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GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

REGIONAL WATER RESOURCES STUDY OF SOUTH JOHOR

VOL. 5
ANNEX

G. FLOOD MITIGATION PLAN

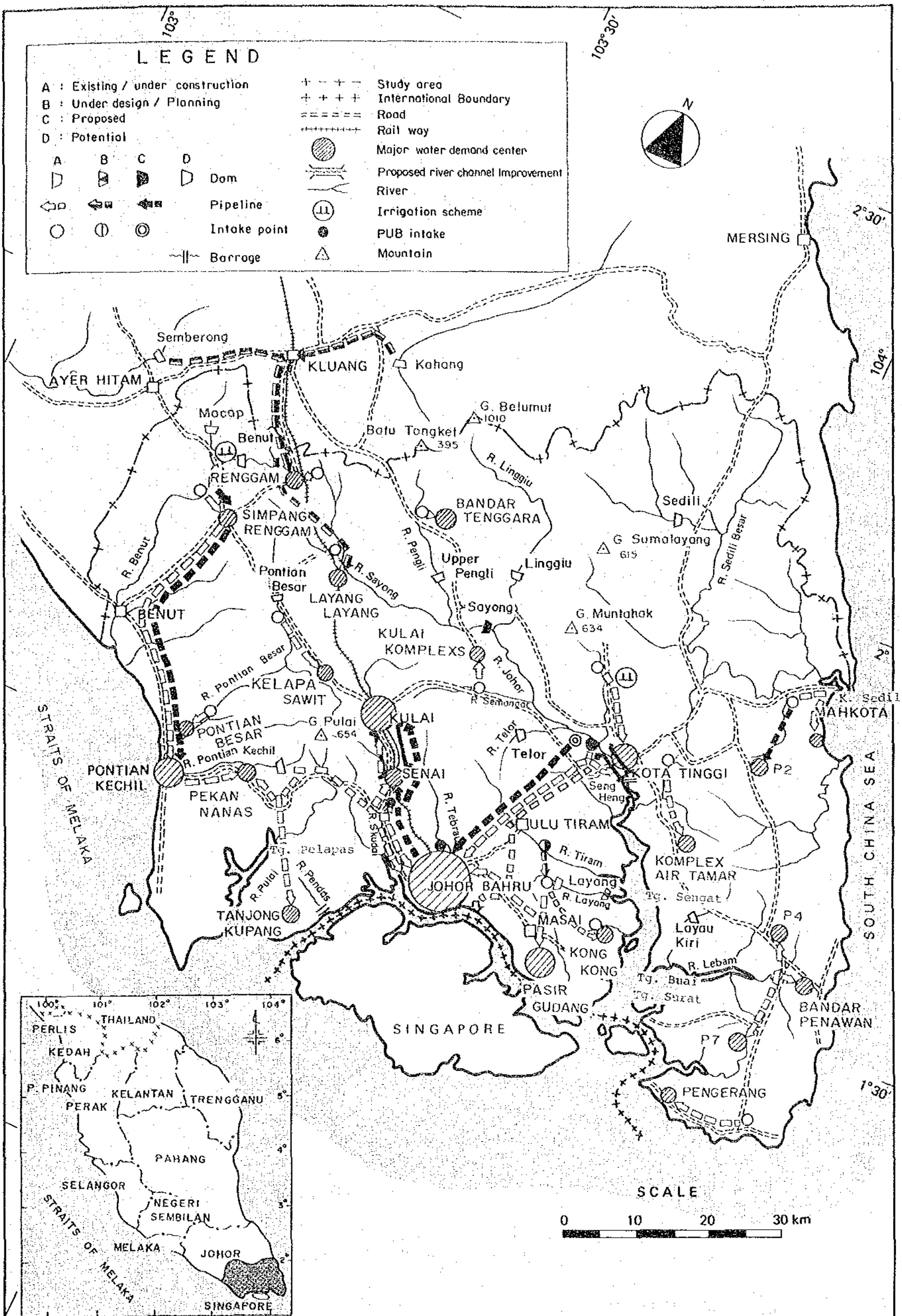
DECEMBER 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

NATIONAL WATER RESOURCES STUDY, MALAYSIA

REGIONAL WATER RESOURCES STUDY OF SOUTH JOHOR

LIST OF VOLUMES



GOVERNMENT OF MALAYSIA
NATIONAL WATER RESOURCES STUDY, MALAYSIA
SOUTH JOHOR
REGIONAL WATER RESOURCES STUDY
JAPAN INTERNATIONAL COOPERATION AGENCY

ABBREVIATIONS

(1) Oreganization/Plan

4MP (5MP)	:	Fourth (Fifth) Malaysia Plan
DID (JPT)	:	Drainage and Irrigation Department
DOA	:	Department of Agriculture
DOE	:	Department of Environment
EPU	:	Economic Planning Unit
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
GSD	:	Geological Survey Department
JICA	:	Japan International Cooperation Agency
KEJORA	:	Lembaga Kemajuan Johor Tenggara
MOA	:	Ministry of Agriculture
MOH	:	Ministry of Health
MTR	:	Mid-Term Review of 4MP
NEB	:	National Electricity Board
NWRS	:	National Water Resources Study
PUB	:	Public Utility Board (Singapore)
PWD (JKR)	:	Public Works Department
RESP	:	Rural Environmental Sanitation Program
RISDA	:	Rubber Industry Smallholders Development Authority
WHO	:	World Health Organization

(2) Others

B	:	Benefit
BOD	:	Biochemical Oxygen Demand
C	:	Cost
COD	:	Chemical Oxygen Demand
D & I	:	Domestic and Industrial
dia.	:	Diameter
DRC	:	Dry Rubber Content
EIRR	:	Economic Internal Rate of Return
EL.	:	Elevation Above Mean Sea Level
Eq.	:	Equation
FFB	:	Fresh Fruit Bunch
Fig.	:	Figure
GDP	:	Gross Domestic Project
GNP	:	Gross National Product
GRP	:	Gross Regional Project
HWL	:	Normal High Water Level
O & M	:	Operation and Maintenance
Q	:	Discharge
Ref.	:	Reference
SS	:	Suspended Solid
VA	:	Value Added

ABBREVIATIONS OF MEASUREMENT

Length

mm = millimeter
cm = centimeter
m = meter
km = kilometer
ft = foot

Area

cm^2 = square centimeter
m^2 = square meter
ha = hectare
km^2 = square kilometer

Volume

cm^3 = cubic centimeter
l = lit = liter
kl = kiloliter
m^3 = cubic meter

Weight

mg = milligram
g = gram
kg = kilogram
ton = metric ton

Time

s = second
min = minute
h = hour
d = day
y = year

Other Measures

% = percent
° = degree
' = minute
" = second
°C = degree in centigrade
10^3 = thousand
10^6 = million

Derived Measures

m^3/s = cubic meter per second
Mgd = million gallon per day
Mld = million litre per day

Money

M$ = Malaysian Ringgit
M¢ = Malaysian Cent

CONVERSION FACTORS

	From Metric System	To Metric System
Length	1 cm = 0.394 inch	1 inch = 2.54 cm
	1 m = 3.28 ft = 1.094 yd	1 ft = 30.48 cm
	1 km = 0.621 mile	1 yd = 91.44 cm
		1 mile = 1.609 km
Area	1 cm^2 = 0.155 sq.in	1 sq.ft = 0.0929 m^2
	1 m^2 = 10.76 sq.ft	1 sq.yd = 0.835 m^2
	1 ha = 2.471 acres	1 acre = 0.4047 ha
	1 km^2 = 0.386 sq.mile	1 sq.mile = 2.59 km^2
Volume	1 cm^3 = 0.0610 cu.in	1 cu.ft = 28.32 lit
	1 lit = 0.220 gal.(imp.)	1 cu.yd = 0.765 m^3
	1 kl = 6.29 barrels	1 gal.(imp.)= 4.55 lit
	1 m^3 = 35.3 cu.ft	1 gal.(US) = 3.79 lit
	10^6 m^3 = 811 acre-ft	1 acre-ft = 1,233.5 m^3
Weight	1 g = 0.0353 ounce	1 ounce = 28.35 g
	1 kg = 2.20 lb	1 lb = 0.4536 kg
	1 ton = 0.984 long ton	1 long ton = 1.016 ton
	= 1.102 short ton	1 short ton = 0.907 ton
Energy	1 kWh = 3,413 BTU	1 BTU = 0.293 Wh
Temperature	°C = (°F − 32)·5/9	°F = 1.8°C + 32
Derived Measures	1 m^3/s = 35.3 cusec	1 cusec = 0.0283 m^3/s
	1 kg/cm^2 = 14.2 psi	1 psi = 0.703 kg/cm^2
	1 ton/ha = 891 lb/acre	1 lb/acre = 1.12 kg/ha
	10^6 m^3 = 810.7 acre-ft	1 acre-ft = 1,233.5 m^3
	1 m^3/s = 19.0 mgd	1 mgd = 0.0526 m^3/s
Local Measures	1 lit = 0.220 gantang	1 gantang = 4.55 lit
	1 kg = 1.65 kati	1 kati = 0.606 kg
	1 ton = 16.5 pikul	1 pikul = 60.6 kg

Exchange Rate

(1985)

US$1 = M$2.41
¥100 = M$0.980

ANNEX G
FLOOD MITIGATION PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

1. INTRODUCTION

ANNEX G of the report presents the data, method and results of flood analysis and the consequent flood mitigation schemes recommended for the South Johor Region with the target year of 2005. It also includes a preliminary design of the flood mitigation scheme for the area of Kota Tinggi and its vicinity along Johor River which is selected as the model river stretch since the flood mitigation has a high priority of flood mitigation scheme.

The study is mainly based on information collected and results of site reconnaissance surveys from August to October 1984. The hydrographic survey for the river channel of the model river stretch was undertaken by the Government of Malaysia.

2. PRESENT RIVER CONDITION

2.1 Studied River Basins

There are nine major river basins in the Region; namely, Johor, Skudai, Tebrau, Benut, Pontian Besar, Pontian Kechil, Pulai, Sedili Besar and Sedili Kechil. The total catchment area of these major river basins is approximately 6,176 km^2, or 84% of the Region.

The river systems in the major river basins are indicated in Table 1 and in Fig. 1, and their features are described hereunder.

(1) Johor river basin

The basin has the largest catchment area of 2,687 km^2 among all the river basins in the Region. The main stream of the Johor River originates in the northwest area of the Region and flows down towards the east until it comes to Kota Tinggi meeting major tributaries such as Sayong, Pengli, Linggiu and Semangar. It turns its course towards the south after it passes through the town area of Kota Tinggi and empties itself to the Strait of Johor.

Rubber and oil palm plantations are well developed along the main stream, while the areas along tributaries especially Linggiu river are mostly covered with dense forest.

Kota Tinggi and its vicinity is highly populated area along the river and is one of the most frequent flood-prone areas in the Regions.

In this basin, Sayong Dam and Linggiu Dam with their catchment areas of 662 km^2 and 206 km^2, respectively, are proposed for the purpose of water supply. The dams are also conceivable to have flood control function. The locations of the dam sites are as indicated in Fig. 1.

(2) Skudai and Tebrau river basins

Both river basins comprise the most developed area in the Region as agricultural land and urban area including Johor Bahru, Senai, Kulai and Skudai.

Both rivers originate in the center of the Region and flow down towards the south in parallel. The catchment area of the Skudai river is 297 km2. And the Tebrau river has a catchment area of 258 km2.

In the downstream reach areas of the rivers, there are two intake weirs with pumping stations owned by PUB. Each weir is provided with three gates for the operation of flood discharge; the size of the gates on Skudai River is 2.2 m or 6.5 feet in height and 6.7 m or 20.0 feet in width, while on Tebrau River, the size is 2.3 m or 7.0 feet in height and 6.7 m or 20.0 feet in width.

(3) Pulai river basin

The basin stretches in the southeast area of the Region with a catchment area of 292 km2. The major tributary of the Pulai River is Jeran Choh River. The downstream reach area from the confluence with the tributary is mostly swamp which occupies 117 km2, or 42% of the basin. While the area along the upstream reach is well developed as the agricultural land.

(4) Benut, Pontian Besar and Pontian Kechil river basins

The basins are located in the western part of the Region. The Benut river basin has a catchment area of 568 km2, 283 km2 the Pontian Besar has 283 km2 and Pontian Kechil has 92 km2.

The middle reach areas thereof form a vast marshy area, while the upper and lower reach areas have been well developed as agricultural lands under the Western Johor Agricultural Development Projects. The populated areas are Ulu Benut located along the lower reach of Benut River, Renggam and Macap along the upper reach of Benut River, and Pontian Kechil along the lower reach of Pontian Kechil River.

There is a flood control dam named Macap Dam on Macap River, a tributary of the upper Benut River.

(5) Sedili Besar and Sedili Kechil river basins

These basins are located in the eastern part of the Region. The catchment area of the Sedili Besar river is 1,397 km^2 and that of the Sedili Kechil river is 302 km^2.

The basins are mostly covered by natural forest, and there is no notable populated area.

2.2 Present River Channel Condition

To assess the present river channel condition and formulate the flood mitigation scheme for the Region, each major river was divided into several stretches as shown in Table 2 and in Fig. 1. The stretch division was made mainly in consideration of the location of the confluence, the layout of river structures and the land use in the riverine area.

The present channel slope, depth and width of each river stretch were estimated through the field reconnaissance surveys and the available maps and results of former river channel surveys. Based on the estimated dimensions, the river channel flow capacity of each stretch was estimated, as shown in Table 3, by means of the uniform flow calculation method using Manning's Coefficient of Roughness of 0.03. The estimated flow capacity was further compared with 2-year flood discharges which were assumed on the basis of the flood records of all available stations in Peninsular Malaysia, as shown in Fig. 2.

As shown in Table 3 and in Fig. 2, many river stretches have flow capacities of less than 0.4 $m^3/s/km^2$, which can hardly cope with a flood of 2-year flood. This extremely low flow capacity of river channels causes inundation which stagnate in the swamps located on some sides of most of the rivers. Moreover, high tide often aggravates flood hazard, because river channels in the lower reaches have gentle slopes of 1/4,000 to 1/20,000.

Among the rivers in the Region, relatively high flow capacities were found in the Skudai, Tebrau, Benut, Pontian Besar, and Pontian Kechil rivers which have been improved by DID.

As for the problems on sedimentation, erosion and meandering of the channels, there are not so serious in the Region. Only the land reclamation for housing development along Skudai River is now producing the sediment and causing the aggradation of the riverbed.

The present river condition is described more in detail for each major river basin, as below:

(1) Johor river basin

The Johor river system has small flow capacity of less than 0.2 $m3/s/km^2$. Especially, the flow capacity of the main channel between the confluences of the Pengli and the Semangar rivers is less than 0.15 $m3/s/km^2$. Moreover, the area of Kota Tinggi and its vicinity is subject to flooding amplified by high tide due to a gentle channel slope of less than 1/4,000.

(2) Skudai and Tebrau river basins

The downstream reach from PUB's intake weirs have a high flow capacity of around 1.0 $m^3/s/km^2$, while the upper stretches from the weirs have a small flow capacity of 0.2 $m^3/s/km^2$ to 0.4 $m^3/s/km^2$. Bottlenecks are observed at Maju Joya Village in the middle reach of Tebrau River, and at Senai Town in the middle reach of Skudai River.

(3) Benut, Pontian Besar and Pontian Kechil river basins

The river systems have relatively high flow capacities which range from 0.6 $m^3/s/km^2$ to 1.4 $m^3/s/km^2$. Although the downstream reaches of rivers have extremely gentle slopes of from 1/6,000 to 1/20,000, the stretches are well protected from high tide by the tidal banks. Moreover, the Benut and the Pontian Besar rivers flow through vast marshy areas in their middle reaches , thereby flood discharges are regulated considerably.

