and left	3740 m
(5) Renewal of bridge	2 sets
(6) Landscaping works	L.S.
3) Relau Diversion Channel, 1.53 km	
(1) Excavation	75900 m ³
(2) Backfill	19700 "
(3) Concrete for U-type channel	10500 "
(4) Construction of bridge, newly	1 set
(5) Landscaping works	L.S.
2.3 Sg. Gelugor, 0.5 km	
a. Excavation	4500 m ³
b. Revetment, wet masonry	2260 m ²
c. Inspection road	1000 m
2.4 Sg. Dua Besar, 2.1 km	
a. Excavation	13860 m ³
b. Revetment, wet masonry	12500 m ²
c. Inspection road	7200 m
3. Drainage works	
3.1 N-12 Drainage System	
a. Excavation	21500 m ³
b. Concrete	3600 "
c. Wooden piling, 100 mm dia., l=4 m	38550 nos.
d. Restoration of road	9800 m ²
e. Backfill	7900 m ³

3.2 S-10 Drainage System

1) Trunk drain

(1)	Excavation	32000 m ³
(2)	Concrete	10000 m ³
(3)	Wooden piling, 100 mm dia., l=4 m	34500 nos.
(5)	Restoration of road	11700 m ²

2) Retention pond

(1)	Embankment, ring levee	64000 m ³
(2)	Revetment, dry and wet masonry	9300 m ²
(3)	Steel sheetpiling, l=10 m, type 2	1000 nos
(4)	Asphalt paving of ring levee	8000 m ²
(5)	Landscaping works	L.S.

3) Pumping house

(1)	Excavation	10000 m ³
(2)	Foundation piling, R.C type (Dia.400 mm, l=30 m)	164 nos
(3)	Steel sheetpile, type-2, l=10 m	423 nos.
(4)	Backfill	4800 m ³
(5)	Building, R.C type, 280 m ²	L.S.
(6)	Drainage pump, horizontal axial flow Q=2.0 m ³ /s, (50 kw/set), H=1.5 m,	3 sets
(7)	Overhead crane, 3.5 tons, 7.1 m span	1 set
(8)	Diesel generator, 225 kva	1 set
(9)	Auxiliary facilities	L.S.
(10)	Gate (3.5 t * 4 sets) and trashrack (3 t * 2 sets)	20 tons
(11)	Garbage equipment, rotary rake	3 sets
(12)	Landscaping works	L.S.

4) Outlet channel

(1)	Excavation	150 m ³
(2)	Embankment	1800 m ³
(3)	Revetment by dry masonry	250 m ²

3.3 S-18 Drainage System

1) Trunk drain

(1)	Excavation	41000 m ³
(2)	Concrete	20000 "
(3)	Wooden piling, 100 mm dia., l=4 m	75000 nos.
(4)	Backfill	13000 m ³
(5)	Restoration of road	18800 m ²

2) Retention pond

(1)	Embankment, ring levee	76000 m ³
(2)	Revetment, dry/wet masonry	11800 m ²
(3)	Steel sheetpiling, l=10 m, type-2	760 nos.
(4)	Asphalt paving for ring levee	8600 m ²
(5)	Landscaping works	L.S.

3) Pumping house

(1)	Excavation	5600 m ³
(2)	Foundation piling, R.C type	153 nos.
	(Dia.400 mm, l=30 m)	
(3)	Steel sheetpile, type-2, l=10 m	395 nos.
(4)	Backfill	3200 m ³
(5)	Building, R.C type, concrete:6000 m ³	L.S.
(6)	Drainage pump, horizontal, axial flow	2 sets
	Q= 1.0 m ³ /s, (50 kw/set), H=1.5 m	
(7)	Overhead crane, 3.5 tons, 7.1 m span	1 set
(8)	Diesel generator, 225 kva	1 set
(9)	Auxiliary facilities	L.S.
(10)	Gate and trashrack	20 tons
(11)	Garbage equipment	3 sets
(12)	Landscaping works	L.S.

4) Outlet channel

(1)	Excavation	150 m ³
(2)	Embankment	1800 m ³
(3)	Revetment by dry masonry	250 m ²
(4)	Landscaping works	L.S.

Following to the river improvement, widening and deepening, existing public utilities will be required to be replaced at several locations. Those are mainly power distribution lines and water supply pipes. In addition to the replacement works of public utilities, protection of existing public utilities will also be required during the construction works at several places where exist closing to working site. As the preparatory works and or general items, access and construction roads, communication facilities, temporary buildings, care of water, traffic control and other items are contemplated to be included to the construction work items.

2.4.3 Preparatory Works

Since the project lies in urban area, there are many public utilities and or support infrastructures. Those are existing roads, electricity, water supply, etc. Consequently, preparatory works to be required for project implementation will be the construction of access and construction roads partly connecting to the existing ones, temporary buildings, and communication system. Vice versa, the construction works in the urbanized area should be conducted without obstruction of function for those utilities and or environmental disruption. A plan of those works are explained as follows.

1) Access and construction roads

It will be required to construct access and construction roads newly at several work sites for approaching the work areas and as the construction use connecting to the existing roads. Those areas are Relau Diversion Channel, retention ponds, pumping station of S-10 and S-18 sites. Of about 5.0 km long in total will be required as the access and construction roads to be constructed newly as follows.

Location	Length	Width
- Along Relau Diversion Channel	1.5 km	3.0 m
- Along retention pond and pumping station of S-10	1.0 "	3.0 "
- Along retention pond and pumping station of S-18	1.0 "	3.0 "
- Along Dondang Retention Ponds	1.0 "	3.0 "

Macadam type road is planned and constructed in the beginning stage of construction works.

