THE GOVERNMENT OF MALAYSIA

REGIONAL STUDY ON THE INTEGRATED DEVELOPMENT OF SOUTH TERENGGANU

VOLUME 2

PREFEASIBILITY STUDY FOR THE DRAINAGE OF CUKAI TOWN AREA

AUGUST 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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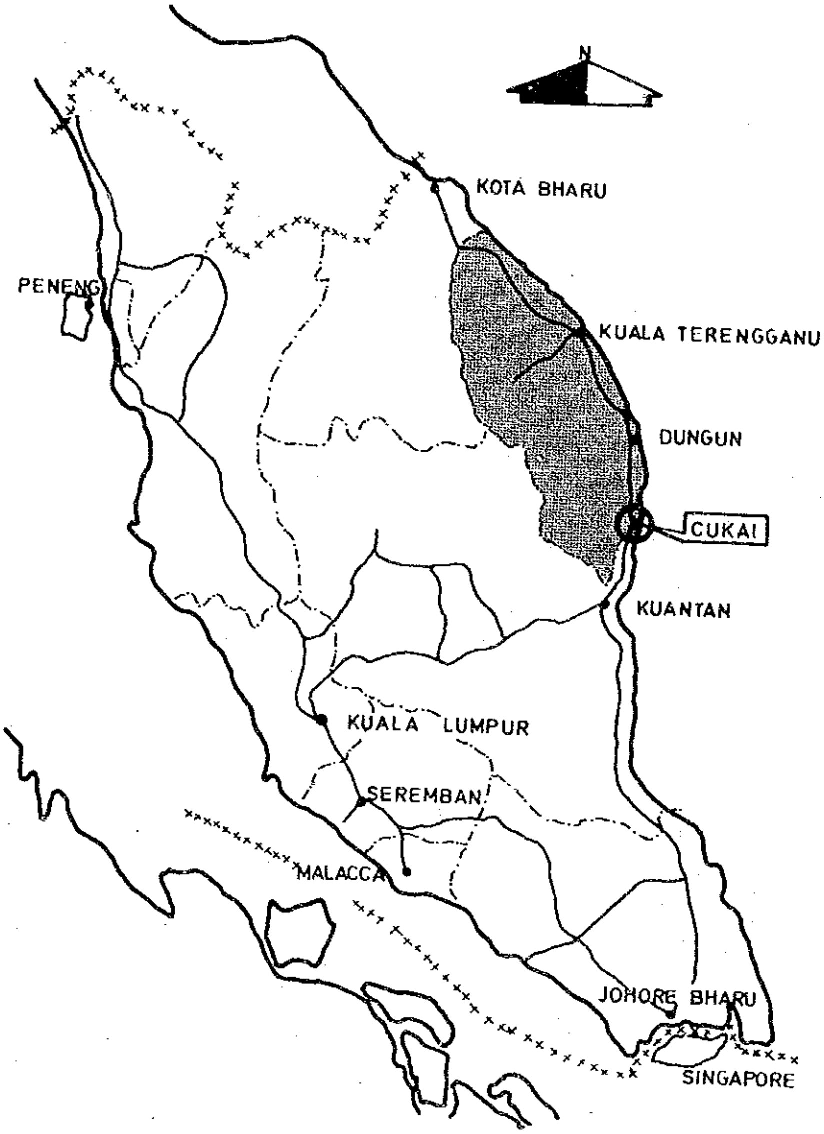

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GLOSSARY

1. Organisations:

DID	–	Drainage and Irrigation Department
EPU	–	Economic Planning Unit, Prime Minister's Department
JICA	–	Japan International Cooperation Agency
JKR	–	Jabatan Kerja Raya
KETENGAH	–	Lembaga Kemajuan Terengganu Tengah
SEDC	–	State Economic Development Corporation

2. Studies:

MWRSM: National Water Resources Study, Malaysia, 1982, Government of Malaysia and JICA.

