APPENDIX D

SOCIO-ECONOMIC CONDITIONS

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APPENDIX D SOCIO-ECONOMIC CONDITIONS

1. ECONOMY OF PENANG IN THE CONTEXT OF NATIONAL ECONOMY

1.1 Economic Planning Framework

In planing framework, the regional approach to development is adopted in the Fifth Malaysia Plan (1986-1990) as a framework for national economic planning because planning on a state basis have failed to attain the benefits of any large-scale project in a particular state.

Malaysia is divided into six planning regions, namely, Northern, Central, Eastern, Southern, Sabah, and Sarawak. Each of these regions, comprising either an entire state or a group of neighbouring states, is dominated by at least a single urban centre. In case of Northern Region, this urban centres are Ipoh and Georgetown.

With the completion of the East-West Highway, the North-South Highway and the Penang Bridge and the improved facilities at the Penang Port and the Bayan Lepas International Airport, Penang is expected to improve its role as a regional centre and expand its sphere of influence even to the East Coast. Influential Area of Penang Economy is shown in Fig. D-1.

1.2 General Features of Penang Economy

The Northern Region is characterized by a large but narrowly-based manufacturing sector and a mobile population.

Since Penang is a major centre in the Northern Region with the largest metropolitan port base in the area, it's economy is affected by the overall growth of the region and the competitive linkage within the state and other states in the region. The areas which generally fall under the influence of the Penang economy include the whole of Kedah/Perlis and the Northern half of Perak, with Kelantan being a potential addition, through the East-West Highway connection. In addition, with the development of North-South Highway, the new Penang Bridge and the improved facilities at the Penang Port, the degree of integration and interaction with the region and the nation as a whole will further increase in the future.

1.3 Structure of Economy

Structure of Penang economy by industrial sector is compared with national/regional levels in Table D-1. Contribution of states and regions to national economy is shown in Table D-2.

Dominant growth core of Penang economy is occupied by a manufacturing sector, accounting for 41.0% of the whole production in Penang. This dominant position of manufacturing sector is sharply prominent in comparison with the national average of 20.6% and North Region's figure of 5.1%. And also this suggests that manufacturing sector with a high value added can lead Penang economy to rise in a dynamic spiral of growth

in progress that economic backward and forward linkages are accumulated in the region.

The contribution of manufacturing sector is very impressive in the Northern Regions as well as Central and Southern Regions. The shares of this sector output in the respective regional GDPs were 21% for the Northern Region, 26% for the Central Region, and 22% for the Southern Region compared with 19% at the national level, in 1985. These three regions together accounted for 88% of the total manufacturing sector output of the country.

The manufacturing sector of the region grew at 4.0% per annum during the period of 1981-1985. The increase in manufacturing output is largely originated from Perak and Penang, which together accounted for more than 90% of the increment in the region.

Manufacturing is followed by sub-sectors of secondary industry. Their title and composition share are as follows;

- Wholesale, retail trade, hotel and restaurants, 13.7%
- Electricity, gas and water, 2.9%
- Transport, storage an communication 11.6%
- Finance, insurance, real estate, and business service 8.4%

These tertiary sub-sectors accounts for 36.6% in total of whole Penang economy and are ranked at a slightly higher than national level of 32.5%, and far higher than Northern average of 6.9%.

Agricultural/fishery sector occupies 4.2% of total Penang economy in production, far less than the national level of 18.2%. This share has shown a gradual decreasing tendency since 1980 in parallel with that of national average figure. Composition share of agriculture/fishery sector is leveled at same level as the average figure of Northern Region.

The output of agricultural sector was the highest in the Northern Region, but the rates of growth in output and productivity were relatively less impressive compared to the other regions.

1.4 GDP Level of the Region

The GDP per capita of Northern Region in 1985 was $3,162 or 84% of national average. This GDP per capita was growing at 2.4% per annum during the period. The State of Penang was the most developed in the Northern Region with a GDP per capita which is 10% higher than the national average. The three remaining states had a GDP per capita lower than the national average, ranging from 63% for Kedah to 85% for Perak. The ratios of GDP per capita to national average for all the states in the region were lower in 1985 compared with their ratios in 1980, indicating that these states grew less rapidly during the period.

1.5 Population and Labour Force

The Northern and Central Regions had the largest concentration of population in the country in 1985. With about eight million people, the two regions accounted for more than 50% of the total population, with the Northern Region having a slightly larger share of 28% of the total population. The share of population in the other regions was significantly less, with the Sabah Region having the smallest share of about 7%.

Given the growing labour force in the region and the limited number of jobs created during the period, agricultural states like Kedah experienced the highest unemployment rate in the region as well as sustained emigration. The relatively higher capacity of Penang to create employment in the secondary sector accounted for its relatively lower unemployment rate in 1985.

Employment creation was significant in the manufacturing sector. Out of 15,000 jobs created in the manufacturing sector, Penang and Perak together accounted for about 13,000 jobs.

In the urban hierarchy of towns, based on population, Georgetown ranked number two after Kuala Lumpur in 1970. However by 1980 its ranked has dropped to third below Kuala Lumpur and Ipoh. The population of Georgetown has in fact been decreasing. In terms of trade and economy, however Georgetown still remains in the second rank after Kuala Lumpur.

2. ANATOMY OF PENANG ECONOMY

Penang Island has been traditionally a trading, commercial and Entreport centre and today it continues to be a major growth centre in Peninsular Malaysia. Several major projects have been implemented in the past or are under implementation to facilitate the emergence of Penang as a regional centre.

In terms of national output, the manufacturing sector continued to spearhead growth with a 15.3% expansion. For the second consecutive year, the sector also continued to maintain its position as the leading contributor to total G.D.P., accounting for 24% of the national average. Expansion in manufacturing output was across the board with the majority of the industries registering double digit growth rates. The main impetus for this robust expansion was the enhanced performance of the traditional export-oriented industries of electronics and electrical goods, which increased by 17.7%, while rubber-based products grew by 75.6%. The growth of the textile and garment industry was rather slow and was only 4.1%.

The Penang economy likewise benefited from the development at national level. In 1988, it was estimated that the G.D.P. of the State grew by 8.9% compared to 6.6% in 1987. The manufacturing sector continued to spearhead the expansion of the economy of the State and grew at 15% in 1988. This sector continued to be the leading contributor accounting for 45.2% of the GDP of the State.. The manufacturing output sector continued to grow during the year and this was reflected in a

7.9% increase in cargo tonnage handled by the Port of Penang in 1988.

During the year, MIDA approved a total of 732 manufacturing projects for the country, an increase of 219.8% over 1987. Potential employment from these projects was 136,000 while proposed capital investment was 9.1 billion Malaysian Ringgit compared with 3.9 billion Malaysian Ringgit in 1987.

The State of Penang maintained its third ranking amongst the States in the country with a total of 73 new approved manufacturing projects for 1988. Potential employment by these projects was 17,833 while proposed capital investment was 730 million Malaysian Ringgit. This compares favourably with the 59 projects approved for 1987, with potential employment of 16,662 and proposed capital investment of 636 million Ringgit.

The real estate market responded favourable to the expansion of economy. Work resumed on many of the residential and commercial development projects which had been shelved or delayed. The high demand for factory premises also helped to boost the construction sector as a whole in 1988. This sector was estimated to have recorded a marginal growth of 1.6%.

The tourism sector too showed signs of recovery, with the direct arrival of foreign visitor to the State growing by 14.6%, with an absolute increase of 22,500 over 1987. Occupancy rates at leading hotels averaged 66.4%, reflecting the mood of the sector in the States.

Although employment by manufacturing sector and its output in Penang and Perak had registered steady growth, still Penang is characterized by a rather narrow industrial base. More than 46% of the employment by manufacturing in Penang were concentrated in electrical, machinery and equipment sub-sector, especially electronics. The electronics industry attracted female labour from neighbouring states, especially Kedah and Perak, into Penang. Despite the inflow of immigrants, Penang recorded a net emigration. A sizeable number of emigrants from Penang, who were largely males and better educated than the immigrants, moved to the Klang Valley in search of employment in modern sectors.

3. ECONOMY OF PENANG IN FUTURE

With forecasts of increasing real growth rates in newly industrializing nations and the projected stabilization of prices of commodities, the Malaysian economy is forecasted to experience a steady growth of 6.5% in 1989. Penang with the manufacturing sector as its main engine of growth is expected to benefit from this uptrend and is estimated to grow by 9% during the coming year.

4. POPULATION

4.1 Population Trend

According to population census of 1980, the total population of Penang Island was approximately 547,300 people, and that of whole state was 1,068,900. Penang is among the states with the lowest growth rates in the decade of 1970 - 1980, with an average annual growth rate of 1.5%, while that of

the Island was even lower with 0.9%. This figure is very much lower than the average annual growth rate of 2.2% in the same decade for Peninsular Malaysia.

At district level, the average annual growth rates for the same decade for Georgetown registered a negative growth rate of about -0.8% per annum. This reflect decentralization of population from Georgetown to other secondary urban centres such as Air Itam, Gelugor, Tanjung Tokong. It also indicates that the areas on the western part of the island like Balik Pulau, Pondok Upeh registered a decline in population.

Georgetown registers a constant increase of population since 1981 according to the population data shown in Table D-3. However, this is attributable to the method of estimation which is based on the mortality and fertility rates, rather than registration of accurate inhabitants.

Average population density of the Island is about 1,650 persons per sq.km. North East District with a population of 455,500 is much denser with 93,370 persons per sq.km. than the South West District with a population of 91,800 and a density of only about 570 persons per sq.km. The North East District contains 84.0% of the Island's population, while the Metropolitan area, the whole urbanized eastern part of the island, contains 88.0% of the island's population.

The immigration cum emigration has a significant impact on the change in population in the Penang Island. During the 1970-1980 decade there had been a significant loss of people from the island. Though there is no accurate data available on this issue, the NIDAS survey estimated that there is a net emigration of as much as 6,000 people per year since 1970.

4.2 Future Projected Population

Penang Island Structure Plan conducted population forecast based on the Cohort Component method, which takes into account the effects of fertility, mortality and migration on population size and structure.

Model 1

- Basic assumption are as follows; Fertility rate will decline from the 1980 level.
- Mortality rate will decline from the 1980 level.
- Net migration level (negative) will remain constant at 1980 level.

Model 2

- Basic assumption are as follows; Fertility rate will decline from the 1980 level.
- Mortality rate will decline from the 1980 level.
- The net migration level are assumed to decrease to zero in a linear fashion during the period of 1980-2000.

The results of population forecast is summarized in Table D-4. Accordingly, the population of Penang Island is

forecasted to be in the range of 63,000 - 66,700 in the year 2000.

The results of analysis concerning future population will be dealt with in detail in subsequent stage.

Tables

Table D-1 STRUCTURE OF ECONOMY BY INDUSTRIAL SECTOR, 1980, 1985 AND 1990

Items	The State of Penang						North Region						Whole Malaysia					
	1980		1985		1990		1980		1985		1990		1980		1985		1990	
Economic sector																		
Agriculture, forestry, livestock, and fishing	223	(6.5%)	228	(5.3%)	230	(4.2%)	2789	(25.2%)	3108	(22.8%)	3387	(20.6%)	10189	(23.4%)	12046	(20.6%)	13713	(18.2%)
Mining and quarrying	18	(0.5%)	21	(0.5%)	22	(0.4%)	1180	(10.6%)	1093	(8.0%)	808	(4.9%)	4487	(10.3%)	6006	(10.3%)	6989	(9.3%)
Manufacturing	1399	(41.0%)	1666	(38.9%)	2246	(41.0%)	2357	(21.3%)	2864	(21.0%)	3798	(23.1%)	8932	(20.5%)	11357	(19.4%)	15509	(20.6%)
Construction	143	(4.2%)	190	(4.4%)	222	(4.1%)	431	(3.9%)	634	(4.6%)	812	(4.9%)	2066	(4.7%)	3048	(5.2%)	4000	(5.3%)
Electricity, gas, and water	68	(2.0%)	101	(2.4%)	157	(2.9%)	151	(1.4%)	240	(1.8%)	375	(2.3%)	640	(1.5%)	988	(1.7%)	1513	(2.0%)
Transport, storage, and communicat	313	(9.2%)	447	(10.4%)	634	(11.6%)	654	(5.9%)	922	(6.8%)	1317	(8.0%)	2542	(5.8%)	3805	(6.5%)	5494	(7.3%)
Wholesale and retail trade, hotels, and resturants	565	(16.6%)	650	(15.2%)	748	(13.7%)	1196	(10.8%)	1469	(10.8%)	1805	(11.0%)	5383	(12.4%)	7551	(12.9%)	10252	(13.6%)
Finance, insurance, real estate, and business services	269	(7.9%)	353	(8.2%)	462	(8.4%)	937	(8.5%)	1244	(9.1%)	1654	(10.1%)	3687	(8.5%)	5212	(8.9%)	7230	(9.6%)
Government services	322	(9.4%)	519	(12.1%)	634	(11.6%)	1154	(10.4%)	1790	(13.1%)	2135	(13.0%)	4563	(10.5%)	7270	(12.4%)	8842	(11.8%)
Other Services	93	(2.7%)	108	(2.5%)	124	(2.3%)	238	(2.1%)	291	(2.1%)	349	(2.1%)	1021	(2.3%)	1312	(2.2%)	1651	(2.2%)
Total	3419	(100%)	4283	(100%)	5479	(100%)	11087	(100%)	13655	(100%)	16440	(100%)	43510	(100%)	58595	(100%)	75193	(100%)
GDP at purchasers' value (M$ million)	3496		4925		5493		16481		13789		16481		44702		59344		75599	
Per capita GDP (M$)	3649		4120		4848		3539		3162		3539		3321		3758		4229	
Ratio to Malaysian average	1.13		1.1		1.15		0.84		0.84		0.84		1		1		1	
Growth rate of GDP per capita (% per annum)		2.5		3.3				2.4		2.3				3.1		2.4		
Population ('000)	958		1050		1139		4040		4360		4658		13879		15791		17988	
Employment ('000)																		
Unemployment ('000)	5.1		6.4		8.9		6.1		7.7		10.2		5.7		7.6		10.1	
Net internal migration ('000)		-2.3		-3.0				-144		-156				n.a.		n.a.		

(Source; Fifth Malaysia Plan)

Table D-2 CONTRIBUTION SHARE ON NATIONAL GDP GROWTH BY REGION AND STATE

Items	Year	Northern					Central					Eastern				Southern	Sabah	Sarawak	Malaysia
		Total	Kedah	Perak	Perlis	Pulau Pinang	Total	Melaka	Negeri Sembilan	Selangor	F.T. of K.Lumpur	Total	Kelantan	Pahang	Teren-gganu	Johor			
GDP at purchasers' Value	1980	11,358	2,355	5,170	337	3,496	16,313	1,072	1,981	7,014	6,246	5,902	1,337	2,553	2,012	4,797	3,235	3,097	44,702
	1985	13,789	2,855	6,179	430	4,325	21,781	1,362	2,405	9,043	8,971	8,281	1,786	3,490	3,005	6,163	4,570	4,760	59,344
	1990	16,481	3,344	7,103	541	5,493	28,058	1,706	2,956	11,328	12,068	11,212	2,316	4,578	4,318	7,653	6,005	6,190	75,599
GDP Share	1980	25.4%	5.3%	11.6%	0.8%	7.8%	36.5%	2.4%	4.4%	15.7%	14.0%	13.2%	3.0%	5.7%	4.5%	10.7%	7.2%	6.9%	100.0%
	1985	23.2%	4.8%	10.4%	0.7%	7.3%	36.7%	2.3%	4.1%	15.2%	15.1%	14.0%	3.0%	5.9%	5.1%	10.4%	7.7%	8.0%	100.0%
	1990	21.8%	4.4%	9.4%	0.7%	7.3%	37.1%	2.3%	3.9%	15.0%	16.0%	14.8%	3.1%	6.1%	5.7%	10.1%	7.9%	8.2%	100.0%
	Difference																		
	1980-1985	-2.2%	-0.5%	-1.2%	0.0%	-0.5%	0.2%	-0.1%	-0.4%	-0.5%	1.1%	0.8%	0.0%	0.2%	0.6%	-0.3%	0.5%	1.1%	-
	1985-1990	-1.4%	-0.4%	-1.0%	0.0%	0.0%	0.4%	0.0%	-0.1%	-0.3%	0.8%	0.9%	0.1%	0.2%	0.6%	-0.3%	0.2%	0.2%	-
GDP Incremental	1980-1985	2,431	500	1,009	93	829	5,468	290	424	2,029	2,725	2,379	449	937	993	1,366	1,335	1,663	14,642
	1985-1990	2,692	489	924	111	1,168	6,277	344	551	2,285	3,097	2,931	530	1,088	1,313	1,490	1,435	1,430	16,255
	1980-1990	5,123	989	1,933	204	1,997	11,745	634	975	4,314	5,822	5,310	979	2,025	2,306	2,856	2,770	3,093	30,897
Incremental GDP Share	1980-1985	16.6%	3.4%	6.9%	0.6%	5.7%	37.3%	2.0%	2.9%	13.9%	18.6%	16.2%	3.1%	6.4%	6.8%	9.3%	9.1%	11.4%	100.0%
	1985-1990	16.6%	3.0%	5.7%	0.7%	7.2%	38.6%	2.1%	3.4%	14.1%	19.1%	18.0%	3.3%	6.7%	8.1%	9.2%	8.8%	8.8%	100.0%
	Difference	0.0%	-0.4%	-1.2%	0.0%	1.5%	1.3%	0.1%	0.5%	0.2%	0.4%	1.8%	0.2%	0.3%	1.3%	-0.2%	-0.3%	-2.6%	-

Table D-3 POPULATION OF THE PULAU PINANG BY DISTRICT

DISTRICTS		1980	1981	1982	1983	1984	1985	1986
TENGAH	(BUKIT MERTAJAM)	171.4	174.7	178.6	182.7	186.7	191.4	196.2
UTARA	(BUTTERWORTH)	210.3	214.5	219.2	224.0	228.7	233.9	239.0
SELATAN	(NIBONG TEBAL)	75.8	77.2	79.0	80.8	82.6	84.4	86.4
TIMUR LAUT	(GEORGETOWN)	417.9	425.4	432.5	438.3	444.0	450.1	455.5
BARAT-DAYA	(BALIK PULAU)	80.3	81.9	83.6	85.3	87.3	89.5	91.8
TOTAL		955.6	973.8	992.8	1,011.2	1,029.3	1,049.3	1,068.9

SOURCE : STATE/DISTRICT DATA BANK, PENANG, 1980-1986, DEPARTMENT OF STATISTICS MALAYSIA, KUALA LUMPUR.

Table D-4 PROJECTED POPULATION AND GROWTH RATE, PENANG ISLAND

MODEL 1

Year	1980		1985		1990		1995		2000	
Ethnic Group	Pop.	Growth Rate % p.a.	Pop.	Growth Rate % p.a.	Pop.	Growth Rate % p.a.	Pop.	Growth Rate % p.a.	Pop.	Growth Rate % p.a.
Malay	120800	3.0	143500	3.5	168900	3.3	195500	3.0	220800	2.5
Chinese	308100	0.9	316400	0.5	324800	0.5	331600	0.4	334900	0.2
Indian	52100	0.7	55900	1.0	59200	1.1	62600	1.1	65200	0.8
others	7500	-2.2	7800	0.8	8100	0.8	8500	1.0	8800	0.7
Total	489500	1.3	523600	1.4	561000	1.4	598200	1.3	629700	1.0

MODEL 2

Year	1980		1985		1990		1995		2000	
Ethnic Group	Pop.	Growth Rate % p.a.	Pop.	Growth Rate % p.a.	Pop.	Growth Rate % p.a.	Pop.	Growth Rate % p.a.	Pop.	Growth Rate % p.a.
Malay	120800	3.0	143700	3.5	168200	3.2	192200	2.7	212500	2.0
Chinese	308100	0.9	316500	0.5	331200	0.9	351400	1.1	374700	1.3
Indian	53100	0.7	56100	1.1	60500	1.5	65800	1.7	71400	1.6
others	7500	-2.2	7800	0.8	8100	0.8	8500	1.0	8800	.7
Total	489500	1.3	524100	1.4	568000	1.5	617900	1.7	667400	1.6

Source : MPPP Structure Plan Survey, 1983

Figures

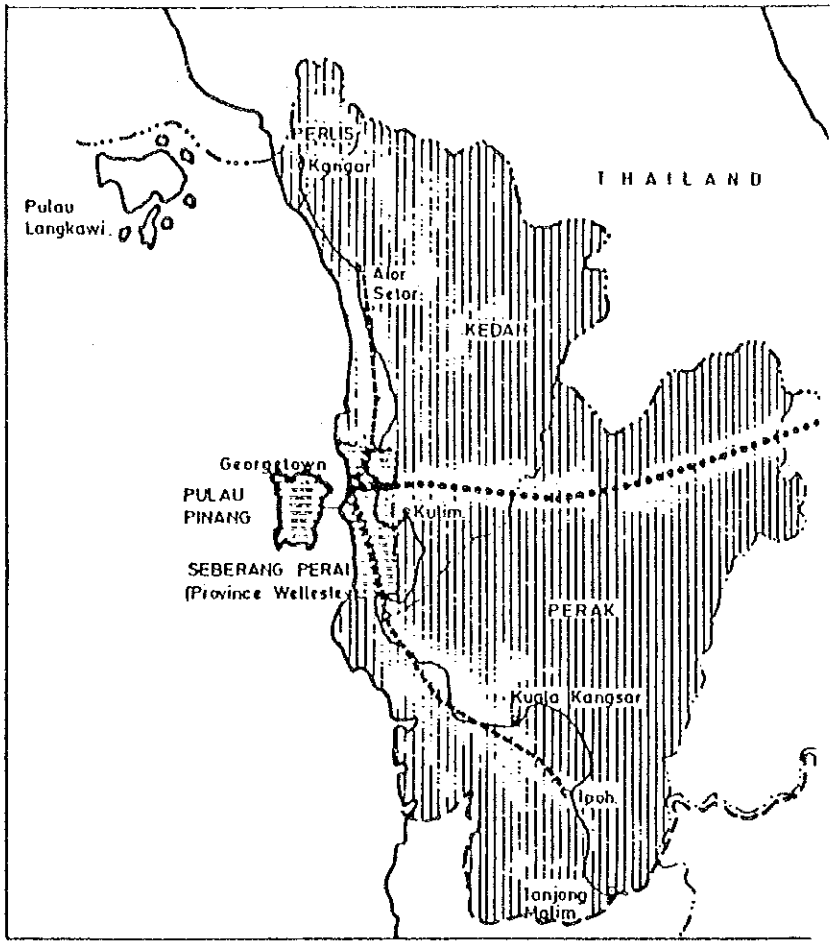


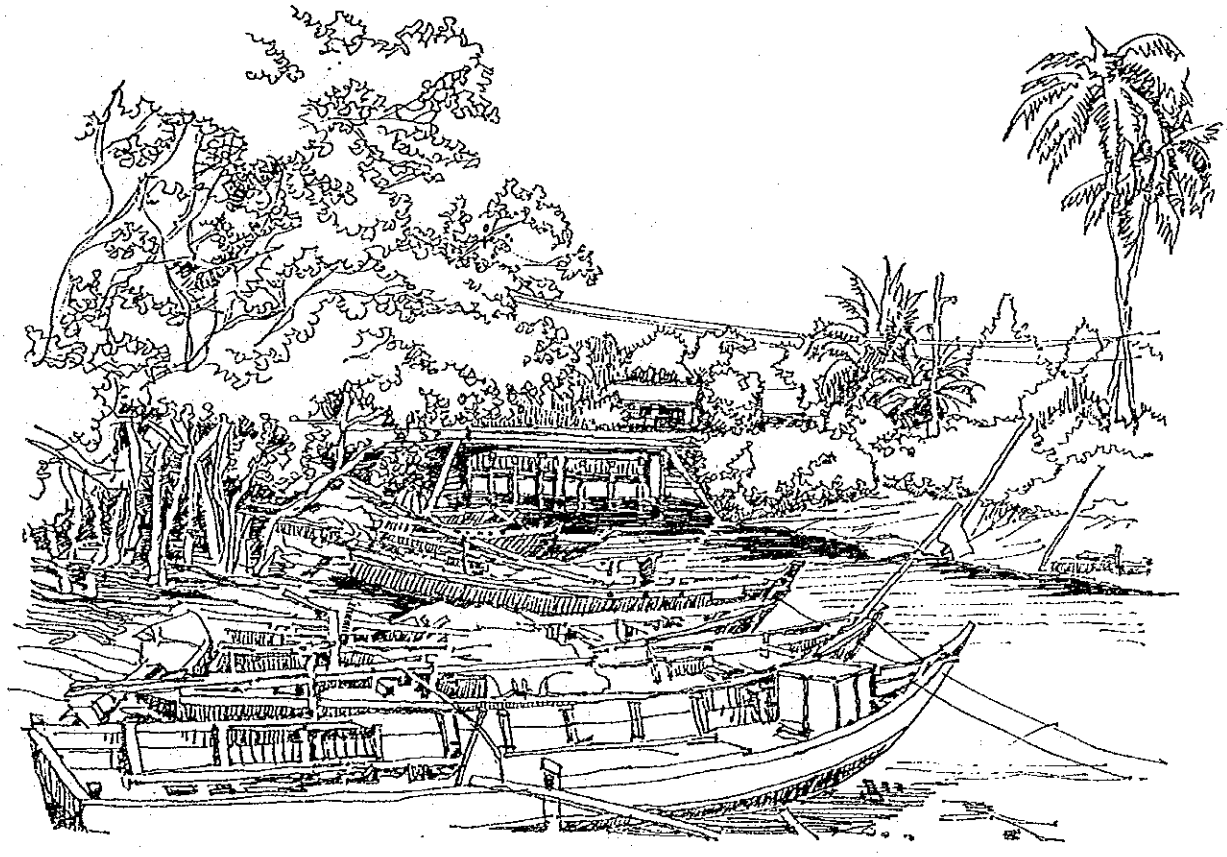
FIG. D-1 **INFLUENTIAL AREA OF PENANG ECONOMY**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

JICA

APPENDIX E

PRESENT CONDITIONS OF THE RIVERS AND BASINS IN PENANG ISLAND



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APPENDIX E PRESENT CONDITIONS OF THE RIVER AND BASINS IN PENANG ISLAND

1. INTRODUCTION

Penang Island with a total area of about 300 km^2 is located in the northern portion of the west coast of Peninsular Malaysia. The total population of the Island in 1985 was about 450,000 out of which about 260,000 lived in the City of Georgetown.

