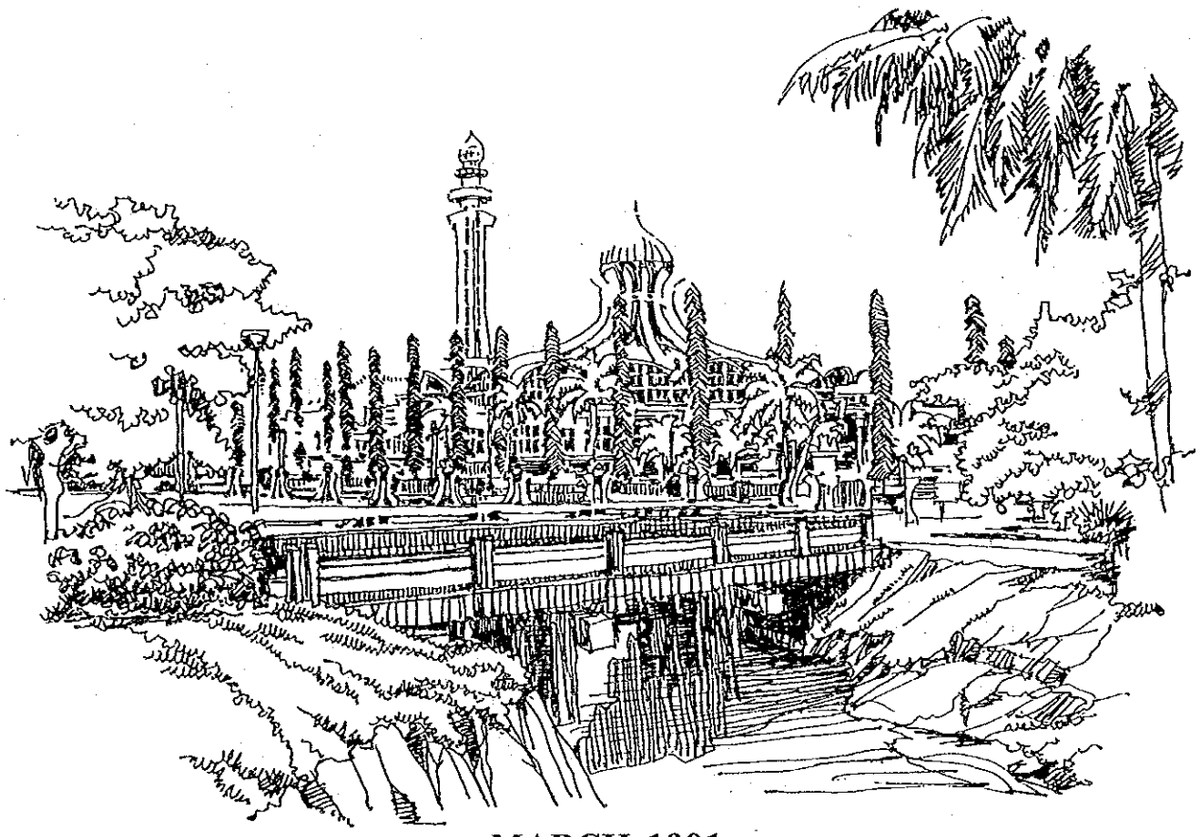
GOVERNMENT OF MALAYSIA

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

SUPPORTING REPORT



MARCH 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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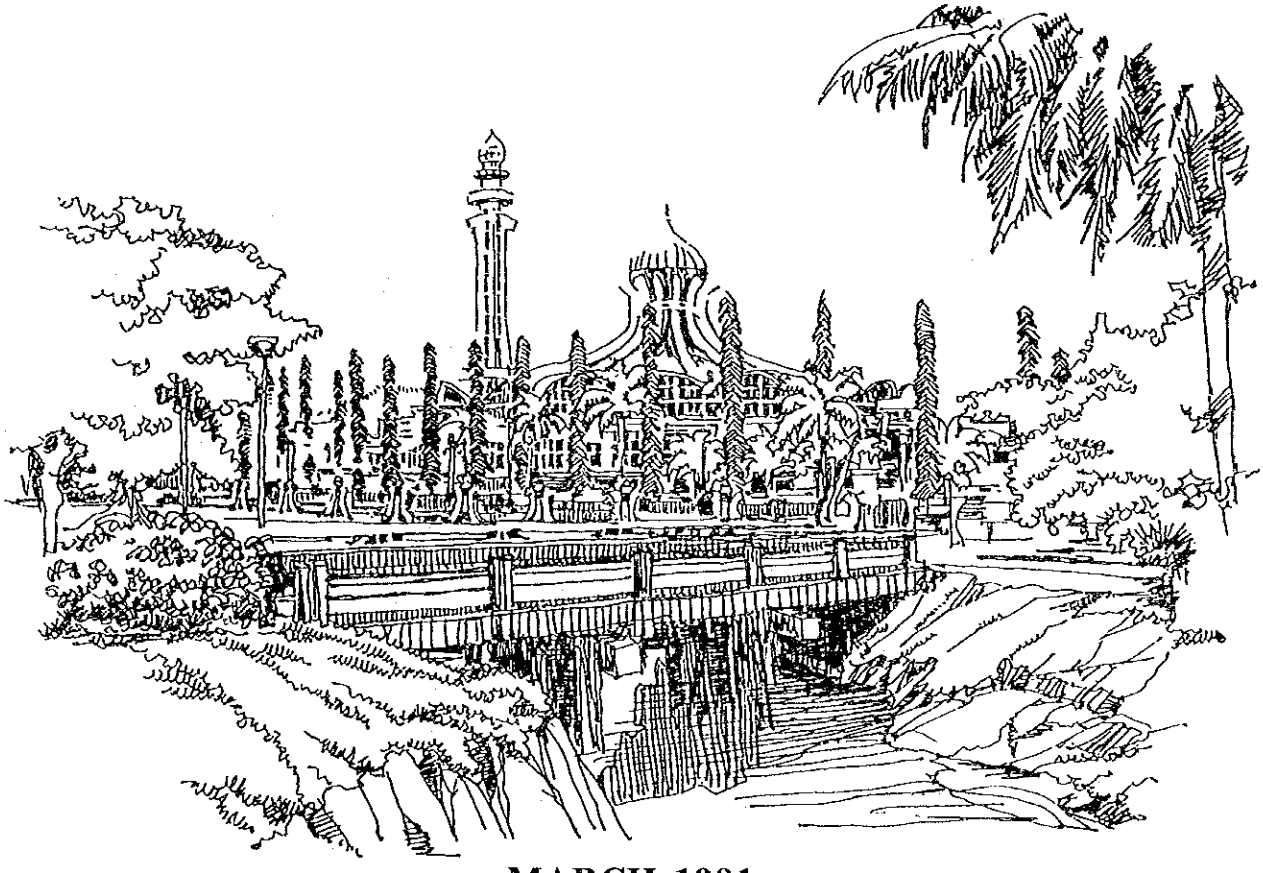

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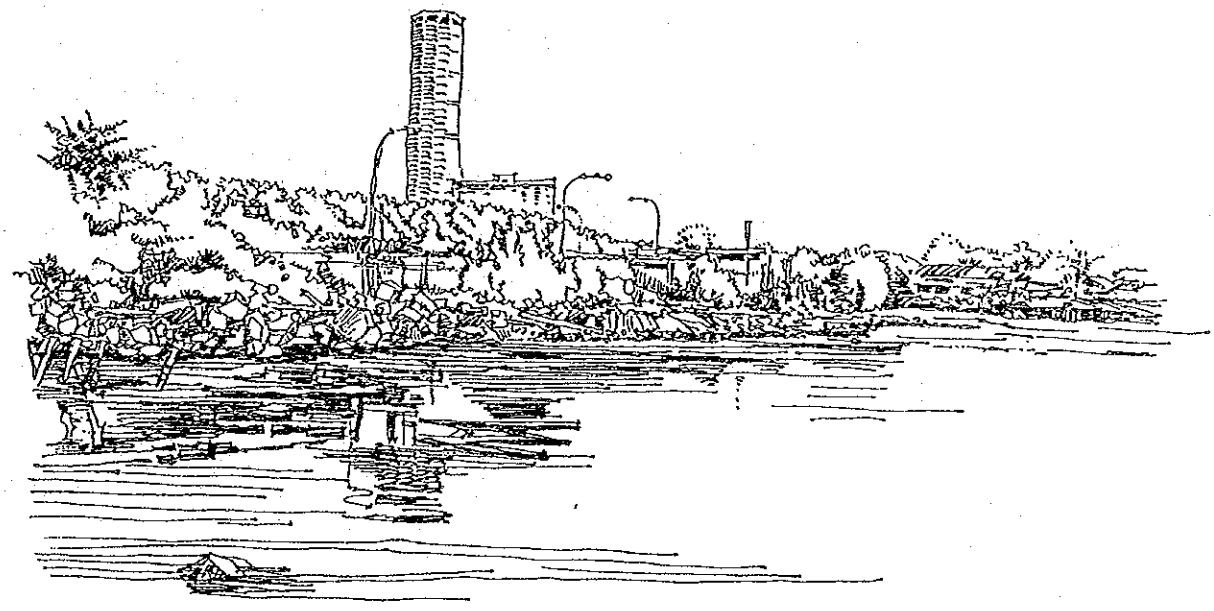
APPENDIX A

TOPOGRAPHICAL SURVEY



APPENDIX A TOPOGRAPHICAL SURVEY

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APPENDIX A TOPOGRAPHICAL SURVEY

1. INTRODUCTION

The topographical survey was planned in order to obtain the necessary data for master plan study and feasibility study for Flood Mitigation and Drainage in Penang Island.

The survey works were carried out in two stages, master plan stage and feasibility study stage, respectively.

The topographical survey for the study includes the following works;

Master Plan Stage

- to collect the existing topographical data,
- to compile the existing topographical data for use in the study,
- to execute the photogrammetric mapping survey, which comprises horizontal control point survey, vertical control survey and monumentation,
- to execute the route survey, which comprises both longitudinal and cross sectional surveys, and
- to execute the minor order levelling for setting the tidal gauge.

The topographical data collected include topographical maps and aerial photographs prepared by the Department of Survey and the Ministry of Land and Regional Development, and river longitudinal profiles and cross sections prepared by DID.

Feasibility Study Stage

Ground survey work was carried out during the period from mid-July to mid-August 1990.

- Point Height Levelling
- Control Traverse for Proposed Retention Ponds Topographical Survey
- Topographical Survey of Proposed Retention Ponds
- Topographical, Cross-sectional and Longitudinal Survey of Proposed Diversion Channel (i.e. Sg. air Terjun)
- Topographical, Cross-sectional and Longitudinal Survey of Drainage Routes S-10 & S-18
- Cross-sectional and Longitudinal Survey of Proposed Diversion Route (i.e. Sg.. Dondang)

- Topographical Survey of Proposed Retention Ponds for Drainage

- Topographical Survey of Proposed Pumping Station Sites

These surveyed sites are shown in Fig. A-6.

2. DATA COLLECTION

2.1 Topographical Maps

The following topographical maps were collected for use in this study.

No.	Scale of Area covered	Unit	Contour interval	sheet
1.	10,000 Georgetown	Feet	20 Feet	2
2.	25,000 Penang Island	Feet	50 Feet	2
3.	50,000 Penang territory	Meter	20 Meter	2
4.	63,360 Penang Island (one inch to a mile)	Feet	100 Feet	1

These topographical maps are drawn on the Malayan Rectified Skew Orthomorphic Projection (R.S.O.) using Everest as a spheroid.

The origin of the Rectified Skew Orthomorphic grid is 4^{o}N, 102^{o} 15'E of Greenwich and the co-ordinates of the origin is 472,854 meters E, 442,420 meters N.

2.2 Aerial Photographs

The latest aerial photographs covering the most of Penang island were taken in 1986 to a scale of 1:20,000. The 2-time enlargements and the 4-time enlargements of this was obtained from Department of Survey and Mapping through DID.

These aerial photographs are as follows:

Film No.	Photo No.
F710 L5	52
F700 L2N	196, 198, 200, 202 & 203
F710 L3N	57, 60, 62, 64 & 66
F703 L3N	29, 31, 33, 35, 37, & 39
F710 L2N	29, 31, 33, 35, 37, 39, 41, & 43
F700 L1S	178, 180, 182, 184, 186, 188, 190, & 192
F703 L4N	12, 14, & 16

2.3 Data of Previous River Survey

The DID HQ have previously carried out plan, longitudinal profile and cross sectional surveys of 25 rivers in the study area, and the survey results for these rivers were collected.

2.4 Data of Bench Marks

The location map and data of BM by MPPP. which were established for only Georgetown Area was collected from MPPP Drawing Section. The basic information are as follows:

a) Scale : 5 inch pada 1 Batu (1/12,672)

b) Elevation is shown in feet

c) (M.P.P.P., BM - 5.19 feet) x 0.3046m = L.S.D.

National Triangulation and Bench Marks were also referred for this work.

3. PHOTOGRAMMETRIC MAPPING

3.1 General

Photogrammetric mapping was carried out, which consists of horizontal control point survey, vertical survey and monumentation of Georgetown area stretch.

The field survey was carried out during the period from July 29, 1989 to August 25, 1989. However, the aerial photo are not taken for all of the proposed area because of bad weather condition.

The national triangulation points furnished by Survey Department which were expected to be available for this work were almost all missing not only around Georgetown but also Butterworth side except the Fort Cornwallis point.

3.2 Method of Survey

3.2.1 Horizontal Control Point Survey (Traversing)

- The coordinates of horizontal control points, which are to be used for succeeding aerial triangulations and stereo plotting, was determined by means of traversing.
- Traversing was connected to the Fort Cornwallis point.
- Azimuth was given by Solar-observation at the point of A7. Such observation has done at other three points, A1, A13, and A10, also for checking bearing.
- The number of the control points determined by traversing was 15. 13 were the concrete monument, the remaining 2 were the iron rivet.

3.2.2 Vertical Control Survey (Minor-order Levelling)

- The ground elevations, which are to be used for succeeding aerial triangulation and stereo plotting, was determined by minor-order levelling.
- Levelling was started in principle from and to the existing national Bench-Marks furnished by Survey Department.
- The interval of pricked points was approximately 200 m on the ground.

3.2.3 Monumentation

- The horizontal control points, which were established newly by means of traversing, was monumented permanently.

- The control points are of 15 numbers; A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, B1, B2.

- The two control points, A7 and B1, are of iron rivet. The rest are of concrete.

3.2.4 Field completion

- The areas partly or locally not photoidentifiable due to shade caused by building, trees, etc. and the information necessary for the annotations in the topographic maps such as administrative boundaries, geographical names, etc. were surveyed in the field.

- The results of the field survey were recorded on the 4-time enlargements.

3.2.5 Pricking

- The locations of the horizontal control points of 15 numbers, composed of traversing points and the national triangulation points, were pricked precisely and clearly on the 4-time enlargements.
- In case the location of the control point is not identified certainly on the photo, the pricking was done after the eccentricity of the control point, transferred eccentrically, shall be fully photoidentifiable.

3.2.6 Aerial triangulation

- On the basis of the result of the horizontal control point survey and vertical control survey, the photographcoordinates, i.e. the coordinates and elevation values of Pass-points and Tie-points necessary for the stereo plotting were determined.

- The aerial triangulatin was done by analytical method.

3.2.7 Stereo Plotting

- On the vasis of the result of the aerial triangulation and other field survey, the features to be expressed in the topographic map were plotted and mapped out by employing precise stereo plotters.

- Plotting scale was 1:2,500. The aerial photographs in the scale of 1:10,000 were employed for the stereo plotting.

3.2.8 Compilation

- Based upon the plotted manuscripts, the result of the field survey and otehr collected data, were compiled to develop the original manuscripts for drafting. The compilation was in compliance with the available Malaysian Standards of Map Symbols and Specifications.

3.2.9 Drafting

- Topographic maps in the scale of 1:2,500 were drafted, based upon the compiled manuscripts (the result of compilation), in compliance with the available Malaysian Standards of Map Symbols and Specifications. INDEX MAP of these maps is shown in Fig. A-1.

4. ROUTE SURVEY (LONGITUDINAL PROFILING AND CROSS SECTIONING)

The route survey carried out consists of longitudinal and cross sectional surveys which are shown in Figs.A-2, A-3, and A-4.

The quantity of the survey are about 12 km length for 9 main drainage routes and about 4 km length for 2 conceivable diversion channel routes.

5. MINOR ORDER LEVELLING FOR TIDE POLE

Direct levelings were done for determining the elevation values of four (4) Tide poles which were set by the Survey Team under the supervision of engineers concerned. The location at those tide poles is shown in Fig.A-5.

Tide pole	1	:	Sg. Babi
	2	:	Teluk Bahang
	3	:	Jabatan Laut
	4	:	Teluk Kumbar
	5	:	Fort Cornwallis

In these tide poles, 2, 3, and 4 are tied to jetty pier with wire rope.

Tide pole 1 was established in the middle of the sea with supporting of angle.

As for tide pole 5 (Fort Cornwallis), it was renewed.

6. POINT OF HEIGHT LEVELLING

Grid lines 100 m apart were overlaid onto the existing 1:2,500 topographical maps to create a network of grid nodes; their elevations were to be determined on the ground by direct levelling.

Having identified these points, a series of levelling networks and loops were carried out to determined their elevations to an accuracy of better than $\pm$1cm/s (where s = distance of observation in km). The datum for these levelling networks were the known-elevation points from PHASE 1 Minor Order Levelling points and Traverse stations for Drainage Routes which were determined to all accuracy better than $\pm$0.6cm/s.

It is unavoidable that some nodes (i.e. intersection of grid lines) happens to fall on buildings, inverts of drains and other inaccessible locations; where such cases were encountered, these nodes were shifted. Nevertheless, the

points chosen to replace these nodes were selected in such a way that they represent the general terrain of the area concerned (i.e. approximately of equal level with the shifted node).

The total area covered for each of the 4 sites are as follows:

Site A	---	2.65 km^2
Site B	---	2.27 km^2
Site C	---	0.47 km^2
Site D	---	0.31 km^2
Total		5.69 km^2

These sites are also shown in Fig.A-7.

7. CONTROL TRAVERSE FOR TOPOGRAPHICAL SURVEYS OF PROPOSED RETENTION PONDS

7.1 Primary Traverse

Topographical surveys were required for each of the five sites identified to be suitable for retention ponds. All five sites were located in the vicinity of Sg. Dondang in close proximity with one another; therefore, a primary traverse was carried out along the outer perimeter of these sites to serve as the datum for the traversing networks for each sites.

7.2 Secondary Traverses

Five separate secondary traversing networks were carried out at each of the five sites based on traverse stations established in the primary traverse network.

8. TOPOGRAPHICAL SURVEY OF PROPOSED RETENTION PONDS

Five sites were identified for this survey exercise. The total area covered by each site are as follows:

Site A	---	7.0 Ha
Site B	---	8.5 Ha
Site C	---	10.5 Ha
Site D	---	8.0 Ha
Site E	---	5.5 Ha
Total		34.5 Ha

EDM (Electromagnetic Distance Measurement) devices were used to pick up details in and around the 5 proposed sites. In areas where no details existed, ground levels were taken approximately 15 metres apart or closer where there is a change of gradient. Topographical plans at a scale of 1:1,000 were produced for each of the five sites.

9. TOPOGRAPHICAL, CROSS-SECTIONAL AND LONGITUDINAL SURVEY OF DIVERSION CHANNEL ROUTE (SG. AIR TERJUN)

A topographical strip survey 30 metres wide was carried out along the whole stretch of this proposed route and as a result of this survey, topographical plans at a scale of 1:500 were produced. These plans were later taken to the field for verification.

As for the Cross-sectional profiles of the proposed route, Cross-sections 30 metres wide were taken at approximately 200 metres interval. Altogether, eleven (11) Cross-sections were taken inclusive of additional Cross-sections taken 20 metres seawards of Chainage 00.

A longitudinal profile for the proposed route was produced from the traversing and levelling data of the chainage pegs which were adopted as the centreline of the route.

10. TOPOGRAPHICAL, CROSS-SECTIONAL AND LONGITUDINAL SURVEY OF PROPOSED DRAIN ROUTES

Two separate sites (sites S-10 and S-18) were identified for this survey task.

A Topographical strip survey in a 20 metre corridor were carried out for both sites.

Elevations of all the traverse stations and chainage pegs were determined through direct levelling from the Minor Order Levelling points established during PHASE 1.

As for the Cross-sectional survey, 7 Cross-sections of 20 metres width were taken at approximately 50 metres intervals for Route 10 while 17 Cross-sections of the same width and interval were taken for Route 18.

Longitudinal profiles for both routes were produced from traversing and levelling data of the chainage pegs which were adopted as the centreline for the proposed drain routes.

11. CROSS-SECTIONAL AND LONGITUDINAL SURVEY OF PROPOSED DIVERSION ROUTE (SG. DONDANG)

Cross-sectional surveys were needed for an area in the vicinity of Sg. Dondang identified as suitable for the purpose of a diversion route.

Chainage pegs for the Cross-sectional survey were placed via a traverse network carried out based on the secondary traverse stations of Retention Ponds B and D. Altogether, 9 Cross-sections in a 30 metre corridor were taken at approximately 50 metres intervals.

A longitudinal profile for this route was also produced from the data of the chainage pegs which were adopted as the centreline of the proposed diversion route.

12. TOPOGRAPHICAL SURVEY FOR PROPOSED RETENTION PONDS FOR DRAINAGE

Two sites located in the vicinity of the seaward end of Diversion Route S-10 and S-18 were proposed to be converted into Drainage Retention Ponds. No addition traverse network were needed for the topographical survey. The traverse stations of routes S-10 and S-18 were used for picking up details and spot heights.

13. TOPOGRAPHICAL SURVEY FOR PROPOSED PUMPING STATIONS

Plans at a scale of 1:2,500 were produced for each of the two sites.