SCTWR: Water Resources Development For Domestic And Industrial Water Uses In The South Terengganu Region, 1981, EPU and Binnie Dan Rakan (M), SMEC and SGV-Kassim Chunsdan Bhd. (South Coastal Terengganu Water Resources)

TCRS: Terengganu Coastal Region Study, 1980, Australian Development Assistance Bureau, The Government of Malaysia And The State Government of Terengganu.

TMPS: Terengganu Master Plan Study, 1983, The Government of Malaysia, The State Government of Terengganu and SYSPLAN.

3. General

B	–	Benefit
BOD	–	Biochemical Oxygen Demand
C	–	Cost
cm	–	centimetre
COD	–	Chemical Oxygen Demand
EIRR	–	Economic Internal Rate of Return
El	–	Elevation above mean sea level
Fig	–	Figure
GDP	–	Gross Domestic Product
G.L	–	Ground Level

GNP	–	Gross National Product
ha	–	hectare
hr	–	hour
HWL	–	High Water Level
Kg.	–	Kampung
km	–	kilometre
km^2	–	sq.km = square kilometre
LWL	–	Low Water Level
m	–	metre
m^3	–	cu.m = cubic metre
m^3/s	–	cubic metre per second
mm	–	millimetre
mgd	–	Million Gallones per Day
Mg/l	–	Milligrams per litre
min	–	minute
m/s	–	Metre per Second
M$	–	Malaysian Ringgit
MSL	–	Mean Sea Level
s	–	second
Sg.	–	Sungai = River
SS	–	Suspended Solids
%	–	percent

Flood Frequency is usually exprssed as "N-year flood" that is, the flood which will, over a long period of time, be equaled or exceeded on the average once every N years.

In this report the Flood Frequency is described as percentages. It means 10 years flood is expressed as 10% and 50 years flood is 2% flood.

1. INTRODUCTION

Cukai has suffered many floods in its history those of 1972 and 1983 being the most recent and best recorded. These floods were extensive and lasted a lengthy period. The disruption caused by the 1983 was greater than that of 1972 because in the intervening time the town had developed significantly, even though the 1972 flood was deeper than that of 1983.

In this back ground follwing two theme has developed.

i) There is a shortage of flood free land

ii) Development is taking place on flood-prone land

As a result of this study the theme has been revised

i) There is NO shortage of flood free land

ii) Development CAN take place on flood free land

2. EXISTING SITUATION

i) Development is now taking place on flood prone land due to insufficient flood free land (Fig. 1 and Fig. 2).

ii) Existing town area above river flood level incurs flooding due to inadequate surface water drainage

iii) Recent developments do not consider flood control or drainage measures

Summary: The necessity for flood control works and urban surface water drainage has become the most important factor for development in the Cukai region.