In the Island, there exist 31 main river systems as shown in Fig. E-1 with varying catchment areas ranging from as low as 1 km^2 to 50 km^2. Among these rivers, Sg. Pinang is the largest river system with a catchment area of 50.97 km^2 (including Sg. Jelutong up-stream basin). Its lower reach flows through the City of Georgetown and severe flood damages occur whenever the river overflows its banks.

The rainy season is from August to January, and flooding usually occurs in the months of September and October. The most severe floods in recent years occurred in October 1980, and an area over 2 km^2 of Georgetown was inundated for 1 to 2 days to a depth of 0.5 to 1 m. Flooding in Sg. Pinang basin has occurred so far mainly in the centre of old Georgetown along Sg. Pinang and along its tributaries, Sg. Air Terjun, Sg. Air Itam and Sg. Jelutong. After completion of Sg. Jelutong diversion channel, flooding in the Sg. Jelutong area has been mitigated ever since. In other basins also, flooding has occurred mainly in the lower basins. However, due to recent intensive land development in the upper basin, especially in the hilly side, flooding now occurs even in the upper or middle basin, such as in the Sg. Dondang, Sg. Gelugor or Sg. Relau.

In addition, the role and responsibilities of the various Departments and Agencies in the planning, development and maintenance of flood mitigation and urban drainage works both within and outside the City of Georgetown are not clearly defined. This has led to confusion and duplication in the role and functions of various Agencies resulting in a decrease in efficiency and effectiveness on the planning, development and maintenance of flood mitigation and urban drainage works. To make matters worse, no effective coordination among DID or MPPP and the Agencies who jurisdict land development or human activities, such as cultivation, housing development, land reclamation, deforestation, and mining, has been done, resulting in erosion and siltation , frequent flooding and drainage problems.

2. PRESENT CONDITIONS OF THE RIVERS AND BASINS IN PENANG ISLAND

2.1 General Description of the Basin

In the Penang Island, there are 31 main river systems which may be broadly classified into five (5) groups based on their topographical conditions, land use pattern, extent and scale of catchment area.

The first is Sg. Pinang Basin, the catchment of which is the largest and the most developed among the 31 river systems.

The second is the basins of mid scale with moderately developed catchment comprising a comparatively large area of flat land. Such river basins are located in the east coast of the Island.

The third is the basins of mid scale with sparsely developed catchment due to their unfavourable topographic conditions comprising much hills and valleys. Such basins exist along the north and south coast of the Island.

The fourth is the basins of small scale with a catchment area less than 5 km^2 and are either highly developed already or planned to be developed. Such basins exist along the north, east and south coast.

The fifth is also basins of mid scale comprising a high degree of agriculturally developed catchment. Such basins are located along the west coast of the Island.

2.2 Characteristics of the Rivers and Basins

The characteristics of each rivers and the respective basins are summarized in Tables E 1-1 ~ E 1-11.

Among these basins, four basins have serious erosion and sediment run-off potential caused by human activities. They are Sg. Pinang, Sg. Tanjung Tokong, Sg. Balik Batu and Sg. Keluang

The river channels of these basins are severely affected by siltation of river beds.

Longitudinal profiles of the 25 rivers excluding the five rivers in the west coast of the Island are shown in APPENDIX H.

Regarding land use, most of the flat land in the Island is expected to be developed into residential, park or agricultural areas until the year of 2010.

Fig. E-2 shows the present and future urbanization in each basin.

The rivers in the east coast will be extended at their river mouths due to land reclamation.

2.3 Existing Discharge Capacity of the Rivers

Existing discharge capacity was estimated for the 24 rivers in which the longitudinal and cross sectional survey have been executed.

Fig. E-3-1~ E-3-10 show the existing flow capacity and probable discharge under the land use conditions in the year 2010.

In the Sg. Pinang system, both the main river and its tributaries generally have very low discharge capacity.

The discharge capacity of the rivers in the north coast is comparatively large. However, the rivers in the east coast have extremely low discharge capacity due to existence of lowlying area and siltation problem.

The rivers in the south coast also have low discharge capacity.

2.4 Comprehensive Evaluation of Rivers and Basins

In order to formulate the implementation program and also to select the urgent project area, a comprehensive evaluation of the rivers and basins were carried out considering the scale of catchment, experienced past floods, flood damage, future land development of basin and anticipated future flood damage.

The results of this comprehensive evaluation for all 31 river basins are presented in Table E-2.

Accordingly the river basins are classified into three grades, Grade A, Grade B and Grade C, expressing the degree of importance of each river for flood control.

The following legend was used for the evaluation of rivers and basins and hence to grade the river basins based on aggregate points of evaluation.

Item	Evaluation Point	Range or Condition
Scale of Catchment	1	5.0 km^2
	2	5.0 - 10.0 km^2
	3	10.0 - km^2
Experienced Floods	1	Non-existence
	2	Sometimes
	3	Frequently
Flood Damaged	1	No damage
	2	Minor damage
	3	Serious damage
Future Development	1	No development or less than 10%
	2	10%-30% of urban expansion area
	3	30% and more
Flood Damage in Future	1	Not anticipated
	2	Minor damage anticipated
	3	Serious damage anticipated

Method of Grading : Grade A for aggregate points > 10
Grade B for aggregate points ≥ 9 but ≤ 10
Grade C for aggregate points < 9

3. EXISTING FLOOD MITIGATION PROJECTS

For the rivers in the Island, neither a comprehensive flood mitigation study nor a master plan of flood mitigation has ever been carried out in the past. The river improvement works have been executed only locally and for some very important river stretches by SDID or MPPP. These improved river stretches exist mainly in the newly urbanized area, such as a river reach with developed area at upstream or a land reclamation area.

These localised river improvement works have been executed, in general, by private housing developers based on the design conditions approved by SDID.

3.1 Completed Flood Mitigation Projects

The major flood mitigation projects already executed by SDID or MPPP are as follows:

3.1.1 Jelutong Diversion Channel

The Jelutong Diversion Channel was completed in 1976 for the purpose of diverting 80% of run-off discharge from Sg. Jelutong Catchment to South Channel.

Sg. Jelutong is a tributary of Sg. Pinang and has a catchment of 6.59 km^2. Total length of diversion channel is about 1 km comprising of 0.20 km open channel at its upstream and 0.8 km closed channel at downstream.

The section of this channel is 7.7 m wide and 2.9 m deep, with a carrying capacity of about 60 m^3/s.

More details about Jelutong diversion channel are described in APPENDIX I.

3.1.2 Sg. Tiram Diversion, Stage I

Sg. Tiram is a small river located in the vicinity at north of the Bayan Lepas International Airport. The River together with its tributaries drain an area of 437 hectares at north-west of the airport comprising mainly of agricultural and undeveloped land. During the construction of the airport runway extension, the natural drainage outlet of Sg. Tiram was blocked off and the flow was diverted into the airport drainage system which soon proved to be inadequate to cope with the increased surface run-off, resulting in nuisance flooding in the airfield.

As the solution to this flooding problem it was decided to divert the run-off from the Sg. Tiram catchment partly north-easterly to Sg. Ara and partly south-westerly to Sg. Bayan Lepas.

The diversion works to Sg. Ara, termed as Sg. Tiram Diversion Channel, Stage 1, was completed in 1970.

It involved the construction of about 2.2km of unlined trapezoidal channel with a design capacity of 34 m^3/s and runs parallel to the airport runway and discharges into Sg. Ara about 610m from the coast. The Sg. Bayan Lepas diversion channel project is termed as Sg. Tiram Diversion Channel, Stage II, and described in the subsequent section

3.2 On-Going Flood Mitigation Projects

The major flood mitigation projects that are on-going are described below:

3.2.1 Sg. Pinang Improvement Works

This river improvement work is planned to be carried out by SDID for 3.2km stretches between the river mouth and Datuk Keramat bridge. The improvement work is comprised of widening and deepening of the existing river channel section.

The design cross-section is a simple unlined one with a discharge capacity for a 2 year rainfall return period.

Alignment of the proposed river channel follows the existing route.

In the stretches to be improved, there exist four concrete bridges, but there is no plan to reconstruct these bridges.This improvement works will start in 1989 and is expected to be completed by 1990.

The construction cost is estimated to be about M$4.5 million.

The adopted design consideration for this river improvement plan is summarized below.

Length to be improved	3.2km
Design rainfall frequency	2 years return period Discharge at River Mouth 105.6m^3/s
Water level at river mouth	1.60m (H.W.S.)
Cross-section	Trapezoidal
Channel type	Storage channel (excavated waterways)
Gradient of Riverbed	1:5,000
Slope protection	Earth channel
Relocation of houses	60

3.2.2 Sg. Tiram Diversion Channel Works, Stage II

The background and basic description concerning this project is described in the previous section under, Sg. Tiram Diversion Channel Works, Stage I. As dealt with in the previous section this Stage II, works consist of diverting a portion of Sg. Tiram to Sg. Bayan Lepas with a diversion channel. The implementation is planned to be commenced in the year 1989 by SDID. The total length of diversion is 2.8km.

The discharge capacity for 0.68km of upstream portion of the diversion channel is 52.4m^3/sec, whereas for the rest 2.62km downstream portion is 76.4m^3/sec. The average width of the channel is 11m with an average depth of 3.5m. Fig. E-4 and E-5 shows the proposed route, longitudinal profile and cross section of Tiram Diversion Channel.

4. EXISTING RIVER AND RELATED STRUCTURE

In the Study area, as the river and related structures, there exist one major water supply dam, about 120 bridges and about 6.1 km of improved river stretches.

The characteristics of these structures are as follows:

4.1 Air Itam Dam

The Air Itam Dam was constructed in 1962 at the upstream of the Sg. Air Itam for the purpose of water supply.

The dam is of earth-fill type with a capacity of about 2.6 million m^3. The catchment area of the dam is 575 hectares and when full the water surface area of the dam is about 20 hectares. The crest length of the dam is about 210 m with the maximum height of about 47 m.

A cross sectional view of the dam is shown in Fig. E-6.

4.2 Bridges

In the river stretches that may require river improvement works, there are about 30 bridges along Sg. Pinang system, and about 40 bridges along the other rivers.

Most of these bridges are of concrete.

In general, the span length of the bridges are greater than the existing river widths, However some bridges are of inadequate size or have many piers thereby interfering with free flow during flood discharges.

Table E-3-1 ~ E-3-7 show the characteristics the existing bridges.

The location of these bridges are shown in Fig. E-7-1 ~ E-7-5.

4.3 Improved River Stretches

The river improvement works executed in the past are predominantly partial channelization of the river stretches.

They are either concrete channel in the newly urbanized area, retaining wall, or stone wall revetment.

The major river improvement works already completed are as follows;

Concrete box of Sg. Jelutong Diversion

Concrete Channel of Sg. Batu Ferringghi

Concrete Channel of Sg. Babi

Concrete channel of Sg. Gelugor Diversion Channel

Concrete Channel of Sg. Dua Besar

The location of these improved stretches, mostly located along the downstream reaches, are shown in Fig. E-7-1 ~ E-7-5 .

Table E-4 shows the completed or proposed length of river improvement.

5. EXISTING INSTITUTIONAL FRAMEWORK FOR RIVER AND BASIN MANAGEMENT

In Penang Island, there are a variety of rapidly progressing land development, land reclamation and other human activities such as mining and quarrying.

These activities are in general independent of each other from the view point of developer, the responsible individual organization, and the intended usage. However, they all exert profound effect on runoff, including sediment run-off, and flooding problem as they all result in change in land use pattern.

At present there exists no single organization to coordinate and control all these land development and the related human activities, that result in increase in both the surface and sediment run-off, from the view point of the overall watershed management of Penang Island.

Leaving this overall watershed management issue aside and if we consider only the operation and maintenance of facilities of flood mitigation and drainage, at present, bulk of the responsibility and jurisdiction lies with SDID and MPPP. This is evident from Table E-5, which illustrates the existing institutional framework of flood mitigation and drainage in the Island.

It is noted that the activities of SDID and MPPP are not well coordinated. For example, at time river improvement works to increase the carrying capacity of an upstream stretch or tributary is being undertaken with no consideration to the limited existing discharge capacity of the river downstream stretches when the respective stretches lies under the jurisdiction of different organizations, for example, SDID and MPPP.

Hence it is evident that the existing institutional framework for river and basin management is rather unsatisfactory, and a stage-wise upgrading is proposed as follows:

- As an urgent measure, coordination of activities among all organization responsible, especially SDID and MPPP, for operation and maintenance of flood mitigation and drainage facilities has to be established.

- It is also necessary to institute an organization to coordinate, regulate, control and manage the whole watershed of Penang Island from the view point of overall run-off.

6. EXISTING FLOOD WARNING SYSTEM

There exists only one automatic flood warning siren in the Sg. Pinang bank at the vicinity of Jalan Perak. This siren with sounding range of about 400 m was installed in 1981 and has a solar battery power source.

This flood warning siren automatically switches on when the river water level reaches EL. 1.83 m and EL. 2.44 m which are the alert and danger water levels respectively.

This siren sounds continuously for 5 minutes once the water level reaches either of the above-mentioned heights.

However, after long period of rainfall, such as 3 days, the siren does not work effectively because of poor power of battery. The vicinity area of the Jalan Perak bridge including Jalan P.Ramlee is a frequently inundated area.

The water level of Sg. Pinang at Jalan Perak bridge exceeds the alert level five to six times per year.

At Jalan Perak Bridge during heavy rainfall the rate of rising of water level is about 45 cm per 1 hour. Most of the houses located in this lowlying area are elevated floor type and evacuation of people is not held so often in comparison to the frequency of flash floods.

Tables

TABLE E-1-1 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.		1		2		3	
Name of River		Sg. Pinang		Sg. Teluk Awak		Sg. Teluk Bahang	
Location		East Coast, George Town		North West Coast, Pantai Acheh		North West Coast, Teluk Bahang	
Catchment Area (km2)		46.07 (excluding Jelutong Diversion Area)		2.95		12.30	
Topography	Highest Point of the Basin	El. 830m, Western Hill		El. 439m, Bt. Batu Itam		El. 731m, Bt. Laksamana	
	Flat Land	11.40 km2 (22%)		0.44 km2 (15%)		1.31 km2 (11%)	
	Mountainous/Hilly Area	39.57 km2 (78%)		2.51 km2 (85%)		10.99 km2 (89%)	
Land Use Pattern in the Basin	Time	Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area	13.80km2(30%)	14.98km2(33%)	0.13km2(4%)	0.29km2(10%)	0.60km2(5%)	1.03km2(8%)
	Park, Open Land, Cemetery	3.15km2(7%)	5.67km2(12%)	0.15km2(5%)	1.66km2(56%)	0.30km2(2%)	2.95km2(24%)
	Forest	22.31km2(48%)	25.42km2(55%)	2.01km2(68%)	0.62km2(21%)	7.58km2(62%)	6.44km2(52%)
	Agriculture Area	6.81km2(15%)	0.00km2(0%)	0.66km2(23%)	0.38km2(13%)	3.82km2(31%)	1.88km2(16%)
	Increase Ratio of Urbanized Area	12 %		123 %			
Erosion & Sediment Run-off	State	Serious		Negligible		Negligible	
	Source	Housing Development, Mining, Cultivation in Hillside					
Inundated Area	Name of the Area						
	Area (km2)						
Existing River Channel	Total Length (m)	20,657 (including Main Tributaries)		2,300 (Study Length : 2,100)		3,500 (3,130)	
	River Width (m)	20 ~ 50		5 ~ 10		10 ~ 15	
	Improved Channel						
	Flow Capacity (m3/sec)	20 ~ 40		5 ~ 10		30 ~ 60	
	Stretch Affected by Tidal Flow(m)	3,000		200		300	
	Sedimentation	Serious		Negligible		Negligible	
	Literal Drift Affect at River Mouth	Moderate		Moderate		Moderate	
	Future Extension of River Channel due to Land Reclamation (m)	710		-		-	
River and Related Structure	Dam	1					
	Bridge			3		2	
	Drop Structure						

TABLE E -1-2 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.		4		5		6	
Name of River		Sg. Batu Ferringghi		Sg. Satu		Sg. Mas	
Location		North Coast, Batu Ferringgi		North Coast, Batu Ferringgi		North Coast, Batu Ferringgi	
Catchment Area (km2)		11.27		2.58		2.11	
Topography	Highest Point of the Basin	El. 825m, Western Hill		El. 581m, Bt. Batu Feringgi		El. 350m	
	Flat Land	0.14 km2 (1%)		0.21 km2 (8%)		0.79 km2 (37%)	
	Mountainous/Hilly Area	11.13 km2 (99%)		2.37 km2 (92%)		1.32 km2 (63%)	
Land Use Pattern in the Basin	Time	Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area	0.06km2(0.5%)	0.57km2(5%)	0.08km2(3%)	0.42km2(16%)	0.30km2(14%)	1.23km2(58%)
	Park, Open Land, Cemetery	0.00km2(0%)	0.12km2(1%)	0.00km2(0%)	0.04km2(2%)	0.29km2(14%)	0.41km2(19%)
	Forest	11.12km2(99%)	10.58km2(94%)	2.22km2(86%)	2.12km2(82%)	0.92km2(44%)	0.47km2(23%)
	Agriculture Area	0.09km2(0.5%)	0.00km2(0%)	0.28km2(11%)	0.00km2(0%)	0.60km2(28%)	0.00km2(0%)
	Increase Ratio of Urbanized Area	850 %		425 %		310 %	
Erosion & Sediment Run-off	State	Negligible		Negligible		Negligible	
	Source						
Inundated Area	Name of the Area						
	Area (km2)						
Existing River Channel	Total Length (m)	1,250 (Study Length : 400)		1,750 (Study Length : 500)		1,500(600)	
	River Width (m)	8		7 ~ 10		5 ~ 10	
	Improved Channel						
	Flow Capacity (m3/sec)	40 ~ 100		10 ~ 60		2 ~ 20	
	Stretch Affected by Tidal Flow(m)	-		-		-	
	Sedimentation	Negligible		Negligible		Negligible	
	Literal Drift Affect at River Mouth	Moderate		Moderate		Moderate	
	Future Extension of River Channel due to Land Reclamation (m)	-		-		-	
River and Related Structure	Dam						
	Bridge	1		1		1	
	Drop Structure	1					

TABLE E-1-3 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.			7		8		9	
Name of River			Sg. Kecil		Sg. Kelian		Sg. Balik Batu	
Location			North East Coast, Batu Ferringgi		North East Coast		North East Coast, Tanjung Tokong	
Catchment Area (km2)			2.75		9.04		0.80	
Topography	Highest Point of the Basin		El. 548m		El. 742m		El. 215m, Mt. Erskine	
	Flat Land		0.40 km2 (15%)		1.36 km2 (15%)		0.23 km2 (29%)	
	Mountainous/Hilly Area		2.35 km2 (85%)		7.68 km2 (85%)		0.57 km2 (71%)	
Land Use Pattern in the Basin	Time		Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area		0.71km2(26%)	0.77km2(28%)	2.41km2(27%)	2.63km2(29%)	0.72km2(90%)	0.71km2(89%)
	Park, Open Land, Cemetery		0.04km2(1%)	0.00km2(0%)	0.02km2(0%)	0.05km2(1%)	0.01km2(1%)	0.02km2(2%)
	Forest		2.00km2(73%)	1.98km2(72%)	5.29km2(58%)	6.36km2(70%)	0.07km2(9%)	0.07km2(9%)
	Agriculture Area		0.00km2(0%)	0.00km2(0%)	1.32km2(15%)	0.00km2(0%)	0.00km2(0%)	0.00km2(0%)
	Increase Ratio of Urbanized Area		8 %		9 %		0 %	
Erosion & Sediment Run-off	State		Moderate		Moderate		Serious	
	Source						Housing Development	
Inundated Area	Name of the Area							
	Area (km2)							
Existing River Channel	Total Length (m)		1,100(705)		2,811		1,250(500)	
	River Width (m)		6 ~ 10		10 ~ 20		4 ~ 20	
	Improved Channel							
	Flow Capacity (m3/sec)		15 ~ 40		20 ~ 40		10 ~ 30	
	Stretch Affected by Tidal Flow(m)		-		-		-	
	Sedimentation		Moderate		Moderate		Serious, 1.2m deep	
	Literal Drift Affect at River Mouth		Moderate		Moderate		Serious	
	Future Extension of River Channel due to Land Reclamation (m)		-		-		-	
River and Related Structure	Dam							
	Bridge							
	Drop Structure							

TABLE E-1-4 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.			10		11		12	
Name of River			Sg. Fettes		Sg. Bagan Jermal		Sg. Babi	
Location			North East Coast, Tanjung Tokong		North East Coast, Tanjung Tokong		North East Coast, Tanjung Tokong	
Catchment Area (km2)			1.36		0.83		0.84	
Topography	Highest Point of the Basin		El. 242m		El. 252m, Mt. Olivia		El. 197m	
	Flat Land		0.45 km2 (33%)		0.28 km2 (34%)		0.40 km2 (48%)	
	Mountainous/Hilly Area		0.91 km2 (67%)		0.55 km2 (66%)		0.44 km2 (52%)	
Land Use Pattern in the Basin	Time		Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area		0.65km2(48%)	0.95km2(70%)	0.27km2(33%)	0.27km2(33%)	0.33km2(39%)	0.49km2(58%)
	Park, Open Land, Cemetery		0.05km2(4%)	0.14km2(10%)	0.26km2(31%)	0.37km2(45%)	0.27km2(32%)	0.27km2(32%)
	Forest		0.66km2(48%)	0.27km2(20%)	0.30km2(36%)	0.19km2(22%)	0.24km2(29%)	0.08km2(10%)
	Agriculture Area		0.00km2(0%)	0.00km2(0%)	0.00km2(0%)	0.00km2(0%)	0.00km2(0%)	0.00km2(0%)
	Increase Ratio of Urbanized Area		46 %		0 %		49 %	
Erosion & Sediment Run-off	State		Moderate		Moderate		Negligible	
	Source		Housing Development		Housing Development		Non Point Source	
Inundated Area	Name of the Area							
	Area (km2)							
Existing River Channel	Total Length (m)		1,250(600)		1,500 (Study Length : 300)		1,700 (Study Length : 1,000)	
	River Width (m)		3 ~ 5		4		4.5 ~ 7.5	
	Improved Channel						150	
	Flow Capacity (m3/sec)		40 (~ Lower Flow Nothing)		140		2 ~ 5	
	Stretch Affected by Tidal Flow(m)		-		-		-	
	Sedimentation		Moderate, 0.3m deep		Moderate		Negligible	
	Literal Drift Affect at River Mouth		Serious		Minor Affect		Moderate	
	Future Extension of River Channel due to Land Reclamation (m)		-		-		-	
River and Related Structure	Dam							
	Bridge				3		3	
	Drop Structure						1	
					1			