2) Temporary building

During construction, temporary buildings will be required as for the site office, warehouse, repair shop, laboratory and others. These buildings will provide at site in the beginning stage of construction works. Required area is estimated of about 2000 m² in total for those buildings. These buildings will be located in the coastal and new reclamation area of south channel.

3) Communication system

Public telephone lines would be extended to the respective site office by the contractor for smooth execution of construction works. Handy talky is useful at respective working area.

4) Arrangement for replacement of public utilities

Following to the river improvement works, widening and deepening, existing power supply cables and water supply pipes are required to replace at several places. The location of these utilities which have to be replaced are shown in the supplementary drawings. The following sequences will be taken in the detailed design stage and beginning stage of construction works for the implementation of this works having due consultation with the NEB, PWA and other agencies concerned.

Detailed design stage

- a. Survey and investigation of existing public and private utilities in the project area.
- b. To specify the utilities which have to be replaced following to the rivers and drainage improvement works.
- c. Presentation and explanation of the project's implementation plan to the agencies concerned having layout plan, detailed drawings and construction time schedule.
- d. To estimate the replacement cost, and incorporate into the project's budget.
- e. To provide the replacement plan and schedule together with the agencies concerned.

Construction stage

- a. Reconfirmation of replacement plan and schedule with the agencies concerned in the beginning time of project's works before starting the construction works.
- b. Execution of replacement works.
- c. Payment to the respective agency for completion with the certificates issued by the engineers both of the agency and project.

5) Traffic control

Required construction works are to be conducted mostly in urbanized area. Traffic control around these construction areas will be required including street closures, bypassing or widenings and other alterations to the roadways and resting bus stop in order to minimize the disruption of traffic during construction works upon due consultation with Penang municipal office and other agencies concerned. Careful plan and control will be required at the construction sites of Air Terjun Diversion Channel, Relau Diversion Channel and bridges crossing the river.

2.4.4 River Improvement Works

1) General

The river improvement works of the urgent project consist of the following river basins and flood mitigation facilities with the protection level of 50-years return period.

(1) Sg. Pinang system

- Improvement works for Sg. Pinang, Sg. Jelutong, Sg. Air Itam and Sg. Dondang respectively of about 13.3 km total long stretch with landscaping works.
- Construction of 1468 m long Air Terjun Diversion Channel having 65 m³/s diverting capacity by concrete box culvert section of 1273 m long and 195 m long open concrete channel by means of improvement the downstream reach of Sg. Babi.
- Construction of Dondang Retention Ponds with a total area of 8.4 ha at 3 locations and 198,000m³ storage capacity, including landscape works.

(2) Sg. Keluang system

- Improvement works along Sg. Keluang , Sg. Relau and Sg. Ara of about 5.25 km long total stretch.
- Construction of 1530 m long Relau Diversion Channel with 70 m³/s diverting capacity by U type open concrete channel.

(3) Sg. Gelugor

- Improvement of downstream stretch of about 500 m

(4) Sg. Dua Besar

- Improvement of downstream stretch of about 2100 m.

Following to the river improvement works, renewal of existing bridges and newly construction are required as follows.

Sg. Pinang system,	Sg. Pinang:	7 sets
	Sg. Jelutong:	17 "
	Sg. Air Itam:	3 "
	Sg. Dondang:	8 "
Amount		35 sets
Sg. Keluang system,	Sg. Ara:	2 sets
	Relau diversion:	1 set (newly)
	Amount	3 sets
Total		38 "

The replacement of public utilities at several places will also be required incorporating the project's construction works following to the widening and deepening the rivers.

2) Sg. Pinang and its tributaries

Sg. Pinang

A 3.15 km long stretch Sg. Pinang is planned to be improved containing the following major construction work items.

- Deepening and widening of the river by means of channel excavation of 275,000 m³
- Levee embankment of 15,200 m³
- Revetment of 38,000 m² by wet masonry
- Jetty construction of 710 m long
- Renewal of 7 sets of bridges
- Replacement of public utilities

Existing river profile is 20 to 50 m of width, slope of 1/1500 in an average and affecting tidal flow of about 3 km. The cross section of Sg. Pinang is designed a single section with 1:1 bank slopes. The depth of river channel will vary from 3.1 m to 3.4 m.

The channel excavation works will be conducted beginning from the estuary and working upstream. The proposed width of

the river is about 60 and 30 m at the estuary and CH 3100 respectively. The channel excavation will be carried out by combination of dragline, backhoe, swamp type bulldozer, crawler loader and dump truck. Amphibious type of excavator will be required for the deepening work in center zone of the river that are difficult area to excavate by dragline or backhoe from the both banks due to the limited cutting radius by light to middle class of equipment which will be selected considering the site conditions. Excavated soils will be planned to utilize as for the levee embankment materials. Excessive soils of about 0.25 million m³ will be used as for the levee of retention ponds for the drainage works and the land reclamation material of CDD 21 project area of 210 ha in total at coastal area between Penang Bridge to Prangin street Ghaut where the area have been proposed to be reclaimed by PDC. Hauling distance is estimated at 0.1 to 4.0 km to the CDD 21 reclamation area. Work period will be one year for the channel excavation with condition that standard progress of 185 m³/h for the excavation work. The levee embankment will be carried out by excavated material from the high water channel using bulldozer, vibration roller and water tanker without dump track as far as possible. The embankment will be carried out upon adjustment of moisture contents as required.