Figures

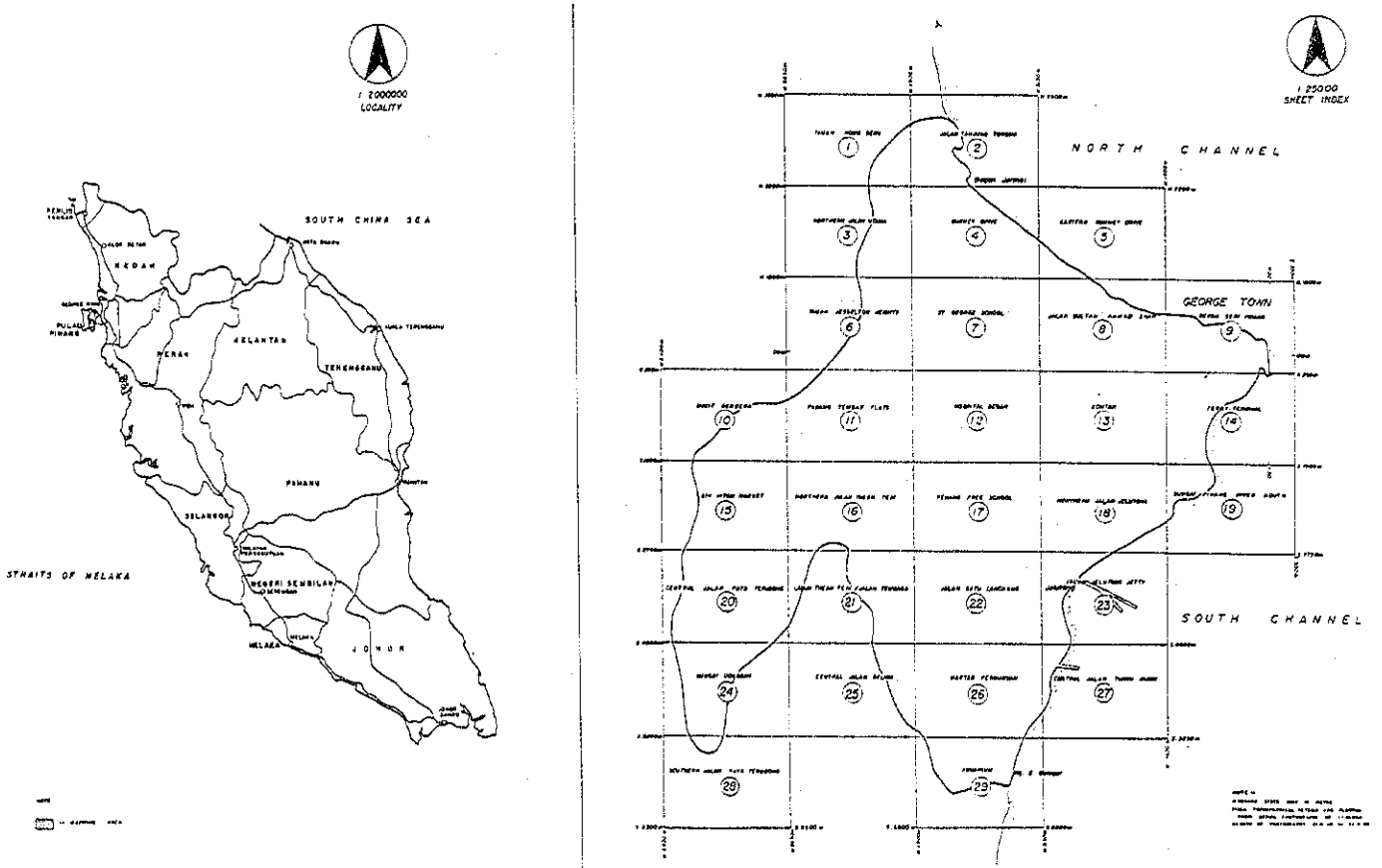

FIG. A-1 **INDEX MAP OF 1:2500 TOPOGRAPHIC MAPS IN GEORGETOWN AREA**

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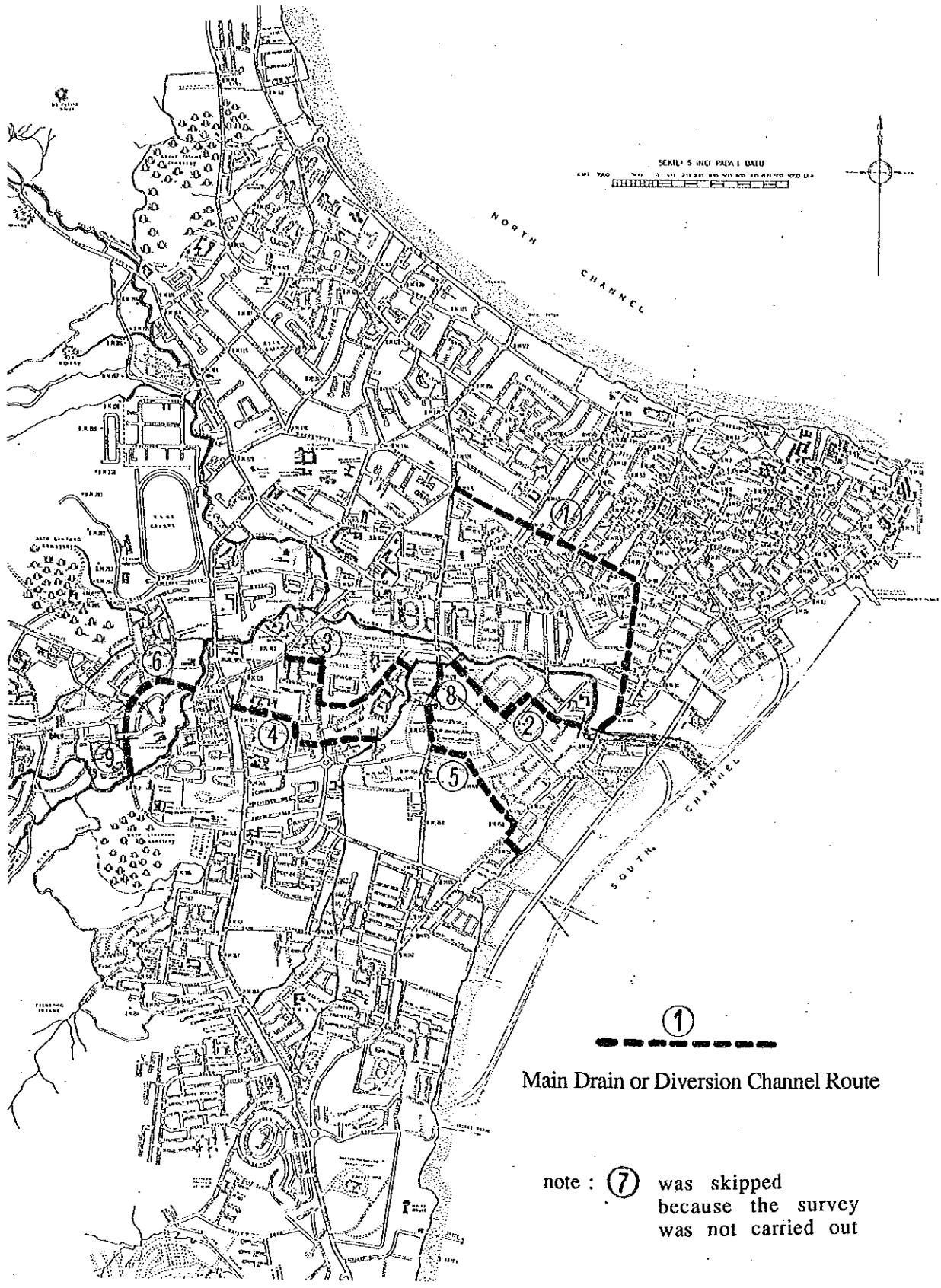

FIG. A-2 **LOCATION OF ROUTE SURVEY**

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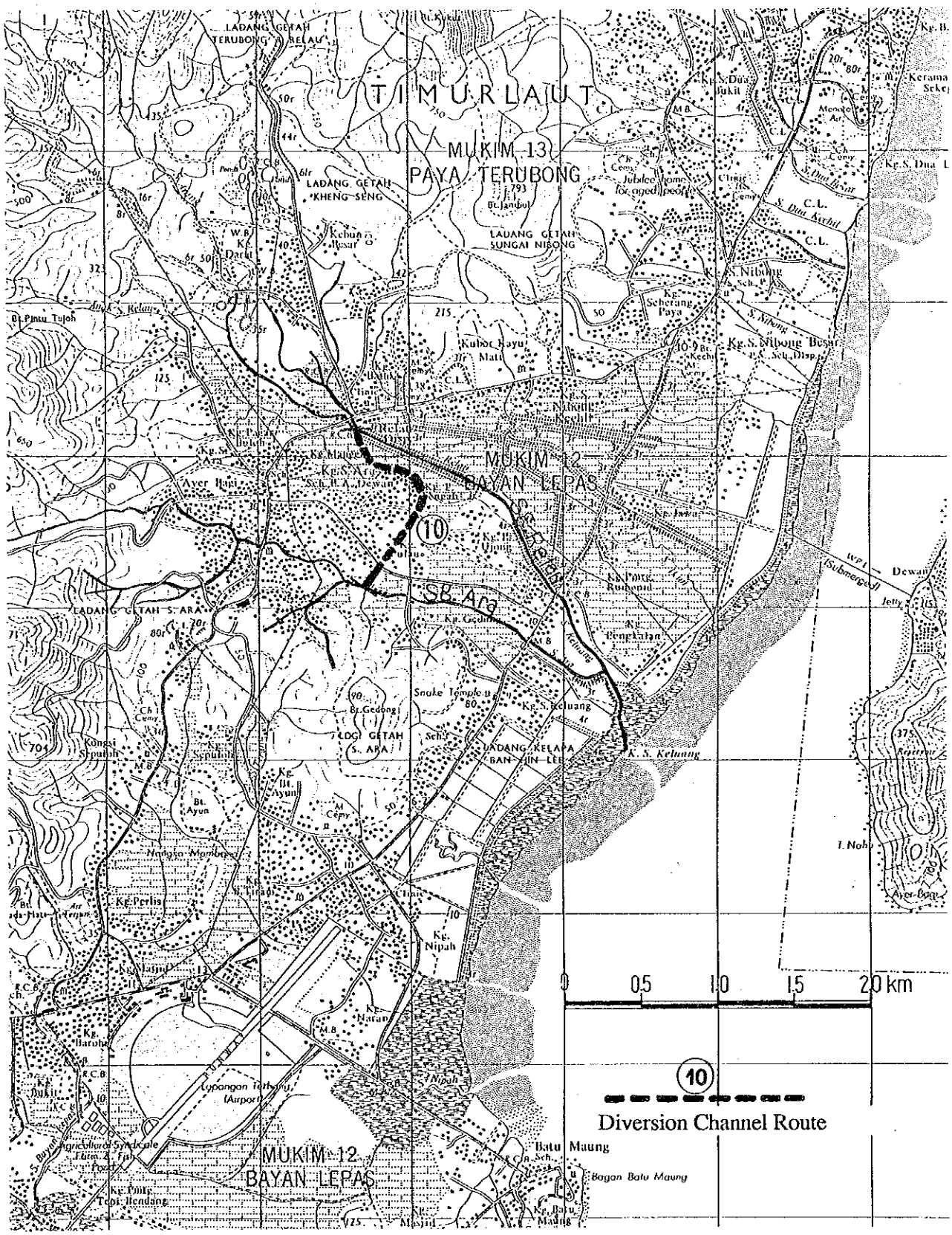

FIG. A-3 **LOCATION OF ROUTE SURVEY OF RELAU DIVERSION CHANNEL**

FIG. A-4 **LOCATION OF ROUTE SURVEY OF DIVERSION CHANNEL ROUTES**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

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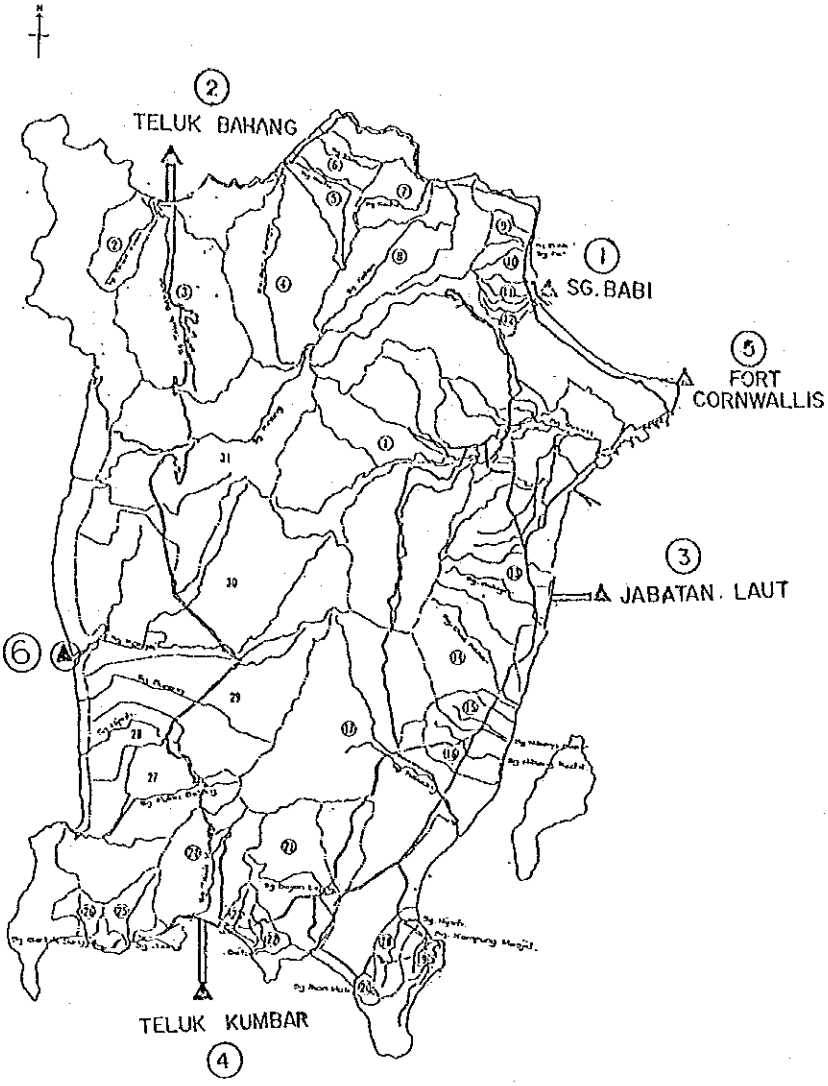

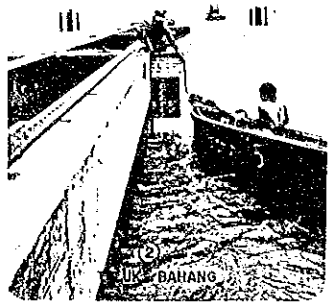

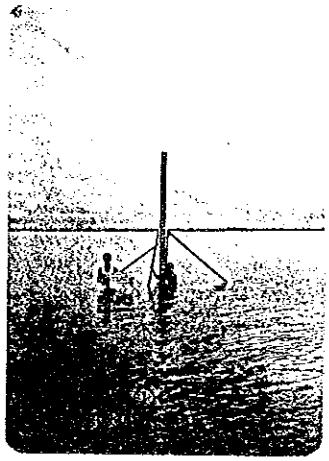

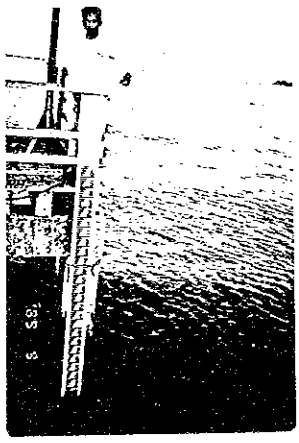

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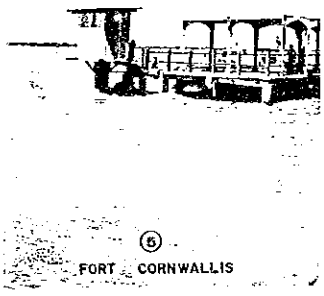

Fig. A-5	**LOCATION OF TIDE POLES**

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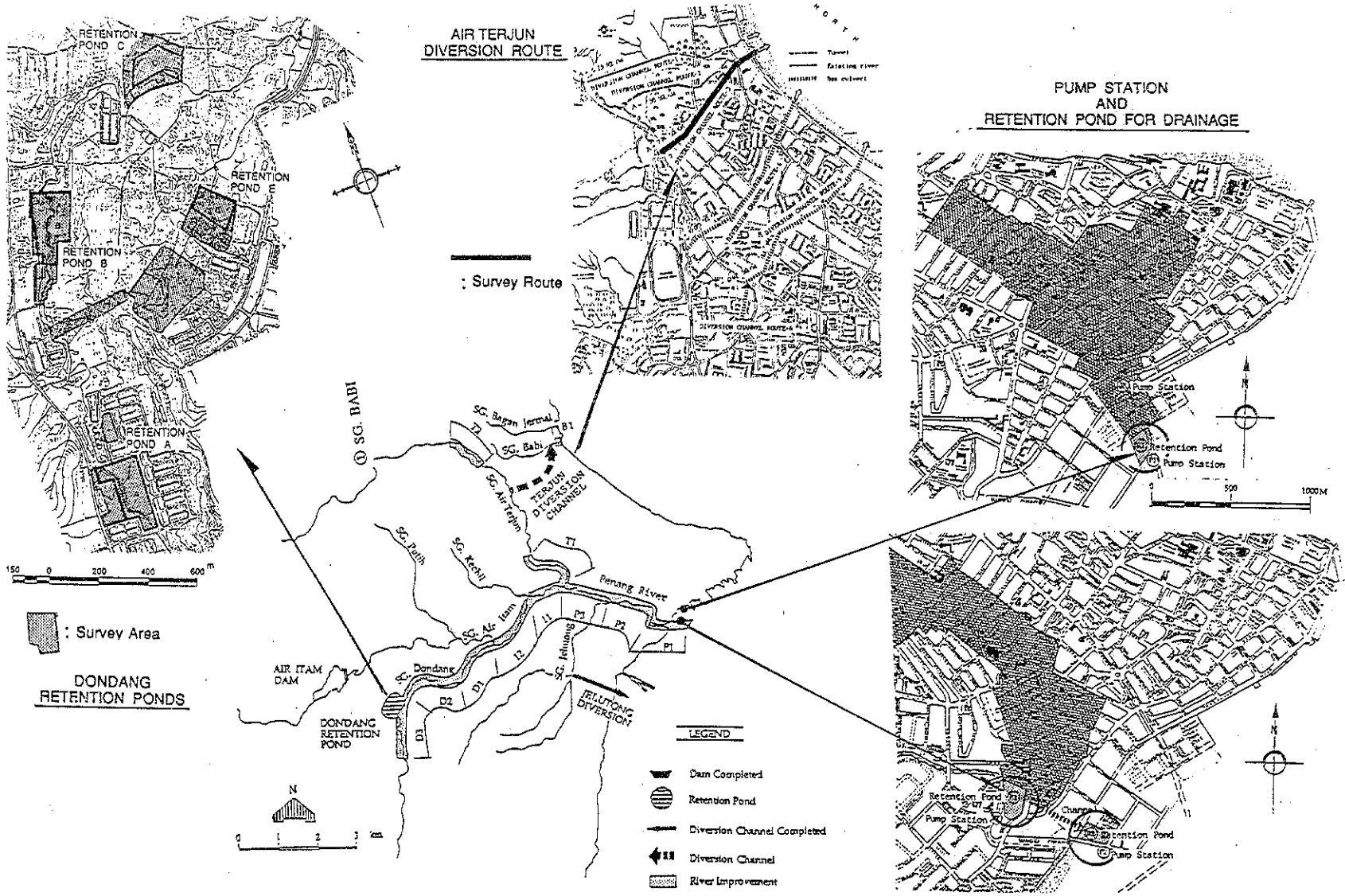

FIG. A-6 **LOCATION OF TOPOGRAPHICAL SURVEY SITE**

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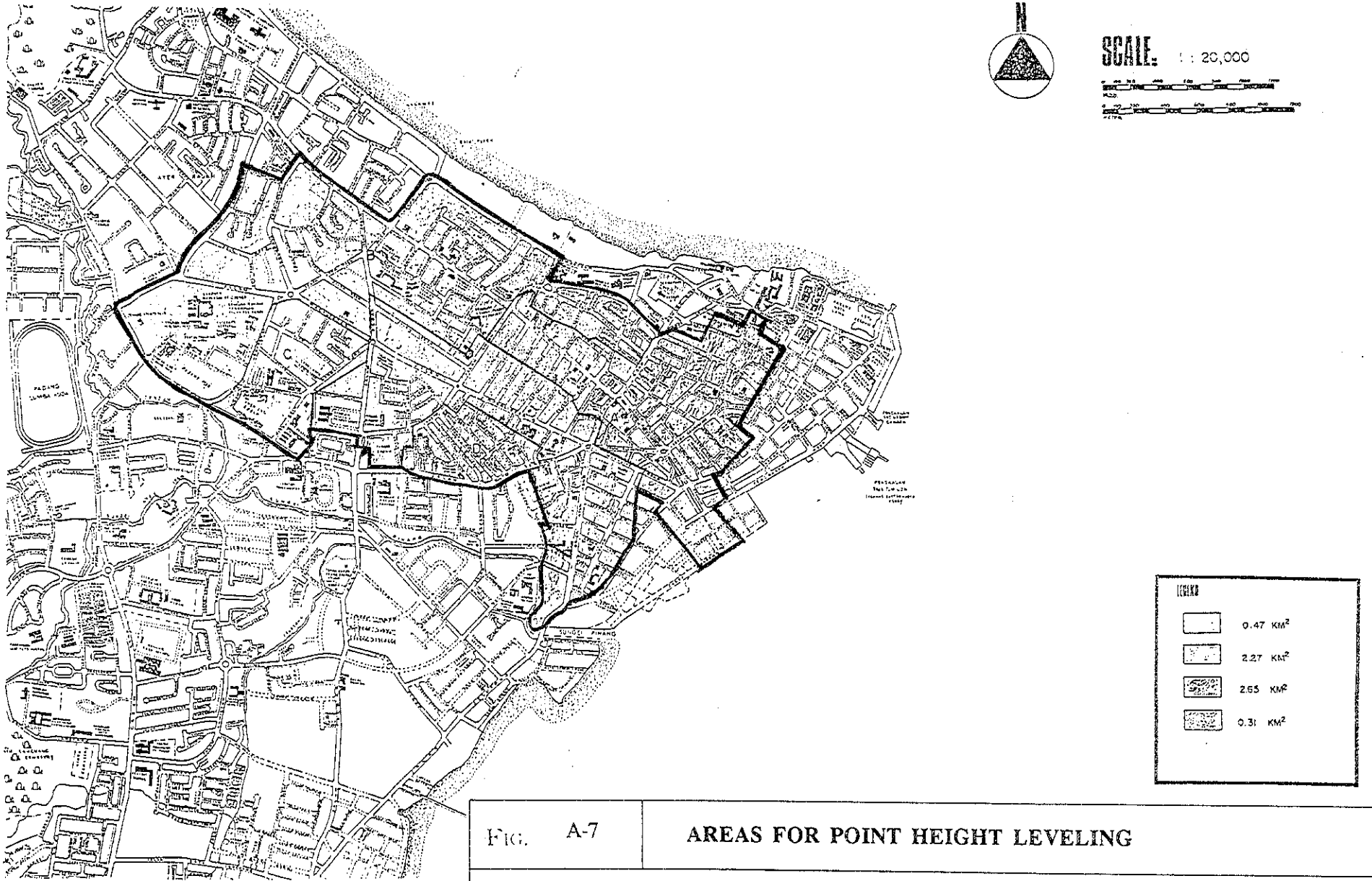
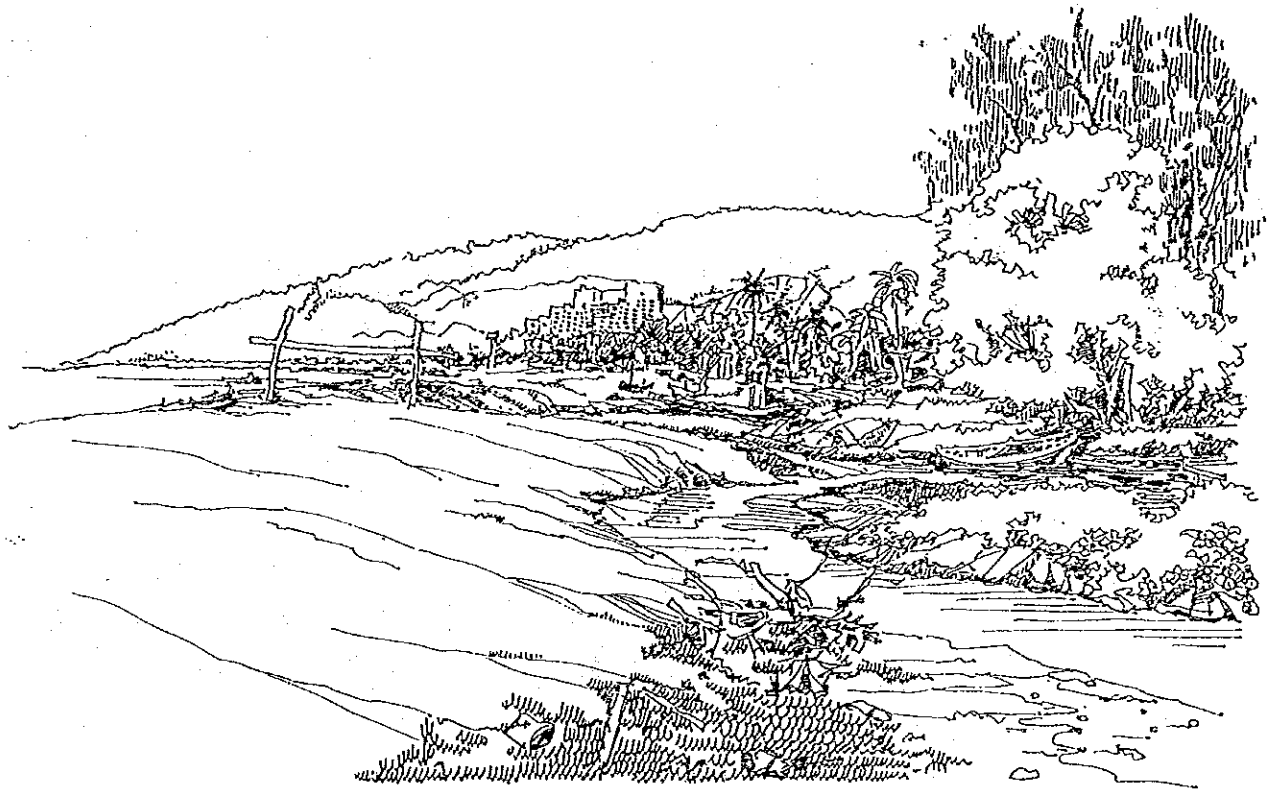


FIG. A-7 **AREAS FOR POINT HEIGHT LEVELING**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

APPENDIX B

TOPOGRAPHY AND GEOTECHNICAL CONDITIONS



APPENDIX B GEOTECHNICAL CONDITIONS

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APPENDIX B TOPOGRAPHY AND GEOTECHNICAL CONDITIONS

1 INTRODUCTION

This chapter on Geotechnical Conditions deals with following investigation results; (i) field reconnaissance survey of the general geological conditions of Penang Island, (ii) investigation of the geotechnical conditions along the whole rivers of Penang Island, and (iii) detail geological and geotechnical investigation for the Feasibility Study areas.