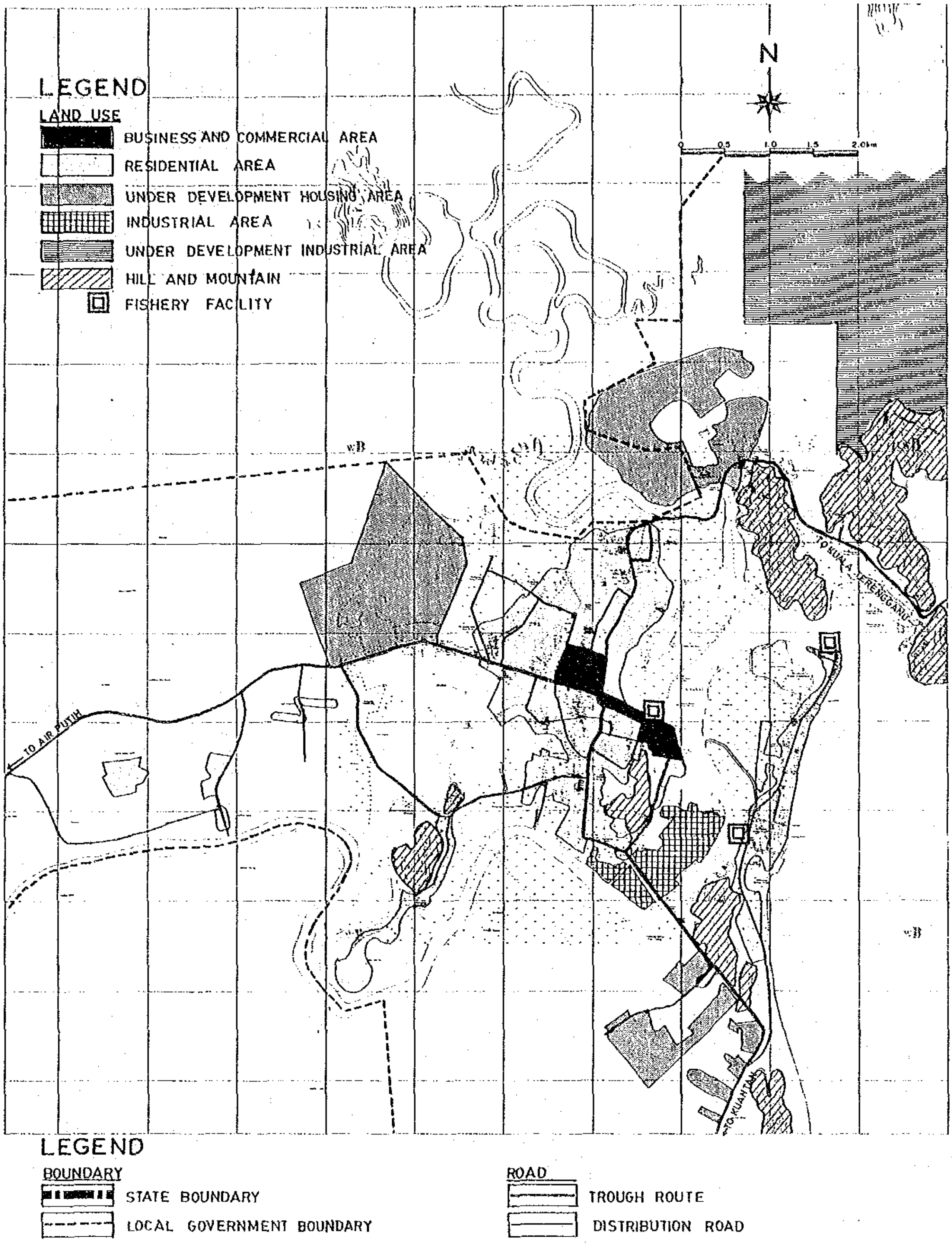