The revetment work will be executed mainly by manual power supported by track crane. The construction of about 110 m long jetty will be carried out by bulldozer and dump truck towards sea side. Granite quarry rock will be transported as the embankment material of jetty from the quarry located at northern area in the Island with the hauling distance of about 10 km. Required embankment volume is estimated of about 5000 m³ including core clay of 500 m³. The landscaping works will be carried out following to the improvement works of the river. The construction period for Sg. Pinang improvement works will be scheduled to be completed in one year.

Sg. Jelutong

Sg. Jelutong improvement works of 2.14 km long stretch from the estuary include the following major construction work items.

- Excavation of river channel of 19700 m³
- Levee embankment of 10000 m³
- Concrete revetment of 5200 m³

The river width is varies 3 to 10 m with slope of 1/1000. This river passing through dense area of housing in the Georgetown. The construction works will be carried out by combination of light class of equipment and manual power of about 12 months work period in 3rd year in parallel with Sg. Keluang improvement works.

Sg. Air Itam

A 3.0 km long stretch of Sg. Air Itam is planned to be improved by means of deepening, widening, levee embankment, and concrete revetment as the major work items.

The bridge renewal of 3 sets is also required according to the river improvement. The construction works will be conducted upwards from the confluence with Sg. Pinang.

The river width is ranges 10 m to 30 m with the slope of 1/1000. Site geology shows that are composed of loose medium dense sand, silty sand with some gravel. At upstream area consists of granite rock, talus deposit, boulder deposit and gravel with sand. Thickness of the weathering of granite rocks is more than 30 to 50 m endulating to flat areas and relatively less in hilly area to 10 to 20 m in depth.

The construction works will be carried out by combination of light to middle class of equipment considering the site conditions. The excavation volume of channel is estimated of about 0.24 million m³. The excavation works will be done from the both banks using backhoe mainly. Of about 10000 m³ of excavated soils are to be utilized as the levee embankment materials. An excessive soils will be hauled to the CDD 21 land reclamation area. Hauling distance is 3.0 km approximately. The concrete lining revetment will be carried out upon partial coffering the river using sandbags. Ready mixed concrete will be poured by concrete pump car. The channel works will be planned at 9 months work period and be conducted after Sg. Pinang channel works shifting the crew and equipment.

Sg. Dondang and Retention Ponds

a. Sg. Dondang

Of about 4.32 km of Sg. Dondang stretch is planned to be improved with a single cross section. Major works are channel excavation of 110000 m³, levee embankment of 14900 m³ and wet masonry of 53300 m². These works will also be carried out upwards from downstream following to Sg. Air Itam channel improvement works shifting the crew and equipment in about 6 months work period. The works will be carried out by the same method of Sg. Pinang and Sg. Air Itam.

b. Dondang Retention Ponds

The retention ponds, pond A, B and C are proposed to be constructed at 3 sites with 8.4 ha of total area along Sg. Dondang having about 0.2 million m³ of capacity in total as the one of important flood mitigation facility. These areas of retention ponds are planned to be parkland. Therefore, landscaping works will also be required in the areas. These ponds will be equipped with weir and outlet structures with sluice and flap gates respectively. Major construction works are excavation of 0.36 million m³, construction of weir structures at 3 sites and installation of gates. The excavation works will be carried out by combination of middle class of bulldozer, crawler loader and dump truck. Rock excavation will be performed by ripper equipped with the

bulldozer. Excavated soils and rock will be planned to be utilized as the reclamation material of CDD 21 area. Hauling distance is 4.0 km approximately to this area. The weir structures will be made by stone pitching. Required stones will be taken from granite quarry in the Island. These ponds construction works will be conducted separating the river improvement works and following to the construction of the Air Terjun Diversion Channel shifting the crew and equipment in about one (1) year work period. A standard progress of the excavation is planned at 240 m³/h.

Air Terjun Diversion Channel

The Air Terjun Diversion Channel is proposed to construct as the major flood mitigation facility of the urgent projects for the purpose to divert flood flow of Sg. Air Terjun basin having 65 m³/s of discharge capacity. The profile of this channel is as follows.

Location (route):	Underground route of Jln. Gottlieb, Jln. Bagan Jermal, and downstream reach of Sg. Babi
Type of cross section:	Concrete rectangular box culvert along Jln. Gottlieb and Bagan Jermal, and concrete open channel at Sg. Babi.
Length in total:	1740 m - Box culvert section : 1530 m (W=5.5 m, H=3.22 m) (W=6.3 m, H=2.76 m) - Concrete open channel : 210 m (W=6.3 m, H=2.76 m) (W=5.5 m, H=2.9 m)
Drop structure:	8 places, H=0.5 m,
Invert level:	Entrance EL.11.5 m, outlet EL.-0.92m
Channel bed slope:	1/200 - 1/250
Earth covering:	Max. 3.5 m at upstream end Min. 0.5 m at downstream end.

The major construction works are excavation of 56220 m³, concreting of 21800 m³ both for box culvert and open channel and restoration of the existing roads. Improvement of Sg. Air Terjun of about 100 m long stretch at the inlet portion the channel is also included of this channel construction works. The box culvert section of 1530 m long comprises the construction of drop structures at 9 places of downstream section between CH 400 and CH 800. Before commencement the works, traffic system and control plan in and around the working area of this Diversion Channel is to be provided with due consultation of MPPP's traffic section. The JICA's technical report No.3, traffic count at intersection of Georgetown in Sept 1987 shows the peak hour traffic flow of intersections at Jln. Kelawei and Burma as shown in Fig. L-6 and L- 8. Traffic between central area and northern part of the Island is mainly along Northam road and Burma road. Traffic of Gottlieb and Bagan Jermal roads are small number

of passenger car unit compared with the Kelawei and Burma roads. The traffic of north-south direction using Kelawei and Burma roads should be maintained during the construction works. Under such conditions, the following method will be considered to be taken for execution of diversion construction works.