Prior to the commencement of geotechnical investigation, the available data, information, and maps related to the investigation were collected with the assistance of DID and PDC staff. The investigation of the general geological conditions of the river basin was conducted by field reconnaissance with the aid of the geological maps published by Geological Survey of Malaysia.

The investigation of the geological conditions of the rivers was made by a combined analysis of the data gathered in this study along with supplementary field investigation results.

These works were executed from 2 to 31 August 1989 covering the whole study area.

The investigation of the detailed geological and geotechnical conditions of the specific locations of the urgent project facilities such as retention ponds, diversion channels and related structures were conducted from 10 June 1990 to July 1990.

2 TOPOGRAPHY

Generally, topography of Penang Island can be broadly divided into two geomorphic unit namely the Hilly Country and the Lowland Areas.

The Hilly Country is mainly confined at the central part of the island with the highest summit at Bukit Western which is about 830 m high. The terrain is usually very rugged with waterfalls and rapids in some of the streams.

The Lowland Areas are generally near the coastal plains and swamps. It includes the beaches and small isolated hills with height less than 15 m above sea level. Morphology of the shoreline is mainly controlled by wave action and monsoon current. Conspicuous head land development in certain part of the shoreline.

These are shown on Fig.B-1, Topography and Slope Analysis of Penang Island.

3 GEOLOGY OF PENANG ISLAND

The geology of the study area consists of middle Palaeozoic to upper Mesozoic Granitic rocks and Cenozoic alluvial formations distributed along the river and low plains covering the bedrock formations.

The granite of Penang Island can be divided into two main bodies on the basis of composition of their alkali feldspars. In the northern portion of the island, the alkali feldspars generally do not exhibit distinct cross-hatched twinning and are believed to be orthoclase to microcline in composition. In the southern portion of the island, they generally exhibit well-developed cross-hated twinning and are believed to be microcline in composition.

Geomorphological and petrological studies also suggest there are two granitic bodies, possibly corresponding to the two ages of granite on Penang Island. Topographically, the northern part of the Island is higher than the southern part. Tija(1971) reported that the skyline on the Island, observed from the east, slopes gently to the south.

The slope is especially pronounced in the central part of the Island where summit elevations drop from 830 m to 406 m over a distance of 12.5 km. The rather distinct break in topography which occurs somewhere in the middle of the Island could indicate the boundary between the two granites.

In the field, the most prominent fault mapped is that which strikes approximately N 10° E and has been traced from Tanjung Bunga in the north to Bayan Lepas in the south. Evidences for such a fault include; (i) alignment of a streams and rivers parallel to the fault, (ii) sheared granite and mylonite, (iii) alignment of quartz veins parallel to the fault (iv) joints running parallel to the fault, and (v) fault scarp.

There are shown on Fig. B-2, Geological Map of Penang Island.

4 GEOTECHNICAL CONDITIONS OF PENANG ISLAND

4.1 General

Penang Island is mainly composed of granite rocks. They were emplaced 150 to 300 million years ago. Other associated igneous rocks found include aplite and pegmatite dykes that intruded into the granitic rocks.

Top portion of the granite rocks was weathered into residual soils due to severe tropical climate. Some holocene deposits were found at lowland areas along some rivers and coastal plains. They consisted of loose sandy soils, soft clayey soils including organic clay deposited in swampy condition and talus deposits which were mainly granite soil washout. Beach sand is common along the beaches. The location of existing boreholes are shown in Fig.B-3.

4.2 Geotechnical Conditions Along the River Stretch

Each investigation site was divided into two sites as follows.

- The area along Sg. Pinang and its tributaries: The sites are composed with lowland area except the base area of mountain.

- Whole river areas along Penang Island coast: All these rivers are almost of small scale except 3 - 4 rivers.

Most part of the topography along the river stretch is relatively low with elevation of 1 m to 15 m above mean sea level. They are confined to the mountain base of the study area. Relatively higher grounds with elevation of 6m to 15m are flanking on both side of the low ground. At the city area site, the ground is relatively higher toward the mountain foot of the site.

There are 3-4 major rivers and many small streams along the study route. These major rivers have their source in the hilly country and drain into the Straits of Malacca.

From the soil profile of Georgetown area, the geotechnical conditions of the area is summarised as follows :- (ref. Figs.B-4 to B-6).

- The coastal area is composed of soft alluvial deposits, sand and clay with N value of 0-5, and is thick to a depth of 10m-15m below ground level.

- Middle part of Georgetown is composed of loose-medium dense sand, silty sand, with some gravel. Below this strata stiff silty clay layers of medium dense sand layers exist. Foundation rock mass is estimated to exist at very deep. Therefore, generally in Georgetown friction pile foundation is common to support building and the bearing layers are the silty clay layer, medium dense sand layer and others.

- Upstream areas consist of granitic rock, Talus deposit, boulder deposit and gravel with sand. Therefore earth-works in this area would require detailed soil investigations.

- Thickness of the weathering of Granitic rocks is more than 30 m - 50 m endulating to flat areas and relatively less in Hilly areas to 10 m - 20 m depth.

5. GEOTECHNICAL CONDITIONS IN THE FEASIBILITY STUDY AREAS

5.1 Introduction

Geotechnical investigations were performed as a part of the feasibility study on Flood Mitigation and Drainage in Penang Island.

The purpose of geotechnical investigations is to clarify the ground conditions at the proposed location of river channel improvement works and flood mitigation facilities.

Eleven exploratory borings performed at the proposed locations in the project area. Locations of exploratory boring are shown in Fig.B-7.

Prior to the commencement of geotechnical investigation, the supplementary data were collected by assistance of SDID and PDC. The investigation of general geological conditions of the river basin was conducted by field checking the geological maps published by Geological Survey of Malaysia.

General geological conditions of the rivers were determined by an analysis of data gathered in this study together with supplementary field inspection.

This investigation was performed continuously from 10 July, 90 to 10 August 90 at each site in the project area.

The main purpose of the geological investigation is to clarify the general geological conditions, such as the distribution of strata and foundation conditions, at each investigation site.

These sites are mainly scattered along Sg. Pinang and the proposed Diversion Channel. Eleven mixed core boring of NX diameter were executed in soil as well as in rock.

Diamond bits were used in the rock portions and Tungsten carbide bits were used in soil portions.

Standard Penetration Test using a Raymond sampler was executed; these results are shown in soil profiles Fig.B-8 to Fig.B-12. Soil tests were also performed to make clear the nature of soil strata in the study area.

The laboratory investigations included analysis for moisture content, specific gravity and particle size distribution.

The general geotechnical conditions of study area are summarized hereinafter.

Most of the topography along the route of Sg. Pinang is relatively low with elevations of 1 m to 15 m above sea level. Relatively higher ground with elevation of 6 m to 15 m are located on both sides of the low ground.

In the urban area, the ground elevation is generally less than 5 m.

There are 3 - 4 major branches or small streams along Sg. Pinang.

5.2 Geotechnical Conditions Along Study Area

For the river improvement plan it is indispensable to determine the sub-surface conditions along the proposed river.

The detailed determination of the sub-surface conditions permits a preliminary design of flood mitigation facilities and preliminary estimate of the cost of earthwork.

Therefore soils/rocks investigation must be performed in these areas to clarify the geotechnical conditions.

Each study area is described as follow.

5.2.1 Proposed Pumping Station (Fig.B-8)

This study site is located just the edge of the sea. The environment of sedimentation at this site is practically the same in the borehole P-1 and P-2.

Loose sandy and soft clayey sediments are deposited to a depth of about 50 m.

There are also marine clay and organic clay layers. N values are quite low (0-10) from the surface to a depth of 10 m with N values of only 20 at a depth of 30 m.

Therefore it is necessary to give detailed consideration to the foundation of the flood mitigation facilities and pumping stations.

From the collected data of drilling logs in the Georgetown area, geotechnical conditions of area are summarized as follows:

i) In the coastal area there are soft alluvial deposits of sand and clay to a depth 10 m - 16 m below ground level. N values are 0.5.

ii) The middle part of Georgetown is composed of loose - medium dense sand, silty sand with some gravel. Below this strata are stiff silty clay layers and medium dense sand layers. Foundation rock mass is estimated to be fairly deep. Generally in Georgetown friction pile foundation are common for supporting buildings, and the bearing layers are considered to be the stiff silty clay layer and medium dense sand layer.

iii) Upstream areas consists of granitic rock, Talus deposits, boulder deposits and gravel with sand. Therefore, earthwork is expected to require excavation of the boulders.

iv) The thickness of the weathered of Granitic rocks is more than 30 m - 50 m on undulating to flat areas and somewhat less (10 m - 20 m) in hilly areas.

5.2.2 River Improvements (Fig.B-9 to Fig.B-11)

In this study area, core drilling points are located along Sg. Pinang from river mouth to the hill of middle streams.

From river mouth to the lower stream, collected data of drilling logs are used. (Figs.B-10 and B-11)

Sub-surface soil is composed of soft sandy and clayey layers. N values are only 0 to 15 and there are no bearing layers to a depth of 10 m.

In addition, there is considerable organic matter included in the clayey layers.

Given these conditions it will be difficult to construct the river improvements.

Therefore it is necessary to consider methods of preventing failure of cut slope, subsidence of embankments and protecting of embankment slopes from erosion.

5.2.3 **Diversion Channel** (Fig.B-12)

This study site is situated in a hilly area with loose and soft alluvial layers to a depth of about 10 m. However, drilling results show the depth to weathered granite at more than 15 m, especially in borehole D-3 due to the effect of river erosion and deposit.

Based on the detailed observation of Boring cores, these layers belong to decomposed soils derived from weathered granite in this area.

The Boring core was clayey with some sand and silt, variable colours and soft to medium consistency.

The clayey layers and sandy layers originate from weathered granite. Therefore, it is difficult to distinguish residual soils from sedimented sandy soil derived from weathered granite.

At borehole D-3 soft alluvial layers are considered to deposit medium sandy materials during floods and after this deposition clayey layers accumulated thick.

5.3 **Evaluation**

The proposed study areas can be divided into the three major areas described below:

i)	Lower streams to river mouth area soft alluvial area (coastal) loose sand and clay area (in land)	BH-P-1 P-2, S-1 S-8, D-1 belong to this area
ii)	Middle stream area sand and clay (marsh, old pond) some boulders	BH-R-1 R-5 belong to this area.
iii)	Hilly area(partly granitic rocks) coarse sand and boulders talus (rock fractures)	BH-D-2 D-3, R-6 belong to this area.

Each of these areas has the geotechnical problems as described in the following:

i) Lower streams to river mouth area

For the foundation of a levee embankment the alluvial deposits of soft clay and loose sand layers are considered to be very poor.

Therefore the critical height of embankment with a general slope of 2:1 is about 2 m.

The settlement is roughly estimated at about 30 to 50% of the embankment height.

With regard to pumping station foundation the proposed construction is considered to be large scale. Therefore pumping station should be based on friction piles.

ii) Middle stream area

This middle stream area is also composed of thick soft alluvial deposits, loose sand and soft clay. It is similar to the lower stream area but sandy soil is predominant at some areas.

With regard to this area the bearing layer is estimated to be deeper than 20 m. Therefore pile foundations should be selected to support the super structure. As the surface layers are very loose and soft, it is necessary to consider the method of construction for bridge abutment to prevent serious failures. Suitable method such as sand drain piles, sand compaction piles, and pre-loading are recommendable to prevent serious failure of abutments.

With regards to proposed embankments foundation considerations are the same as mentioned above under i).

iii) Hilly area

In this rather hilly area three borings were executed near boring D-1. In this area there is a very soft, self penetration marine clay from 5 m to 10 m below ground level.

Considering this matter, it is important not to disturb the existing ground condition. Once soft clayey soil is disturbed the strength of soil decreases considerably. In this area a large scale culvert is expected to be constructed for a diversion channel. The proposed alignment is under the existing road.

It should be easy to excavate the proposed route because the soil layer is composed of sandy clay but slope failures may occur. Therefore it is necessary to consider methods such as the use of retaining walls.

No rock excavation is expected along this diversion route.

From the viewpoint of levee embankment, deposited sand layers of uniform gradation are judged to be unfavourable because of their poor resistance against erosion.

However, sand materials are available for the main levee embankment provided there is a lining of clayey soil or other appropriate materials.

Decomposed rock may be suitable for earth lining materials of clayey soil as well for the embankment materials of levee. Decomposed rock layers are thick in the many hills distributed widely along the rivers.

Excavation of rock is not expected because there is no hard rock near the surface layers in the study area.

The nature of soils in study area is summarized in the table attached hereinafter.

6 EROSION

Granitic rocks underlay almost the entire Penang Island. Therefore heavy erosion from rock mass is considered to occur easily due to their petrological and structural properties; this matter has been observed in many countries having the same granitic rocks.

Because of the constant high temperature and occasional heavy rains on the granitic rock mass, this phenomena is very common throughout Penang Island.

In addition to this factor other reasons for erosion are considered as follows:

i)	Cultivation	:	rubber plantation, coconut plantation, sugar-cane field etc.
ii)	Mining	:	quarry and sand mine.
iii)	Urban Development	:	land, house, road etc.

Quarry operations and sand mine are undertaken on a large scale in Penang Island.

Sand is scarce in Penang Island and is usually obtained from granite waste or decomposed granite. The sand is separated by the use of monitor pumps and 'palongs'. Water under pressure from the monitors is directed onto the weathered granite outcrop to form a slurry which is then pumped up the 'palong' where the sand is trapped. Generally 2 sizes of sand are collected, one is medium sand and the other is coarse sand. In some cases, the clay slurry is discharged into settling tanks and the water recycled. The high price of sand in Penang Island makes this method of mining profitable.

Concerning the development of Penang Hill, careful consideration is necessary to avoid the occurrence of a major slope failure.

Because of the land development for house and cultivation, trees have been cut down at the base of the mountain to expose the entire area of Penang Hill.

In addition to the natural erosion of Penang Hill these recent developments have greatly accelerated its erosion rate.

Figures

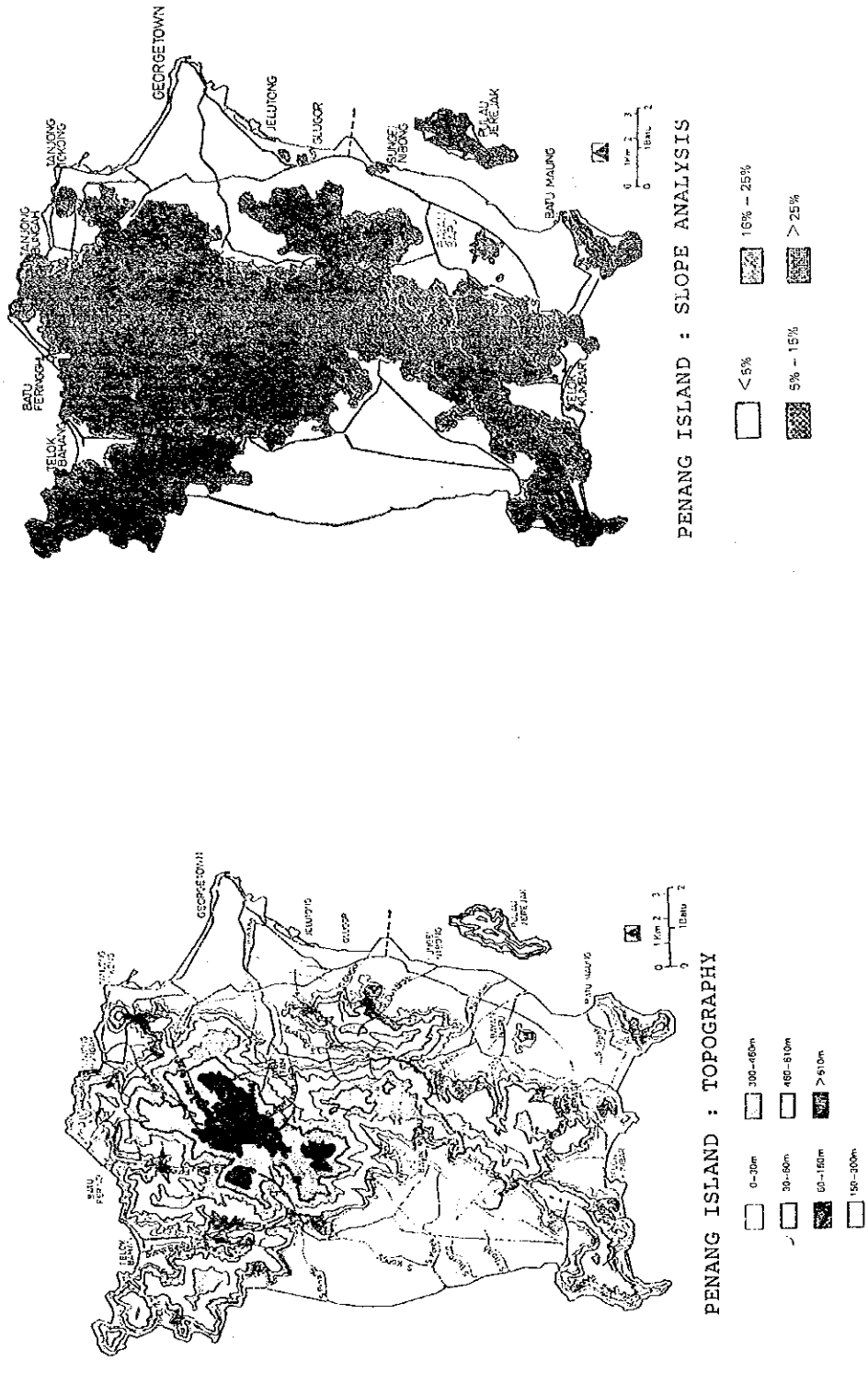
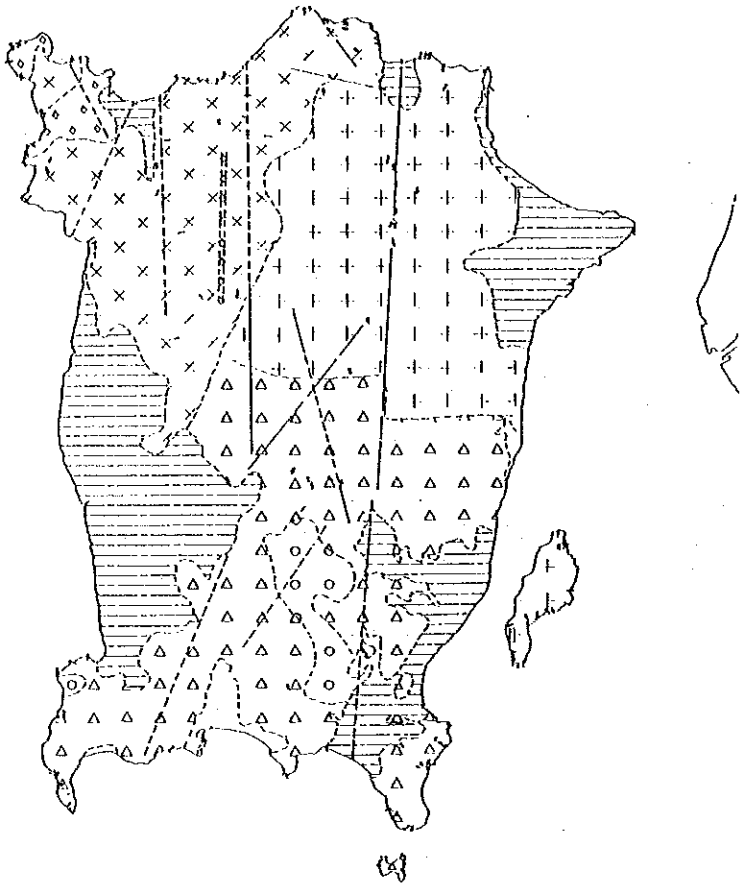
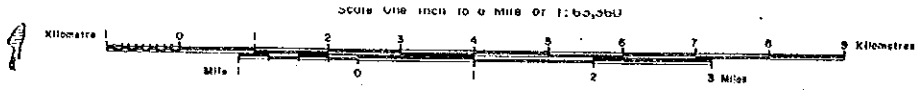


FIG. B-1	**TOPOGRAPHY AND SLOPE ANALYSIS OF PENANG ISLAND**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND





GEOLOGICAL SEQUENCE

AGE	FORMATION			DESCRIPTION
QUATERNARY	RECENT SEDIMENTS			Unconsolidated marine clay, sand and gravel deposits of the coastal plain and fluviatile deposits along the valleys.
				UNCONFORMITY
POST - GRANITE (Age Unknown)	MINOR IGNEOUS INTRUSIVES	QUARTZ VEINS & DYKES		Numerous quartz veins and dykes of variable length and width. (not to scale).
		APLITE VEINS & DYKES		Numerous aplite veins and dykes with marks of biotite or tourmaline. (not to scale).
		PEGMATITE VEINS & DYKES		Pegmatites are generally composed of quartz, feldspar and biotite or tourmaline. May be banded (not to scale).
TRIASSIC - JURASSIC (?) PERMO - CARBONIFEROUS (?)	MAJOR IGNEOUS INTRUSIVES	ORTHOCLASE TO INTERMEDIATE MICROCLINE ALKALI FELDSPAR GRANITE		Fine-grained biotite granite. Texture varies from fine-grained saccharoidal to fine-grained porphyritic.
				Medium- to coarse-grained porphyritic biotite granite.
				Mainly fine- to coarse-grained porphyritic. (Altered granite).
		MICROCLINE ALKALI FELDSPAR GRANITE		Fine-grained biotite granite. Exhibits only fine-grained saccharoidal texture. Muscovite present.
				Medium- to coarse-grained porphyritic biotite granite. In most areas it is more of medium grained. Muscovite is primary and as abundant as biotite. Andalusite is present as an accessory mineral.
SILURIAN - ORDOVICIAN (?)		SUNGAI PETANI FORMATION (?)		Mainly of ferruginous and carbonaceous slate. Encountered only on the island of Pulau Kendi.