TABLE E-1-5 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.		13		14		15	
Name of River		Sg. Gelugor		Sg. Dua Besar		Sg. Nibong Besar	
Location		East Coast, Paya Terubong		East Coast, Paya Terubong		East Coast ; Paya Terubong, Bayan Lepas	
Catchment Area (km2)		4.07		6.19		1.50	
Topography	Highest Point of the Basin	El. 413m, Bt. Relau		El. 411m, Bt. Relau		El. 240m. Bt. Jambul	
	Flat Land	1.31 km2 (32%)		2.85 km2 (46%)		1.22 km2 (81%)	
	Mountainous/Hilly Area	2.76 km2 (68%)		3.34 km2 (54%)		0.28 km2 (19%)	
Land Use Pattern in the Basin	Time	Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area	1.79km2(44%)	2.36km2(77%)	2.83km2(46%)	3.95km2(64%)	0.98km2(65%)	1.25km2(83%)
	Park, Open Land, Cemetery	0.93km2(23%)	0.27km2(9%)	0.74km2(12%)	1.79km2(29%)	0.33km2(22%)	0.10km2(7%)
	Forest	1.06km2(26%)	0.43km2(14%)	0.68km2(11%)	0.45km2(7%)	0.14km2(9%)	0.15km2(10%)
	Agriculture Area	0.29km2(7%)	0.00km2(0%)	1.94km2(31%)	0.00km2(0%)	0.05km2(4%)	0.00km2(0%)
	Increase Ratio of Urbanized Area			39 %		28 %	
Erosion & Sediment Run-off	State	Moderate		Moderate		Negligible	
	Source						
Inundated Area	Name of the Area	Taman Brown, Minden Heights		Tapak Pesta, Pantai Jerjak			
	Area (km2)	0.12		0.63			
Existing River Channel	Total Length (m)	2,900		3,950 (Study length : 2,900)		2,000 (Study Length : 1,050)	
	River Width (m)			20 ~ 30		10	
	Improved Channel					1,500	
	Flow Capacity (m3/sec)	8 ~ 15		5 ~ 15		5 ~ 20	
	Stretch Affected by Tidal Flow(m)	500		1,200		800	
	Sedimentation	Negligible		Negligible		Negligible	
	Literal Drift Affect at River Mouth	Negligible		Negligible		Negligible	
	Future Extension of River Channel due to Land Reclamation (m)	-		650		600	
River and Related Structure	Dam						
	Bridge			3		3	
	Drop Structure						

TABLE E-1-6 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.		16		17		18	
Name of River		Sg. Nibong Kecil		Sg. Keluang		Sg. Nipah	
Location		East Coast, Paya Terubong, Bayan Lepas		East Coast ; Paya Terubong, Bayan Lepas		South East Coast, Bayan Lepas	
Catchment Area (km2)		2.77		22.17 (excluding Sg. Tiram Diversion Area)		1.69	
Topography	Highest Point of the Basin	El. 240m, Bt. Jambul		El. 513m, Bt. Meriyam		El. 157m, Bt. Tempoyak	
	Flat Land	2.32 km2 (84%)		6.53 km2 (29%)		1.29 km2 (76%)	
	Mountainous/Hilly Area	0.45 km2 (16%)		15.64 km2 (71%)		0.40 km2 (24%)	
Land Use Pattern in the Basin	Time	Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area	1.72km2(62%)	2.31km2(83%)	4.76km2(21%)	8.73km2(40%)	0.21km2(12%)	1.40km2(83%)
	Park, Open Land, Cemetery	1.04km2(38%)	0.32km2(12%)	1.09km2(5%)	0.95km2(4%)	0.15km2(9%)	0.02km2(1%)
	Forest	0.01km2(0%)	0.14km2(5%)	3.06km2(14%)	11.73km2(53%)	0.40km2(24%)	0.18km2(11%)
	Agriculture Area	0.00km2(0%)	0.00km2(0%)	13.26km2(60%)	0.77km2(3%)	0.93km2(55%)	0.09km2(5%)
	Increase Ratio of Urbanized Area	34 %		83 %		567 %	
Erosion & Sediment Run-off	State	Negligible		Serious		Negligible	
	Source			Mining			
Inundated Area	Name of the Area			1. PDC Housing Area, Jalan Tengah 2. Bayan Lepas, Free Trade Zone			
	Area (km2)			1. 1.18 2. 0.46			
Existing River Channel	Total Length (m)	2,500 (Study Length : 900)		5150 (Study Length : 3,760)		2,500(1,906)	
	River Width (m)	10.5		13 ~ 20 (ARA 5)		Up Stream 2.5 Lower 15.3	
	Improved Channel	600					
	Flow Capacity (m3/sec)	20 ~ 40		10 ~ 30		1 ~ 20	
	Stretch Affected by Tidal Flow(m)	1,000		2,800		1,500	
	Sedimentation	Organic Mud		Serious		Negligible	
	Literal Drift Affect at River Mouth	Negligible		Reclamation (ongoing)		Negligible	
	Future Extension of River Channel due to Land Reclamation (m)	490		900		500	
River and Related Structure	Dam						
	Bridge	1		5			
	Drop Structure						
	Gate	1 (River Mouth)					

TABLE E-1-7 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.		19		20		21	
Name of River		Sg. Kampung Masjid		Sg. Ikan Mati		Sg. Bayan Lepas	
Location		South East Coast, Bayan Lepas		South East of Island, Bayan Lepas		South East of Island, Bayan Lepas	
Catchment Area (km2)		0.84		0.38		7.04	
Topography	Highest Point of the Basin	El. 109m		El. 157m, Bt. Tempoyak		El. 405m. Bt. Gambir	
	Flat Land	0.51 km2 (61%)		0.18 km2 (47%)		1.08 km2 (15%)	
	Mountainous/Hilly Area	0.33 km2 (39%)		0.20 km2 (53%)		5.96 km2 (85%)	
Land Use Pattern in the Basin	Time	Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area	0.30km2(36%)	0.60km2(71%)	0.11km2(29%)	0.35km2(92%)	0.80km2(11%)	1.32km2(19%)
	Park, Open Land, Cemetery	0.13km2(16%)	0.11km2(13%)	0.02km2(5%)	0.00km2(0%)	0.02km2(0%)	0.60km2(9%)
	Forest	0.08km2(10%)	0.08km2(10%)	0.00km2(0%)	0.03km2(8%)	0.44km2(6%)	5.08km2(72%)
	Agriculture Area	0.33km2(38%)	0.05km2(6%)	0.25km2(66%)	0.00km2(0%)	5.78km2(83%)	0.04km2(0%)
	Increase Ratio of Urbanized Area	100 %		218 %		65 %	
Erosion & Sediment Run-off	State	Negligible		Negligible		Negligible	
	Source						
Inundated Area	Name of the Area					Parmatang Damar Laut	
	Area (km2)						
Existing River Channel	Total Length (m)	950(600)		500(150)		3,500 (Study length : 2,400)	
	River Width (m)	3 ~ 5		1.5 ~ 4		7	
	Improved Channel						
	Flow Capacity (m3/sec)	10		2		10 ~ 30	
	Stretch Affected by Tidal Flow(m)	400		-		200	
	Sedimentation	Negligible		Negligible		Negligible	
	Literal Drift Affect at River Mouth	Negligible		Negligible		Negligible	
	Future Extension of River Channel due to Land Reclamation (m)	-		-		-	
River and Related Structure	Dam						
	Bridge					5	
	Drop Structure						

TABLE E-1-8 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.		22		23		24	
Name of River		Sg. Batu		Sg. Mati		Sg. Teluk Kumbar	
Location		South Coast of Island, Teluk Kumbar		South Coast, Teluk Kumbar		South Coast, Bt. Gemuroh	
Catchment Area (km2)		0.9		0.95		7.06	
Topography	Highest Point of the Basin	El. 172m, Bt. Payong		El. 269m		El. 413m	
	Flat Land	0.45 km2 (50%)		0.60 km2 (63%)		2.31 km2 (33%)	
	Mountainous/Hilly Area	0.45 km2 (50%)		0.35 km2 (37%)		4.75 km2 (67%)	
Land Use Pattern in the Basin	Time	Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area	0.23km2(26%)	0.38km2(42%)	0.29km2(30%)	0.47km2(49%)	0.93km2(13%)	1.13km2(16%)
	Park, Open Land, Cemetery	0.00km2(0%)	0.01km2(1%)	0.07km2(7%)	0.00km2(0%)	0.12km2(2%)	0.01km2(0%)
	Forest	0.64km2(71%)	0.43km2(48%)	0.02km2(2%)	0.20km2(21%)	1.52km2(22%)	4.95km2(70%)
	Agriculture Area	0.03km2(3%)	0.08km2(9%)	0.57km2(60%)	0.28km2(30%)	4.49km2(63%)	0.97km2(14%)
	Increase Ratio of Urbanized Area	164 %		62 %		22 %	
Erosion & Sediment Run-off	State	Moderate		Negligible		Negligible	
	Source	Non Point					
Inundated Area	Name of the Area	Teluk Kumbar / Sg. Batu					
	Area (km2)						
Existing River Channel	Total Length (m)	1,150(1,000)		1,037(800)		3,000(1,700)	
	River Width (m)	2 ~ 5		5 ~ 10			
	Improved Channel			700			
	Flow Capacity (m3/sec)	5		2		5 ~ 30	
	Stretch Affected by Tidal Flow(m)	-		-		800	
	Sedimentation	Moderate, Recently Dredged		Negligible		Negligible	
	Literal Drift Affect at River Mouth	Negligible		Negligible		Moderate	
	Future Extension of River Channel due to Land Reclamation (m)	-		-		-	
River and Related Structure	Dam						
	Bridge						
	Drop Structure						

TABLE E-1-9 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.		25		26		27	
Name of River		Sg. Gemuroh		Sg. Gertak Sanggul		Sg. Pulau Betong	
Location		South West Coast, Bt. Gemuroh		South West Coast, Pasir Paniang Hills		South West Coast, Benting, Plain Genting Hills	
Catchment Area (km2)		1.91		1.03		11.04	
Topography	Highest Point of the Basin	El. 303m, Bt. Gemuroh		El. 360m, Bt. Pulau Betong		El. 413m	
	Flat Land	0		0.18 km2 (17%)		6.58 km2 (60%)	
	Mountainous/Hilly Area	1.91 km2 (100%)		0.85 km2 (83%)		4.46 km2 (40%)	
Land Use Pattern in the Basin	Time	Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area	0.02km2(1%)	0.02km2(1%)	0.09km2(9%)	0.09km2(9%)	0.69km2(6%)	0.68km2(6%)
	Park, Open Land, Cemetery	0.03km2(2%)	0.03km2(2%)	0.00km2(0%)	0.00km2(0%)	0.07km2(1%)	0.07km2(1%)
	Forest	0.67km2(35%)	1.35km2(71%)	0.22km2(21%)	0.79km2(77%)	2.95km2(27%)	3.85km2(35%)
	Agriculture Area	1.19km2(62%)	0.51km2(26%)	0.72km2(70%)	0.15km2(14%)	7.33km2(66%)	6.44km2(58%)
	Increase Ratio of Urbanized Area	0 %		0 %		0 %	
Erosion & Sediment Run-off	State	Negligible		Negligible		Negligible	
	Source						
Inundated Area	Name of the Area					Pulau Betong	
	Area (km2)					0.22	
Existing River Channel	Total Length (m)	-		483.50		4,250	
	River Width (m)			2 ~ 5			
	Improved Channel						
	Flow Capacity (m3/sec)	-		20			
	Stretch Affected by Tidal Flow(m)	-		-			
	Sedimentation	Negligible		Negligible		Desiltation requested at lower reach	
	Literal Drift Affect at River Mouth	Negligible		Moderate			
	Future Extension of River Channel due to Land Reclamation (m)	-		-			
River and Related Structure	Dam						
	Bridge						
	Drop Structure						

TABLE E-1-10 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.		28		29		30	
Name of River		Sg. Nipah		Sg. Burong		Sg. Kongsi	
Location		West Coast, Sungai Burong, Pulan Betong		West coast, Sungai Burong, Pondok Upeh		West Coast Bagan Air Itam, Batu Itam	
Catchment Area (km2)		3.24		13.79		20.63	
Topography	Highest Point of the Basin	El. 92m		El. 452m		El. 720m, Batu Itam	
	Flat Land	3.11 km2 (96%)		6.95 km2 (50%)		8.06 km2 (39%)	
	Mountainous/Hilly Area	0.13 km2 (4%)		6.84 km2 (50%)		12.57 km2 (61%)	
Land Use Pattern in the Basin	Time	Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area	0.87km2(27%)	0.87km2(27%)	2.50km2(18%)	2.41km2(17%)	2.18km2(11%)	2.23km2(11%)
	Park, Open Land, Cemetery	0.05km2(1%)	0.02km2(1%)	0.61km2(4%)	0.34km2(3%)	0.61km2(3%)	0.10km2(0%)
	Forest	0.00km2(0%)	0.04km2(1%)	0.84km2(6%)	5.47km2(40%)	2.67km2(13%)	8.44km2(41%)
	Agriculture Area	2.32km2(72%)	2.31km2(71%)	9.84km2(72%)	5.57km2(40%)	15.17km2(73%)	9.86km2(48%)
	Increase Ratio of Urbanized Area	0 %		0 %		2 %	
Erosion & Sediment Run-off	State	Negligible		Negligible		Negligible	
	Source						
Inundated Area	Name of the Area			1. Kampong Paya 2. Balik Pulau		Kampong Titi Tras	
	Area (km2)			1. 0.17 2. 0.14		1.08	
Existing River Channel	Total Length (m)	3,000		6,500		8,375 (Tributary : Sg. Korok)	
	River Width (m)						
	Improved Channel						
	Flow Capacity (m3/sec)						
	Stretch Affected by Tidal Flow(m)						
	Sedimentation					Negligible	
	Literal Drift Affect at River Mouth			Negligible		Negligible	
	Future Extension of River Channel due to Land Reclamation (m)						
River and Related Structure	Dam						
	Bridge						
	Drop Structure						

TABLE E-1-11 CHARACTERISTICS OF RIVERS AND BASINS

Catchment No.			31					
Name of River			Sg. Pinang					
Location			West Coast, Sungai Pinang					
Catchment Area (km2)			19.99					
Topography	Highest Point of the Basin		El. 830m, Western Hill					
	Flat Land		5.53 km2 (28%)					
	Mountainous/Hilly Area		14.46 km2 (72%)					
Land Use Pattern in the Basin	Time		Present (1989)	Future (2010)	Present (1989)	Future (2010)	Present (1989)	Future (2010)
	Build-up Area		1.70km2(9%)	1.69km2(8%)				
	Park, Open Land, Cemetery		0.38km2(2%)	0.13km2(1%)				
	Forest		8.04km2(40%)	14.66km2(73%)				
	Agriculture Area		9.87km2(49%)	3.51km2(18%)				
	Increase Ratio of Urbanized Area		0 %					
Erosion & Sediment Run-off	State		Negligible					
	Source							
Inundated Area	Name of the Area							
	Area (km2)							
Existing River Channel	Total Length (m)		3,750 (Main Tributary : Sg. Rusa)					
	River Width (m)							
	Improved Channel							
	Flow Capacity (m3/sec)							
	Stretch Affected by Tidal Flow(m)							
	Sedimentation		Desiltation requested at lower reach					
	Literal Drift Affect at River Mouth		Negligible					
	Future Extension of River Channel due to Land Reclamation (m)							
River and Related Structure	Dam							
	Bridge							
	Drop Structure							

TABLE E-2 COMPREHENSIVE EVALUATION OF RIVERS AND BASINS

Catchment No.	Name	Scale of Catchment	Experienced Floods	Flood Damage	Future Development	Flood Damage In Future	Total	Grade
1	Sg. Pinang	3	3	3	2	3	14	A
2	Sg. Teluk Awak	1	1	1	3	2	8	C
3	Sg. Teluk Bahang	3	1	1	3	2	10	B
4	Sg. Batu Ferringghi	3	1	1	1	1	7	C
5	Sg. Salu	1	1	1	2	1	6	C
6	Sg. Mas	1	1	1	3	2	8	C
7	Sg. Kecil	1	1	1	1	1	5	C
8	Sg. kellan	2	1	1	1	1	6	C
9	Sg. Balik Batu	1	1	1	1	1	5	C
10	Sg. Fettes	1	2	1	3	2	9	B
11	Sg. BaganJermal	1	1	1	2	1	6	C
12	Sg. Babi	1	2	1	2	1	7	C
13	Sg. Gelugor	1	2	2	2	2	9	B
14	Sg. Dua Besar	2	2	1	3	3	11	A
15	Sg. Nibong Besar	1	1	1	2	2	7	C
16	Sg. Nibong Kecil	1	1	1	2	2	7	C
17	Sg. Keluang	3	2	2	2	3	12	A
18	Sg. Nipah	1	1	1	3	1	7	C
19	Sg. Kampung Masjid	1	1	1	3	1	8	C
20	Sg. Ikan Mati	1	1	1	3	1	7	C
21	Sg. Bayan Lepas	2	2	1	2	1	9	B
22	Sg. Batu	1	1	1	2	1	6	C
23	Sg. Mati	1	1	1	2	1	6	C
24	Sg. Teluk Kumbar	2	1	1	1	1	6	C
25	Sg. Gemuroh	1	1	1	1	1	5	C
26	Sg. Gertak Sanggul	1	1	1	1	1	5	C
27	Sg. Pulau Betong	3	2	1	1	1	8	C
28	Sg. Nipah	1	1	1	1	1	5	C
29	Sg. Burong	3	2	1	1	1	8	C
30	Sg. Kongsi	3	2	1	1	1	8	C
31	Sg. Pinang in West Coast	3	1	1	1	1	7	C

The above are evaluated by following criteria:

Scale of Catchment	1	5.0 km^2
	2	5.0 - 10.0 km^2
	3	10.0 - km^2
Experienced Floods	1	Non-existence
	2	Sometimes
	3	Frequently
Flood Damaged	1	No damage
	2	Minor damage
	3	Serious damage
Future Development	1	No development or less than 10%
	2	10%-30% of urban expansion area
	3	30% and more
Flood Damage In Future	1	Not anticipated
	2	Minor damage anticipated
	3	Serious damage anticipated

Method of Grading : Grade A for aggregate points > 10
Grade B for aggregate points ≥ 9 but ≤ 10
Grade C for aggregate points < 9

TABLE E-3-1 FEATURES OF EXISTING BRIDGES

SG.PINAG	(m)	(m)	(m)	(m^2)	(m)	(m)	(m)	(m^2)	
	CHAIN	SPAN LENGTH	WIDTH	AREA	SOFIT LEVEL	DESIGN LENGTH	DIFFERENCE	AREA	NECESSITY
	400+7	29	10	290	3.57	44.46	15.46	444.6	CHANGE
	900+4	20	6	120	3.13	40.45	20.45	242.7	CHANGE
	1250+23	25	10	250	4.1	40.45	15.45	404.5	CHANGE
	2100+22	18	15	270	2.83	30.4	12.4	456	CHANGE
	3100+29	18	16	288	4.09	30.4	12.4	486.4	CHANGE
				1218				2,034	
SG.AIR ITAM									
	1050+12	13	30	390	6.39	25.4	12.4	762	CHANGE
	1450+43	18	18.5	333	6.55	23.6	5.6	426.6	CHANGE
	1550+31	23.8	8	*	6.8	23.6	-0.2		
	1900+37	23.7	2.5	*		23.6	-0.1		
	2450+21	21.8	9.5	207.1	8.1	23.6	1.8	224.2	CHANGE
				930				1,423	
SG.AIR TERJUN	(m)	(m)	(m)	(m^2)	(m)	(m)	(m)	(m^2)	
	CHAIN	SPAN LENGTH	WIDTH	AREA	SOFIT LEVEL	DESIGN WIDTH	DIFFERENCE	AREA	NECESSITY
	200	6.6	8	52.8	4.55	11.3	4.7	90.4	CHANGE
	520	6.6	8	52.8	4.55	11.3	4.7	90.4	CHANGE
	570	7.4	5	37	5.25	11.3	3.9	56.5	CHANGE
	720	10	6	60	6.37	11.3	1.3	67.8	CHANGE
	940	8	5	40	7.05	11.3	3.3	56.5	CHANGE
	1150	15.1	22	*	7.25	11.3	-3.8	248.6	
	3490	5.4	9	48.6	16.7	11.8	6.4	106.2	CHANGE
	3800	4.5x2x2	4.5	20.25	*	11.8	#VALUE!	53.1	CHANGE
	4380	7	2	14	18.25	11.8	4.8	23.6	CHANGE
	4640	8.5	7	59.5	22.48	11.8	3.3	82.6	CHANGE
				385				876	
2. Sg.Tehik Awak	(m)	(m)	(m)	(m^2)	(m)	(m)	(m)	(m^2)	
	CHAIN	SPAN LENGTH	WIDTH	AREA	SOFIT LEVEL	DESIGN WIDTH	DIFFERENCE	AREA	NECESSITY
	230	D1.x2	8		*	10.2	#VALUE!	81.6	CHANGE
	510	3.1	8	24.8	*	10.2	7.1	81.6	CHANGE

TABLE E-3-2 FEATURES OF EXISTING BRIDGES

	1450	D1.5x2	3.5	#VALUE!	*	9.5	#VALUE!	33.25	CHANGE
				50				196	
3. SG.TELUK BAHANG									
	280	17	6	102	*	18.3	1.3	109.8	CHANGE
	1310	8.2	3.1	25.42	*	18.3	10.1	56.73	CHANGE
				127				167	
4. Sg. Batu Perringgi	210	7.7	4	30.8	*	11.2	3.5	44.8	CHANGE
5. Sg. Satu	300	8	6	48	*	8.9	0.9	53.4	CHANGE
	1130	13	5	*	*				
6. Sg. Mas	265	9.9	8	*	*	9.1	-0.8	72.8	NO
8. Sg. Kelian	140	13	9.4		*	10.2	-2.8	95.88	NO
	620	8	10.3	82.4	*	10.2	2.2	105.06	CHANGE
	1070	6	13.8	82.8	*	10.2	4.2	140.76	CHANGE
	1310	13	7.8	*	*	10.2	-2.8	*	NO
	1720	5.8	3.2	18.56	*	10.2	4.4	32.64	CHANGE
	2300	7.3	6.1	44.53	*	10.2	2.9	62.22	CHANGE
				184				374	
11. Sg. Bagan Jermai	150	1.6x1.1x2.0	19	30.4	1.186	4.8	#VALUE!	91.2	CHANGE
	252	8	4		*	4.8	-3.2	*	NO
	650	6	13		*				
				30					
12. Sg. Babi	220	0.9x3	60	54	*	4.8	#VALUE!	288	CHANGE
	930	4	12		*	3.9	-0.1	*	NO
	1690	D0.6x1	3		*				
	1730	D0.7x1	17		*				
								288	
14. Sg. Dua Besar	615	18.7	35		3.006	17.6	-1.1	*	NO
	1430	15	14		*	11.4	-3.6	*	NO
	2870	2.1x2.2x1	4		11.434	*			
	3200	2.4x1.3x2	4		13.846	*			
								0	

