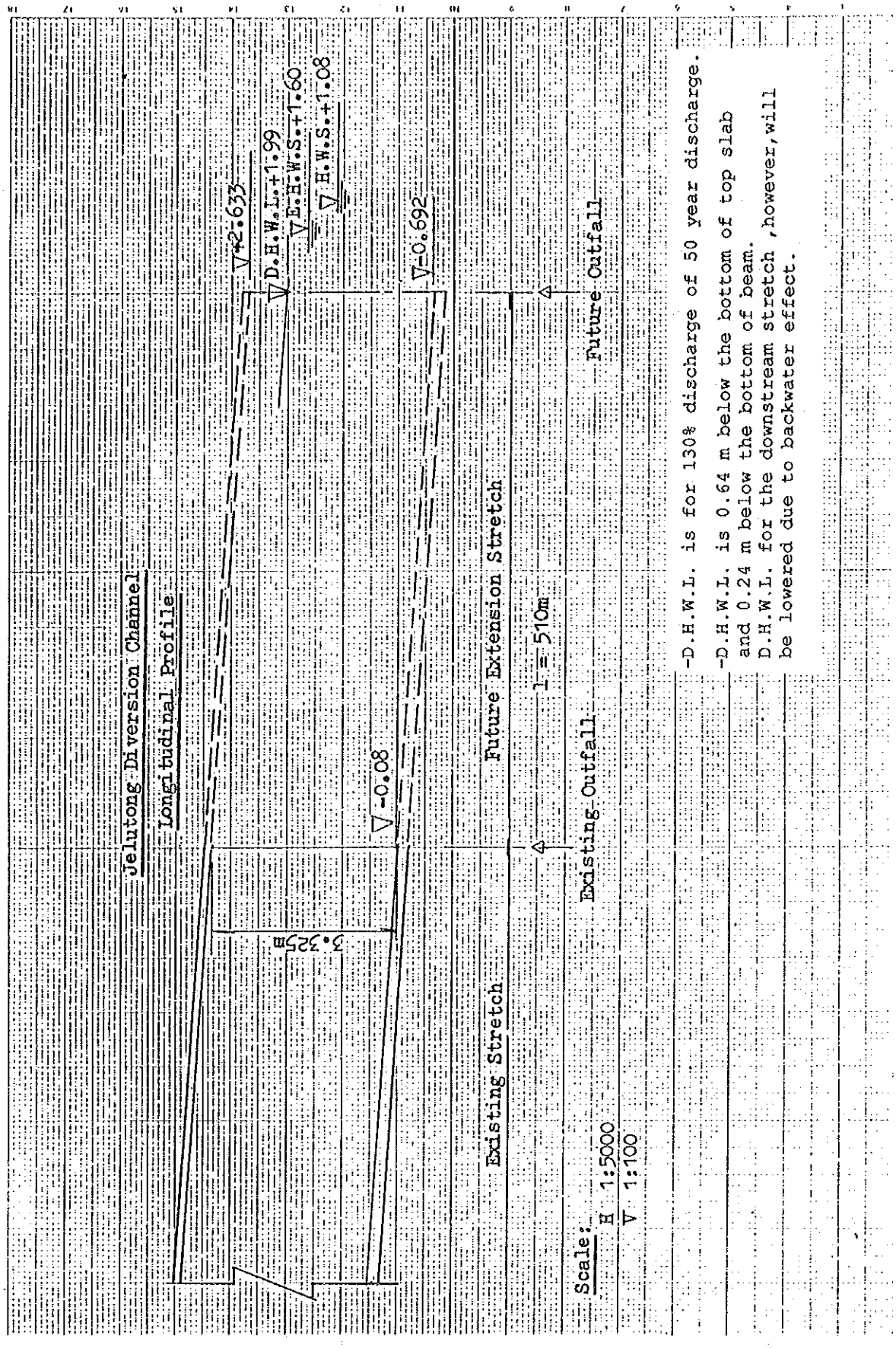


FIG. I-9 LONGITUDINAL PROFILE OF FUTURE EXTENSION OF JELUTONG DIVERSION CHANNEL

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

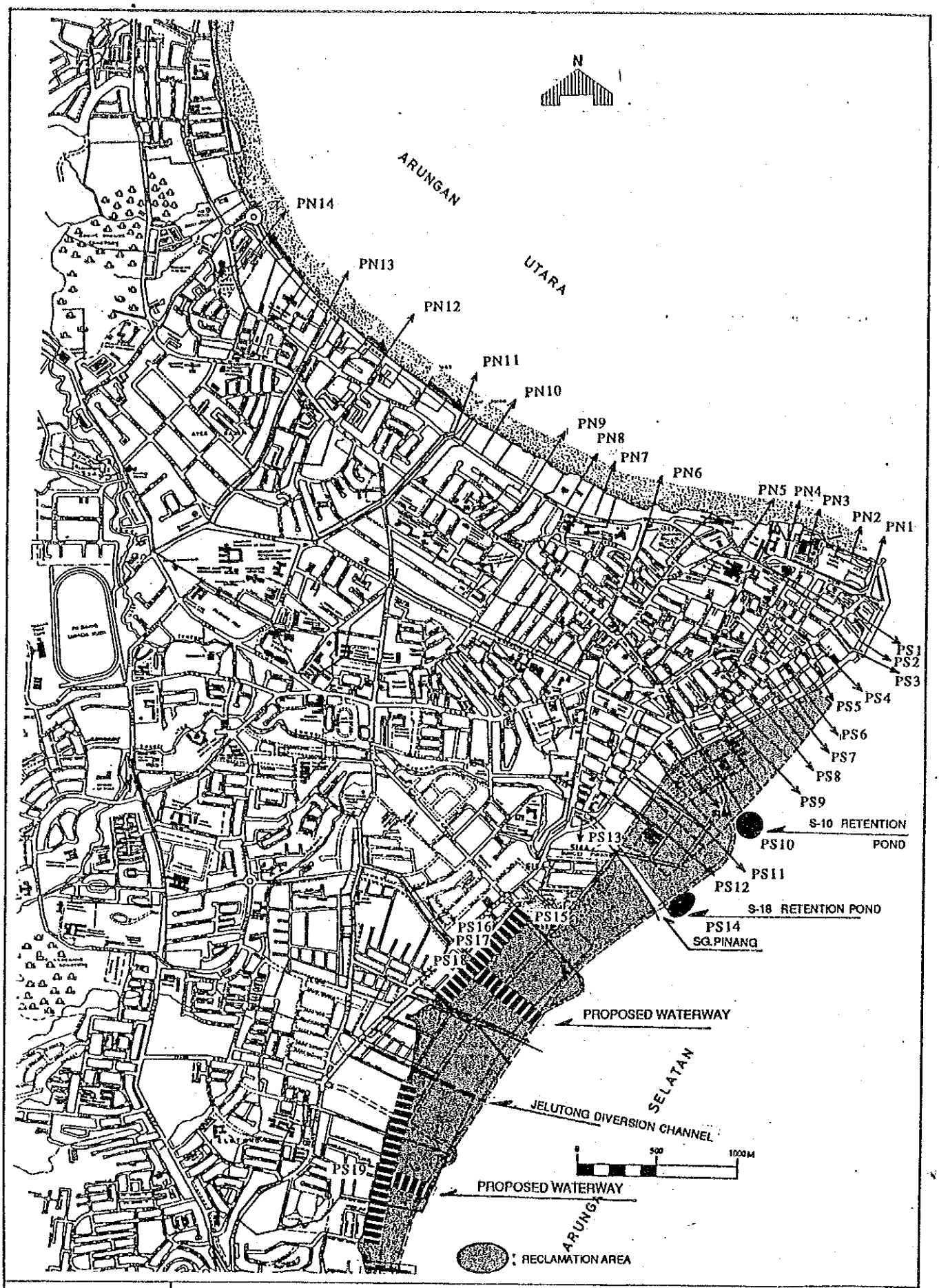


FIG. I- 10 PROPOSED DRAINAGE OUTFALLS IN GEORGETOWN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

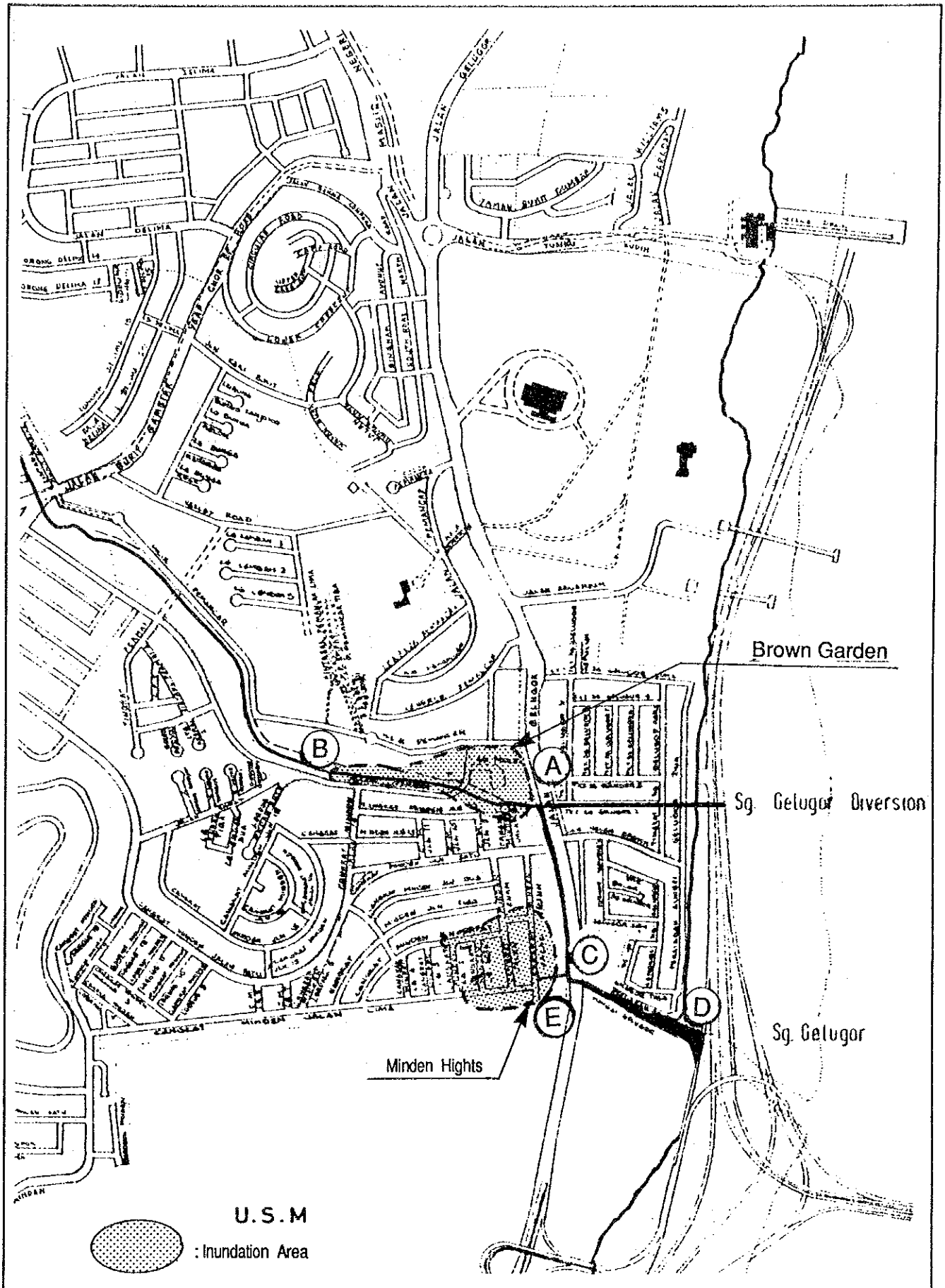


FIG. I- 11 INUNDATION AREA IN SG. GELUGOR BASIN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

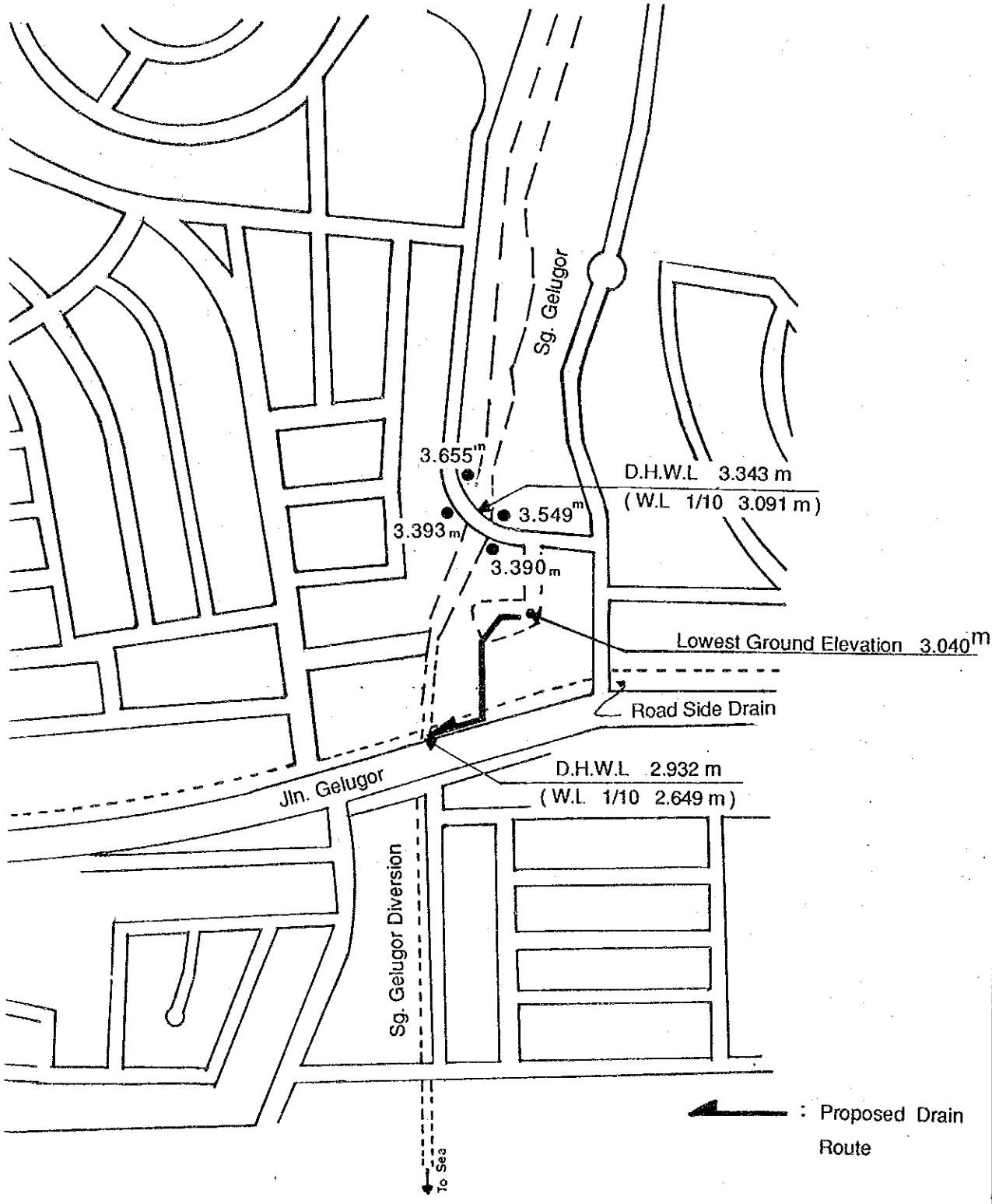
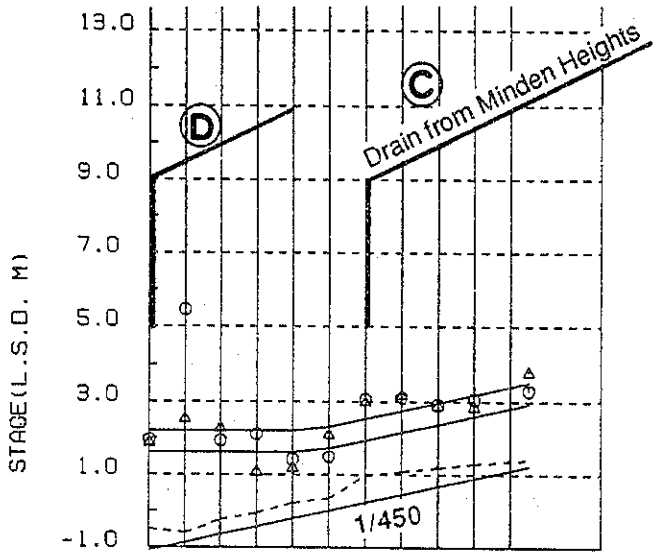
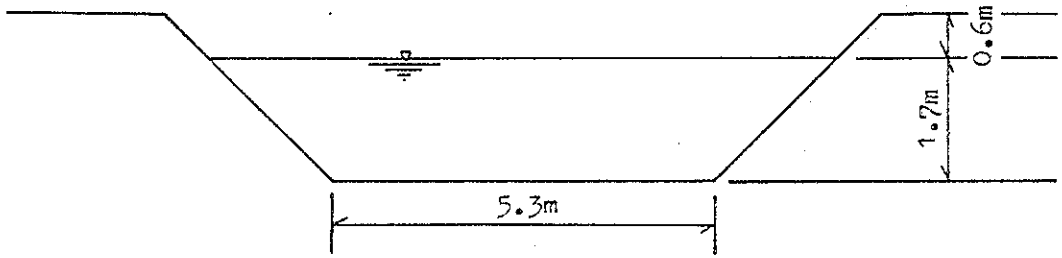


FIG. I- 12	PROPOSED ROUTE OF NEW DRAIN IN BRAWN GARDEN AREA

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



PROPOSED BED LEVEL	-1.100	-0.878	-0.656	-0.433	-0.211	0.011	0.233	0.456	0.678	0.900	1.233
DESIGN H.W.L.	1.600	1.600	1.600	1.600	1.600	1.711	1.933	2.156	2.378	2.600	2.933
PROPOSED BANK LEVEL	2.200	2.200	2.200	2.200	2.200	2.311	2.533	2.756	2.978	3.200	3.533
DISTANCE	0.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	150.000
CHAINAGE	0.000	0.100	0.200	0.300	0.400	0.500	0.650	0.700	0.800	0.900	1.050

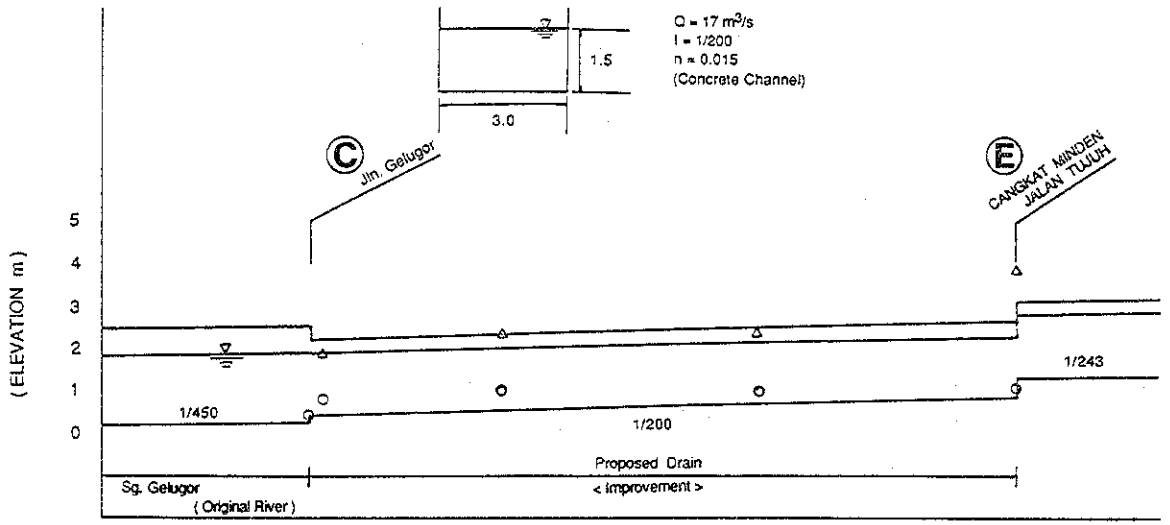


Proposed Cross Section of Original Sg. Gelugor Downstream Stretch

Q=25 m^3/s
n=0.025

FIG. I-13 PROPOSED CROSS SECTION OF ORIGINAL SG. GELUGOR DOWNSTREAM STRETCH

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



DISTANCE (m)	0	1.6	22.4	52.9	83.3
PROPOSED BANK LEVEL	2.533	2.233			2.649 3.149
PROPOSED WATER LEVEL (m)	1.933				2.349 2.849
PROPOSED INVERT LEVEL (m)	0.233	0.433			0.849 1.349
EXISTING INVERT LEVEL (m)	0.27	0.82	1.03	1.04	1.15

FIG. I- 14 PROPOSED LONGITUDINAL PROFILE AND CROSS SECTION OF DRAIN IN MINDEN HEIGHTS AREA

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

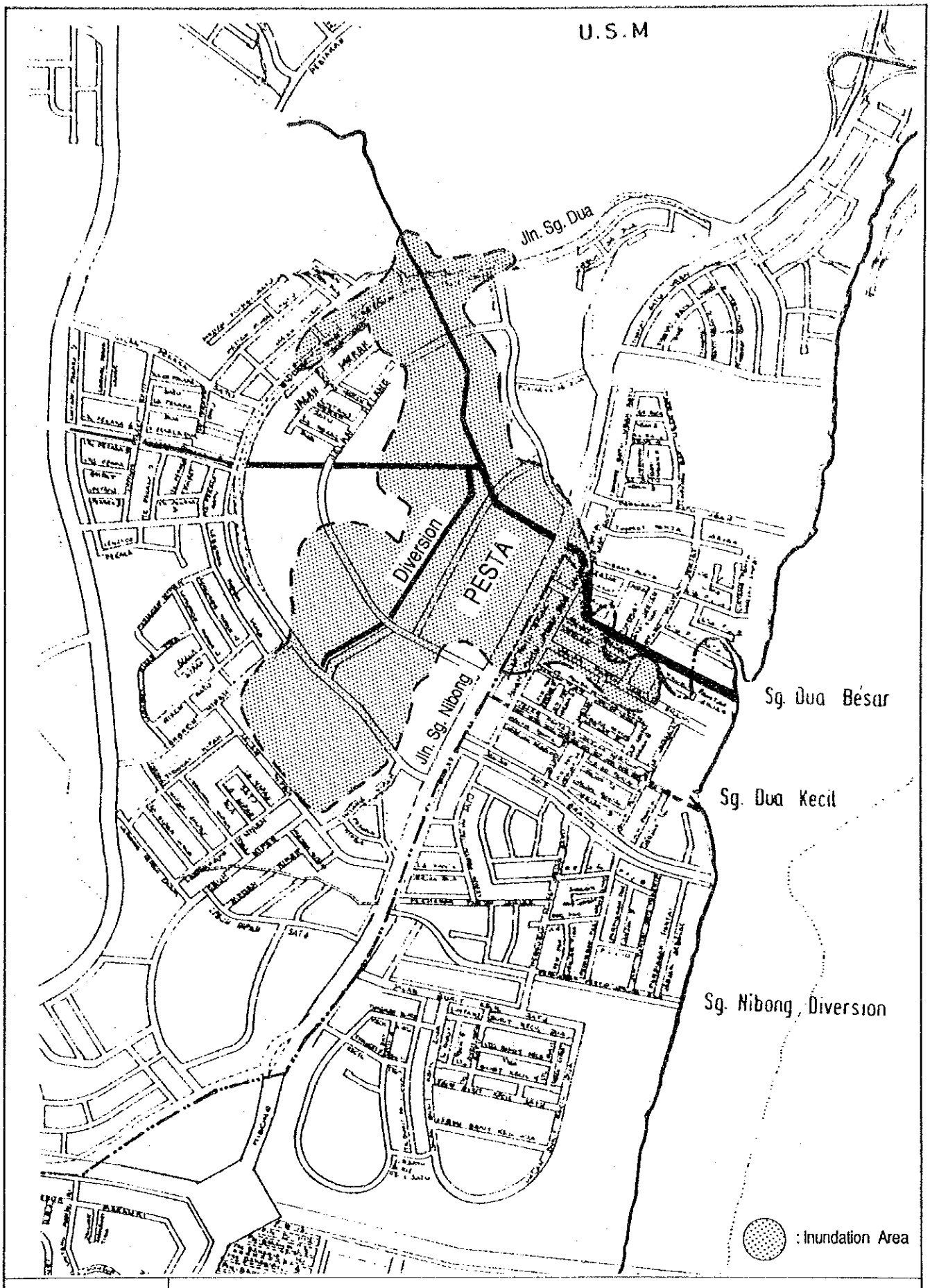


FIG. I- 15 INUNDATION AREA IN SG. DUA BESAR BASIN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