SYMBOLS	Geological boundary.	Fault observed in the field.	Fault interpreted from aerial photographs.

FIG. B-2 **GEOLOGICAL MAP OF PENANG ISLAND**

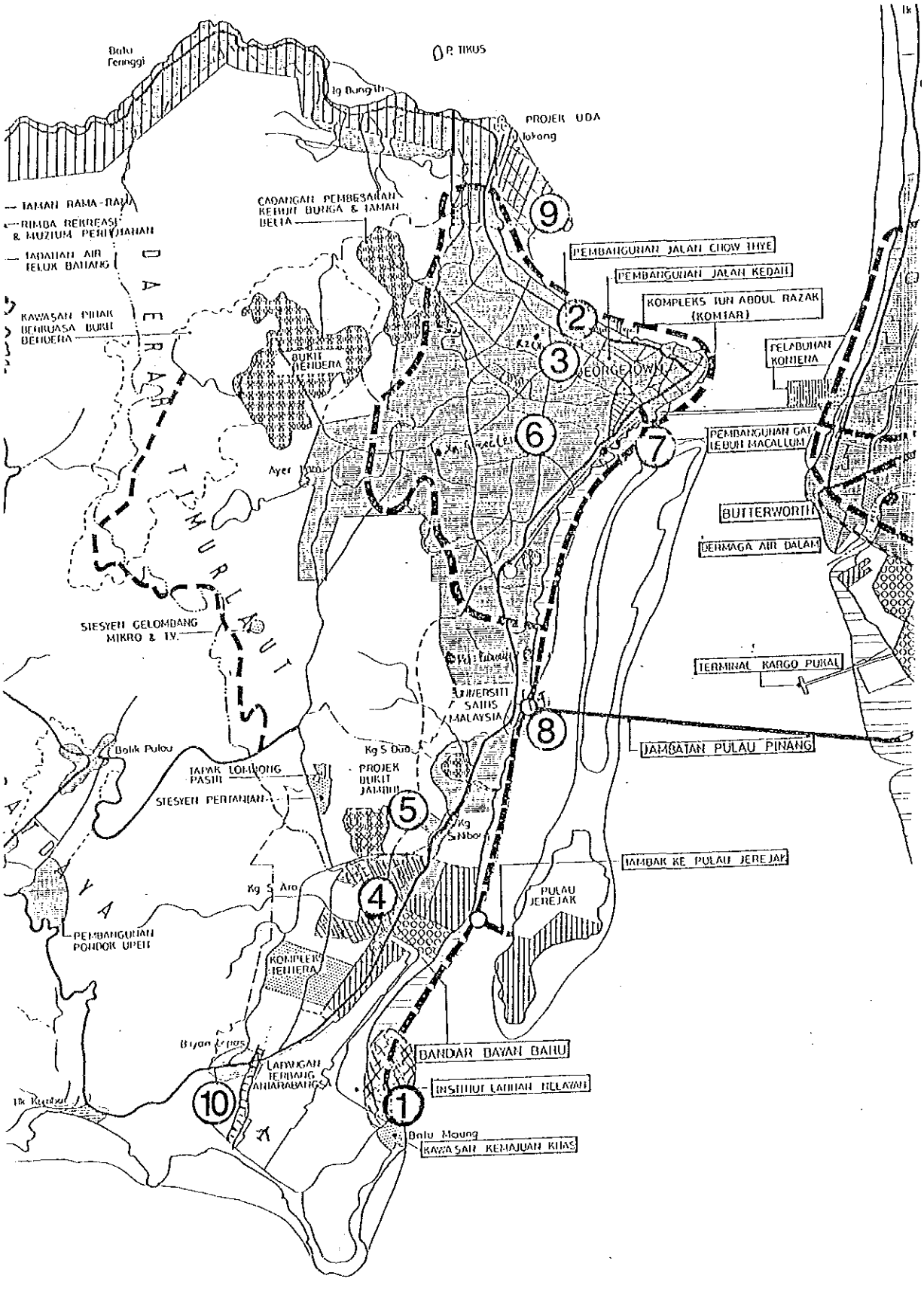


Fig. B-3 **LOCATION OF EXISTING BORE HOLES**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

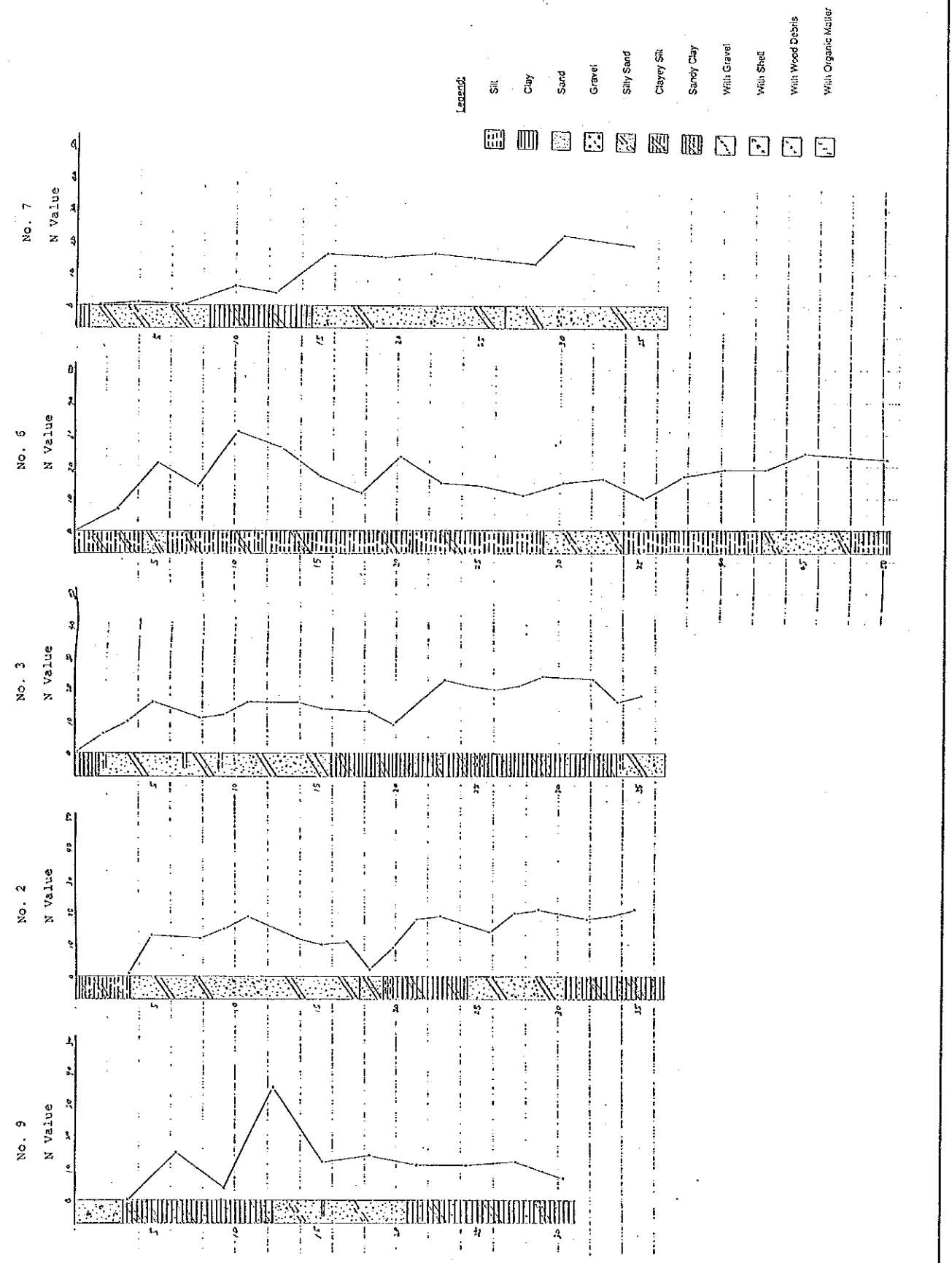


Fig. B-4 **LONGITUDINAL SECTION OF STUDY AREA (I)**

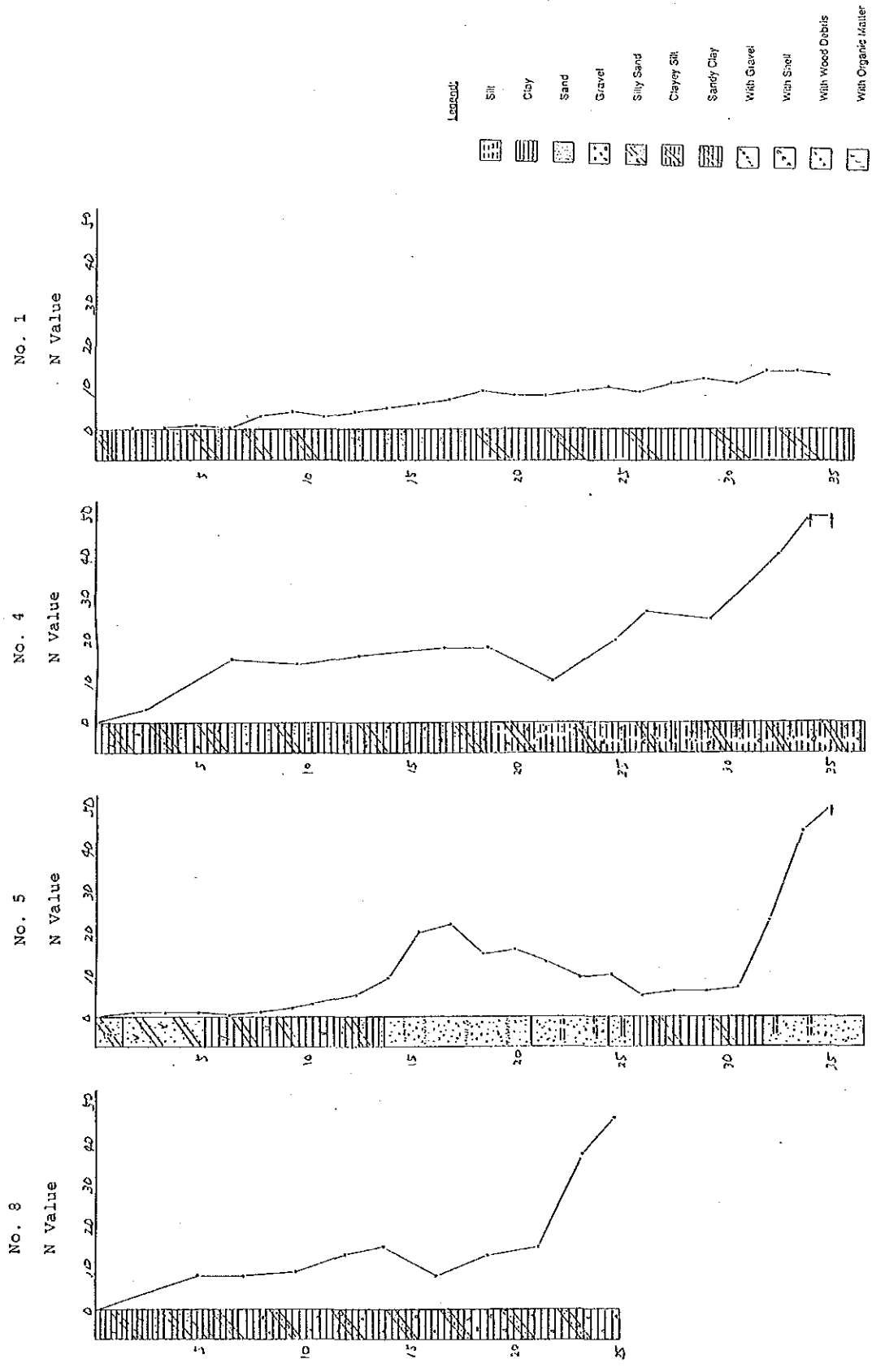


FIG. B-5 **LONGITUDINAL SECTION OF STUDY AREA (II)**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

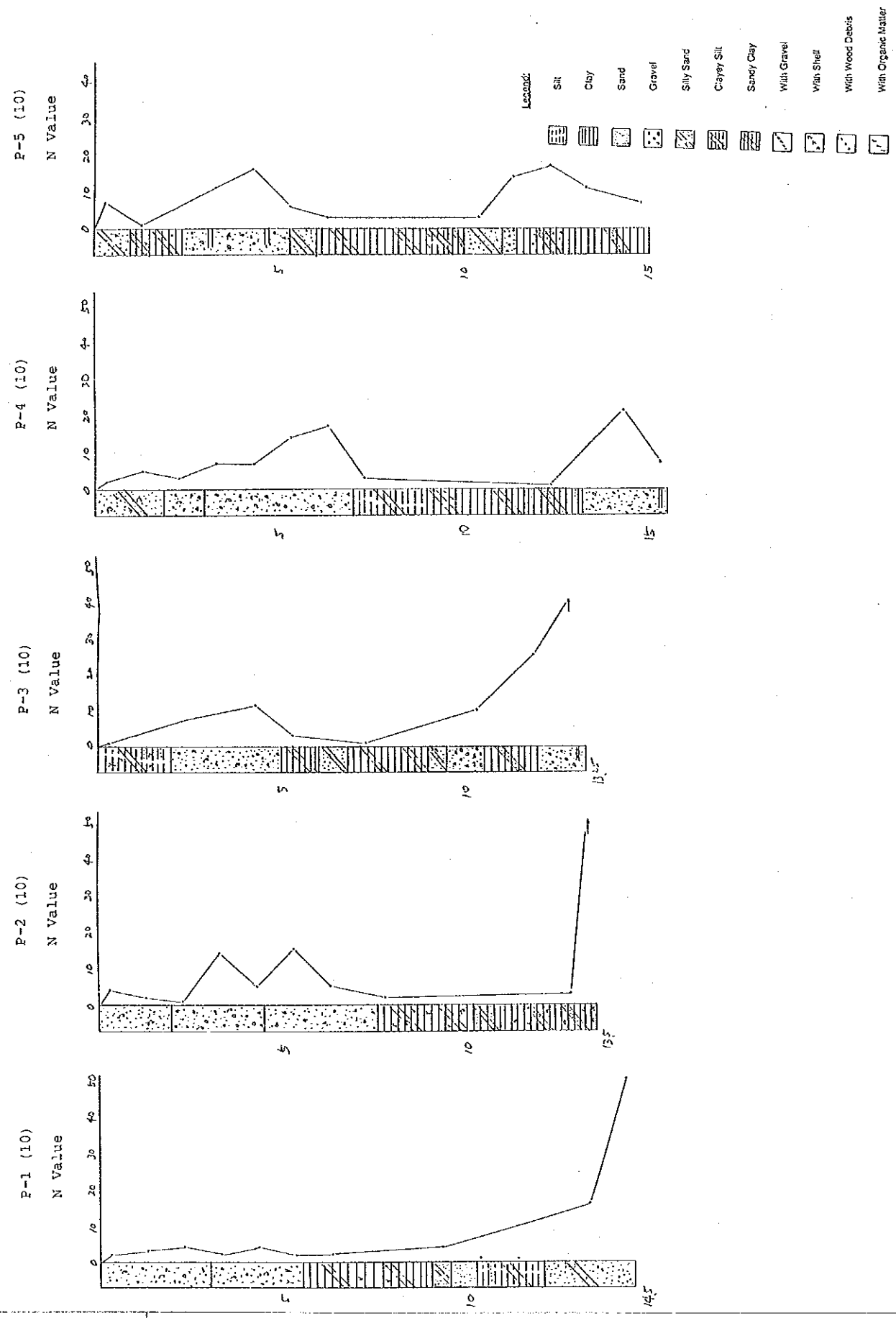


Fig. B-6 **LONGITUDINAL SECTION OF STUDY AREA (III)**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

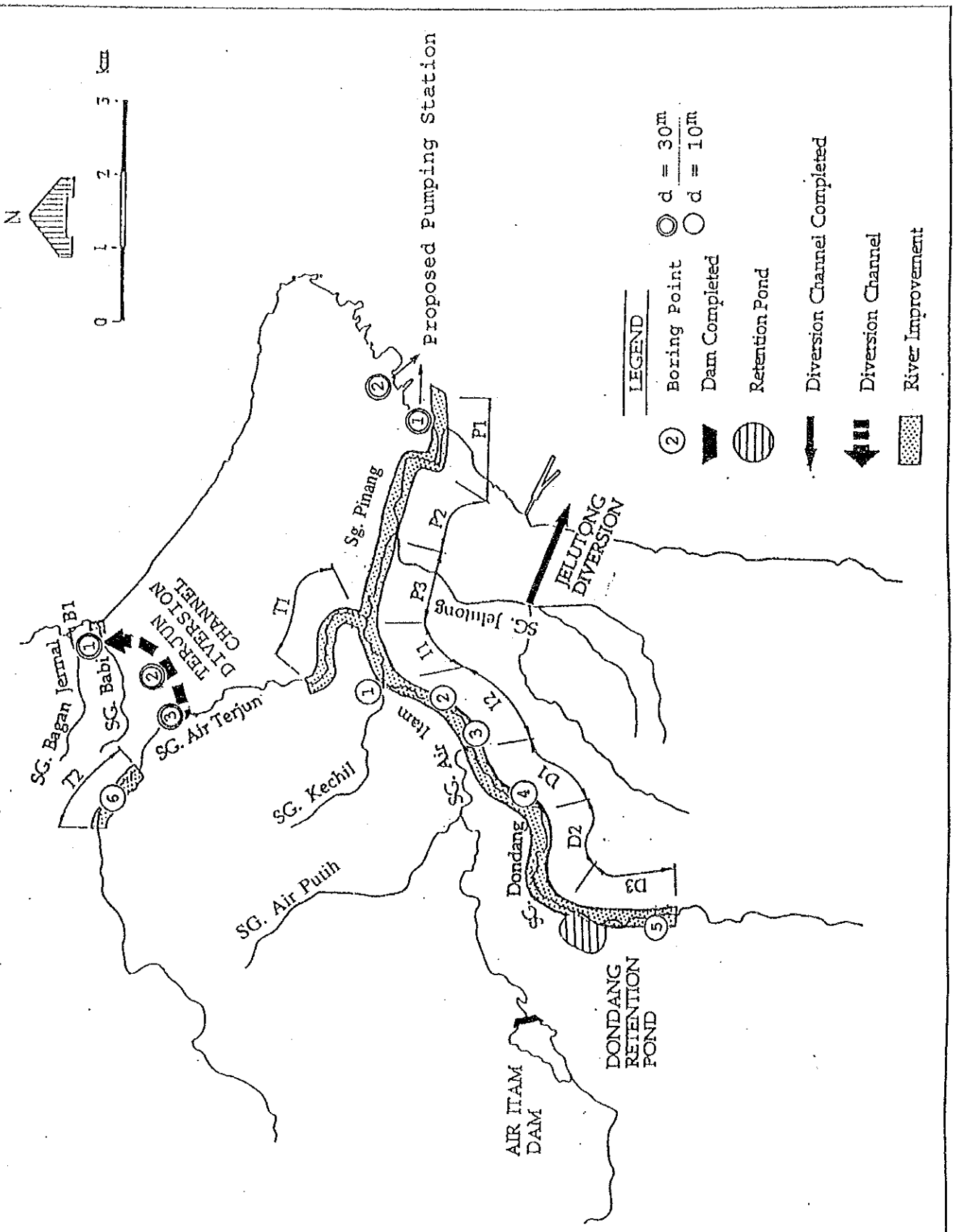


FIG. B-7 **LOCATION OF EXPLORATORY BORING**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