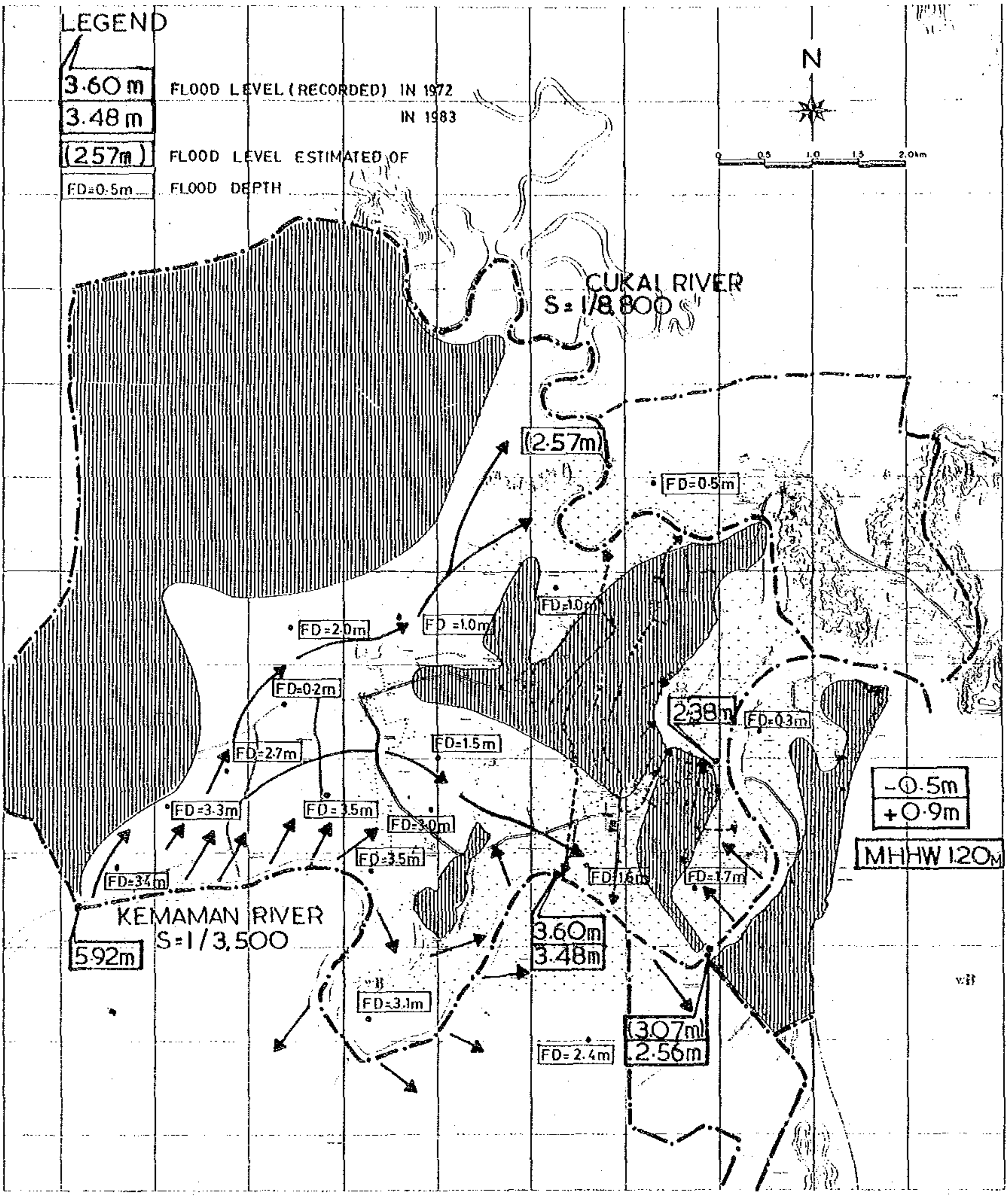