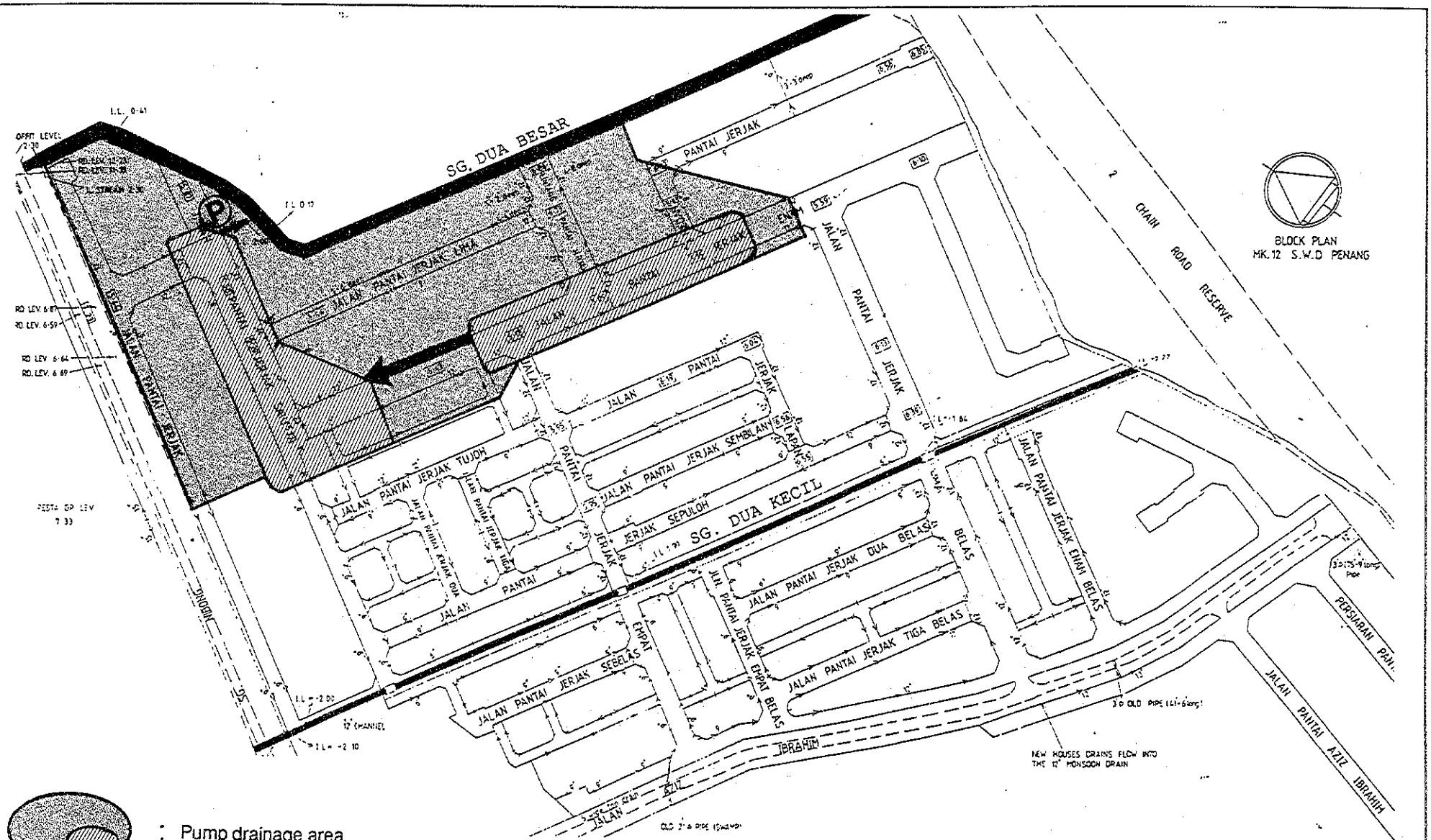
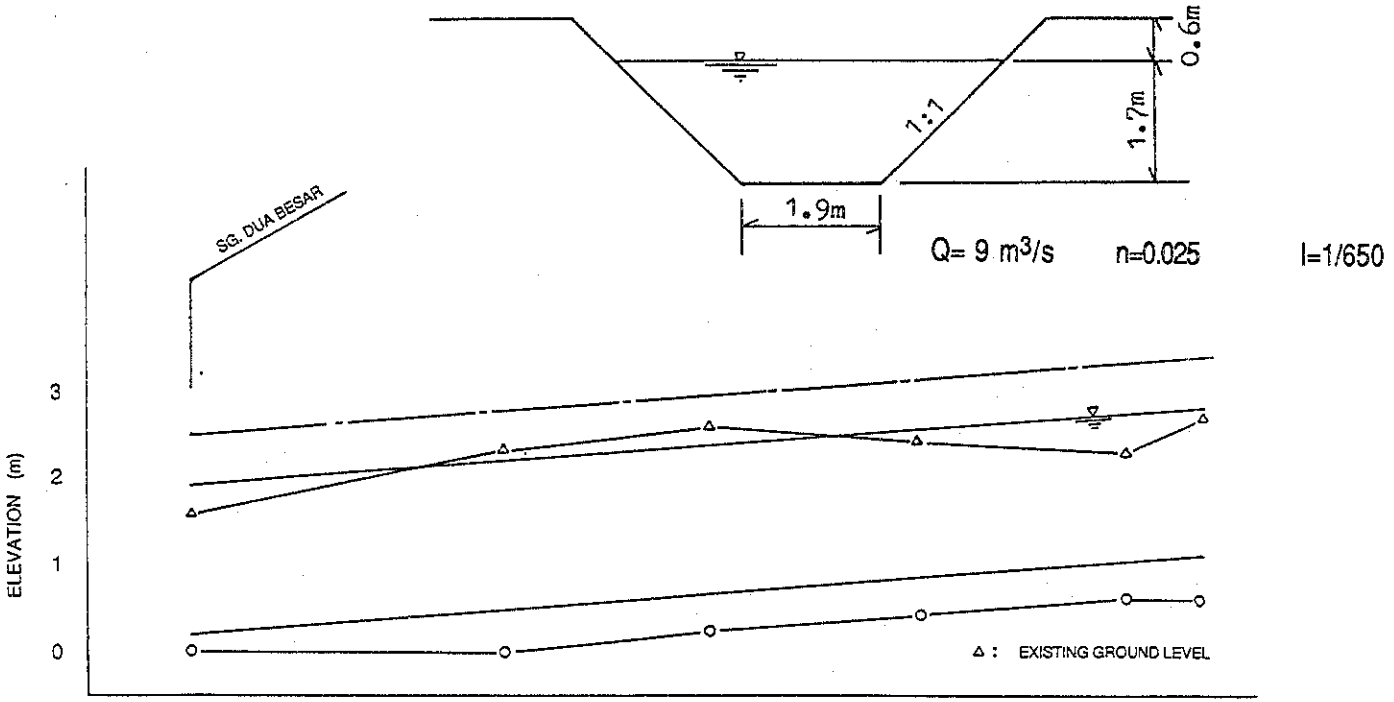


FIG. I- 16 PLAN OF PROPOSED DRAINAGE SYSTEM IN LOWLYING AREA ALONG SG. DUA BESAR

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



DISTANCE (m)	60	240	360	480	600	642
PROPOSED BANK LEVEL (m)	2.507	2.783	2.968	3.153	3.337	3.402
PROPOSED WATER LEVEL (m)	1.907	2.183	2.368	2.553	2.737	2.802
PROPOSED INVERT LEVEL (m)	0.207	0.483	0.668	0.853	1.037	1.102
EXISTING INVERT LEVEL O (m)	-0.096	-0.042	0.233	0.436	0.63	0.62

FIG. I- 17 PROPOSED LONGITUDINAL PROFILE AND CROSS SECTION OF DIVERSION CHANNEL FROM SG. DUA KECIL CATCHMENT

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

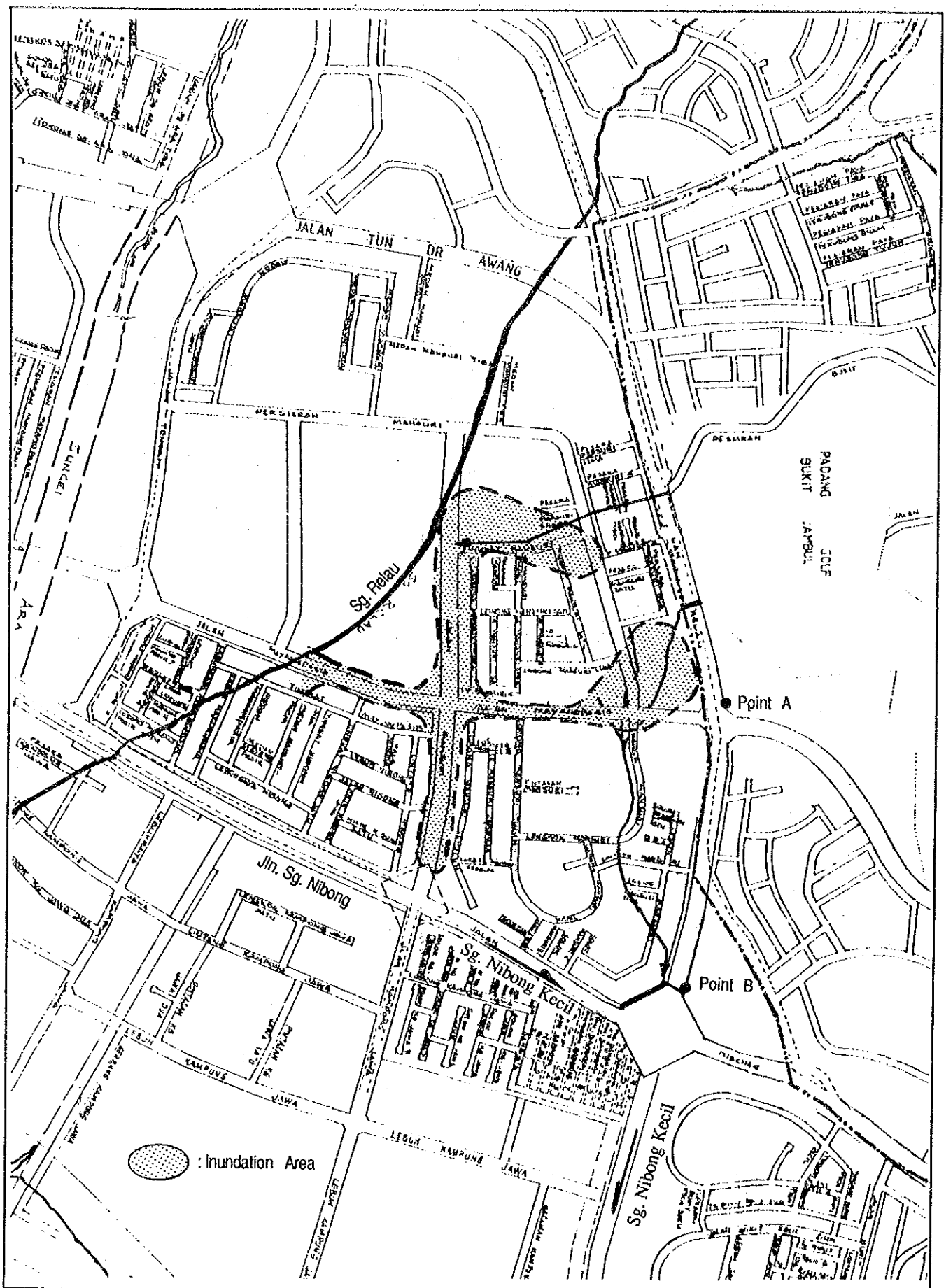


FIG. I- 18	INUNDATION AREA IN SG. NIBONG BASIN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

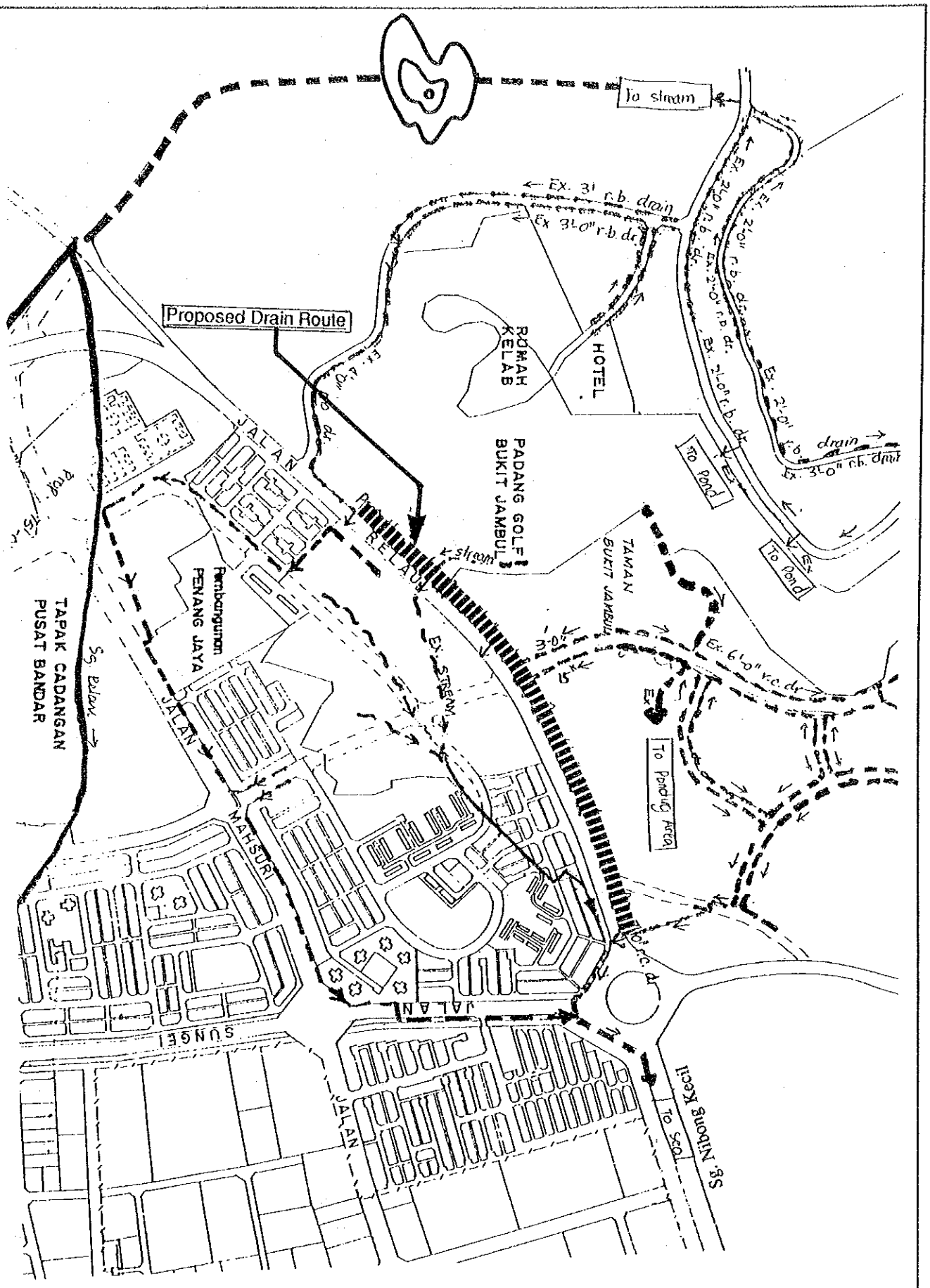
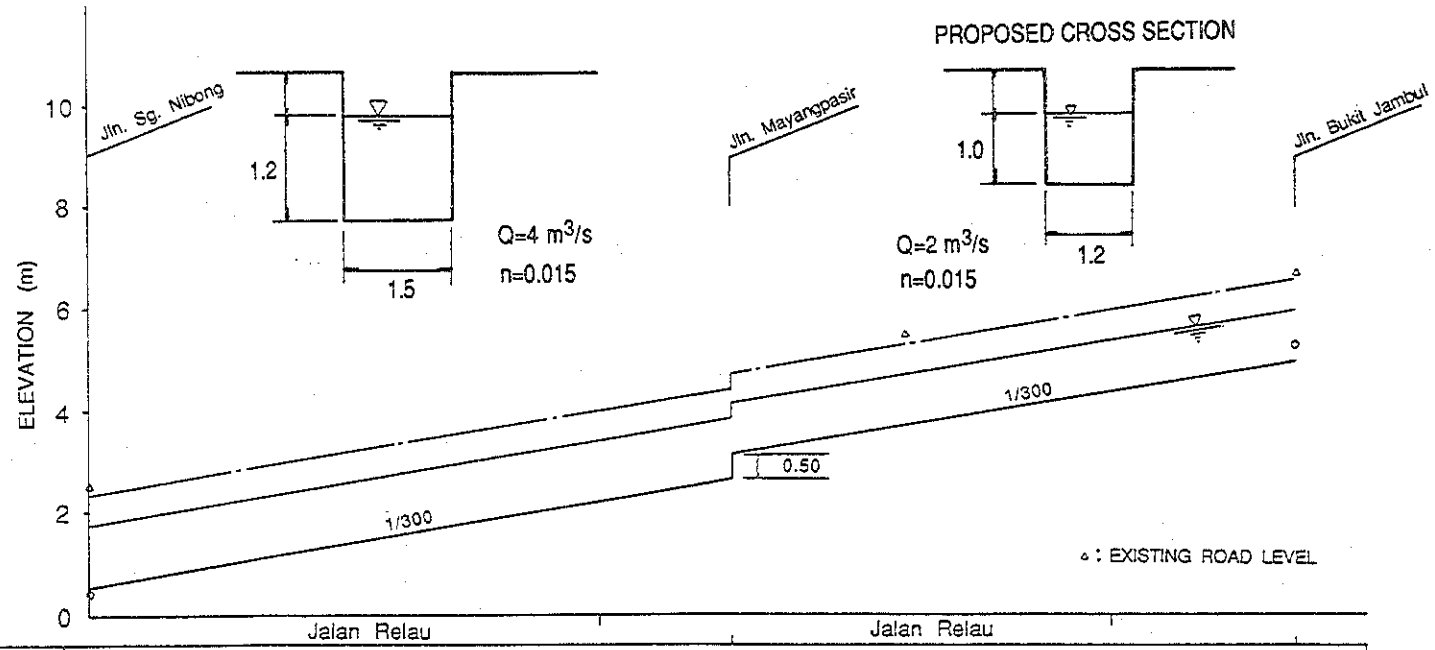


FIG. I- 19	PROPOSED DRAIN ROUTE ALONG JLN. RELAU



DISTANCE (m)	0	630	1,180
PROPOSED BANK LEVEL (m)	2.367	4.467 4.767	6.600
PROPOSED WATER LEVEL (m)	1.767	3.867 4.167	6.000
PROPOSED INVERT LEVEL (m)	0.567	2.667 3.167	5.000
EXISTING INVERT LEVEL (m)	0.130		5.300

Q=4 m3/s Q=2 m3/s

FIG. I-20 PROPOSED LONGITUDINAL PROFILE AND CROSS SECTIONS OF DRAINS ALONG JLN. RELAU

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

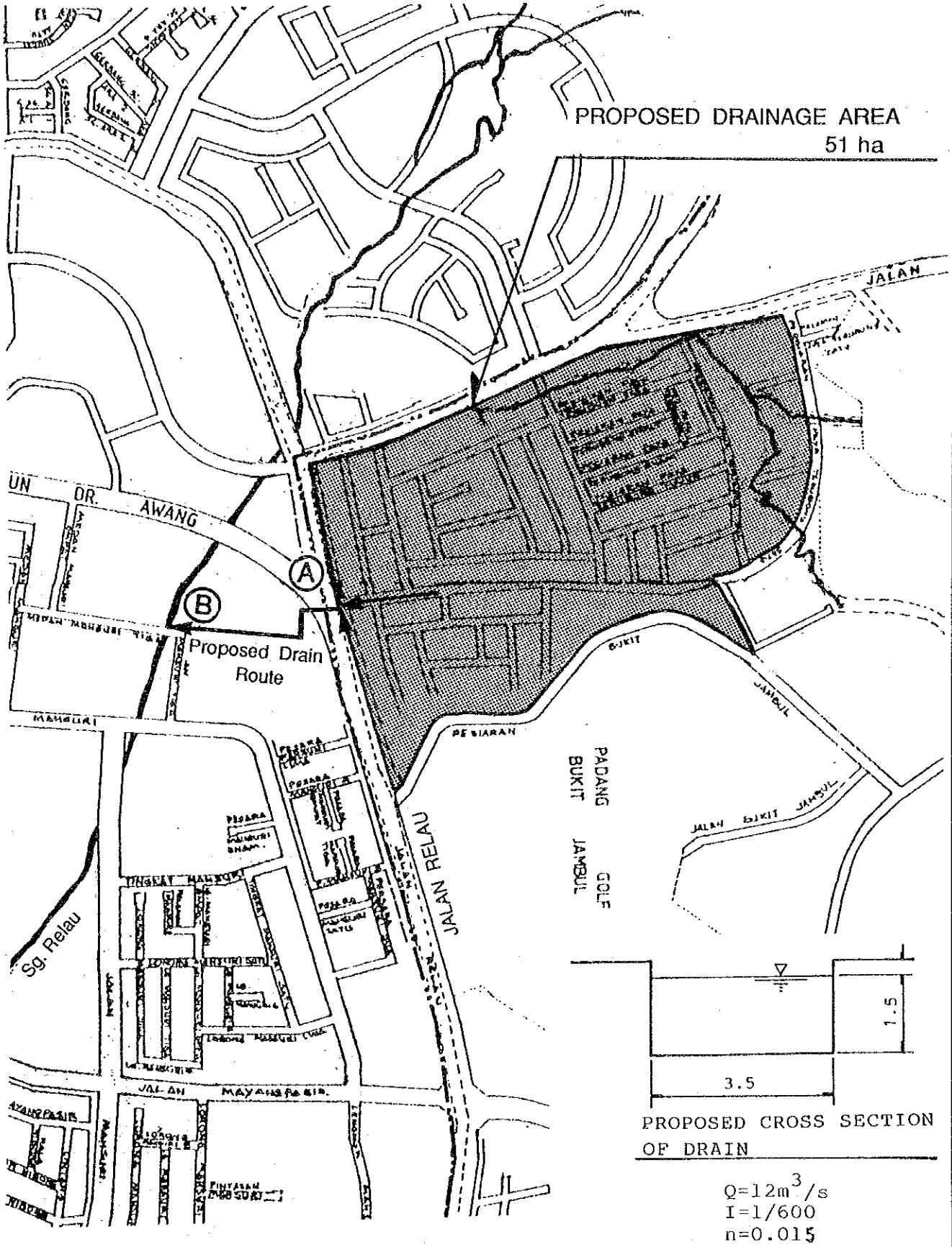


FIG. I-21	PROPOSED DRAIN ROUTE AND CROSS SECTION OF DRAIN FROM BUKIT JAMBUL TO SG. RELAU

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

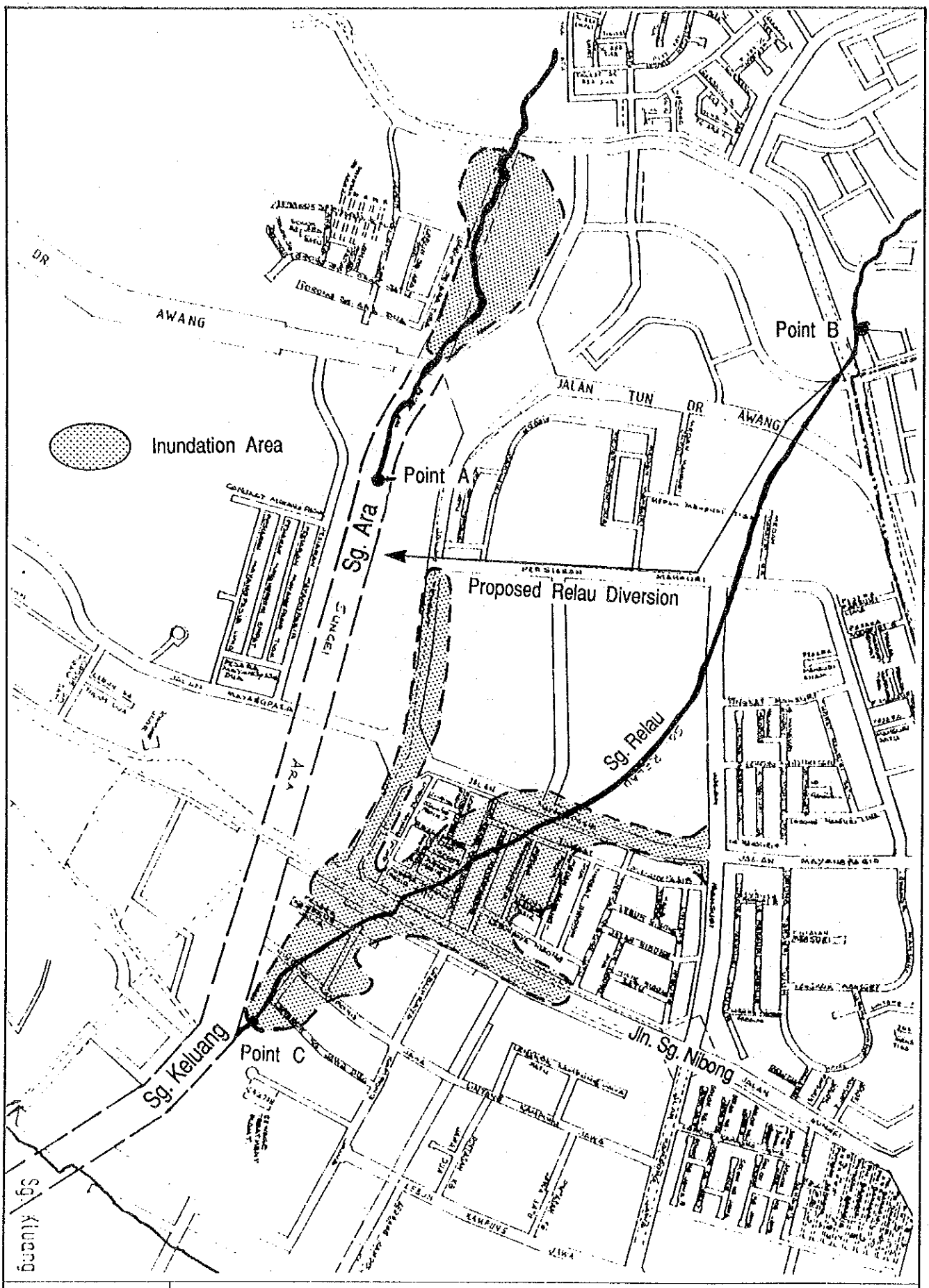


FIG. I-22 INUNDATION AREA IN SG. RELAU AND SG. ARA BASINS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

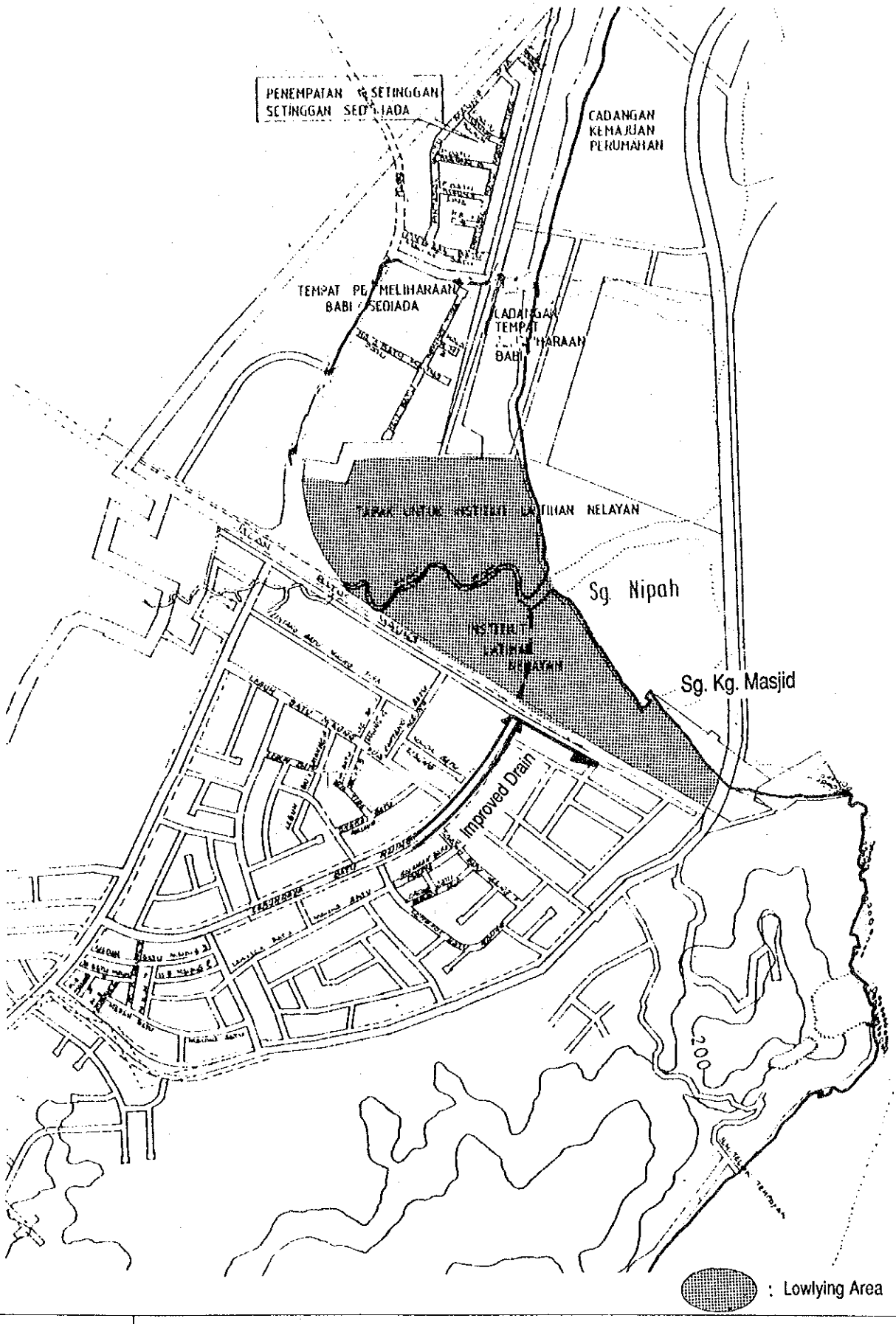


FIG. I-23	EXISTING CONDITIONS OF SG. NIPAH AND SG. KANPUMG MASJID BASINS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