TABLE E-3-3 FEATURES OF EXISTING BRIDGES

15. Sg. Nibong Besar	400	9	*			3.24	7.48	-1.52	*	NO
	830	4.5	25	112.5	*		7.48	2.98	187	CHANGE
	1250	5	25	125	*		5.88	0.88	147	CHANGE
	1400	1.9x1.85x1	82	155.8		5.32	5.88	#VALUE!	482.16	CHANGE
	1600	1.8x1.2x2	33	59.4		5.89	5.88	#VALUE!	194.04	CHANGE
				452.7						
									1,010	
16. Sg. Nibong Kecbil	1170	10.5	10	*		2.05	*		*	NO
17. Sg. Kelubang	1550	80	*		*		2.38	54.2	-25.8	* NO
	1880	75	*		*		3.75	54.2	-20.8	* NO
	2830	80	*		*		6.58	24	-56	* NO
	3420	9	27	243	?		24	15	648	CHANGE
	4260	12	*				*			*
				243					648	
21. Sg. Bayan Lepas	400	6	9	54		1.78	25.9	19.9	233.1	CHANGE
	1250	5	4.5	22.5		3.14	16	11	72	CHANGE
	1450	6	4	24		4.1	10.3	4.3	41.2	CHANGE
	2060	4	9.5	38		6.77	9.4	5.4	89.3	CHANGE
	2600	5.5	*			7.7	*			*
				138.5					436	
13. SG. GELUGOR		(m)	(m)	(m^2)		(m)	(m)	(m)	(m^2)	
	CHAIN	SPAN LENGTH	WIDTH	AREA		SOFIT LEVEL	DESIGN WIDTH	DIFFERENCE	AREA	NECESSITY
CON.	0+27	35	16	*			11.4	-23.6	*	NO
CON.	100+5	22	10	*			11.4	-10.6	*	NO
CON.	150	27	14	*			11.4	-15.6	*	NO
CON.	150+25	22	10	*			11.4	-10.6	*	NO
CON.	500+27						11.4	11.4	0	NO
	650+17						11.4	11.4	0	NO
CON.	850+7.5	11	10	110			11.4	0.4	114	CHANGE
CON.	950+48	18	5	*			11.4	-6.6	*	NO
CON.	1150+40	7	11	77			9.9	2.9	108.9	CHANGE
	1450+9	*	*				*	*	*	NO
	1550+11	*	*				*	*	*	NO
CON.	1800+19	7	2	14			8.5	1.5	17	CHANGE
CON.	2000+37	12	7	*			8.5	-3.5	*	NO
WDN	2200+39	13	10	*			2.5	-10.5	*	NO
CON.	2550+49	6	12	*			2.5	-3.5	*	NO
				201					240	
22. SG. BATU										
WDN.	300+21		3				13.6	13.6	*	*

TABLE E-3-4 FEATURES OF EXISTING BRIDGES

WDN.	350+27.5		2.24			13.6	13.6	*	*
CON.	400+11	6.3	1.5	9.45	1.86	13.6	7.3	20.4	CHANGE
	450+11.2								
	550+46								
	650+6								
	700+13								
	750+18								
	800+11								
	1100+15								
	1100+29								
	1100+48							20	
23. SG. MATI									
	00+18.5		2.23			13.8			
	50+17.5		1.94			13.8			
CON.	150+8.5	22.5	1.5		2.23	13.8	-8.7	*	NO
CON.	250+22	5.08	2.15	10.922	1.94	13.8	8.72	29.67	CHANGE
CON.	450+19	8.6	4.5	38.7	3.42	13.8	5.2	62.1	CHANGE
	150+23					13.8			
	450+40.5					13.8			
	650+9					13.8			
CON.	650+15.5	3.75	2.2	8.25	3.52	13.8	10.05	30.36	CHANGE
	650+16.5					13.8			
	650+19					13.8			
	580+4.5					13.8			
CON.	950+45	7.1	1.5		6.85				
								122	
				57.872					
20. SG. IKAN MATI									
CULVERT	00+44	1.5	3.5	5.25		6.9	5.4	24.15	CHANGE
	50+7	1	5	5		6.9	5.9	34.5	CHANGE
	50+9					6.9			
	50+29					6.9			
	100+1	3	3	9		6.9	3.9	20.7	CHANGE
	250+5	2	3						
	300+14	8	1.5						
	300+43	3	3						
	350+13	3	4						
	400+33	2	8						
								79	
				19.25					
18. SUNGAI NIPAH									

TABLE E-3-5 FEATURES OF EXISTING BRIDGES

	150								
	200+48					10.5			*
CON.	750+28	11.5	7.1		1.06	10.5	-1	*	NO
CON.	1400+14	2.55	3	7.65	1.35	10.5	7.95	31.5	CHANGE
	1650+8					10.5			*
	1700+18					10.5			*
24. SG. TELOK KUMB								32	
	50+24.8					25.4			
	50+29					25.4			
CON.	50+37	13.5	5.5	74.25	1.7	25.4	11.9	139.7	CHANGE
	100+32.5					25.4			
	100+28					25.4			
	200+35.4					25.4			
	250+30					25.4			
WDN.	500+36		1.7			25.4			
	600+23					25.4			
	1100+35					20.7			
	1150+5					20.7			
	1150+6					20.7			
CON.	1150+12	3.9	3.1	12.09	3.1	20.7	16.8	64.17	CHANGE
	1200+22					20.7			
WDN	1500+45		5.04			20.7			
	1550+42					20.7			
	1650+27					20.7			
	1700+45					20.7			
WDN.	1750+19		6.19						
CON.	1950+45		*						
			21.53					204	
9. SG. BALIK BATU									
	200+3					6.6			
	200+27					6.6			
	300+29					6.6			
	600+22.5								
CON.	600+33.5	20	12						
	600+39								
	700+36								
	750+27								
CON.	750+38.7	7	6						
	800+43								
CON.	800+48.6	13	12						
	850+5								
	950+1.8								
								0	

TABLE E-3-6 FEATURES OF EXISTING BRIDGES

19. SG. KAMPONG MA									
	100+32					9.2			
	100+34					9.2			
CON.	100+39	5.5	5.6	30.8	1.71	9.2	3.7	51.52	CHANGE
	100+43.5					9.2			
	100+47					9.2			
	150+9					9.2			
	200+55					9.2			
CON.	400+37.5	2.4	4	9.6	1.52	9.2	6.8	36.8	CHANGE
	500+16.5					9.2			
	600+26.5								
CON.	650+26	2.4	5		3.74		-2.4 *		*
	700+61								
	750+31								
CON.	750+37.5	3	10.5				-3 *		*
	750+44			40				88	
	750+45								
	950+16								
	950+28								
10. SG. FETTES									
	50+34								
CON.	90+54					4.3 *		0	NO
CON.	150+46	6	2.6			4.3	-1.7 *		NO
CON.	150+49					4.3 *		0	NO
CON.	350+9	7	4.2			4.3	-2.7 *		NO
WDN.	400+34					4.3			
	400+36								
	500+10								
	500+24								
	500+30								
	500+34								
	550+40								
								0	
7. SG. KECIL									
CON.	100+16	8.8	6	52.8		9.5	0.7	57	CHANGE
	200+44					9.5			
CON.	350+36	3	4	12		9.5	6.5	38	CHANGE
	700+13					9.5			
CON.	700+28	5	4	20		9.5	4.5	38	CHANGE
	1050+17								
CON.	1450+14	10.5	3						

TABLE E-3-7 FEATURES OF EXISTING BRIDGES

	150+8								
				84.8					
								133	
SG.DONDANG	(m)	(m)	(m)	(m^2)	(m)	(m)	(m)	(m^2)	
	CHAIN	SPAN LENGTH	WIDTH	AREA	SOFIT LEVEL	DESIGN LENGTH	DIFFERENCE	AREA	NECESSITY
	500	9	4	36	3.57	14	5	56	CHANGE
	527	9	5	45	3.13	14	5	70	CHANGE
	806	7	11	77	4.1	14	7	154	CHANGE
	1880	7	5	35	2.83	10.2	3.2	51	CHANGE
	4520	6	14	84	4.09	8.9	2.9	124.6	CHANGE
	4880	8	21	168		8.9	0.9	186.9	CHANGE
	5130	7.5	6	45		8.9	1.4	53.4	CHANGE
	5387	3	3.5	10.5		8.9	5.9	31.15	CHANGE
	5925	4	4	16		8.9	4.9	35.6	CHANGE
	5595	D1.1 X 3.6	9.5	10.45		8.9	#VALUE!	84.55	CHANGE
				526.95				847	

TABLE E-4 COMPLETED OR PREVIOUSLY PROPOSED LENGTH OF RIVER IMPROVEMENT

No.	Name	Total Length (m)	Completed (m)	Proposed (m)
1.	Sg. pinang	3,100		
1-1	Sg. Dondang	6,400		240-C
1-2	Sg. Air Terjun	3,800		250-C
1-3	Sg. Air Itam	6,057		550-C
1-4	Sg. Air Putih	1,200		
1-5	Sg. Jelutong	3,650		
4	Sg. Batu Ferringghi	1,100	200-C	500-C
6	Sg. Mati	1,750	900-C,200-C	
8	Sg. Kelian	1,720	440-C	470-C
12	Sg. Babi	1,600	150-C	140-E
14	Sg. Dua Besar	2,600	250-C, 350-C	900-C
15	Sg. Nibong Besar	1,300	700-C, 130-C	
17	Sg. Keluang	4,500	1,530-E, 250-E	

C=Concrete Channel

E=Earth Channel

Figures

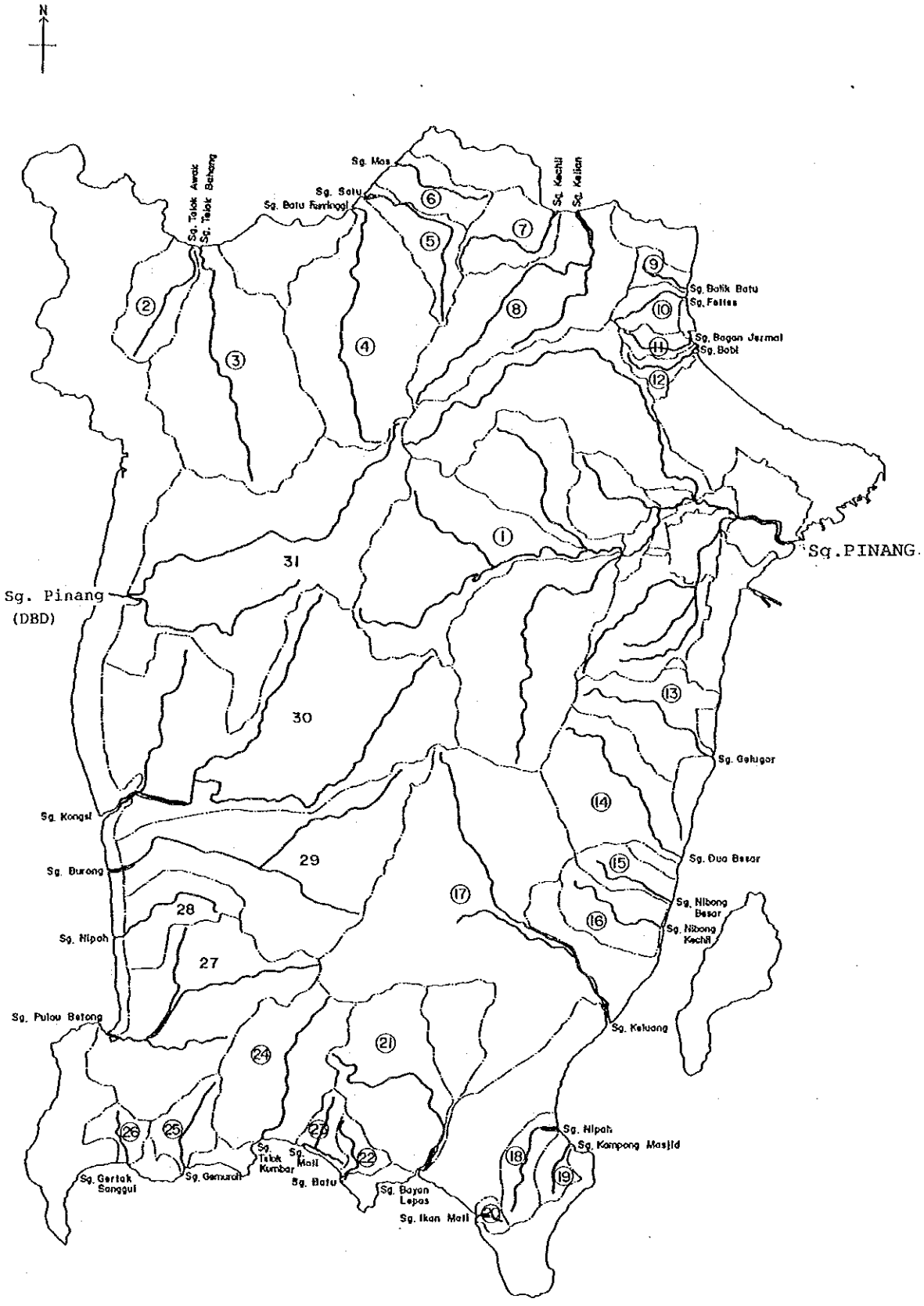


FIG. E-1 **RIVERS IN PENANG ISLAND**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

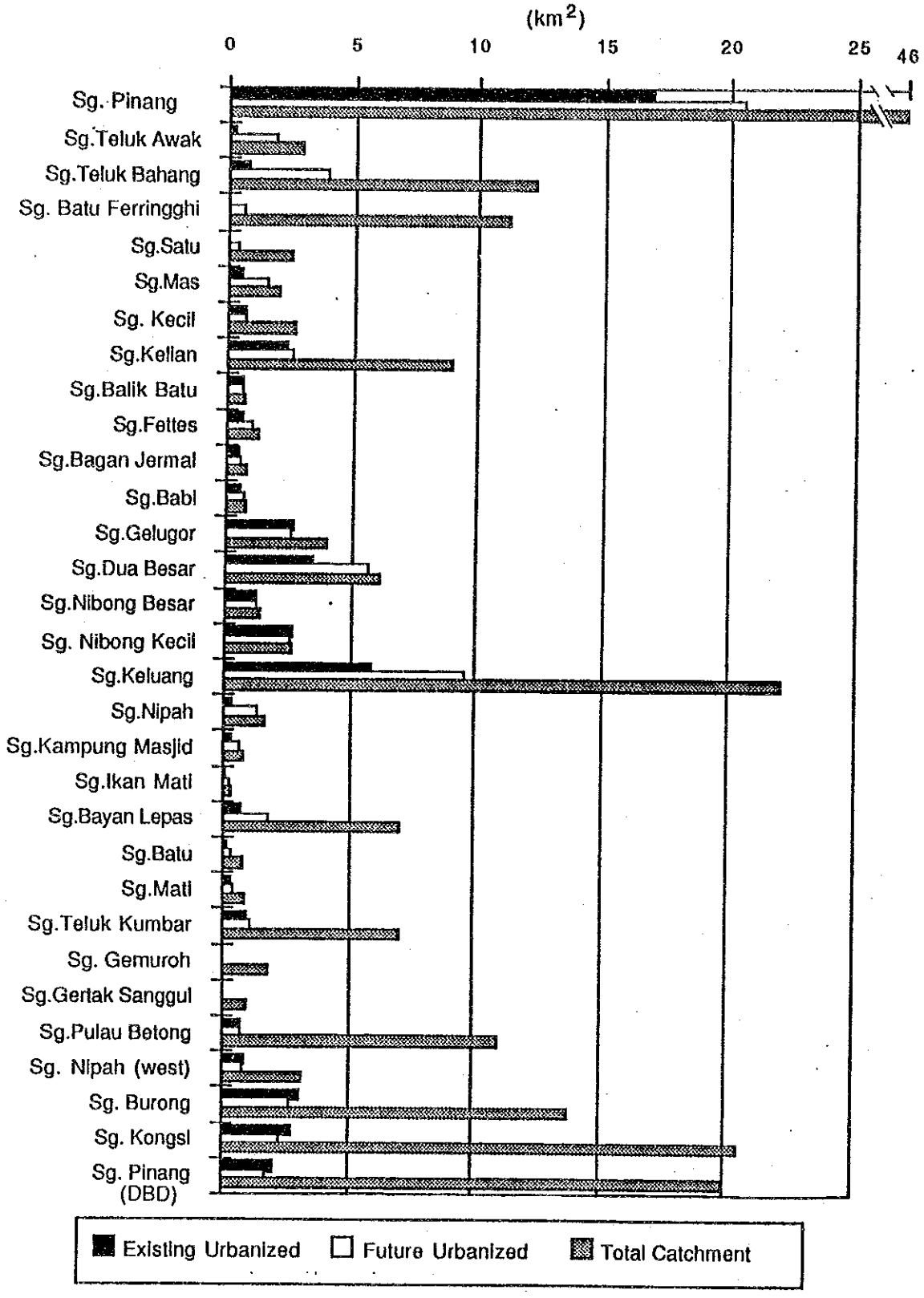
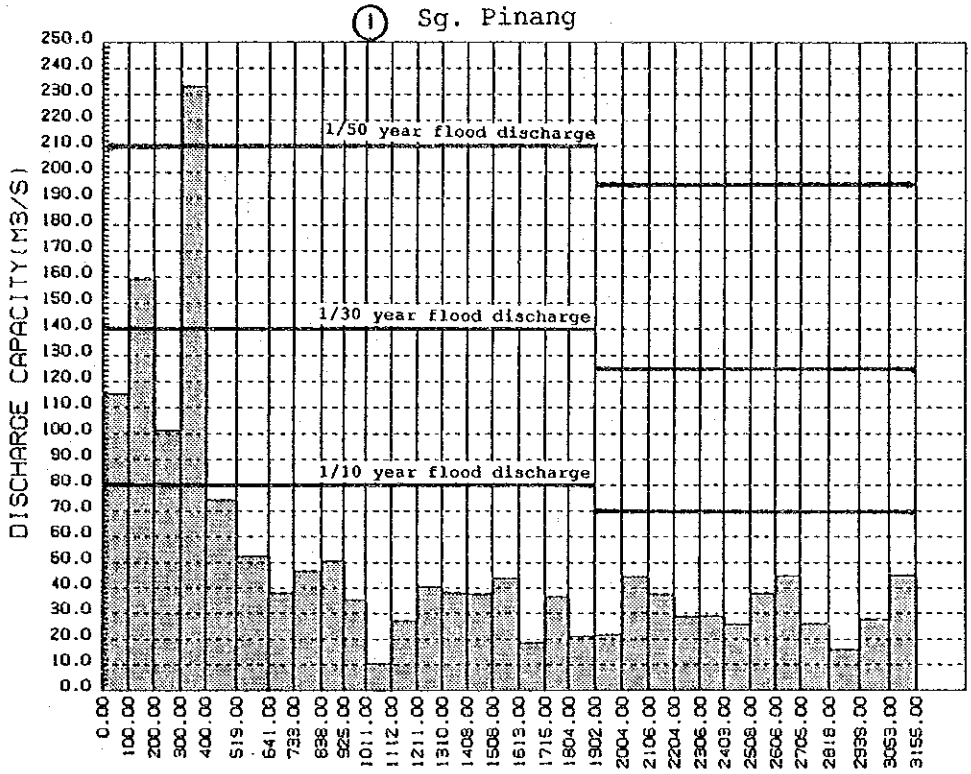


FIG. E-2 PRESENT AND FUTURE URBANIZATION IN EACH BASIN

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND



Note: Probable flood discharges are the values with retention pond and diversion channel.