Fig. 1 PRESENT DEVELOPMENT CONDITION



LEGEND

- DRAINAGE AREA BOUNDARY
- EXISTING MAIN DRAINAGE CHANNEL
- FLOW OF FLOOD WATER
- NON FLOOD AREA

Note: 1/ Data for Tide is Tide Table of TG. GELANG
2/ Data of Water Surface Slope of Cukai River is FL=+2.0m (the junction of Kemaman River) and FL=+5.0m (180K bridge, 26.4km from the junction) in 1983
3/ Data of Water Surface Slope of Kemaman River is FL=+2.38m (3.3km upstream of the river mouth) and FL=+5.92m (15.7km upstream of the river mouth) in 1972

Fig. 2 EXISTING FLOOD MECHANISM

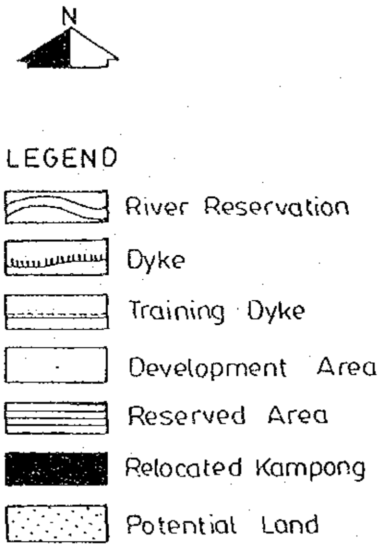
3. ALTERNATIVE PROPOSALS

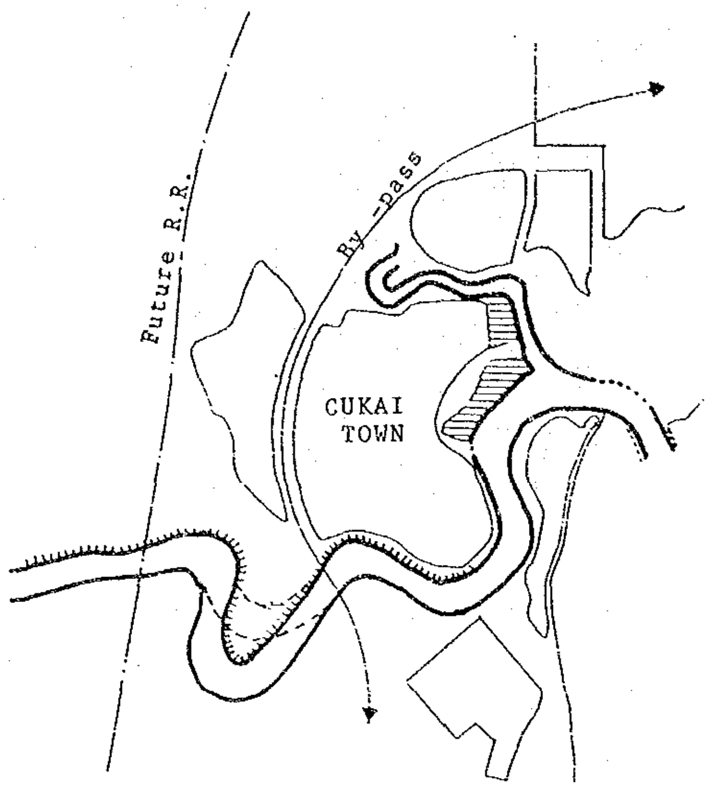
Two basic schemes were prepared, alternatives 1 and 2 and one variation of each 4 and 3 respectively. One urban surface water drainage scheme was prepared with different outlet conditions for each flood control alternatives. (Fig. 3)

Each alternative was examine from the aspects of flood control, drainage and landuse. Each was examined with the same constant factors. It was determined that each alternative must be considered as a whole package and cannot be broken down into stage packaging.

Summary: This is presented in Table 10.1 which shows costs, and the relative advantages and disadvantages of each alternative. As these consideration factors have not been weighted no numerical basis has been used to recommend one alternative over another.

The clear advantage of Alternative 3 must make this the logical scheme to be examined in more detail. ner

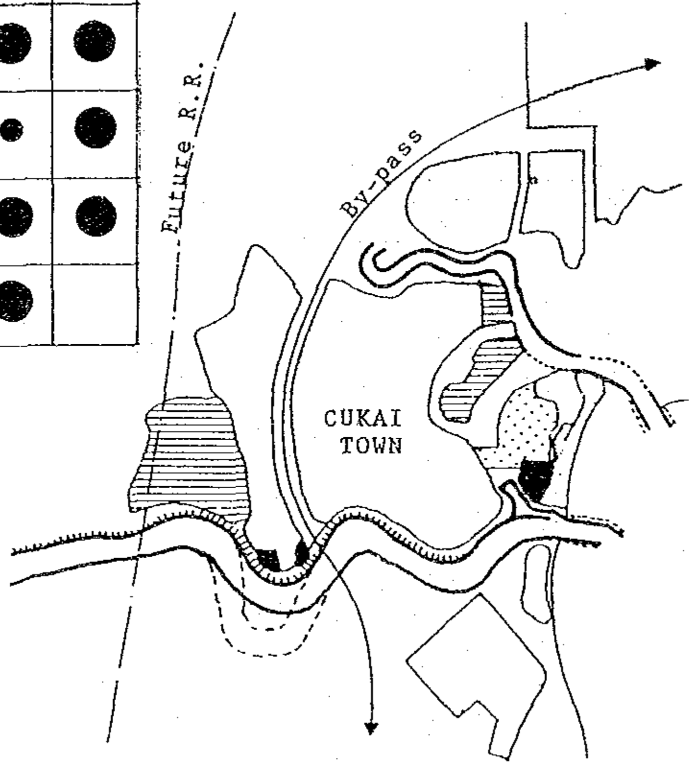




COMPONENT OF ALTERNATIVE

DESCRIPTION OF COMPONENT	ALTERNATIVES			
	1	2	3	4
WIDENING THE RIVER RESERVATION AND DYKE CONSTRUCTION	●	●	●	●
RIVER MOUTH IMPROVEMENT	●	•	•	●
SHORT-CUT			●	●
DIVERSION CHANNEL		●	●	