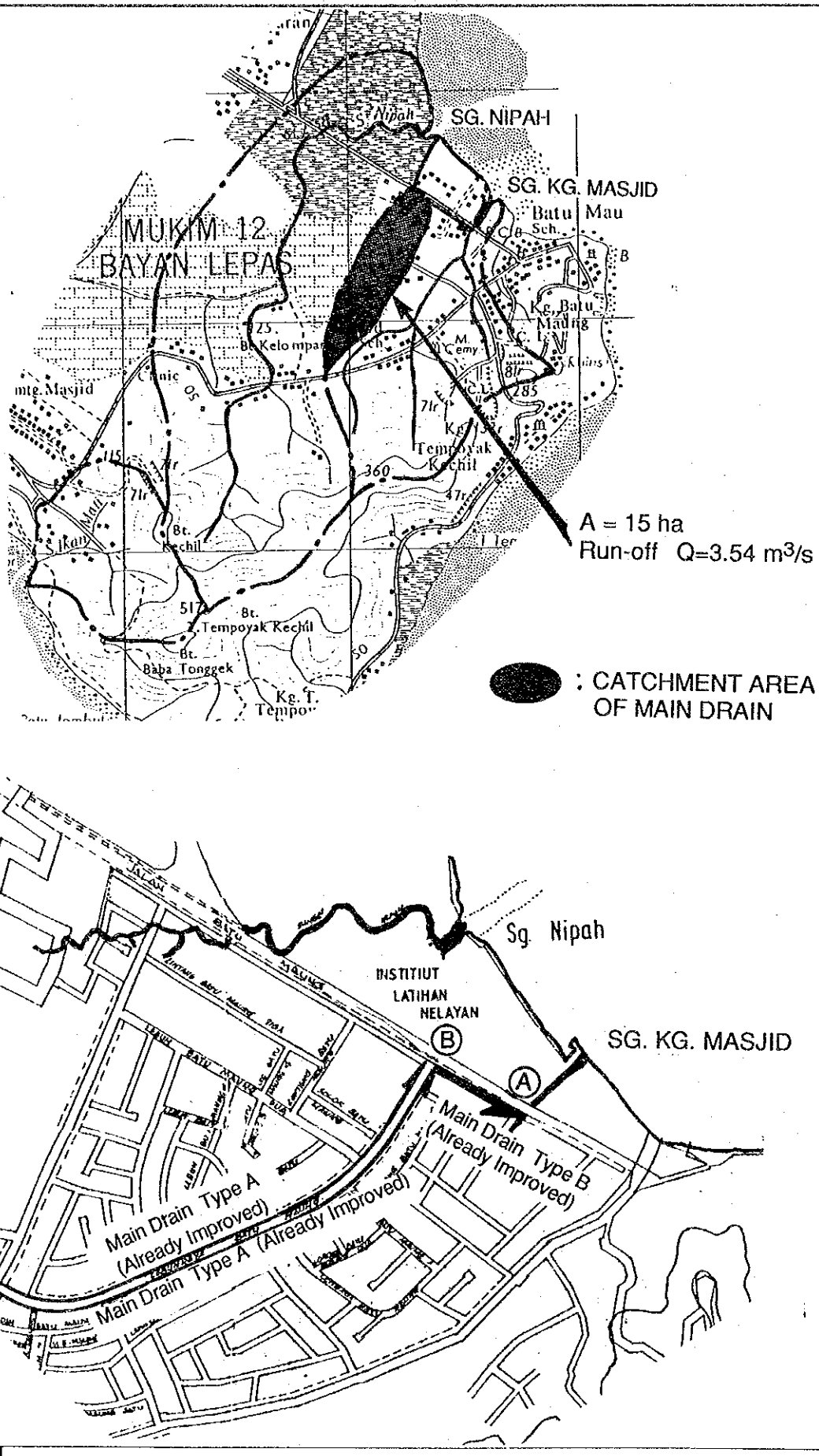
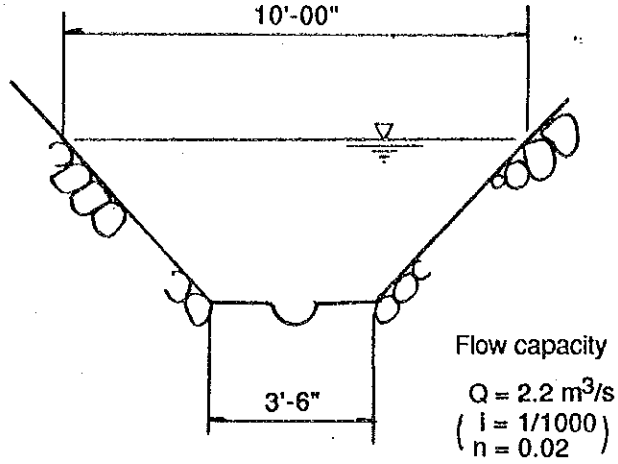
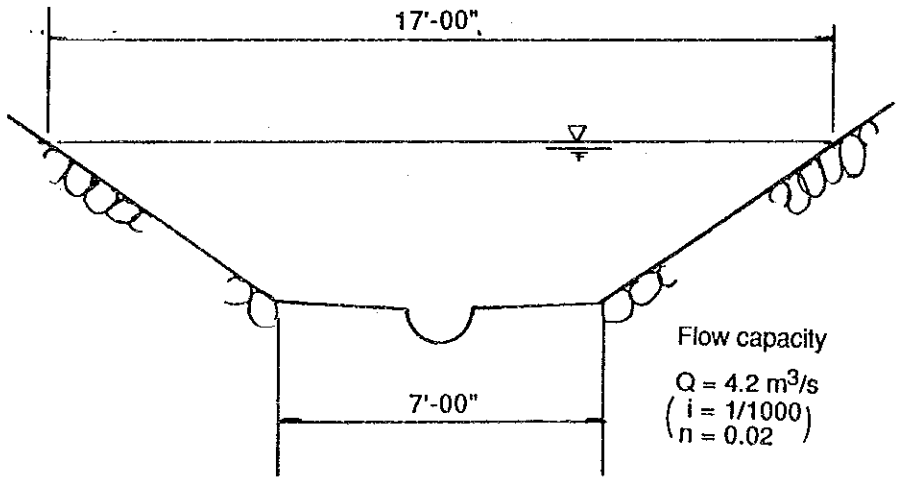


FIG. I- 24	EXISTING CROSS SECTIONS OF DRAINS IN KG. MASJID AREA

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



Main Drain Type A



Main Drain Type B

FIG. I- 25	PROPOSED CROSS SECTIONS OF DRAINS IN KG. MASJID AREA

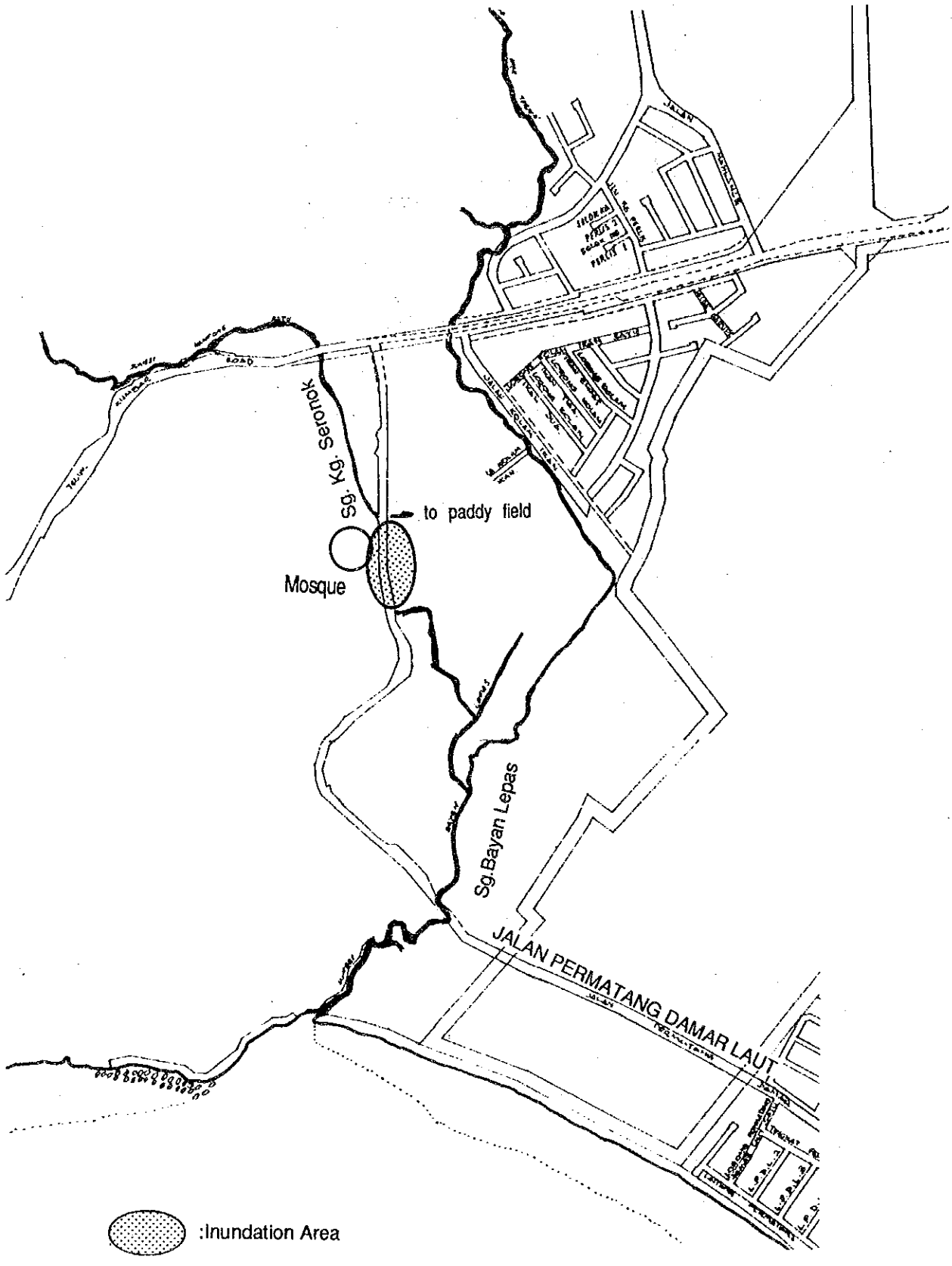


FIG. I- 26 GENERAL PLAN OF EXISTING CONDITION OF SG. KG. SERONOK

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

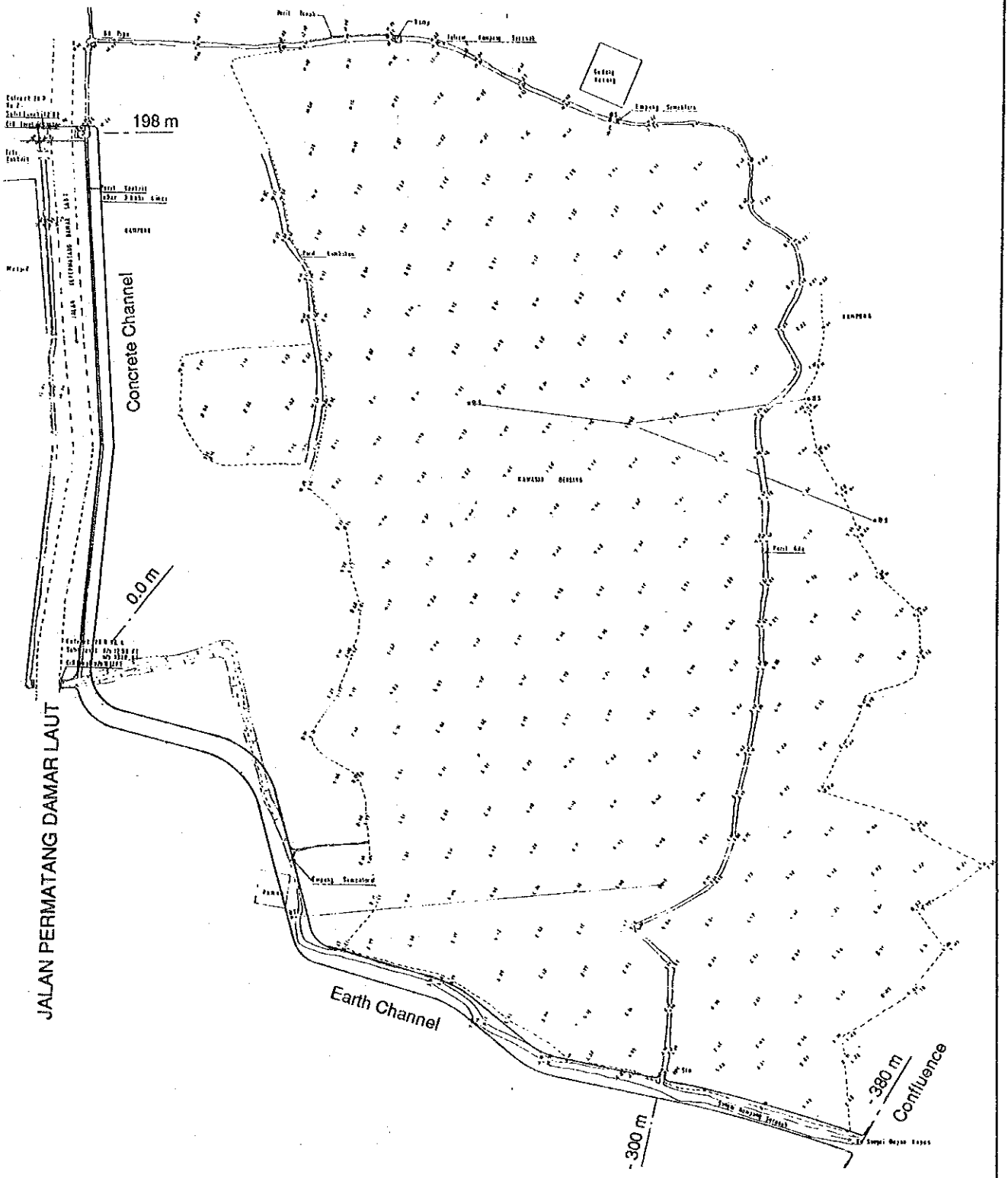
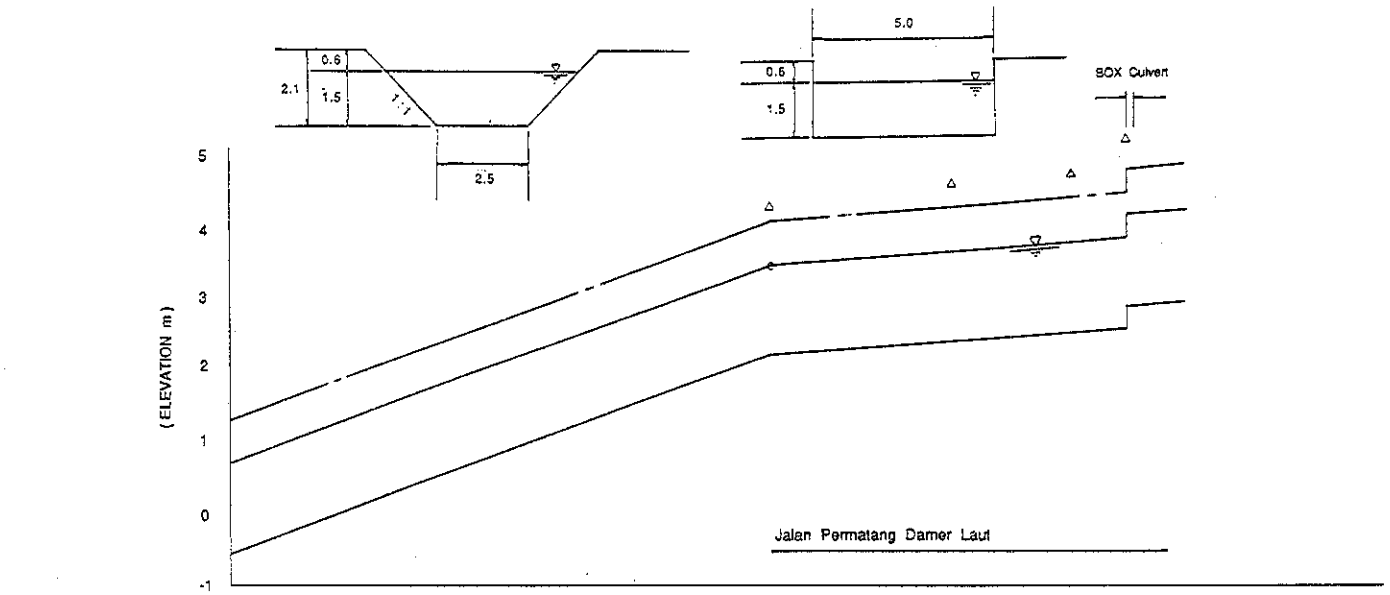


FIG. I- 27 PROPOSED ALIGNMENT OF SG. KG. SERONOK DOWNSTREAM STRETCH

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



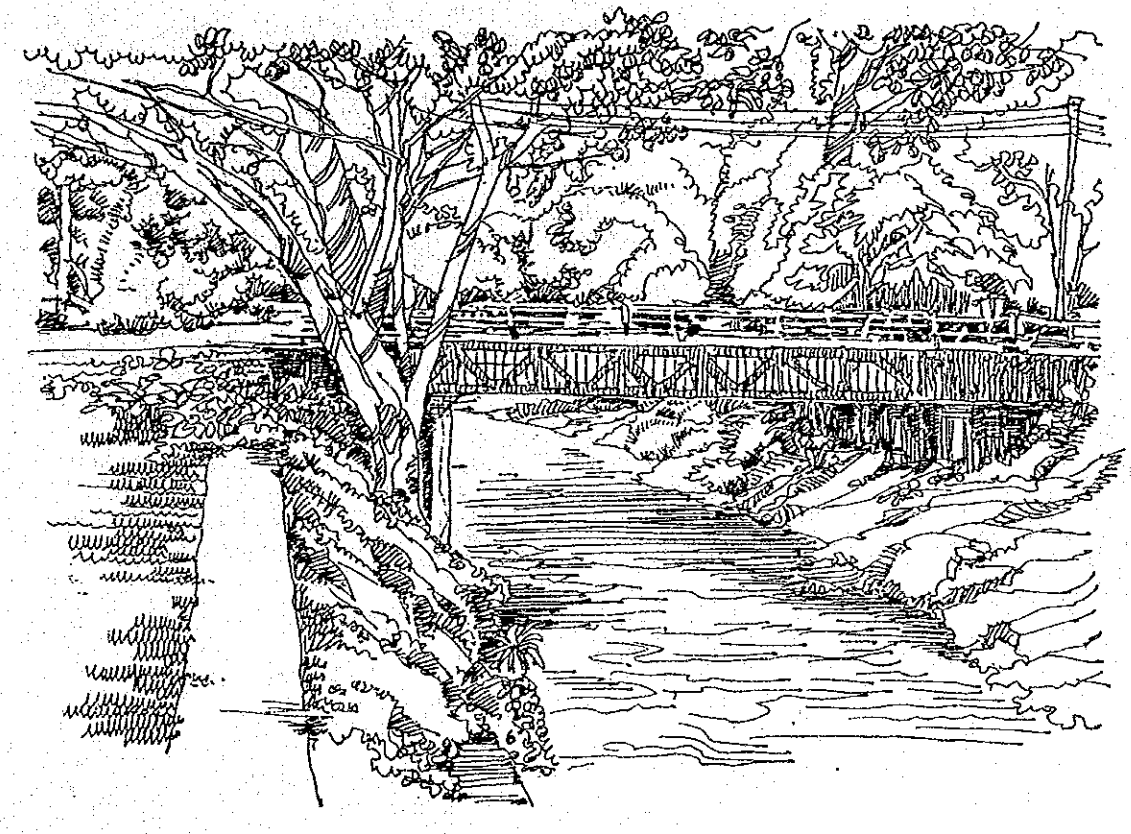
PROPOSED RIVER BED SLOPE	1/110		1/500			
DISTANCE (m)	-300	0	102	168	190	298
PROPOSED BANK LEVEL (m)	1.272	4.600	4.204	4.316	4.396	4.716
PROPOSED WATER LEVEL	0.672	3.400	3.604	3.736	3.796	4.116
PROPOSED RIVER BED LEVEL (m)	-0.828	1.900	2.104	2.236	2.296	2.616
EXISTING GROUND LEVEL (m)	1.400	4.200	4.500	4.700	5.100	5.100
EXISTING INVERT LEVEL (m)		3.402				

FIG. I- 28 PROPOSED LONGITUDINAL PROFILE AND CROSS SECTIONS OF SG. KG. SERONOK

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

APPENDIX J

URGENT FLOOD MITIGATION PLAN



APPENDIX J URGENT FLOOD MITIGATION PLAN

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APPENDIX J URGENT FLOOD MITIGATION PLAN

1. PRIORITY AREAS AND FLOOD MITIGATION FACILITIES SELECTED FOR THE FEASIBILITY STUDY

1.1 Priority Areas Selected for the Feasibility Study

The study areas and flood mitigation facilities for the urgent project are generally to be selected by taking into account the following factors:

- The extent of economic effectiveness
- Degree of urgency based on social requirement
- Scale of investment
- Frequency of inundation
- Current situation of on-going river and drainage improvement works
- Effects imparted to downstream due to the project
- Extent of compensation for existing facilities
- Degree of complexity involved in project execution.

The degree of urgency of each of the concerned 25 rivers was comprehensively evaluated in APPENDIX E.

This comprehensive evaluation was based on the size of the catchment area, previous flood experience, anticipated future basin development, and present and future flood damage.

A priority ranking as Grade A, Grade B and Grade C in descending order for each river was carried out and accordingly Sg. Pinang, Sg. Dua Besar and Sg. Keluang were ranked as Grade A with high priority.

Finally, Sg. Pinang and Sg. Keluang were selected for urgent flood mitigation projects for Feasibility Study based on the considerations described below:

Sg. Pinang

Sg. Pinang has the largest catchment area with most urbanized land use, encompassing the state capital Georgetown, with the highest concentration of assets in the Island.

The discharge capacity of the river is very small at its downstream reaches, which is the major cause of flooding. And even after the completion of on-going river improvement works a flood protection level of only a 2-year return period will be attained.

The existing high concentration of built-up areas has already made land acquisition for flood mitigation extremely

difficult. Further postponement of project implementation will only aggravate this situation.

Sg. Keluang

In comparison to the basin of Sg. Dua Besar the degree of inundation is higher in Sg. Keluang. In addition, the existing discharge capacity of the river (Sg. Keluang) is severely reduced due to siltation of river bed as a result of sediment run-off caused by sand mining activities.

There exists an urban development plan for the upper and middle reaches of the river, the implementation of which is expected to be commenced in the very near future. To cope up with this development plan, a diversion channel project has already been proposed connecting Sg. Relau to Sg. Ara.

1.2. Flood Mitigation Facilities Selected for the Feasibility Study

The flood mitigation facilities for urgent project were also selected mainly by taking into account the following factors:

- Downstream effects due to the project realization.
- Existing flow capacity of river reaches.
- Time requirement for land acquisition.
- Degree of urgency based on social factors.

The flood mitigation facilities for Sg. Pinang and Sg. Keluang are shown in Fig.J-1 and Fig.J-2, respectively.

The proposed flood mitigation works of urgent projects are as follows:

1.2.1 Sg. Pinang System

1) River improvement

River improvement works along the Sg. Pinang and its tributaries with a total length of 13.32 km.

Sg. Pinang
- Deepening and widening of 3.15 km river stretches after completion of on-going river improvement works
- Extension of river mouth portion with a length of 0.71 km.
- Reconstruction of 7 bridges (including 2 wooden bridges)

Sg. Air Itam
- Deepening and widening of 3.00 km of river channel
- Reconstruction of 3 bridges

Sg. Jelutong
- Deepening and widening of 2.14 km of river channel
- Reconstruction of 17 bridges

Sg. Dondang
- Deepening and widening of 4.32 km of river channel between confluence to Sg. Air Itam and Retention pond A.
- Reconstruction of 8 bridges.

Improvement of Sg. Air Terjun and the upstream portion of Sg. Dondang are not included in the Urgent Project, because these stretches are not so critical.

2) Construction of Air Terjun Diversion Channel

This channel consists of the construction of a 1,550 m stretch of concrete box culvert, deepening and widening of the downstream reach (150 m) of Sg. Babi, and construction of 50 m stretch of inlet.

3) Construction of the Dondang Retention Ponds

Three retention ponds will be constructed by excavation.

The total proposed pond area, using parks and open areas proposed by MPPP, is 8.4 ha and the total maximum potential capacity is 235,200 m^3.

1.2.2 Sg. Keluang

1) River improvement

River improvement works with a total length of 5.25 km along reaches of Sg. Keluang, Sg. Ara and Sg. Relau.

- Sg. Keluang:
  1.74 km of river improvements will be executed including a river course extension of 0.20 km.

- Sg.Ara:
  1.87km of river improvement will be executed.

- Sg. Relau
  1.64 km of river improvement will be executed in the upstream portion of diversion point.

2) Relau Diversion Channel

A diversion channel of 1.53 km in length, connecting Sg. Relau to Sg. Ara, will be constructed through the planned new development area.

2. DESIGN SCALE OF URGENT PROJECTS

In the Master Plan, as a design scale for river flood mitigation works, a 50-year return period was selected.

In general, the design scale of flood mitigation works in the Master Plan was as large as possible considering the future urban land use condition.

Urgent projects, on the other hand, are to be implemented in the short term and not always at the same scale as in that of the Master Plan.

For the urgent projects of Sg. Pinang and Sg. Keluang, the design scale of 50-years return period was selected considering the following conditions.

- Construction period for the urgent project might be about 5 years.

- Project cost should not be excessive.

- The Air Terjun Diversion Channel should be constructed to the final design scale because once the box culvert is constructed, it would be difficult and costly to enlarge.

- The retention ponds in Dondang area should be constructed to the final design scale because the land was already acquired for parks and the cost of the earth work for retention pond is rather low; also this kind of flood mitigation facilities is very effective for downstream flood protection.

- The maximum protection level of the proposed works for Sg. Pinang, is a 10-year return period, without any reconstruction of major bridges, but with the proposed retention ponds and diversion channel.

  In the case of reconstruction of the major bridges, the design scale for the bridges should be for the design 50-year floods.

- Regarding the river improvement works of the Sg. Pinang system, a major portion of the project cost is for land acquisition and house evacuation; these items comprises about 75% of total project cost not including the proposed diversion channel and retention ponds. The cost of bridge reconstruction and river improvement works comprise about 8% and 15%, respectively, of the total project costs (excluding the diversion channel and retention ponds).

  Land acquisition along the river should be done in one stage for all the works of Master Plan.

- For the case of enlargement of the river width in two stages, the river revetment would have to be demolished and reconstructed at least on one side.

- The length of the major river stretches (i.e. Sg. Pinang and Sg. Air Itam) to be improved is only 6 km.

- After completion of DID's on-going river improvement project for Sg. Pinang, the entire length of Sg. Pinang will have flow capacity of about 110 m^3/s.

  However, the degree of protection level of this stretch will still be for floods with a return period less than 10-years.

- The degree of protection for each reach to be improved in the Sg. Pinang system are as follows:

	Present Condition	With Retention Pond	With Diversion Channel	With Retention Pond & Diversion Channel
Sg. Pinang*	1/10	1/15	1/20	1/25
Sg. Air Itam	1/10	1/20	1/10	1/20
Sg. Dondang D1	<1/5	1/20	<1/5	1/20
D2	<1/5	<1/5	<1/5	<1/5
Sg. Air Terjun				
T1	1/5	1/5	1/30	1/30
T2	1/10	1/10	1/10	1/10
Sg. Jelutong	<1/5	<1/5	<1/5	<1/5

*: For Sg. Pinang, conditions after completion of on-going river improvement works were considered.

- With the proposed retention ponds and diversion channel but without any river improvement works, the protection level of the major stretches of Sg. Pinang system would be only for floods with a 20 ~ 25-year return period.

- In order to obtain the 30-year return period protection level, almost all bridges would have to be reconstructed.

- In the Dondang area, flooding is common. To solve this problem, it is necessary to deepen Sg. Dondang and Sg. Air Itam.

Considering the above mentioned conditions, the 50-years design scale was adopted for the urgent projects for the Sg. Pinang system and Sg. Keluang.

3. PROPOSED URGENT FLOOD MITIGATION PLAN

3.1 River Improvement

3.1.1 Distribution of Proposed Design Discharge

The design discharges for Sg. Pinang and Sg. Keluang are formulated under the following conditions.

i) A design storm of 50-year return period was adopted for Urgent Project.

ii) Land use condition is for the year 2010.

iii) Three Dondang Retention Ponds and Air Terjyn Diversion Channel are used for flood mitigation for Sg. Pinang system and Relau Diversion Channel for Sg. Keluang system respectively.