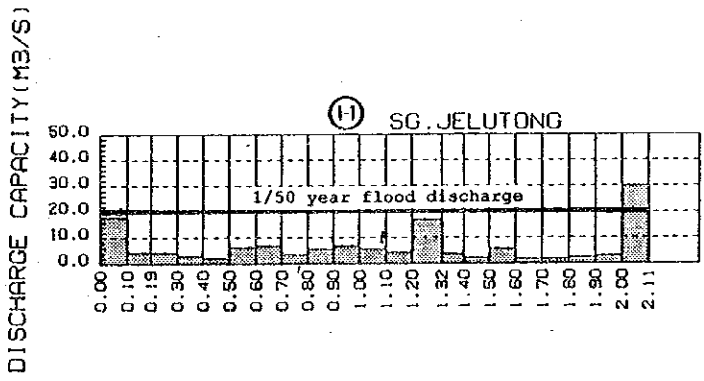


FIG. E-3-1	EXISTING DISCHARGE CAPACITY OF SG. PINANG& SG. JELUTONG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

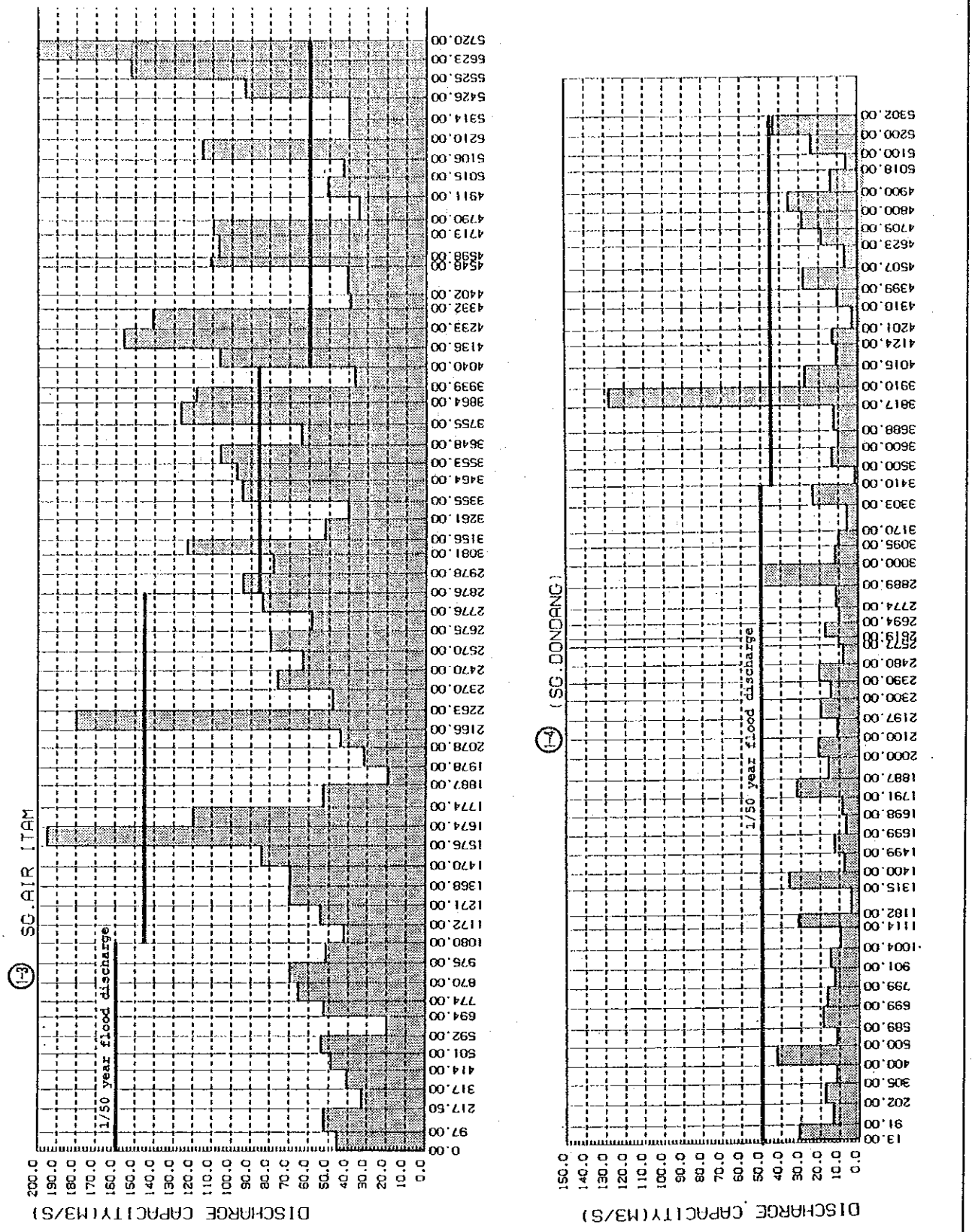


FIG. E-3-2 EXISTING DISCHARGE CAPACITY OF SG. AIR ITAM & SG. DONDANG

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

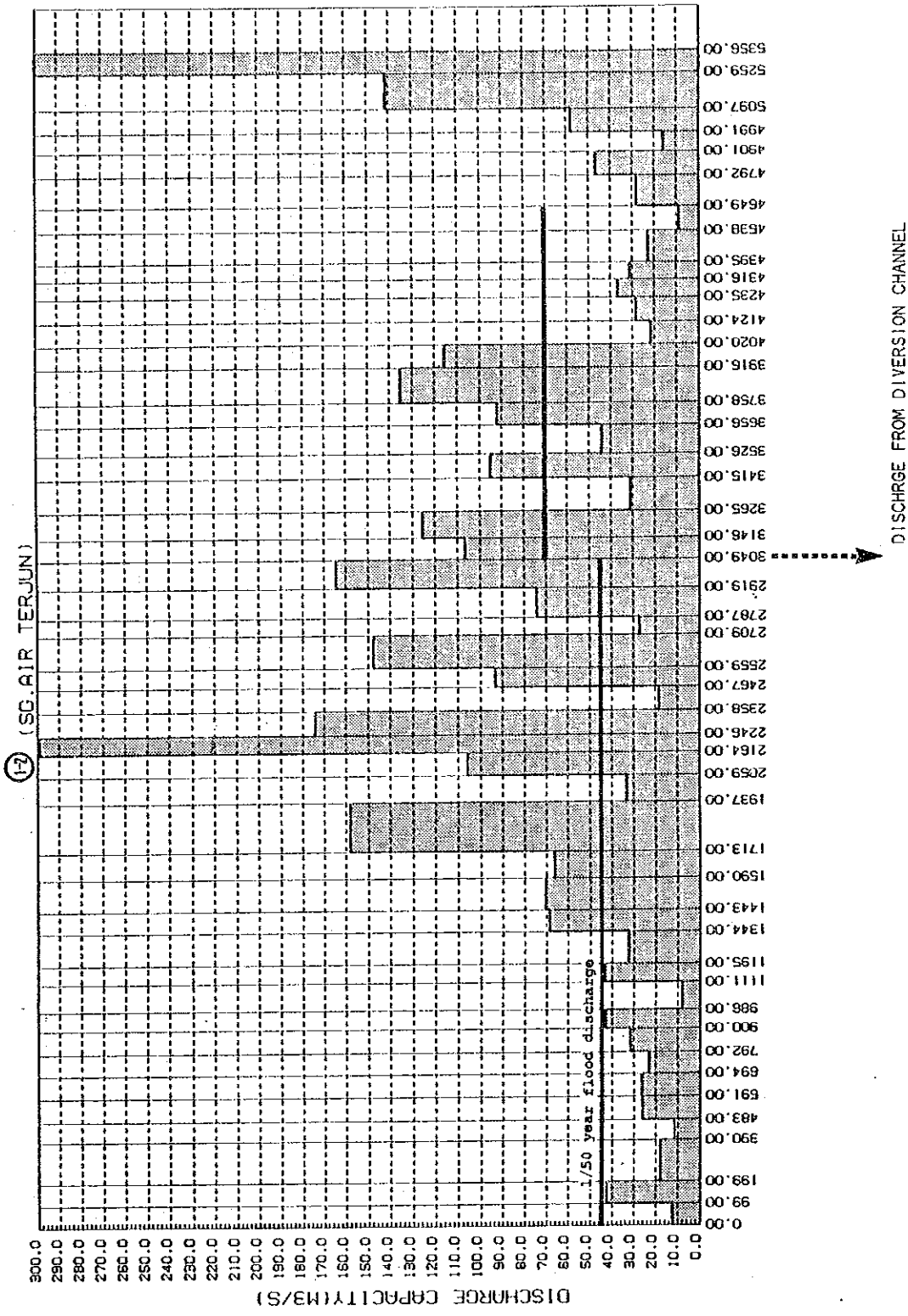


FIG. E-3-3 EXISTING DISCHAGE CAPACITY OF SG. AIR TERJUN

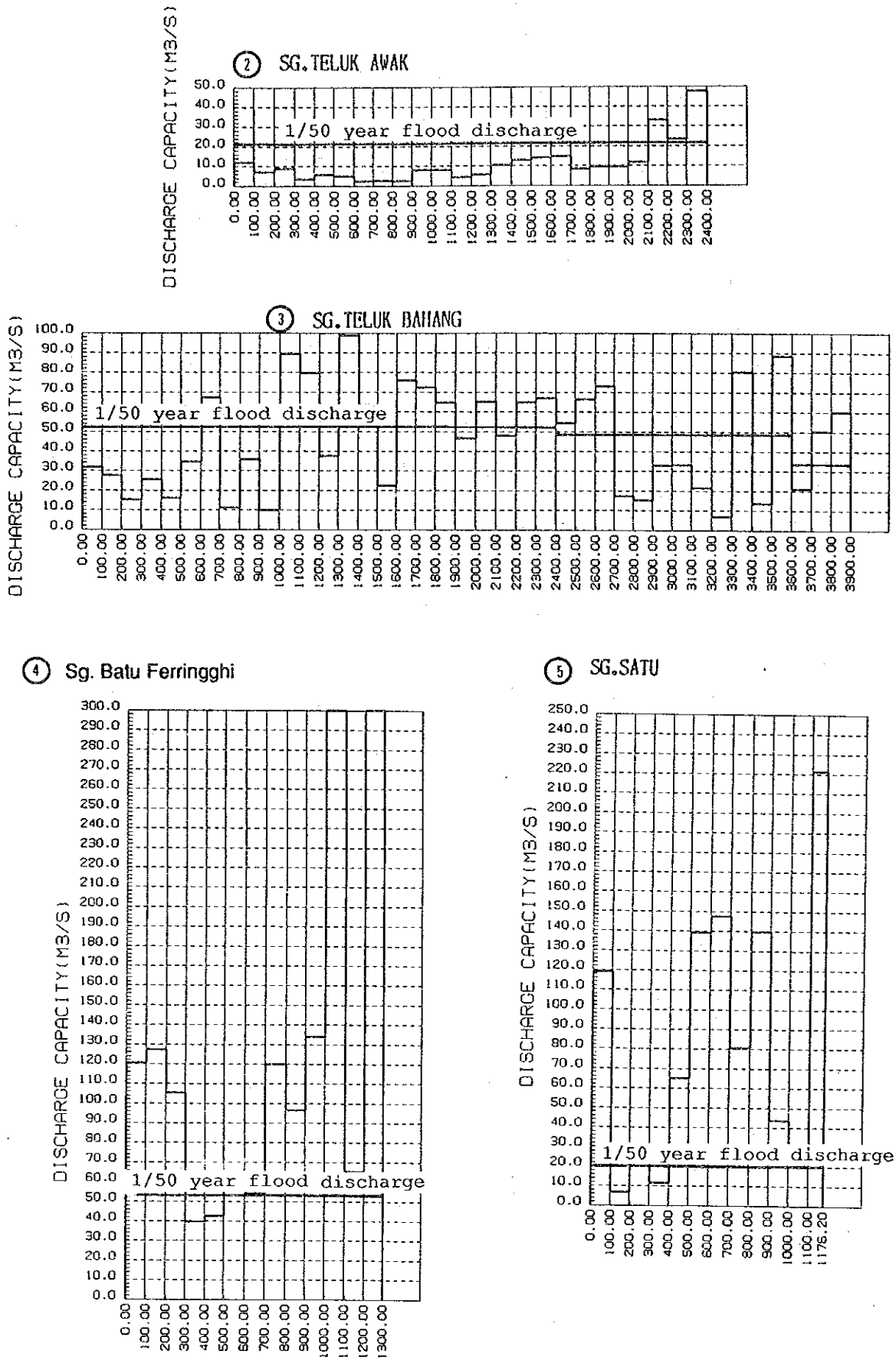
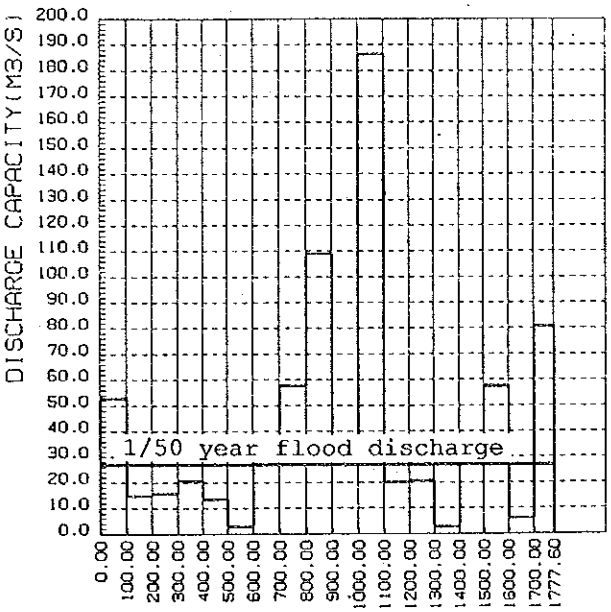


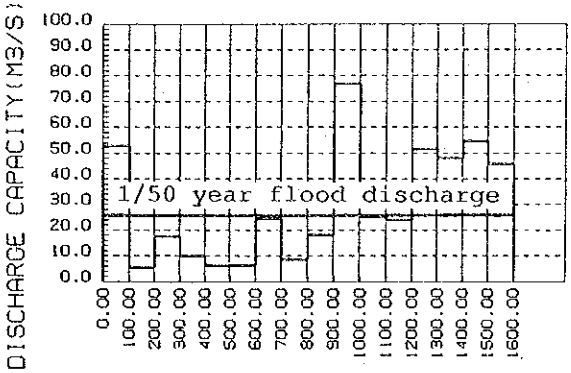
FIG. E-3-4 EXISTING DISCHAGE CAPACITY OF RIVERS NO.2~NO.5

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

⑥ SG.MAS



⑦ SG.KECIL



⑧ SG.KELIAN

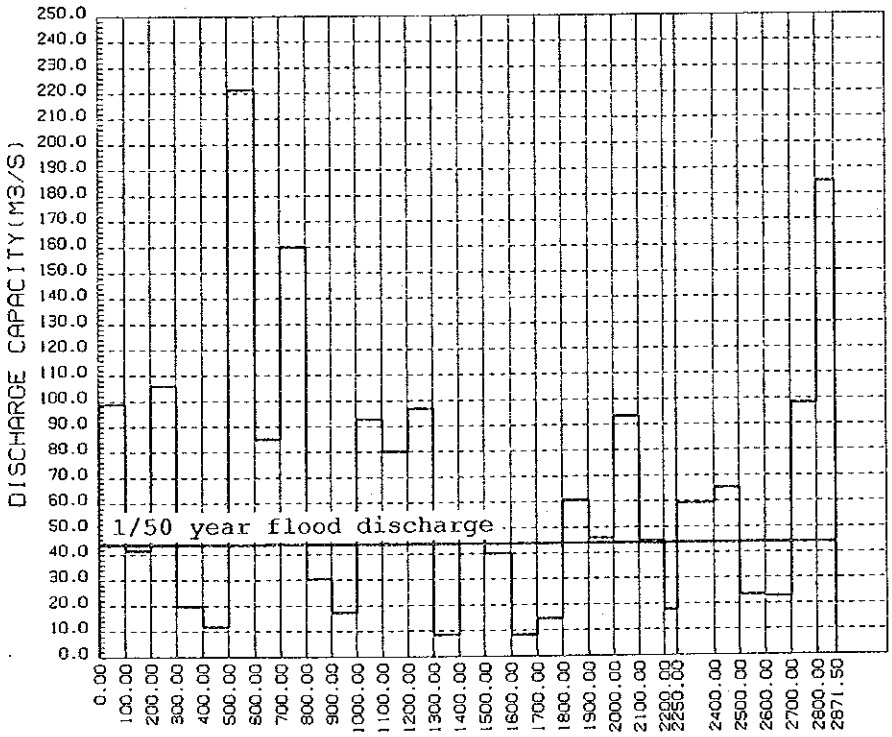
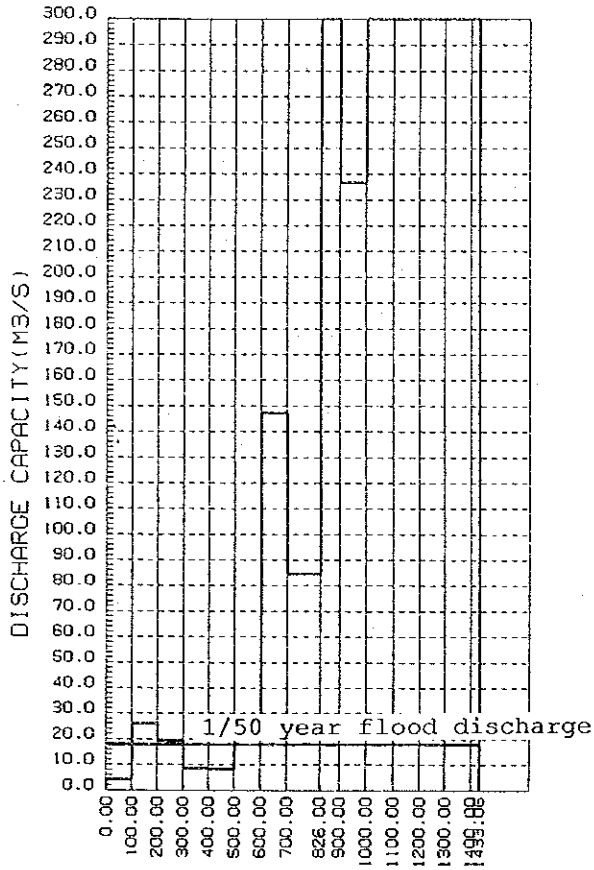


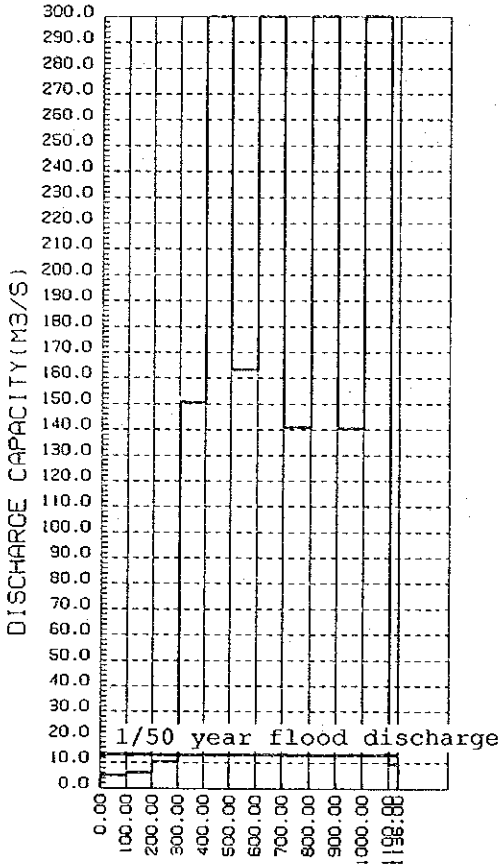
FIG. E-3-5 EXISTING DISCHAGE CAPACITY OF RIVERS NO.6~NO.8

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

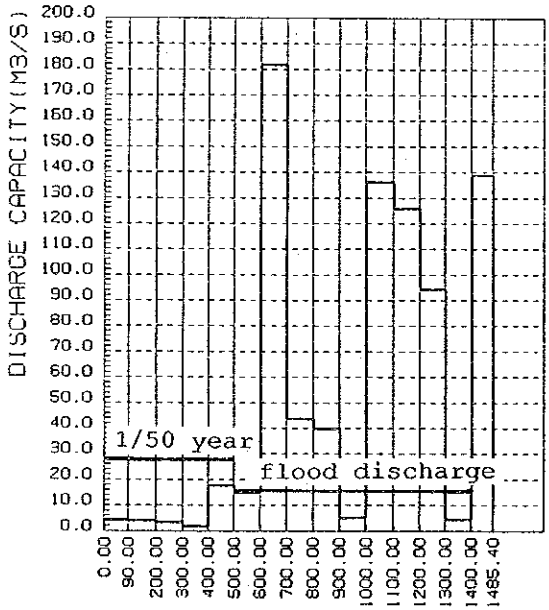
⑨ SG.BALIK BATU



⑪ SG.BAGAN JERMAL



⑩ SG.FETTES



⑫ SG.BABI

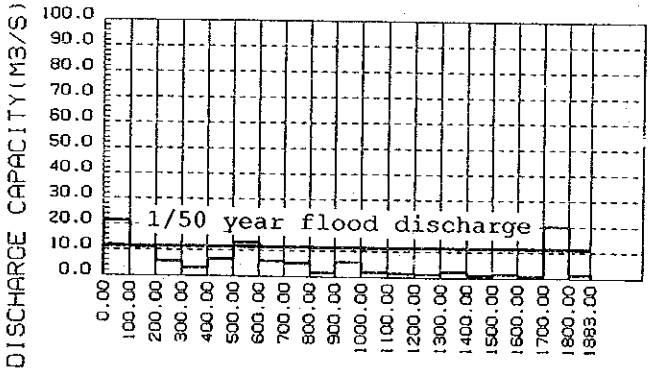
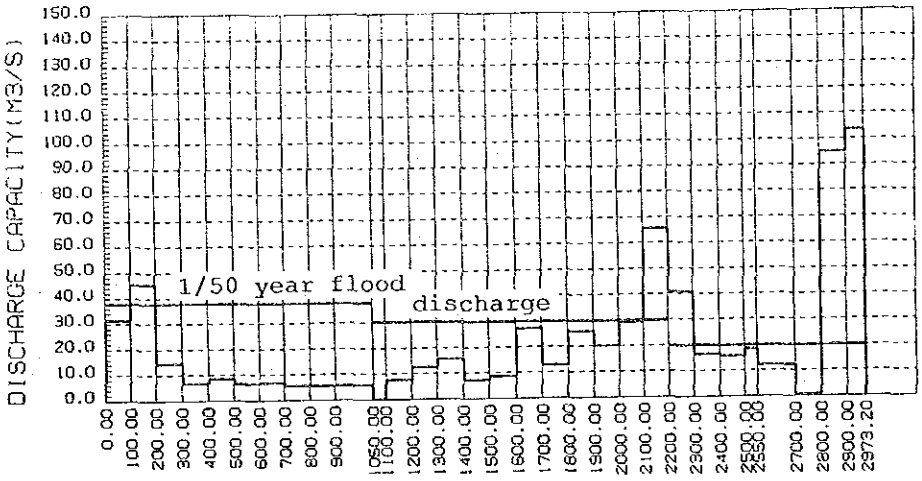