(4) Pulai, Sedili Besar and Sedili Kechil river basins

The river systems have flow capacities of less than 0.1 m3/s/km2, which is the smallest among the major rivers in the Region. The Sedili Besar and Sedili Kechil rivers also have extremely gentle channel slopes; especially, Sedili Besar has a channel slope of 1/10,000 to 1/15,000 which extends to 60 km upstream from the river mouth.

2.3 Existing and On-Going Flood Mitigation Works

2.3.1 Existing Flood Mitigation Works

DID had completed flood mitigation works, such as river channel improvement, tidal dike and flood control dam, for the strategic stretches of the Skudai, Tebrau, Benut, Pontian Besar and the Pontian Kechil rivers. These completed flood mitigation works are illustrated in Fig. 1.

(1) Skudai and Tebrau rivers

The river channel improvement works in the Skudai and the Tebrau rivers were completed in 1974 for the stretches downstream from PUB's intake weirs. By this work, the flow capacity equivalent to the discharge of 20-year flood is provided to the improved channel for 6 km in the downstream reach of the Skudai River. The flow capacity equivalent to 10-year flood is provided to the downstream reach of the Tebrau River for 5 km.

(2) Benut River

Tidal dikes were provided on the left and the right banks of the lower channel of the Benut River from the river mouth to upstream for 11 km. Dikes were also provided to the Pinggam River, a tributary of the Benut River. River channel improvement was completed in 1982 for the upper channels from the end point of the tidal bank mentioned above to Simpang Renggam for 18.0 km. The improvement work was planned to provide the flow capacity equivalent to the discharge of a flood of 5-year return period.

For the Macap River, a flood control dam, Macap Dam, was constructed in 1982. Macap Dam is located in the upstream reach of the Macap River, the tributary of the Benut River, having a catchment area of 78 km^2. The primary purpose of the dam is flood control against a design inflow equivalent to a flood of 25-year return period to protect the lower basin including Simpang Renggam Town and its environs. It has the gross storage volume of 30.6×10^6 m^3, out of which 10.4×10^6 m^3 is used for the flood control, another 10.4×10^6 m^3 for the water supply of about 10 Mgd or 45.5 Mld, and the remaining 9.8×10^6 m^3 is dead storage.

Furthermore, several drains, such as the Ulu Benut Catch Drain and the Benut High Level Drain, were provided in the middle reaches of the Benut River.

(3) Pontian Besar River

Tidal dikes were provided on the left and the right banks of the lower channel of the Pontian Besar River from the river mouth to the confluence with Ayer Hitam River, the principal tributary. River channel improvement was carried out for the channels of the Pontian Besar River from the river mouth for about 25.0 km. Improvement was also undertaken on the Ayer Hitam River from the confluence with the main channel for 7.0 km. The design discharge provided by these improvement works corresponds to that of a flood of 5-year return period.

(4) Pontian Kechil River

The river channel improvement was carried out to enlarge the flow capacity from Kampong Doku about 3.0 km upstream from the river mouth to Pengkalan Raja for 11.0 km. The design discharge of this channel improvement is estimated to correspond to the discharge of a flood of about 10-year return period.

(5) Johor, Pulai, Sedili Besar and Sedili Kechil rivers

No major flood mitigation measure has so far been provided for these rivers.

2.3.2 On-Going Flood Mitigation Schemes

DID plans to extend the aforesaid flood mitigation works. The plan envisaged the river channel improvement work of Skudai River from the PUB's intake weir to Kulai with an improvement length of about 15 km, as shown in Fig. 1. The improvement works have already started partly for the length of 5.9 km from PUB's intake weir to Senai so taht the channel flow capacity is estimated to be increased from the existing one of less than 50 m^3/s to 310 m^3/s which is equivalent to a flood of 10-year return period. The channel improvement will reduce the present high flood damage on the Senai and the Kulai, which have high population growth.

Channel improvement works downstream from the Macap Dam is almost completed, as shown in Fig. 1. This channel improvement, together with the flood control by the Macap Dam, will contribute to mitigate a flood of 25-year return period.

3. FLOOD DAMAGE

3.1 Historical Flood Events

The historical flood events between 1963 and 1979 compiled by NWRS were reviewed and updated to 1985 by incorporating new information in the Annual Flood Damage Report of DID, and the results of interview with the State DID and local peoples.

The Region is subject to frequent flooding from November to February during which the rainfall pattern is dominated by the Northeast Monsoon. As stated in the previous chapter, many of the river stretches have an extremely insufficient flow capacity against flood runoff. The insufficient flow capacity easily induce a flood damage whenever the Region receives a precipitation of around 100 mm which occurs every one or two years. Moreover, because of the gentle channel slope, the backwater effect due to tide could be a significant contributing factor in a flood.

The flood in December 1969 was especially serious and extensive. It was the largest flood in the major rivers during the past 20 years. On that occasion, precipitation of 250 to 300 mm during 4 to 7 days was recorded. Flood brought inundation all over the Region, as shown in Fig. 3. The total flooded area was about 570 km^2. The flood duration was 5 to 7 days, and the maximum depth reached 1.0 to 2.0 m.

The recent major floods following the aforesaid December 1969 flood occurred in December 1978, November 1979 and December 1981 with a precipitation of 200 to 250 mm, but these floods extended in a limited area unlike the December 1969 flood.

The December 1978 flood hit mainly the southwestern part of the Region covering the Skudai, Tebrau, Pontian Besar, Pontian Kechil and the Pulai river basins. On the other hand, the November 1979 flood inundated Johor river basin located in the northern part of the Region. As for the flood in December 1981, the flooded area was concentrated to the eastern part of the Region covering the Sedili Besar and the Sedili Kechil river basins.

According to the record of the Department of Welfare, hundreds of people fled to the evacuation centers due to the aforesaid floods, especially in December 1978 and November 1979 when people in the lower reaches of the Johor, Skudai and the Tebrau river basins were affected. Furthermore, floods often cut the highways linking Johor Bahru to Mersing and to Ayer Hitam. The railroad going to Kuala Lumpur from Singapore was submerged by the flood of December 1969.

3.2 Present Land Use Status and Population in Past Flooded Area

The present land use and population within the past flooded area were estimated to evaluate the flood damage potential of the Region.

(1) Land use

The land use states as of 1985 within the past flooded area was estimated, as shown in Table 4, by superimposing the undermentioned land use map and the flooded areas caused by the past major floods:

- The land use map as of 1985 was presumed by updating the Land Use Map in 1981 prepared by MOA based on the information obtained during the present survey.

- The flooded area of the past major floods was estimated by incorporating the flood maps prepared by DID and the information obtained by site investigation. Depth and duration of the flooded were also estimated on the basis of the same data source.

(2) Population and number of households

The population as of 1985 within the flooded area was estimated and shown in Table 5, by multiplying the aforesaid past flooded area with the population density in 1985 which is assumed on the basis of the results of the Socio-Economic Study.

The number of urban and rural households as of 1985 within the past flooded area was also assumed, as shown in Table 5, by the average number of persons per household and the above estimated population. The average number of persons per household was set from the 1980 Population and Housing Census, DOS.

3.3 Amount of Flood Damage for Past Flood Events

3.3.1 Unit Value of Assets and Flood Damage Factors

To estimate the monetary value of flood damage, the unit values of assets to be damaged by a flood and their damage rates were assumed. The unit values of assets area estimated at 1985's price level and the flood damage rates or factor are to be defined corresponding to the flood depth and duration.

The unit values and damage factors were estimated for agricultural damage, non-agricultural damage and indirect damage by referring to the data in the previous study, as below:

(1) Agricultural Damage

The damage is divided into loss for production of crops and loss for investment due to mortalities of crops. The unit values and damage factors for the said losses were estimated, as shown in Tables 6 and 7, by referring to results of the field survey made under the Western Johor Agricultural Development Project (Ref. 6). The field survey was done for the recent 1982-1983 flood and the February/March 1984 flood in Batu Pahat river basin; the basin is adjacent to the Region and its major flood damage comes from the agricultural one.

According to the results of the field survey, different mortalities and production losses were observed for different ages of crops and different flood durations. As shown in Table 6, high mortality rates of more than 60% focussed on the tender ages of less than three years old, but the rates decrease rapidly to less than 10%

for the ages of more than six years old. As for the loss of production, rubber and coconut plam have their production loss for the ages of more than 5 to 6 years old, while oil palm and mixed horticulture have their production loss of more than 2 to 3 years old. For the sake of estimation for the average value of damage per hectare, it is herein assumed that crops of each different age is uniformly distributed in each farm land of the crop.

(2) Non-Agricultural Damage

The damages on houses/buildings and public utilities were estimated by referring to the date in NWRS and the Property Market Price 1983.

Tables 8 and 9 show the estimated unit value and flood damage factors for houses/buildings. In this connection, the flood damage on roads, bridges, irrigation facilities, electric power facilities, water supply facilities, and other public facilities were assumed to be 30% of the damage on the houses/buildings.

(3) Indirect Damage

Economic losses due to suspension of produciton, trade, transportaiton and communications, called indirect damage, are assumed to be 30% of the total value of direct flood damage by referring to the data in NWRS and reports for other river basins in Malaysia (Ref. 12 to 14).

3.3.2 Present Flood Damage Value

The present flood damage value was estimated from the following information:

- The agricultural area and the number of households as of 1985 to be flooded by reappearance of past major floods (Ref. Tables 4 and 5);

- The depth and duration of the above-mentioned flood (Ref. Table 4);

- The unit value of assets (Ref. Tables 6 to 8); and

- The flood damage factors corresponding to the depth and duration of flood (Ref. Tables 6, 7 and 9).

The results of estimation are compiled in Table 10, which implies that the flood damage value as of 1985 could be brought by the reappearance of past major floods.

3.3.3 Future Flood Damage Value

The future flood damage value is assumed to change due to more intensive use of land resources, increase or decrease of households, and the incremental value of assets. To estimate the future damage value, the following assumptions were made:

- Number of households to be affected by flood will change in accordance with the average annual growth of population.

- Housing and its properties will have quantity increment per household at a rate of per capita GRP growth.

The aforesaid average annual growth of population and per capita GRP is assumed in the Socio-Economic Study (Ref. Annex A). Following the above assumptions, the present flood damage value was made trend toward the future damage value. The future damage value as of 2005, thus estimated, is compiled in Table 11.

The population as of 2005 to be affected by floods was also estimated by multiplying the present population within the past flooded area shown in Table 5 with the average annual growth of population. The results of estimation are compiled in Table 12.

3.4 Probable Flood Damage

The frequency curves of the past major floods were estimated to know the relation between the flood damage and its recurrence probability. This estimation was made based on the annual maximum of flood records. The results of the estimation are compiled in Table 13 and in Fig. 4.

The flood damages corresponding to the past major flood scales are assumed to have the aforesaid recurrence probability. As for the recurrence probability of non-flood damage, the following assumptions are applied.

- If no flood mitigation works has been provided to the river stretch, the recurrence probability of non-flood damage is estimated to be approximately 2-year return period considering the present flow capacity as referred to in Seciton 2.1.

- If some flood mitigation works has already been provided to the river stretch, the recurrence probability of non-flood damage is estimated to be same as that of designed flood protection level.

Through the above assumptions, the relationship between the return period and the flood damage could be established, as shown in Figs. 5 and 6.

The probable flood damages corresponding to annual averages and various return periods were estimated from the relationship, as shown in Tables 14 and 15.

3.5 Notable Damageable Area in the Region

A notable high potential of flood damage is found, as shown in Tables 14 and 15, in the areas along Stretch No. 1 of Johor River and along Stretch No. 2 and No. 3 of Skudai River from the PUB weir.

These high potential areas implicate the densely populated towns, such as Kota Tinggi along Johor River, and Senai and Kulai along Skudai River. Agricultural plantations are also well developed in these areas, but in spite of such high land use value, no major flood mitigation has been provided so far and flood overflows frequently due to the insufficient flow capacity of the existing river channels.

The annual average of flood damage in the above areas presently amounts to about M$2.6 million, or 55% of the Region total. As for the population to be affected by a flood, it is assumed that there is presently 8,500 people in the areas, which correspond to 62% of the Region total.

Furthermore, the future population growth in the areas are predicted to be comparatively high; the annual average of population growth from 1985 to 2005 is estimated at 5.1% at Kota Tinggi, and 6.2% at Senai and Kulai, while the average growth in the Region is 4.6%. Consequently, the potential flood damage in the areas will be further increased.

The areas along other river stretches aside from the aforesaid Johor and Skudai rivers are evaluated to have a low potential flood damage, which is attributable to the existing high flood protection level provided by the existing flood mitigation facilities such as the case of Benut, Pontian Besar and Kechil rivers, or the low value of land such as the case of Pulai, Pontian Besar, Pontian Kechil and the upper reaches of Johor River.

4. FLOOD MITIGATION MASTER PLAN

4.1 Concept of Master Plan

The Master Plan is aimed at the formulation of the flood mitigation program to be implemented up to the year 2005 for the nine major river basins. The flood mitigation program will set out the recommendable flood mitigation measures and their required design flood level for the target area to be protected from floods.

The flood mitigation program was examined principally based on the economic comparison between the probable damage reduction and its corresponding cost brought about by the flood mitigation works. The following factors were also taken into account: (1) the population to be relieved from floods, and (2) the completed and on-going flood mitigation projects.

The aforesaid economic comparison was done through studies on various alternative flood mitigation measures and design flood levels.

As described in Section 2.1, each major river was divided into several river stretches, as shown in Table 2 and in Fig. 1. The above-stated flood mitigation program has been examined area by area along each river stretch.

4.2 Alternative Flood Mitigation Measures

Alternative flood mitigation measures are selected for each river stretch in the nine major river basins.

The selection for each river stretch was done with consideration on the topographical condition, land use status, and existing flood mitigation measures of each river stretch.

(1) Johor River

The major target area for flood mitigation is Kota Tinggi and its vicinity along River Stretch No. 1. Several villages along Stretch No. 2 to No. 4 and Layan Layan Town area along Stretch No. 7 are also considered as secondary target areas.

The feasibility of river channel improvement has been examined for the whole river stretches from Kota Tinggi and its environs to Layang Layang. Especially, River Stretch No. 1 was carefully examined because the stretch has the problems of high tide influence, as well as river channel flow capacity.

Flood diversion channel is also considered for River Stretch No. 1 where the riverine areas are densely populated and difficulty is foreseeable in the acquisition of land for the improvement works of the existing river channel. The diversion channel is planned to short-cut the river stretch from about 1.5 km upstream from Kota Tinggi bridge to about 2.5 km downstream where the river line is notably bending.

As for the flood control dam, this study deals with the Sayong Dam and Linggiu Dam. The dams are proposed to be with their catchment areas of 662 km^2 and 206 km^2, and expected to mitigate the flood discharge flowing into River Stretches No. 1, No. 2, No. 3 and No. 4.

In addition to the above structural measures, the natural flood retarding effect is expected by the jungle swamp area. The jungle swamp areas appear during the flood season along the main stream of Johor River and its major tributaries, such as the Semangar, Linggiu, Pengli and the Sayon rivers. The size of the swamp is between 5.0 km^2 to 50 km2. Since there is no regional development plan for these swamp area until 2005, it is expected that they are available as natural retarding basins.

(2) Skudai and Tebrau rivers

The major target of flood mitigation works is located at Senai and Kurai along River Stretch No. 2 and No. 3 of Skudai River. Since these areas are located in the middle and upper reaches, the tidal influence is small, and the flood problem is mainly caused by the insufficient flow capacity.