The design discharges for these river stretches are shown in Fig.J-3 and Fig.J-4.

3.1.2 Design Concept and Conditions of River Improvement

All stretches of a waterway to be protected should be planned to allow the safe passage of a 50-year design flood discharge with at least 60 cm of freeboard and to be able to handle the 100-year flood discharge without overflowing the banks. Also to be taken into consideration are the promotion of river utilization, preservation of natural environment, present land use in the areas along river banks, etc.

1) Plan of alignment

The alignment of waterways should be decided considering the existing riparian land use conditions, river reserve, future urban development plans, on-going river improvement plans, land reclamation plans, topographical conditions and difficulty of land acquisition, etc.

For the following stretches, special consideration should be taken.

- The extension at the mouth of Sg. Pinang will be aligned considering future reclamation plans and existing topographical conditions of the sea bed.
- The on-going river improvement plan of Sg. Pinang, with the alignment generally following the existing waterway, will be reviewed because of the extreme meandering of some stretches.
- Alignment of the Sg. Dondang will basically follows the existing waterway. However, urban development plans and the effective use of retention ponds should also be looked into.
- Sg. Ara has already been partially improved with a compound section, and this concept will be followed in this project.
- The route of Relau Diversion Channel will follow the alignment approved by DID.
- Alignment shall be set by as smooth curves as possible with less meandering and the minimum radius of curvature should be bigger than five times of river width as far as possible.

2) Plan of longitudinal profile

The design slope was basically determined by the existing average bed slope, since the existing slope is considered to be the most stable slope under the present flow conditions.

The stretches of Sg. Pinang and Sg. Air Itam to be improved will be deepened by about one meter. The Sg. Dondang bed will also be deepened by 1 to 2 meters to solve the inner drainage problem in the basin and also to enable the effective use of retention ponds.

Especially in the downstream stretches of Sg. Pinang, the existing geotechnical conditions to design the revetment were also taken into account to decide the river bed height.

3) Cross section

The cross sections of Sg. Pinang and its tributaries will have a single section with 1:1 bank slopes because of the high cost and difficulty of land acquisition.

The depth of river channel will vary from 3.1 m to 3.7 m.

The cross section of Sg. Keluang and Sg. Ara will be a compound cross section with a high-water channel and low-water channel.

The berms of high-water channel will be used for the purpose of river front park or maintenance and rehabilitation of the waterway.

For the Relau Diversion Channel, a concrete channel with single section will be planned following PDC plan because of land use restriction, even though a compound section is recommended because this stretch has a comparatively ample base flow and the water quality is still good.

4) River reserve

The width of river reserves for maintenance and rehabilitation of the river channel should be as follows:

W < 3 m	one side 3 m; other side 1.5 m
3 m < W < 15 m	one side 3 m; other side 6.0 m
15 m < W	both sides 6.0 m

where W = width of river.

5) Revetment

The revetment type of river bank for Sg. Pinang system will be rubble pitching considering construction cost, geotechnical conditions, and landscaping.

For Sg. Keluang, the proposed cross section of the river channel will be of the compound type with high-water revetment to protect the bank slope under high water conditions, and the low-flow revetment with a low flow channel.

The high water revetment will be of sod facing or rubble pitching and the low-water revetment of rubble pitching.

6) Design conditions

(1) Discharge capacity

The discharge capacity should be calculated on the basis of uniform flow or non-uniform flow according to the conditions of the waterway.

For uniform flow conditions, Manning's formula was adopted.

$Q = 1/n \cdot R^{2/3} \cdot I^{1/2} \cdot A (m^3/s)$
R = hydraulic mean depth (m)
Sectional area of river flow divided length of wetted perimeter
I : Slope of bed slope
n : Manning's coefficient of roughness

For the downstream stretches of Sg. Pinang and Sg. Keluang, non-uniform flow calculations were carried out because these stretches are affected by high tide.

(2) Coefficient of Roughness

For Manning's coefficient of roughness, the following values are recommended in "Urban Drainage Design Standards and Procedures for Peninsular Malaysia" by J.P.T.

Recommended Values for Manning's 'n'

	Type of Channel and Description	Minimum	Normal	Maximum
1	Close conduits Flowing Partly Full			
	Concrete culvert, straight and free of debris	.010	.011	.013
	Concrete culvert with bends, connections with some debris	.011	.013	.014
2	Lined or Built up Channels			
	Precast invert sections and concrete lines channels	.013	.015	.017
	Concrete bottom with cemented rubble stone sides	.017	.0020	.024
	Channels with earth bottom, rubble sides	.020	.023	.026
3	Natural Streams(1)			
	Clean straight grassed banks	.025	.030	.035
	Some weeds and stones	.030	.035	.040
4	Vegetal Lining	.030	.035	.050

(1) For a more complete list see Appendix D, Table D-1

Referring to these values, the following coefficients of roughness were adopted for this study.

- For earth or grass sections: n = 0.03
  e.g. Sg. Batu, Sg. Mati, Sg. Teluk Kumbar
- For channels with earth bottom, rubble sides n = 0.025
- For concrete sections n = 0.020
- For compound section with rubble pitching for low-water and high-water revetment, and with earth bottom, with earth or sod facing berm n = 0.030

3.1.3 Proposed River Improvement

Based on the above mentioned concept and conditions, the river alignments, longitudinal profiles and cross sections for the two river systems were planned.

The features of the proposed river improvement works in the Sg. Pinang and Sg. Keluang system are shown in Fig. J-1 and J-2.

The proposed longitudinal profiles and cross sections of the river improvement are shown in Fig. J-5 to J-15, and Fig.J-17 and Fig. J-18 show the typical cross sections of the river improvement.

Fig. J-19 shows the typical section of the drop structure of bridges.

3.2 Diversion Channel

3.2.1 General

There are two proposed diversion channels in the Urgent Project areas.

One is Air Terjun Diversion Channel which connects Sg. Air Terjun with North Channel diverting about 50 m^3/s of design discharge. The proposed diversion channel route is shown in Fig. J-2.

This diversion channel is to be constructed mostly under the existing roads; Jalan Gottlieb and Jalan Bagan Jermal.

At the diversion point, all base flow under normal condition flows through the existing Sg. Air Terjun.

However, during floods, a major portion of the discharge will be diverted to the diversion channel.

The other is the Relau Diversion Channel in the Sg. Keluang system which connects Sg. Relau with Sg. Ara. This diversion channel diverts 100% of Sg. Relau at 1.9 km point of Sg. Relau.

3.2.2 Present Conditions of Proposed Sites for Diversion Channels

1) Air Terjun Diversion Channel

The upper most 60 meter stretch of the Diversion Channel flows through a residential area and one or two houses will have to be relocated.

After this stretch, the route will be along the existing road, Jalan Gottlieb and Jalan Bagan Jermal.

The width of the existing road is about 9 meter for most stretches and road has a 6 ~ 7 meter footpath on both sides.

On the footpaths, there exist about 60 royal palm trees with about 40 cm diameter.

As the downstream stretch, Sg. Babi will be one of the alternative routes.

On the left side of Sg. Babi, there exist some six houses. On the right side, the sewerage plant exist. Another alternative route will be under existing road up to the sea without any jointing with Sg. Babi was studied. However this route has no merit comparing with Sg. Babi route, and was rejected.

Topographically, the upper portion of this channel route has a rather gentle slope (1:400), while the downstream portion has a rather steep slope (1:100).

In the diversion channel route, there are two major underground sewers which cross the channel route at downstream stretch.

The sewer located 100 m from the mouth of Sg. Babi is located deep enough and will not constitute an obstruction.

Another sewer 427 m above the mouth of Sg. Babi will have to be reconstructed.

As a future plan, a bridge of Outer Ring Road is proposed about 40 meter downstream at the existing mouth of Sg. Babi.

2) Relau Diversion Channel

The present land use of the proposed diversion channel route consists of undeveloped rural area and agricultural land where the existing ground level is about 4.5 m. (see Fig. J-2)

In the future, whole areas along this route will be developed for housing.

The proposed diversion channel route is planned to be alongside the future road.

The major structures crossing this route are the proposed federal highway with 40 m width and the existing Jalan Thegah.

3.2.3 Design Conditions

The general features of diversion channel studied in the Master Plan stage and design conditions are as follows.

1) Air Terjun Diversion Channel

-	Location of channel route	Jalan Gottlieb, Jalan Bagan Jermal, and Sg.Babi
	Total length	1,740 m
-	diversion point	3,155 m point of Sg.Air Terjun
-	Catchment area at diversion point	7.74km^2

-	Design peak discharge st diversion point of Sg.Air Terjun	70 m^3/s (1/50)
-	Diverting discharge	50 m^3/s
-	Design discharge for diversion channel	1.3 x 50 = 65 m^3/s
-	Design discharge for Sg.Babi	12 m^3/s or 62 m^3/s
Type of Cross Section		Concrete rectangular culvert L = 1,558 m or 1610 m Open Concrete Channel (in case of use of Sg.Babi) L=150m
Invert Level		El. 11.00 m at entrance El. -0.60 m at outlet
Maximum earth covering		3.5 m st upstream end
Minim earth covering		0.5 m at downstream end

2) Relau Diversion Channel

-	Location of channel route	See Fig.J-2
-	Total length	1,530 m
-	Catchment area of diverting point	10.5 km^2
-	Design peak discharge (diverting discharge)	70 m^3/s
-	Type of Cross Section	open concrete channel
-	Existing ground level	3.0 m ~ 6.0 m

3.2.4 Structural Plan of Diversion Channel

1) Air Terjun Diversion Channel

(1) Alignment of diversion channel route

The uppermost 60 meter stretch of the diversion channel flows through a residential area and one or two houses will have to be relocated.

After this stretch, the route will be along the existing road.

The exact route was decided considering the existing underground structures and traffic conditions during construction. At the downstream stretch of the confluence with Sg.Babi, the diversion channel route is

located on the left side of Sg.Babi because of the existing sewerage plant adjacent to the right bank.

In this stretch, some six houses are located near the river bank.

Any extension of the existing river mouth was not considered.

Alignment of the inlet of the diversion channel was set up according to the diversion conditions.

(2) Longitudinal profile of diversion channel

The Design High Water Level (D.H.W.L.) at point of diversion on Sg. Air Terjun is 13.7 m and the Mean High Water Spring (M.H.S.) of the sea is +1.08 m .

Hence, there exist 12.6 m of head between these two points, and the average gradient will be about 1:136. This gradient is steep enough to permit the economic channel section and also to flush away sediments.

However, topographically, the upper portion of this channel route has a rather gentle slope (1:400), while the downstream portion has a rather steep slope (1:100).

As a proposed longitudinal profile, 1:200 gradient was selected as shown in Fig. J-21, considering the following conditions.

a. The depth of excavation shall be shallow as far as possible. However, minimum earth covering should be kept.

b. Generally, the maximum velocity for tunnel river is limited to 5 ~ 7 m/s. For this diversion channel, channel gradient at 1/80 gives 7 m/s of velocity and 1/200 gives 5 m/s.

c. Since the average slope between the inlet and outlet of the channel is rather steep, it is expected that the drop structures will be installed to control the velocity in the channel. The relationship between design gradient and number of required drop structures is as follows :

channel gradient	channel width (m)	number of drop structure: n*
1:150	-	4
1:200	5.5	9
1:250	6.1	11
1:300	6.7	14
1:350	7.3	15
1:400	7.7	16

*: n = (12.6 - 1650 m x gradient)) /0.5
(Height of drop structure is 50 cm)

(3) Plan of cross section

The cross section of the diversion channel is rectangular and mostly of concrete box culvert.

The channel width was decided considering hydraulic and structural conditions.

Consideration should be given to minimize the social and environmental impacts during construction.

The width of the existing road is about 9 meter for most stretches and road has a 6 - 7 meter footpath on both sides.

While the proposed diversion channel has a width of about 6.5 meters it is not impossible to keep the one way road for the residents.

The cross section of a 160 meter stretch at downstream of Sg. Babi was planned to be an open type concrete channel.

The typical cross section of the Air Terjun Diversion Channel is shown in Fig. J-22 and J-23.

2) Relau Diversion Channel

The alignment of proposed Relau Diversion Channel is shown in Fig.J-2.

This alignment was planned to be located alongside the future road authorized in the urban development plan by PDC considering effective land use rather than hydraulic components.

The cross section of this channel is planned to be rectangular concrete type because of land use restriction.

The slope of longitudinal profile was set up to be 1:400 considering the design bed levels of Sg. Relau diverting point and of confluence with Sg. Ara.

Fig. J-16 shows the proposed longitudinal cross section of the Relau Diversion Channel.

3.3 Retention Ponds

3.3.1 General

In the Master Plan stage of this study, five potential retention pond sites were selected in the Dondang area where intensive housing development is taking place.

These five sites were proposed as a park area. However, some of them have been partially changed to another purpose of land use.

Hence, the available park area for retention pond was reviewed and finally three sites, A,B and C park areas were selected for retention pond.

These retention ponds will regulate the discharge of Sg. Dondang from 80 m^3/s to 60 m^3/s.

These ponds will serve as a retention pond during floods with return periods exceeding 30-years.

And they will normally be used as a park land to cater for the needs of diversified facilities for sports and recreational activities.

3.3.2 Present Conditions of Proposed Sites for Retention Ponds

Present land use conditions of each proposed retention pond site are as follows.

1) Site A

This site has been already developed to park land without any permanent facilities. Sg. Dondang which flows through this park area has been improved. The park area for Retention Pond A, which has 3.05 ha in area, is located at elevation of 21.5 m.

2) Site B

The proposed park area consists of agriculture land, some village houses and river reserve. In the upstream area adjacent to this park, a large scale of housing development project is in full swing at present. The park B has 3.27 ha in area and is located at elevation of 15.6 m. The existing river channel flows through the central part of the park.

3) Site C

Park C area is open land including some agriculture land and has gentle slope from elevation 13.5 m to 13.1 m. Park area is 2.12 ha and is located at left side of the existing river.

4) Site D and Site E

These parks are located along the tributary of Sg. Dondang. The site D was initially planned as the park with about 4.74 ha of area. However, the area has been reduced to 0.66 ha because of change of land use pattern for housing. This site is located at elevation of 18 m which requires deep excavation.

While, the available area of park E is only 1.87 ha because of existence of small scale sewerage treatment plant. This park area is open land at present and located at elevation of 14 m.

3.3.3 Selection of Retention Pond Site

As noted in the Paragraph 3.3.1, the five retention pond sites were selected in the Master Plan Stage. These sites are shown in Fig.J-24.

These sites are located along the Sg. Dondang main stream or its tributary where the necessary storage capacity can be secured.

The longitudinal profiles of these ponds and rivers are schematically shown on Figs.J-25.

Among these five sites, three sites were selected for retention pond considering topographical conditions, recreational use, construction cost, etc. as described below.

- The park area D, which has only 0.66 ha, is located at elevation of 18 m , and seems to be rather difficult for multi-purpose use because this pond would have to be excavated to a depth of 7 m to obtain a suitable amount of storage capacity. Accordingly, this site was rejected.

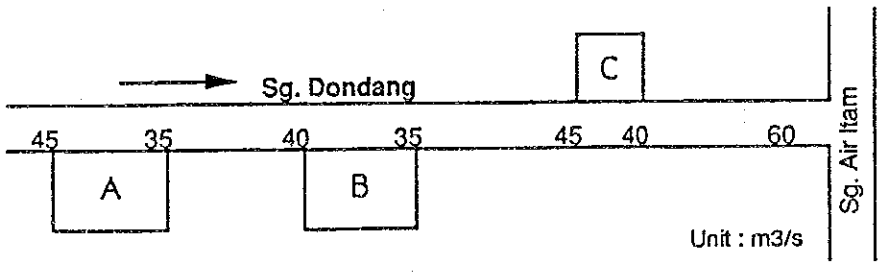
- The park area E has 1.87 ha and is able to serve as a multi-purpose retention pond. However, the diversion channel of about 700 m long connecting Sg. Dondang with pond D will be necessary. Furthermore, in order to release the storage flood water, the new water way has to be excavated. Because the existing tributary of Sg. Dondang has been partially filled up by new housing development project.

- In case without these two sites, D and E, it is possible to keep the required storage capacity by three site A, B, and C without any excessive deep excavation.

3.3.4 Design Concept and Conditions

1) Proposed design discharge distribution

The design discharge of Sg. Dondang is as follows.



The discharge for 50-year return period at the river month of Sg. Dondang is 80 m^3/s and this will be reduced to 60 m^3/s after regulating by three retention ponds.

The discharge exceeding about 30-year return period will be diverted into the retention ponds through the overflow weir installed at the upstream portion of the pond.

2) Design storage capacity

The design storage capacity was decided from the net storage and the free storage including storage from the retention pond area.

The value of the net storage of each retention pond will be decided from a simulation model considering the most suitable distribution of flood control volume for each retention pond.

About 30% of the net storage is set as free storage to cover the difference between the estimated volume and actual volume, storage from the retention pond area, etc.

3) Effective Depth of Retention Pond

The effective depth of each retention pond will depend on the difference between design H.W.L. of the upstream portion of the pond and L.W.L. at the downstream portion of the pond. These conditions will depend on the topographic conditions and longitudinal profile after completion of the river channel improvement works.

The design H.W.L. of the pond is set at the same level as top of overflow weir in order to enable free overflow. While the design L.W.L. will be set at least 50 cm above the design bed level of the river.

Freeboard of the retention pond will be 0.6 m, the same as for the river channel.

4) Typical Cross Section

In general, the multi-purpose retention ponds will be sub-divided into several portions to meet the retention capacity required for various probable floods.

The park area in Dondang area, however, will be sub-divided into only two portions because of the very low frequency of use for flood mitigation.

The lower area of the pond will be inundated with floods having return periods greater than 30-years, and the highest area will remain as permanent park land.

5) Internal drainage of the retention pond

The lower area of the pond should be planned considering internal drainage to keep this area dry during non-flooding periods.

3.3.5 Structural Plan of Retention Pond

1) Maximum available volume for flood control

The maximum available volume for each retention pond will be estimated considering the H.W.L. of Sg. Dondang at diverting point, the L.W.L. of Sg. Dondang at discharging point and effective area of park area excluding the river channel.

The existing river channels which flows through the park area, will be shifted to the edge of the park in order to increase the effective capacity of the ponds and also the effective and functional use of park land.

The maximum potential volume for each pond is as follows.

(1) Pond A

1.	Max. capacity	90,060 m^3
2.	Existing Ground Level	EL. 21.5 m
3.	H.W.L.	El. 20.28 m
4.	Bed Level	EL. 16.80 m
5.	Maximum Water Depth	3.48 m
6.	Depth of Excavation	4.70 m

(2) Pond B

1.	Max. capacity	86,470 m^3
2.	Existing Ground Level	EL. 15.60 m
3.	H.W.L.	El. 14.00 m
4.	Bed Level	EL. 10.90 m
5.	Maximum Water Depth	3.10 m
6.	Depth of Excavation	4.70 m

(3) pond C

1.	Max. capacity	58,680 m^3
2.	Existing Ground Level	EL. 13.10 m
3.	H.W.L.	El. 11.97 m
4.	Bed Level	EL. 7.90 m
5.	Maximum Water Depth	3.57 m
6.	Depth of Excavation	5.60 m

2) Determination of required capacity of each retention pond

The discharge of Sg. Dondang will be reduced from 80 m^3/s to 60 m^3/s for 50-year floods by three retention ponds.

The maximum available storage capacity of these three ponds is 235,210 m^3

While the net volume for required flood control is 152,510 m^3.

The Design storage capacity will be 130% of this net volume, i.e.198,270 m^3 which is equivalent to about 85 % of the maximum available storage capacity.

The distribution of this required storage capacity for each retention pond was decided based on the comparison of the following cases for combination of storage capacity.

i) The maximum use of one pond, and about 80% of use of the other two ponds.

ii) The maximum use of two pond.

iii) About 85% to 90% use for each pond,

The results are shown in Table.J-1 to Table.J-3.

Finally, case iii-1 was selected considering the following reasons.

i) The maximum storage capacity was decided under the condition of pond bed level which is 50cm higher than the river bed. However, it is recommended to get the more higher level as far as possible to keep the pond bed dry.

ii) Less excavation depth is more desirable for multi-purpose use of retention pond.

iii) Pond C needs rather deep excavation comparing with other two ponds. Hence, it is desirable to reduce the required storage capacity for pond C.

The characteristics of each pond are shown in Table J-4. Plan, longitudinal profiles and typical cross sections of these ponds are shown in Fig.J-26 to Fig.J-34, respectively.

3) Overflow weir

The overflow weir is to be constructed at the upstream portion of the retention pond along the Sg. Dondang.

The dimensions of the weir of each retention pond are as follows.

	height	length
A Pond	El 20.278 m	80 m
B Pond	El 14.013 m	50 m
C Pond	El 11.470 m	40 m

The length of weir was set by hydraulic calculation.

The longitudinal section at overflow weir is shown in Fig. J-35.

The final dimensions of these weirs should be decided by carrying out hydraulic model test.

4) Outlet gate

At the downstream portion of each retention pond, the outlet sluice gate and flap gate will be installed to release the flood discharge.

The sluice gate will serve to release flood discharge during and after flooding while the flap gate will serve to release the rain water in the pond area.

The dimensions of these gates are as follows and the plan and section are shown in Fig J-36.

	Sluice Gate width	Sluice Gate height	Flap gate
A-pond	2.0 m	2.0 m ,	ø 0.5 m
B-pond	2.0 m	2.0 m ,	ø 0.5 m
C-pond	1.0 m	1.0 m ,	ø 0.5 m

3.4 Bridges

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

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

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

One new bridge obstruction will be necessary in the Relau Diversion Channel.

All the bridges to be reconstructed for urgent projects are shown in Table J-5-1 and J-5-2.

3.5 Public Utilities

Following to the river improvement works by widening and deepening of river channel, the existing public utilities will be required to be replaced at several locations.

The features and locations of these utilities are shown in Table J-6-1 to 6-3

The locations of these utilities are shown in the supplementary drawings..

Tables

TABLE J-1 REQUIRED STORAGE CAPACITY (1) (Maximum Use of One Pond)

Pond A

	Inflow (m3/s)	Cut (m3/s)	Outflow (m3/s)	Vol. (m3)	Storage Ratio %	Max. Capacity m3
Pond A	40.627	10.0	30.627	64,552	93	69,277
Pond B	37.139	5.5	31.639	52,258	79	66,515
Pond C	43.399	4.5	38.899	35,700	79	45,138
		20.0		152,510	84	180,930

Pond B

	Inflow (m3/s)	Cut (m3/s)	Outflow (m3/s)	Vol. (m3)	Storage Ratio %	Max. Capacity m3
Pond A	40.627	8.5	32.127	53,579	77	69,277
Pond B	37.139	7.0	30.139	63,230	95	66,515
Pond C	43.399	4.5	38.899	35,700	79	45,138
		20.0		152,509	84	180,930

Pond C

	Inflow (m3/s)	Cut (m3/s)	Outflow (m3/s)	Vol. (m3)	Storage Ratio %	Max. Capacity m3
Pond A	40.627	9.0	31.627	57,179	83	69,277
Pond B	37.139	6.0	31.139	54,230	82	66,515
Pond C	43.399	5.0	38.399	41,100	91	45,138
		20.0		152,509	84	180,930

TABLE J-2 REQUIRED STORAGE CAPACITY (2) (Maximum Use of Two Ponds)

Pond A and Pond B

	Inflow (m3/s)	Cut (m3/s)	Outflow (m3/s)	Vol. (m3)	Storage Ratio %	Max. Capacity m3
Pond A	40.627	10.0	30.627	64,552	93	69,277
Pond B	37.139	6.5	30.639	63,058	95	66,515
Pond C	42.399	3.5	38.899	24,900	55	45,138
		20.0		152,510	84	180,930

Pond A and Pond C

	Inflow (m3/s)	Cut (m3/s)	Outflow (m3/s)	Vol. (m3)	Storage Ratio %	Max. Capacity m3
Pond A	40.627	10.0	30.627	64,552	93	69,277
Pond B	37.139	5.0	32.139	46,858	70	66,515
Pond C	43.399	5.0	38.399	41,100	91	45,138
		20.0		152,510	84	180,930

Pond B and Pond C

	Inflow (m3/s)	Cut (m3/s)	Outflow (m3/s)	Vol. (m3)	Storage Ratio %	Max. Capacity m3
Pond A	40.627	7.5	33.127	46,379	67	69,277
Pond B	39.639	7.5	32.139	65,030	98	66,515
Pond C	43.899	5.0	38.899	41,100	91	45,138
		20.0		152,509	84	180,930

TABLE J-3 REQUIRED STORAGE CAPACITY (3) (Even Use of Three Ponds)

J3-1

	Inflow (m3/s)	Cut (m3/s)	Outflow (m3/s)	Vol. (m3)	Storage Ratio %	Max. Capacity m3
Pond A	40.627	9.5	31.127	60,779	88	69,277
Pond B	37.639	6.0	31.639	56,030	84	66,515
Pond C	43.399	4.5	38.899	35,700	79	45,138
		20.0		152,509	84	180,930

J3-2

	Inflow (m3/s)	Cut (m3/s)	Outflow (m3/s)	Vol. (m3)	Storage Ratio %	Max. Capacity m3
Pond A	40.627	9.5	31.127	60,779	88	69,277
Pond B	37.639	5.5	32.139	50,630	76	66,515
Pond C	43.899	5.0	38.899	41,100	91	45,138
		20.0		152,509	84	180,930

J3-3

	Inflow (m3/s)	Cut (m3/s)	Outflow (m3/s)	Vol. (m3)	Storage Ratio %	Max. Capacity m3
Pond A	40.627	9.0	31.627	57,179	83	69,277
Pond B	38.139	6.5	31.639	59,630	90	66,515
Pond C	43.399	4.5	38.899	35,700	79	45,138
		20.0		152,509	84	180,930

J3-4

	Inflow (m3/s)	Cut (m3/s)	Outflow (m3/s)	Vol. (m3)	Storage Ratio %	Max. Capacity m3
Pond A	40.627	9.0	31.627	57,179	83	69,277
Pond B	38.139	6.0	32.139	54,230	82	66,515
Pond C	43.899	5.0	38.899	41,100	91	45,138
		20.0		152,509	84	180,930

TABLE J-4 CHARACTERISTICS OF DONDANG RETENTION PONDS

	Inflow (m3/s)	Cut Q (m3/s)	Outflow (m3/s)	Volume (m3)	Vol. x1.3 (m3)	Ground Level (El. m)	Design High Water Level (El. m)	Design Pond Bed Level (El. m)	Pond Depth (m)	Water Depth (m)
Pond A	40.627	9.500	31.127	60,779	79,013	21.50	20.28	17.26	4.24	3.02
Pond B	37.639	6.000	31.639	56,030	72,839	15.60	14.00	11.42	4.18	2.58
Pond C	43.399	4.500	38.899	35,700	46,410	13.50	11.47	8.73	4.77	2.74
Total		20.000		152,509	198,262					

TABLE J-5-1 BRIDGES TO BE RECONSTRUCTED FOR URGENT PROJECTS

Sg. Pinang

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

Sg. Air Itam

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

Sg. Dondang

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

TABLE J-5-2 BRIDGES TO BE RECONSTRUCTED FOR URGENT PROJECT

Sg. JELUTONG

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

Sg.Keluang

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

TABLE J-6-1 PUBLIC UTILITIES TO BE REPLACED

RIVER NAME : Sg. Pinang

WATER PIPE & OTHER PIPES			
CHR (m)	LENGTH (m)	DIAMETER (inch)	REMARKS
0	110	24"	submarine pipe
0	110	24"	submarine pipe(under sea bed)
400	15	9"	JALAN JELUTONG
900	30	9"	JALAN SUNGAI
900	30	4"	JALAN SUNGAI
1270	30	6"	JALAN PATANI
1270 - 1400	142	3"	JALAN PATANI
1336	9	3"	JARAN PATANI
1383	10	3"	JARAN PATANI
2120	25	9"	JALAN DERAK
2130	25	24"	JALAN DERAK
3075	25	18"	JALAN AYER ITEM
3085	25	30"	JALAN AYER ITEM