- Phased construction work is applied.
- The excavation and concrete works of box culvert will be done alternately (cut and cover method) in about 10 to 20 m long for each phase providing the temporary retaining walls using steel sheetpiles.
- At the intersections of Jln. Kelawei and Burma, the works will be carried out in night time with shortest work period as far as possible divided into a half section of the road, upstream half and downstream half, for the purpose to keep the traffics as illustrated in Fig.L-6 to L-9.
- A detour route will be provided during construction of the section under the Jln. Utama as illustrated in Fig.L-10.
- A part of the existing walkways along Jln. Gottlieb and Bagan Jermal will be used as temporary traffic route only for the house holders in the areas during construction for the said section.

The excavation will be carried out using backhoe after demolishing the paved concrete and base materials the existing road by breaker equipped with excavator. Excavated materials will be hauled to the CDD 21 reclamation area as for the reclamation materials. Ready mixed concrete will be used for the culvert concrete. In site concreting method will be applied for the box culvert and open channel at Sg. Babi. The concrete placement will be 3 days of cycle for one step of 10 to 20 m long. Partial coffering using sandbags will be required for the construction works at inlet and outlet portions respectively. One (1) year construction period will be scheduled for this Diversion Channel works considering the cycle time of concrete placement. The works will be proceeded having maintenance and protection of street trees, and minimizing the obstruction of traffic as practicable as possible.

The following alternatives will be studied in the detailed design stage for execution of this works.

- 1) Two to three shift operation for whole length the channel construction works.
- 2) Construction with active condition of traffic.

Renewal of bridges

Following to the improvement works the rivers, widening, 18 sets of bridges crossing the rivers are planned to be replaced in the Sg. Pinang system summarized as follows and as shown in Table xx. The freeboard is designed at least 60 cm.

Bridge name	Type	Length (m)	Width (m)	Span No.	(Notes) Bridge No.
<u>Sg. Pinang (7 sets)</u>					
- Jln. Jelutong	Steel truss	45.0	10.0	2	P1
- Jln. Sungai	R.C-I girder	41.0		2	P2
- Jln. Patani	R.C-T girder	41.0	10.0	2	P3
- Jln. Perak	R.C-T girder	31.0	15.0	1	P4
- Wooden bridge (2 sets)		31.0	3.0	1	P5 & P6
- Jln. Air Itam	R.C-T girder	31.0	16.0	1	P7
<u>Sg. Air Itam (3 sets)</u>					
- Jln. Scotland	T-girder	26.0	33.0	1	A1
- Jln. Air Itam	R.C-I girder	14.0	25.0	1	A2
- Jln. L. Lancang	T-girder	14.0	6.0	1	A3
<u>Sg. Dondang (8 sets)</u>					
- Jln. T. Thean	T-girder	14.0	4.0	1	D1
- Jln. T. Thean	T-girder	14.0	5.0	1	D2
- Jln. T. T. Dua	T-girder	14.0	11.0	1	D3
- Jln. T. Teik	T-girder	9.0	5.0	1	D4
- Wooden bridge (1 set)		14.0	3.0	1	D5
- Wooden bridge (3 sets)		9.0	3.0	1	D6-D8
<u>Sg. Jelutong (17 sets)</u>					
- R.C. Slab bridge (17 sets)		5.0-8.0	1.0-4.0	1	J1-J17

The construction works will be conducted by the following basic schedule, order of renewal and work period after the widening and deepening the rivers based on the site conditions especially the traffic. (Basic schedule of bridges renewal for 35 sets, Sg Pinang system).

Sg. Pinang (7-set) --> Sg. Air Itam (3-set) --> Sg. Dondang (8-set) --> Sg. Jelutong (17-set)
(Scheduling of renewal of respective river)

The renewal works will be planned to be carried out started with the bridge located at estuary side towards upstream side following to the channel improvement works. A proposed renewal schedule crossing Sg. Pinang is as follows.

Construction Order	Bridge No	Construction Time	Construction Period
1	P1	1st year	4 months
2	P2	1st "	4 "
3	P3	1st "	3 "
4	P4	1st "	3 "
5	P5	2nd "	1 "
6	P6	2nd "	1 "
7	P7	1st "	3 month
Amount			19 months

The renewal works will be carried out separating 2 to 3 parties concurrently with the work period of 3 to 4 months for 1 set of truss and girder type bridge and 1 month for wooden bridge. The R.C type bridge construction works will

involve temporary support, assembling and disassembling of forms, processing and setting of steel bars and concreting with curing. Foundation piles will be required at several bridges. Driving of these piles will be carried out using diesel pile hammer. Temporary pier will be required for the construction of bridge pier including the foundation piling. Ready mixed concrete will be placed by concrete pump car. Crawler type crane will be required for the erection works of beams, girders and other materials.

Replacement of public utilities

As tabulated in Table J-6, replacement works of public utilities are required following to the improvement of the rivers. These works will be planned to conduct by the respective agency. Required cost for the replacement work will be allocated by the urgent projects. Further, the following arrangement for this replacement works will be required at the detailed design stage.