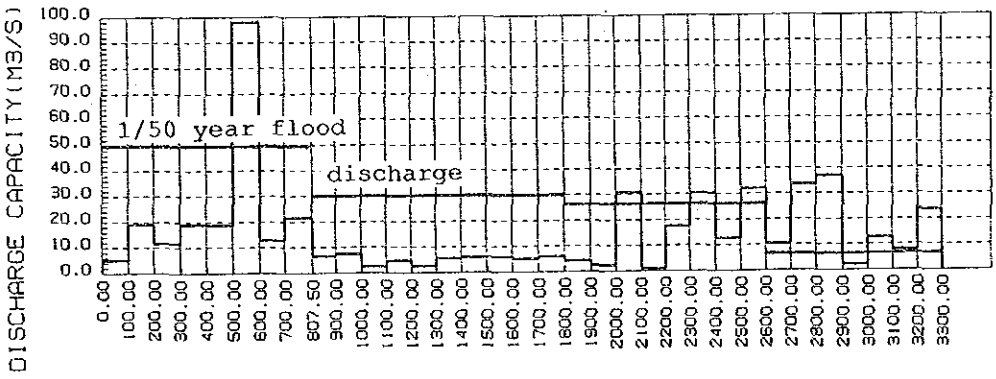
FIG. E-3-6 EXISTING DISCHAGE CAPACITY OF RIVERS NO.9~NO.12

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

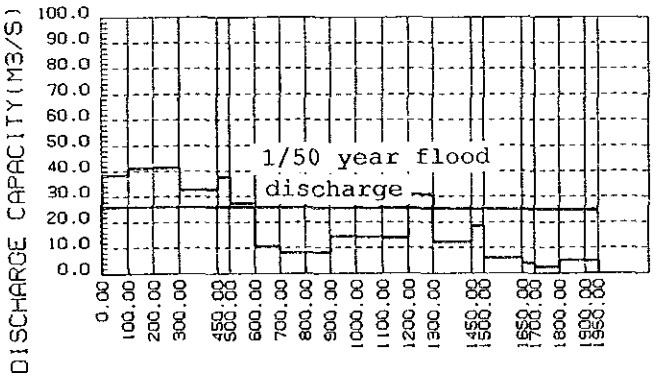
⑬ SG.GELUGOR



⑭ SG.DUA BESAR



⑮ SG.NIBONG BESAR



⑯ SG.NIBONG KECIL

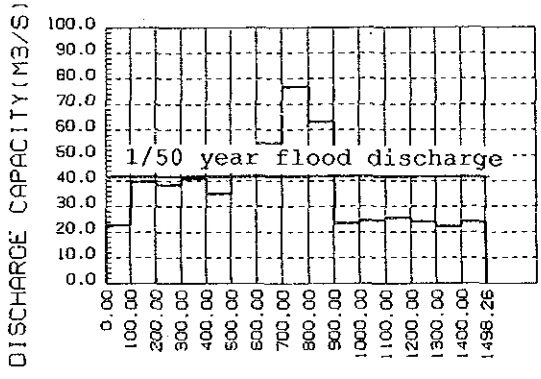


FIG. E-3-7 EXISTING DISCHAGE CAPACITY OF RIVERS NO.13~NO.16

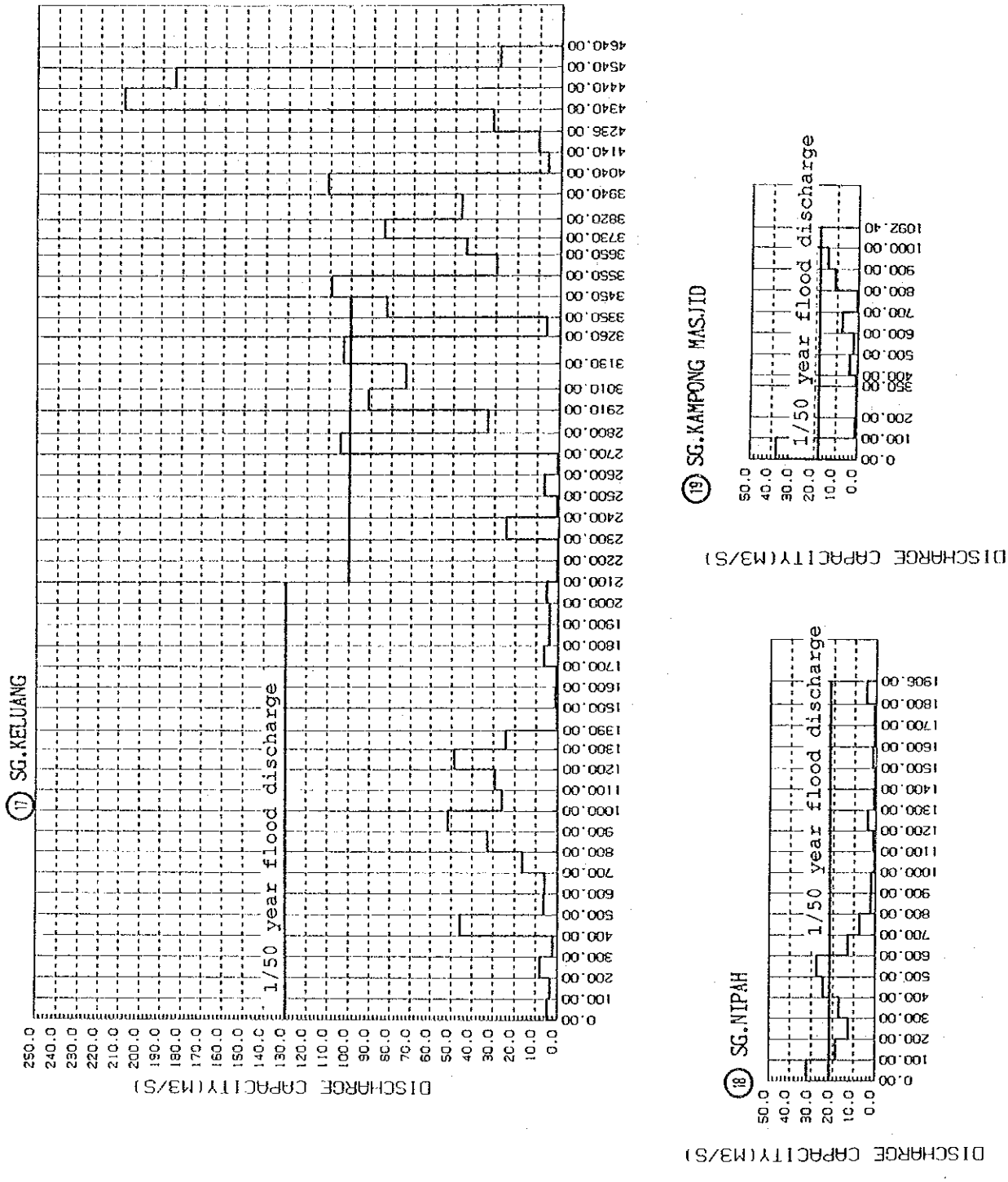


FIG. E-3-8 EXISTING DISCHAGE CAPACITY OF RIVERS NO.17~NO.19

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

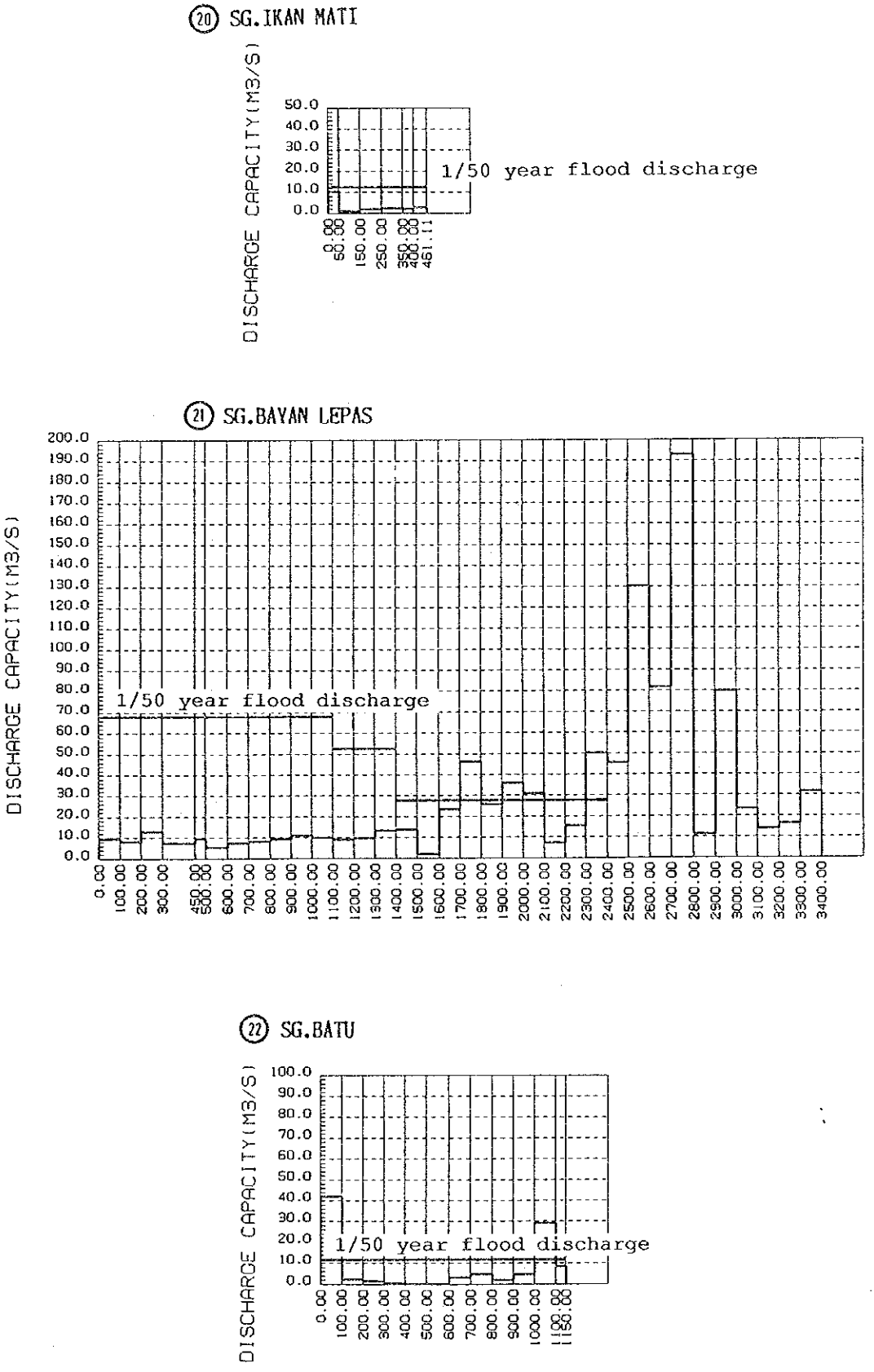
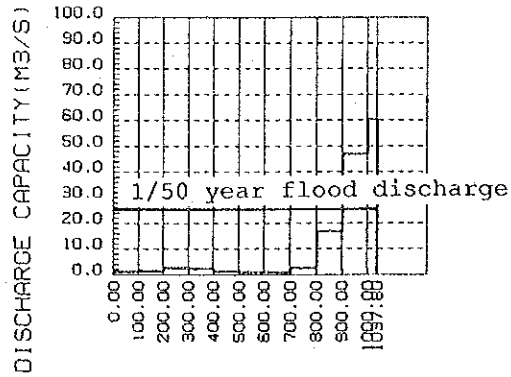


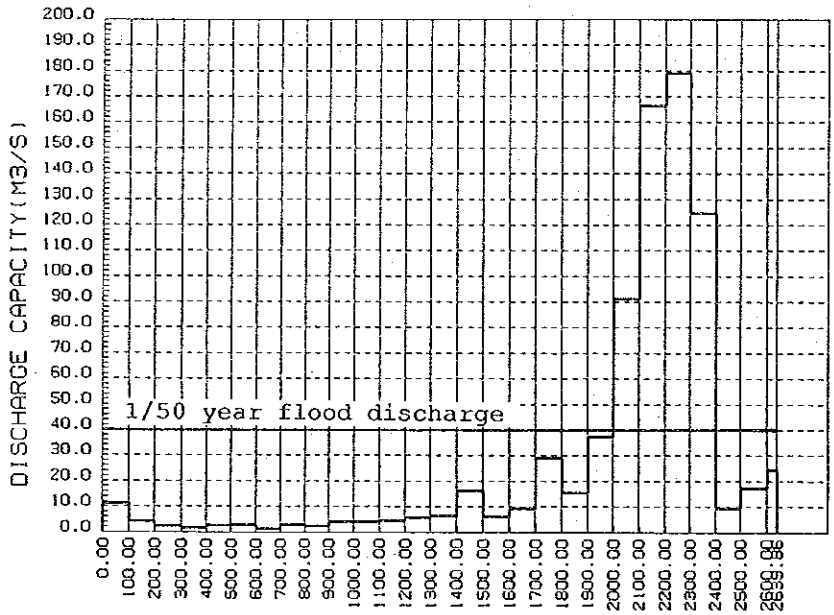
FIG. E-3-9 EXISTING DISCHAGE CAPACITY OF RIVERS NO.20~NO.22

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

(23) SG.MATI



(24) SG.TELUK KUMBAR



(26) SG.GERTAK SANGGUL

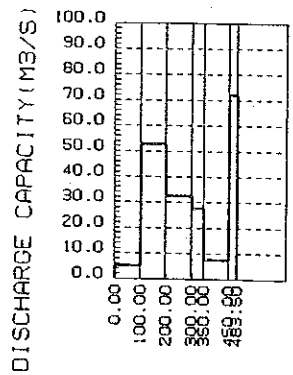


FIG. E-3-10	EXISTING DISCHAGE CAPACITY OF RIVERS NO.23,NO.24&NO.26

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

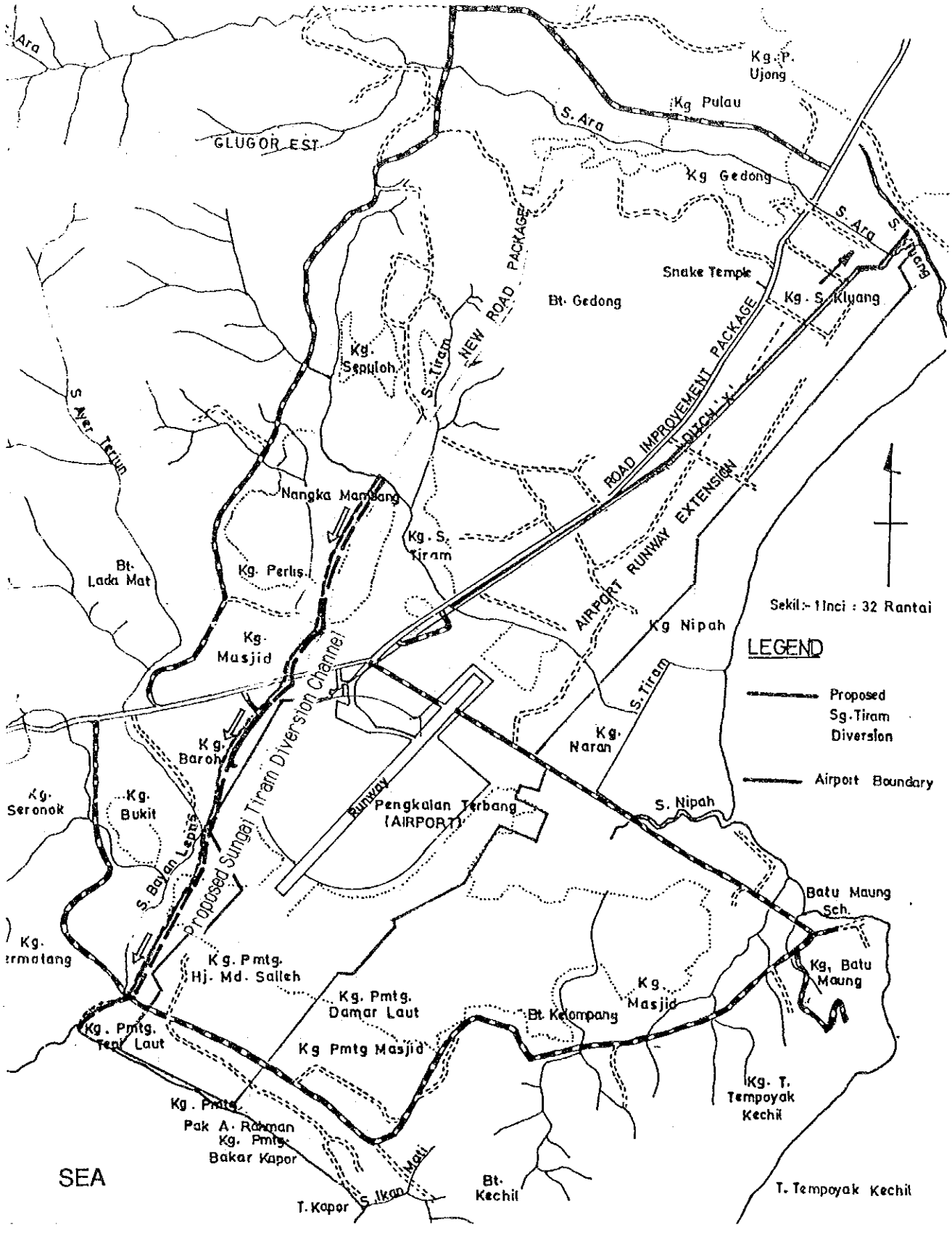


FIG. E-4 PROPOSED ROUTE OF SG. TIRAM DIVERSION CHANNEL

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

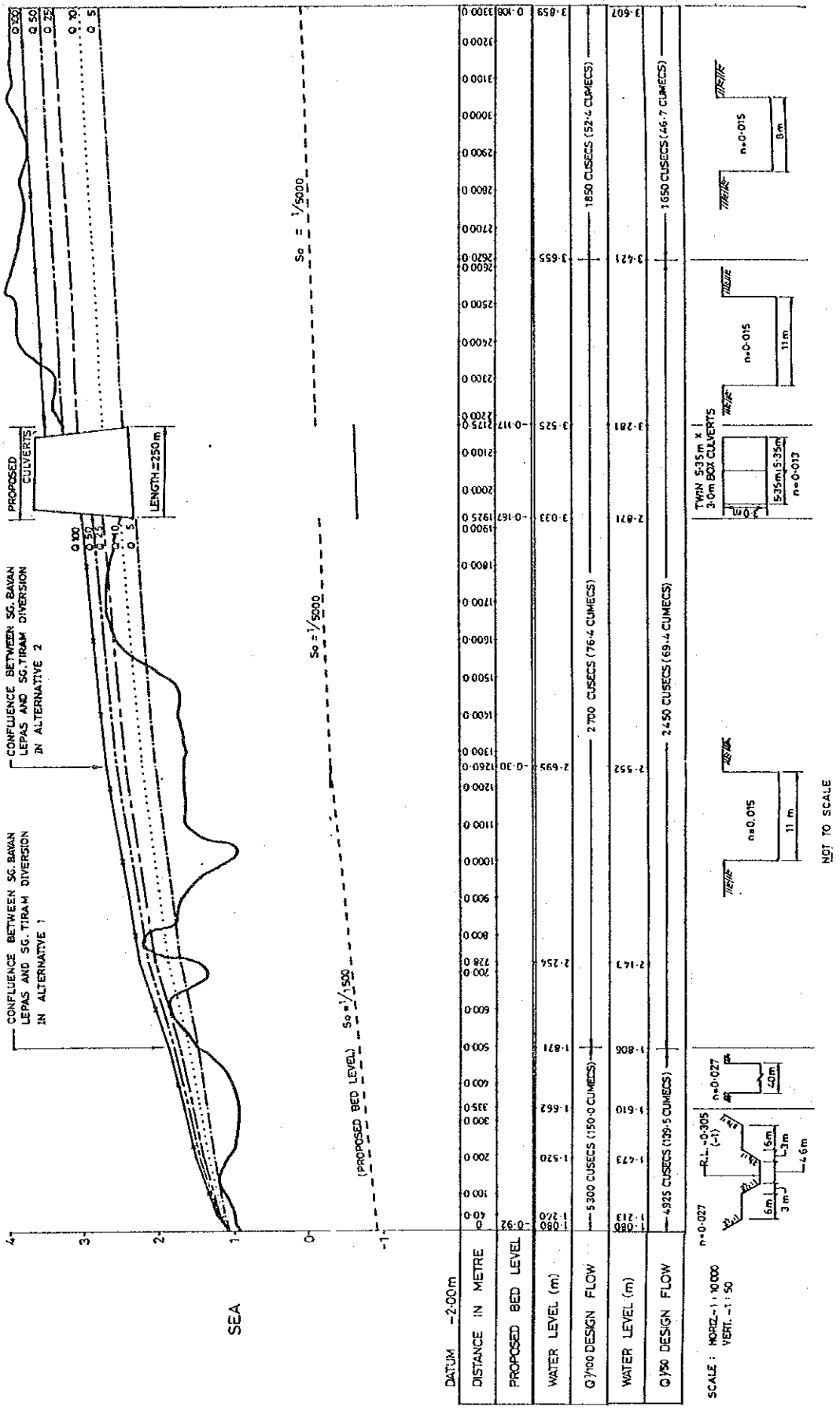
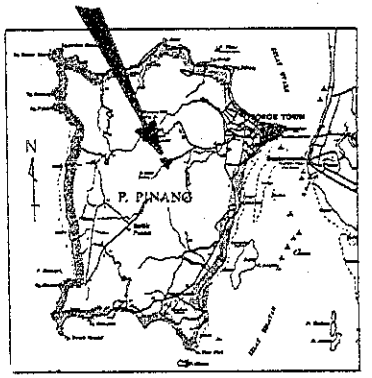
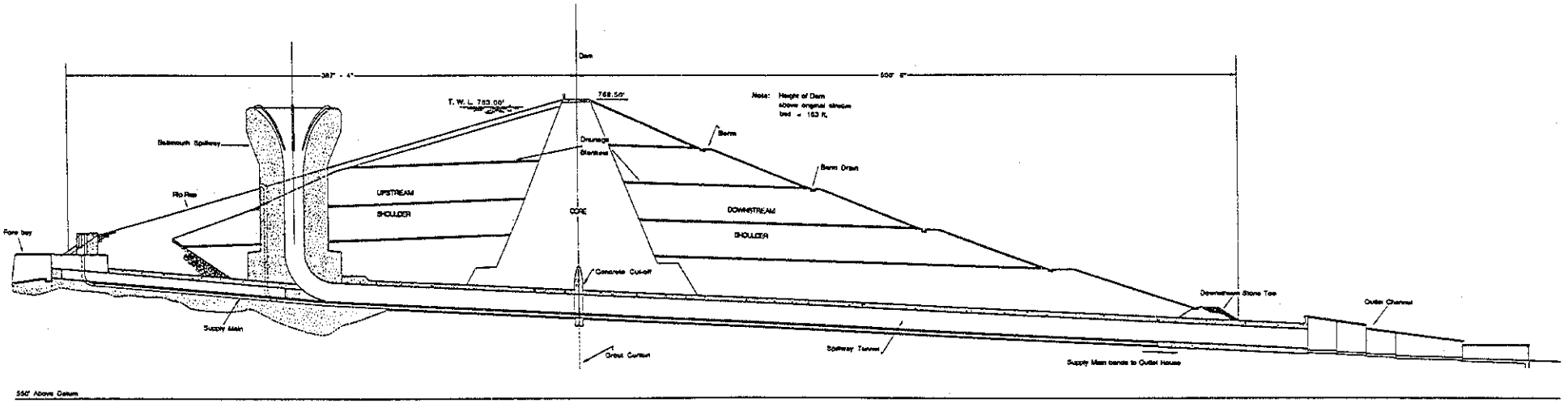
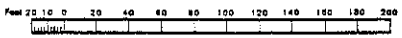