The flood mitigation measure study focussed on the river channel improvement. Other measures such as flood control dam and flood diversion channel should be disregarded due to the unfavorable topographic condition and the present land use status.

River channel improvement works have been already introduced on the lower stretches to some extent as mentioned before, and the existing river channel slopes are rather steep as 1/1,000 to 1/300, which is favorable for the further river channel improvement works.

(3) Benut, Pontian Besar and Pontian Kechil rivers

Major targets of flood mitigation works are several populated towns such as Ulu Benut, Simpang Renggam and Pontian Kechil. The agricultural land has been developed by the Western Johor Agricultural Development Project in the lower reaches of the basins, and will also be encompassed in the objective area of flood mitigation works.

Among the above populated towns, the Simpang Renggam and its vicinity are located in the upstream reach of Benut river, and already well protected by Macap Dam and the completed river channel improvement works.

The flood mitigation measures of river channel improvement and tidal dikes were also provided for the lower reach covering the agricultural land and the populated towns such as Ulu Benut and Pontian Kechil. The vast jungle swamp areas extend in the middle reach, and are expected to naturally retard the flood discharge flowing down into the lower reach.

This study examined whether if it is necessary to provide further river channel improvement works for the aforesaid completed flood mitigation works. The flood control dam is disregarded as an alternative measure since there is no suitable dam site for flood control which has a dominant extent of catchment area. Other alternative measures were also not considered due to the topographic and land use condition.

(4) Pulai River

The major target areas of flood mitigation are very limited and concentrated on the villages of Pulai and Ulu Pulai; their locations are as shown in Fig. 3. These areas are affected by the high tide, as well as the insufficient flow capacity.

The alternative measures are composed of the tidal dike construction and the existing river dredging works along the aforesaid target areas.

(5) Sedili Besar and Sedili Kechil rivers

Although a few damageable villages are located in the lower and the middle reaches as shown in Fig. 3, most of the basins are covered by jungle forest and the damage value of the basins are relatively small.

The above villages are affected by the high tide and the insufficient flow capacity. Hence, the tidal dike and the existing river dredging works were examined as alternative measures.

4.3 Alternative Design Floods

The alternative design flood discharges are estimated to set the structural size of flood mitigation measures.

Among the alternative flood mitigation measures, the flood diversion channel is solely applied to the stretch No. 1 of Johor River. A detailed examination for the diversion channel is separately done as a model stretch study described in Chapter 5. The study contains the estimation of design flood discharges that will flow into the diversion channel, as well as the design and cost estimation for the diversion channel.

Accordingly, the estimation is herein done for other alternative flood mitigation measures different from the flood diversion channel, i.e., for river channel improvement and flood control dam.

(1) Design flood discharge without flood control dam

The probable storm rainfall were studied by means of frequency analysis. The recurrence probabilities of floods were estimated on the basis of the corresponding stormy rainfall and the recurrence probabilities thereof. The established envelop curves of probable flood discharges which were estimated from the flood records of all available gauging stations in Peninsular Malaysia were applied to confirm the probabilities of floods. The envelop curves are shown in Fig. 7, and the estimated design flood discharges are as illustrated in Figs. 8 to 11.

(2) Design flood discharge with flood control dam

The alternative measure of flood control dam was studied for the flood in the Johor river basin, where Sayong and Linggiu dams are proposed.

To set the structural size related to the flood control dam, the following matters were examined:

- The necessary storage volume of each dam to regulate the probable inflow discharge; and

- The design discharge after regulation by the above-mentioned dams for the stretches No. 1, 2, 3 and 4 of Johor River which are located below the dam sites.

A flood runoff study was done in Annex C (Meteorology and Hydrology), principally based on the hourly flood data recorded in the 1978 flood. As described in Subsection 5.2, the probable flood hydrographs at the dam sites and the lower river stretches are established by the flood runoff study.

The necessary storage volume of a flood control dam has been estimated, as shown in Table 23, assuming that the flood control dam will store the above-mentioned probable flood exceeding a 2-year return period discharge which corresonds to 85 m^3/s at Sayong dam site and 60 m^3/s at Linggiu dam site.

The design discharges at the lower river stretches are estimated as the peak discharges of probable flood hydrographs after regulation by dams, as shown in Fig. 12.

4.4 Design and Cost for Flood Mitigation Measures

4.4.1 Design for Flood Mitigation Measures

(1) River channel improvement

The proposed longitudinal gradient for river channel improvement is assumed from the existing one listed in Table 3. Based on the assumed gradient, typical cross sections are set corresponding to each alternative flood discharge by using the uniform flow calculation method, as shown in Table 16.

The typical cross section is principally proposed to have a double cross section type in view of its favorable aspects of hydraulic efficiency and channel stabilization. The double cross section is such that the low water channel is formed by dredging the present river channel to cover a 2-year return period flood, while the high water channel is designed by levee to shouder a flood of more than 2-year return period.

Single cross section type is also assumed, if the land acquisition for the right-of-way is difficult or the design flood discharge is comparatively small below 200 m^3/s.

The extent of river channel improvement is set from the length of each river stretch in Table 2.

(2) Flood control dam

The necessary flood control storage volume has been estimated, as shown in Table 23, for the proposed Sayong and Linggiu dams, corresponding to various design return period floods, as described in Subsection 4.3.

4.4.2 Cost for Flood Mitigation Measures

(1) Financial cost

The construction cost was estimated based on work volume being multiplied by unit prices. The estimated cost represents financial costs at 1985 price level, comprising direct construction cost, engineering cost (10% of direct construction cost), compensation cost and physical contingencies (30% of the former three). The compensation cost is estimated for land procurement and resettlement.

As for the river channel improvement, the work volume was estimated in accordance with the hydraulic dimensions of the aforesaid designed channels and the existing channels. It also includes the reconstruction of existing bridges required for the improvement works. The number and size of the bridges are tabulated in Table 17.

The houses and land area expropriated for improved works were estimated based on the present land use map, as shown in Tables 18 and 19.

The unit costs for construction work and compensation were assumed mainly by interviewing the related offices and referring to the previous reports, as shown in Table 20.

Based on the above work volume and their unit costs, the financial cost required for river channel improvement was estimated, as shown in Tables 21 and 22.

As for the flood control dams, the cost estimation was done based on the study in Annex K, which sets forth the necessary cost for the maximum effective storage capacity. The cost for flood control dams was calculated, as shown in Table 24, by the following manner:

$$C = V \times Co/Vo$$

where, C : cost for flood control dam

V : effective storage capacity required for flood control dam (Ref. Table 23)

Co: cost estimated in Annex K

Vo: maximum effective storage capacity estimated in Annex K

(2) Annual average cost

The financial cost is converted into annual cost as of 1985 by a discount rate of 8% with the assumption that the construction period is 5 years starting from 1986, the project life was assumed to be 50 years, and O&M cost is 2% of project cost for the river channel improvement and flood diversion channel, and 0.5% for the flood control dam.

The results of the above estimation are compiled in Table 25 for the river channel improvement without flood control dam, and in Table 26 for the river channel improvement with flood control dam. Table 27 also reveals the annual average cost allocated for flood control dam.

4.5 Flood Damage Reduction

Flood damage reduction is defined as the difference of annual averages of flood damage with and without flood mitigation measures.

The above annual average value was derived from the probable flood damages estimated in Subsection 3.4.

The flood damage reduction is expressed in terms of monetary and population relieved, as described hereinafter.

(1) Flood damage reduction in monetary terms

The annual averages of flood damage with and without flood mitigation measures were estimated, as shown in Table 28, assuming the following conditions:

- The probable flood damage as of 1985 will increase or decrease depending on the future change of land use status, number of households and per capita GRP, as described in Subsection 3.3.3.

- The above probable flood damages to be increased or decreased in the future can be converted into an annual average value as of 1985 using a discount rate of 8% for a period of 50 years which is assumed to start in 1991.

Based on the aforesaid annual averages of flood damage with and without flood mitigation measures, the damage reduction was estimated, as shown in Table 29.

(2) Flood damage reduction in population terms

The annual averages of affected population were estimated on the basis of the population in 1985 and 2005, as shown in Table 30. This estimation was done based on the present probable population damage and the average annual growth of population described in Subsections 3.3 and 3.4.

The population damage reduction was estimated, as shown in Table 31, by the difference of annual averages of flood damage with and without flood mitigation measures.

4.6 Economic Comparison of Alternatives

Economic comparison is made by net economic benefit, that is, the balance of annual averages of flood damage reduction and cost brought about by flood mitigation measures. The results of the estimation for the net economic benefit are listed in Tables 32 and 33.

As can be seen from Tables 32 and 33, the positive net economic benefits are found in the areas along the stretch No. 1 of Johor River and the stretches from No. 1 to No. 3 of Skudai River.

(1) Area along stretch No. 1 of Johor River

The area contains the densely populated Kota Tinggi which has a high potential of flood damage, as described in Subsection 3.4.

The positive net economic benefit is derived from the river channel improvement without flood control dam for the design discharge of more than 10-year flood. It is, however, noted that as for the design discharge more than 50-year flood, the river channel improvement with the flood diversion channel is more economical than the river channel improvement, as estimated in the model river study described in Chapter 5.

Among the above-mentioned design flood levels, the largest net economic benefit comes out from the design discharge of 30-year flood.

(2) Area along stretch No. 1, No. 2 and No. 3 of Skudai River

The Senai and Kulai towns are located along the stretches No. 2 and No. 3 of Skudai River, respectively. These towns are also recognized to be the comparatively high flood damage potential areas, similar to Kota Tinggi. The areas show the positive net economic benefit at the design discharge from 5-year flood to 50-year flood, and the largest net economic benefit is derived from the design discharge of 20-year flood. All these positive net economic benefits are provided solely by the river channel improvement.

The river channel improvement will be done from downstream toward upstream. It is, however, noted that river channel improvement for stretch No. 1 of Skudai River is no longer required for the design discharge of less than 20-year flood, since the present flow capacity of the stretch has already reached 20-year flood.

4.7 Recommended Flood Mitigation Schemes

The net economic benefit is considered as a principal factor to recommend the flood mitigation schemes, but the following factors are also taken into account, namely; the expected reduction of population damage, and the completed and on-going flood mitigation works.

Consequently, flood mitigation works are recommended to stretch No. 1 of Johor River and stretches Nos. 2 to 3 of Skudai River in the Region with the design discharge of 30-year flood for Johor River and 20-year flood for Skudai River. Other river stretches cannot be given any priority of the flood mitigation scheme to be implemented by 2005, which can be attributed to the effectiveness of completed flood mitigation works or the extremely low flood damage potential.

It is estimated that the annual average flood damage will be M$6.2 x 10^6/y, and the population to be affected by a flood in 2005 will reach about 24,000/y in the Region, while the recommended flood mitigation scheme will reduce the said flood damage by M$3.3 x 10^6 and relieve about 14,000 affected population. These damage reductions correspond to 54% and 60% of the region total damage, respectively.

The principal features of the above-mentioned recommended flood mitigation schemes are shown in Table 34, and the scheme for each river basin is elaborated hereinafter.

(1) Johor river basin

River channel improvement of 6.7 km in length and with a design flood level of 30-year return period is recommended, starting at about 3.5 km downstream from Kota Tinggi bridge up to the PUB intake point.

This river channel improvement is selected to be an object of preliminary design for the model river stretch, as described in Chapter 5. The proposed longitudinal profile, cross section and alignment are shown in Plates 1 and 2, Figs. 21 to 23.

The total financial cost for the river channel improvement is estimated at M$7.7 x 10^6 as of 1985 price level, including the construction cost of M$5.2 x 10^6.

It is expected that annual average flood damage of M$1,363 x 10^3 along the river stretch No. 1 will be reduced by M$1,181 x 10^3 or 87% by the proposed river channel improvement. The value of EIRR is estimated to be 10.7%.

It is also estimated that about 4,600 population will be affected at the riverine area along stretch No. 1 by a flood on an annual average in 2005, if no flood mitigation work is provided. Among the aforesaid population damage, about 4,100 population or 90% will be relieved by the proposed river channel improvement.

Flood control dam is concluded to be economically inferior to the proposed river channel improvement which is attributable to a condition that there is no notable damageable area except Kota Tinggi town area which is located some 30 km downstream from the dam. Furthermore, since the natural retarding effect is well expected by jungle swamp areas which appear during a rainy season, it is not necessary to build up the further retarding effect brought by dam.

(2) Skudai river basin

The recommended scheme is the river channel improvement of 15 km in length from the PUB intake point to the Kulai town area, with a design flood of 20 years in return period. River channel improvement of about 8 km in length had already been completed in 1974 for the stretch downstream from the PUB intake point, with a design flood of 20 years in return period.

The total financial cost is estimated to be M$13.6 x 10^6 as of 1985 price level for the proposed river channel improvement, including the construction cost of M$9.5 x 106.

Annual average flood damage of M$2,664 x 10^3 will be reduced by M$2,158 x 10^6 or 81% along stretches No. 2 and No. 3 by the proposed river channel improvement. The value of EIRR is estimated to be 11.0%.

As for the population damage, about 12,000 population will be affected by a flood on an annual average in 2005 along the river stretches No. 2 and No. 3, assuming no further flood mitigation works. However, if the proposed river channel improvement is completed, about 10,200 population or 86% of the above damageable people will be relieved from a flood on an annual average, specially in and around the areas of Kulai and Senai.

(3) Tebrau river basin

Although the area along stretch No. 1 of Tebrau river covers a relatively populated part of Johor Bahru City, the area is already well protected by river channel improvement works applied to the stretch downstream from the PUB intake weir with a design flood of 10 years in return period.

Assuming that no further flood mitigation measure is applied, the annual average of flood damage will be M$414 x 10^3 and 1,700 population will be affected in 2005. These damage correspond to 7% of the region total. Since this damage value cannot economically induce the flood mitigation measure, no further flood mitigation measure is recommended.

(4) Benut, Pontian Besar and Pontian Kechil river basins

Since the basins are presently protected by the completed river channel improvement with design discharge of 5 to 10 years flood, tidal dike and Macap dam, further flood mitigation measures are judged to be not economically feasible.

Assuming that no further flood mitigation measure is made, the annual average of flood damage will be M$475 x 10^3 and 770 population as of 2005 in total for the three basins which are 8% and 3% of the region total, respectively.

(5) Pulai, Sedili Besar and Sedili Kechil river basin

Although no flood mitigation measure has been provided to the basins, the damage potential is extremely small and no flood mitigation measure is recommended for the period until 2005.

The annual average of flood damage in 2005 will be M$74 x 10^3 and 170 population in total, which are 1% of the region total even with the assumption that no flood mitigation measure is involved.

5. PRELIMINARY DESIGN FOR MODEL RIVER STRETCH

5.1 The Model River Stretch

The high priority of flood mitigation measure is recommended for the flood-prone areas along the stretch No. 1 of Johor River and the stretches No. 2 and No. 3 of Skudai river, as mentioned in the flood mitigation master plan in Chapter 4.

Of two rivers, Skudai River is being provided with a detailed design for its river channel improvement by DID, and the flood mitigation for the river is expected to be realized. On the other hand, no measure has been prepared to mitigate the flood damage in Johor river basin.

Hence, the stretch No. 1 of Johor River is selected as the model river stretch subject to the preliminary design. Fig. 13 shows the general map around the model river stretch. The major target for the flood mitigation is the Kota Tinggi town area.

Prior to the preliminary design, the Government of Malaysia conducted the longitudinal and cross sectional survey for the model river stretch in November 1984. The extent of the survey is included in the general map in Fig. 13.

5.2 Hydrological and Hydraulic Analysis of Floods

(1) Probable flood discharges on the model river stretch

Hourly flood discharge and rainfall data could be collected from the record of the 1978 flood observed at Jam Johor Tenggara and Sek Men Bekit Besar. These two gauging stations are located near the proposed Sayong dam site. The one-day rainfall data are also available for the recent 22 years at 8 gauging stations located in the upper basin of Sayong dam site or near the basin.