ALTERNATIVE-1



ALTERNATIVE-3

Fig. 3 ALTERNATIVES

Table 10.1 Comparison of Alternatives

ITEM			ALTERNATIVE	WITHOUT PROJECT	ALT. 1	ALT. 2	ALT. 3	ALT. 4
Flood Level of Kemaman River at 14KM (MSL, M)		10% Flood (10-Year Flood)		5.3	5.0	4.3	3.8	4.5
		2% Flood (50-Year Flood)		6.9	6.3	5.5	5.0	5.8
Total Construction Cost (10^6 M$)		(Flood Control, Drainage, Land Filling, Bridge Reconstruction, Kg. Relocation etc.)		–	(181)	(193)	(180)	(178)
Advantages	Potential Flood Damage (Year 2000 Conditions, 10^6 M$)		10% Flood	(37.8)	(8.6)	(5.1)	(5.1)	(7.6)
			2% Flood	(70.3)	(32.7)	(27.5)	(27.5)	(33.2)
	Possibility of New Town Centre	Potential Land Area (HA)		–	–	62	62	–
		Land Value Increase (10^6 M$)		–	–	(89)	(89)	–
	Expected Land Value Change	Flood Free Area (HA) <Area Increased>		–	1364 <877>	1324 <837>	1374 <887>	1364 <877>
		Land Value Increase (10^6 M$) Min.		–	(114)	(109)	(115)	(114)
	Possibility of Urban Sructure			△	△	○	◎	△
	Possibility of New Small Craft Harbour			–	–	○	○	–
	Support for Industrial Development			×	○	○	○	○
	Image of Cukai Town			×	○	◎	◎	○
	Effects on Socio-Economic Activity			×	○	○	○	○
	Stabilization of Living People			×	○	○	○	○
Dis-Advantages	River Navigation (Because of Barrage)			–	△	△	△	△
	Difficulty in Kampong Relocation			–	△	○	△	×
	Possibility of Refects on Sand Dlift of Neighboring Coast			–	△	△	△	△
EIRR (Flood Damage Saving Only)				–	6.0	6.5	7.2	6.2
Overall Evaluation				×	△	○	◎	△

Source: Study Team

LEGEND ◎ Very Good ○ Good, △ Fair × Poor

4. CONCLUSIONS

4.1 Selection of Alternatives

i) Based on the conclusions of the study, Alternative 3 is recommended for the flood control works project together with the urban stormwater drainage scheme and outlet works compatible with Alternative 3.

ii) The reasons for selection are:

- Mimimizes flood damage
- Lowers flood levels of the river:
  diversion and dredging 1.1 metres and shortcut and dredging 0.4 metres
- Reduced land filling by development of approximately 15 $\times 10^6$ cu. metres
- Pumping stations are avoided
- Increases land use potential area 62 (ha) and incremental land value (M\$ 89×10^6)
- Enhances urban structure with new town centre.
- Potential for improving fishing industry
- Promotes image formation
- Supports industrial development

Fig. 4 shows the drainage system of Alternative 3, and Fig. 5 shows the future land-use in case of Alternative 3 carried out.

4.2 Proviso

Should kampung relocation become difficult, Alternative 1 is the second recommentation. However this still involves the relocation of Kampung Kulala Kemaman and has less flood control effects.

4.3 Upstream of Study Area

This study was restricted to the downstream area of both rivers, and flood control works are designed for stable upstream conditions.

i) Development of upstream floodfree areas must consider the ffects of increase of sediment inflow and flood discharge.

ii) Trunk drain discharges from Telok Kalong area should be into the nearest to mouth of Cukai River or otherwise must be held in retention ponds.