- To specify the utilities to be replaced
- To explain necessitation of the project implementation to the agencies concerned
- To collect a cost proposal from the agencies concerned for the replacement of proper utilities together with a work plan and schedule
- Budgeting the required replacement cost and incorporate their work plan and schedule to the main civil works upon evaluation and adjustment of the said cost proposal, plan and schedule.

3) Sg. Keluang and its tributaries

Sg. Keluang

Sg. Keluang , Sg.Ara and Sg. Relau upstream stretches of 5.25 km are planned to improve as the part of the urgent projects within 7.66 km of total river length. Existing river characteristics show that river width of 13 to 20 m, flow capacity of 10 to 30 m³/s, stretch affecting the tidal flow of 2.8 km and river slope of 1/1000 to 1/2000.

The proposed cross section of the river channel is a compound section with wet masonry for low and high water channels to protect the bank slope. Required major construction work items are channel excavation of 29000 m³, levee embankment of 58,000 m³ and 23,400 m² of wet masonry. The construction works will be carried out by the same method of Sg. Pinang improvement works. The embankment materials are obtained from the channel excavation and excavated soils at the Relau Diversion Channel. The hauling distance is 1.0 to 2.0 km to the Relau Diversion Channel. The revetment works will be performed by combination of equipment and manpower. Partial coffering using sandbags will be required of this revetment works at low water channel. The improvement works for Sg. Keluang will be scheduled in 3 months construction period.

Sg. Ara

Sg. Ara of 1.87 km long stretch is planned to be improved by means of channel excavation, levee embankment, and revetment of low and high water channel as the major work items. These works will be conducted to the same method of Sg. Pinang and other rivers using dragline, backhoe and other earth moving equipment shifting from Sg. Pinang system. Of about 50000 m³ of excessive soils in the channel excavation will be planned to be used as the land reclamation materials for PDC's projected area minimizing the hauling distance as far as possible. Following to the river improvement works, 2 sets of bridge renewal works will be conducted. Sg. Ara improvement works will be scheduled in 6 months total period including the bridges renewal.

Relau Diversion Channel

The Relau Diversion Channel is planned to construct connecting Sg. Relau to Sg. Ara through the proposed new development area having the following features.

Total length	: 1530 m
Diversion capacity	: 70 m ³ /s
Type of cross section	: Open concrete channel, U type W=10.9 m, H=2.6 m, Thickness t=40 cm
Existing ground level	: 3.0 m - 6.0 m

Major construction works are excavation of about 76000 m³ and 10500 m³ of channel concrete. The excavation works will be carried out by bulldozer, crawler loader, backhoe and dump truck mainly shifting the Dondang Retention Ponds with dry condition of the working area. The excavated soils will be utilized effectively as the levee embankment materials of Sg. Keluang and, backfill and land reclamation materials for the PDC's project area. Ready mixed concrete will be used for the channel concreting with 3 days pouring cycle. A detour route will be provided in the intersection of Tun Datuk road during construction of that section. One (1) year work period will be required for construction of this Diversion Channel.

4) Sg. Gelugor

Sg. Gelugor of about 500 m long downstream stretch is planned to be improved comprising the urgent projects. Required works are channel excavation of 4500 m³, wet masonry of 2260 m² and 1.0 km long inspection roads at both banks with macadam pavement. These works will be carried out in parallel with Sg. Keluang and Sg. Ara improvement works in 3rd year.

5) Sg. Dua Besar

Sg. Dua Besar of about 2.1 km long downstream stretch is also planned to be improved incorporating the urgent projects. Required works are excavation of 14000 m³, wet

masonry of 12500 m² and macadam paved inspection roads at both banks of 4.2 km long. These works will be conducted in 3rd year.

2.4.5 Drainage Works

1) General

The urgent project comprises the urban drainage plan of 3 basins for N-12, S-10 and S-18 drainages in the Georgetown. The basic concept of the drainage plan is the design flood protection level of 10-years return period. Major components of this plan consist of realignment and reorganization of the existing main drains, and pumped drainage for lowlying drainage areas. Drains are designed by rectangular reinforced open concrete channel with cast-in-place retaining wall and box culvert for heavy traffic areas. The S-10 and S-18 drainage system consist of construction of a pumping station and retention pond which will be located in the proposed land reclamation area by the structure plan as the CDD 21. It is assumed that the construction of pumping station and retention pond will be conducted only after completion of reclamation of these areas.

2) N-12 drainage system

The reorganization of the existing N-12 outlet was contemplated to reduce excessive run-off in the catchment area of 156 ha. This reorganization divides N-12 into 2 drainage areas of N12-1 and N12-2. The construction works for the N-12 drainage system are mainly improvement of existing drains by means of widening and deepening the existing channels and trunk drain. The trunk drain of 2.66 km to be improved is routed along Jln. Pangkor. The required main works are excavation of 21500 m³, concrete of 3600 m³, wooden piling of 39000 numbers, backfill of 7900 m³ and restoration of Jln. Pangkor. These works will be carried out mainly by light to middle class of equipment considering the site conditions and be conducted in parallel with the S-10 drainage improvement works in first year. Excavated materials will be used as the levee embankment materials of S-10 retention pond. Traffic obstruction will be avoided as far as possible applying the same idea to the construction of Air Terjun Diversion Channel.

3) S-10 and S-18 drainage systems

The S-10 and S-18 drainage systems involve of 4 kinds of major construction work items of 1) improvement of trunk drains, 2) construction of a retention pond, 3) construction of a drainage pumping station equipped with the retention pond, and 4) construction of outlet channel respectively having the following features. The construction works for both systems will be planned to carried out in 3 years considering the degree of urgency of this area.