RIVER NAME : Sg. Jelutong

WATER PIPE & OTHER PIPES			
CHR (m)	LENGTH (m)	DIAMETER (inch)	REMARKS
50	15	6"	JALAN SVNGEI
200	15	24"	JALAN PERAK
200	15	9"	JALAN PERAK
1300	15	12"	JALAN FREE SCHOOL
1310	15	6"	JALAN FREE SCHOOL
1500	10	2"	BRIDGE
1650	10	4"	SOLOK VAN
1800	10	4"	along the river
1910	10	4"	JALAN PRAAGH

RIVER NAME : Sg. Air Itam

WATER PIPE & OTHER PIPES			
CHR (m)	LENGTH (m)	DIAMETER (inch)	REMARKS
925	15	12"	JALAN SCOTLAND
955	15	4"	JALAN SCOTLAND
1370	20	18"	IYER ITEM
1815	25	4"	BRIDGE
2310	30	24"	LORONG BATU LANCANG
3300	20	24"	JALAN THEAN TER
3300	20	6"	JALAN THEAN TER
4350	25	18"	JALAN ZOO
5450	25	6"	LEBUH PAYA TERUBONG
5720	15	2"	LEBUH PAYA TERUBONG

RIVER NAME : Sg. Air Terjun

WATER PIPE & OTHER PIPES			
CHR (m)	LENGTH (m)	DIAMETER (inch)	REMARKS
250	10	4"	JALAN YORK
525	10	6"	JALAN ROSS
600	10	4"	BRIDGE
1150	15	6"	JALAN SCOTLAND
1650	10	6"	BROOK ROAD
1880	15	9"	JALAN TAMA
2450	15	2"	BRIDGE
3100	25	4"	BRIDGE
3510	10	16"	JALAN KESUN SUNGA
3510	10	12"	JALAN KESUN SUNGA
3800	10	4"	JALAN AIR TERJUN BRIDGE

TABLE J-6-2 PUBLIC UTILITIES TO BE REPLACED

RIVER NAME : Sg. Dondang

WATER PIPE & OTHER PIPES			REMARKS
CHR (m)	LENGTH (m)	DIAMETER (inch)	
500	10	2"	BRIDGE
500	10	4"	JALAN THEAN TER
500	10	24"	BRIDGE
750	10	4"	BRIDGE
1645	10	6"	JALAN THEAN TER
4586	5	4"	along the river
4852	2	12"	LEBUH PAYA TERUSONG
4852	2	6"	LEBUH PAYA TERUSONG

RIVER NAME : Sg. Keluang

WATER PIPE & OTHER PIPES			REMARKS
CHR (m)	LENGTH (m)	DIAMETER (m)	
1550	50	0.38	
1550	50	0.2	
1870	50	0.45	
3420	25	0.23	
3430	25	0.15	
1500	10	0.05	
1650	10	0.1	
1800	10	0.1	
1910	10	0.1	

WATER PIPES ON EACH DRAINAGE

NO.	WATER PIPE			REMARKS
	PLACE	LENGTH (m)	DIAMETER (inch)	
S-10	1	10.5	48	PENGKALAN WELD
	2	10.5	8	LESON PANTAI
	3	10.5	24	LESON PANTAI
	4	10.5	8	CARNARVON STREET
	5	10.5	24	CARNARVON STREET
	6	420	4	along the MAXWELL ROAD
	7	10.5	12	PENANG ROAD
S-18	1	800	12	along the BRICK KILN ROAD
N-12	1	350	6	along the cross JALAN PANGKOR
	2	350	12	along the cross JALAN PANGKOR
	3	9	24	JALAN BURMA
	4	9	9	JALAN BURMA
	5	550	24	along the JALAN PERAK
	6	5	12	along the JALAN PERAK

TABLE J-6-3 PUBLIC UTILITIES TO BE REPLACED

RIVER NAME : Sg. Pinang

ELECTRIC CABLE NO.	CHR. (m)	CAPACITY (KV)	REMARKS
1	402	33	JALAN JELUTONG
2	404	33	do
3	412	11	do
4	915	11	JALAN SUNGAI
5	916	11	do
6	917	11	do
7	918	11	do
8	1265	11	JALAN PATANI
9	2136	132	JALAN PERAK
10	2137	132	do
11	2140	11	do
12	3135	11	JALAN AYER ITAM
13	3136	11	do
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

RIVER NAME : Sg. Air Itam

ELECTRIC CABLE NO.	CHR. (m)	CAPACITY (KV)	REMARKS
1	1480	11	JALAN AIR ITAM
2	1482	11	do
3	2357	2X132	
4	2471	11	LORONG BATU LANCANG
5	2472	11	do
6	2480	11	do
7	2481	11	do
8	2460 - 2940	2X132	
9	2934	11	
10	2935	11	
11	2936	11	
12	2937	11	
13	2940	2x132	
14	3474	11	JALAN THEAN TEIK
15	4584	11	
16	4585	11	
17	5695	33	JALAN PAYA TERUBONG
18	5697	33	do
19			
20			
21			
22			
23			
24			
25			

RIVER NAME : Sg.Jelutong

ELECTRIC CABLE NO.	CHR. (m)	CAPACITY (KV)	REMARKS
1	75	11	JALAN SUNGAI PINANG
2	200	11	JALAN PERAK
3	202	2x33	do
4	208	11	do
5	2099	11	LORONG TENANG
6	2100	11	
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

RIVER NAME : Sg. DONDANG

ELECTRIC CABLE NO.	CHR. (m)	CAPACITY (KV)	REMARKS
1	508	11	
2	1867	11	JALAN THEAN TEIK
3	4515	11	JALAN PAYA TERUBONG
4	5392	2x132	do
5	5395	11	do
6	5397	11	do
7	5938	2x132	
8	5946	11	
9			
10			
11			
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RIVER NAME : Sg.Keluang

ELECTRIC CABLE NO.	CHR. (m)	CAPACITY (KV)	REMARKS
1	1542	11	JALAN SUNGAI NIBONG
2	1564	11	do
3	1565	11	do
4	1566	11	do
5	1568	132	do
6	1875	11	JALAN MAYANG PASIR
7			
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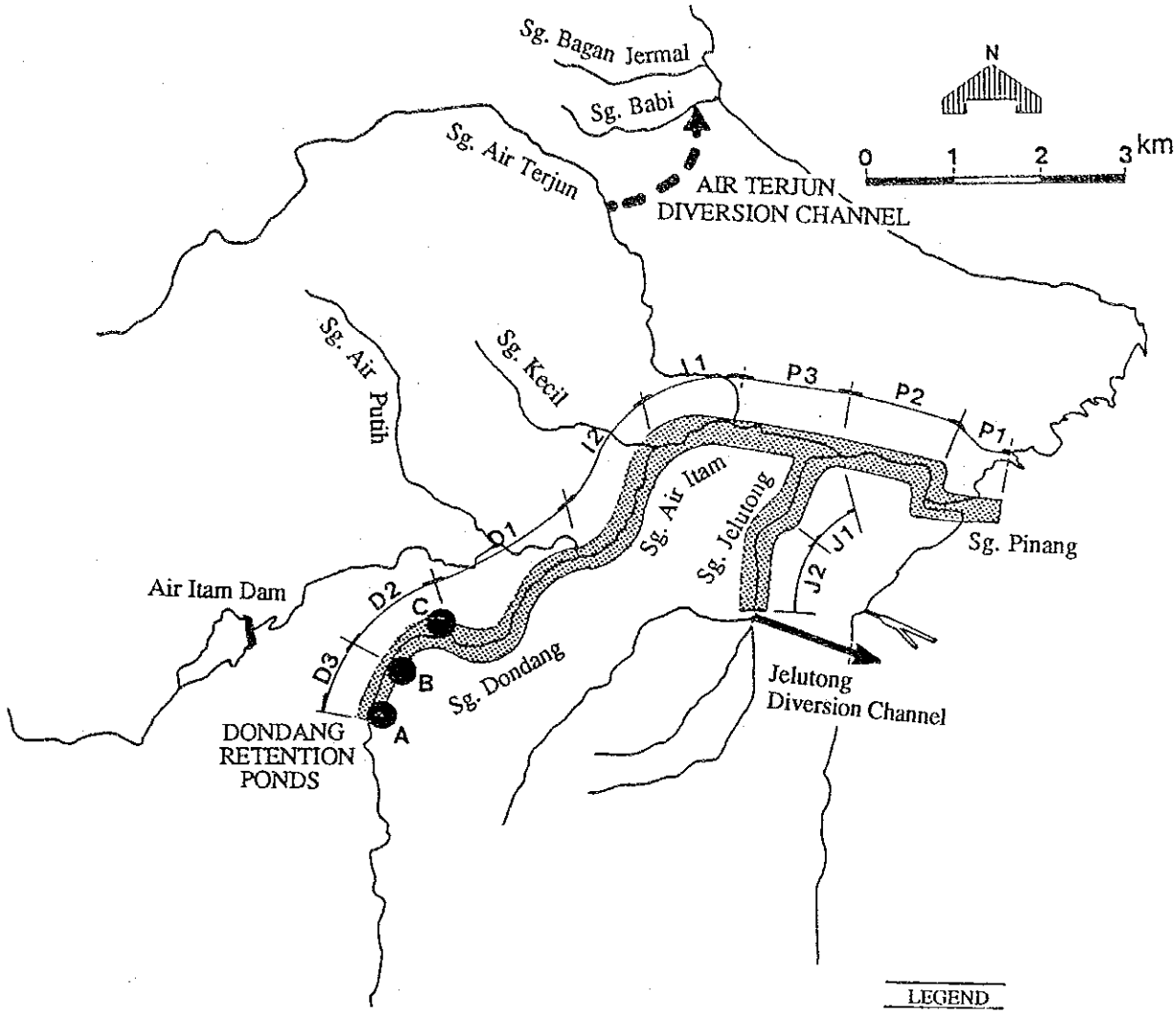
25			

Figures



LEGEND

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

RIVER IMPROVEMENT

PART	CHAINAGE	DISTANCE (m)	RIVER BED SLOPE	RIVER BED WIDTH (m)	WIDTH (m)	WATER DEPTH (m)	DESIGN DISCHARGE (m3/s)
P1	-0.71 to 0.4	1,110	1/2000	36.50	44.460 ~ 44.304	3.380 ~ 3.302	210
P2	0.4 to 1.9	1,500	1/2000	36.50	44.304 ~ 40.295	3.302 ~ 3.195	210
P3	1.9to 3.1	1,250	1/950	23.00	40.295 ~ 30.400	3.195 ~ 3.100	195
I1	0.0 to 1.1	1,100	1/800	18.20	25.4	3.0	160
I2	1.1 to 3.0	1,900	1/800	16.40	23.6	3.0	145
J1	0.0to 1.306	1,330	1/1070	4.70	4.7	2.5	20
J2	1.306 to 2.015	819	1/1070	2.00	2.0	2.5	6
D1	0.014 to 2.302	2,100	1/680	8.30	14.5	2.5	60
D2	2.302 to 3.732	1,210	1/680	6.00	12.5	2.5	45
D3	3.732 to 4,854	1,010	1/190	2.30	8.5	2.5	40

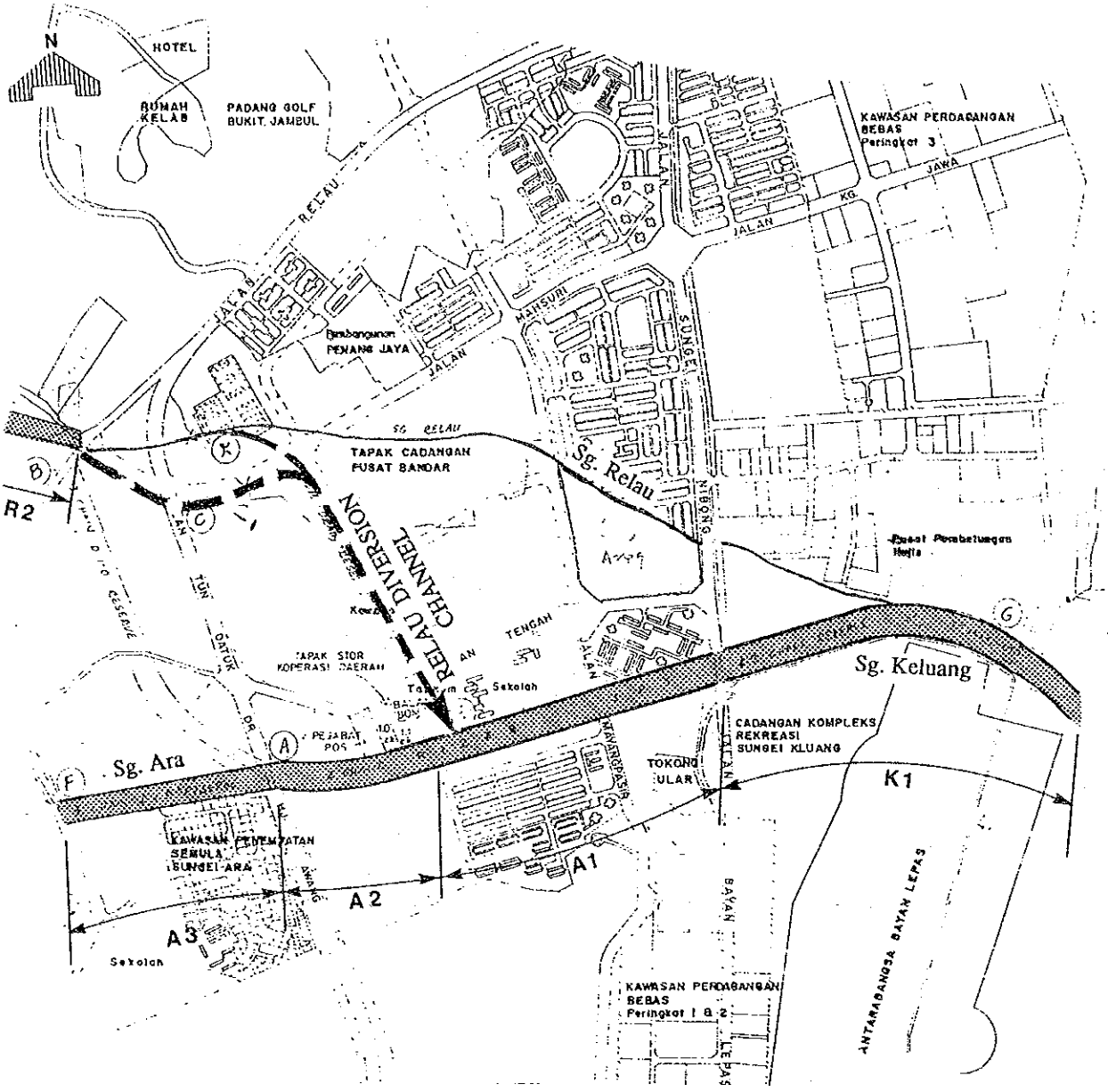
DONDANG RETENTION PONDS

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

AIR TERJUN DIVERSION CHANNEL

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

FIG. J-1 FLOOD MITIGATION FACILITIES OF URGENT PROJECTS; OF SG. PINANG



RIVER IMPROVEMENT

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

RELAU DIVERSION CHANNEL

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

LEGEND

Diversion Cannel

River Improvement

FIG. J-2 FLOOD MITIGATION FACILITIES OF URGENT PROJECTS OF SG. KELUANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

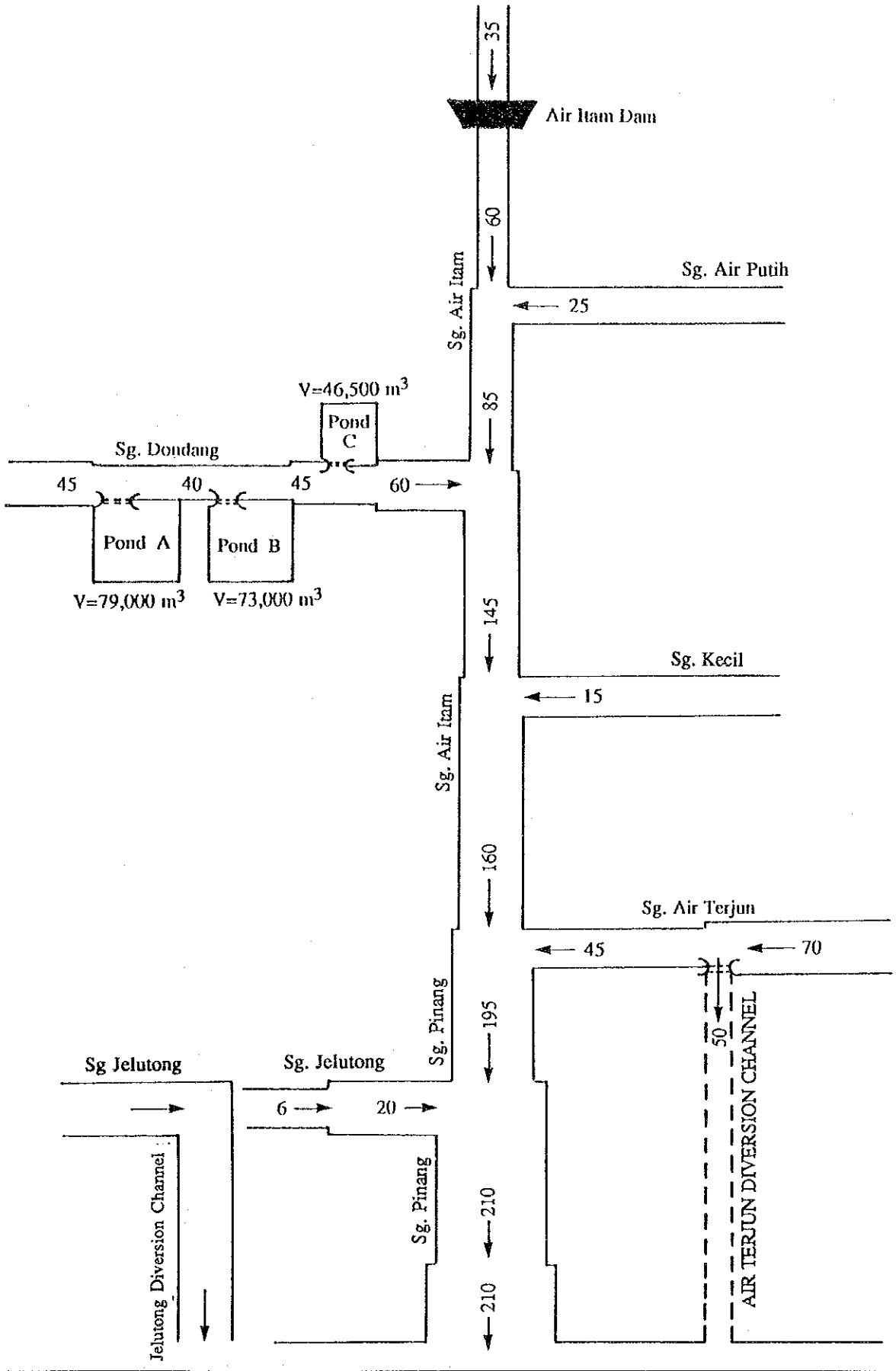


FIG. J-3 DESIGN DISCHARGE DISTRIBUTION OF SG. PINANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

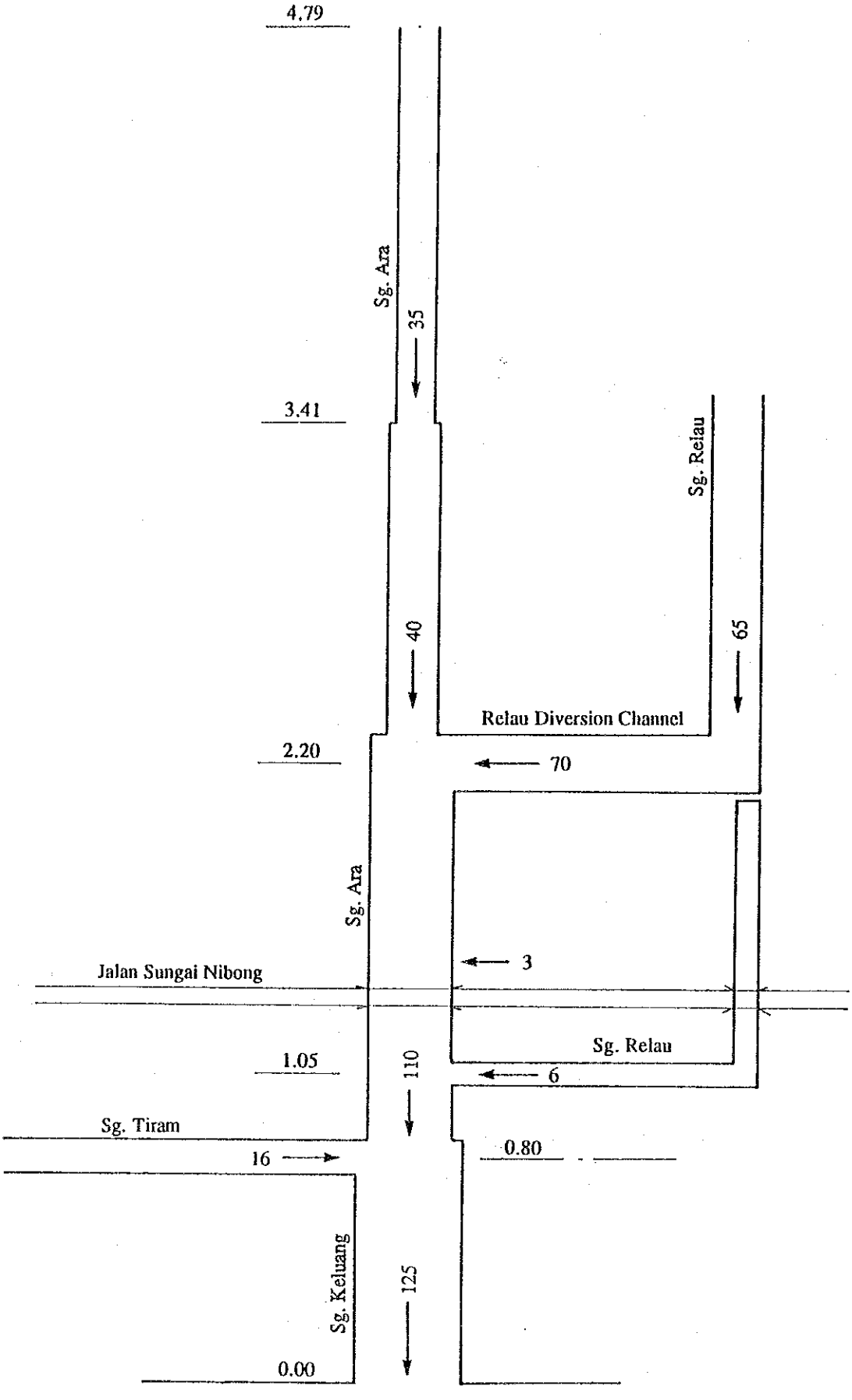
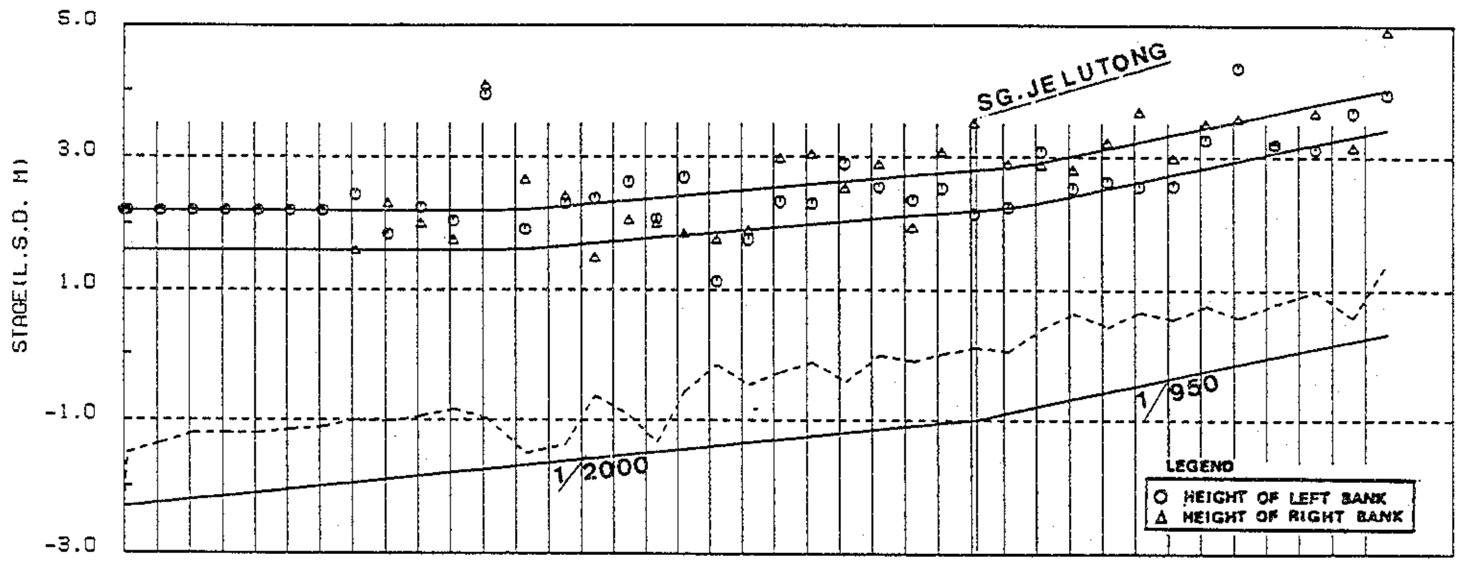


FIG. J- DESIGN DISCHARGE DISTRIBUTION OF SG. KELUANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



CHAINAGE	DISTANCE	PROPOSED BANK LEVEL	DESIGN H.W.L.	PROPOSED BED LEVEL
-710.0	0.0	2.200	1.600	-2.30
-700.0	10.0	2.200	1.600	-2.285
-600.000	100.000	2.200	1.600	-2.245
-500.000	100.000	2.200	1.600	-2.195
-400.000	100.000	2.200	1.600	-2.145
-300.000	100.000	2.200	1.600	-2.095
-200.000	100.000	2.200	1.600	-2.045
-100.000	100.000	2.200	1.600	-1.995
0.000	100.000	2.200	1.600	-1.945
100.000	100.000	2.200	1.600	-1.895
200.000	100.000	2.200	1.600	-1.845
300.000	100.000	2.200	1.600	-1.795
400.000	100.000	2.200	1.600	-1.745
500.000	119.000	2.207	1.607	-1.686
600.000	122.000	2.259	1.659	-1.625
700.000	92.000	2.299	1.699	-1.579
800.000	105.000	2.344	1.744	-1.526
900.000	87.000	2.382	1.782	-1.483
1000.000	86.000	2.419	1.819	-1.440
1100.000	101.000	2.462	1.862	-1.389
1200.000	99.000	2.504	1.904	-1.340
1300.000	99.000	2.547	1.947	-1.290
1400.000	98.000	2.589	1.989	-1.241
1500.000	100.000	2.632	2.032	-1.191
1600.000	105.000	2.678	2.078	-1.139
1700.000	102.000	2.721	2.121	-1.088
1800.000	89.000	2.759	2.159	-1.043
1900.000	98.000	2.801	2.201	-0.994
2000.000	102.000	2.845	2.245	-0.887
2100.000	102.000	2.921	2.321	-0.779
2200.000	98.000	3.024	2.424	-0.676
2300.000	102.000	3.131	2.531	-0.569
2400.000	97.000	3.233	2.633	-0.467
2500.000	105.000	3.344	2.744	-0.356
2600.000	98.000	3.447	2.847	-0.253
2700.000	99.000	3.551	2.951	-0.149
2800.000	113.000	3.670	3.070	-0.030
2900.000	121.000	3.798	3.198	0.098
3000.000	114.000	3.918	3.318	0.218
3100.000	102.000	4.025	3.425	0.325