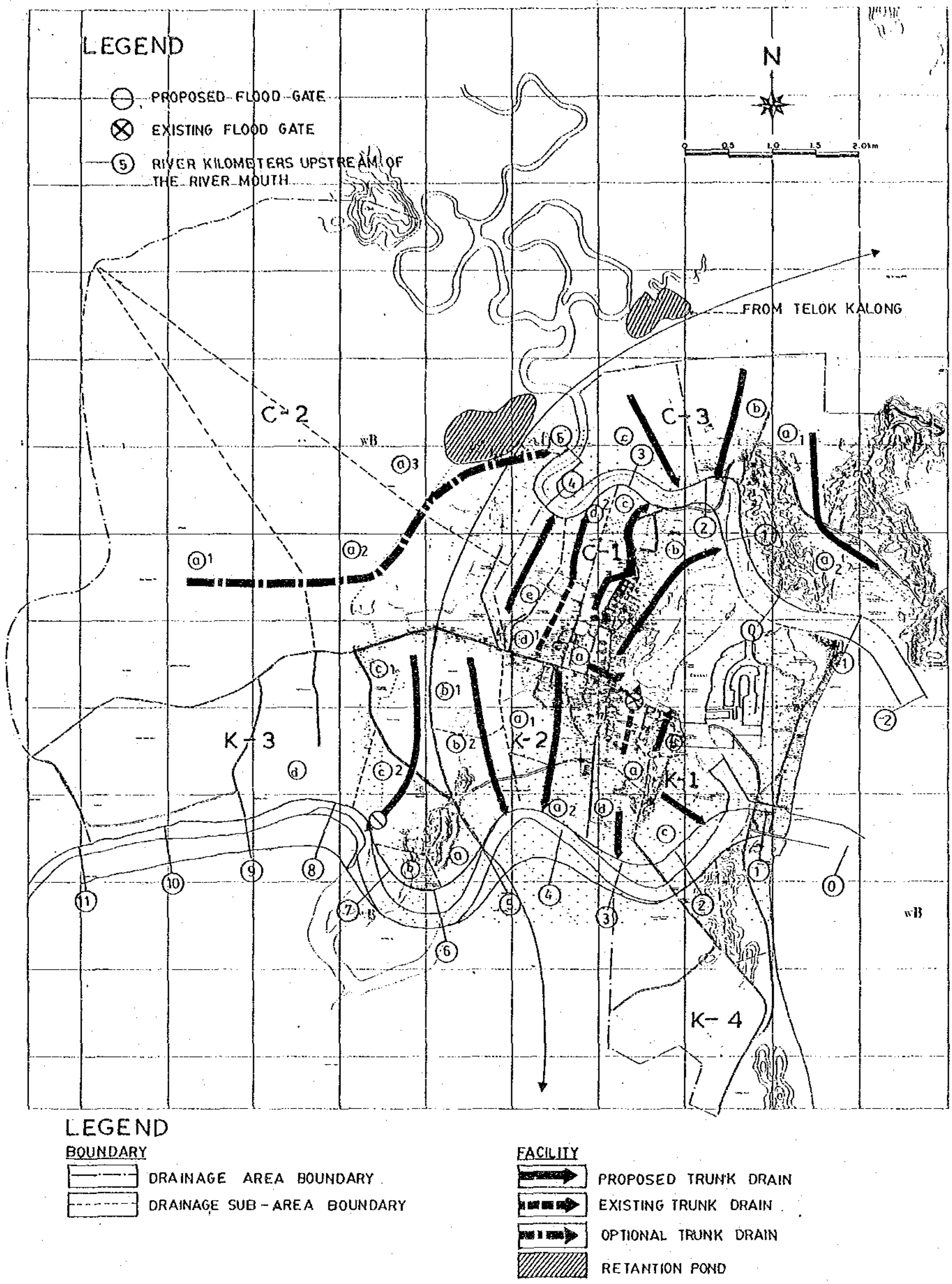


Fig. 4 DRAINAGE SYSTEM (ALTERNATIVE–3)