FIG. E-5 PROPOSED LONGITUDINAL PROFILE AND CROSS SECTION OF SG. TIRAM DIVERSION

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND







SCALE : 40 FEET TO AN INCH

FIG. E-6	TYPICAL CROSS SECTION OF AIR ITAM DAM
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND	

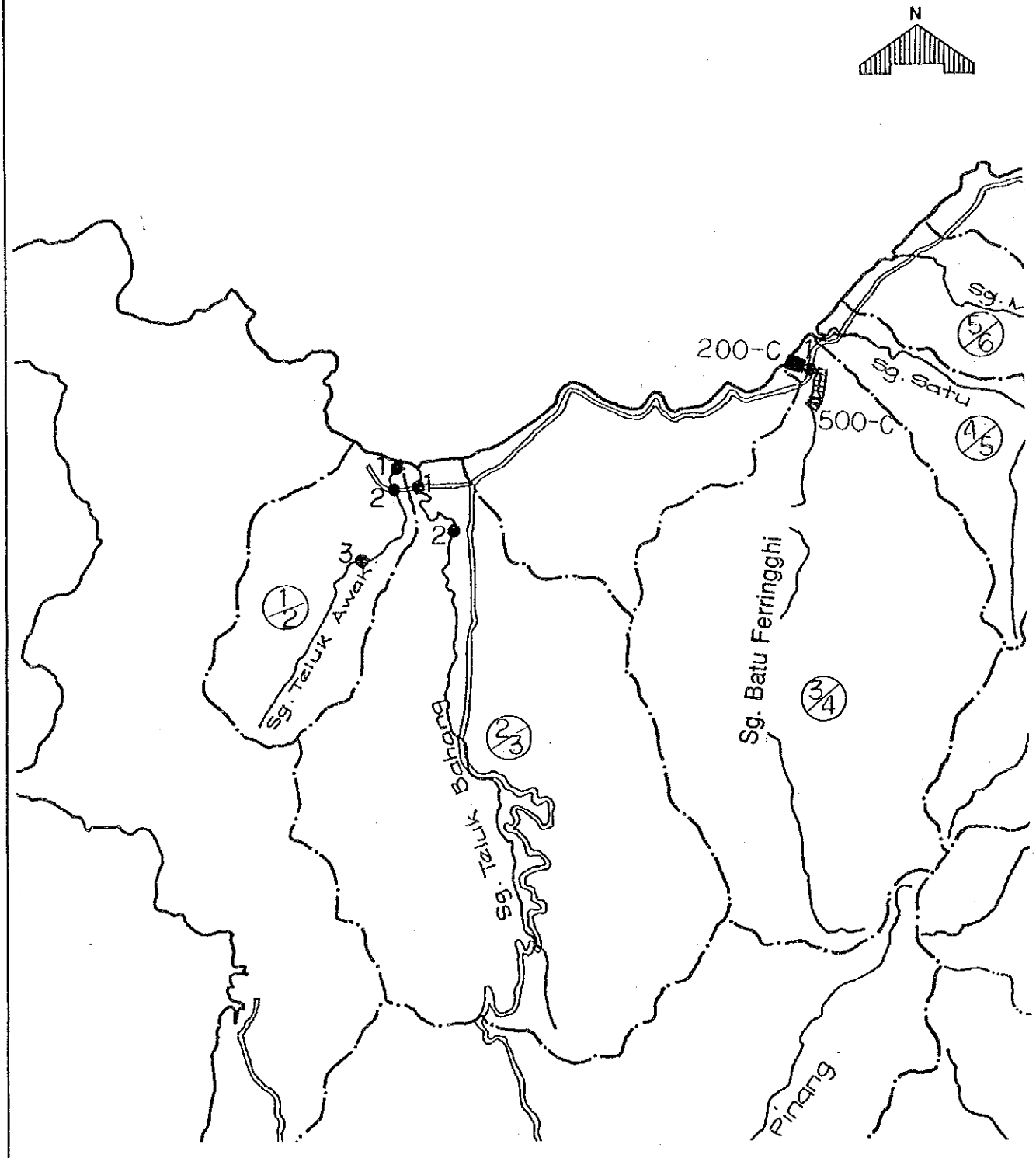


FIG. E-7-1 **LOCATION MAP OF RIVER AND RELATED STRUCTURES**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

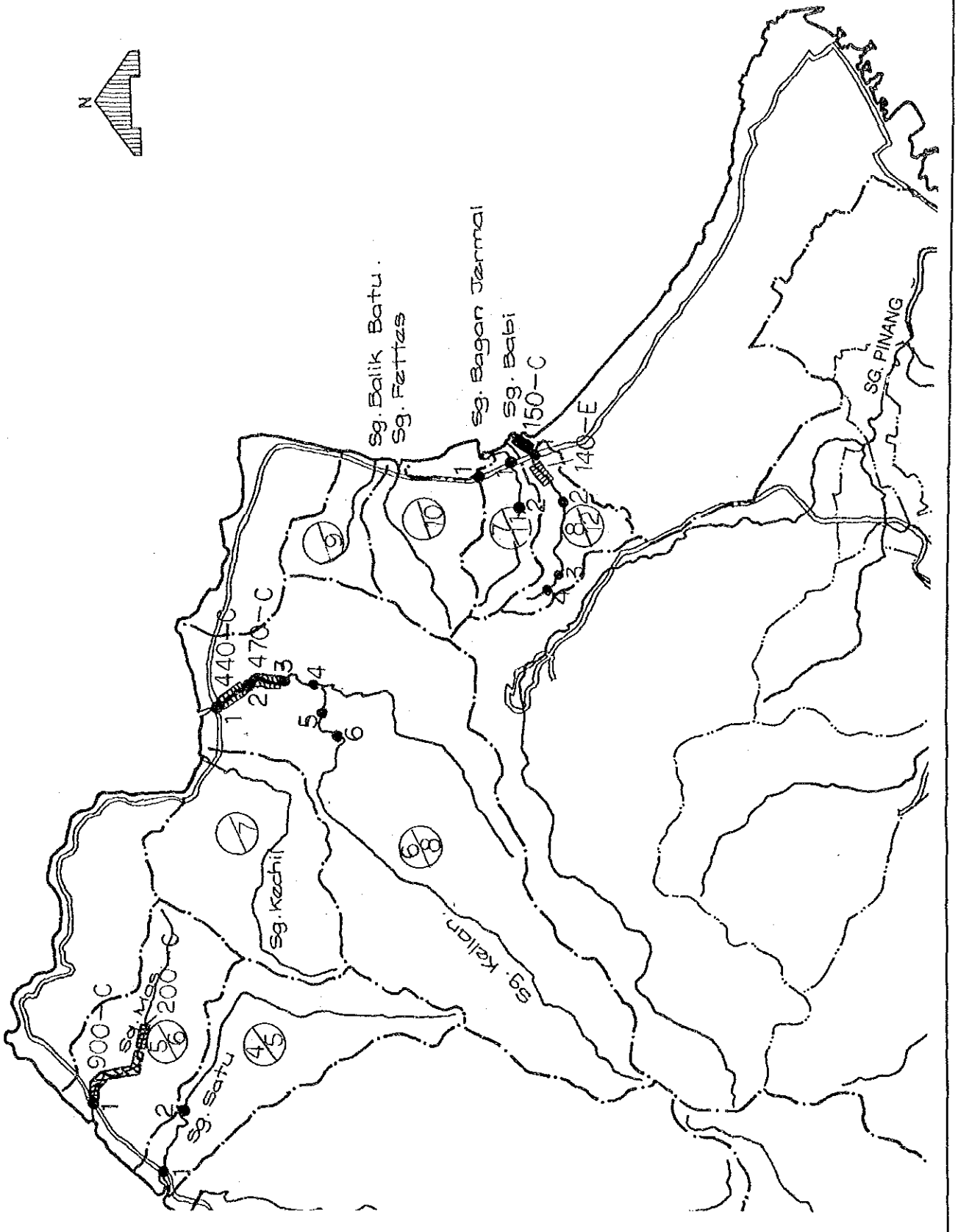


FIG. E-7-2 **LOCATION MAP OF RIVER AND RELATED STRUCTURES**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

JICA

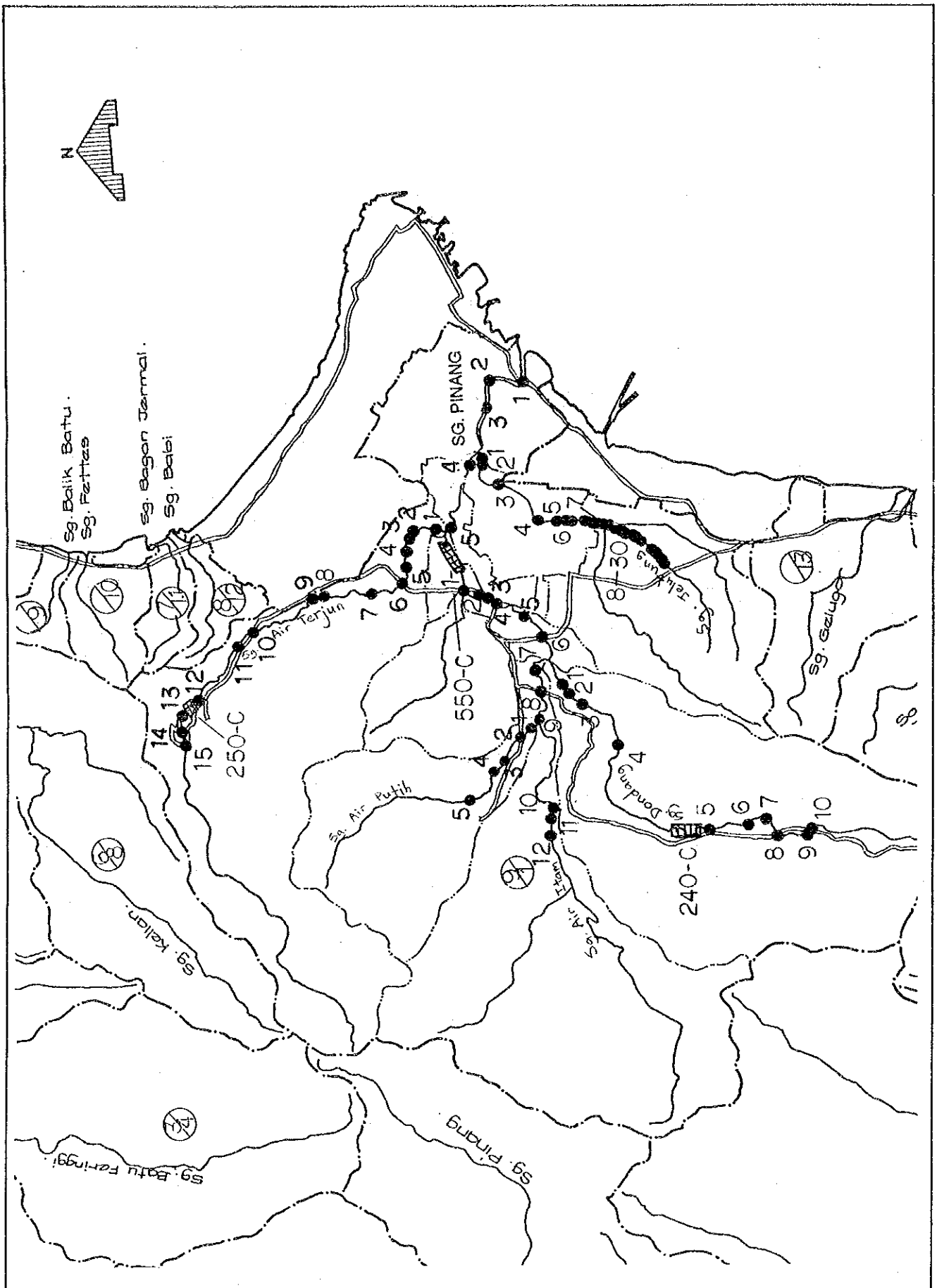


FIG. E-7-3 **LOCATION MAP OF RIVER AND RELATED STRUCTURES**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

JICA

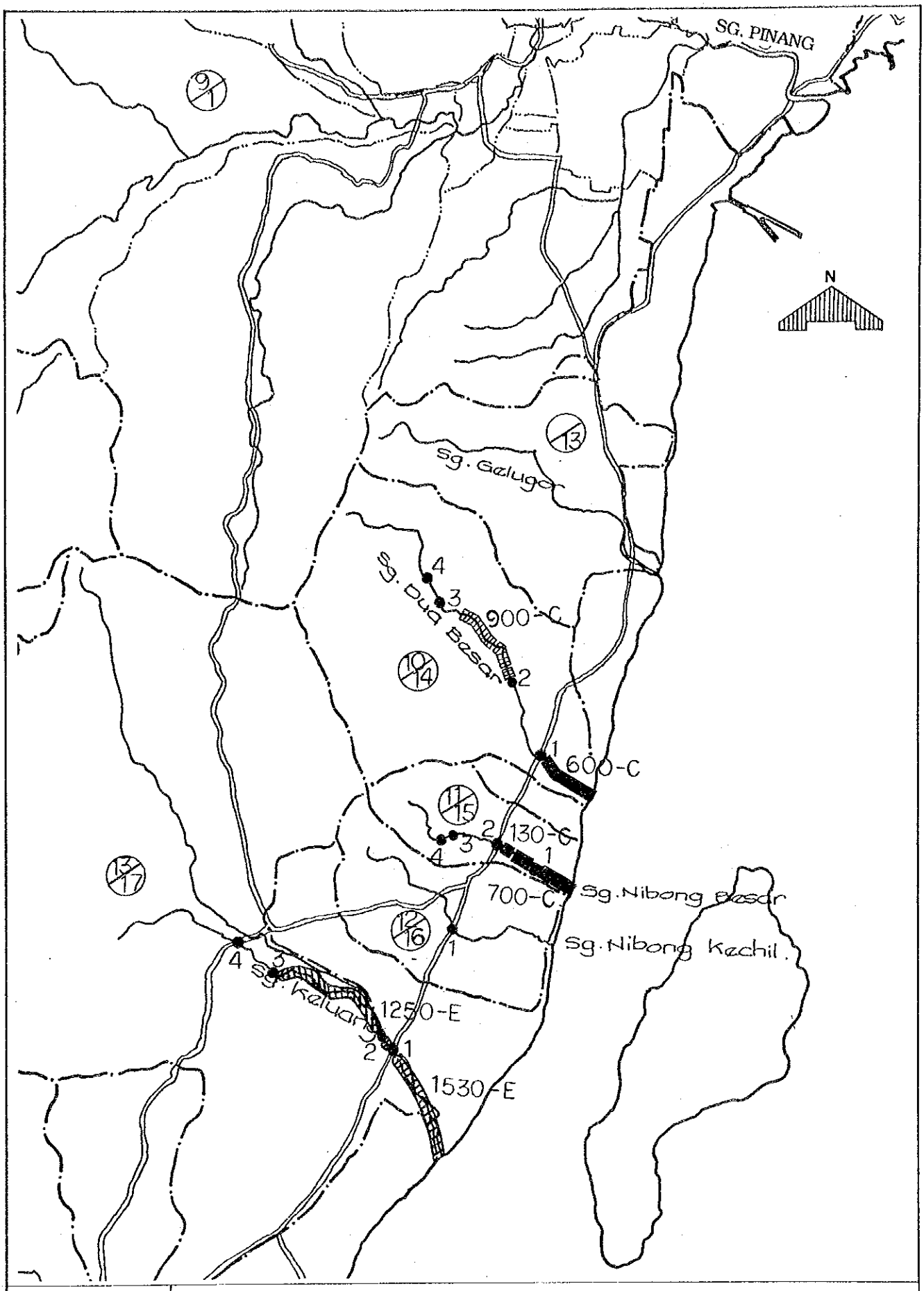


FIG. E-7-4 **LOCATION MAP OF RIVER AND RELATED STRUCTURES**

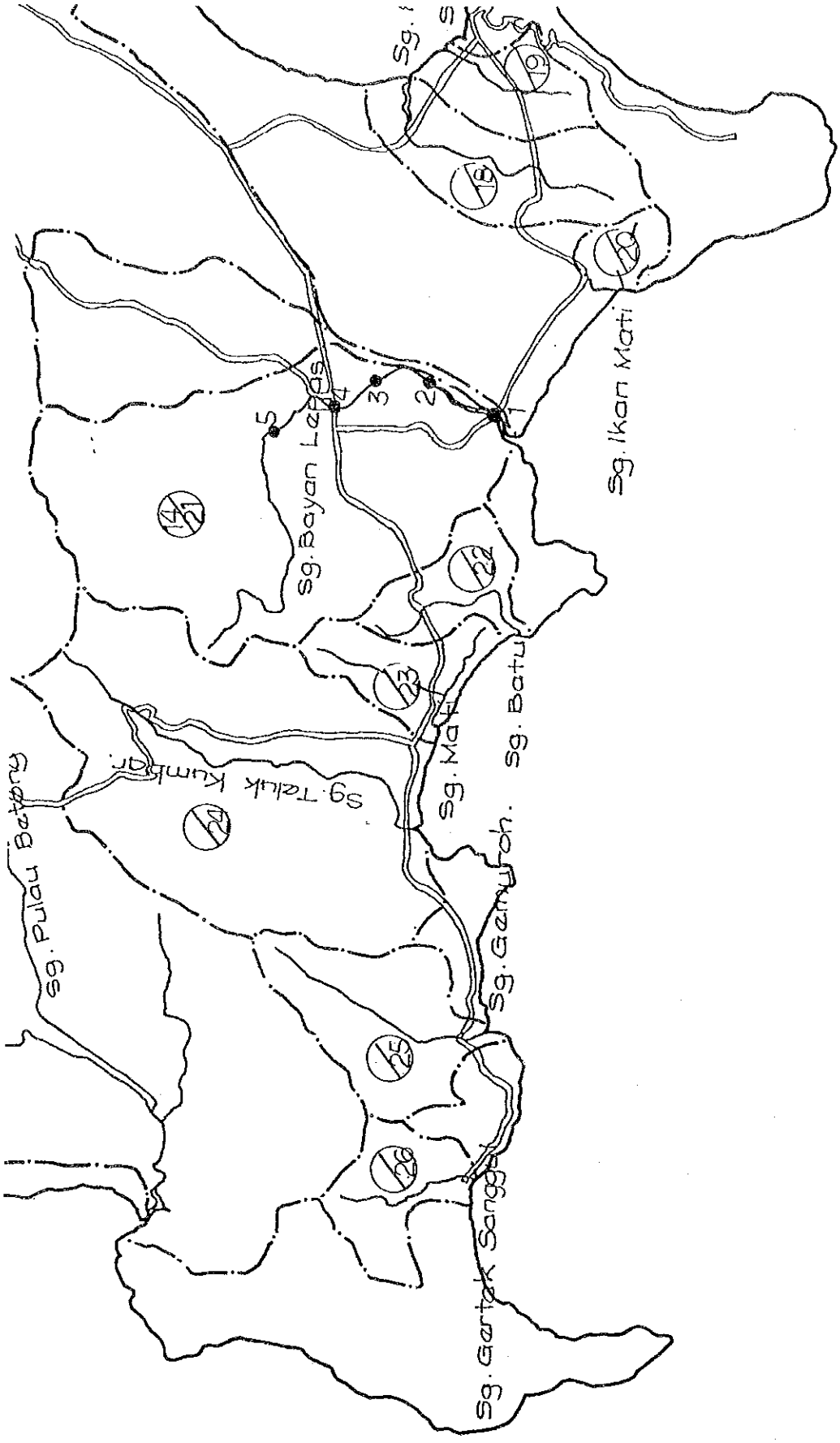
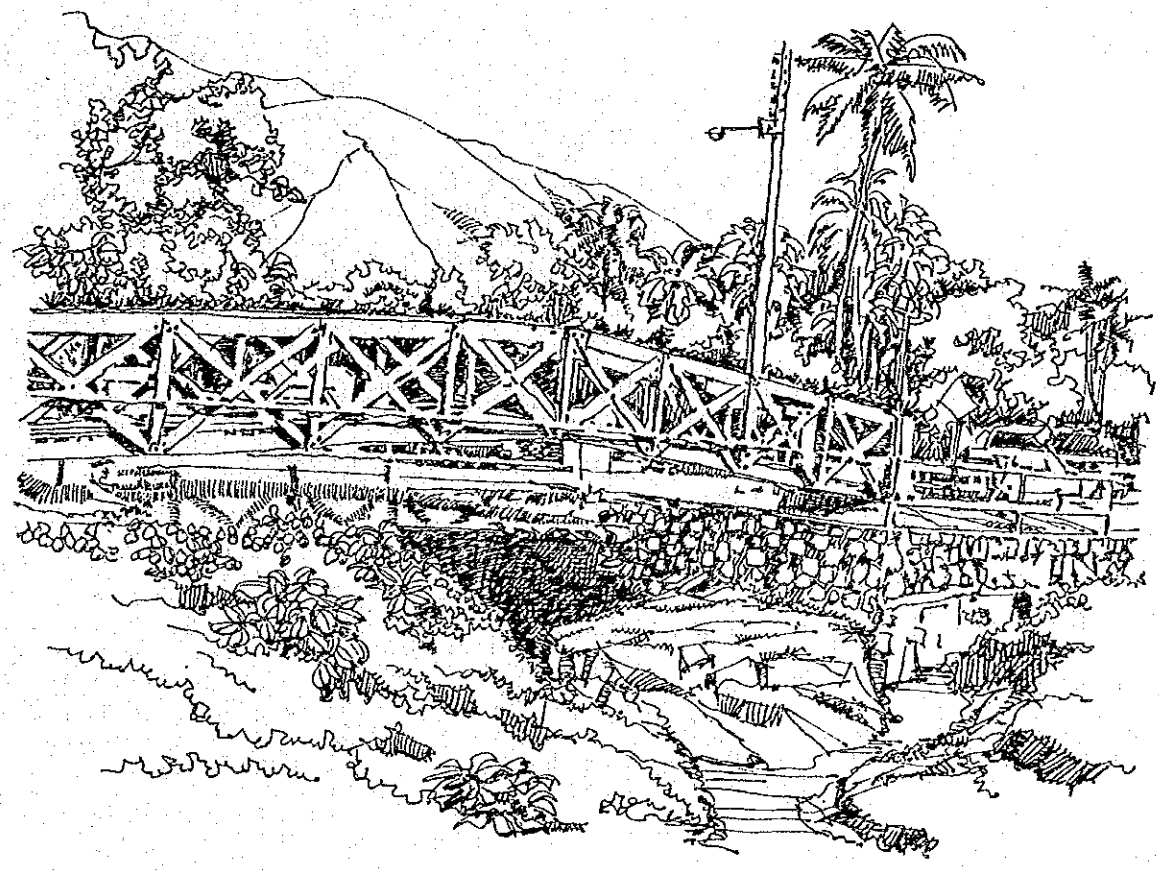


FIG. E-7-5	**LOCATION MAP OF RIVER AND RELATED STRUCTURES**

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

APPENDIX F

FLOODS AND FLOOD DAMAGE



APPENDIX F FLOODS AND FLOOD DAMAGE

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APPENDIX F FLOODS AND FLOOD DAMAGE

1. INTRODUCTION

Flooding in various parts of the Island has been very frequent. In order to investigate these floods and their damages, the collection of relevant information had been carried out but few information were found to be available except several information complied by SDID and MPPP.

The area in Penang which is affected by floods can be classified into the following three categories:-

i) The areas which are flooded after a few hours of sustained rainfall several times throughout the year.

ii) The areas which are flooded during the wettest period of the north-east monsoon season in December/January causing crops and livestock damages.

iii) The areas which are flooded when rainfall of greater than usual intensity recurs over a period of some years and where damages are more extensive due to the unexpected magnitude of the floods.

Furthermore, the type of floods can be divided into the following three categories:-

i) Flood which occurs during the heavy rains of flash storms coinciding with high tide.

ii) Flood which occurs during spring tide affecting the lowlying areas.

iii) Flood which occurs in 10/12 years due to abnormally heavy rains and coinciding with high tides during the monsoon seasons.

Overview of past flood conditions and their damages are dealt with in the following section.

2. PAST RECORD OF FLOOD CONDITION

2.1 Flooding in the City of Georgetown

Table F-1 shows the highest flood water level and rainfall pattern in each flood occurred in Georgetown, based on the past flood records from 1976 to 1987.

Flood prone areas in Georgetown can be categorized into three districts.

a) Lowlying areas alongside Sg. Pinang and its tributary, Sg. Jelutong, e.g. Caunter Hall area, Makloom area, Van Praagh Road Area, etc.

b) Areas with undersized or inadequate drainage system, and unaffected by tides, e.g. Barrack Road, Khaw Sim Bee Road, Perak Road etc.

c) Lowlying areas outside Sg. Pinang catchment area having separated outlets and affected by tides, e.g. Pengkalan Kota area, Prangin Canal catchment area, Perak Road, McNair Street and Kimberly Street area, Carnarvon Street areas and its side streets, etc.

The flood affected areas within the city limits are shown in Fig.F-1. The flood prone areas in Floods of April 19, 1984 and Floods of September 20, 1986 are shown in Fig.F-2.

2.2 Flooding in the Areas Outside City Limits

Floods outside city limits usually occurs in areas alongside the main rivers and mostly at the downstream sections. The flood affected areas of each river basin are shown in Fig.F-3 and the followings are the areas severely affected by floods:

- Sg. Gelugor Catchment - Around Jalan Permai in Brown Garden
- Sg. Dua Besar Catchment - Saw Kit Garden, Pesta site and lowlying areas alongside its tributaries
- Sg. Nibong Catchment - Jalan Aziz Ibrahim areas
- Sg. Relau Catchment - Mayan Pasir Residential area and lowlying area alongside Sg. Ara
- Sg. Ara Catchment - Jalan Tengah area, etc.
- Sg. Tiram Catchment
- Sg. Pulau Catchment - Lowlying areas in Kampong Pulau Betong.
- Sg. Burong Catchment - Swampy areas around Kampong Paya.
- Sg. Kongsi Catchment - Lowlying areas in Kampong Titi Teras and Kampong Setol.

Flood prone areas and causes of floods are tabulated in Table F-2.

3 IDENTIFICATION OF FLOOD DAMAGE

In this study, five (5) kinds of the flood damages are identified and incorporated in the project evaluation of the proposed projects, which are all tangible and quantitatively measurable damages. They are:

- General property damage
- Public property damage
- Agricultural damage

- Loss of income/sales

- Vehicle's Running Cost

Each flood damage item mentioned above is composed of sub-items.

Intangible flood damages are also identified as shown below. And their impacts are described in general terms.

First, these projects can contribute to remove the development constraint in the future. Floods generally cause an interruption of traffic and therefore make it difficult to deliver inputs/outputs of manufacturing sector on time. In some cases, their production schedule might be changed because of floods. It is also anticipated that, without project, future investment might be depressed in the future. This development constraint can be removed by the project.

Secondly, these projects can contribute to an improvement of people's public health and amenity. It is obvious that flooding especially in the town area causes epidemic disease and aggravate living amenity. In addition, it also gives unfavourable impression on town, especially to the foreign tourists. These defects of the floods should be removed and the pre-requisite of the living circumstance should be guaranteed by the projects.

Thirdly, implementation of the flood mitigation and drainage projects most effectively contribute to meet the inhabitants' preference to the government investment policy. Interview survey clarifies that the drainage system improvement project ranks at the top of project list anticipated by the people in the Penang Island. Priority preference is given to these projects below;

Top preference;	drainage system improvement
2nd preference;	sewage system improvement
3rd preference;	housing development
4th preference;	river/sea water purification
5th preference;	road network and traffic improvement
6th preference;	public transport system improvement

4. FLOOD DAMAGE ESTIMATION

Results of the flood damage estimation works for Sg. Pinang basin are briefly shown below;

(unit; million M$)

Year	Flood frequency					
	1/1.1	1/5	1/10	1/30	1/50	1/100
1990	6.2	18.5	92.0	192.5	251.1	306.3
2010	6.5	19.6	102.1	213.1	278.5	341.3

4.1 General Property Damage

This general property damage composes of five (5) kinds of sub-damage items.

4.1.1 Houses

Damage of houses are the major component of the total flood damage in terms of value and thus counts as the representative damage item.

Flood damage of houses is estimated according to the following function;

Damage =	Average Value of of House	x	Damage Ratio in Flood Prone Area	x	No. of House

Average value of house was set in cooperation with Valuation Department, Penang. As a results, semi-detached, semi-permanent house is selected as a standard house in the flood prone area. Value of the house is determined by the following function;

(value of house)
= {(construction cost) + (developer's profit)}
x (depreciation ratio)
= 69,800 M$ x (depreciation ratio)

Damage ratio is set by the regression function derived from the results of the interview survey, which are summarized with other flood damage ratios below;

Water Depth	Flood Damage Ratio			
	House	Household Article	Commercial Assets	Commercial Stocks
0<H<50	0.004	0.057	0.052	0.127
50≤H<100	0.030	0.096	0.121	0.276
100≤H<200	0.068	0.135	0.161	0.379
200≤H<300	0.112	0.336	0.208	0.479
300≤H	0.170	0.687	0.243	0.562

Number of the houses in the flood prone area is reckoned based on the population density and family size for the case of Sg. Pinang, Sg. Keluang and Georgetown Drainage basins as shown in Table F-3 through F-5. As for the other flood prone area, it is estimated based on the building area ratio and house lot size.