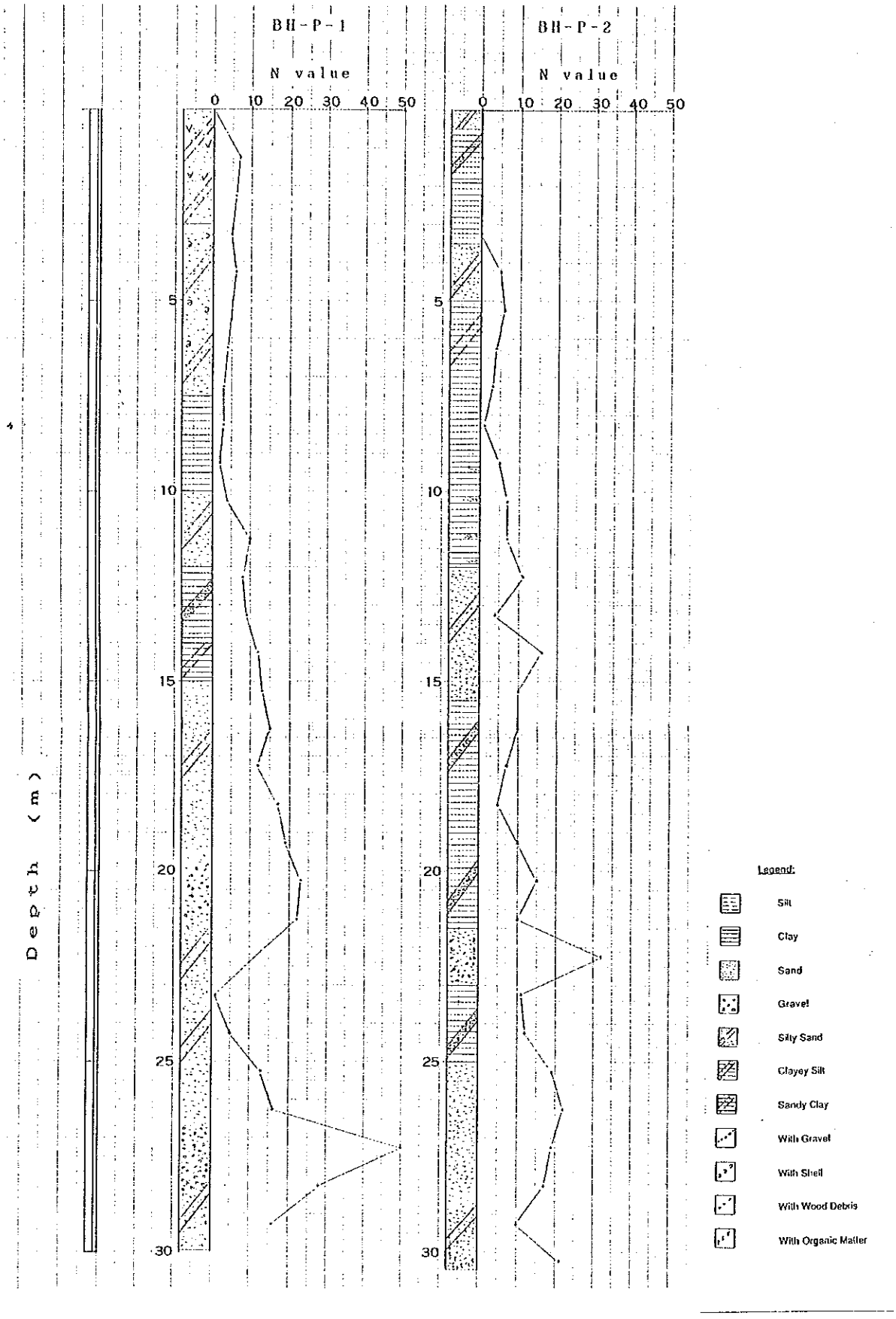


FIG. B-8 **SOIL PROFILES AT PUMPING STATION SITES**

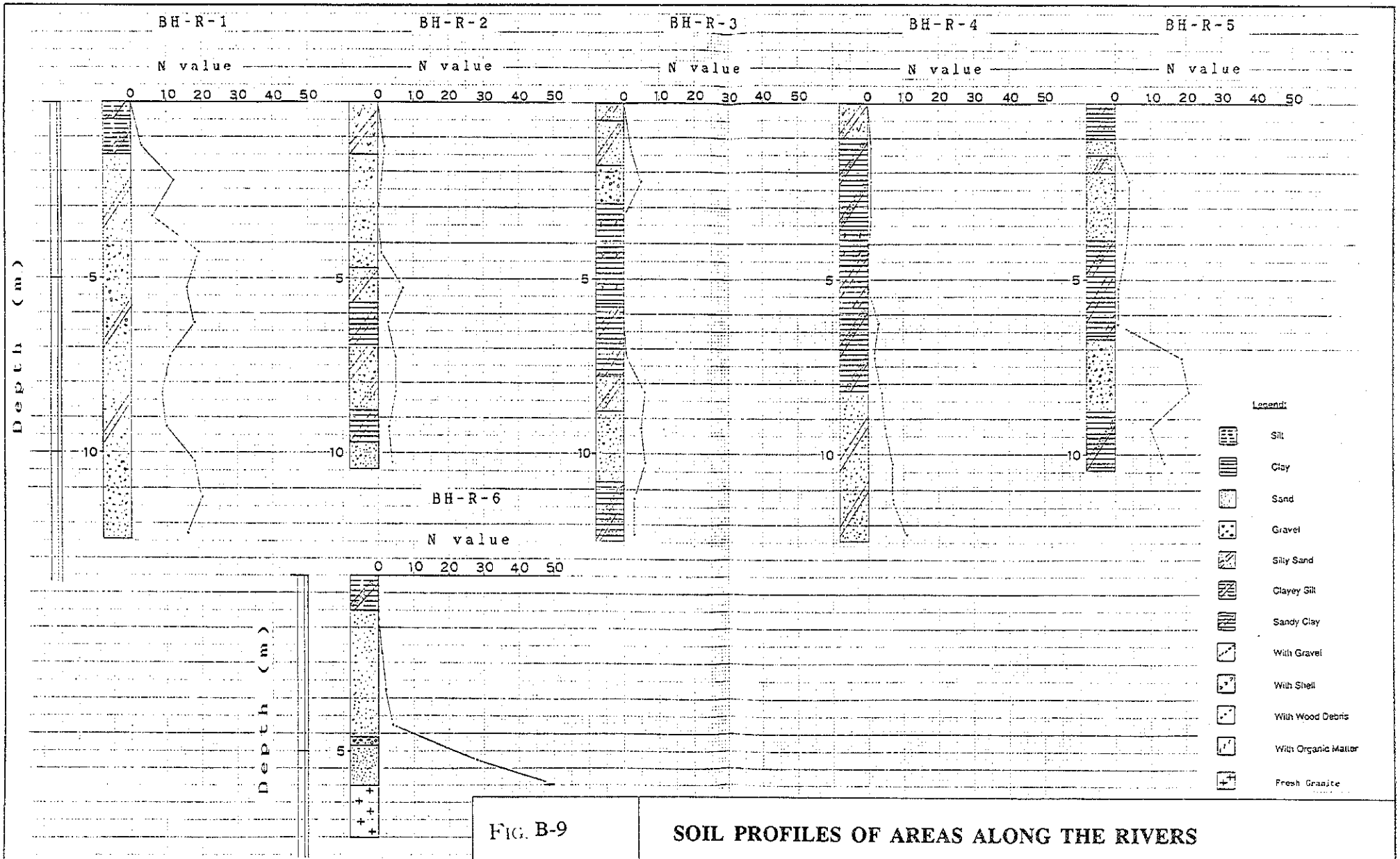


FIG. B-9 **SOIL PROFILES OF AREAS ALONG THE RIVERS**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

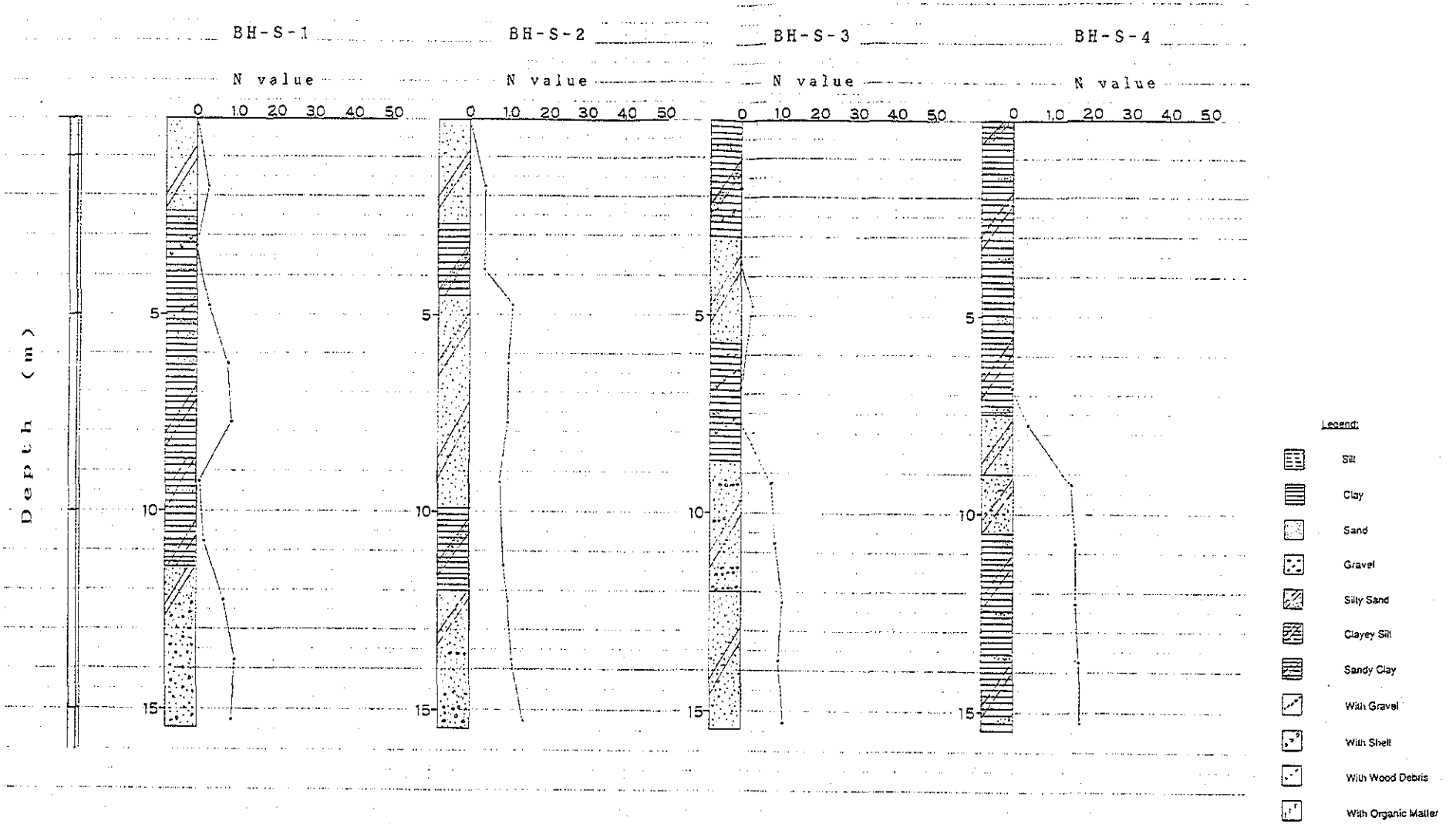


FIG. B-10 **SOIL PROFILES OF AREAS ALONG SG. PINANG (1)**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

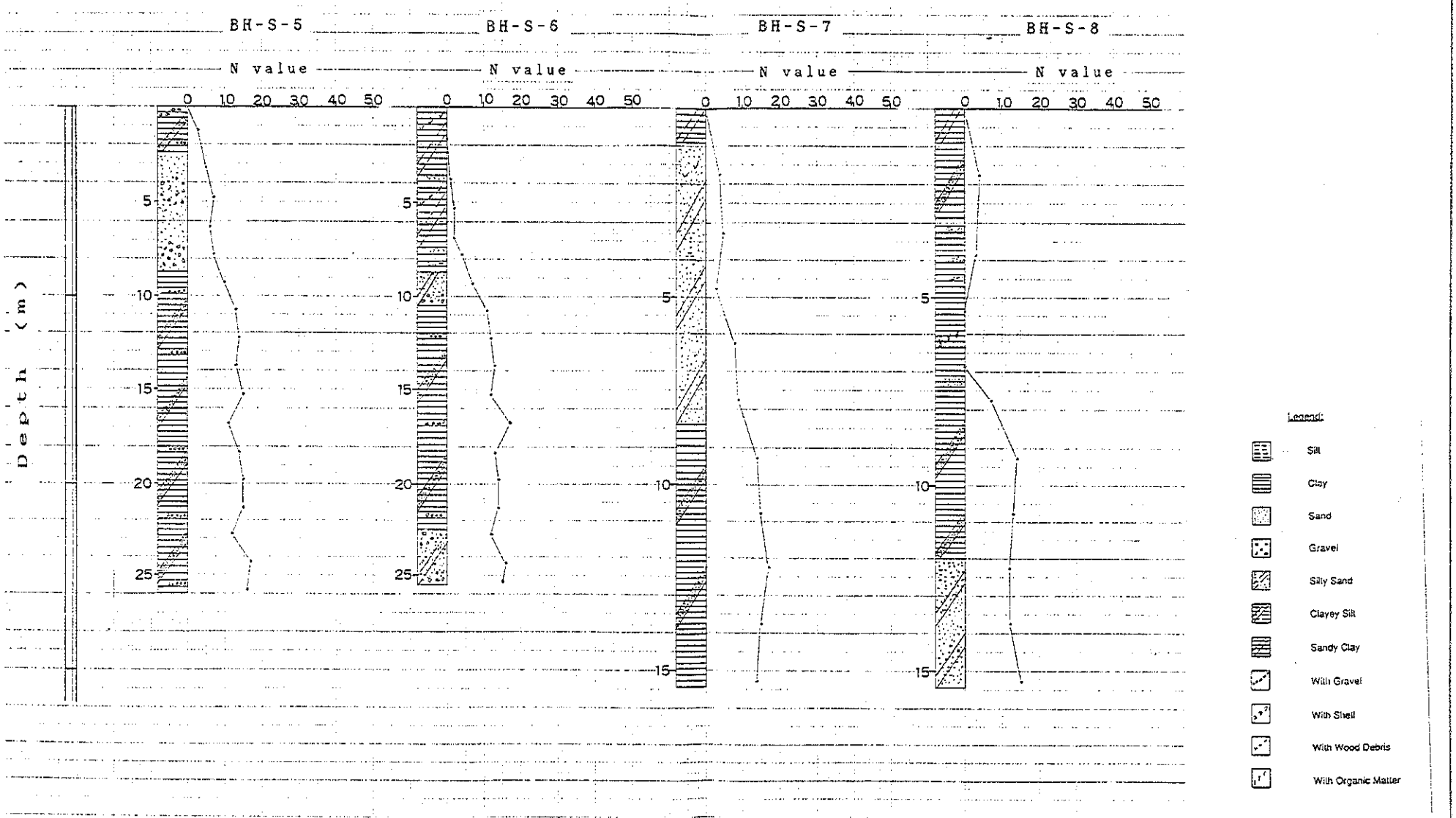


FIG. B-11 **SOIL PROFILES OF AREAS ALONG SG. PINANG (2)**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

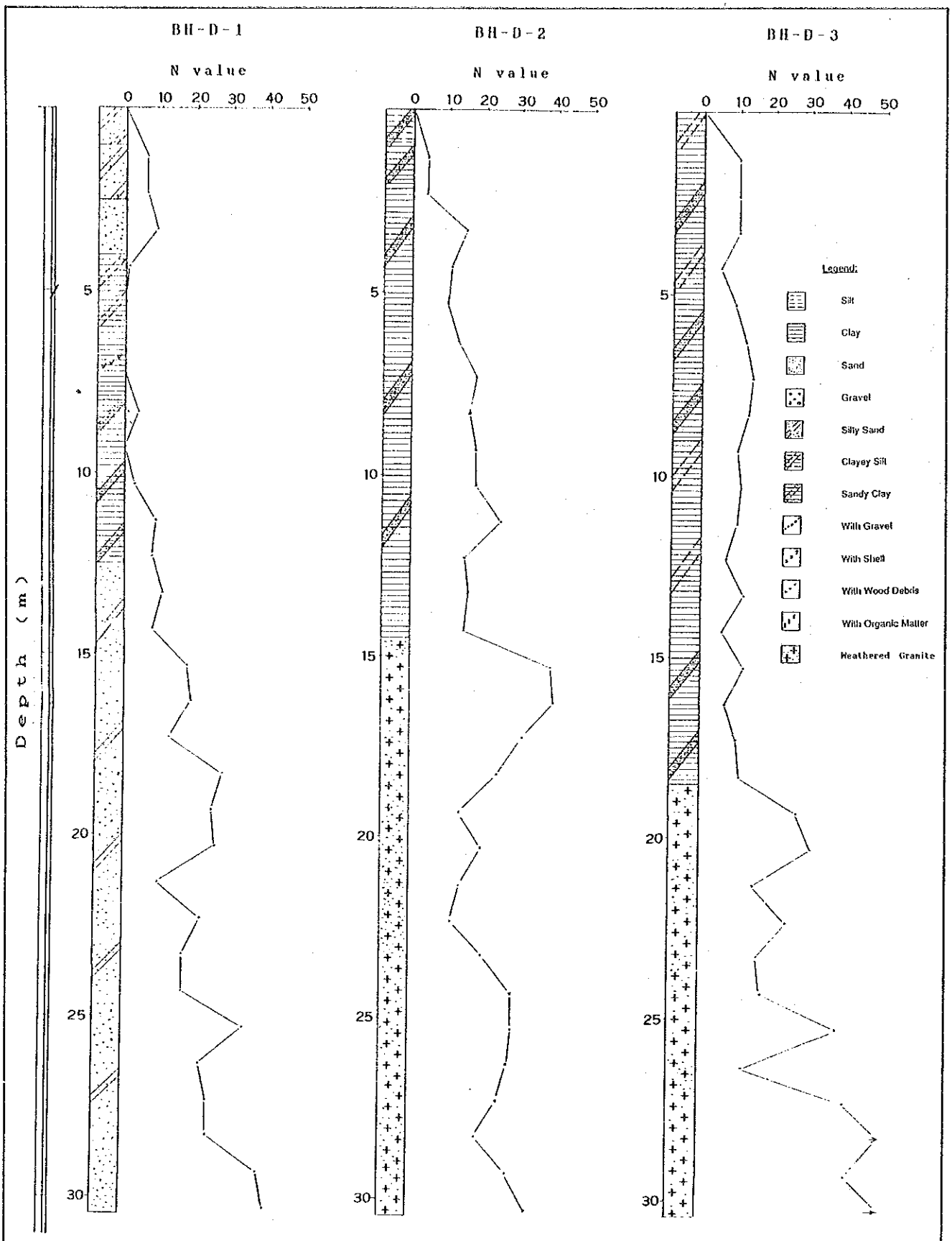


FIG. B-12 **SOIL PROFILES OF AREAS DIVERSION CHANNEL ROUTE**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

JICA

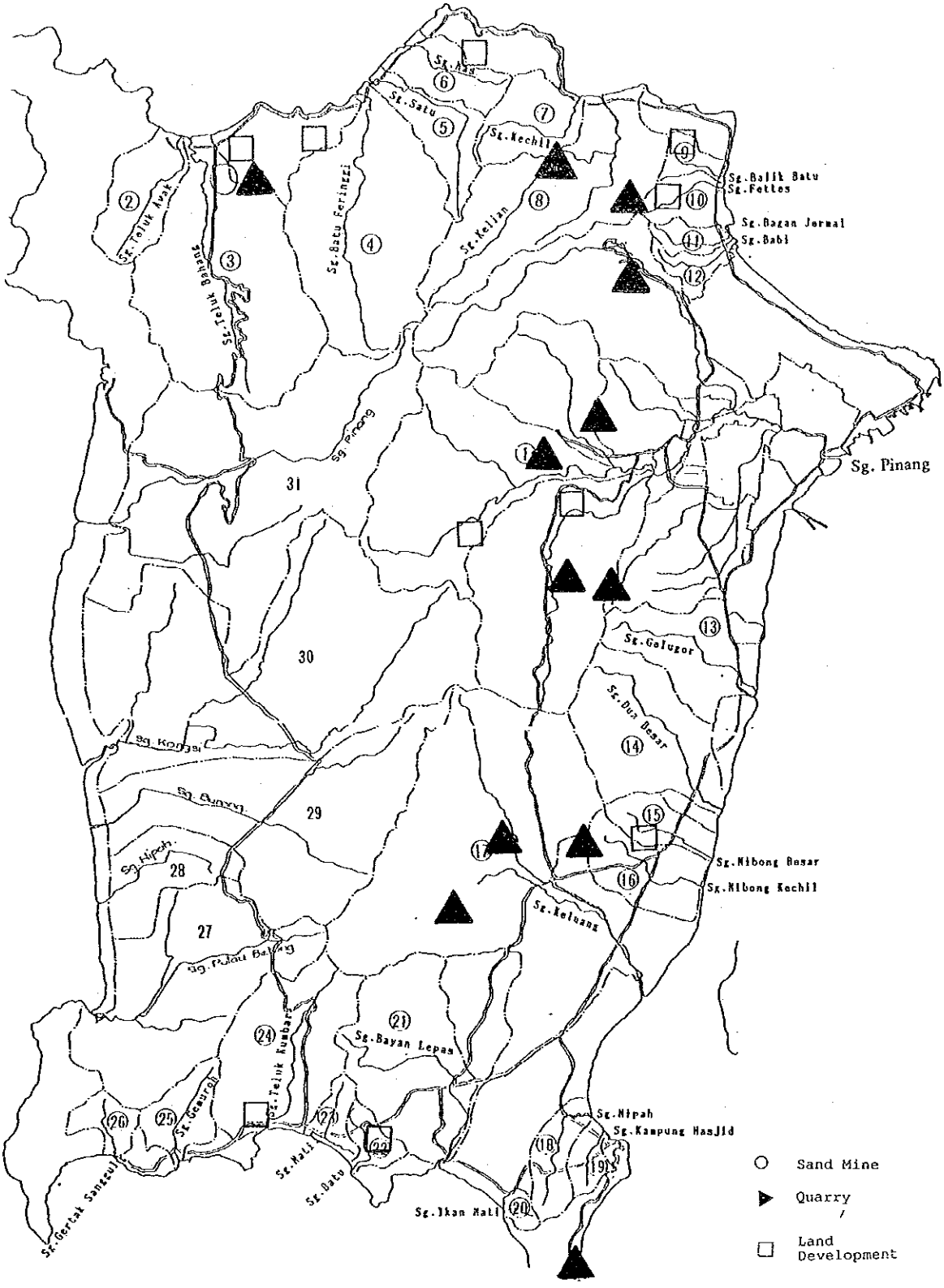
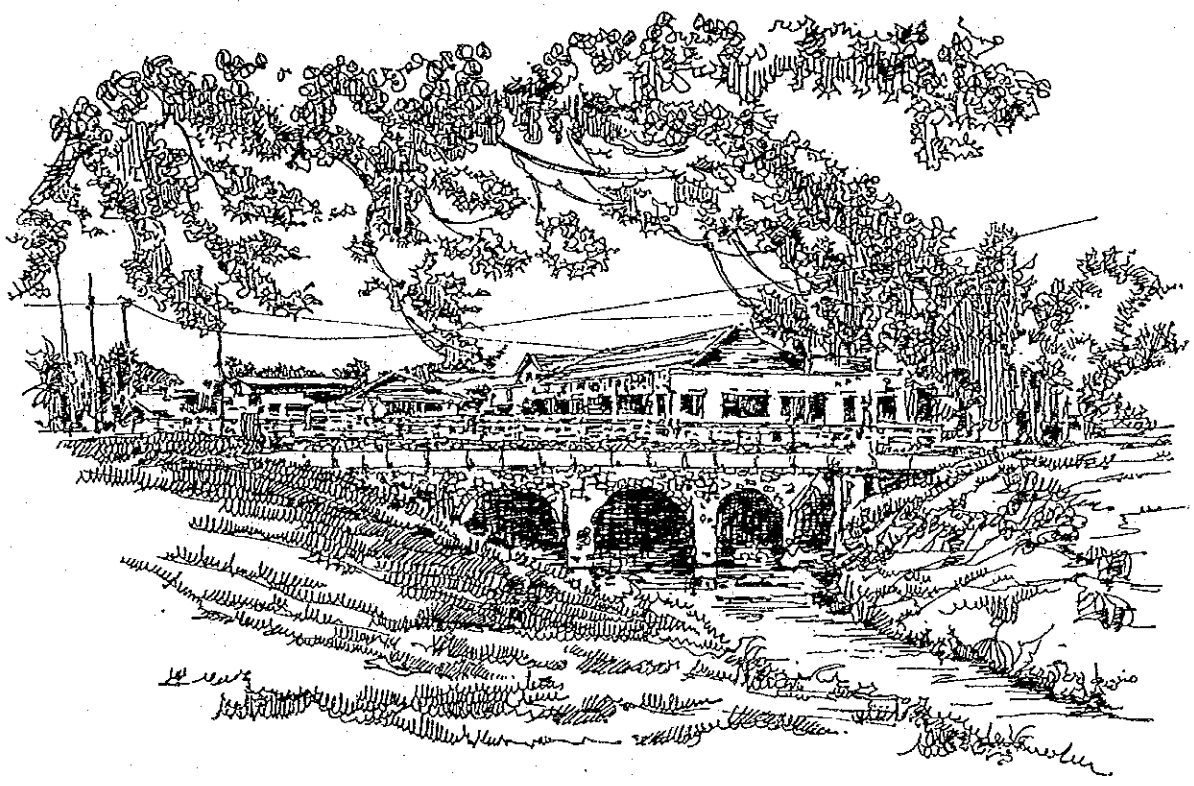


FIG. B-13 **LOCATION OF ORIGINAL SOURCE OF EROSION**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

APPENDIX C

URBAN AND LANDUSE PLANNING STUDY



APPENDIX C. URBAN AND LANDUSE PLANNING STUDY

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APPENDIX C. URBAN AND LANDUSE PLANNING STUDY

1. INTRODUCTION

The objectives of the urban and landuse planning study are:

i) Collecting and getting information for review of existing data concerned with present and future landuse plans, urban development as well as other related development conditions and trends along with catchment areas of the objective river system and feasibility study areas in Penang Island.

ii) Review of existing landuse conditions, and development sites in detail relevant to feasibility study along with objective area of the river system.

iii) Formulating an updated landuse composition mosaic patterns on the map by each aligned catchment area of the Penang Island, making an adjustment study for future landuse in order to maintain watershed preservation and flood control on the basis of the structure plan, urban and regional development schemes.

iv) Formulating a future landuse composition mosaic pat terns on the map by the same aligned catchment area, and setting up of the landuse patterns through analysis on the area of the landuse composition within each catchment area.

v) Identifying the landuse changes towards the target year of 2010 by each of 26 sub-catchment areas and incorporating the result of landuse composition to hydrological and river engineering studies.