In Annex C (Meteorology and Hydrology), the probable one-day rainfall volume and its flood runoff mechanism are analyzed based on the aforesaid flood records. Consequently the probable hydrographs of flood discharge are established at the proposed Sayong dam site; the detailed methodology is referred to in Annex C.

The probable flood hydrographs are further estimated by the same methodology described in Annex C for the model river stretch. The estimated probable flood hydrographs are as shown in Fig. 14 and the peak discharges of these hydrographs are listed in Table 35.

As described in Subsection 4.3, the probable peak discharges were also estimated from envelop curves (Ref. Fig. 7). Compared with the peak discharges estimated from envelop curves, lower estimation results are given by the peak discharges derived from the aforesaid flood runoff analysis, as shown in Table 35.

The estimation from envelop curves give conservative values applicable to a regional master plan basis, while the estimation from the flood runoff analysis has a more definite value limitedly applicable to the model river stretch. In view of this, the preliminary design for the model river stretch will be done based on the probable flood discharges derived from the flood runoff analysis.

(2) Tidal effect to floods

The available data of tidal stage were collected from the gauging station of Sembawang Shipyard which is located at the mouth of Johor River, 1°28'N and 103°50'E. The tidal stage at the gauging station shows almost a regular diurnal pattern. The mean high water spring tide (MHWS) is observed to be 1.37 m above the mean sea level (MSL) at the gauging station, while the riverbed elevation ranges from -5.0 to -3.0 m above MSL at the model river stretch. Accordingly, it is estimated that the water stage of the model river stretch is easily affected by the tidal level.

The water surface profile of the model river stretch was calculated, as shown in Fig. 15, for various river discharges under the condition of MHWS. This calculation is done by non-uniform flow calculation method using the results of the river channel survey. As shown in Fig. 15, if the river discharge comes out at 500 m3/s assuming the condition of MHWS, the water stage exceeds the existing bank elevation at respective part of the model river stretch.

(3) Present channel flow capacity

Fig. 16 shows the present channel flow capacity of the model river stretch. The flow capacity was estimated by the comparison between:

- the existing bank elevations which were surveyed during this study period,

- the water surface profiles for various river discharges assuming MHWS as mentioned above.

As shown in Fig. 16, the present channel flow capacity will be approximately 450 m^3/s to 500 m^3/s at the stretch above Kota Tinggi bridge; its riverine area is developed as the populated urban center. However, the flow capacity drops to less than 200 m^3/s in the vicinity of the populated area, where only the agricultural and swamp area are observed.

Thus, the present channel flow capacities are divided roughly into two groups; one with 450 m^3/s to 500 m^3/s along the populated town center, and the other with 200 m^3/s along agricultural and swamp areas. As compared with the probable flood discharges estimated in Table 35, the channel flow capacity of 450 m^3/s to 500 m^3/s will cover around a 5-year flood, while the flow capacity of 200 m^3/s is less than 2-year flood.

As estimated by the Flood Damage Study in Chapter 3, the populated town center experienced its slight river overflow damage in the 1983 flood which is estimated to have a return period of 4.6-year, while the agricultural damage was inflicted by the 1978 flood which corresponds to only 2.6-year flood. (Ref. Tables 10 and 13.) This past flood damage condition could coincide with the above estimation of channel flow capacity.

The channel flow capacities were also examined for the major tributaries. The existing bank elevation of Permandi River is less than 2.0 m above MSL even at 1.0 km upstream from the main channel, as shown in Fig. 17. This bank elevation is generally lower than the water stage at the main channel in case of MHWS. Accordingly, the channel flow capacity of Permandi River is estimated to be almost nil during the time of high spring tide. On the other hand, the existing bank of Tembeyoh has relatively high bank elevations of 2.5 m to 3.3 m above MSL, as shown in Fig. 18. The flow capacity of Tembeyoh is estimated to be 10 m^3/s to 50 m^3/s even at the time of high spring tide.

5.3 Comparative Study for Flood Mitigation Measure

Following the course of the master plan, a comparative study is further done to examine various alternative manners of river channel improvement, including flood diversion channel, and clarify the optimum measure.

(1) River channel improvement

A comparative study was made for the following alternatives of river channel improvement.

- Alternative A: Construct levee only without dredging the existing river channel.
- Alternative B: Construct levee and dredge the existing river channel; the proposed riverbed profile is set at the existing riverbed level.
- Alternative C: Construct levee and dredge the existing river channel; the proposed riverbed profile is set at 1.0 m below the existing riverbed level.

- Alternative D: Construct levee and dredge the existing river channel; the proposed riverbed profile is set at 2.0 m below the existing riverbed level.

The preliminary design for the above alternatives is subject to the following premises:

- The design is done based on the longitudinal and cross sectional survey conducted during the study term.

- The proposed river channel slope is determined in the manner of preserving the existing slope of 1:4,000, since neither serious erosion nor sedimentation is observed in the model river stretch and the existing riverbed slope is judged to be stable.

- The cross section of the improved channel is proposed to be single cross section type due to the limited space for land acquisition. The maximum width for the improvement work space is assumed to be 120 m.

Based on the above premises, the costs required for each alternative were estimated for various design discharges, as shown in Table 36.

As shown in Table 36, the most economical measure for river channel improvement is Alternative A for the design discharge of 300 m^3/s, but changes to Alternative B for the design discharges of more than 500 m3/s. Thus, it is concluded that the manners of river channel improvement by deepening the proposed riverbed such as Alternative C and D are not so effective, which is attributed to the high tide influence.

(2) Flood diversion channel

The effectiveness of flood diversion channel is also examined as one of the alternative measures to reduce the design discharge of the main channel. The flood diversion channel is conceived to short cut the model river stretch from cross sectional survey point No. 11 to point No. 4, as illustrated in Fig. 13. The diversion channel has a total length of 2,600 m and a channel slope of 1:2,600. The diversion channel needs to cut the area to be developed as a residential area for 800 m, half of which has the ground elevation of more than 15 m above MSL.

The possible diverting discharges were estimated by non-uniform flow calculation method for various design discharges and various depths and widths of diversion channel, as shown in Fig. 19. This estimation was done assuming the main channel is improved by the measure of Alternative B and the tide level is the mean high water spring tide.

The work volume and cost required for the diversion channel were also estimated for various depth and widths of the diversion channel.

Consequently, the most economical size of diversion channel is fixed for each design discharge, and the total necessary cost was estimated for the most economical combination of river channel improvement of main channel and construction of diversion channel, as shown in Table 37.

(3) Optimum flood mitigation measure

The relation between the design discharge and the most economical construction cost was drawn, as shown in Fig. 20, for the river channel improvement without and with flood diversion channel.

As shown in Fig. 20, the river channel improvement without the diversion channel is recommendable for the design discharge of less than 850 m3/s, while it is better to provide the diversion channel for the design discharge of more than 850 m^3/s. The design discharge of 850 m3/s corresponds approximately to a 50-year flood.

The construciton cost for the above recommendable measures were further converted to the annual average value, and compared with the annual average of damage reduction, as shown in table 38 and 39; the methodology for converting to the annual average value is referred to in Subsection 4.4, and the annual average of damage reduction is derived from Subsection 4.5.

As shown in Table 39, it is concluded that the largest net economic benefit is brought about by the river channel improvement by means of Alternative B with the design flood discharge of 30-year flood.

There are several measures of river channel improvement for the model stretch of Johor River that may possibly puff up the aforesaid present saline water intrusion. It is, however, estimated that river channel improvement by means of Alternative B will not cause any serious adverse effect to the present saline water intrusion, since the measure of Alternative B sets its proposed riverbed level almost same as the existing riverbed level and never narrows the existing river bed width, as shown in Figs. 21 to 23.

From the above viewpoints, the optimum flood mitigation measure is recommended to be the river channel improvement by means of Alternative B with the design discharge of 30-year flood. The diversion channel is herein evaluated as a lower priority measure.

5.4 Preliminary Design for Optimum Flood Mitigation Measure

(1) Designing premises

This preliminary design is subject to the following premises:

(a) In accordance with the optimum measure selected in Subsection 5.3, the preliminary design discharge is prepared for the river channel improvement by means of Alternative B without diversion channel for the design flood discharge of a 30-year return period which corresponds to 770 m^3/s.

(b) The design is done based on the results of longitudinal and cross sectional survey. Among the cross sectional survey points, the cross sectional survey points of No. 1 and No. 2 have the present flow capacity of more than 770 m^3/s. Accordingly, the river channel improvement is assumed to start from the cross sectional survey point of No. 3.

(2) Preliminary design for main channel

The proposed riverbed profile is determined to be set on the average existing riverbed level with the average channel slope of 1:4,000. This manner is derived from the aforesaid measure of Alternative B.

The proposed cross section and its HWL are set by the non-uniform flow calculation method assuming the proposed riverbed profile and the MHWS.

By the above setting, the proposed alignment and the typical cross section are drawn in Plate 1. The proposed longitudinal profile and the proposed cross section for each survey point are also drawn in Plate 2 and Figs. 21 to 23, respectively.

(3) Preliminary design for tributaries

The major tributaries, Permandi and Tembeyoh, are designed as shown in Fig. 24.

As for Permandi, since the existing bank elevation is 2.5 m lower than the proposed dike elevation of the main channel, the design is arranged as below:

- A weir is proposed at the confluence with the main channel to check a reverse flow from the main channel to the upper stream of Permandi.

- The height of the proposed dike is arranged to be almost the same as the height of the ground level in the hinterland to avoid interruption of inland drainage.

As for Tembeyoh, since both the ground level in the hinterland and the existing bank levee are relatively high, the levee is proposed to be constructed on the existing bank with the height same as the proposed dike level of the main channel.

5.5 Preliminary Cost Estimation

In accordance with the preliminary design described in Subsection 5.4, the cost estimation was done as shown in Table 40, where the work items, their work values and cost required for the river channel improvement are listed. The unit prices are set up as the value estimated in the aforesaid regional master plan. The estimated cost represents financial cost with time basis of 1986 comprising construction and compensation costs.

The construction cost covers direct cost, engineering cost (10% of direct cost), compensation cost and physical contingencies (30% of the former three). The compensation cost is composed of those for resettlement of house and procurement of agricultural land. The compensation objects were counted based on the data such as the present land use map prepared by MOA and the map of urbanizing structural plan for Kota Tinggi prepared by the State Government.

The total cost amounts to M$7.7 x 10^6 out of which M$5.2 x 10^6 is appropriated for construction cost.

5.6 Preliminary Construciton Schedule

The construciton work of the project is scheduled for 5 years, including 1 year for preparation and detailed engineering works.

The river improvement work consists of excavation, embankment, and reconstruction of Kota Tinggi bridge, etc. These works are assumed to be executed from downstream toward upstream and from main channel toward tributaries.

Of the above-mentioned works, the earthwork composed of excavation and embankment can be said to have the greatest work volume. The critical path of the schedule is determined by the progress of earthwork, and other works are scheduled in accordance with the earthwork schedule. Following this concept, the construction schedule was prepared, as shown in Fig. 25, where the average annual work period is assumed to be in 8 months from April to November; avoiding a rainy season, since earthwork in a rainy season is difficult to undertake.

The maximum annual volumes of earthwork are 67,000 m^3 of excavation and 40,000 m^3 of embankment. The number of heavy equipment required for the earthwork has been estimated through the following formula:

$$N = V / (W \times T)$$

where, N: number of heavy equipment required for earthwork

V: annual earthwork volume

W: hourly work ability of heavy equipment

T: total work hours of heavy equipment in a year

(= 7 hours/day x 8 months x 26 days = 1,456 hours)

As the result of the above estimation, the required heavy equipment have been roughly anticipated, as shown in Table 41.

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TABLES

Table 1. CATCHMENT AREA OF EACH RIVER SYSTEM IN MAJOR RIVER BASINS

River Basin	River System	Catchment Point	Catchment Area (km^2)
Johor	Johor	River Mouth	2,687
	Johor	Kota Tinggi Town	1,580
	Semangar	River Mouth	143
	Sayon	River Mouth	662
	Linggu	River Mouth	391
	Pengli	River Mouth	149
Skudai	Skudai	River Mouth	297
	Skudai	PUB Barrage	188
Tebrau	Tebrau	River Mouth	258
	Tebrau	PUB Barrage	127
Benut	Benut	River Mouth	568
	Macap	River Mouth	81
Pontian Besar	Potian Besar	River Mouth	283
	Ayar Hitam	River Mouth	189
Pontian Kechil	Potian Kechil	River Mouth	92
Pulai	Pulai	River Mouth	292
	Pulai	Pulai Village	99
Sedili Besar	Sedili Besar	River Mouth	1,397
	Kamban	River Mouth	123
	Mawai	River Mouth	92
	Dohor	River Mouth	135
Sedili Kechil	Sedili Kechil	River Mouth	302
Total Catchment Area			6,176

Table 2. RIVER STRETCHES DIVIDED FOR FLOOD MITIGATION PLAN

River Basin	Stretch No.	River System	Starting Point of River Stretch	Stretch Length (m)
Johor	1	Johor	T. Putus (downstream of Kota Tinggi Town)	6.7
	2	Johor	PUB Intake Point	7.1
	3	Johor	Confluence of Telor River	5.5
	4	Johor	Confluence of Semangar River	12.5
	5	Johor	Confluence of Linggiu River	7.1
	6	Sayon	Confluence of Pengli River	7.5
	7	Sayon	Confluence of Belicong River (up to Layan Layan Town Area)	11.8
Skudai	1	Skudai	8.1 km downstream of PUB Barrage	8.1
	2	Skudai	PUB Barrage	5.6
	3	Skudai	Senai Town	9.3
	4	Skudai	Kulai Town (up to Sedenak Village)	10.6
Tebrau	1	Tebrau	6.2 km downstram of PUB Barrage	6.2
	2	Tebrau	PUB Barrage	5.0
	3	Tebrau	Maju Jaya Village (up to Seelong Village)	6.2
Benut	1	Benut	Confluence of Benut High Drain	5.0
	2	Benut	Confluence of Ulu Benut Catch Drain	9.6
	3	Benut	Confluence of Hj Hashim River (up to confluence of Macap River)	4.4
Pontian Besar	1	Potian Besar	River mouth	7.5
	2	Potian Besar	Confluence of Ayar Hitam River	8.7
	3	Potian Besar	South Malaya Pinapple Plantation	6.2
	4	Potian Besar	Confluence of Ulu Pontian Besar (up to Seri Paya Village)	5.3
Pontian Kechil	1	Pontian Kechil	River Mouth (up to 8.1 km upper-stream)	8.1
Pulai	1	Pulai	T. Kupan	1.9
	2	Pulai	Pulai Village (up to Ulu Pulai Village)	2.5
Sedili Besar	1	Sedili Besar	Sedili Basar Village (river mouth)	8.7
	2	Sedili Besar	Hutan Lesong Village	26.5
	3	Sedili Besar	Confluence of Mawai River	6.9
	4	Sedili Besar	Confluence of Dohor River (up to confluence of Ambel River)	23.7
Sedili Kechil	1	Sedili Kechil	River Mouth	4.3
	2	Sedili Kechil	Confluence of Bahar River (up to confluence of Lukoh River)	17.8