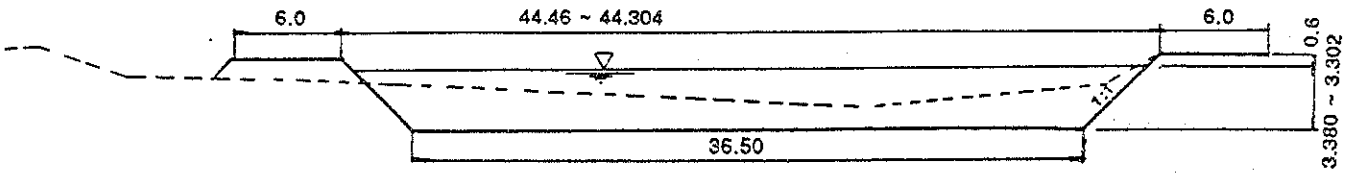
Q = 210 m³/s (-710.0 to 1900.000)

Q = 195 m³/s (1900.000 to 3100.000)

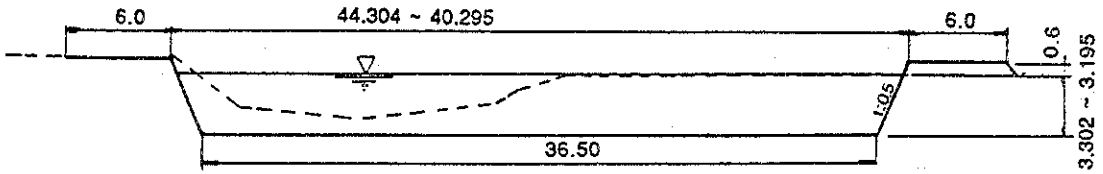
FIG. J-5 LONGITUDINAL PROFILE OF SG. PINANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

JICA



CH -710 ~ CH 400



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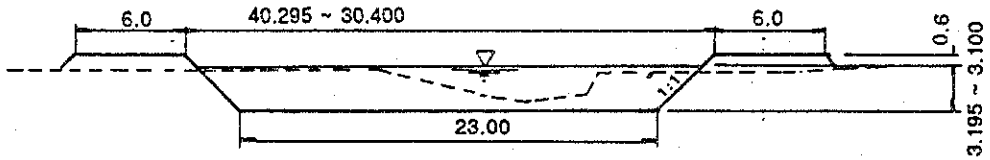


CH 1900 ~ CH 3100

FIG. J-6	PROPOSED CROSS SECTIONS OF SG. PINANG
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND	

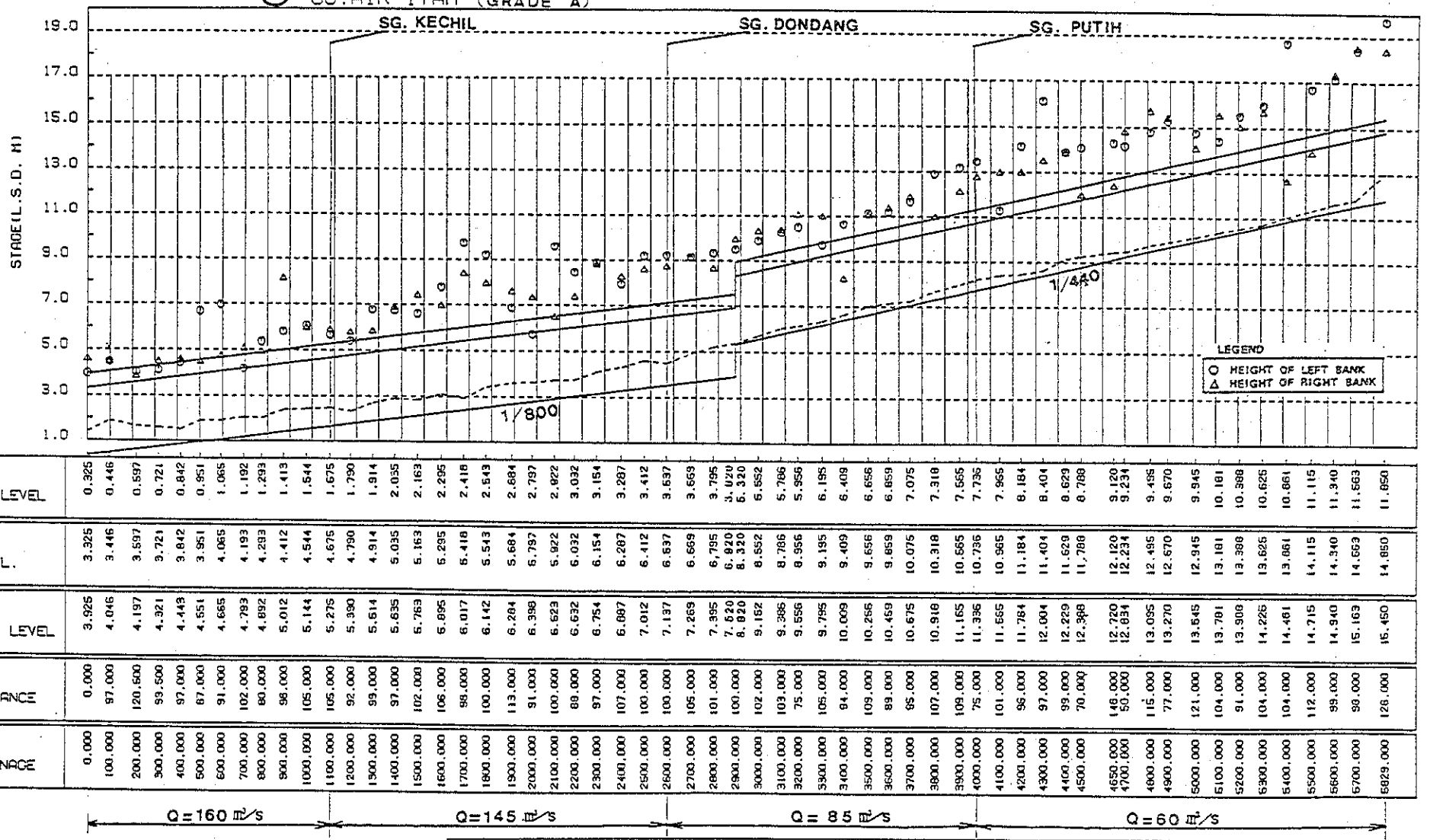


FIG. J-7 LONGITUDINAL PROFILE OF SG. AIR ITAM

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

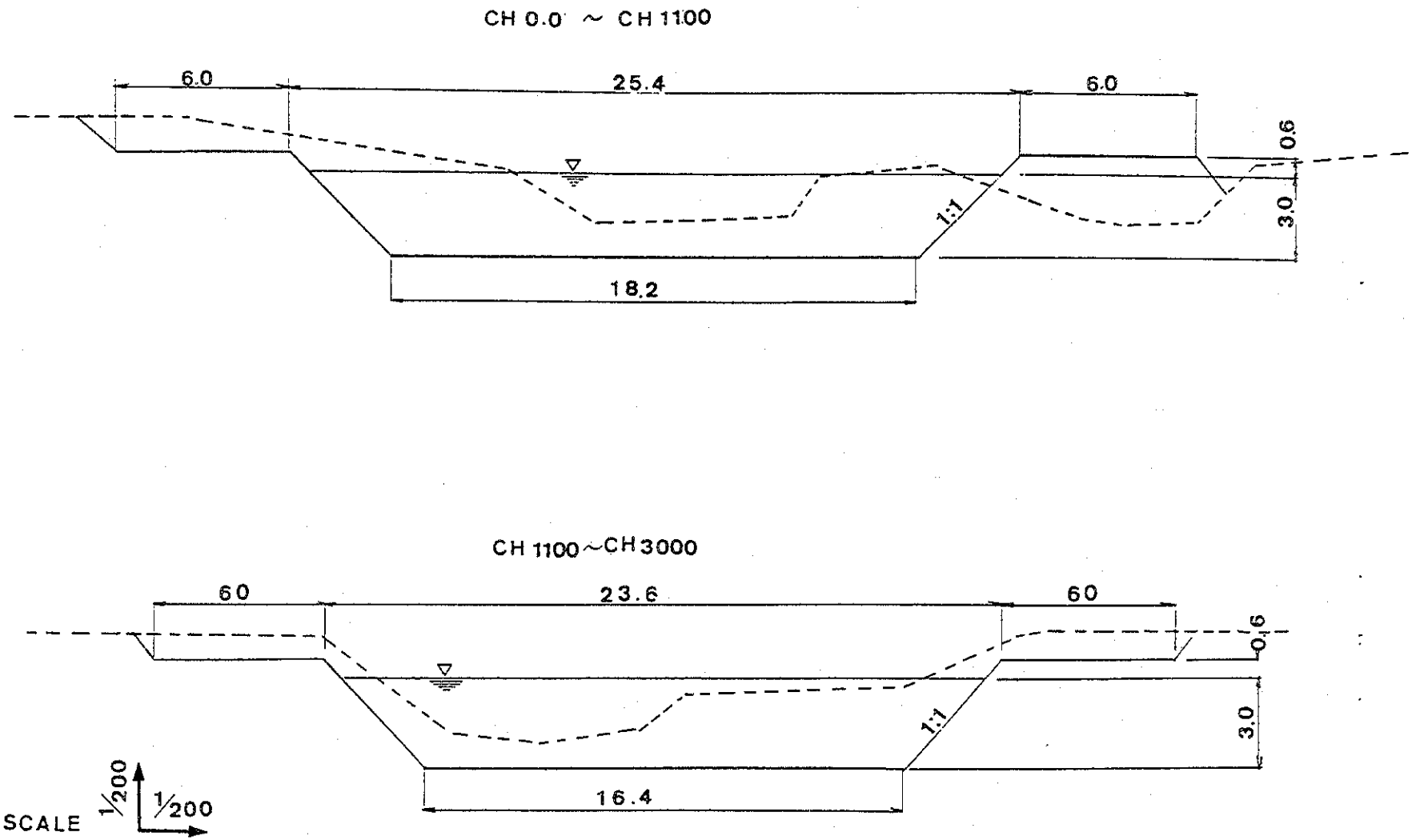
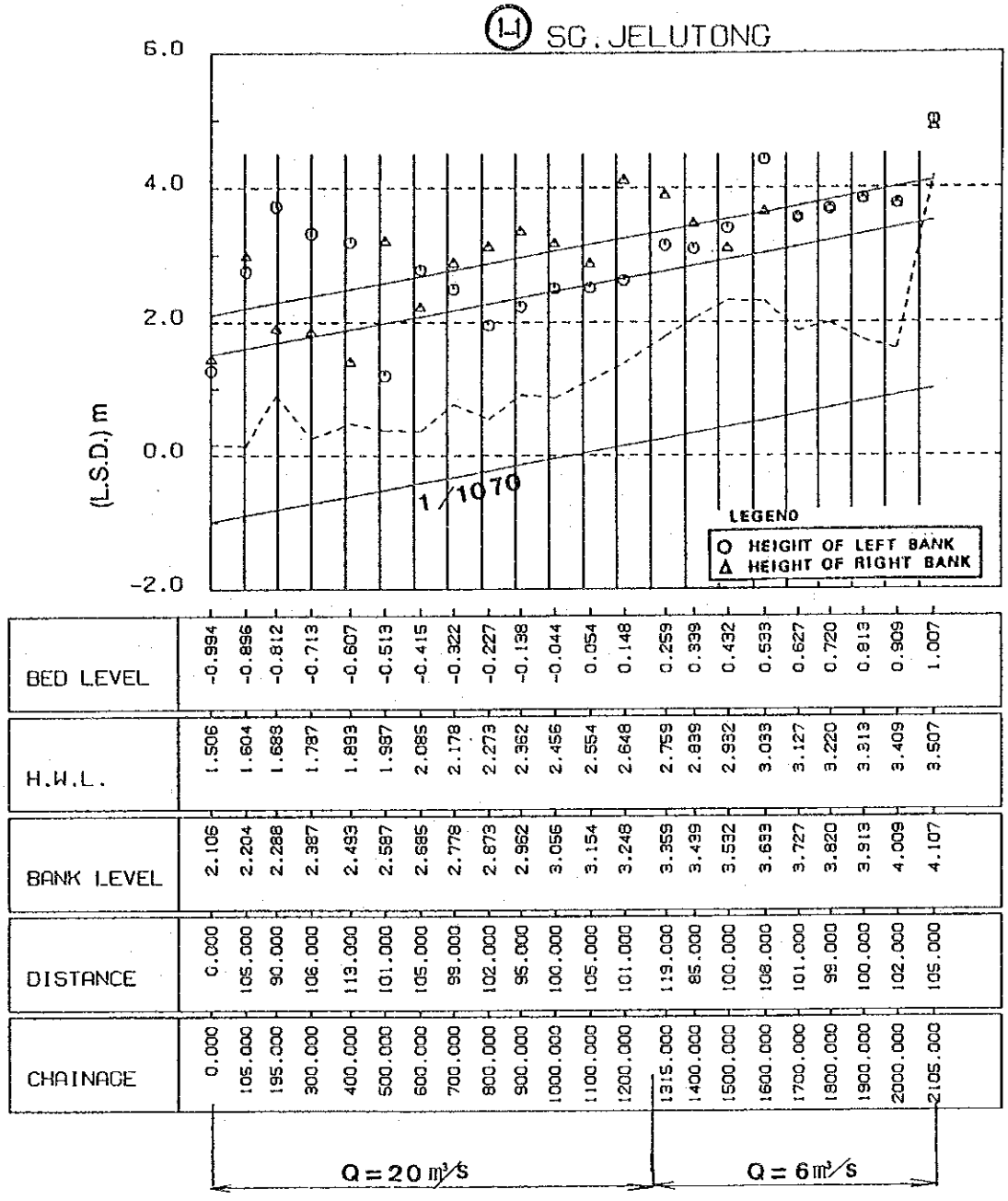


FIG. J-8 PROPOSED CROSS SECTIONS OF SG. AIR ITAM

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



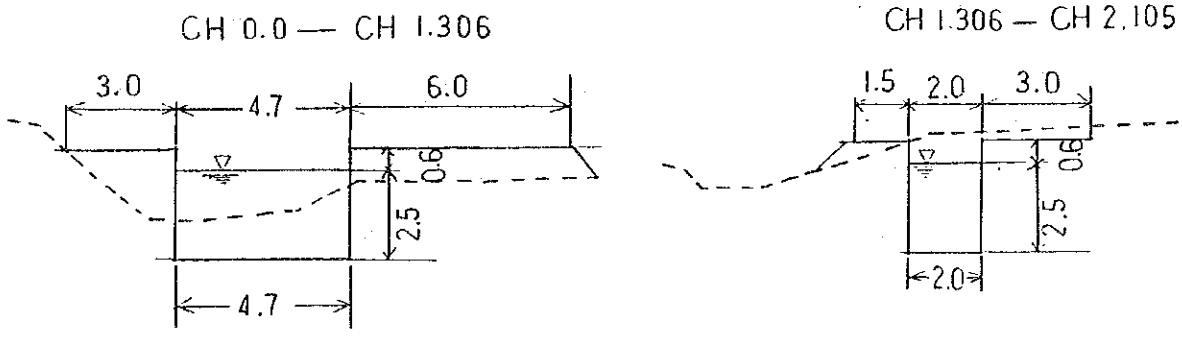


FIG. J-9 LONGITUDINAL PROFILE AND PROPOSED CROSS SECTIONS OF SG. JELUTONG

CHAINAGE	DISTANCE	BANK LEVEL	H.W.L.	BED LEVEL
0.014	13.000	7.642	6.942	4.442
0.092	78.000	7.672	7.072	4.572
0.203	111.000	7.957	7.257	4.757
0.335	103.000	8.028	7.428	4.826
0.435	95.000	8.187	7.567	5.087
0.527	100.000	8.353	7.753	5.253
0.620	89.000	8.502	7.802	5.402
0.757	110.000	8.685	8.085	5.685
0.852	100.000	8.852	8.252	5.762
1.059	102.000	9.022	8.422	5.922
1.160	103.000	9.193	8.593	6.093
1.286	110.000	9.377	8.777	6.277
1.413	68.000	9.490	8.690	6.390
1.647	133.000	9.712	9.112	6.612
1.836	85.000	9.897	9.275	6.775
1.731	99.000	10.040	9.440	6.940
1.827	100.000	10.207	9.607	7.107
1.987	84.000	10.378	9.778	7.278
2.159	155.000	12.257	11.657	9.157
2.239	119.000	12.423	11.823	9.323
2.302	100.000	12.570	11.970	9.470
2.400	97.000	12.713	12.113	9.613
2.549	103.000	12.864	12.264	9.764
2.636	90.000	12.997	12.397	9.897
2.736	90.000	13.129	12.529	10.029
2.825	97.000	13.273	12.673	10.173
2.917	42.000	13.333	12.733	10.233
3.033	78.000	13.443	12.843	10.343
3.173	80.000	14.781	14.181	11.681
3.285	115.000	14.950	14.350	11.850
3.415	111.000	15.113	14.513	12.013
3.509	95.000	15.263	14.653	12.153
3.695	75.000	15.363	14.763	12.263
3.732	133.000	15.659	14.959	12.459
3.841	107.000	16.122	15.522	13.022
3.963	90.000	16.596	15.996	13.496
4.013	100.000	17.122	16.522	14.022
4.215	88.000	17.585	16.985	14.485
4.356	129.000	18.264	17.664	15.164
4.449	93.000	18.753	18.153	15.653
4.559	108.000	19.309	18.709	16.209
4.660	109.000	20.088	20.288	17.788
4.736	77.000	21.090	20.490	17.990
4.654	109.000	21.377	20.777	18.277
5.002	89.000	21.812	21.012	18.612
5.155	108.000	21.896	21.296	18.796
5.294	116.000	22.506	21.906	19.406
5.387	68.000	22.955	22.359	19.859
5.614	91.000	23.498	22.898	20.398
5.617	100.000	23.964	23.364	20.864
5.782	118.000	24.505	23.905	21.405
5.893	82.000	25.017	24.417	21.917
5.993	100.000	25.543	24.943	22.443
6.094	102.000	26.080	25.480	22.980

FIG. J-10 LONGITUDINAL PROFILE OF SG. DONDANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

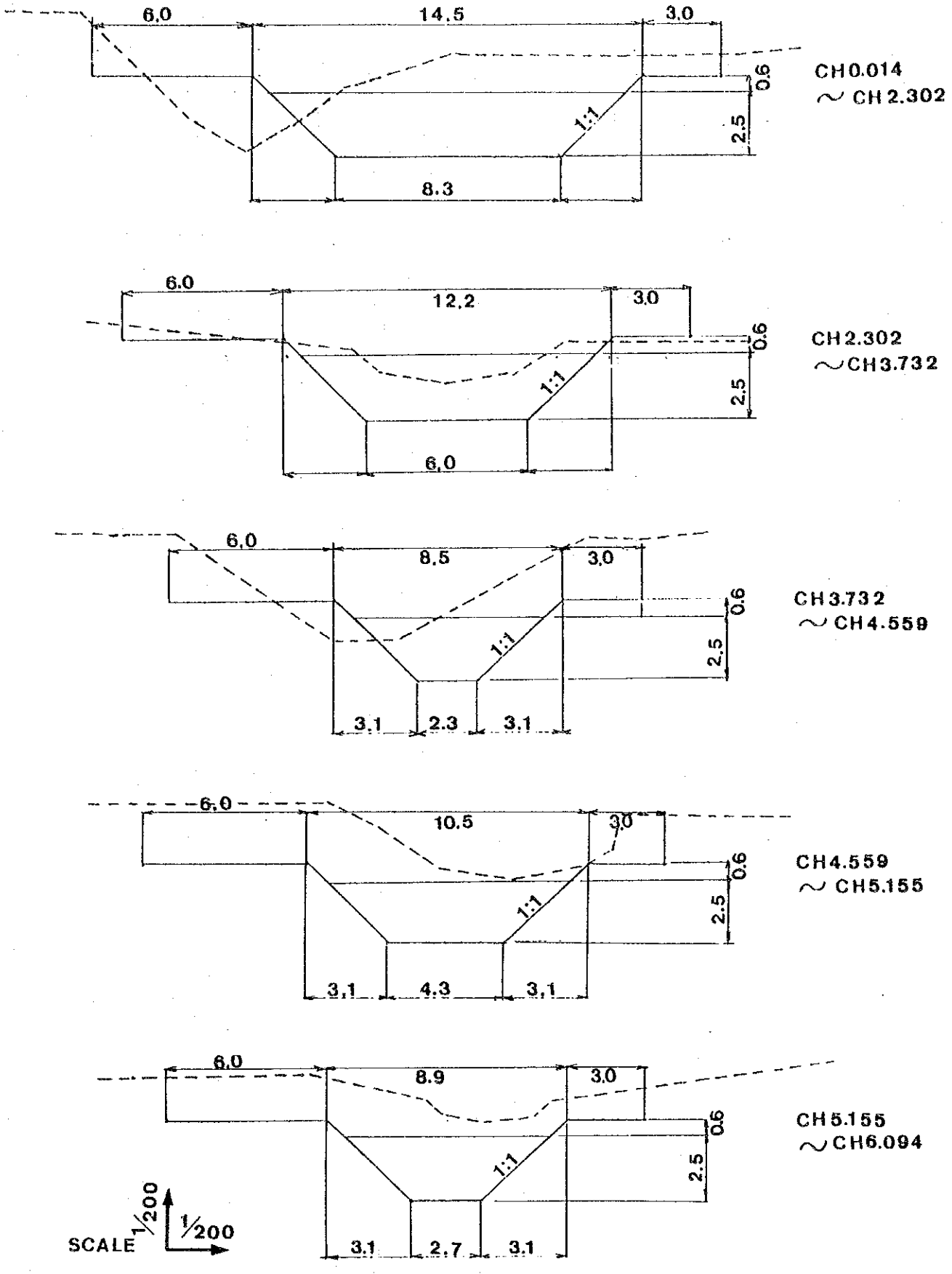
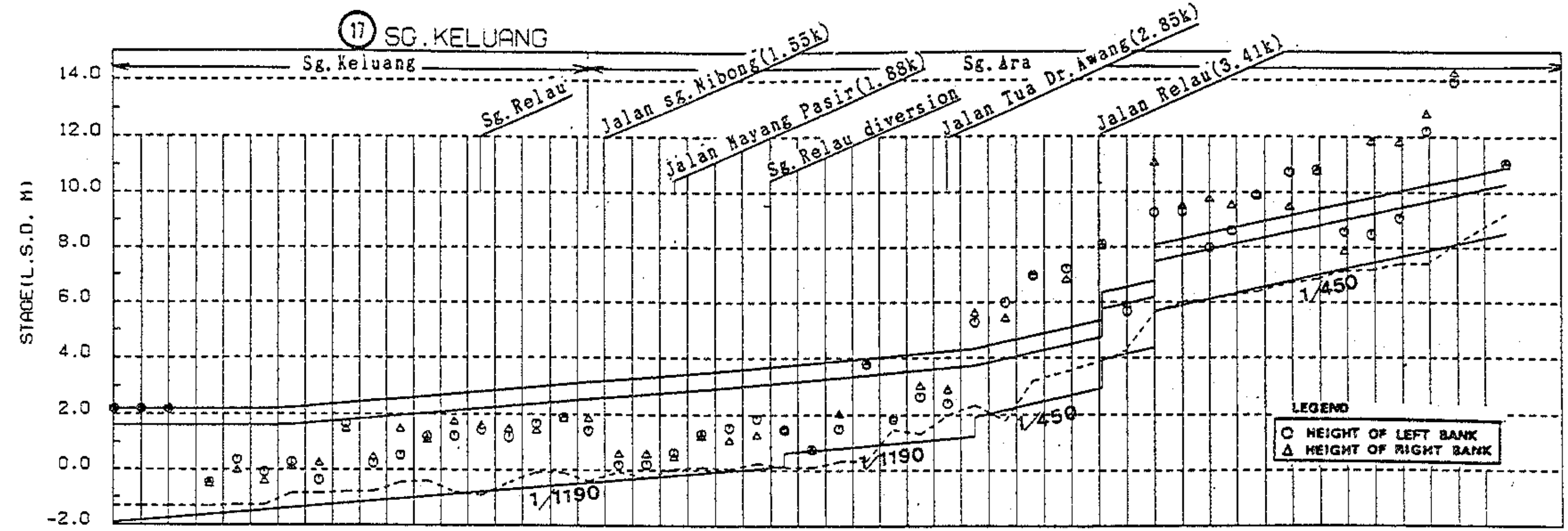


FIG. J-11	PROPOSED CROSS SECTIONS OF SG. DONDANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



CHAINAGE	DISTANCE	PROPOSED BANK LEVEL	DESIGN H.W.L.	PROPOSED BED LEVEL
-200.000	0.000	2.200	1.600	-1.920
-100.000	100.000	2.200	1.600	-1.836
0.000	100.000	2.200	1.600	-1.752
150.000	150.000	2.200	1.600	-1.626
250.000	100.000	2.200	1.600	-1.542
350.000	100.000	2.200	1.600	-1.458
450.000	100.000	2.226	1.626	-1.374
550.000	100.000	2.310	1.710	-1.290
650.000	100.000	2.394	1.794	-1.206
750.000	100.000	2.478	1.878	-1.122
850.000	100.000	2.562	1.962	-1.038
950.000	100.000	2.646	2.046	-0.954
1050.000	100.000	2.730	2.130	-0.870
1150.000	100.000	2.814	2.214	-0.786
1250.000	100.000	2.898	2.298	-0.702
1350.000	100.000	2.983	2.383	-0.617
1450.000	100.000	3.067	2.467	-0.533
1540.000	90.000	3.142	2.542	-0.458
1650.000	110.000	3.235	2.635	-0.365
1750.000	100.000	3.319	2.719	-0.281
1850.000	100.000	3.403	2.803	-0.197
1950.000	100.000	3.487	2.887	-0.113
2050.000	100.000	3.571	2.971	-0.029
2150.000	100.000	3.655	3.055	0.055
2250.000	100.000	3.738 3.738	3.138 3.138	0.138 0.638
2350.000	100.000	3.823	3.223	0.723
2450.000	100.000	3.907	3.307	0.807
2550.000	100.000	3.991	3.391	0.891
2650.000	100.000	4.075	3.475	0.975
2750.000	100.000	4.159	3.559	1.059
2850.000	100.000	4.243	3.643	1.143
2950.000	100.000	4.327 4.327	3.727 3.727	1.227 1.827
3060.000	110.000	4.572	3.972	2.172
3160.000	100.000	4.794	4.194	2.394
3280.000	120.000	5.060	4.460	2.660
3410.000	130.000	6.340 6.348	4.740 5.748	2.840 3.848
3500.000	90.000	6.549	5.949	4.149
3600.000	100.000	6.772 8.072	6.172 7.472	4.372 5.672
3700.000	100.000	8.294	7.694	5.894
3800.000	100.000	8.516	7.916	6.116
3880.000	80.000	8.694	8.094	6.294
3970.000	90.000	8.894	8.294	6.494
4090.000	120.000	9.160	8.560	6.760
4190.000	100.000	9.383	8.783	6.983
4290.000	100.000	9.605	9.005	7.205
4386.000	96.000	9.818	9.218	7.418
4490.000	104.000	10.049	9.449	7.649
4590.000	100.000	10.272	9.672	7.872
4690.000	100.000	10.494	9.894	8.094
4879.000	189.000	10.914	10.314	8.514

Q = 125 m³/s (chainage -200.000 to 1540.000); Q = 110 m³/s (1540.000 to 2250.000); Q = 40 m³/s (2250.000 to 3410.000); Q = 35 m³/s (3410.000 to 4879.000)

FIG. J-12 LONGITUDINAL PROFILE OF SG. KELUANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