2. EXISTING LANDUSE AND DEVELOPMENT TREND

2.1 Existing Landuse

In general, Penang Island has an area of about 295.3 sq.km and topographical features show a clear distinction between coastal plains and large portion of interior hilly terrains. About 43% of the Island is situated below 30 m altitude, land between 30 m and 45 m is about 3.9%, and another 3% of the land is situated 45 m to 60 m altitude range. Fig.C-1 shows the study area for flood mitigation and drainage.

Within these topographic condition of the Penang Island, generally about 25% of the land is forest area which is distributed in 300 m to 750 m in altitude, and some mangrove forests are distributed mainly along the west coast.

Agriculture area covers 40.7% of the Island, out of which 32.4% is under rubber plantation, 18.6% under orchards, 15.8% under coconut plantation and 9.4% under paddy cultivation. The rest 23.8% is under the landuse of mixed horticulture, vegetable and nutmegs.

Regarding built-up area at present, about 22.2% of the total Island area has been built up. This built-up area cover

Georgetown and expands along 3 directions, northwards to Tanjung Bunga and Batu Feringghi, westwards to Air Itam and the Paya Terubong valley, and southwards to Bayan Baru new township and Bayan Lepas.

This built-up urban area is formulated as a large scale metropolitan area along the eastern coastal zone of the Island. Rather small mosaic patterns of other built-up area of the Island are the minor towns and villages such as Teluk Bahang. Teluk Kumbar and Balik Pulau which are mainly composed of agriculture and fishery oriented settlements.

Within the built-up area, indigenous Kampong-type residential areas occupy a large portion with 37.6% of the total built-up area. Permanent type residential areas occupy 21.9% of the total built-up area. While commercial area makes up to 3.5%, industrial area which is mostly located in Bayan Lepas makes up to 2.6%, and educational area 6.4%, and cemeteries 4.0%. The institutional landuse accounts for 12.3% of the total built-up area.

Table C-1 and Fig.C-2 show the composition of present landuse pattern of Penang Island, and Fig.C-3 shows the urban growth trend from 1960 to 1985.

2.2 Development Trends

2.2.1 Development Trend in Regional Context

Traditionally, Penang Island has been a trading and commercial base and a tourism centre in the state.

Georgetown is one of the top ranking towns in Malaysia. Penang continues to be a major growth centre for the northern region of Peninsular Malaysia, and Georgetown is identified as the Northern Regional Centre.

Table C-2, Fig.C-4 show the future landuse pattern of Penang Island.

2.2.2 Industrialization and Urbanization

The Penang state has embarked on a rural industrialization programme which has resulted in the development of industrial estates such as the Free Trade Zone of Bayan Lepas and Prai. Over the next 5 to 10 years, the State government will further promote the industrial sector on this zone.

In conjunction with the rural industrialization programme, the State government will implement the rural urbanization programme.

The aim of this strategy is to transform the rural areas into planned, urban settlements by introducing modern urban facilities to the rural population and labour force employed in the industrial estates with a view to reducing the problem of rural-urban migration.

This programme involves the building of housing facilities, the provision of commercial space, basic social amenities and recreational facilities. These urbanization programme have

been implemented at the new township of Bandar Bayan Baru and Seberang Jaya.

Also the State housing development has started numerous housing projects in accordance with the urbanization programme.

2.2.3 Commercial Development

Georgetown urban form lies in the conurbation and development of old buildings located at fringe commercial area into modern shop-houses and offices.

The most of residential use at inner city area tends to change into mixed use, the trends toward commercial use has increased. Georgetown's urban form characteristically changes to multi-story office complexes on lots. Redevelopment of these lots are fairly active, especially in the Central Business District.

2.2.4 Residential Development

In the environ of Georgetown, the demand for residential developments has risen. There are redevelopment of underdeveloped properties inside of Georgetown and an extension of existing development of new housing schemes.

The new development areas are predominantly in the township of Air Itam, Gelugor, Paya Terubong, Sungai Nibong, Sungai Ara, Batu Uban, Tanjung Tokong. The most of housing development tend to be low cost flat type with an emphasis on maximizing the density.

The extra space for the housing area has become difficult to obtain inside of Georgetown, and hence the housing developments tend to scroll toward the township, such as Bayan Baru, Sungai Nibong, Sungai Ara, Sungai Dua, Gelugor and Air Itam to Paya Terubong.

2.2.5 Agriculture

In accordance with National Agriculture Policy, implementation of the Integrated Agriculture Development Project and the improvement of infrastructure facilities especially in paddy growing areas have been proceeded. Also the State emphasises on the optimum utilization of agricultural land.

2.2.6 Land Reclamation

Three major land reclamation programme are planned for reinforcing the long term development of Penang. Objective areas for the reclamation are situated along eastern coastal zone.

The reclamation project along Batu Maung to Penang bridge is under implementation. The Penang Development Corporation (PDC) has been carrying out the land reclamation of about 570 ha which is planned to be completed by 1995.

Meanwhile approximately 210 ha of the coastal area from Penang bridge to Prangin Street Ghaut has been proposed for reclamation. This will be one of the most important area of

development for the future growth and function for Penang, which is recognized as "Central District Development 21" (CDD21). Most of this area is planned to be commercial with luxurious residential and recreational zone.

The other reclamation has also been proposed at Tanjung Tokong for tourism oriented residential and commercial purpose, however the project would be a rather long term one beyond 21st century.

Fig.C-5 shows a future land reclamation scheme in Penang Island.

2.2.7 Tourism

Penang Island as a major international tourist destination, the State Government is taking greater effort to develop Tanjung Bunga, Batu Feringghi and Teluk Bahang as major tourist areas, and variety of hotels, resort residential areas, tourism facilities and amenity cores are projected in line with the policy.

3. DEVELOPMENT FRAMEWORKS

3.1 Penang Island Structure Plan

According to the Town and Country Planning Act, (Act 172), which introduced for the first time a comprehensive system of town and country planning in the states of Peninsular Malaysia, the Municipal Council of Penang Island has embarked on drafting a structure plan covering whole Penang Island.

This preparation of the Penang Island Draft Plan consisted of 2 stages, study of the planning area and preparation of report, and formulation of the draft structure plan. Series of survey and study were made and the Draft Structure Plan by Municipal Council in September 1987.

Within this Draft Structure Plan, the planning goals which described broadly the future desired situation, towards which all the policies and strategies of the local planning authority are aimed at, and objectives to be translated into more details, and also strategies and programmes for action formulated to achieve the objectives, are incorporated.

This Draft Structure Plan has been made a minor amendments and additions, and been approved as the Structure Plan by the State Committee on October 1989.

In accordance with the Draft Structure Plan, Urban and Landuse Planning Study on the Flood Mitigation and Drainage has been undertaken to review the Draft Structure Plan.

On the basis of the Draft Structure Plan, some of Local Plan is in progress in the most urgent local units such as Batu Feringghi for tourism development. Also some adjustment and modification covering whole Penang Island have been made on the landuse plan. These most up-dated data and information have been used in the study on flood mitigation and drainage in Penang Island in corporation with Municipal Council as well as State Government.

3.2 Future Landuse Plan

To draw a master plan for the flood mitigation and drainage,a future landuse plan is of vital importance. this future landuse plan must conform with policies set up in the regional and urban development plans.

In Penang Island, the Draft structure Plan for major urban areas were prepared and published in 1986. On the basis of the Structure Plan, Municipal Council has started an alteration of the landuse framework towards year of 2010. Also the implementation of detailed local plans have started. According to the Penang Island Structure Plan, the future landuse policies had been proposed as follows.

i) The landuse structure plan and strategy for Penang Island in the target year of 2000 are described in Draft Structure Plan.

ii) For particular areas of east coastal zone such as Georgetown, Bayan Baru, Bayan Lepas and Tanjung Tokong conurbation, and estate lands, which are currently under pressure for conversion and development, landuse and local specific landuse are decided to prepare at the earliest possible stage;

Based on the above future landuse plan as shown in Table C-2, the landuse composition in Penang Island in the year of 2010 will take up the pattern as shown in Table C-2 and Fig. C-4.

4. LANDUSE COMPOSITION BY SUB-CATCHMENT AREA

4.1 Data and Information sources and Method of Analysis

Data and information of landuse composition pattern both present and future condition in the target year of 2010 are mostly relied in the Municipal Council, Structure Plan Unit, and town Planning Department, Planning Control Section, and the State Town and Country Planning Department.

On the basis of complied data and information, the existing condition of landuse pattern was plotted on the map of scale 1:25,000, and projected into the respective catchment areas of objective 25 river systems. Same preparation was made for the presumed future condition of landuse pattern. Fig.C-3 shows a sub-catchment area for the study.

For calculation of each landuse composition pattern, the dot counting method has been applied for measurement of areas with 1 ha counting unit for each 26 river catchment areas beside 5 river catchment area located at the western part of the Island as a study reference.

The catchment area designation for both present status and future status has been applied on the same basis, and the landuse composition changes of each individual catchment area has been identified for both the present and future uses. Fig.C-6 shows the map of sub-catchment area of the study.

4.2 Analysis on Landuse Changes Towards 2010

As a result, the general landuse analysis are shown in Table C-3, Table C-4, Table C-5 and Fig. C-7.

Landuse composition of the catchment area of Sg. Pinang system covered by the City of Georgetown is about 39% of the whole urbanized area at present, and this portion of urbanized area will expand to about 46% in the year of 2010.

Especially greater urbanization trend is expected at the catchment area of Sg. Air Terjun, Sg. Dondang and Sg. Air Itam. These will be mostly of residential expansion encroached into the agriculture landuse zone of the hilly area. In northern coastal zone between Georgetown and Teluk Bahang, the catchment areas of Sg. Teluk Bahang, Sg. Teluk Awak and Sg. Mas would tend to expand as an urbanized area, and the 7% to 14% of present built-up areas would reach 30% to 70% of the landuse in the future. These areas are mostly of residential landuse with some tourism oriented development along Batu Ferringghi to Teluk Bahang.

In some eastern coastal zones lying between Georgetown and Batu Maung, the catchment areas of Sg. Keluang, Sg. Dua Besar, Sg. Nipah and Sg. Gelugor would characteristically tend to expand as an urbanized area. About 12% to 46% of present built-up areas will reach to 44% to 93% of the landuse in future. These are mostly of residential landuse with some industrial and industrial related residential use.

In southern coastal zone between Batu Maung and Gertak Sanggul, the catchment area of Sg. Bayan Lepas and its bypass would characteristically tend to expand as an urbanized area.

5. FUTURE PARK LANDUSE AREAS ALONG RIVERS

Penang Municipal Council has carried the study of future landuse plan through the structure plan procedure, and within the structure plan there are quite numbers and amount of park land areas have been designated for improvement of the environment of urban area. Riverside areas also designated as park areas along major river system in Penang Island.

In connection with flood mitigation and drainage study, these park landuse areas are vitally important to improve river channels and retention ponds development as well as gradation of riverine environment condition and landscape when these spaces would be sufficiently acquired.

5.1 Park Area Along Sg. Pinang

Landuse pattern of Sg. Pinang is specifically identified at river front park area for future landuse scheme targeting year of 2010.

Future park landuse area is parallel allocated at both side of the Sg. Pinang with width of 10 meter to 50 meter. These status of the park landuse area is efficiently functioned for retaining enough river reserve width, and these continuous park land constitution become so vital for creating a sequential

river front park system development in both quantitative and qualitative.

Especially at the confluence of Sg. Air Itam and Sg. Terjun also upper stream of this point of Sg. Air Itam, future park landuse area is paid quite vitally important role to rehabilitate and enhance the riverine environment and urban scape as well as function of recreational park.

5.2 Park Area Along Sg. Dondang

Recreation parks adjacent Sg. Dondang and neighborhood parks for the objective retention ponds projection are both allocated within the housing development area. Two neighborhood park sites out of other three parks involve partially old cemeteries remained in mosaic pattern, and these cemeteries allocation may affects difficulties for formulating effective space for retention ponds. So that these group of old cemeteries have to reallocate or remove to other places for development of the retention ponds for flood mitigation purpose, if necessary.

Meanwhile, a neighborhood park which already implemented within newly developed housing area shall be considered for readjusting to obtain the function of retention ponds within the park area.

5.3 Park Area along Sg. Ara and Sg. Keluang

Park landuse area along Sg. Ara and Sg. Keluang is sufficiently and continuously allocated approximately 4.5 km from estuary to the hillside area. This park landuse pattern has width of 20 meter to 50 meter at both river banks, and these land condition meant the maintain of river reserve as well as high potential of the riverside park system establishment.

Along the down stream of Sg. Ara and Sg. Keluang there is a well maintained on the wide river reserve with approximately 80 meter space for future river side pedestrian network and landscaping space.

Fig. C-8 and C-9 show river side parks area and conceptual water front park system in relation with necessity of the retention pond.

6. EXISTING LANDUSE AND DEVELOPMENT TRENDS AT FEASIBILITY STUDY AREA

In general, existing landuse condition and development trends on the objective area for the feasibility study are rather limited areas along the river system. These objective areas are mainly at Sg. Pinang and Sg. Dondang of the tributary, Sg. Ara and Sg. Keluang, diversion channel route along the Jln. Gottlieb, Jln. Bagan Jermal and Sg. Babi, and reclamation area near the estuary of Sg. Pinang.

6.1 Sg. Pinang Area

The landuse of the upper reach vicinity to the confluence of Sg. Air Itam and Sg. Air Terjun is more traditional residential, and public facilities sited.

The middle reaches around Jln. Pantai bridge, traditional houses are mainly sited and some settlements of squatters houses are existed near the edge of the river.

The down reaches around Jln. Perak to Jln. Sungai Bridge, the government quarters and public facilities. Further down to the Sg. Pinang estuary, landuse consists of warehouse, small industrial facility and workshop areas.

Generally the river reserve area is irregularly formed in it's shape. Most of their residential houses and industrial buildings which faces to the river are rather in old and not so good at condition.

General outlooks of the river reserve along the river is mostly keeping at moderately well maintained within bank slopes comparing with the condition of previous years.

6.2 Sg. Ara and Sg. Keluang Area

The river reserve of this area is quite identifiable clear in form comparing other river system within Penang island, and landuse pattern adjacent to the river is balanced stable without affecting any development activities and other influences.

PDC's landuse scheme had been well projected to formulate the landuse pattern and controlled the development trends in well balanced condition. The character within vicinity along the river show representative village groves and riparian groves.

6.3 Sg. Dondang Area for Proposed Retention ponds

Most of this area is residential landuse pattern at Paya Terubong, the river passes through new housing development area of Taman Terubong Jaya, Bandar Sun Moon and Taman Rambai,. Quite large scale of the housing development projects are in full swing at this moment. This housing development has been already finalized the earth works and in a stage of building construction.

High rise condominium type, detached type and semi-detouched type housings are coming to be realized in so many numbers within the project site.

Further down stream after Taman Rambai a new housing development area is now under construction stage. And the river passes through residential areas at Halaman Zoo and adjoining areas is expected to be developed.

The park areas which are projected in the structure plan on the Penang Island are coming to be appeared as shape of remained village groves and river fringe groves. A park has been already implemented with open green space covered with neat grasses surface at the surrounding housing area for ready to serve for public.

6.4 Diversion Channel Route Area

The diversion points at Sg. Terjun at upper stream is residential area adjacent to the Youth park, the most portion of the route is located at road side area within good conditioned residential area, commercial facilities as shop-houses, hotels and schools through Jln. Gottlieb. Hawkers activities at night time are the characteristics of the road side business zone along Jln. Gottlieb.

Along Jln. Bagan Jermal the landuse is more residential and institutional. Most of the residential buildings are single story houses types with quite good quality.

Down stream of the diversion channel is in Sg. Babi and most of the vicinity area along the Sg. Babi is kampong style residential.

6.5 Retention Ponds for Urban Drainage at Reclamation Area

Objective area at the Sg. Pinang estuary is a part of the CDD21 reclamation project area, and some of the estuary portion has been reclaimed and high rise of low cost housings has been implemented and some cluster type housing project will become to be projected soon.

At north west side of the proposed retention ponds site, there is squatter area of fishermen settlement with wooden jetties, and at offshore area there are cage culture for fishes.

The CDD 21 project is aiming to set up of good quality residential and commercial sub-center of Georgetown by large scale of land reclamation.

The retention ponds for urban drainage are proposed to be located on the outer fringes of reclamation areas.

7. PARK LANDUSE FOR TEMPORARY RETENTION PONDS

On the basis of the hydrological and river engineering study consideration, parks itself for using temporary function for retention purpose with approximately 10 years of return periods for diverting flood water.

Parks usually are utilized for recreational activities for vicinity and community peoples, no permanent pond or impound water situation may projected within these park areas.

These parks belong to MPPP and are utilized as either classification of recreational parks or neighborhood parks in accordance to the Structure Plan, and in most of the case there is any differentiation to other public park usage except 10 years return period of flood water retention.

8. LANDUSE ABOVE 200 FEET AREA

The draft structure plan of Penang Island has been approved as the structure plan by the State planning committee in late 1989, and landuse regulation regarding above 200 feet has been modified and became somewhat not so strict regulative status comparing the contents on the draft structure plan.

On this point of view for the flood mitigation and conservation of the greenery, followings may be considered.

- Private owned agriculture lands of above 200 feet are in keeping a good condition with quite stable tree type plantation greenery at present. This agriculture lands are strictly conserved as they are, and they are more carefully regulated not to be easily changed to such as housing development sites.

- Agriculture lands above 200 feet are to be given more strict guideline for introducing tree type agriculture instead of vegetable and crop type agriculture, so that surface soil shall be more safely conserved.

- Housing development above 200 feet land area shall be given strict guideline which establishes and conserves sufficient greenery belt or forest at downward surroundings of the development site due to maintain greenery volume and ground surface vegetation. Individual retention pond shall compulsory be installed incorporated with original runoff volume within the development site.

Tables

TABLE C-1 LANDUSE COMPOSITION OF PENANG ISLAND IN 1986

Landuse	Area (sq.km)	% over total Penang Island	% over total built-up Areas
Residential (permanent)	14.33	4.85	21.91
Indigeneous Housing	24.58	8.33	37.58
Commercial	2.27	0.77	3.47
Industrial	1.68	0.57	2.57
Educational	4.21	1.43	6.44
Government & Special Uses	8.06	2.73	12.32
Cemetries	2.63	0.89	4.02
Other Built-up Areas	7.65	2.59	11.69
Open Spaces	3.03	1.03	-
Forest & Scrub Forest	88.65	30.02	-
Agriculture	120.23	40.72	-
Vacant Land & Reclaimed Land	17.94	6.07	-
Total Area of Penang Island	295.26	100%	100%

Source: Report of Survey, Penang Island Structure Plan

TABLE C-2 PROPOSED LANDUSE PLAN OF PENANG ISLAND IN 2010

Landuse	North East George-town	District Rest of NED	NED Total	South West District (SED)	Total
Residential	997	2462	3429	969	4398
Commercial	202	62	264	84	348
Industrial	57	14	71	257	328
Public Utilities & Government Uses	201	139	340	666	1006
Tourism Facilities	Incl. com-mercial	10	10	6	16
Limited Uses	-	-	-	131	131
Park,Open Spaces	115	550	665	1477	2142
Area of Special Cha-ractor (Penang Hill)	-	42	42	-	42
Cemetry	213	79	292	82	374
Agriculture	-	-	-	10407	10407
Hill Land	137	Over all Penang Island			11241
Total					30133

Note: Tourism facilities mainly involves Hotel and Restaurant.
Limited use is mainly composed of Car port zone.

Source: Municipal Council, Structure Plan Unit

TABLEL C-3 LANDUSE COMPOSITION IN PENANG ISLAND
IN 1988 BY SUB-CATCHMENT AREA

Unit: hoctar

River No.	River name	Catchment area (ha)	resi-dential	Com-mercial	Indus-try	Educat-ional	Park area	Ceme-try	Open land	reserve area	Forest area	Agri-culture	Built-up area total
1-1	Sg.Air Itam	1064	107	9	0	2	0	0	0	0	828	118	118
1-2	Sg.Air Puteh	456	73	2	0	1	0	0	0	14	233	133	76
1-3	Sg.Dondang	1133	363	1	0	8	0	21	29	0	334	377	393
1-4	Sg.Air Itam/Sg.Pinang	105	53	1	3	17	8	14	3	6	0	0	96
1-5	Tributary/Sg.Air Itam	242	95	21	0	3	1	30	8	8	50	26	150
1-6	Sg. Air Terjun	1076	119	1	0	4	173	6	4	50	692	27	303
1-7	Sg.Pinang	73	49	8	0	6	6	0	1	3	0	0	69
1-8	Sg.Jelutong	169	135	0	2	22	0	5	2	3	0	0	164
1-9	Sg.Pinang	289	224	13	27	11	4	0	0	10	0	0	279
1-10	Sg.Jelutong	490	277	0	0	21	5	22	0	16	149	0	325
	Sub total	5097	1495	56	32	95	197	98	47	110	2286	618	1973
2	Sg.Teluk Awak	295	13	0	0	0	0	15	0	0	201	66	28
3	Sg.Teluk Bahang	1230	54	0	0	6	19	8	3	0	758	382	87
4	Sg.Batu Ferringghi	1127	0	6	0	0	0	0	0	0	1112	9	6
5	Sg.Satu	258	7	1	0	0	0	0	0	0	222	28	8
6	Sg.Masu	211	24	6	0	0	0	0	29	1	91	60	30
7	Sg.Kecil/Sg.Siru	275	65	2	0	4	0	0	4	0	200	0	71
8	Sg.Kelian	904	231	0	0	10	0	0	2	0	529	132	241
9	Sg.Balik Batu	80	70	0	0	2	1	0	0	0	7	0	73
10	Sg.Fettes	136	64	1	0	0	0	0	5	0	66	0	65
11	Sg.Bagan Jermal	83	27	0	0	0	0	26	0	2	28	0	53
12	Sg.Babi	84	28	0	0	5	1	26	0	2	22	0	60
13	Sg.Gelugor	407	158	2	0	19	0	0	93	16	90	29	179
14	Sg.Dua Besar	619	205	0	0	78	0	0	74	15	53	194	283
15	Sg.Nibon Besar	150	97	0	0	1	4	1	28	14	0	5	103
16	Sg.Nibon Kecil	277	121	4	46	1	45	0	59	1	0	0	217
17	Sg.Keluang	2217	415	0	54	7	9	0	100	74	232	1326	485
18	Sg.Nipah/Batu Maung	169	18	0	0	3	0	0	15	17	23	93	21
19	Sg.Kampung Masjid	84	30	0	0	0	0	0	13	8	0	33	30
20	Sg.Ikan Mati	38	11	0	0	0	0	0	2	0	0	25	11
21	Sg.Bayan Lepas	704	73	6	0	1	0	0	2	0	44	578	80
21'	By-pass of No.21	259	47	0	0	20	0	2	21	39	0	130	69
22	Sg.Batu	90	23	0	0	0	0	0	0	0	3	64	23
23	Sg.Mati	95	27	1	0	1	0	0	7	0	2	57	29
24	Sg.Teluk Kumbar	706	92	0	0	1	1	0	11	1	151	450	94
25	Sg.Gemuroh	191	2	0	0	0	0	3	0	0	67	119	5
26	Sg.Gertak Sanggul	103	9	0	0	0	0	0	0	0	22	72	9
	Sub-total	10792	1911	29	100	159	80	81	468	190	3923	3852	2360
	Total	15889	3406	85	132	254	277	179	515	300	6209	4533	4333
Ref.1	Sg.Pulau Betong	1104	66	0	0	3	0	4	3	0	295	733	73
Ref.2	Sg.Nipah	324	79	0	0	8	2	0	3	0	0	232	89
Ref.3	Sg.Burong	1379	218	3	0	29	0	0	61	2	82	984	250
Ref.4	Sg.Kongsi	2063	212	2	0	4	0	10	51	2	265	1517	228
Ref.5	Sg.Pinang	1999	167	1	0	2	0	0	38	3	801	987	170
	Sub-total	6869	742	6	0	46	2	14	156	7	1443	4453	810

Note:Figure of Agriculture landuse area is included that of Hill land as a part of Forest area.
Figure of Residential area involves that of Village area.