Table 3. HYDRAULIC DIMENSIONS AND FLOW CAPACITY OF PRESENT RIVER CHANNEL

River Basin	Stretch No.	Hydraulic Dimensions					Flow Capacity		
		Gradient		River Bed Width (m)	River Channel Depth (m)	Channel Cross Section	Velocity (m/s)	Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)
		River Bed	Water Surface						
Johor	1	1:4000	1:5000	50	4.5	Single	1.2	296	0.19
	2	1:4000	1:5000	50	4.0	Single	1.1	239	0.16
	3	1:4000	1:4000	45	3.5	Single	1.1	194	0.15
	4	1:3600	1:3600	40	3.0	Single	1.1	142	0.13
	5	1:2500	1:2500	25	2.8	Single	1.2	91	0.14
	6	1:2500	1:2500	15	2.5	Single	1.2	50	0.13
	7	1:1000	1:1000	10	2.5	Single	1.6	49	0.37
Skudai	1	1:1500	1:6000	34	3.2	Double	1.2	308	1.38
	2	1:1200	1:1200	15	2.0	Single	1.3	45	0.30
	3	1:1000	1:1000	9	1.5	Single	1.2	21	0.36
	4	1:1000	1:1000	7	2.0	Single	1.3	21	0.38
Tebrau	1	1:1500	1:2000	30	2.1	Single	1.1	123	0.86
	2	1:1300	1:1300	12	1.5	Single	0.9	17	0.24
	3	1:1000	1:1000	5	1.5	Single	1.1	13	0.34
Benut	1	1:5822	1:5822	27	5.2	Double	1.2	242	0.61
	2	1:1409	1:1409	18	2.8	Double	1.9	182	0.61
	3	1:1409	1:1409	12	1.7	Double	1.7	117	0.65
Pontian Besar	1	1:20000	1:20000	37	3.8	Double	0.7	205	0.61
	2	1:20000	1:20000	37	3.8	Double	0.7	205	0.61
	3	1:20000	1:20000	24	3.0	Double	1.4	147	0.83
	4	1:758	1:758	12	2.2	Single	1.5	42	0.98
Pontian Kechil	1	1:7900	1:7900	15	4.6	Double	0.9	99	1.38
Pulai	1	1:3000	1:3000	5	2.0	Single	0.7	9	0.09
	2	1:3000	1:3000	5	1.5	Single	0.6	5	0.05
Sedili Besar	1	1:15000	1:15000	70	5.0	Single	0.5	120	0.09
	2	1:15000	1:15000	45	3.0	Single	0.5	75	0.07
	3	1:10000	1:10000	30	2.5	Single	0.6	48	0.05
	4	1:15000	1:15000	22	2.0	Single	0.4	20	0.04
Sedili Kechil	1	1:15000	1:15000	20	2.0	Single	0.4	17	0.06
	2	1:7000	1:7000	15	1.5	Single	0.5	12	0.06

Table 4 PRESENT LAND USE STATES WITHIN PAST FLOOD AREA (AS OF 1985)

Past Flood Event	Stretch No.	Flood Duration (day)	Flood Depth (m)	Probable Flood Area for Each Land Use: Urban Area (ha)	Rubber (ha)	Oil Palm (ha)	Horti-culture (ha)	Other Crops (ha)	Forest/ Swamp (ha)	Total (ha)
JOHOR 1969	1	7.	2.00	138.	343.	87.	145.	0.	172.	885.
	2	7.	2.00	0.	92.	0.	74.	0.	744.	910.
	3	7.	2.00	0.	93.	0.	152.	0.	470.	715.
	4	7.	2.00	0.	66.	51.	83.	38.	895.	1133.
	5	7.	2.00	0.	0.	0.	0.	0.	680.	680.
	6	7.	2.00	0.	0.	0.	0.	0.	762.	762.
	7	7.	2.00	31.	0.	26.	23.	0.	731.	811.
	TOTAL			169.	594.	164.	477.	38.	4454.	5896.
JOHOR 1979	1	7.	1.00	113.	231.	58.	163.	0.	172.	737.
	2	4.	1.20	0.	79.	0.	63.	0.	733.	875.
	3	4.	1.20	0.	81.	0.	145.	0.	420.	646.
	4	4.	1.50	0.	61.	23.	77.	22.	872.	1055.
	5	3.	1.20	0.	0.	0.	0.	0.	640.	640.
	6	3.	1.20	0.	0.	0.	0.	0.	640.	640.
	7	3.	1.20	28.	0.	26.	18.	0.	694.	766.
	TOTAL			141.	452.	107.	466.	22.	4171.	5359.
JOHOR 1983	1	4.	1.00	32.	48.	0.	151.	0.	133.	364.
	2	8.	1.50	0.	61.	0.	48.	0.	444.	553.
	3	4.	1.00	0.	73.	0.	140.	0.	318.	531.
	4	4.	1.00	0.	22.	0.	75.	0.	621.	718.
	5	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	TOTAL			32.	204.	0.	414.	0.	1516.	2166.
JOHOR 1982	1	4.	1.00	0.	22.	0.	57.	0.	118.	197.
	2	2.	1.20	0.	9.	0.	22.	0.	196.	227.
	3	7.	1.80	0.	32.	0.	51.	0.	56.	139.
	4	7.	1.10	0.	18.	16.	51.	0.	148.	233.
	5	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	TOTAL			0.	81.	16.	181.	0.	518.	796.
JOHOR 1981	1	3.	1.00	0.	18.	0.	52.	0.	106.	176.
	2	4.	1.40	0.	0.	0.	16.	0.	38.	54.
	3	7.	1.40	0.	0.	0.	50.	0.	38.	88.
	4	7.	1.50	0.	11.	0.	43.	0.	147.	201.
	5	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	TOTAL			0.	29.	0.	161.	0.	329.	519.
JOHOR 1978	1	3.	1.00	0.	14.	0.	33.	0.	71.	118.
	2	3.	1.20	0.	0.	0.	4.	0.	32.	36.
	3	3.	1.50	0.	0.	0.	43.	0.	24.	67.
	4	3.	1.50	0.	4.	0.	38.	0.	72.	114.
	5	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	TOTAL			0.	18.	0.	118.	0.	199.	335.
SKUDAI 1978	1	2.	1.83	132.	191.	36.	0.	0.	206.	565.
	2	2.	2.13	87.	132.	0.	102.	29.	33.	383.
	3	2.	1.52	308.	514.	98.	113.	0.	53.	1086.
	4	2.	1.22	35.	221.	27.	0.	18.	0.	301.
	TOTAL			562.	1058.	161.	215.	47.	292.	2335.
SKUDAI 1981	1	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	2	2.	0.91	64.	101.	0.	63.	0.	33.	261.
	3	2.	0.91	224.	185.	61.	26.	0.	0.	496.
	4	3.	0.91	13.	115.	0.	0.	0.	0.	128.
	TOTAL			301.	401.	61.	89.	0.	33.	885.
SKUDAI 1979	1	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	2	2.	0.91	43.	47.	0.	33.	0.	33.	156.
	3	2.	0.91	113.	138.	0.	16.	0.	24.	291.
	4	2.	0.61	2.	46.	0.	0.	0.	0.	48.
	TOTAL			158.	231.	0.	49.	0.	57.	495.
TEBRAU 1978	1	2.	0.91	195.	73.	146.	0.	110.	42.	566.
	2	2.	1.52	0.	260.	144.	48.	19.	69.	540.
	3	3.	2.44	0.	185.	32.	0.	13.	435.	665.
	TOTAL			195.	518.	322.	48.	142.	546.	1771.
TEBRAU 1982	1	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	2	1.	0.61	0.	46.	63.	8.	19.	6.	142.
	3	1.	0.61	0.	107.	0.	0.	13.	101.	221.
	TOTAL			0.	153.	63.	8.	32.	107.	363.
BENUT 1969	1	3.	0.91	0.	3265.	0.	42.	1057.	1409.	5773.
	2	5.	0.91	0.	223.	0.	55.	0.	4147.	4425.
	3	3.	0.91	118.	779.	0.	104.	354.	2181.	3536.
	TOTAL			118.	4267.	0.	201.	1411.	7737.	13734.
BENUT 1981	1	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	2	6.	1.22	0.	13.	0.	33.	0.	203.	249.
	3	3.	1.22	0.	0.	0.	78.	0.	84.	162.
	TOTAL			0.	13.	0.	111.	0.	287.	411.
PONTIAN B. 1969	1	7.	0.61	0.	832.	47.	239.	128.	64.	1310.
	2	7.	0.61	0.	1315.	0.	109.	1045.	7.	2476.
	3	4.	0.61	0.	212.	18.	0.	12.	2782.	3024.
	4	4.	0.61	0.	183.	0.	171.	83.	972.	1409.
	TOTAL			0.	2542.	65.	519.	1268.	3825.	8219.
PONTIAN B. 1978	1	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	2	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	3	2.	1.52	0.	212.	18.	0.	12.	2782.	3024.
	4	2.	1.52	0.	166.	0.	153.	83.	972.	1374.
	TOTAL			0.	378.	18.	153.	95.	3754.	4398.
PONTIAN K. 1969	1	7.	0.61	0.	2826.	0.	76.	1156.	299.	4357.
PULAI 1969	1	1.	0.91	0.	0.	0.	5.	78.	315.	398.
	2	1.	0.91	0.	397.	0.	7.	0.	70.	474.
	TOTAL			0.	397.	0.	12.	78.	385.	872.
PULAI 1978	1	1.	0.91	0.	0.	0.	3.	0.	315.	318.
	2	1.	0.91	0.	246.	0.	4.	78.	59.	387.
	TOTAL			0.	246.	0.	7.	78.	374.	705.
SEDILI B. 1981	1	5.	1.40	0.	24.	15.	0.	0.	2945.	2984.
	2	6.	1.40	0.	0.	0.	18.	0.	2647.	2665.
	3	6.	1.09	0.	3.	0.	7.	0.	1978.	1988.
	4	3.	1.40	0.	0.	0.	0.	0.	2198.	2198.
	TOTAL			0.	27.	15.	25.	0.	9768.	9835.
SEDILI K. 1981	1	0.	0.0	0.	0.	0.	0.	0.	0.	0.
	2	5.	1.40	0.	0.	0.	0.	0.	5194.	5194.
	TOTAL			0.	0.	0.	0.	0.	5194.	5194.

Table 5 PRESENT POPULATION AND NUMBER OF HOUSEHOLDS WITHIN PAST FLOOD AREA (AS OF 1985)

Past Flood Event	Stretch No.	Flood Area (ha) Urban	Flood Area (ha) Rural	Population (people) Urban	Population (people) Rural	Population (people) Total	Number of Households (nos) Urban	Number of Households (nos) Rural	Number of Households (nos) Total
JOHOR 1969	1	138.	145.	5851.	3612.	9463.	1104.	681.	1785.
	2	0.	74.	0.	1843.	1843.	0.	348.	348.
	3	0.	152.	0.	3786.	3786.	0.	714.	714.
	4	0.	83.	0.	2068.	2068.	0.	390.	390.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	31.	23.	1314.	573.	1887.	248.	108.	356.
	TOTAL	169.	477.	7166.	11882.	19048.	1352.	2242.	3594.
JOHOR 1979	1	113.	163.	4791.	4060.	8852.	904.	766.	1670.
	2	0.	63.	0.	1569.	1569.	0.	296.	296.
	3	0.	145.	0.	3612.	3612.	0.	681.	681.
	4	0.	77.	0.	1918.	1918.	0.	362.	362.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	28.	18.	1187.	448.	1636.	224.	85.	309.
	TOTAL	141.	466.	5978.	11608.	17586.	1128.	2190.	3318.
JOHOR 1983	1	32.	151.	1357.	3761.	5118.	256.	710.	966.
	2	0.	48.	0.	1196.	1196.	0.	226.	226.
	3	0.	140.	0.	3487.	3487.	0.	658.	658.
	4	0.	75.	0.	1868.	1868.	0.	352.	352.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	32.	414.	1357.	10313.	11670.	256.	1946.	2202.
JOHOR 1982	1	0.	57.	0.	1420.	1420.	0.	268.	268.
	2	0.	22.	0.	548.	548.	0.	103.	103.
	3	0.	51.	0.	1270.	1270.	0.	240.	240.
	4	0.	51.	0.	1270.	1270.	0.	240.	240.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	181.	0.	4509.	4509.	0.	851.	851.
JOHOR 1981	1	0.	52.	0.	1295.	1295.	0.	244.	244.
	2	0.	16.	0.	399.	399.	0.	75.	75.
	3	0.	50.	0.	1245.	1245.	0.	235.	235.
	4	0.	43.	0.	1071.	1071.	0.	202.	202.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	161.	0.	4011.	4011.	0.	757.	757.
JOHOR 1978	1	0.	33.	0.	822.	822.	0.	155.	155.
	2	0.	4.	0.	100.	100.	0.	19.	19.
	3	0.	43.	0.	1071.	1071.	0.	202.	202.
	4	0.	38.	0.	947.	947.	0.	179.	179.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	118.	0.	2939.	2939.	0.	555.	555.
SKUDAI 1978	1	132.	0.	5314.	0.	5314.	871.	0.	871.
	2	87.	102.	3503.	3121.	6624.	574.	612.	1186.
	3	308.	113.	12400.	3458.	15858.	2033.	678.	2711.
	4	35.	0.	1409.	0.	1409.	231.	0.	231.
	TOTAL	562.	215.	22626.	6579.	29205.	3709.	1290.	4999.
SKUDAI 1981	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	64.	63.	2577.	1928.	4504.	422.	378.	800.
	3	224.	26.	9018.	796.	9814.	1478.	156.	1634.
	4	13.	0.	523.	0.	523.	86.	0.	86.
	TOTAL	301.	89.	12118.	2723.	14842.	1987.	534.	2521.
SKUDAI 1979	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	43.	33.	1731.	1010.	2741.	284.	198.	482.
	3	113.	16.	4549.	490.	5039.	746.	96.	842.
	4	2.	0.	81.	0.	81.	13.	0.	13.
	TOTAL	158.	49.	6361.	1499.	7860.	1043.	294.	1337.
TEBRAU 1978	1	195.	0.	10940.	0.	10940.	2145.	0.	2145.
	2	0.	48.	0.	1469.	1469.	0.	288.	268.
	3	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	195.	48.	10940.	1469.	12408.	2145.	288.	2433.
TEBRAU 1982	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	8.	0.	245.	245.	0.	48.	48.
	3	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	8.	0.	245.	245.	0.	48.	48.
BENUT 1969	1	0.	42.	0.	823.	823.	0.	147.	147.
	2	0.	55.	0.	1078.	1078.	0.	193.	193.
	3	118.	104.	4751.	2038.	6789.	779.	364.	1143.
	TOTAL	118.	201.	4751.	3940.	8690.	779.	704.	1482.
BENUT 1981	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	33.	0.	647.	647.	0.	116.	116.
	3	0.	78.	0.	1529.	1529.	0.	273.	273.
	TOTAL	0.	111.	0.	2176.	2176.	0.	389.	389.
PONTIAN B. 1969	1	0.	239.	0.	4684.	4684.	0.	837.	837.
	2	0.	109.	0.	2136.	2136.	0.	382.	382.
	3	0.	0.	0.	0.	0.	0.	0.	0.
	4	0.	171.	0.	3352.	3352.	0.	599.	599.
	TOTAL	0.	519.	0.	10172.	10172.	0.	1817.	1817.
PONTIAN B. 1978	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.	0.	0.
	3	0.	0.	0.	0.	0.	0.	0.	0.
	4	0.	153.	0.	2999.	2999.	0.	536.	536.
	TOTAL	0.	153.	0.	2999.	2999.	0.	536.	536.
PONTIAN K. 1969	1	0.	76.	0.	1490.	1490.	0.	266.	266.
PULAI 1969	1	0.	5.	0.	98.	98.	0.	18.	18.
	2	0.	7.	0.	137.	137.	0.	25.	25.
	TOTAL	0.	12.	0.	235.	235.	0.	42.	42.
PULAI 1978	1	0.	3.	0.	59.	59.	0.	11.	11.
	2	0.	4.	0.	78.	78.	0.	14.	14.
	TOTAL	0.	7.	0.	137.	137.	0.	25.	25.
SEDILI B. 1981	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	18.	0.	448.	448.	0.	85.	85.
	3	0.	7.	0.	174.	174.	0.	33.	33.
	4	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	25.	0.	623.	623.	0.	117.	117.
SEDILI K. 1981	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	0.	0.	0.	0.	0.	0.	0.