Total number of houses in flood prone area by flood return year is shown in Table F-6.

Number of houses in flood prone area outside Georgetown and flooding water depth for 24 river basins are shown in Table F-7.

4.1.2 Household Articles

This item's damage is reckoned by the following function;

Damage	=	average value of the household articles	x	damage ratio	x	No. of house in the flood prone area

Average value of the household articles are set to be the 21,200 Ringgit per house according to the interview survey. Damage ratio used are shown in the table with house damage ratio.

Quantity of household articles per unit is expected to increase with increasing per capita GRDP. The function $(1+g/100)^t$ reflects this increase in household effects.

4.1.3 Commercial Assets/Stocks

Machines and various other kinds of facilities are subjected to flood damage. Especially machines and electric equipments are major damaged items. In addition, goods in stock and goods on display at shops are also subject of flood damage.

Damage	=	average value of asset and stock	x	damage ratio	x	No. of shops/ factories in the flood prone area

In estimating these damage, data collected by means of interview survey did not have any statistically reliable correlations between the actual damage and the water level. In addition, value of assets and stocks which shops/factory varies so widely and it is judged that the responses from the shopkeepers to the interviewers are not reliable.

In setting the value of average asset and stock, figures were quoted from "The Study on the Flood Mitigation of the Klang River Basin." 165,000 Ringgit and 28,900 Ringgit were adopted for the commercial assets and commercial stocks respectively. Damage ratio, shown in Table F-8, is also the same as the same study.

The estimation procedure of flood damage potential for house and commercial assets (50 year flood) is shown in Table F-9.

4.2 Public Property Damage

Six (6) kinds of public facilities are identified as sub-item of this flood vulnerable.

- road
- bridge
- electricity facility
- telecommunication facility
- school, hospital

- government building facility

Among the damage items above, information of actual flood damage in the past is recorded and kept only for the road by the M.P.P.P. It is confirmed that no other items had been suffered from any flood damage in the past.

Road damage, in general, accrues to the shorter interval of pavement repair and maintenance works due to inundation. In the case of Penang Island, road surface and structure are deteriorated by the frequent inundation and therefore repavement works are necessary every three years in the flood prone area, while every seven years outside the flood prone area, according to the M.P.P.P. This difference in repavement work interval counts as a road damage attributable to the floods. With the proposed project, repavement interval works would be every seven years instead of every three years. Saving in annual road maintenance cost is thus reckoned to be (1/3-1/7) of the present cost.

Annual road maintenance cost is derived by averaging actual expenditures for the last five years, which reaches 3.7 million Ringgit per year. This figure is expanded in proportion with the house damage and converted into the damage potential by the flood frequency. Calculation procedure is summarized in Table F-10 and brief summary are shown below;

(unit; million M$)

	1/1.1	1/5	1/10	1/30	1/50	1/100
Road Damage	3.7	11.2	49.0	86.9	102.0	109.7

4.3 Agricultural Product Damage

Production of paddy and vegetable is influenced by floods and reduction of the agricultural yields owing to floods is also a flood damage, and is determined by:

Damage = average yield by species x damage ratio x area

However, this damage is not reported in Penang Island. Determination of this damage was thus excluded in this study.

4.4 Loss of Income/Sales Value

4.4.1 Bus

At present five bus companies offer public bus services in Penang Island. Floods causes loss in earning opportunity in forms of 1) interruption of bus operation, 2) reduction of travel speed of bus and therefore reduction in number of bus trips and 3) lower person trip generation in rainy day. First two items are considered as a flood damage.

Data of actual earning loss due to flood is collected by means of interview with the five bus companies. It shows that the earning loss varies from 40 percent to 5 per cent of the

one day earning of each company, depending on the bus route locations. Total loss reaches 56,000 Ringgit per year in the case of habitual floods. Its damage potential for other flood frequency are expanded according to the flood prone area for each flood frequency.

Each company's loss of the earning per year is shown below and its estimation procedure is shown in Table F-11;

1.	Lim Seng Seng Bus Com.	5,750
2.	Hin Bus Com.	8,000
3.	Sri Negara Bus Com.	8,750
4.	Penang Yellow Bus Com.	4,000
5.	MPPP	29,500
	Total	56,000

4.4.2 Taxi

According to the Taxi Association of Penang, it is reported that 524 taxies are operating in Penang Island in 1990. Their income reduction in the flooded day is about 15 per cent of the daily earning. Since the average earning per taxi is about 70 ringgit per day, their actual loss is estimated to be 10.5 Ringgit per day and then arrived at 55,020 Ringgit by multiplying earning reduction with annual flood days (10 days) and total number of taxi (524).

Calculation procedure of flood damage is shown in Table F-12.

4.4.3 Trishaw

In 1990, 1,728 trishaws are operating in Penang Island. According to the Trishaw Association of Penang, their income loss attributable to the flood is about 15 per cent of the daily earning. Since the average earning per trishaw is about 30 Ringgit per day, their actual loss is estimated to be 4.5 Ringgit and arrived at 77,760 by multiplying annual flood days (10 days) and total number of trishaw (1,728).

Calculation procedure of flood damage is shown together with the loss of taxies in Table F-12.

4.5 Loss in Vehicle's Running Cost

Extra expenditure of the vehicle running cost which is induced by (1) in-efficient consumption of the fuel, oil and other running cost of the vehicle and (2) longer travelling distance and time owing to re-routing of traffic.

4.5.1 Vehicle's Operating Cost

Travel speed of vehicles is slower on the inundated roads than on the normal roads outside the flood prone area and results in in-efficient consumption of fuel, oil etc. This difference counts as a flood damage.

Usual travel speed is assumed to be 40 km per hour and it decreases to 10 km per hour during flooding, according to the "Feasibility Study of Computerized Area Traffic Control System

in Penang." In the case of the sedan, vehicle operating cost at 40 km per hour is set 21.9 cent/vehicle-km while 26.9 cent/vehicle-km at 10 km of running speed. Difference of 5.0 cent/vehicle-km is considered to be flood damage. Vehicle operating cost of other modes of the transportation are shown in Table F-13.

Vehicle operating cost for each transportation mode are weighted with the composition share shown in Table F-13 and arrived at the general vehicle operating cost, which are 15.09 cent per PCU-km (passenger car unit) at 10 km per hour and 9.84 cent per PCU-km. Results are shown in Tables F-15 and F-16.

Total loss in vehicle operating cost is estimated to be 24,700 Ringgit in 1990 and 37,600 Ringgit in 2010. Savings for the habitual flood are expanded according to the flood prone area.

4.5.2 Time Cost

Lower traveling speed due to flood results in longer traveling time and therefore reduces the working time. This is coincides with the reduction of the production. This is the reason why this item can count as a flood damage.

Basic data of unit time cost of the vehicle was provided in the Report of "Feasibility Study of Computerized Area Traffic Control System in Penang". This was converted into the 1990 figures based on the price increase since 1988. It is assumed to be 0.57 Ringgit per hour.

Unit time value is multiplied with the difference in aggregated travel time both in cases of flood and normal situation. Results are shown in Table F-16 with VOC saving. In 1990 loss in time value reaches 201,000 Ringgit per year and 305,800 Ringgit per year in 2000.

4.6 Flood Damage by Frequency and Annual Average Flood Damage

The flood damages for public property and indirect damage due to habitual floods are shown in Table F-17.

In the Master Plan Study, only direct damage such as general property damage and public property damage were contemplated.

While, in the Feasibility Study, the indirect damage other than direct damage was taken into account.

Flood damage potential by item and flood frequency for three urgent project areas are shown in Tables 18-1 through 18-3.

The average annual flood damage reduction is calculated by using the following equation:

$$D = \sum [(N_{m-1} - N_m) \times (L_{m-1} + L_m)/2]$$

where, D : Average annual damage reduction
N : Probability of floods

L : Damage potential corresponding to probability of floods
m : Ordinal number

In estimating the annual average damage, the 50-year return period was adopted as a maximum frequency for the rivers because this return period corresponds to the design flood frequency of flood mitigation. For the Georgetown Drainage Project, the 10 year return period was adopted.

The average annual flood damage potentials for three urgent projects, Sg. Pinang, Sg. Keluang and Georgetown Drainage, are shown in Table F-19.

5. FLOOD DAMAGE SURVEY

5.1 Purpose of the Flood Damage Survey

Flood damage survey was conducted in the course of the Study by the JICA Study Team in cooperation with Department of Irrigation and Drainage, Penang.

Purpose of this interview survey is to clarify the flood condition in cases of 1985 floods and annual floods. The other purpose is to collect data on actual flood damage in the two cases and to provide the basic data for the flood damage estimation according to the flood frequency.

5.2 Procedure of the Flood Damage Survey

Procedure are shown below:

- Period; September 11 to September 22 1989 (6 days)
- Sample number; 1,100 in total for Interview Sheet-1
  140 in total for Interview Sheet-2
- Interviewees; 20 persons
- Area; Flood prone area in Georgetown (Whole area is divided into 10 zones, corresponding to the drainage zones.)
- Interview sheet Two kinds(Interview Sheet-1,2)

5.3 Major contents of the Interview Sheet

Two kinds of interview sheets were used, namely, Interview Sheet-1 and Interview Sheet-2. Contents of the Interview Sheet-2 is similar to the Interview Sheet-1.

Major items clarified in this Interview Sheet-1 are as follows:

- Item A treats the flood situation. Major items clarified in this section are (1) flood depth, (2) level of ground elevation, (3) duration, (4) flood frequency, and (5) causes of floods.

- Item B treats the property value of houses in terms of original construction cost and present value.

- Item C aims at quantifying the value of whole property (except house and land) and its damage due to floods.

- Item D is to clarify the value of income/sales loss due to floods.

- Last item (Item E) aims at evaluating the priority ranking of infrastructure investment as anticipated by the inhabitants in the flood prone area. Development alternatives questioned are:

  - Housing development
  - Drainage system
  - Public transport system
  - River/sea water purification
  - Road network and traffic improvement
  - Sewage system improvement.

5.4 Results of Analysis

Data input of the interview and compilation of the data were carried out and the results of analysis are as shown in Table F-20.

Tables

Table F-1 RECORD OF HIGHEST FLOOD WATER LEVEL AND RAINFALL IN GEORGETOWN

Year	M.	D.	H.F.W.L.	Observation Site
1976	9	18	R.L. + 10.0 ft	Caunter Hall
1977	11	25	R.L. + 8.5 ft	Caunter Hall
1978	9	6	R.L. + 8.9 ft	Caunter Hall
1979	11	27	R.L. + 9.5 ft	Caunter Hall
1980	9	5	R.L. + 9.5 ft	Caunter Hall
1981	10	18	R.L. + 9.5 ft	Caunter Hall
1982	10	29	R.L. + 8.5 ft	Caunter Hall
1983	10	15	R.L. + 8.5 ft	Caunter Hall
1984	4	16	R.L. + 8.2 ft	Caunter Hall
		18 ~ 19	22;00 ~ 8;00 ~ 17;00 4.6 ft - 10.6 ft - 9.1 ft	Caunter Hall
			20;00 ~ 4;00 ~ 10;00 7mm - 42mm - 5mm (255mm)	5402002 (Kolam Bersih)
		28	6;00 ~ 15;00 ~ 24;00 6.0 ft - 11.0 ft - 5.6 ft	Caunter Hall
			1;00 ~ 9;30 ~ 13;00 0 - 40mm - 1mm (147.5mm)	5303001 (Rumah Kebajikan)
	5	17	5;00 ~ 9;30 ~ 15;30 5.3 ft - 9.3 ft - 6.0 ft	Caunter Hall
			4;00 ~ 4;30 ~ 7;30 4mm - 46mm - 0.5mm (96mm)	5302003 (Kolam Takongan)
	7	14 15	22;00 ~ 2;00 ~ 6;00 4.3 ft - 8.5 ft - 6 ft	Caunter Hall
		15 16	21;00 ~ 3;00 ~ 7;00 5.6 ft - 8.6 ft - 7.3 ft	Caunter Hall
		16 17	23;00 ~ 4;00 ~ 8;15 5.6 ft - 10.5 ft - 8.7 ft	Caunter Hall
1985	8	8	14;00~15;00~17;00 6.0 ft - 7.6 ft - 6.8 ft	Caunter Hall
			13;00 - 15mm	5303001
	10	11 ~ 12	13;55 ~ 20;00 ~ 11;30 7.0 ft - 10.8 ft - 7.2 ft	Caunter Hall
			10/10 2;00 ~ 18;00 16mm 11/10 6;00 ~ 24;00 232mm 12/10 2;00 ~ 6;30 25.5mm	5402002
	12	7 ~ 8	16;00 ~ 20;30 ~ 14;00 4.3 ft - 9 ft - 3.5 ft	Caunter Hall
			7/12 16;30 ~ 17;30 57mm	5303001
1986	9	14 ~ 15	22;00~12;45~11;00 6 ft - 7.5 ft - 3.9 ft	Caunter Hall
			14/9 2;00 ~ 24;00 98mm 15/9 0;00 ~ 5;00 18mm	5303001
		20	5;00 ~ 10;00 ~ 12;00 6.8 ft - 9.6 ft - 9.2 ft	Caunter Hall
			1;00 ~ 8;00 (92mm)	5303001
	10	5 ~ 6	15;00~18;00~10;00 4.6 ft - 7.2 ft - 4.0 ft	Jalan Perak
			5/10 12;00 ~ 23;00 (70mm) 6/10 2;00 ~ 8;30 (40mm)	5302003
	11	13	5;00 ~ 9;00 ~ 15;00 5.5 ft - 7.1 ft - 4.6 ft	Caunter Hall
			1;00 ~ 9;00 (81mm)	5402002
1987	3	19	7;00 ~ 9;30 ~ 12;30 4.2 ft - 7.1 ft - 5 ft	Jalan Perak
			2;00 ~ 10;15 (55mm)	5402002
	6	5	5;00 ~ 9;00 ~ 13;00 4 ft - 7.8 ft - 5 ft	Jalan Perak
			6;30 ~ 9;45 (70mm) 0;15 ~ 9;00 (87mm)	5202003 5402002
	7	22	6;00 ~ 7;30 5.8 ft - 6.9 ft	Jalan Perak
			2;00 ~ 10;00 (55mm)	5402002
	9	14 ~ 16	20;00~14;55~14;00 6.5 ft - 6.7 ft - 4.5 ft	Caunter Hall
	10	25 ~ 26	18;00 ~ 21;30 ~ 4;30 5.6 ft - 8.5 ft - 3.6 ft	Jalan Perak
			25/10 6;00 ~ 23;00 (105mm)	5402002
	11	9	2;15 ~ 5;00 ~ 12;00 5 ft - 8.4 ft - 4.8 ft	Caunter Hall
			83mm	5402002
		13	10;30~13;15~14;00 3.6 ft - 9 ft - 8 ft	Caunter Hall
			9;30 ~ 12;00 (80mm)	5402002

Table.F-2 EXISTING FLOODED AREA AND ITS CAUSE IN THE BASINS OUTSIDE GEORGETOWN

CATCHMENT *	INUNDATED AREA	FREQUENCY (times/yr)	DURATION (hr)	CAUSES
13	Sungai Gelugor - Taman Brown Area: 0.12 km2		(2-3)	1. Lowlying area 2. Land erosion due to development
14	Sungai Dua Besar - Tapak Pesta - Pantai Jerjak Area: 0.63 km2		(2-3)	1. Overflow of water from Sg.Dua Besar 2. Shallowness of the river due to land erosion because of development 3. Construction activities of upstream of Sg. Dua Besar 4. Illegal dumping makes the river narrower
17	1. Sungai Relau - PDC Housing Area - Jalan Tengah Area: 1.18 km2		(2-3)	1.1 Lowlying areas 1.2 Due to construction activities - Sg. Relau becomes shallower
21	Permatang Damar Laut		(2-3)	Flash Flood
22	Teluk Kumbar/ Sg. Batu		(2-3)	Flash Flood
27	1. Pulau Betong Area: 0.22km2			1. Lowlying areas
29	1. Kampong Paya Area: 0.17 km2 2. Balik Pulau Area: 0.14 km2 3. Genting			Lowlying areas (swampy area)
30	Kampong Titi Tras Area: 1.08 km2			Lowlying areas

TABLE F-3-1 NUMBER OF RESIDENTIAL DWELLINGS IN THE FLOOD PRONE AREA BY FLOOD FREQUENCY (SG. PINANG)

Flood Frequency: 50-Year Return Flood

Name of Flood Prone Area	Sub Basin	Inundation Depth (cm)	Total Flood Prone Area (1000m2)	1990				2010			
				Population Density (person/ha)	Area per Person (m2/person)	No. of Persons per House (persons)	Number of Residential Dwellings	Population Density (person/ha)	Area per Person (m2/person)	No. of Persons per House (persons)	Number of Residential Dwellings
Georgetown	1-1	0<H<50	0	100	100	6.56	0	142	70	6.18	0
		50≤H<100	72	100	100	6.56	110	142	70	6.18	165
		100≤H<200	56	100	100	6.56	85	142	70	6.18	128
		200≤H<300	26	100	100	6.56	40	142	70	6.18	60
		300≤H	0	100	100	6.56	0	142	70	6.18	0
		Total	154				234				353
	1-2	0<H<50	0	125	80	6.56	0	150	67	6.18	0
		50≤H<100	0	125	80	6.56	0	150	67	6.18	0
		100≤H<200	0	125	80	6.56	0	150	67	6.18	0
		200≤H<300	0	125	80	6.56	0	150	67	6.18	0
		300≤H	0	125	80	6.56	0	150	67	6.18	0
		Total	0				0				0
	1-3	0<H<50	12	20	500	6.56	4	26	385	6.18	5
		50≤H<100	190	20	500	6.56	58	26	385	6.18	80
		100≤H<200	77	20	500	6.56	23	26	385	6.18	32
		200≤H<300	40	20	500	6.56	12	26	385	6.18	17
		300≤H	0	20	500	6.56	0	26	385	6.18	0
		Total	318				97				134
	1-4	0<H<50	74	50	200	6.56	56	53	189	6.18	64
		50≤H<100	80	50	200	6.56	61	53	189	6.18	69
		100≤H<200	145	50	200	6.56	111	53	189	6.18	125
		200≤H<300	235	50	200	6.56	179	53	189	6.18	202
		300≤H	0	50	200	6.56	0	53	189	6.18	0
		Total	535				407				458
	1-5	0<H<50	40	50	200	6.56	30	57	175	6.18	37
		50≤H<100	0	50	200	6.56	0	57	175	6.18	0
		100≤H<200	108	50	200	6.56	82	57	175	6.18	100
		200≤H<300	117	50	200	6.56	89	57	175	6.18	108
		300≤H	0	50	200	6.56	0	57	175	6.18	0
		Total	265				202				245

TABLE F-3-2 NUMBER OF RESIDENTIAL DWELLINGS IN THE FLOOD PRONE AREA BY FLOOD FREQUENCY (SG. PINANG)

Flood Frequency: 50 Year Return Flood

Name of Flood Prone Area	Sub Basin	Inundation Depth (cm)	Total Flood Prone Area (1000m2)	1990				2010			
				Population Density (person/ha)	Area per Person (m2/person)	No. of Persons per House (persons)	Number of Residential Dwellings	Population Density (person/ha)	Area per Person (m2/person)	No. of Persons per House (persons)	Number of Residential Dwellings
Georgetown	1-6	0<H<50	132	50	200	6.56	100	73	137	6.18	155
		50≤H<100	64	50	200	6.56	49	73	137	6.18	76
		100≤H<200	198	50	200	6.56	151	73	137	6.18	233
		200≤H<300	112	50	200	6.56	85	73	137	6.18	132
		300≤H	10	50	200	6.56	8	73	137	6.18	12
		Total	515				392				608
	1-7	0<H<50	56	150	67	6.56	127	150	67	6.18	135
		50≤H<100	23	150	67	6.56	51	150	67	6.18	55
		100≤H<200	82	150	67	6.56	188	150	67	6.18	199
		200≤H<300	303	150	67	6.56	693	150	67	6.18	736
		300≤H	194	150	67	6.56	444	150	67	6.18	471
		Total	657				1,503				1,596
	1-8	0<H<50	132	190	53	6.56	382	190	53	6.18	406
		50≤H<100	40	190	53	6.56	116	190	53	6.18	123
		100≤H<200	150	190	53	6.56	434	190	53	6.18	461
		200≤H<300	495	190	53	6.56	1,434	190	53	6.18	1,522
		300≤H	569	190	53	6.56	1,649	190	53	6.18	1,750
		Total	1,386				4,015				4,262
	1-9	0<H<50	61	230	43	6.56	212	230	43	6.18	225
		50≤H<100	0	230	43	6.56	0	230	43	6.18	0
		100≤H<200	987	230	43	6.56	3,461	230	43	6.18	3,673
		200≤H<300	1,390	230	43	6.56	4,873	230	43	6.18	5,173
		300≤H	584	230	43	6.56	2,046	230	43	6.18	2,172
		Total	3,021				10,592				11,243
	1-10	0<H<50	80	200	50	6.56	244	200	50	6.18	259
		50≤H<100	69	200	50	6.56	210	200	50	6.18	223
		100≤H<200	620	200	50	6.56	1,889	200	50	6.18	2,005
		200≤H<300	200	200	50	6.56	610	200	50	6.18	647
		300≤H	0	200	50	6.56	0	200	50	6.18	0
		Total	968				2,952				3,134

TABLE F-3-3 NUMBER OF RESIDENTIAL DWELLINGS IN THE FLOOD PRONE AREA BY FLOOD FREQUENCY (SG. PINANG)

Flood Frequency: 50 Year Return Flood

Name of Flood Prone Area	Sub Basin	Inundation Depth (cm)	Total Flood Prone Area (1000m2)	1990				2010			
				Population Density (person/ha)	Area per Person (m2/person)	No. of Persons per House (persons)	Number of Residential Dwellings	Population Density (person/ha)	Area per Person (m2/person)	No. of Persons per House (persons)	Number of Residential Dwellings
Georgetown	NO.1	0<H<50	80	88	114	6.56	107	50	200	6.18	65
		50≤H<100	40	88	114	6.56	54	50	200	6.18	32
		100≤H<200	348	88	114	6.56	467	50	200	6.18	282
		200≤H<300	901	88	114	6.56	1,208	50	200	6.18	729
		300≤H	1,002	88	114	6.56	1,344	50	200	6.18	811
		Total	2,371				3,180				1,918
	NO.2	0<H<50	40	144	69	6.56	88	230	43	6.18	149
		50≤H<100	280	144	69	6.56	615	230	43	6.18	1,042
		100≤H<200	2,035	144	69	6.56	4,468	230	43	6.18	7,575
		200≤H<300	394	144	69	6.56	865	230	43	6.18	1,466
		300≤H	445	144	69	6.56	977	230	43	6.18	1,656
		Total	3,194				7,011				11,887
	NO.3	0<H<50	80	140	71	6.56	171	190	53	6.18	246
		50≤H<100	133	140	71	6.56	284	190	53	6.18	409
		100≤H<200	358	140	71	6.56	764	190	53	6.18	1,100
		200≤H<300	492	140	71	6.56	1,050	190	53	6.18	1,512
		300≤H	215	140	71	6.56	459	190	53	6.18	661
		Total	1,278				2,727				3,928
	B	0<H<50	0	50	200	6.56	0	50	200	6.18	0
		50≤H<100	0	50	200	6.56	0	50	200	6.18	0
		100≤H<200	0	50	200	6.56	0	50	200	6.18	0
		200≤H<300	0	50	200	6.56	0	50	200	6.18	0
		300≤H	141	50	200	6.56	107	50	200	6.18	114
		Total	141				107				114
Total		0<H<50	786				1,522				1,745
		50≤H<100	990				1,606				2,273
		100≤H<200	5,163				12,121				15,912
		200≤H<300	4,705				11,138				12,303
		300≤H	3,160				7,033				7,646
		Total	14,803				33,421				39,880