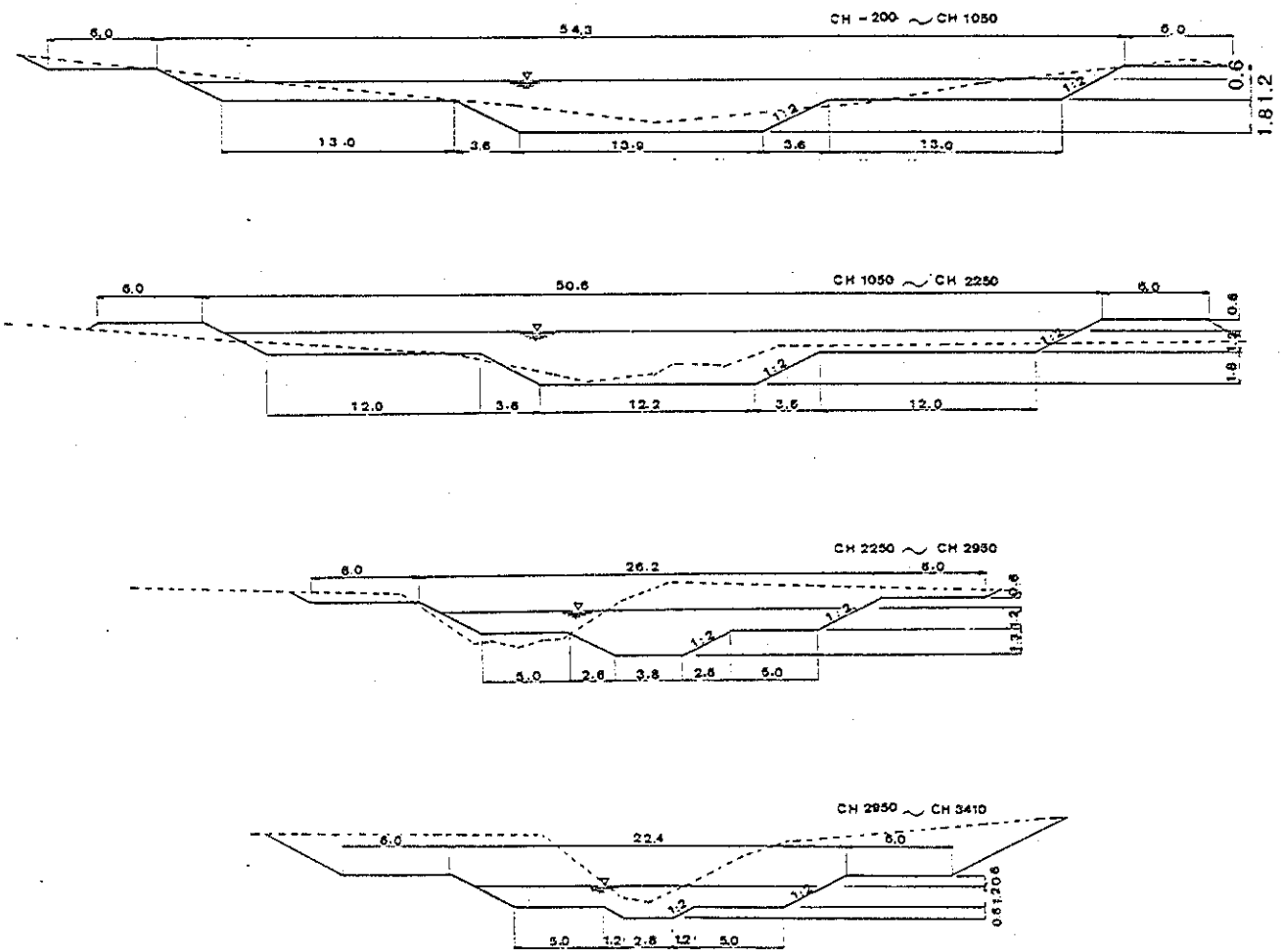
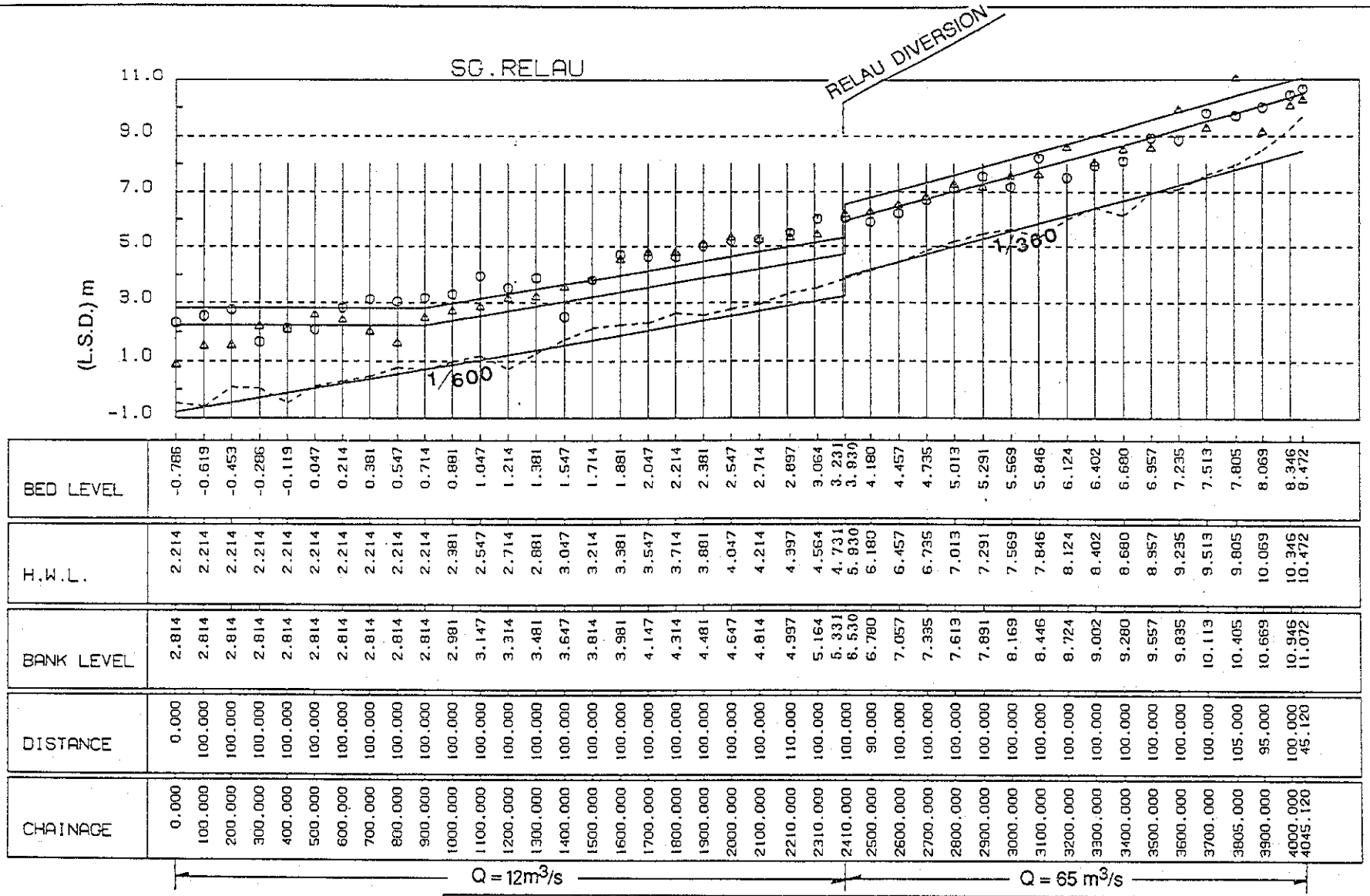


FIG. J-13	PROPOSED CROSS SECTIONS OF SG. KELUANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



CHAINAGE	DISTANCE	BANK LEVEL	H.W.L.	BED LEVEL
0.000	0.000	2.814	2.214	-0.786
100.000	100.000	2.814	2.214	-0.619
200.000	100.000	2.814	2.214	-0.453
300.000	100.000	2.814	2.214	-0.286
400.000	100.000	2.814	2.214	-0.119
500.000	100.000	2.814	2.214	0.047
600.000	100.000	2.814	2.214	0.214
700.000	100.000	2.814	2.214	0.381
800.000	100.000	2.814	2.214	0.547
900.000	100.000	2.814	2.214	0.714
1000.000	100.000	2.981	2.381	0.881
1100.000	100.000	3.147	2.547	1.047
1200.000	100.000	3.314	2.714	1.214
1300.000	100.000	3.481	2.881	1.381
1400.000	100.000	3.647	3.047	1.547
1500.000	100.000	3.814	3.214	1.714
1600.000	100.000	3.981	3.381	1.881
1700.000	100.000	4.147	3.547	2.047
1800.000	100.000	4.314	3.714	2.214
1900.000	100.000	4.481	3.881	2.381
2000.000	100.000	4.647	4.047	2.547
2100.000	100.000	4.814	4.214	2.714
2210.000	110.000	4.997	4.397	2.897
2310.000	100.000	5.164	4.564	3.064
2410.000	100.000	5.331	4.731	3.231
2500.000	90.000	6.530	5.930	3.930
2600.000	100.000	6.780	6.180	4.180
2700.000	100.000	7.057	6.457	4.457
2800.000	100.000	7.335	6.735	4.735
2900.000	100.000	7.613	7.013	5.013
3000.000	100.000	7.891	7.291	5.291
3100.000	100.000	8.169	7.569	5.569
3200.000	100.000	8.446	7.846	5.846
3300.000	100.000	8.724	8.124	6.124
3400.000	100.000	9.002	8.402	6.402
3500.000	100.000	9.280	8.680	6.680
3600.000	100.000	9.557	8.957	6.957
3700.000	100.000	9.835	9.235	7.235
3805.000	105.000	10.113	9.513	7.513
3900.000	95.000	10.405	9.805	7.805
4000.000	100.000	10.669	10.069	8.069
4045.120	45.120	10.946 11.072	10.346 10.472	8.346 8.472

FIG. J-14 LONGITUDINAL PROFILE OF SG. RELAU

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

Typical Cross Section of SG. RELAU

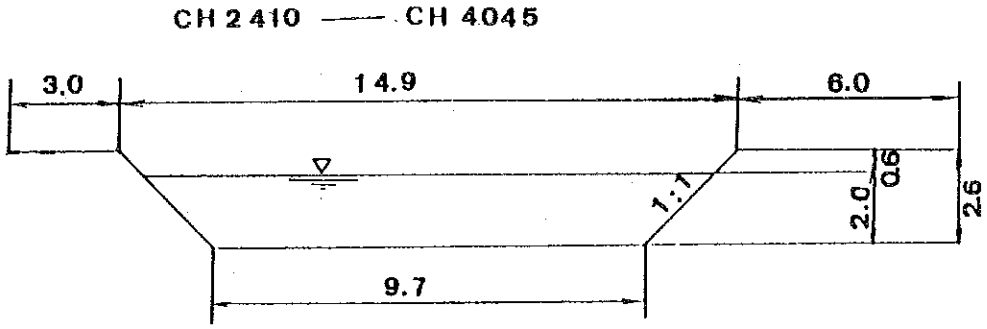
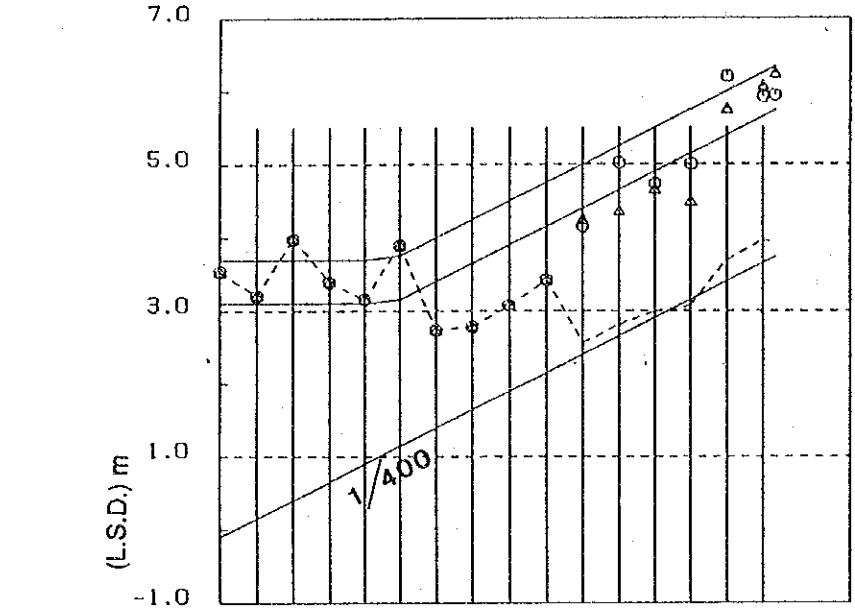


FIG. J-15	PROPOSED CROSS SECTION OF SG. RELAU



BED LEVEL	-0.097	0.153	0.403	0.653	0.903	1.153	1.403	1.653	1.903	2.153	2.403	2.653	2.903	3.153	3.403	3.653
H.W.L.	3.097	3.097	3.097	3.097	3.097	3.153	3.403	3.653	3.903	4.153	4.403	4.653	4.903	5.153	5.403	5.653
BANK LEVEL	3.697	3.697	3.697	3.697	3.697	3.753	4.003	4.253	4.503	4.753	5.003	5.253	5.503	5.753	6.003	6.253
DISTANCE	0.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	99.000
CHAINAGE	0.000	100.000	200.000	300.000	400.000	500.000	600.000	700.000	800.000	900.000	1000.000	1100.000	1200.000	1300.000	1400.000	1499.000

Q =70

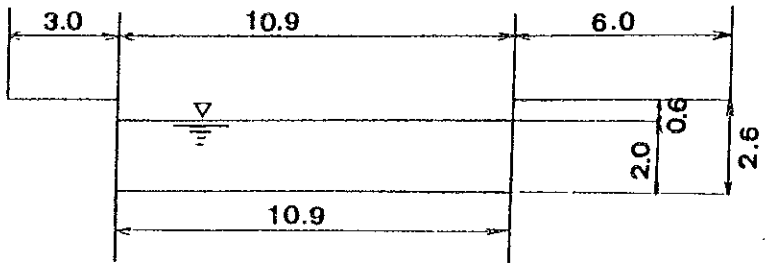
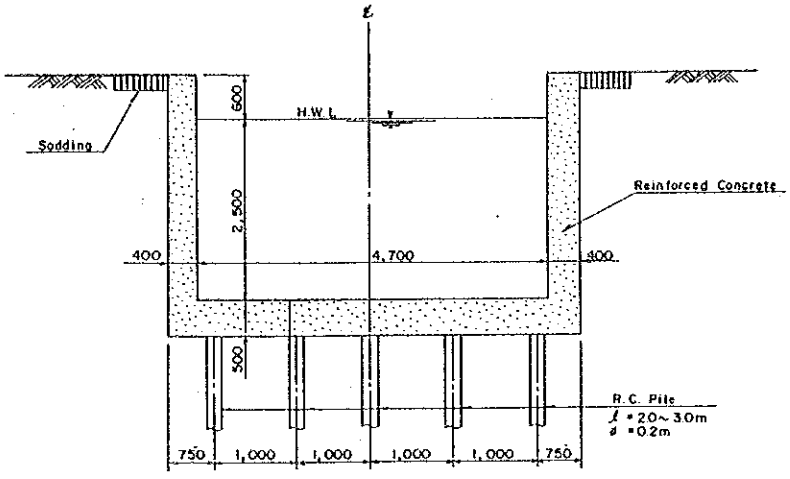
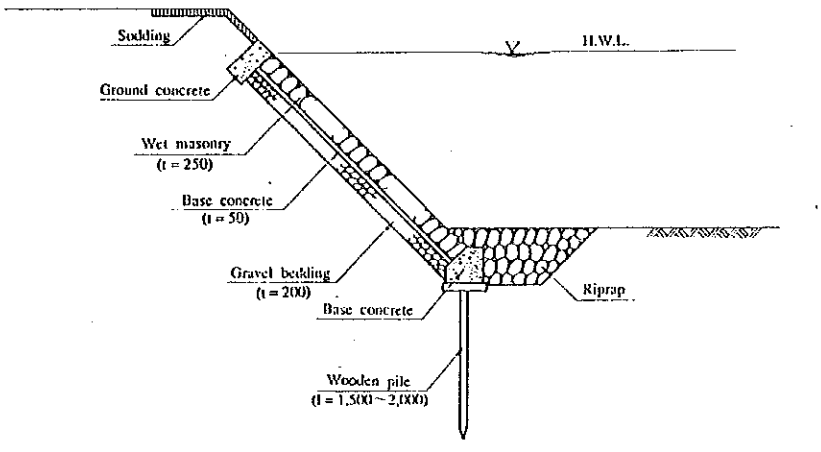


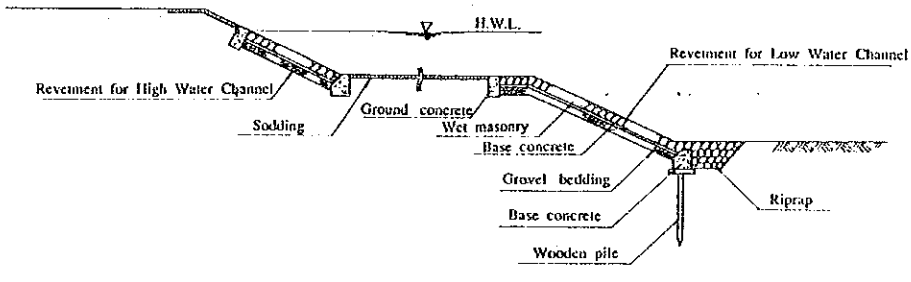
FIG. J-16 LONGITUDINAL PROFILE AND PROPOSED CROSS SECTION OF SG. RELAU DIVERSION CHANNEL



Typical Cross Section of Revetment (Concrete Section)



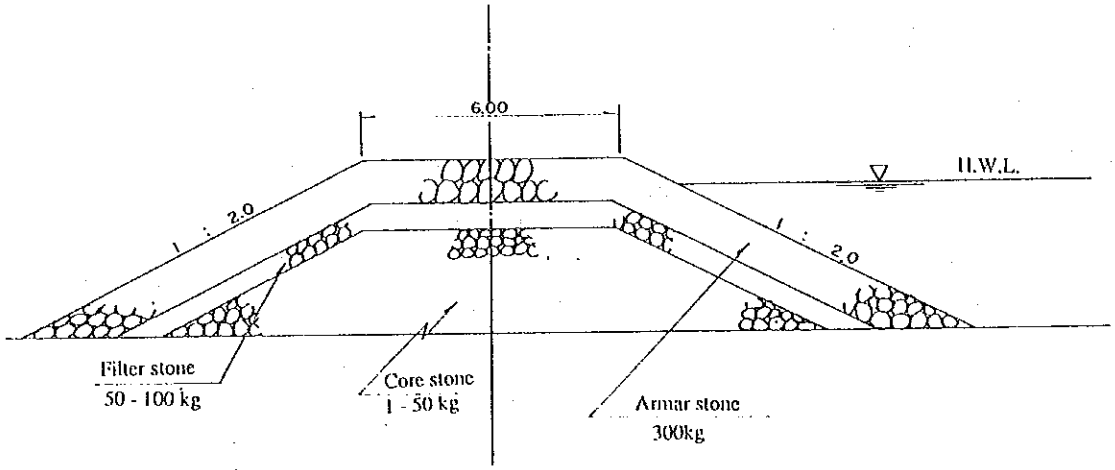
Typical Cross Section of Revetment (Single Section)

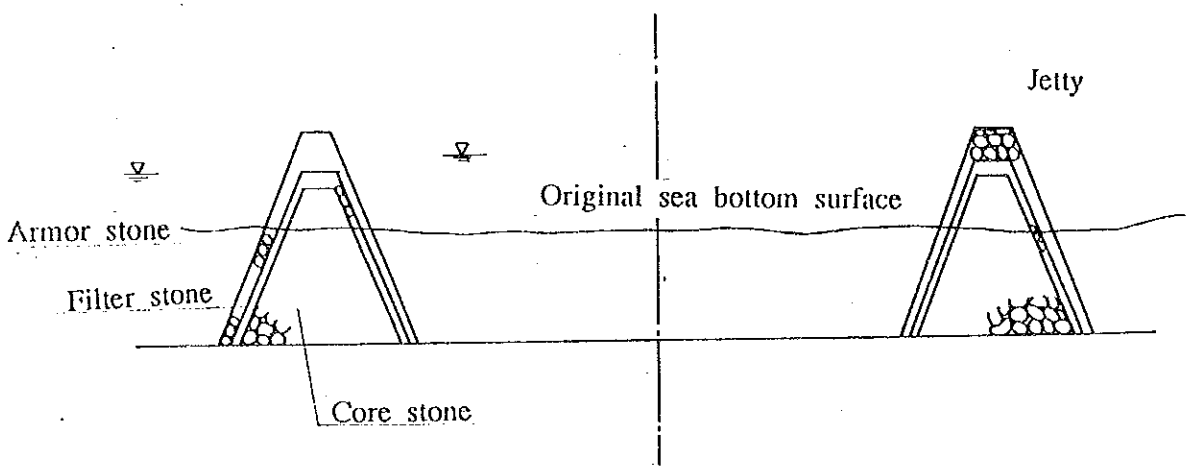


Typical Cross Section of Revetment (Compound Section)

FIG. J-17	TYPICAL CROSS SECTION OF RIVER IMPROVEMENT

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

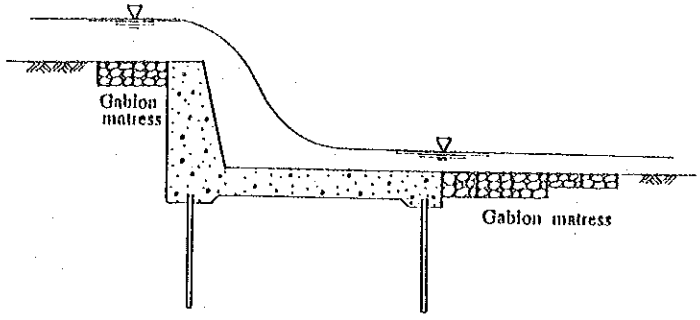




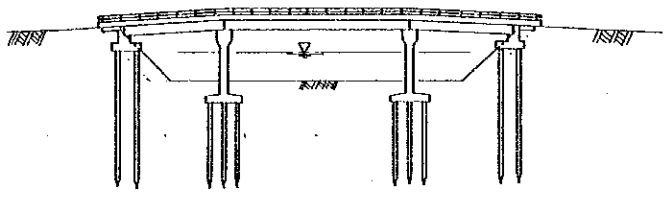
Typical Cross Section of Jetty

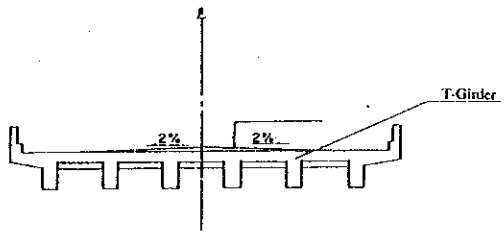
FIG. J-18	TYPICAL CROSS SECTIONS OF JETTY AT SG. PINANG MOUTH

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

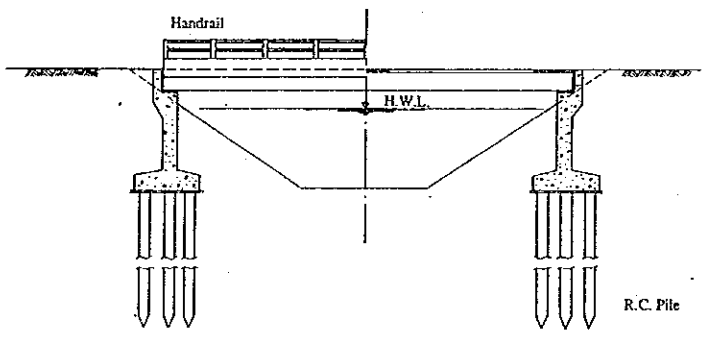


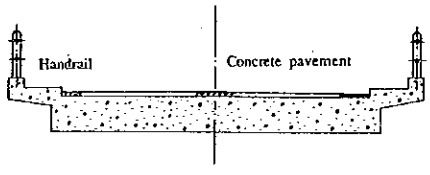
Typical Section of Drop Structure





Typical Section of Bridge (I)





Typical Section of Bridge (II)

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

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

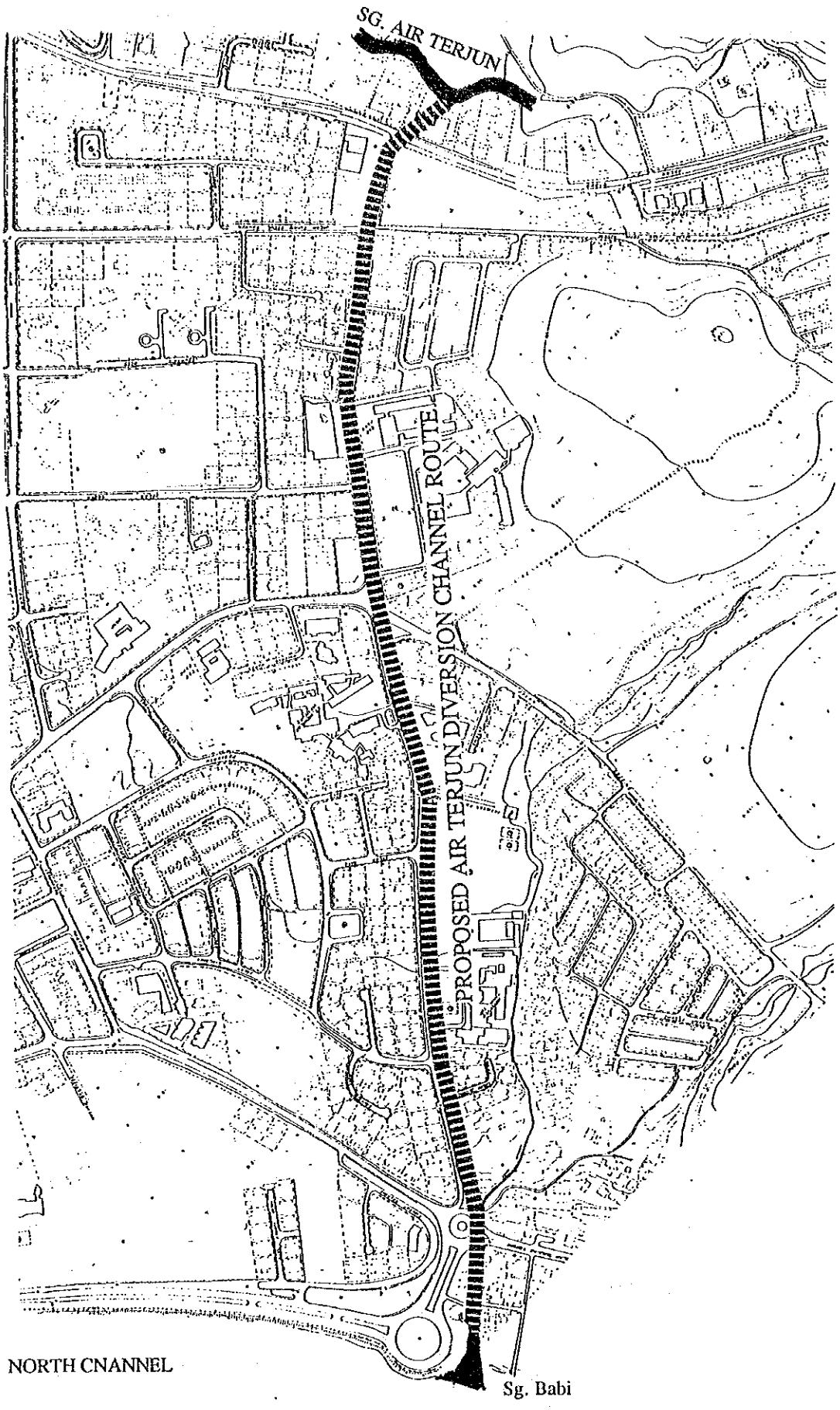
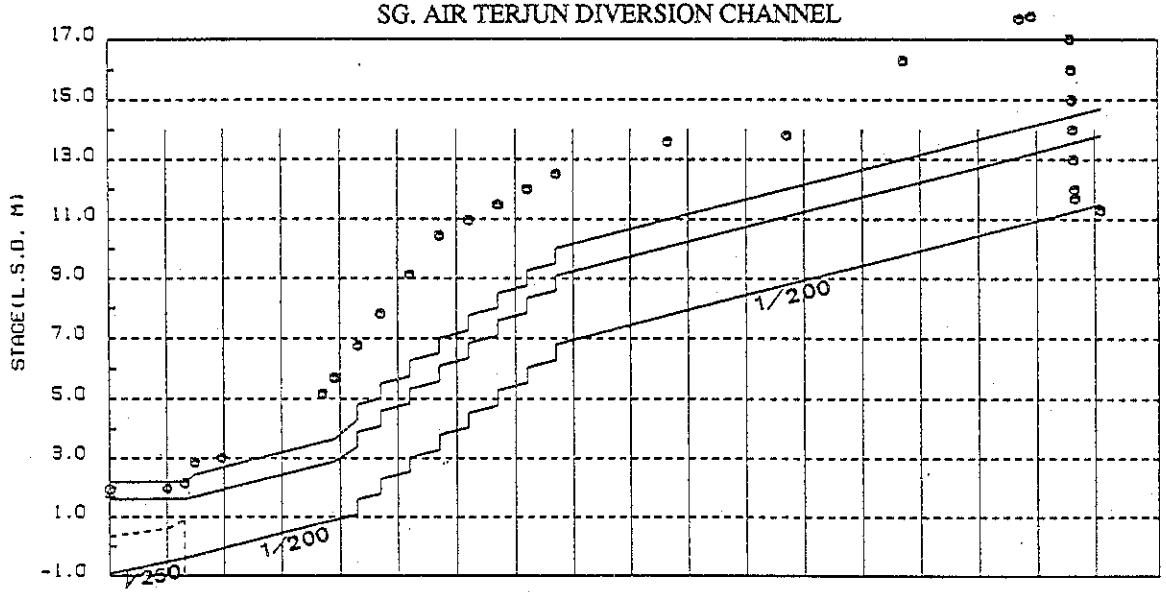