Table 6. UNIT VALUE AND FLOOD DAMAGE FACTOR FOR MORTALITY OF AGRICULTURAL CROPS

Crop Item	Age of Crop (Year)	(1) Value If Killed (M$/ha)	Flood Duration <14 Days: (2) Kill Factor	Flood Duration <14 Days: (3) Loss From Death [(1)x(2)] (M$/ha)	Flood Duration >14 Days: (4) Kill Factor	Flood Duration >14 Days: (5) Loss From Death [(1)x(4)] (M$/ha)
Rubber	1	2,371	0.95	2,252	1.00	2,371
	2	3,435	0.85	2,920	0.95	3,263
	3	4,711	0.40	1,884	0.60	2,827
	4	6,235	0.30	1,871	0.50	3,118
	5	7,767	0.20	1,553	0.20	1,553
	6	10,055	0.10	1,006	0.20	2,011
	7	10,825	0.10	1,082	0.20	2,165
	8	11,204	0.05	560	0.10	1,120
	9	11,484	0.05	574	0.10	1,148
	10	11,488	0.05	574	0.10	1,149
	11	11,492	0	0	0.05	575
	12-25	-	0	0	0	0
			Average* =	571	Average* =	852
Oil Palm	1	3,514	0.95	3,338	1.00	3,514
	2	5,706	0.65	3,710	0.85	4,850
	3	9,220	0.30	2,766	0.60	5,532
	4	12,075	0.20	2,415	0.30	3,623
	5	14,241	0.20	2,848	0.30	4,272
	6	15,226	0.10	1,523	0.20	3,045
	7	16,510	0.05	826	0.20	3,302
	8	16,958	0.05	848	0.20	3,392
	9	17,543	0.05	877	0.10	1,754
	10	17,351	0	0	0.10	1,735
	11	17,100	0	0	0.05	855
	12-25	-	0	0	0	0
			Average* =	766	Average* =	1,435
Mixed Horticulture	1	2,300	1.00	2,300	1.00	2,300
	2	4,222	0.95	4,011	1.00	4,222
	3	6,703	0.60	4,022	0.90	6,033
	4	9,635	0.50	4,818	0.80	7,708
	5	12,666	0.30	3,800	0.50	6,333
	6	15,897	0.20	3,179	0.40	6,359
	7	18,697	0.20	3,739	0.30	5,609
	8	19,464	0.10	1,946	0.20	3,893
	9	20,598	0.05	1,030	0.10	2,060
	10	22,184	0.05	1,109	0.10	2,218
	11-20	-	0	0	0	0
			Average* =	1,498	Average* =	2,337
Other Crops (Represented by Coconut Palm)	1	2,457	1.00	2,457	1.00	2,457
	2	3,062	0.75	2,297	0.95	2,909
	3	4,014	0.40	1,606	0.60	2,408
	4	4,431	0.20	886	0.40	1,772
	5	4,835	0.05	242	0.20	967
	6	5,012	0	0	0.10	501
	7	5,183	0	0	0.05	259
	8	5,128	0	0	0.05	256
	9	5,075	0	0	0.05	254
	10	4,780	0	0	0.05	239
	11-25	-	0	0	0	0
			Average* =	300	Average* =	481

Note; *: The average value of flood damage is the sum of the total loss per hectare at each year of age divided by the total number of years considered. It assumes an even distribution of crops of all ages in the flood area.

Source : Western Johor Integrated Agricultural Development Project, Phase II.

Table 7. UNIT VALUE AND FLOOD DAMAGE FACTOR FOR PRODUCTION LOSS OF AGRICULTURAL CROPS

Crop Item	Age of Crop (Year)	(1) Unit Value (M$/ha)	Flood Duration <14 Days: (2) Flood Damage Factor	Flood Duration <14 Days: (3) Loss of Production Value [(1)x(2)] (M$/ha)	Flood Duration >14 Days: (4) Flood Damage Factor	Flood Duration >14 Days: (5) Loss of Production Value [(1)x(4)] (M$/ha)
Rubber	1-6	0	-	0	-	0
	7	1,952	0.045	88	0.08	156
	8	2,370	0.0475	113	0.09	213
	9	2,509	0.0475	119	0.09	226
	10	2,788	0.0475	132	0.09	251
	11	2,788	0.05	139	0.095	265
	12-14	2,788	0.05	139	0.10	279
	15-19	3,067	0.05	153	0.10	307
	20-25	3,346	0.05	168	0.10	335
			Average* =	111	Average* =	220
Oil Palm	1-3	0	-	0	-	0
	4	1,035	0.08	83	0.21	217
	5	2,295	0.04	92	0.14	321
	6	3,860	0.045	174	0.08	309
	7	3,860	0.0475	183	0.08	309
	8	4,896	0.0475	233	0.08	392
	9	4,896	0.0475	233	0.09	441
	10	5,590	0.05	280	0.09	503
	11	5,590	0.05	280	0.095	531
	12-14	5,590	0.05	280	0.1	559
	15-19	5,160	0.05	258	0.1	516
	20-25	4,730	0.05	237	0.1	473
			Average* =	203	Average* =	405
Mixed Horticulture	1-2	0	-	0	-	0
	3	488	0.16	78	0.09	44
	4	943	0.15	142	0.16	151
	5	1,945	0.14	272	0.25	487
	6	2,698	0.08	215	0.24	647
	7	4,063	0.04	162	0.21	853
	8	6,357	0	0	0.16	1,017
	9	6,357	0	0	0.09	572
	10	6,443	0	0	0.045	290
	11-20	8,020-8,397	0	0	0	0
			Average* =	43	Average* =	203
Other Crops (Represented by Coconut Palm)	1-5	0	-	0	-	0
	6	346	0.05	17	0.18	62
	7	346	0.05	17	0.095	33
	8	691	0.05	35	0.095	66
	9	691	0.05	35	0.095	66
	10	1,100	0.05	55	0.10	110
	11-25	1,100	0.05	55	0.10	110
			Average* =	39	Average* =	79

Note; *: The average value of flood damage is the sum of the total loss per hectare at each year of age divided by the total number of years considered. It assumes an even distribution of crops of all ages in the flood area.

Source : Western Integrated Agricultural Development Project, Phase II.

Table 8. UNIT VALUE OF NON-AGRICULTURAL ASSETS

Item of Asset	Unit Value
1. Private House in Urban Area	M$9,500/house
2. Private House in Rural Area	M$3,700/house
3. Public House/Building	M$200/person

Source: Property Market Report, 1983, and National Water Resources Study, Malaysia, Sectoral Report Vol. 5.

Table 9. FLOOD DAMAGE FACTORS OF NON-AGRICULTURAL ASSETS

Flood Depth (m)	<0.25	0.25-0.50	0.50-1.00	1.00-2.00	2.00-3.00	>3.00
Damage Factor (%)	3	5	7	11	15	22

Source: National Water Resources Study, Malaysia, Sectoral Report Vol. 5.

Table 10 PRESENT FLOOD DAMAGE VALUE
(ASSUMED YEAR OF ASSETS: 1985)

(Unit: M$10^3)

Past Flood Event		Stretch No.	Houses/ Buildings	Public Facilities	Rubber	Oil Palm	Horti-culture	Other Crops	Indirect Damage	Total Damage
JOHOR	1969	1	2159.	648.	233.	84.	223.	0.	1004.	4351.
		2	245.	73.	63.	0.	114.	0.	148.	643.
		3	503.	151.	63.	0.	234.	0.	285.	1236.
		4	274.	82.	45.	49.	128.	13.	178.	769.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	453.	136.	0.	25.	35.	0.	195.	845.
		TOTAL	3634.	1090.	404.	159.	735.	13.	1810.	7844.
JOHOR	1979	1	1404.	421.	157.	56.	251.	0.	687.	2976.
		2	153.	46.	54.	0.	97.	0.	105.	454.
		3	352.	105.	55.	0.	223.	0.	221.	956.
		4	187.	56.	41.	22.	119.	7.	130.	562.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	293.	88.	0.	25.	28.	0.	130.	565.
		TOTAL	2388.	716.	307.	104.	718.	7.	1272.	5513.
JOHOR	1983	1	652.	196.	33.	0.	233.	0.	334.	1446.
		2	116.	35.	41.	0.	74.	0.	80.	347.
		3	339.	102.	50.	0.	216.	0.	212.	919.
		4	182.	55.	15.	0.	116.	0.	110.	477.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	1289.	387.	139.	0.	638.	0.	736.	3188.
JOHOR	1982	1	138.	41.	15.	0.	88.	0.	85.	367.
		2	53.	16.	6.	0.	34.	0.	33.	142.
		3	124.	37.	22.	0.	79.	0.	78.	339.
		4	124.	37.	12.	16.	79.	0.	80.	347.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	439.	132.	55.	16.	279.	0.	276.	1196.
JOHOR	1981	1	126.	38.	12.	0.	80.	0.	77.	333.
		2	39.	12.	0.	0.	25.	0.	23.	98.
		3	121.	36.	0.	0.	77.	0.	70.	305.
		4	104.	31.	7.	0.	66.	0.	63.	272.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	390.	117.	20.	0.	248.	0.	233.	1008.
JOHOR	1978	1	80.	24.	10.	0.	51.	0.	49.	214.
		2	10.	3.	0.	0.	6.	0.	6.	24.
		3	104.	31.	0.	0.	66.	0.	61.	262.
		4	92.	28.	3.	0.	59.	0.	54.	235.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	286.	86.	12.	0.	182.	0.	170.	736.
SKUDAI	1978	1	987.	296.	130.	35.	0.	0.	434.	1882.
		2	1314.	394.	90.	0.	157.	10.	589.	2554.
		3	2650.	795.	350.	95.	174.	0.	1219.	5283.
		4	262.	79.	150.	26.	0.	6.	157.	680.
		TOTAL	5213.	1564.	719.	156.	331.	16.	2400.	10399.
SKUDAI	1981	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	428.	128.	69.	0.	97.	0.	216.	938.
		3	1117.	335.	126.	59.	40.	0.	503.	2180.
		4	62.	19.	78.	0.	0.	0.	48.	206.
		TOTAL	1606.	482.	273.	59.	137.	0.	767.	3324.
SKUDAI	1979	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	269.	81.	32.	0.	51.	0.	130.	562.
		3	569.	171.	94.	0.	25.	0.	257.	1116.
		4	10.	3.	31.	0.	0.	0.	13.	57.
		TOTAL	848.	254.	157.	0.	75.	0.	400.	1735.
TEBRAU	1978	1	1517.	455.	50.	142.	0.	37.	660.	2860.
		2	147.	44.	177.	140.	74.	6.	177.	765.
		3	0.	0.	126.	31.	0.	4.	48.	210.
		TOTAL	1664.	499.	352.	312.	74.	48.	885.	3835.
TEBRAU	1982	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	16.	5.	31.	61.	12.	6.	39.	171.
		3	0.	0.	73.	0.	0.	4.	23.	100.
		TOTAL	16.	5.	104.	61.	12.	11.	63.	271.
BENUT	1969	1	49.	15.	2220.	0.	65.	359.	812.	3520.
		2	64.	19.	152.	0.	85.	0.	96.	415.
		3	683.	205.	530.	0.	160.	120.	509.	2207.
		TOTAL	795.	239.	2902.	0.	310.	480.	1417.	6142.
BENUT	1981	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	60.	18.	9.	0.	51.	0.	41.	180.
		3	143.	43.	0.	0.	120.	0.	92.	397.
		TOTAL	203.	61.	9.	0.	171.	0.	133.	577.
PONTIAN B.	1969	1	278.	83.	566.	46.	368.	44.	415.	1800.
		2	127.	38.	894.	0.	168.	355.	475.	2057.
		3	0.	0.	144.	17.	0.	4.	50.	215.
		4	199.	60.	124.	0.	263.	28.	202.	877.
		TOTAL	604.	181.	1729.	63.	799.	431.	1142.	4949.
PONTIAN B.	1978	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	0.	0.	0.	0.	0.	0.	0.	0.
		3	0.	0.	144.	17.	0.	4.	50.	215.
		4	280.	84.	113.	0.	236.	28.	222.	963.
		TOTAL	280.	84.	257.	17.	236.	32.	272.	1178.
PONTIAN K.	1969	1	88.	27.	1922.	0.	117.	393.	764.	3311.
PULAI	1969	1	6.	2.	0.	0.	8.	27.	13.	54.
		2	8.	2.	270.	0.	11.	0.	87.	379.
		TOTAL	14.	4.	270.	0.	18.	27.	100.	433.
PULAI	1978	1	3.	1.	0.	0.	5.	0.	3.	12.
		2	5.	1.	167.	0.	6.	27.	62.	268.
		TOTAL	8.	2.	167.	0.	11.	27.	65.	280.
SEDILI B.	1981	1	0.	0.	16.	15.	0.	0.	9.	40.
		2	44.	13.	0.	0.	28.	0.	25.	110.
		3	17.	5.	2.	0.	11.	0.	10.	45.
		4	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	61.	18.	18.	15.	38.	0.	45.	195.
SEDILI K.	1981	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	0.	0.	0.	0.	0.	0.	0.	0.