Items	S-10 (120 ha)	S-18 (104 ha)
Trunk drains ;		
- No.of drain :	1	1
- Total length :	1.66 km	1.73 km
Retention pond ;		
- Area :	1.9 ha	2.4 ha
Pumping station ;		
- Building area :	280 m ²	280 m ²
- No.of pump :	3 sets	2 sets
- Capacity, max. :	2 m ³ /s per unit	1 m ³ /s per unit
Outlet channel ;		
- Length :	20 m	20 m

The basins is located in the city centre, and this lowlying area have been inundated frequently, urgent countermeasures are required for this area. The construction works will be conducted by 3 years work period for all the drainage works. The S-10 and N-12 systems will be carried out in first half of construction stage, and be carried out S-18 by later half.

(Trunk drains)

The construction works of trunk drains for S-10 and S-18 involve the following major work items and quantities.

Work item		S-10	S-18
Excavation	(cu.m)	32000	41000
Concrete	(cu.m)	10000	20000
Backfill	(cu.m)	21000	13000
Restoration of roads	(sq.m)	11700	18800
wooden piling	(nos.)	34500	75000

The trunk drains are routed in the center zone along Jln. Maxwell and Jln. Dr Lim Chwee Leong for S-10 and Jln. Brick Kiln and Jln. Sandilands for S-18. The construction works will be conducted by applying same idea to the construction of the Air Terjun Diversion Channel without obstruction of traffic as far as possible. The works will be carried out by middle to small class of equipment. Major equipment will be backhoe and dump track. The excavated soils will be planned to be utilized as the embankment materials for the levee of retention ponds and land reclamation materials of CDD 21 area. About one year work period will be allowed for S-10 and S-18 drainage works respectively.

(Retention pond)

The retention pond for S-10 and S-18 is planned to be constructed independently located in the land reclamation area of CDD 21 project. It is assumed that proposed areas for the retention ponds will not be reclaimed according to the mutual confirmation between the officials concerned of CDD 21 project and the study team of this flood mitigation and drainage project. So that no excavation work will be required for the retention ponds. Required major works are

the construction of 500 m long ring levees along offshore line of east channel involving following work items.

Work items	S-10	S-18
Embankment (cu.m)	64000	76000
Revetment, dry and wet masonry (sq.m)	9300	11800
Restoration of roads (sq.m)	8000	8600
Steel sheetpiling, 1=10 m, type-2 (nos.)	1000	760

The embankment materials will be taken from the excavated soils at trunk drains of S-10 and S-18, and Sg. Pinang channel.

(Pumping house)

Two drainage pumping stations are planned to be constructed outside Coastal Road in the South Channel. Major work items and quantity are as follow:-

Work items	S-10	S-18
- Excavation	10000 m ³	12000 m ³
- R.C foundation piling, 400 mm, 1=30 m	164 nos	64 nos.
- Steel sheetpiling, type-2, 1=10 m	423 "	325 "
- Concreting of pump house	4800 m ³	4500 m ³
- Manufacturing and installation of drainage pumps	2 m ³ /s x 3 sets	1 m ³ /s x 2 sets
- Gate, 3.5 tons	4 sets	4 sets
- Trashrack, 3 tons	2 "	2 "
- Garbage equipment	3 "	3 "

The construction of pumping station is divided into two categories of civil and building works, and mechanical and electrical works. Of about 1.5 years will be scheduled for the each pumping station from overall schedule of 3 years. Partial coffering will be required around the construction area of pumping station by sandbags or other materials to keep dry condition the site from tidal affection. The foundation piles will be driven till the N15 values using diesel pile hammer. Steel sheetpiles are also driven around the gated structures for the protection of seepage water by vibration hammer. Reinforced concrete building of 200 m² with one floor type are constructed following to the civil works in about 5 months work period. In the first 2nd year, an installation of 3 sets of drainage pumps, motors and other mechanical and electrical facilities are commenced. An overhead travelling crane of 3.5 tons is to be completed to install in the end of 1st year accordingly. The S-10 drainage pump station will be functioned from middle of 2nd year in 1994 upon dry and wet test successfully. In the later half stage of 1.5 years, S-18 pumping station will be constructed with same method, equipment and crew shifting from S-10. A diesel generator is planned to provide as the emergency of power. The sluice type gate of 4 sets with trashrack are also be planned to be provided equipped with the pumping station. These works will be conducted in parallel with the construction of the pumping house.

Landscaping works are carried out after completion of pumping house.

(Outlet channel)

The outlet channel works comprise the excavation, embankment and revetment and small quantities. These works will be carried out by manual power mainly in parallel with the construction of pumping house.

2.5 Construction Time Schedule

Following to the implementation schedule proposed herein, the construction works for the urgent projects are planned to be conducted in 3 years in total construction period to realize the both for rivers and urban drainage improvement plan as earlier as possible to protect the areas from probable flood. A construction time schedule is proposed as shown in Fig.L-3 based on the following conditions and assumptions.