FIG. J-20	PLAN OF PROPOSED AIR TERJUN DIVERSION CHANNEL ROUTE

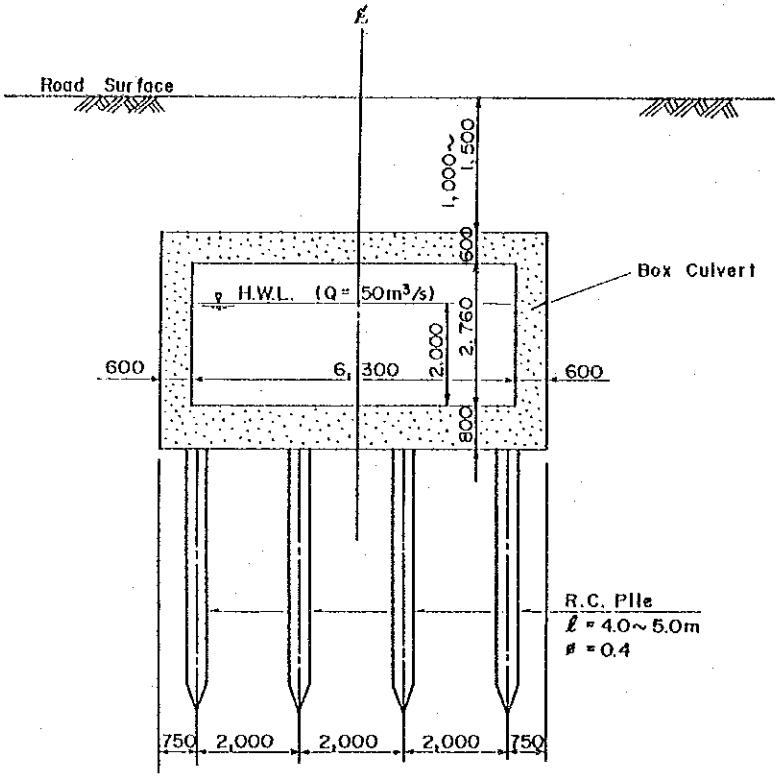


PROPOSED COPING LEVEL	2.200	2.200	2.200	2.450	2.685	3.560	3.660	4.820	5.820	6.270	6.820	7.270	7.820	8.270	10.020	10.990	12.020	13.020	14.020	14.120	14.720
PROPOSED H.W.L.	1.600	1.600	1.600	1.690	1.925	2.800	2.900	3.800	4.600	5.650	6.400	6.650	7.600	8.650	8.600	10.070	11.100	12.100	13.100	13.200	13.800
PROPOSED INVERT LEVEL	-0.920	-0.520	-0.400	-0.310	-0.075	0.800	0.900	1.600	2.800	2.850	3.800	4.850	5.800	6.050	6.800	7.770	8.800	9.800	10.800	10.900	11.500
EXISTING GROUND LEVEL	1.940	1.980	2.150	2.660	3.010	5.160	5.710	6.760	7.810	9.130	10.440	10.960	11.480	12.000	12.520	13.600	13.600	16.300	17.670	17.750	11.300
DISTANCE	0.000	100.000	60.000	18.000	47.000	175.000	20.000	40.000	40.000	50.000	50.000	50.000	50.000	50.000	50.000	194.000	206.000	200.000	200.000	20.000	44.000
CHAINAGE	0.000	100.000	160.000	178.000	225.000	400.000	420.000	460.000	500.000	550.000	600.000	650.000	700.000	750.000	800.000	994.000	1200.000	1400.000	1600.000	1620.000	1740.000

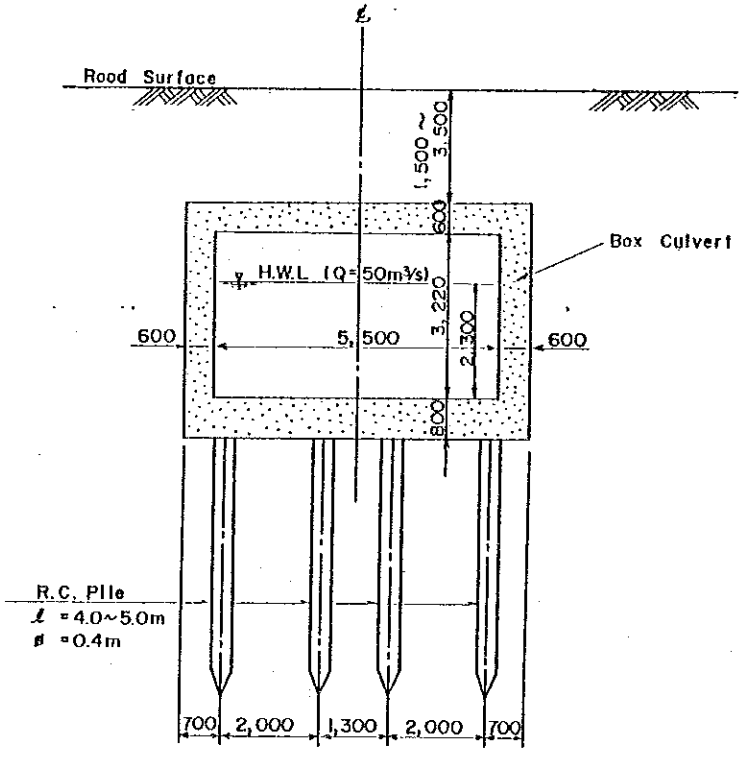
FIG. J-21 LONGITUDINAL PROFILE OF AIR TERJUN DIVERSION CHANNEL

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

JICA



CH225 ~ CH420



CH420 ~ CH1693

Cross Section of Air Terjun Diversion Channel

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

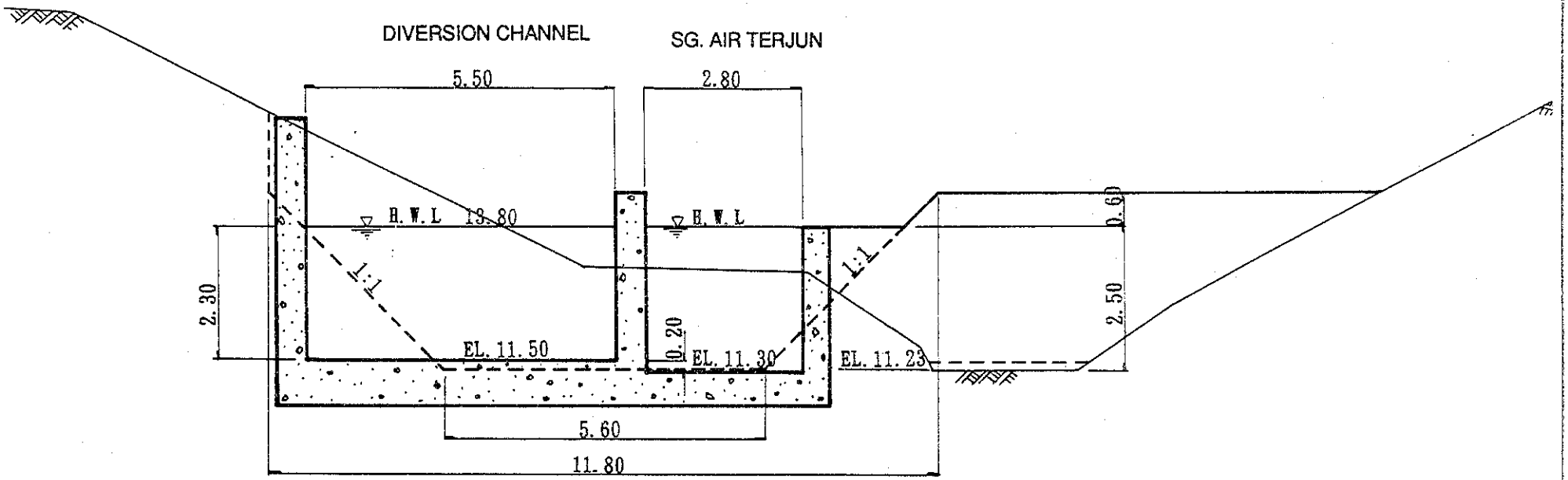


FIG. J-23	CROSS SECTION OF AIR TERJUN DIVERSION CHANNEL (INLET)
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND	

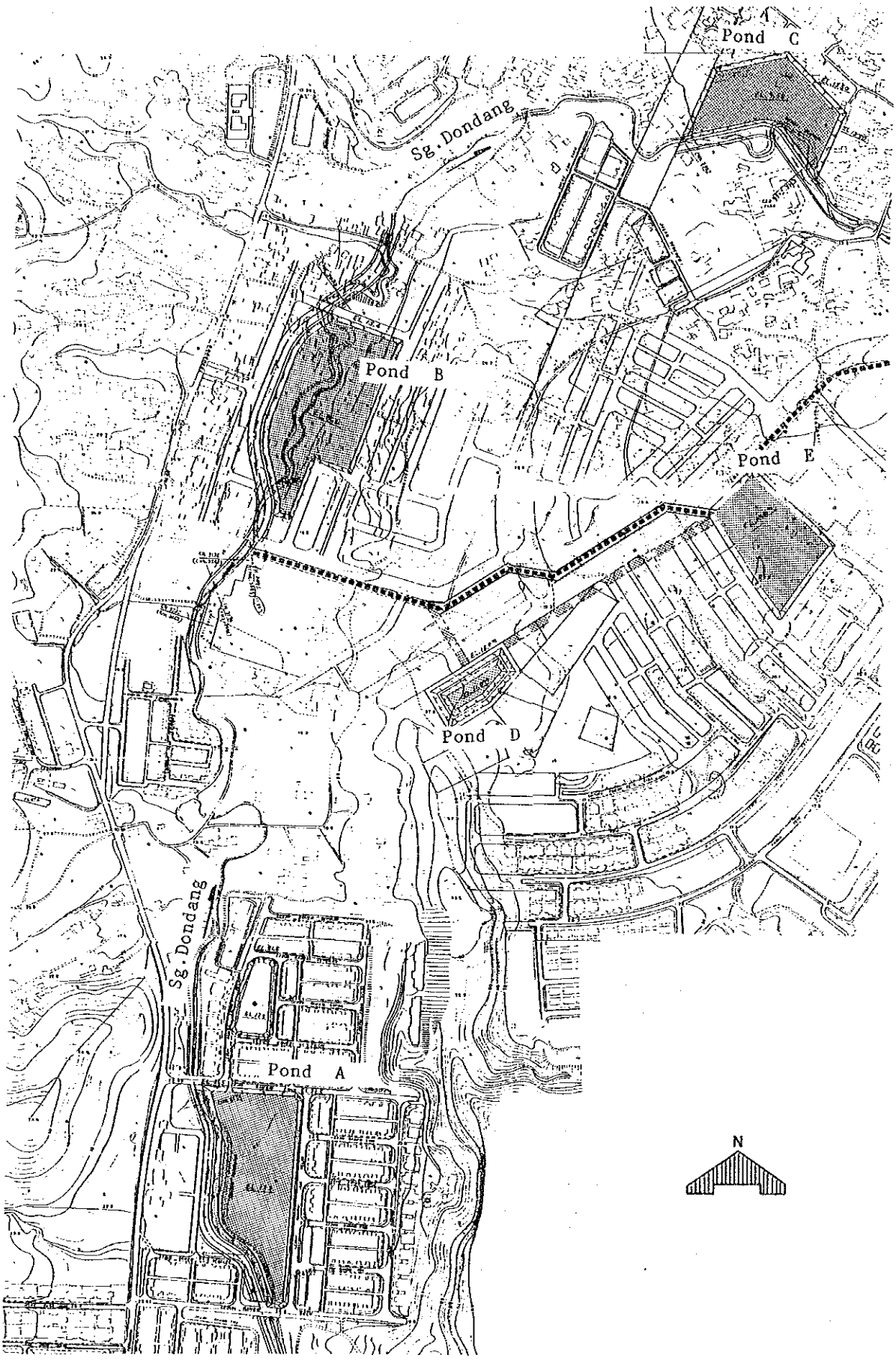
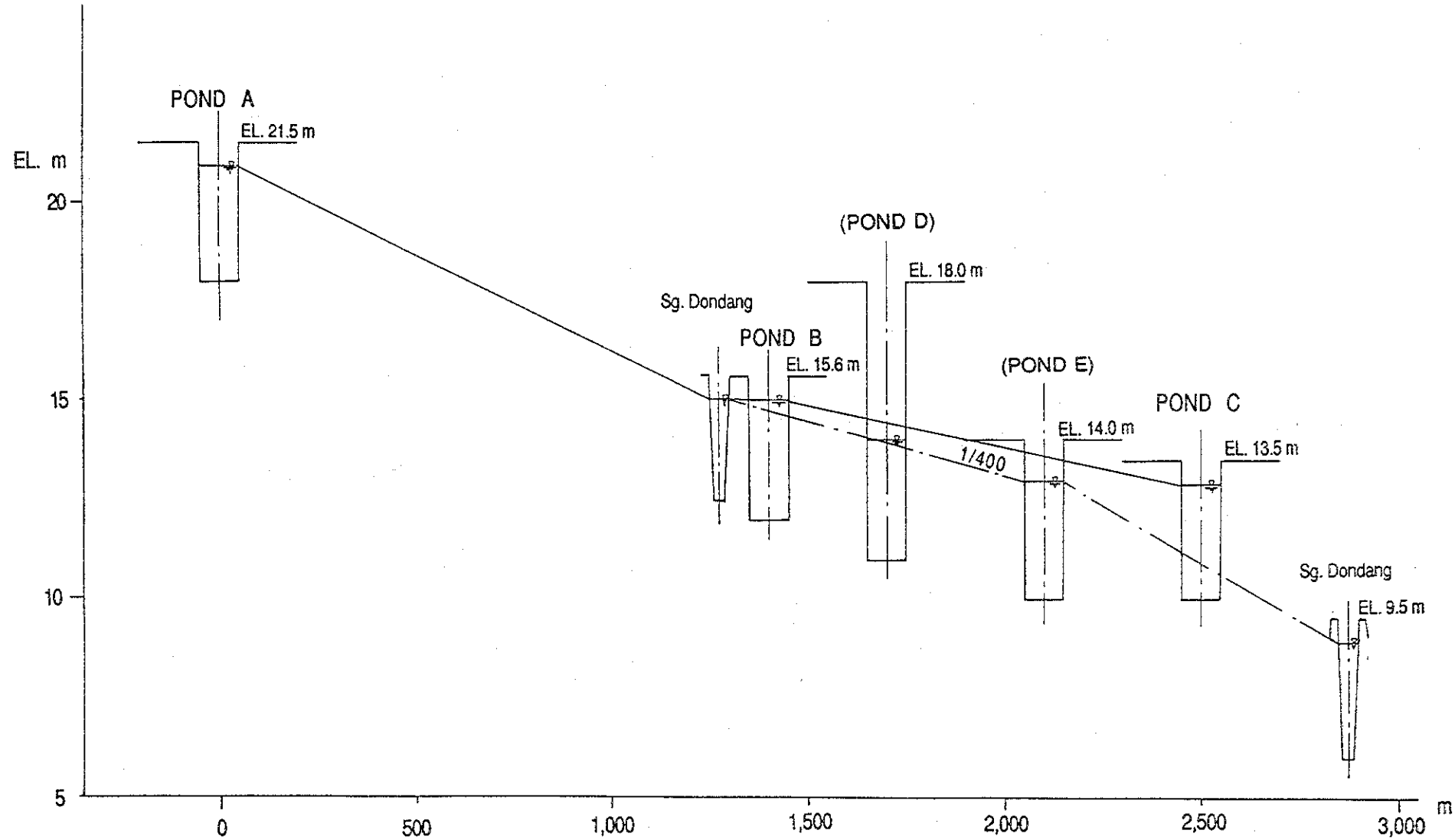


FIG. J-24 LOCATION OF PROPOSED DONDANG RETENTION PONDS



Note: Pond D & Pond E were rejected.

FIG. J-25 LONGITUDINAL PROFILES OF PROPOSED RETENTION PONDS AND RIVERS

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

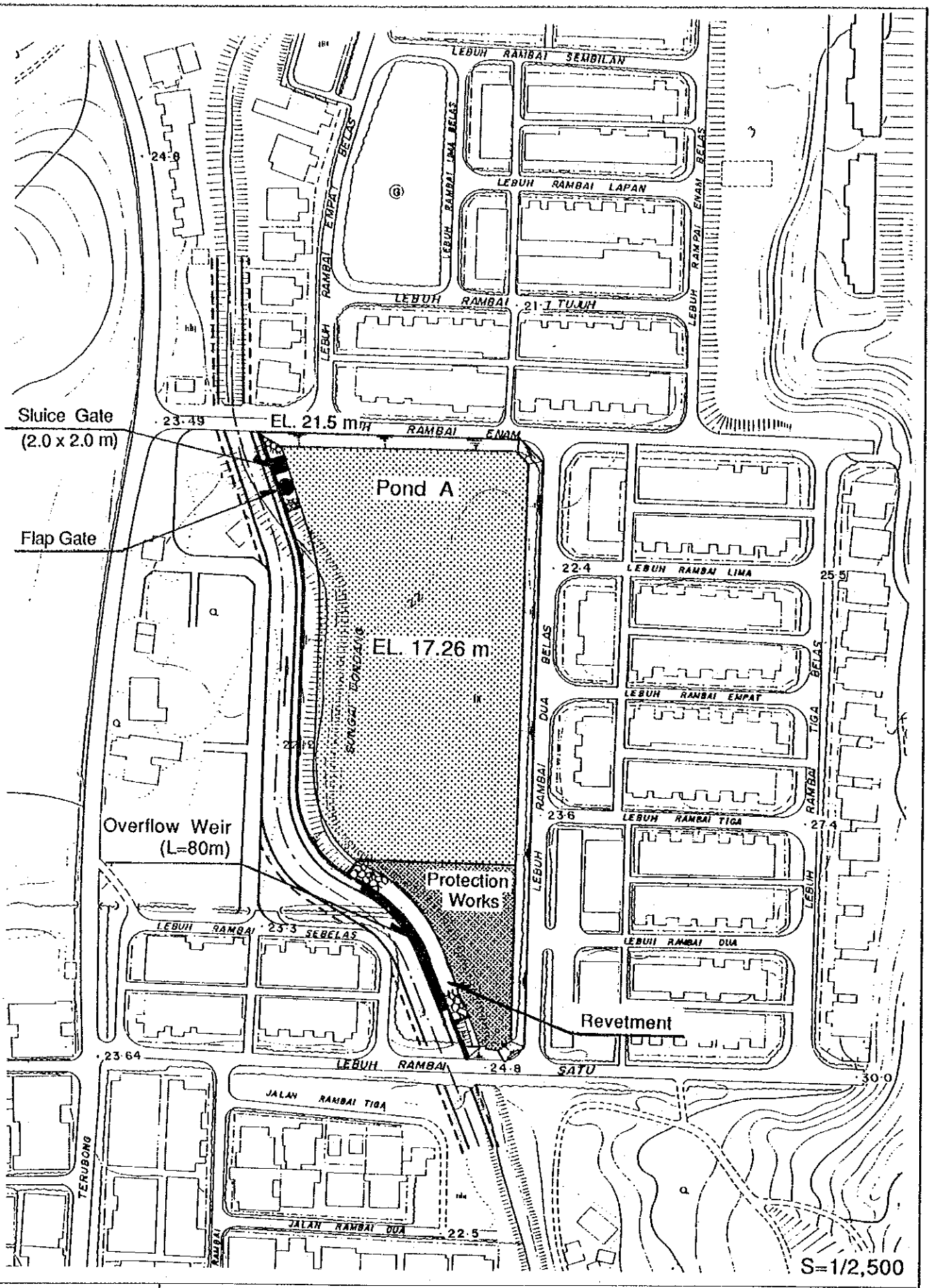


FIG. J-26	PLAN OF PROPOSED RETENTION POND A

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

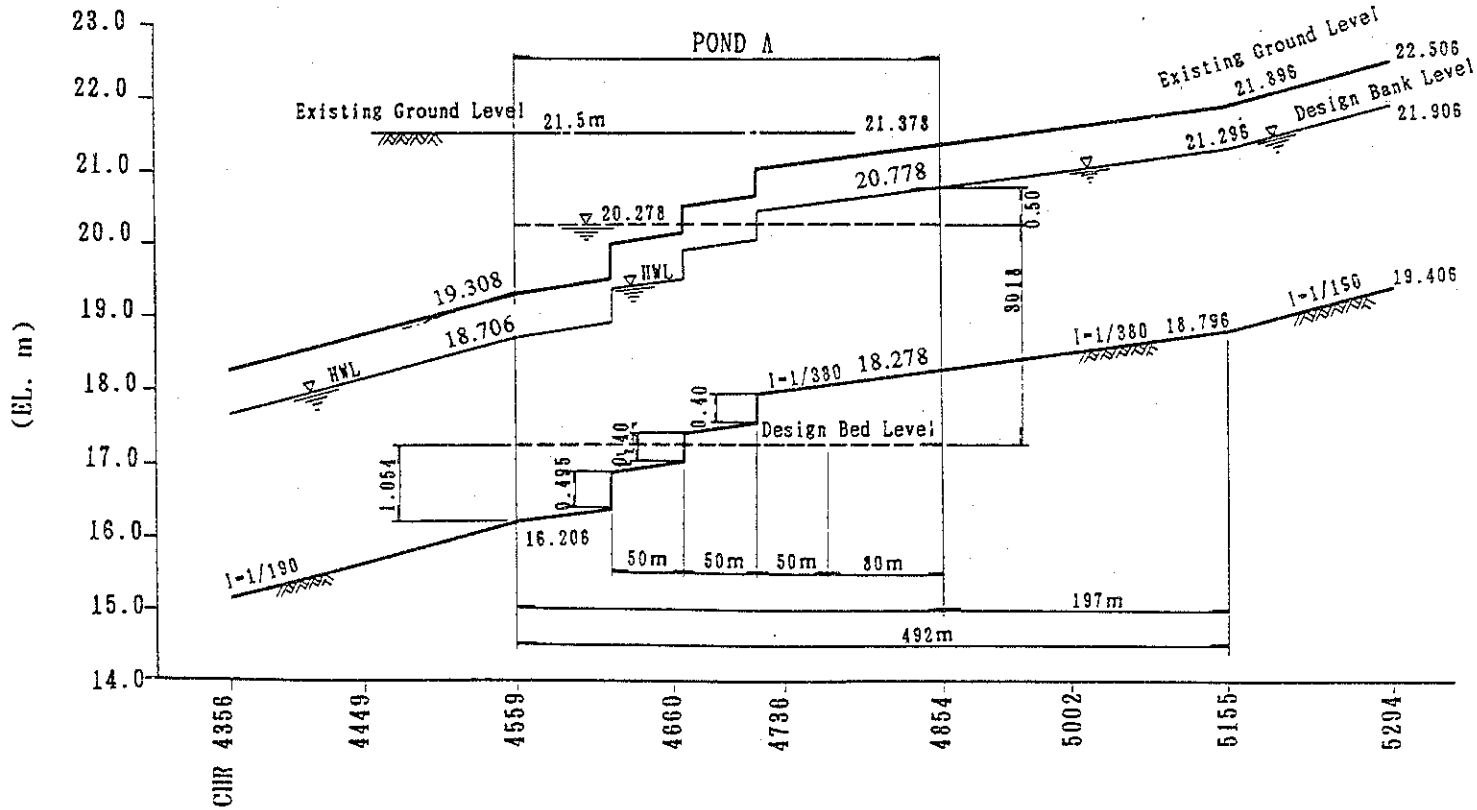


FIG. J-27 LONGITUDINAL PROFILE OF PROPOSED RETENTION POND A

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

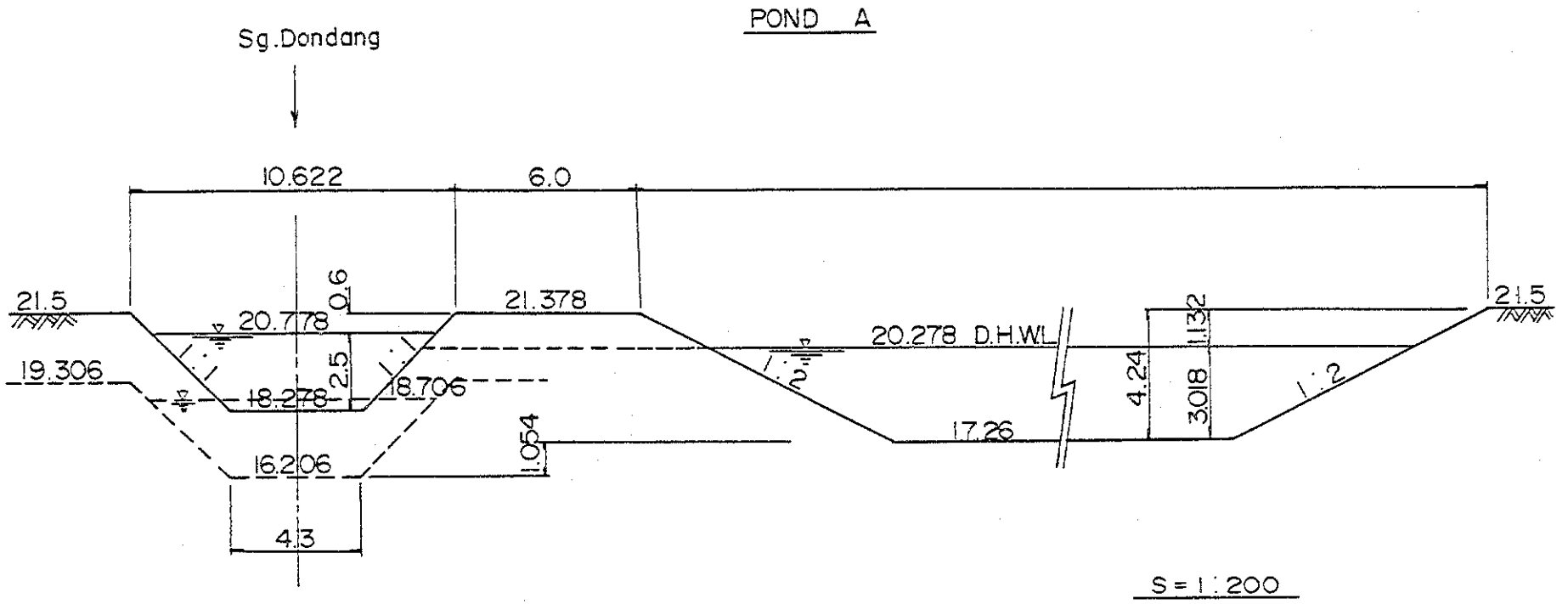


FIG. J-28 TYPICAL CROSS SECTION OF PROPOSED RETENTION POND A

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