Table 11 FUTURE FLOOD DAMAGE VALUE (ASSUMED YEAR OF ASSETS: 2005)

(Unit: M$10^3)

Past Flood Event		Stretch No.	Houses/ Buildings	Public Facilities	Rubber	Oil Palm	Horti-culture	Other Crops	Indirect Damage	Total Damage
JOHOR	1969	1	7686.	2306.	139.	50.	233.	0.	3124.	13538.
		2	387.	116.	62.	0.	119.	0.	205.	890.
		3	796.	239.	62.	0.	245.	0.	402.	1744.
		4	434.	130.	45.	49.	134.	13.	242.	1047.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	1359.	408.	0.	24.	37.	0.	548.	2376.
		TOTAL	10662.	3199.	308.	123.	767.	13.	4522.	19594.
JOHOR	1979	1	4785.	1436.	88.	32.	262.	0.	1981.	8584.
		2	242.	73.	54.	0.	101.	0.	141.	610.
		3	557.	167.	54.	0.	233.	0.	303.	1315.
		4	296.	89.	41.	22.	124.	7.	174.	753.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	889.	267.	0.	24.	29.	0.	363.	1572.
		TOTAL	6768.	2031.	238.	78.	750.	7.	2961.	12833.
JOHOR	1983	1	1757.	527.	21.	0.	243.	0.	765.	3314.
		2	184.	55.	41.	0.	77.	0.	107.	465.
		3	537.	161.	49.	0.	225.	0.	292.	1264.
		4	288.	86.	15.	0.	121.	0.	153.	663.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	2767.	830.	127.	0.	666.	0.	1317.	5706.
JOHOR	1982	1	219.	66.	15.	0.	92.	0.	117.	508.
		2	84.	25.	6.	0.	35.	0.	45.	197.
		3	196.	59.	21.	0.	82.	0.	107.	465.
		4	196.	59.	12.	15.	82.	0.	109.	473.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	695.	208.	54.	15.	291.	0.	379.	1643.
JOHOR	1981	1	200.	60.	12.	0.	84.	0.	107.	462.
		2	61.	18.	0.	0.	26.	0.	32.	137.
		3	192.	58.	0.	0.	80.	0.	99.	429.
		4	165.	50.	7.	0.	69.	0.	87.	378.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	618.	185.	19.	0.	259.	0.	325.	1406.
JOHOR	1978	1	127.	38.	9.	0.	53.	0.	68.	295.
		2	15.	5.	0.	0.	6.	0.	8.	34.
		3	165.	50.	0.	0.	69.	0.	85.	369.
		4	146.	44.	3.	0.	61.	0.	76.	329.
		5	0.	0.	0.	0.	0.	0.	0.	0.
		6	0.	0.	0.	0.	0.	0.	0.	0.
		7	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	453.	136.	12.	0.	190.	0.	237.	1028.
SKUDAI	1978	1	3559.	1068.	75.	20.	0.	0.	1416.	6138.
		2	3632.	1090.	57.	0.	66.	6.	1455.	6305.
		3	11246.	3374.	34.	9.	73.	0.	4421.	19157.
		4	1394.	418.	101.	18.	0.	4.	580.	2514.
		TOTAL	19830.	5949.	267.	47.	139.	10.	7873.	34115.
SKUDAI	1981	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	1232.	370.	38.	0.	41.	0.	504.	2184.
		3	3421.	1026.	8.	4.	17.	0.	1343.	5819.
		4	329.	99.	56.	0.	0.	0.	145.	630.
		TOTAL	4983.	1495.	102.	4.	57.	0.	1992.	8633.
SKUDAI	1979	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	816.	245.	14.	0.	21.	0.	329.	1425.
		3	2003.	601.	5.	0.	10.	0.	786.	3405.
		4	51.	15.	28.	0.	0.	0.	28.	122.
		TOTAL	2870.	861.	47.	0.	32.	0.	1143.	4952.
TEBRAU	1978	1	5467.	1640.	14.	39.	0.	10.	2151.	9322.
		2	94.	28.	187.	148.	31.	7.	148.	642.
		3	0.	0.	126.	31.	0.	4.	48.	210.
		TOTAL	5561.	1668.	326.	218.	31.	22.	2348.	10173.
TEBRAU	1982	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	10.	3.	32.	63.	5.	7.	36.	156.
		3	0.	0.	73.	0.	0.	4.	23.	100.
		TOTAL	10.	3.	105.	63.	5.	11.	59.	257.
BENUT	1969	1	46.	14.	2226.	0.	40.	360.	806.	3493.
		2	60.	18.	152.	0.	53.	0.	85.	368.
		3	2326.	698.	506.	0.	99.	115.	1123.	4867.
		TOTAL	2432.	730.	2885.	0.	192.	475.	2014.	8728.
BENUT	1981	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	57.	17.	9.	0.	32.	0.	34.	149.
		3	134.	40.	0.	0.	75.	0.	75.	324.
		TOTAL	191.	57.	9.	0.	106.	0.	109.	473.
PONTIAN B.	1969	1	262.	78.	614.	49.	228.	47.	384.	1662.
		2	119.	36.	910.	0.	104.	362.	459.	1990.
		3	0.	0.	144.	17.	0.	4.	50.	215.
		4	187.	56.	131.	0.	163.	30.	170.	738.
		TOTAL	568.	170.	1799.	67.	496.	442.	1063.	4605.
PONTIAN B.	1978	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	0.	0.	0.	0.	0.	0.	0.	0.
		3	0.	0.	144.	17.	0.	4.	50.	215.
		4	263.	79.	118.	0.	146.	30.	191.	827.
		TOTAL	263.	79.	262.	17.	146.	34.	241.	1042.
PONTIAN K.	1969	1	83.	25.	1935.	0.	73.	396.	753.	3264.
PULAI	1969	1	5.	2.	0.	0.	5.	27.	12.	50.
		2	8.	2.	271.	0.	7.	0.	86.	375.
		TOTAL	13.	4.	271.	0.	11.	27.	98.	425.
PULAI	1978	1	3.	1.	0.	0.	3.	0.	2.	9.
		2	4.	1.	168.	0.	4.	27.	61.	265.
		TOTAL	8.	2.	168.	0.	7.	27.	63.	275.
SEDILI B.	1981	1	0.	0.	16.	15.	0.	0.	9.	40.
		2	69.	21.	0.	0.	29.	0.	36.	154.
		3	27.	8.	2.	0.	11.	0.	14.	63.
		4	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	96.	29.	18.	15.	40.	0.	59.	257.
SEDILI K.	1981	1	0.	0.	0.	0.	0.	0.	0.	0.
		2	0.	0.	0.	0.	0.	0.	0.	0.
		TOTAL	0.	0.	0.	0.	0.	0.	0.	0.

Table 12. FUTURE POPULATION AND NUMBER OF HOUSEHOLDS WITHIN PAST FLOOD AREA (AS OF 2005)

Past Flood Event	Stretch No.	Flood Area (ha)		Population (people)			Number of Households (nos)		
		Urban	Rural	Urban	Rural	Total	Urban	Rural	Total
JOHOR 1969	1	376.	151.	15928.	3773.	19701.	3005.	712.	3717.
	2	0.	77.	0.	1926.	1926.	0.	363.	363.
	3	0.	159.	0.	3955.	3955.	0.	746.	746.
	4	0.	87.	0.	2160.	2160.	0.	408.	408.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	67.	24.	2848.	599.	3446.	537.	113.	650.
	TOTAL	443.	498.	18776.	12413.	31189.	3543.	2342.	5885.
JOHOR 1979	1	308.	170.	13043.	4242.	17284.	2461.	800.	3261.
	2	0.	66.	0.	1639.	1639.	0.	309.	309.
	3	0.	151.	0.	3773.	3773.	0.	712.	712.
	4	0.	80.	0.	2004.	2004.	0.	378.	378.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	61.	19.	2572.	468.	3041.	485.	88.	574.
	TOTAL	368.	487.	15615.	12126.	27741.	2946.	2288.	5234.
JOHOR 1983	1	87.	158.	3694.	3929.	7623.	697.	741.	1438.
	2	0.	50.	0.	1249.	1249.	0.	236.	236.
	3	0.	146.	0.	3643.	3643.	0.	687.	687.
	4	0.	78.	0.	1952.	1952.	0.	368.	368.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	87.	432.	3694.	10773.	14467.	697.	2033.	2730.
JOHOR 1982	1	0.	60.	0.	1483.	1483.	0.	280.	280.
	2	0.	23.	0.	572.	572.	0.	108.	108.
	3	0.	53.	0.	1327.	1327.	0.	250.	250.
	4	0.	53.	0.	1327.	1327.	0.	250.	250.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	189.	0.	4710.	4710.	0.	889.	889.
JOHOR 1981	1	0.	54.	0.	1353.	1353.	0.	255.	255.
	2	0.	17.	0.	416.	416.	0.	79.	79.
	3	0.	52.	0.	1301.	1301.	0.	245.	245.
	4	0.	45.	0.	1119.	1119.	0.	211.	211.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	168.	0.	4190.	4190.	0.	790.	790.
JOHOR 1978	1	0.	34.	0.	859.	859.	0.	162.	162.
	2	0.	4.	0.	104.	104.	0.	20.	20.
	3	0.	45.	0.	1119.	1119.	0.	211.	211.
	4	0.	40.	0.	989.	989.	0.	187.	187.
	5	0.	0.	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	123.	0.	3071.	3071.	0.	579.	579.
SKUDAI 1978	1	314.	0.	12643.	0.	12643.	2073.	0.	2073.
	2	218.	43.	8757.	1308.	10065.	1436.	257.	1692.
	3	973.	47.	39173.	1449.	40622.	6422.	284.	6706.
	4	123.	0.	4952.	0.	4952.	812.	0.	812.
	TOTAL	1628.	90.	65525.	2757.	68282.	10742.	541.	11282.
SKUDAI 1981	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	160.	26.	6442.	808.	7250.	1056.	158.	1214.
	3	470.	11.	18922.	333.	19256.	3102.	65.	3167.
	4	46.	0.	1839.	0.	1839.	302.	0.	302.
	TOTAL	676.	37.	27203.	1141.	28345.	4460.	224.	4683.
SKUDAI 1979	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	108.	14.	4328.	423.	4751.	710.	83.	792.
	3	275.	7.	11072.	205.	11277.	1815.	40.	1855.
	4	7.	0.	283.	0.	283.	46.	0.	46.
	TOTAL	390.	21.	15682.	628.	16311.	2571.	123.	2694.
TEBRAU 1978	1	464.	0.	26026.	0.	26026.	5103.	0.	5103.
	2	0.	20.	0.	616.	616.	0.	121.	121.
	3	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	464.	20.	26026.	616.	26642.	5103.	121.	5224.
TEBRAU 1982	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	3.	0.	103.	103.	0.	20.	20.
	3	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	3.	0.	103.	103.	0.	20.	20.
BENUT 1969	1	0.	26.	0.	511.	511.	0.	91.	91.
	2	0.	34.	0.	669.	669.	0.	119.	119.
	3	307.	65.	12352.	1265.	13617.	2025.	226.	2251.
	TOTAL	307.	125.	12352.	2445.	14797.	2025.	437.	2462.
BENUT 1981	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	20.	0.	401.	401.	0.	72.	72.
	3	0.	48.	0.	949.	949.	0.	169.	169.
	TOTAL	0.	69.	0.	1350.	1350.	0.	241.	241.
PONTIAN B. 1969	1	0.	148.	0.	2908.	2908.	0.	519.	519.
	2	0.	68.	0.	1326.	1326.	0.	237.	237.
	3	0.	0.	0.	0.	0.	0.	0.	0.
	4	0.	106.	0.	2080.	2080.	0.	371.	371.
	TOTAL	0.	322.	0.	6314.	6314.	0.	1127.	1127.
PONTIAN B. 1978	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.	0.	0.
	3	0.	0.	0.	0.	0.	0.	0.	0.
	4	0.	95.	0.	1861.	1861.	0.	332.	332.
	TOTAL	0.	95.	0.	1861.	1861.	0.	332.	332.
PONTIAN K. 1969	1	0.	47.	0.	925.	925.	0.	165.	165.
PULAI 1969	1	0.	3.	0.	61.	61.	0.	11.	11.
	2	0.	4.	0.	85.	85.	0.	15.	15.
	TOTAL	0.	7.	0.	146.	146.	0.	26.	26.
PULAI 1978	1	0.	2.	0.	36.	36.	0.	7.	7.
	2	0.	2.	0.	49.	49.	0.	9.	9.
	TOTAL	0.	4.	0.	85.	85.	0.	15.	15.
SEDILI B. 1981	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	19.	0.	468.	468.	0.	88.	88.
	3	0.	7.	0.	182.	182.	0.	34.	34.
	4	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	26.	0.	651.	651.	0.	123.	123.
SEDILI K. 1981	1	0.	0.	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.	0.	0.
	TOTAL	0.	0.	0.	0.	0.	0.	0.	0.

Table 13. OCCURRENCE PROBABILITY OF PAST MAJOR FLOODS

River Basin	Flood Event	Return Period of Net Precipitation		Return Period of Max. Flood Discharge		Adopted Return Period (yr.)
		Precipitation (mm)	Return Period (yr.)	Discharge (m^3/s)	Return Period (yr.)	
Johor	Dec. '69	377	25.6	437	23.8	23.8
	Nov. '79	264	6.3	337	6.7	6.7
	Dec. '83	N.R.	-	312	4.6	4.6
	Dec. '82	243	4.3	296	4.2	4.2
	Dec. '81	228	3.6	279	3.6	3.6
	Dec. '78	202	2.6	244	2.6	2.6
Skudai	Dec. '78	349	33.3	N.R.	-	33.5
	Dec. '81	203	2.5	N.R.	-	2.5
	Nov. '79	177	2.0	N.R.	-	2.0
Tebrau	Dec. '78	349	33.3	N.R.	-	33.5
	Dec. '82	210	3.5	N.R.	-	3.5
Benut	Dec. '69	318	52.6	N.R.	-	52.6
	Dec. '81	212	5.9	N.R.	-	5.9
	Nov. '79	187	3.1	N.R.	-	3.1
Pontian Besar and Kechil	Dec. '69	436	50.0	N.R.	-	50.0
	Dec. '78	349	33.3	N.R.	-	33.3
	Dec. '82	210	3.5	N.R.	-	3.5
Pulai	Dec. '78	349	33.3	N.R.	-	33.5
	Dec. '82	212	3.5	N.R.	-	3.5
Sedili Besar and Kechil	Dec. '81	618	14.3	N.R.	-	14.3
	Dec. '78	470	6.7	N.R.	-	6.7
	Dec. '82	247	2.0	N.R.	-	2.0

NOTE: Flood discharges of the Johor River were observed at Rantan Panjang (catchment area: 1,130 km^2).

Table 14. PROBABLE FLOOD DAMAGE (ASSUMED YEAR OF ASSETS: 1985)

River Basin	Stretch No.	Flood Damage ($M\$10^3$/yr.) 5-Year Design Flood	10-Year Design Flood	20-Year Design Flood	30-Year Design Flood	50-Year Design Flood	Annual Average	People To Be Affected (person/yr.) 5-Year Design Flood	10-Year Design Flood	20-Year Design Flood	30-Year Design Flood	50-Year Design Flood	Annual Average
Johor	1	1,785	3,410	4,162	4,477	4,754	898	5,946	9,045	9,379	9,519	9,642	2,484
	2	371	514	617	660	698	155	1,279	1,656	1,806	1,868	1,924	500
	3	927	1,044	1,197	1,261	1,318	345	3,515	3,667	3,762	3,802	3,837	1,224
	4	496	628	741	788	830	197	1,879	1,965	2,047	2,081	2,111	658
	5	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0
	7	125	653	806	870	927	130	363	1,715	1,853	1,910	1,961	324
	Total	3,704	6,250	7,524	8,057	8,527	1,724	12,981	18,048	18,847	19,181	19,476	5,191
Skudai	1	0	0	0	1,795	2,041	67	0	0	0	5,068	5,761	189
	2	1,263	1,733	2,204	2,479	2,690	538	4,930	5,547	6,165	6,526	6,802	1,819
	3	2,803	3,707	4,610	5,139	5,544	1,162	11,028	12,788	14,548	15,578	16,366	4,156
	4	301	439	577	658	720	134	701	959	1,217	1,368	1,484	298
	Total	4,367	5,879	7,391	10,071	10,994	1,902	16,659	19,294	21,930	28,539	30,413	6,463
Tebrau	1	0	0	2,207	2,720	3,114	178	0	0	8,441	10,405	11,909	679
	2	265	447	629	736	818	132	438	814	1,189	1,409	1,577	236
	3	118	151	185	204	219	48	0	0	0	0	0	0
	Total	382	598	3,021	3,661	4,151	357	438	814	9,631	11,814	13,487	915
Benut	1	0	0	2,011	2,679	3,520	173	0	0	470	626	823	40
	2	0	238	314	359	415	41	0	753	893	975	1,078	119
	3	0	0	0	1,774	2,207	56	0	0	0	5,532	6,789	172
	Total	0	238	2,325	4,812	6,142	269	0	753	1,363	7,133	8,690	332
Pontian Besar	1	0	0	0	0	1,800	36	0	0	0	0	4,684	93
	2	0	0	0	0	2,057	41	0	0	0	0	2,136	42
	3	0	123	176	207	215	22	0	0	0	0	0	0
	4	0	551	788	927	877	95	0	1,716	2,455	2,888	3,352	309
	Total	0	674	964	1,134	4,949	193	0	1,716	2,455	2,888	10,172	444
Pontian Kechil	1	0	0	2,368	2,785	3,311	190	0	0	1,066	1,253	1,490	85
Pulai	1	4	7	10	11	54	3	19	34	48	57	98	11
	2	87	153	219	258	379	47	26	45	64	75	137	14
	Total	91	160	229	269	433	49	45	79	112	132	235	25
Sedili Besar	1	19	33	44	48	53	9	0	0	0	0	0	0
	2	51	90	119	130	145	25	209	367	487	533	591	104
	3	21	37	49	54	60	11	81	143	189	207	230	40
	4	0	0	0	0	0	0	0	0	0	0	0	0
	Total	91	160	212	232	257	45	290	510	676	740	821	144
Sedili Kechil	1	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total		8,635	13,959	24,036	31,022	38,765	4,730	30,413	41,214	56,080	71,680	84,784	13,599