TABLEL C-4 FUTURE LANDUSE COMPOSITION IN PENANG ISLAND IN 2010 BY SUB-CATCHMENT AREA

Unit: hectar

River No.	River name	Catchment area (ha)	resi-dential	Com-mercial	Indus-try	Educat-ional	Park area	Ceme-try	Open land	reserve area	Forest Hill lan	Agri-culture	Built-up area total
1-1	Sg.Air Itam	1064	107	6	0	0	54	0	0	40	857	0	167
1-2	Sg.Air Puteh	456	73	3	0	0	1	0	0	271	108	0	77
1-3	Sg.Dondang	1133	397	12	12	34	21	38	0	0	619	0	514
1-4	Sg.Air Itam/Sg.Pinang	105	53	0	0	30	12	7	0	0	3	0	102
1-5	Tributary/Sg.Air Itam	242	111	1	1	2	0	54	15	0	58	0	169
1-6	Sg. Air Terjun	1076	152	1	0	4	272	13	48	67	519	0	442
1-7	Sg.Pinang	73	45	9	1	6	9	1	2	0	0	0	71
1-8	Sg.Jelutong	169	142	0	0	22	0	5	0	0	0	0	169
1-9	Sg.Pinang	289	120	103	37	14	10	2	3	0	0	0	286
1-10	Sg.Jelutong	490	277	3	1	23	8	25	4	0	149	0	337
	Sub total	5097	1477	138	52	135	387	145	72	378	2313	0	2334
2	Sg.Teluk Awak	295	29	0	0	0	141	21	4	0	62	38	191
3	Sg.Teluk Bahang	1230	92	4	0	7	275	18	2	0	644	188	396
4	Sg.Batu Ferringghi	1127	41	0	5	11	11	0	1	0	1065	0	68
5	Sg.Satu	258	42	0	0	0	0	0	4	0	212	0	42
6	Sg.Masu	211	110	6	0	7	24	0	17	1	47	0	147
7	Sg.Kecil/Sg.Siru	275	66	2	0	9	0	0	0	3	195	0	77
8	Sg.Kelian	904	231	9	0	23	5	0	0	0	633	0	268
9	Sg.Balik Batu	80	70	1	0	0	1	1	0	0	7	0	73
10	Sg.Fettes	136	84	7	0	4	3	11	0	0	27	0	109
11	Sg.Bagan Jermal	83	27	0	0	0	5	32	0	0	24	0	64
12	Sg.Babi	84	41	1	0	7	0	27	0	0	9	0	76
13	Sg.Gelugor	407	185	0	0	51	26	1	0	0	43	0	263
14	Sg.Dua Besar	619	303	0	0	92	178	1	0	0	45	0	574
15	Sg.Nibon Besar	150	107	2	10	6	10	0	0	0	15	0	135
16	Sg.Nibon Kecil	277	156	5	63	7	25	0	7	0	14	0	256
17	Sg.Keluang	2217	706	44	81	42	92	1	2	0	1173	77	966
18	Sg.Nipah/Batu Maung	169	137	0	0	3	0	0	2	0	18	9	140
19	Sg.Kampung Masjid	84	54	4	0	2	8	1	2	0	8	5	69
20	Sg.Ikan Mati	38	34	1	0	0	0	0	0	1	3	0	35
21	Sg.Bayan Lepas	704	126	5	0	1	60	0	0	1	524	4	192
21'	By-pass of No.21	259	138	0	0	3	0	3	0	0	56	48	144
22	Sg.Batu	90	32	0	0	6	0	1	0	1	42	8	39
23	Sg.Mati	95	45	0	0	2	0	0	0	5	15	28	47
24	Sg.Teluk Kumbar	706	112	0	0	1	0	1	0	2	493	97	114
25	Sg.Gemuroh	191	2	0	0	0	0	3	0	4	131	51	5
26	Sg.Gertak Sanggul	103	9	0	0	0	0	0	0	1	78	15	9
	Sub-total	10792	2979	91	159	284	864	122	41	19	5583	568	4499
	Total	15889	4456	229	211	419	1251	267	113	397	7896	568	6833
Ref.1	Sg.Pulau Betong	1104	66	0	0	2	0	7	0	0	385	637	75
Ref.2	Sg.Nipah	324	79	0	0	8	2	0	0	0	4	131	89
Ref.3	Sg.Burong	1379	210	2	0	29	33	1	0	0	547	549	275
Ref.4	Sg.Kongsi	2063	212	1	7	3	0	10	0	0	844	934	233
Ref.5	Sg.Pinang	1999	167	0	0	2	13	0	0	0	1466	351	182
	Sub-total	6869	734	3	7	44	48	18	0	0	3246	2602	854

Note: Figure of Forest,Hill land partially includes that of Agriculture landsue area.

TABLE C-5 URBANISATION TREND ON LANDUSE COMPOSITION IN PENANG ISLAND BY SUB-CATCHMENT AREA

Unit: hectar

Zone	River No.	River name	Catchment area (ha)	Built-up area Present (ha)	%	Presumed built-up area, Future (ha)	%	Urban expantion area and rate (ha)	%
George Town Zone	1-1	Sg.Air Itam	1064	118	11.1	167	15.7	49	4.6
	1-2	Sg.Air Puteh	456	76	16.7	77	16.9	1	0.2
	1-3	Sg.Dondang	1133	393	34.7	514	45.4	121	10.7
	1-4	Sg.Air Itam/Sg.Pinang	105	96	91.4	102	97.1	6	5.7
	1-5	Tributary/Sg.Air Itam	242	150	62.0	169	69.8	19	7.9
	1-6	Sg. Air Terjun	1076	303	28.2	442	41.1	139	12.9
	1-7	Sg.Pinang	73	69	94.5	71	97.3	2	2.7
	1-8	Sg.Jelutong	169	164	97.0	169	100.0	5	3.0
	1-9	Sg.Pinang	289	279	96.5	286	98.9	7	2.4
	1-10	Sg.Jelutong	490	325	66.3	337	68.8	12	24.5
		Sub total	5097	1973	38.7	2324	45.6	351	6.9
Northern Zone	2	Sg.Teluk Awak	295	28	9.5	191	64.7	163	55.3
	3	Sg.Teluk Bahang	1230	87	7.1	396	32.2	309	35.1
	4	Sg.Batu Ferringghi	1127	6	0.5	68	6.0	62	5.5
	5	Sg.Satu	258	8	3.1	42	16.3	34	13.2
	6	Sg.Masu	211	30	14.2	147	69.7	117	55.5
	7	Sg.Kecil/Sg.Siru	275	71	25.8	77	28.0	6	2.2
	8	Sg.Kelian	904	241	26.7	268	29.6	27	3.0
	9	Sg.Balik Batu	80	73	91.3	73	91.3	0	0
	10	Sg.Fettes	136	65	47.8	109	80.1	44	32.4
	11	Sg.Bagan Jermal	83	53	63.9	64	77.1	11	13.3
	12	Sg.Babi	84	60	71.4	76	90.5	16	19.0
Eastern Zone	13	Sg.Gelugor	407	179	44.0	263	64.6	84	20.6
	14	Sg.Dua Besar	619	283	45.7	574	92.7	291	47.0
	15	Sg.Nibon Besar	150	103	68.7	135	90.0	32	21.3
	16	Sg.Nibon Kecil	277	217	78.3	256	92.4	39	14.1
	17	Sg.Keluang	2217	485	21.9	966	43.6	481	21.7
	18	Sg.Nipah/Batu Maung	169	21	12.4	140	82.8	119	70.4
	19	Sg.Kampung Masjid	84	30	35.7	69	82.1	39	46.4
	20	Sg.Ikan Mati	38	11	28.9	35	92.1	24	63.2
Southern Zone	21	Sg.Bayan Lepas	704	80	11.4	192	27.3	112	15.9
	21'	By-pass of No.21	259	69	26.6	144	55.6	75	29.0
	22	Sg.Batu	90	23	25.6	39	43.3	16	17.8
	23	Sg.Mati	95	29	30.5	47	49.5	18	18.9
	24	Sg.Teluk Kumbar	706	94	13.3	114	16.1	20	2.8
	25	Sg.Gemuroh	191	5	2.6	5	2.6	0	0
	26	Sg.Gertak Sanggul	103	9	8.7	9	8.7	0	0
		Sub-total	10792	2360	21.9	4499	41.7	2139	19.8
		Total	15889	4333	27.3	6833	43.0	2500	15.7
Western Zone	Ref.-1	Sg.Pulau Betong	1104	73	6.6	75	6.8	2	0.2
	Ref.-2	Sg.Nipah	324	89	27.5	89	26.9	0	0
	Ref.-31	Sg.Burong	1379	250	18.1	275	19.9	25	14.0
	Ref.-4	Sg.Kongsi	2063	228	11.1	233	11.3	5	0.2
	Ref.-5	Sg.Pinang	1999	170	8.5	182	9.1	12	0.6
		Sub-total	6869	810	11.8	854	12.4	44	0.6