- a. The construction works of the urgent project are scheduled to be implemented in three (3) years total period.
- b. The river improvement and drainage works are conducted in parallel.
- c. Sg. Pinang system excluding Sg. Jelutong will be implemented firstly of about two (2) years construction period.
- d. Sg. Jelutong and Keluang system will be implemented following to the Sg. Pinang system in 3rd year.
- e. Sg. Gelugor and Dua Besar will be scheduled to improve in 3rd year.
- f. The renewal of bridges and public utilities will be scheduled to carried out following to the river improvement works.
- g. For the construction of Air Terjun Diversion Channel, one (1) year work period will be scheduled considering the traffic in this working area, and this works will be carried out in 1st year.
- h. Dondang Retention Ponds will be constructed following to the Air Terjun Diversion Channel of about one (1) year work period in 2nd year.
- i. The Relau Diversion Channel will be scheduled to start the construction after completion of Dondang Retention Ponds of about one (1) year work period in 3rd year.
- j. The civil and building works of drainage pumping station will be completed mostly in 2nd year, so that overhead travelling crane will become available in the beginning of 3rd year for the installation of drainage pumps.
- k. The construction of pumping stations and retention ponds are scheduled to conduct after completion of land reclamation of those area in CDD 21.

The construction works in each year are summarized as follows.

1st year

- Sg. Pinang improvement with related structures
- Construction of Air Terjun Diversion Channel
- Improvement of N-12 drainage system
- Improvement of S-10 drainage system

2nd year

- Sg. Air Itam improvement with related structures
- Sg. Dondang improvement with related structures
- Construction of Dondang Retention Ponds
- Improvement of S-10 drainage system
- Improvement of S-18 drainage system after completion of S-10

3rd year

- Sg. Dondang improvement
- Sg. Jelutong improvement
- Sg. Keluang and Sg. Ara improvement
- Sg. Gelugor and Sg. Dua Besar improvement
- Construction of Relau Diversion Channel
- Improvement of S-18 drainage system.

As requested by the Steering Committee meeting on 24th January, 1991, and taking into account the implementation capacity of DID as well as other constraints, the revised implementation schedule as shown in Fig. L-11 was prepared.

It shall be noted that the results of the economic analysis has been based on the original implementation schedule. With the proposed revision due to implementation capacity of DID, there is a need to re-evaluate the economic analysis results.

3. FINANCIAL COST ESTIMATE

3.1 General

The financial cost for the urgent project was estimated herein based on the surveys, investigations and collected data at site in July to August 1990. Major survey items were as follows.

- Unit construction cost recently

- Unit prices of construction materials
- Labour wages
- Plant and equipment cost
- Land transportation cost
- Taxation
- Unit cost for land acquisition and building compensation cost
- Social charges

The project financial cost is worked out upon examination and scrutinization of these collected data on the survey works as presented hereinafter.

3.2 Conditions and Assumptions for Cost Estimate

The following conditions and assumptions are applied for the financial cost estimate.

1) Price level

The price level of August 1990 was applied that are the time of execution of survey and investigation works at site.

2) Exchange rate

The foreign exchange rate was adopted as below to convert to US\$ and Japanese Yen.

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

3) Composition of financial cost

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

4) Currency of estimate

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

5) Disbursement of investment cost

The investment cost is assumed to disburse following to the proposed implementation schedule started with the detailed design stage.

3.3 Estimate of Construction Cost

1) Direct construction cost

The direct construction cost for the 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 by lump sum basis and incorporated as the general items. The replacement costs for the public utilities are estimated by lump sum basis and treated as the provisional sum cost items incorporating the general items.

The unit costs for civil construction works are developed based on the construction plan and schedule described in previous clause and collected cost data at the site. The unit costs element of labour, material and equipment are explained briefly as follows.

Labour

The labour cost is estimated by daily basis and 8 hours per day. As the day work schedule, the charges for respective type of labourers are tabulated in Table-L-10 includes all the social charges and fringe benefits such as vacation, sick leaves, insurance charges, medicare and living allowances.

Material cost

Unit prices of construction materials in local markets were canvassed at site, and tabulated in Table L-11. They are principally counted into the local currency component but their certain proportions are considered into foreign currency components according to their usage of imported raw materials and production facilities. Unit prices of imported materials are the prevailing market prices in Japan. The cost of freight, insurance, handling and other incidental cost are included as part of the prices of imported materials.

Equipment cost

The equipment cost consists of the depreciation cost, maintenance and repairing cost and administration cost which are calculated by a ratio against delivered cost of the said equipment. Table L-12 shows the hourly cost for major equipment which will be used for the urgent projects, and were estimated based on the collected data at site and current purchase cost and assuming the following currency components. Foreign currency component

- 100 % of depreciation cost
- 80 % of maintenance and repair cost local currency component
- 0 % of administration and management cost
- 20 % of maintenance and repair cost

Salvage value of 10 % was considered.

Contractor's overhead and profit

Contractor's expenses are taken into account in the unit cost which is assumed to be 25 % of direct cost representing the following cost items.

- field overhead and administration cost including all insurances and bonds
- material warehousing and handling
- camp operation and maintenance
- communication charges
- corporate overhead
- profit
- estimated risk
- taxes
- Other incidentals

The cost for the electro-mechanical works is based on past tendered record of similar projects with consideration made on locality of this project. The cost includes on engineering design, material cost, manufacturing, painting, testing, packing, delivery to the site and installation works including dry and wet tests. Principally, F.O.B cost on imported item, ocean freight and insurance premium are considered as part of the foreign currency component while, other costs are counted in local component.

2) Foreign and local currency allocation

The foreign and local currency components are allocated by the following criteria and assumptions.

Cost items	<u>F.C and L.C allocation</u>	
	F.C (%)	L.C (%)
a. Equipment cost		
Imported equipment		

- Depreciation and interest	100	0
- Maintenance and repair cost	80	20
- Management and administration	0	100

Produced domestically		

- Depreciation and interest	50	50
- Maintenance and repair cost	80	20
- Management and administration	0	100
b. Construction material cost		
- Imported materials	100	0
- Produced domestically	50	50
c. Labour cost		
- Labour cost, local	0	100

3) Land acquisition and building compensation cost

Those cost are estimated based on the unit cost which are established following to the data sourced from the State Valuation Department. The costs are incorporated into the local currency component.