Table 15. PROBABLE FLOOD DAMAGE (ASSUMED YEAR OF ASSETS: 2005)

River Basin	Stretch No.	Flood Damage (M$10³/yr.) 5-Year Design Flood	10-Year Design Flood	20-Year Design Flood	30-Year Design Flood	50-Year Design Flood	Annual Average	People To Be Affected (person/yr.) 5-Year Design Flood	10-Year Design Flood	20-Year Design Flood	30-Year Design Flood	50-Year Design Flood	Annual Average
Johor	1	4,482	10,149	12,858	13,990	14,988	2,548	9,765	18,048	19,370	19,922	20,409	4,592
	2	498	699	852	916	972	210	1,336	1,730	1,886	1,952	2,009	523
	3	1,276	1,450	1,685	1,783	1,869	478	3,672	3,831	3,930	3,972	4,009	1,279
	4	683	846	1,006	1,074	1,133	269	1,963	2,053	2,138	2,174	2,206	687
	5	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0
	7	349	1,826	2,265	2,449	2,611	363	674	3,169	3,391	3,483	3,565	597
	Total	7,287	14,969	18,666	20,212	21,574	3,867	17,410	28,830	30,716	31,503	32,198	7,678
Skudai	1	0	0	0	5,854	6,655	219	0	0	0	12,057	13,707	451
	2	3,012	4,212	5,412	6,114	6,652	1,302	7,815	8,635	9,455	9,934	10,302	2,847
	3	8,498	12,382	16,267	18,539	20,279	3,788	23,547	29,769	35,992	39,632	42,420	9,445
	4	1,008	1,557	2,106	2,427	2,673	470	2,464	3,371	4,277	4,808	5,214	1,048
	Total	12,518	18,151	23,785	32,934	36,259	5,778	33,826	41,775	49,724	66,431	71,642	13,790
Tebrau	1	0	0	7,193	8,866	10,148	579	0	0	20,083	24,755	28,333	1,616
	2	233	382	531	618	685	114	184	341	498	591	661	99
	3	118	151	185	204	219	48	0	0	0	0	0	0
	Total	351	533	7,909	9,689	11,052	740	184	341	20,581	25,345	28,994	1,715
Benut	1	0	0	1,995	2,658	3,493	172	0	0	292	389	511	25
	2	0	203	274	316	368	35	0	468	554	605	669	74
	3	0	0	0	3,781	4,867	122	0	0	0	10,589	13,617	342
	Total	0	203	2,269	6,755	8,728	329	0	468	846	11,583	14,797	441
Pontian Besar	1	0	0	0	0	1,662	33	0	0	0	0	2,908	57
	2	0	0	0	0	1,990	39	0	0	0	0	1,326	26
	3	0	123	176	207	215	22	0	0	0	0	0	0
	4	0	473	677	796	738	82	0	1,065	1,524	1,792	2,080	192
	Total	0	597	853	1,004	4,605	176	0	1,065	1,524	1,792	6,314	276
Pontian Kechil	1	0	0	2,335	2,746	3,264	187	0	0	661	778	925	53
Pulai	1	3	5	8	9	50	2	12	21	30	35	61	7
	2	86	152	217	255	375	46	16	28	40	47	85	9
	Total	89	157	225	264	425	49	28	49	70	82	146	15
Sedili Besar	1	19	33	44	48	53	9	0	0	0	0	0	0
	2	72	126	168	183	204	36	218	383	508	557	617	109
	3	29	51	68	75	83	15	85	149	198	216	240	42
	4	0	0	0	0	0	0	0	0	0	0	0	0
	Total	120	210	279	306	339	60	303	532	706	773	858	151
Sedili Kechil	1	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total		20,365	34,821	56,322	73,909	86,247	11,185	51,751	73,060	104,828	138,287	155,873	24,119

Table 16. HYDRAULIC DIMENSIONS OF DESIGNED RIVER CHANNEL

River Basin	Stretch No.	River Bed Gradient	Typical Cross Section (m) 5-Year Design Flood				10-Year Design Flood				20-Year Design Flood				30-Year Design Flood				50-Year Design Flood			
			B1	H1	H2	B2	B1	H1	H2	B2	B1	H1	H2	B2	B1	H1	H2	B2	B1	H1	H2	B2
(1) WITHOUT FLOOD CONTROL DAM																						
Johor	1	1:4300	54.5	5.5	0.0	0.0	62.0	5.5	0.0	0.0	69.0	6.0	0.0	0.0	69.0	6.5	0.0	0.0	69.0	7.0	0.0	0.0
	2	1:4300	50.0	4.0	1.5	10.0	50.0	4.0	2.0	3.0	50.0	4.0	3.0	3.0	50.0	4.0	3.0	3.0	50.0	4.0	3.5	4.0
	3	1:4000	45.0	3.5	1.5	10.0	45.0	3.5	2.0	6.0	45.0	3.5	3.0	6.0	45.0	3.5	3.0	7.0	45.0	3.5	3.5	7.0
	4	1:3600	40.0	3.0	1.5	10.0	40.0	3.0	2.0	6.0	40.0	3.0	3.0	6.0	40.0	3.0	3.5	7.0	40.0	3.0	3.5	20.0
	5	1:2500	25.0	2.8	1.5	15.0	25.0	2.8	2.0	15.0	25.0	2.8	2.5	15.0	25.0	2.8	3.5	15.0	25.0	2.8	3.5	20.0
	6	1:2500	34.0	3.5	0.0	0.0	15.0	2.5	2.0	20.0	15.0	2.5	2.5	20.0	15.0	2.5	3.0	20.0	15.0	2.5	3.5	20.0
	7	1:1000	18.0	2.5	0.0	0.0	22.5	2.5	0.0	0.0	10.0	2.5	1.2	20.0	10.0	2.5	1.5	20.0	10.0	2.5	2.0	20.0
Skudai	1	1:1500	<— Improved —>												36.6	3.2	2.0	13.0	36.6	3.2	2.5	13.0
	2	1:1200	23.0	2.5	0.0	0.0	23.0	3.0	0.0	0.0	25.0	2.0	1.3	10.0	25.0	2.0	1.5	13.0	25.0	2.0	2.0	15.0
	3	1:1000	20.0	2.5	0.0	0.0	20.0	3.0	0.0	0.0	20.0	2.0	1.3	10.0	20.0	2.0	1.5	13.0	20.0	2.0	2.0	15.0
	4	1:1000	16.0	2.0	0.0	0.0	16.0	2.5	0.0	0.0	16.0	3.0	0.0	0.0	16.5	3.5	0.0	0.0	15.0	2.0	1.5	15.0
Tebrau	1	1:1500	<— Improved —>								38.0	3.0	0.0	0.0	38.0	2.5	1.0	4.5	38.0	3.0	1.0	4.5
	2	1:1300	22.0	2.0	0.0	0.0	39.0	2.0	0.0	0.0	33.0	2.5	0.0	0.0	33.0	3.0	0.0	0.0	33.0	2.5	1.0	4.5
	3	1:1000	13.0	2.0	0.0	0.0	16.0	2.0	0.0	0.0	31.0	2.0	0.0	0.0	31.0	2.5	0.0	0.0	31.0	2.0	1.0	4.5
Benut	1	1:5822	<— Improved —>				27.4	3.2	2.0	5.0	27.4	3.2	3.0	5.0	27.4	3.2	3.5	5.0	27.4	3.2	4.2	5.0
	2	1:1409	<— Improved —>				16.0	4.2	0.0	0.0	18.3	2.7	2.0	5.0	18.3	2.7	2.5	5.0	18.3	2.7	3.0	5.0
	3	1:1409	<— Improved —>				10.6	3.9	0.0	0.0	15.0	4.4	0.0	0.0	12.2	2.4	2.5	5.0	12.2	2.4	3.0	5.0
Pontian Besar	1	1:20000	<— Improved —>				36.6	3.8	2.2	8.0	36.6	3.8	3.3	9.0	36.6	3.8	4.0	11.0	36.6	3.8	5.0	9.0
	2	1:20000	<— Improved —>				36.6	3.8	2.2	8.0	36.6	3.8	3.2	9.0	36.6	3.8	4.0	8.0	36.6	3.8	4.8	9.0
	3	1:2000	<— Improved —>				30.0	3.0	0.0	0.0	24.4	2.0	1.7	12.0	24.4	2.0	2.3	8.0	24.4	2.0	2.6	11.0
	4	1:758	12.3	1.9	0.0	0.0	13.7	2.0	0.0	0.0	24.0	2.0	0.0	0.0	37.5	2.0	0.0	0.0	12.2	1.0	2.5	11.0
Pontian Kechil	1	1:7900	<— Improved —>								12.1	6.1	0.0	0.0	15.0	6.6	0.0	0.0	15.2	3.6	3.3	5.0
Pulai	1	1:3000	8.0	4.0	0.0	0.0	12.0	4.0	0.0	0.0	18.0	4.5	0.0	0.0	20.0	3.0	1.7	4.2	25.0	3.0	2.0	2.5
	2	1:3000	8.0	4.0	0.0	0.0	12.0	4.0	0.0	0.0	18.0	4.5	0.0	0.0	20.0	3.0	1.7	4.2	25.0	3.0	2.0	2.5
Sedili Besar	1	1:15000	70.0	5.0	1.0	4.0	70.0	5.0	1.4	10.2	70.0	5.0	2.3	13.4	70.0	5.0	2.7	24.0	70.0	5.0	3.0	35.0
	2	1:15000	45.0	3.0	3.6	4.0	45.0	3.0	4.0	5.5	45.0	3.0	5.0	7.7	45.0	3.0	5.5	21.0	45.0	3.0	6.0	13.0
	3	1:10000	30.0	2.5	3.9	4.0	30.0	2.5	4.5	5.0	30.0	2.5	5.5	7.0	30.0	2.5	6.0	9.0	30.0	2.5	6.5	10.4
	4	1:15000	22.0	2.0	5.0	4.0	22.0	2.0	5.5	4.0	22.0	2.0	6.5	7.0	22.0	2.0	7.5	5.0	22.0	2.0	8.0	7.8
Sedili Kechil	1	1:15000	17.1	6.0	0.0	0.0	21.1	6.0	0.0	0.0	20.0	2.0	5.0	3.0	20.0	2.0	6.0	5.9	20.0	2.0	6.0	10.6
	2	1:7000	15.5	4.0	0.0	0.0	20.8	4.0	0.0	0.0	24.0	5.0	0.0	0.0	15.0	1.5	4.5	2.9	15.0	1.5	5.0	6.8
(2) WITH FLOOD CONTROL DAM																						
Johor	1	1:4000	54.0	5.0	0.0	0.0	54.0	5.5	0.0	0.0	57.0	5.5	0.0	0.0	65.0	5.5	0.0	0.0	65.0	6.0	0.0	0.0
	2	1:4000	45.0	4.0	1.5	10.0	45.0	4.0	1.5	10.0	50.0	4.0	1.7	10.0	50.0	4.0	2.0	4.0	50.0	4.0	2.5	3.0
	3	1:4000	40.0	3.5	1.5	10.0	40.0	3.5	1.5	10.0	45.0	3.5	1.7	10.0	45.0	3.5	2.0	6.0	45.0	3.5	2.5	6.0
	4	1:3600	40.0	2.5	1.0	10.0	40.0	3.0	1.0	10.0	40.0	3.0	1.3	10.0	40.0	3.0	1.5	10.0	40.0	3.3	1.5	10.0

NOTE: B1: Riverbed width
H1: Channel depth of a single cross section and low water channel depth of a double cross section
H2: Highwater channel depth
B2: Width of highwater channel bed

Table 17. RECONSTRUCTION OF BRIDGE REQUIRED FOR RIVER CHANNEL IMPROVEMENT

River Basin	Stretch No.	Number of Bridges			Length of Bridge (m)				
		Main Road	2nd. Road	Rail-way	5-year Design Flood	10-year Design Flood	20-year Design Flood	30-year Design Flood	50-year Design Flood
Johor	1	1	-	-	100 (100)	110 (105)	115 (110)	120 (120)	120 (120)
	6	-	1	-	70	105	110	115	120
	7	-	1	-	50	55	91	95	100
Skudai	1	1	-	-	-	-	-	115	120
	2	-	3	1	42	60	85	95	100
	3	1	2	-	40	55	80	90	100
	4	-	1	-	30	45	50	50	90
Tebrau	1	1	1	-	-	-	75	85	90
	2	-	2	-	55	60	70	70	80
	3	-	2	-	45	45	60	65	75
Benut	3	-	2	-	45	45	55	60	70
Pontian Besar	1	1	-	-	-	110	125	135	140
	2	-	1	-	-	110	125	130	140
Pontian Besar	1	1	4	-	-	-	70	80	95
Pulai	1	-	1	-	55	60	65	80	85
	2	-	1	-	55	60	65	80	85
Sedili Besar	4	-	2	-	100	105	120	125	125

NOTE: Figures in parentheses are bridge lengths required for the river channel improvement with the flood control dams in the upper reaches.

Table 18. RELOCATION OF HOUSES REQUIRED FOR RIVER CHANNEL IMPROVEMENT

(Unit : house)

River Basin	Stretch No.	Number of Houses To Be Relocated				
		5-year Design Flood	10-year Design Flood	20-year Design Flood	30-year Design Flood	50-year Design Flood
Johor	1	0 (0)	0 (0)	2 (0)	4 (2)	4 (2)
Skudai	1	0	0	0	0	10
Tebran	1	0	0	0	10	20

NOTE: Figures in parentheses are number of houses to be relocated due to the river channel improvement with the flood control dams in the upper reaches.

Table 19. LAND ACQUISITION AREA REQUIRED FOR RIVER CHANNEL IMPROVEMENT

(Unit : ha)

River Basin	Stretch No.	Farming Area To Be Acquired				
		5-year Design Flood	10-year Design Flood	20-year Design Flood	30-year Design Flood	50-year Design Flood
Johor	2	2.9 (0)	3.6 (0)	3.6 (3.6)	3.6 (3.6)	4.1 (3.6)
Johor	4	15.1 (5.3)	16.3 (10.7)	18.9 (13.2)	21.5 (15.1)	31.3 (15.5)
Skudai	2	8.6	10.5	22.9	26.9	30.9
Skudai	3	20.5	22.3	46.5	53.9	62.3
Skudai	4	13.8	14.8	23.2	30.0	60.4
Tebrau	1	0	0	1.0	7.2	10.0
Tebrau	2	10.3	13.8	18.3	19.1	23.8
Tebrau	3	10.2	12.1	21.4	22.3	28.5
Benut	1	0	0	14.2	19.0	23.8
Benut	2	0	0	3.2	8.5	11.2
Benut	3	0	0	0	18.3	22.5
Pontian Besar	1	0	2.6	12.3	20.6	25.1
Pontian Besar	2	0	3.0	13.4	18.6	27.3
Pontian Besar	4	0	0	0	2.7	5.8
Pontian Kechil	1	0	0	6.0	12.4	23.1
Pulai	1	2.9	3.3	4.1	5.3	5.7
Pulai	2	3.7	4.1	5.2	6.7	7.3

NOTE: Figures in parentheses are areas to be acquired for the river channel improvement with the flood control dams in the upper reaches.