Figures

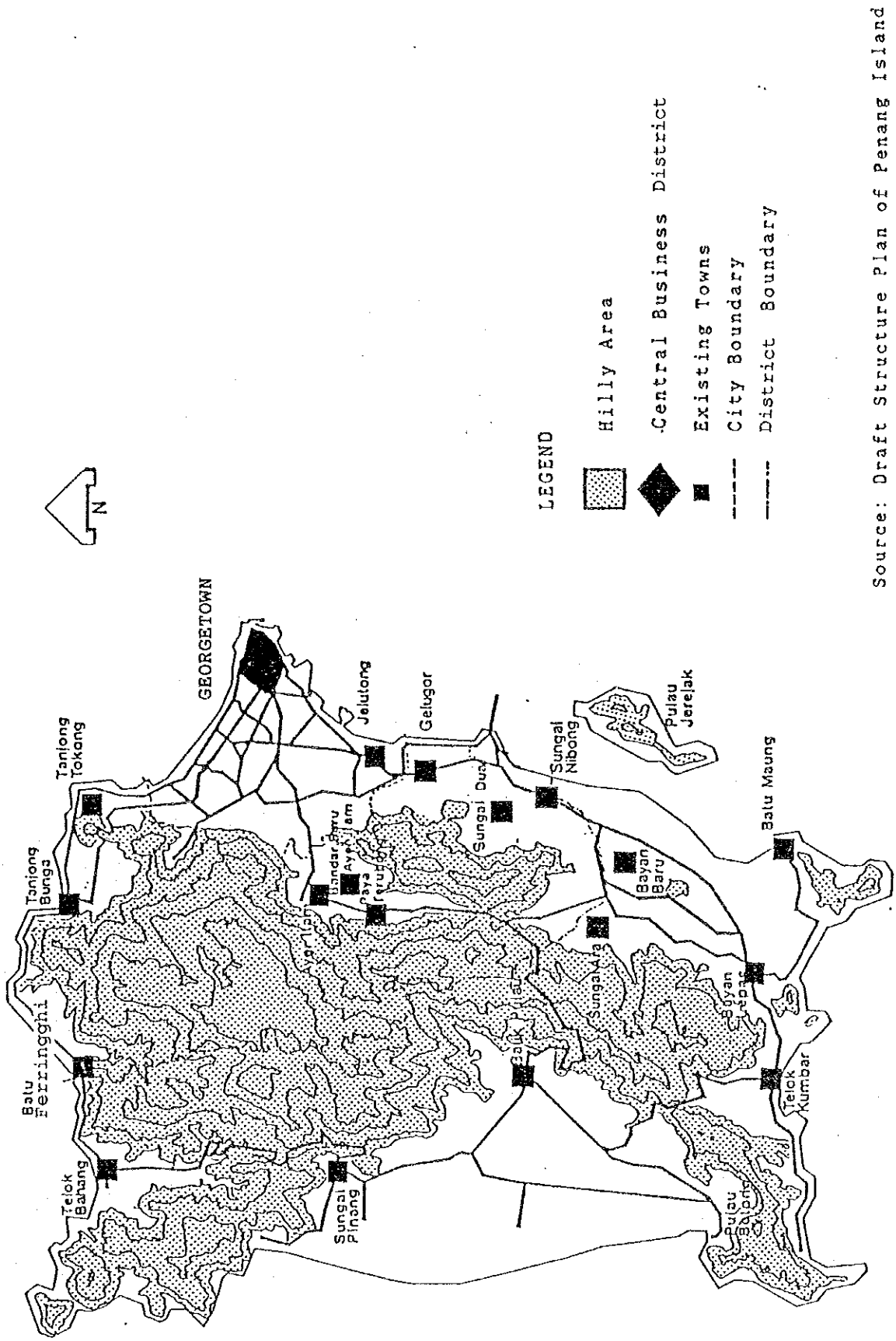

Fig. C-1 MAP OF THE STUDY AREA

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

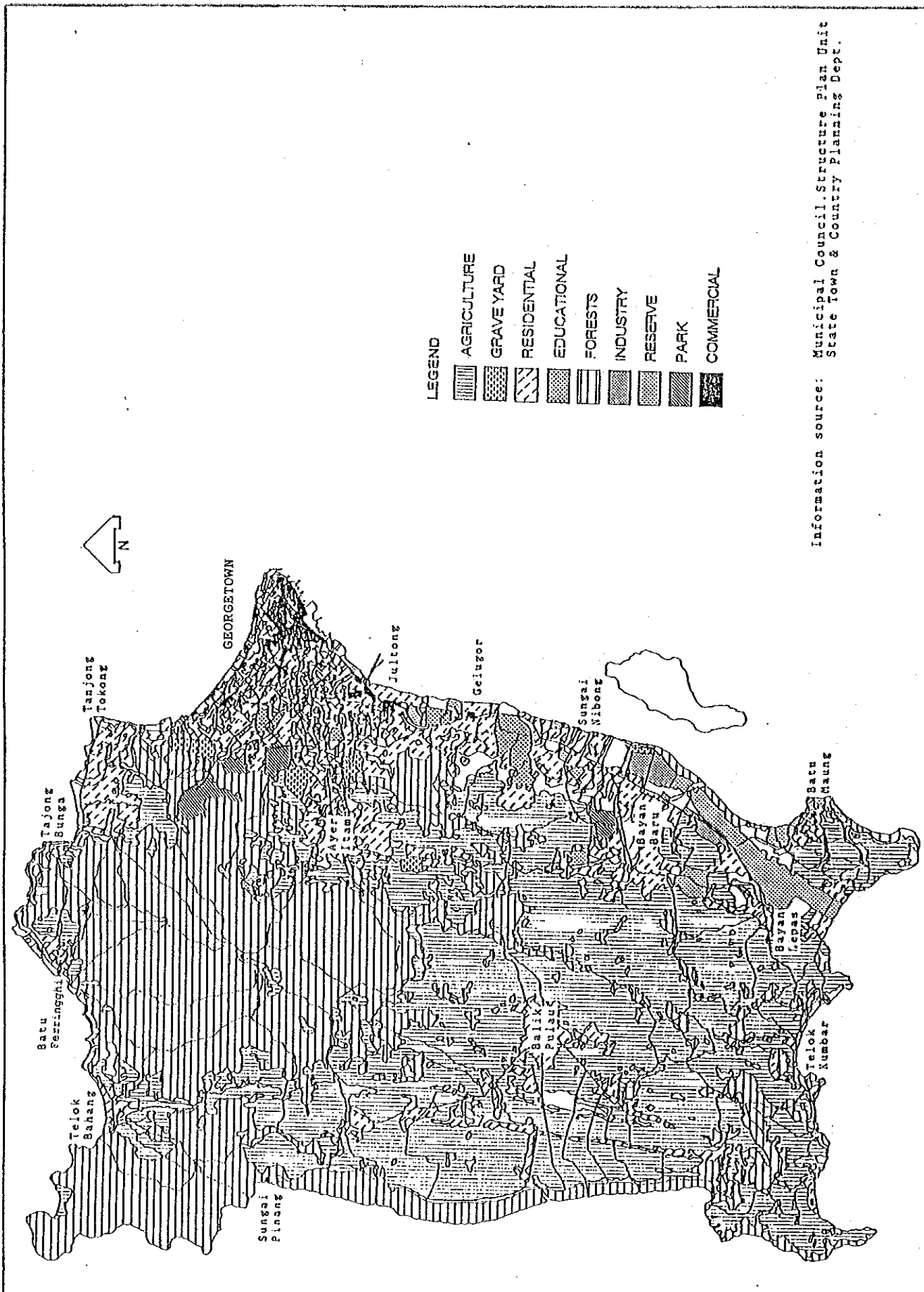

Fig. C-2 EXISTING LANDUSE COMPOSITION PATTERN IN 1988

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

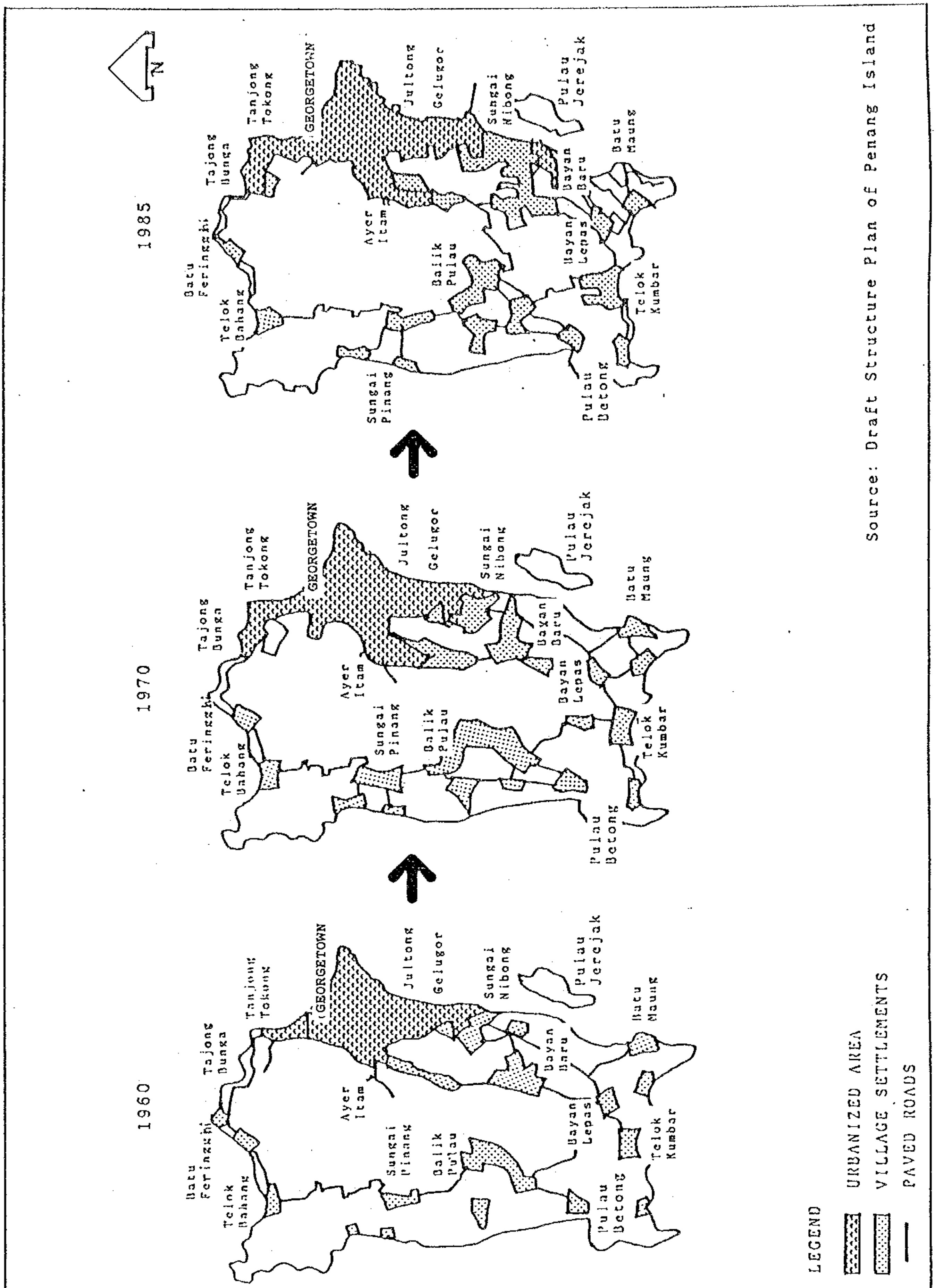

Fig. C-3 URBANIZATION GROWTH, 1960 TO 1985

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

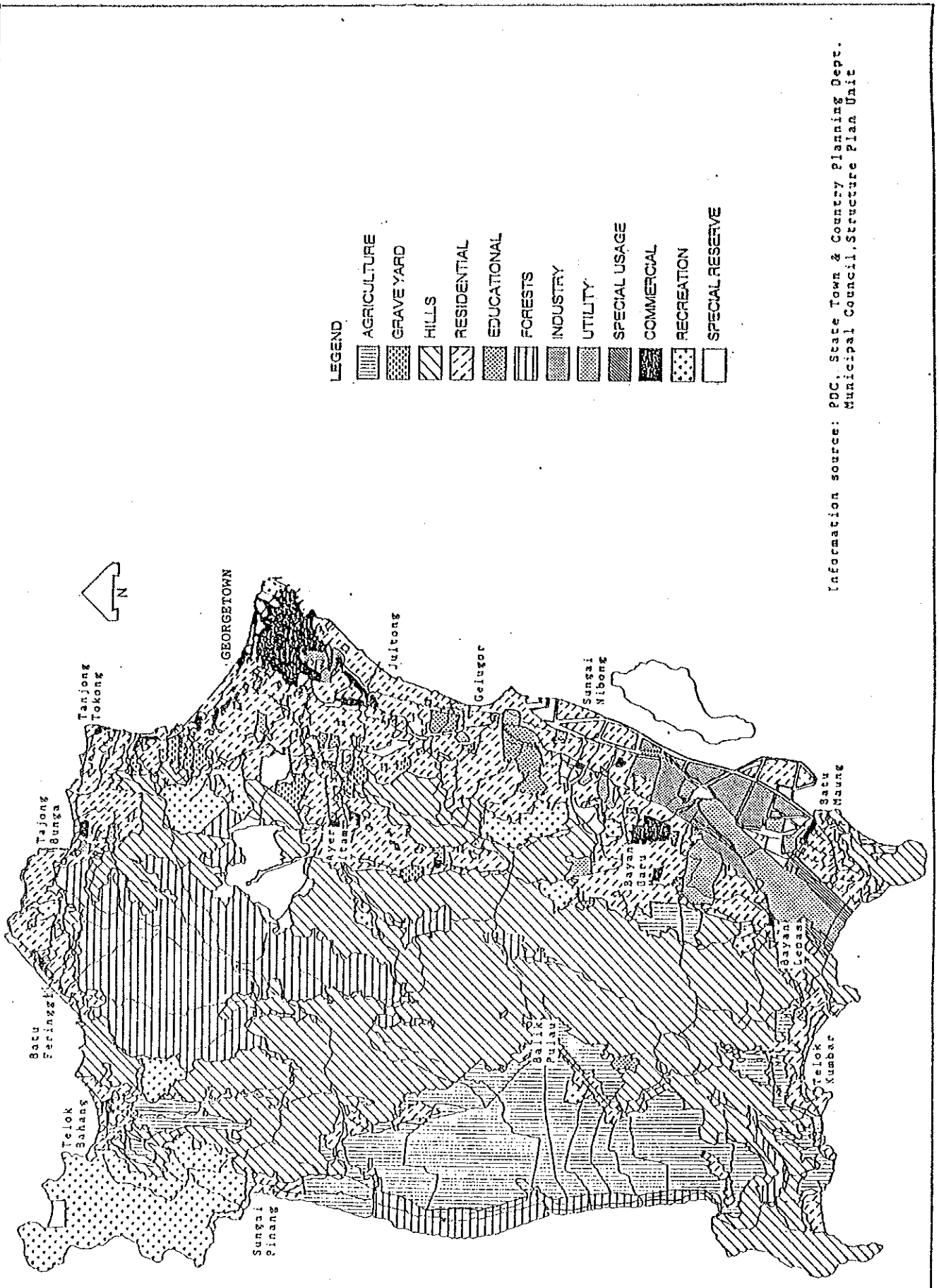

Fig. C-4 FUTURE LANDUSE COMPOSITION IN 2010

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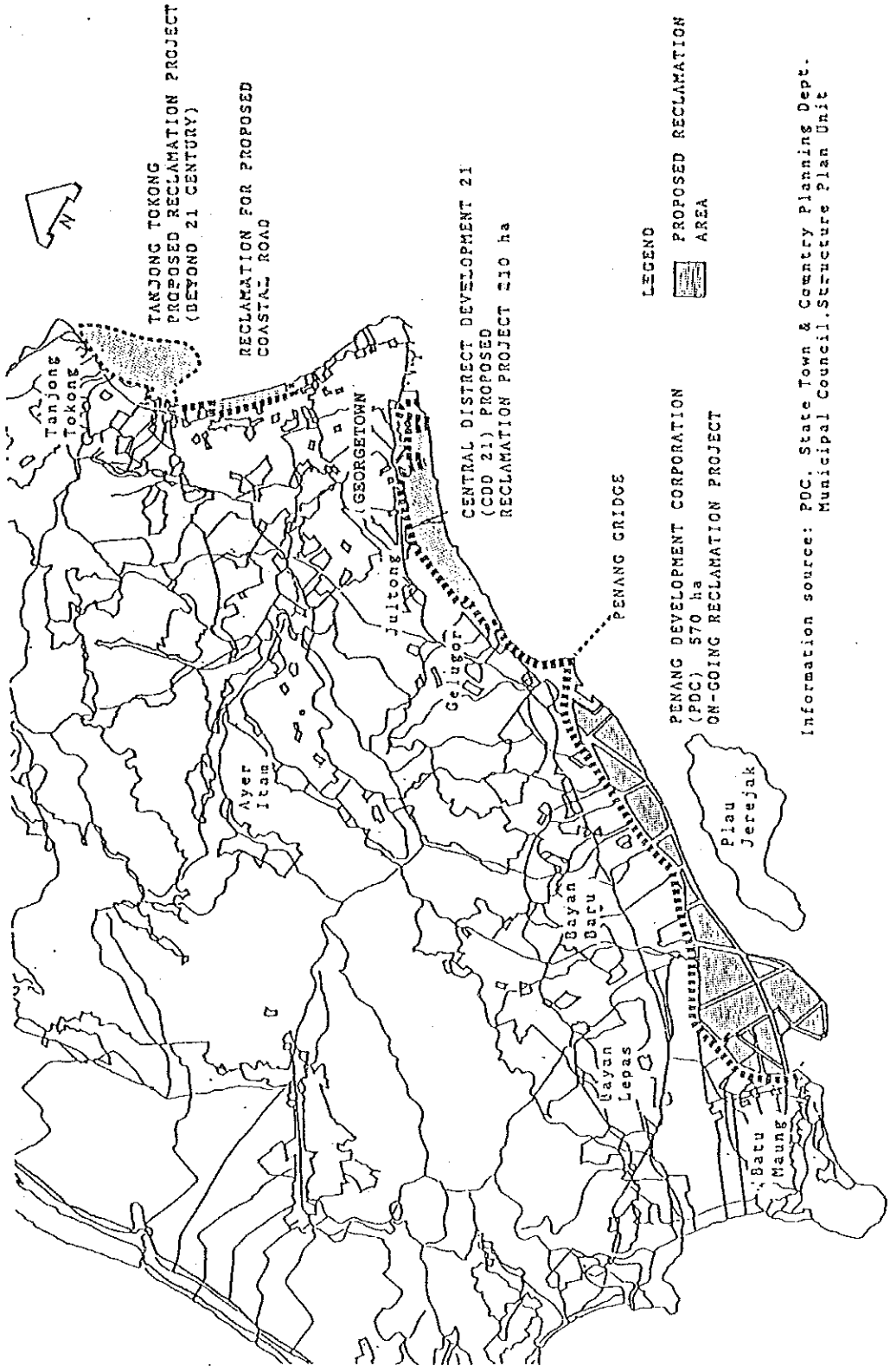
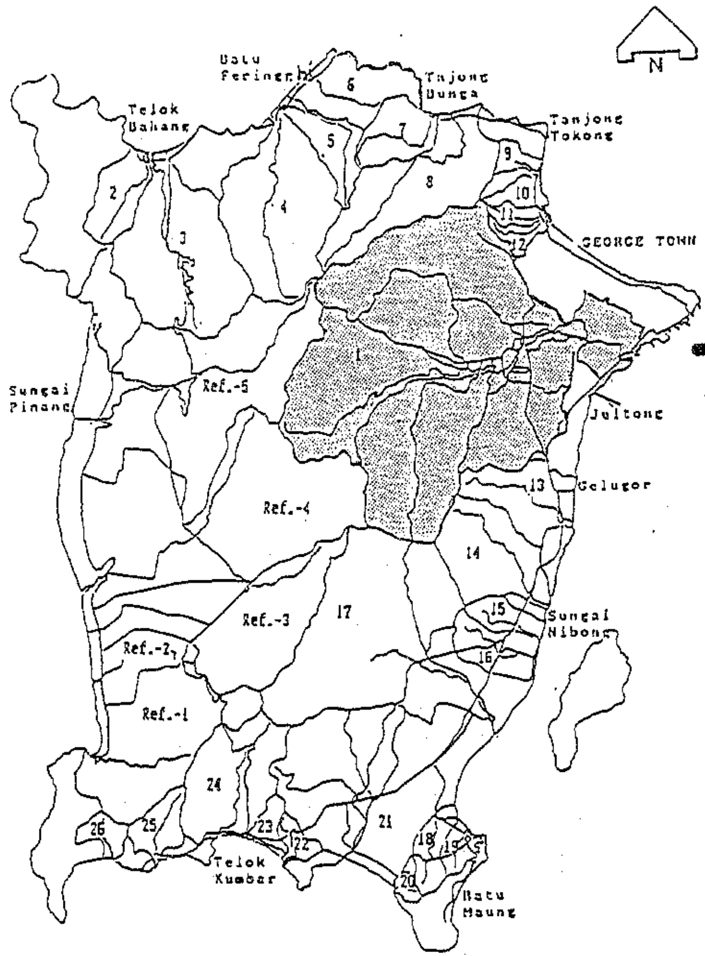
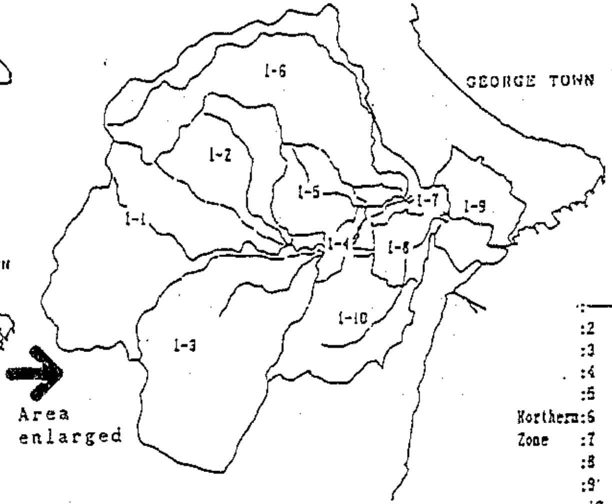


Fig. C-5 LANDUSE PATTERN PLAN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



Area enlarged



Zone	River No.	River name	Catchment area (ha)
George Town Zone	1-1	Sg. Air Itam	1064
	1-2	Sg.Air Puteh	456
	1-3	Sg.Dondang	1133
	1-4	Sg. Air Itam/Sg Pinang	105
	1-5	Tributary/Sg.Air Itam	242
	1-6	Sg.Terjun	1076
	1-7	Sg.Pinang	73
	1-8	Sg.Julutong	169
	1-9	Sg.Pinang	289
	1-10	Sg.Julutong	490
Western Zone	Ref.-1	Sg.Pulau Betong	1104
	Ref.-2	Sg.Nipah	324
	Ref.-3	Sg.Burong	1379
	Ref.-4	Sg.Kongsi	2063
	Ref.-5	Sg.Pinang	1999
Northern Zone	2	Sg.Telok Awak	295
	3	Sg.Telok Bahang	1230
	4	Sg.Batu Feringghi	1127
	5	Sg.Satu	258
	6	Sg.Kasu	211
	7	Sg.Kechil/Sg.Siru	275
	8	Sg.Keliam	904
	9	Sg.Balik Batu	80
	10	Sg.Fettes	136
	11	Sg.Bagan Jermal	83
	12	Sg.Babi	84
Eastern Zone	13	Sg.Gelugor	407
	14	Sg.Dua Besar	619
	15	Sg.Nibong Besar	150
	16	Sg.Nibong Kechil	277
	17	Sg.Keluang	2217
	18	Sg.Nipah/Batu Maung	169
	19	Sg.Kampong Masjid	84
	20	Sg.Ikan Mati	38
Southern Zone	21	Sg.Bayan Lepas	704
	21'	By-pass of No.21	259
	22	Sg.Batu	90
	23	Sg.Mati	95
	24	Sg.Telok Kumbar	706
	25	Sg.Gemuroh	191
	26	Sg.Gertak Sanggul	103

Fig. C-6 MAP OF SUB-CATCHMENT AREA

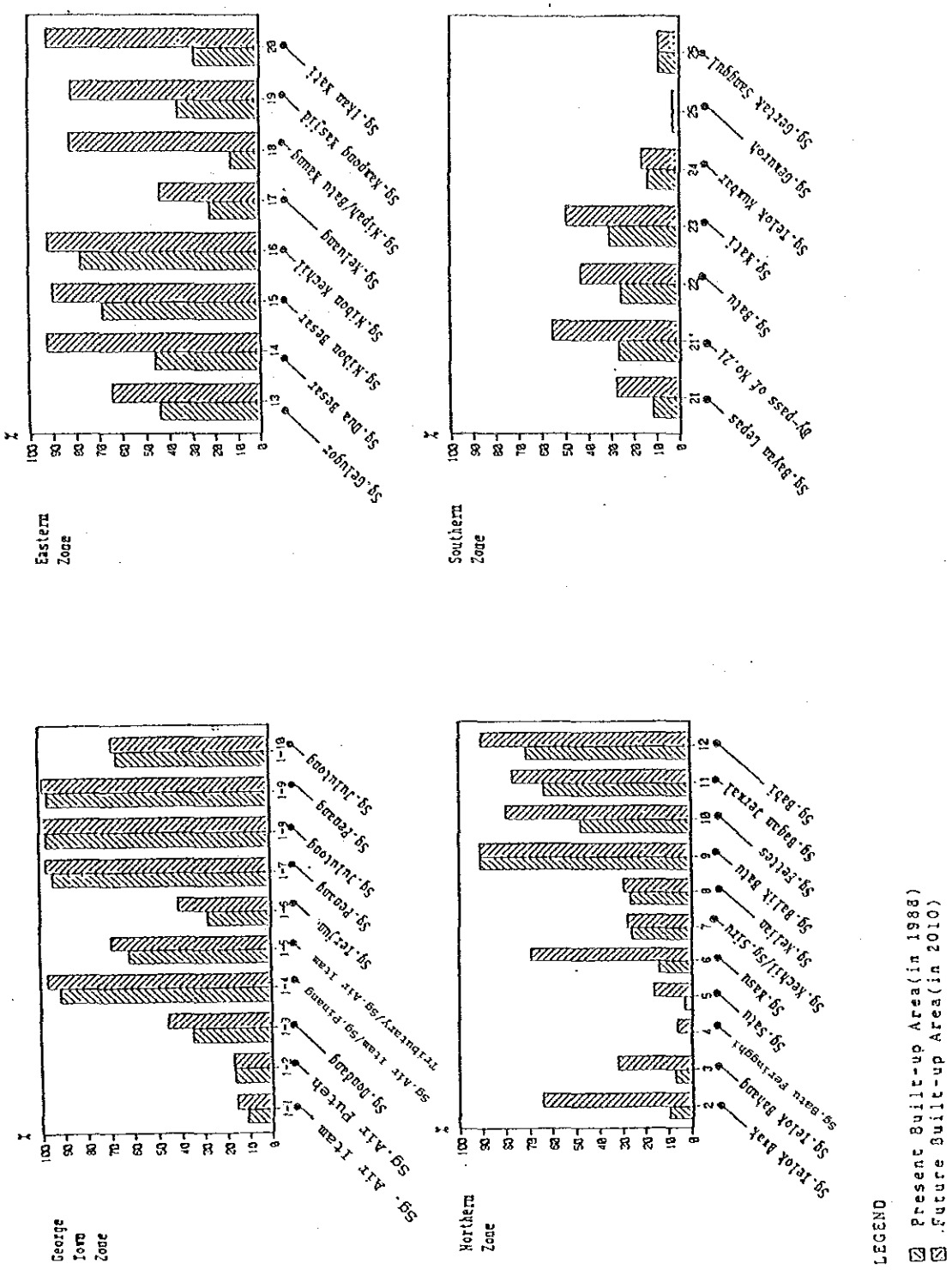


Fig. C-7 URBANIZATION TREND TOWARDS FUTURE

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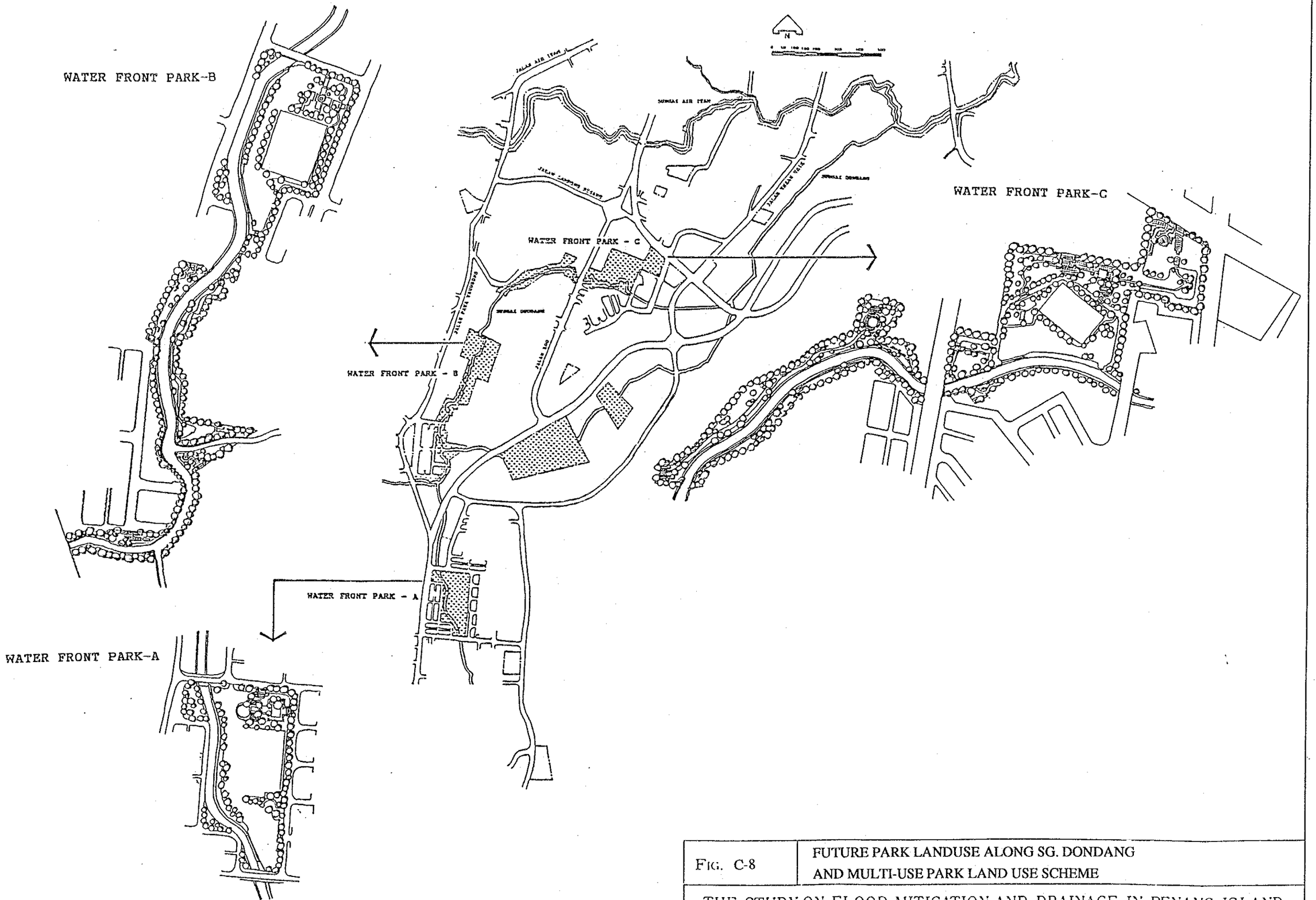

FIG. C-8	FUTURE PARK LANDUSE ALONG SG. DONDANG AND MULTI-USE PARK LAND USE SCHEME

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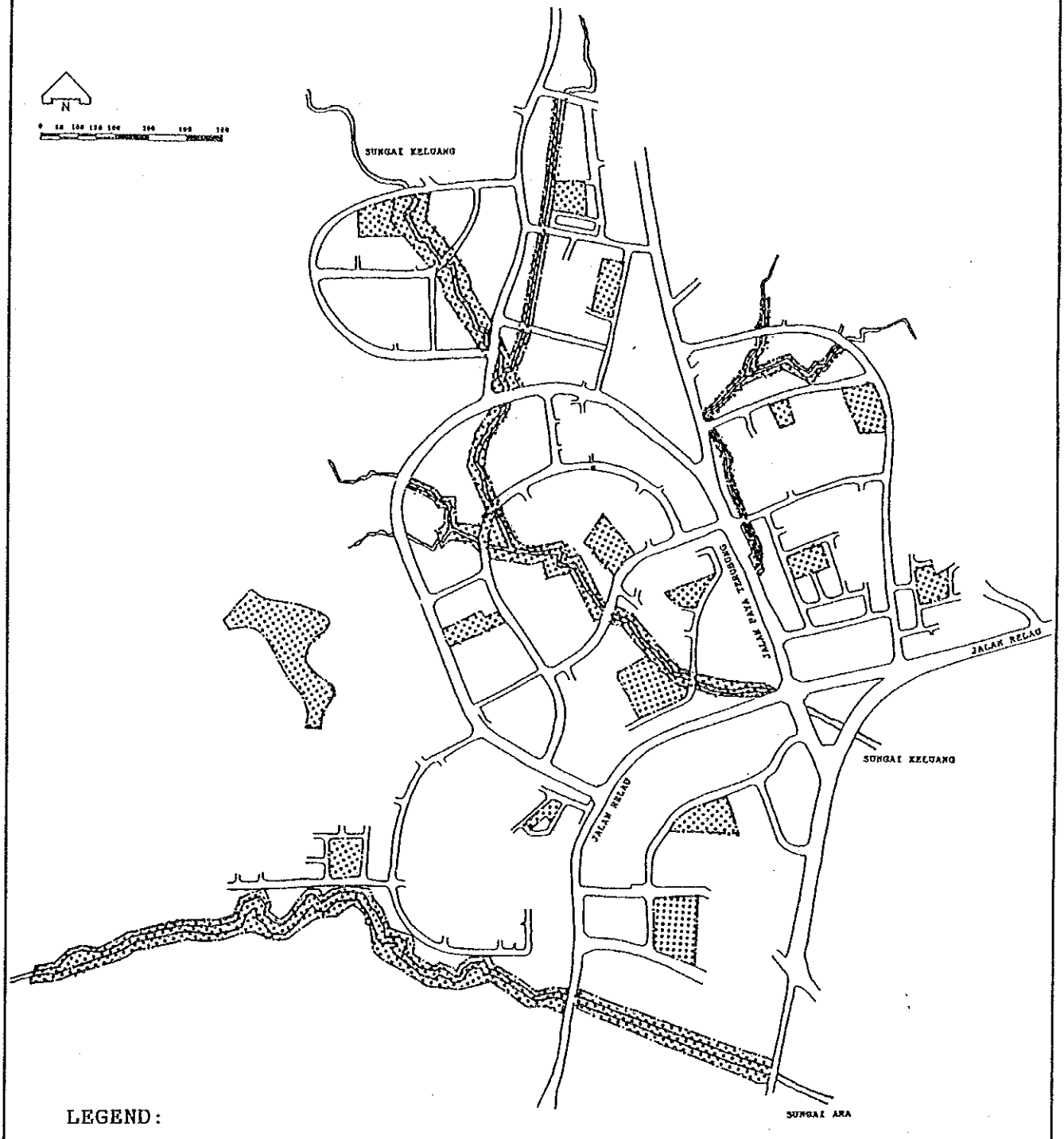

FIG. C-9 FUTURE RIVERSIDE PARK AREAS AND PARK LANDUSE PATTERN AT UPPER STREAM OF SG.KELUANG AND SG.ARA