4) Administration cost

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

5) Engineering services cost

The cost was also estimated in proportion to the direct construction cost to cover the detailed design, hydraulic model test and construction supervision by consultant/s. The engineering services cost was estimated of about 10 % of total direct construction cost and incorporated to the foreign of 80 % and local currency portions of 20 % respectively.

6) Contingency

Physical contingency

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

Price contingency

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

3.4 Financial Cost of Urgent Projects

The financial cost for the urgent projects was worked out as tabulated in Table L-4 and L-5 and summarized as follows.

Unit : thousand

Project	Amount (M\$)	Equivalent US\$
- Sg. Pinang System	135,500	(50,170)
- Sg. Keluang System	40,200	(14,900)
- Georgetown Drainage	37,900	(14,050)
Total	213,600	(79,120)

3.5 Annual Disbursement Schedule

The annual disbursement of investment costs was allocated on the basis of the implementation schedule as shown in Table L-6, and summarized as follows.

Unit : thousand

Year	F.C	L.C	Amount (M\$)
1991	1,200	1,300	2,500
1992	1,300	61,700	63,000
1993	22,100	73,200	95,300
1994	17,300	8,700	26,000
1995	17,800	9,000	26,800
Total	59,700	153,900	213,600

3.6 Operation and Maintenance Cost

The annual operation and maintenance costs for the urgent projects was estimated for the said works as shown in Table L-13. 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 costs for the urgent projects were estimated to be M\$ 0.3 million in total.

Unit : thousand

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

The organization chart for operation and maintenance works by DID and MPPP is shown in Fig. L-5

3.7 Replacement Cost

Some of project's facilities, especially mechanical and electrical equipment have shorter useful life than concrete or earthing structures, and require replacement at a certain time within the project service life. The replacement costs were estimated to be approximately M\$ 0.1 million for the flood mitigation facilities every 20 years and about M\$ 3.0 million for drainage facilities every 15 years as tabulated in Table L-14.

Tables

TABLE L-1 ESTIMATION SHEET OF ANNUAL WORKABLE DAYS

Rainfall station

Month	Precipitation		mm					Calendar day	Amount, work suspend days	Holidays	Workable days
	Rainy day (days)	Work suspend *(days)	0	<5	5 - 10	10 - 20	>20				
January,	Rainy day (days)	Work suspend *(days)	27.4	1.6	0.2	0.6	1.2	31	3.0	4	24
February,	Rainy day (days)	Work suspend (days)	22.4	2.8	1.2	1.2	0.6	28	2.4	4	22
March,	Rainy day (days)	Work suspend (days)	21.2	5.6	0.8	2.0	1.4	31	4.8	4	22
April,	Rainy day (days)	Work suspend (days)	18.4	5.6	1.8	1.4	2.8	30	7.0	4	19
May,	Rainy day (days)	Work suspend (days)	15.6	6.0	3.0	1.6	4.8	31	11.2	4	16
June,	Rainy day (days)	Work suspend (days)	18.4	5.6	2.2	1.8	2.0	30	5.8	4	20
July,	Rainy day (days)	Work suspend (days)	16.0	6.6	3.0	2.8	2.6	31	8.0	4	19
August,	Rainy day (days)	Work suspend (days)	14.6	8.4	3.8	2.4	1.8	31	6.0	4	21
September,	Rainy day (days)	Work suspend (days)	8.6	8.6	3.6	4.6	4.6	30	13.8	4	12
October,	Rainy day (days)	Work suspend (days)	9.6	10.0	3.2	3.2	5.0	31	13.2	4	14
November,	Rainy day (days)	Work suspend (days)	13.8	7.0	1.8	2.8	4.6	30	12.0	4	14
December,	Rainy day (days)	Work suspend (days)	19.6	5.4	1.8	1.8	2.4	31	6.6	4	20
Total											223

* <10 mm : No work suspend
 10 - 20 mm : Work suspend on that date
 <20 mm : Work suspend on that date plus the next day

TABLE L-2 MAJOR EQUIPMENT REQUIRED FOR THE URGENT PROJECTS

No.	Equipment	Capacity	No. required		
			River	Drainage	Total
1.	Backhoe	0.6 m ³	5	1	6
2.	Backhoe	0.4 m ³	3	1	4
3.	Bulldozer, swamp	16 t	4	1	5
4.	Bulldozer	11 t	3	1	4
5.	Crawler loader	2.0 m ³	4	0	4
6.	Crawler loader	1.5 m ³	1	1	2
7.	Dump truck	10 t	22	3	25
8.	Dump truck	6 t	2	3	5
9.	Dragline	0.6 m ³	1	0	1
10.	Amphibious excavator	0.6 m ³	1	0	1
11.	Vibration roller	5 t	5	2	7
12.	Diesel pile hammer	2.5 t	(common use)		1
13.	Vibration hammer W/generator	30 kw	(common use)		1
14.	Concrete pump car	40 m ³ /h	(common use)		1
15.	Concrete vibrator	30 kg	(common use)		10
16.	Motor grader	3.1 m	(common use)		1
17.	Road roller	8 t	(common use)		1
18.	Water tanker	6 kl	(common use)		1
19.	Workshop car	6 t	(common use)		1
20.	Truck Crane	10 t	1	1	2
21.	Crawler Crane	30 t	1	1	2