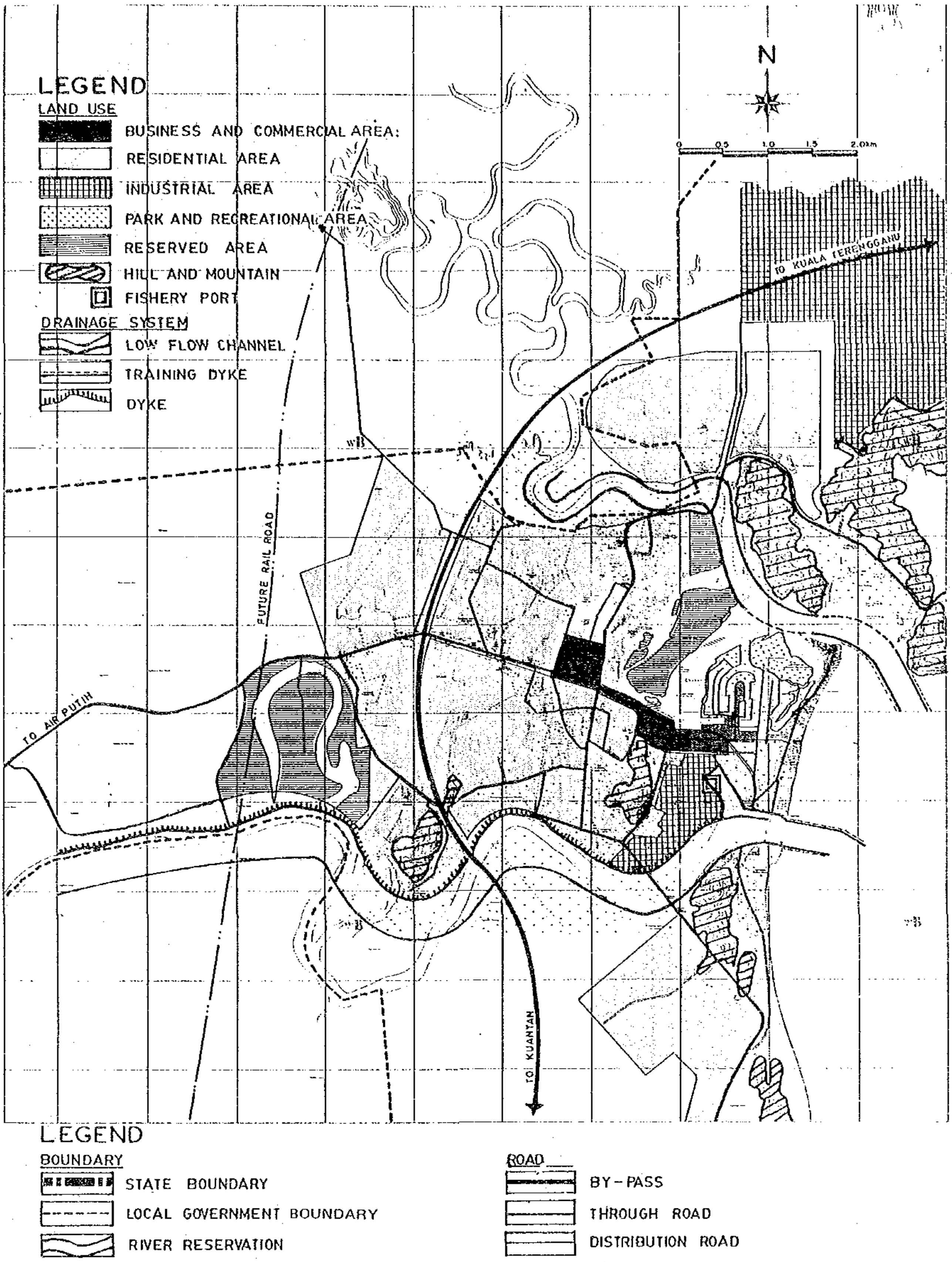
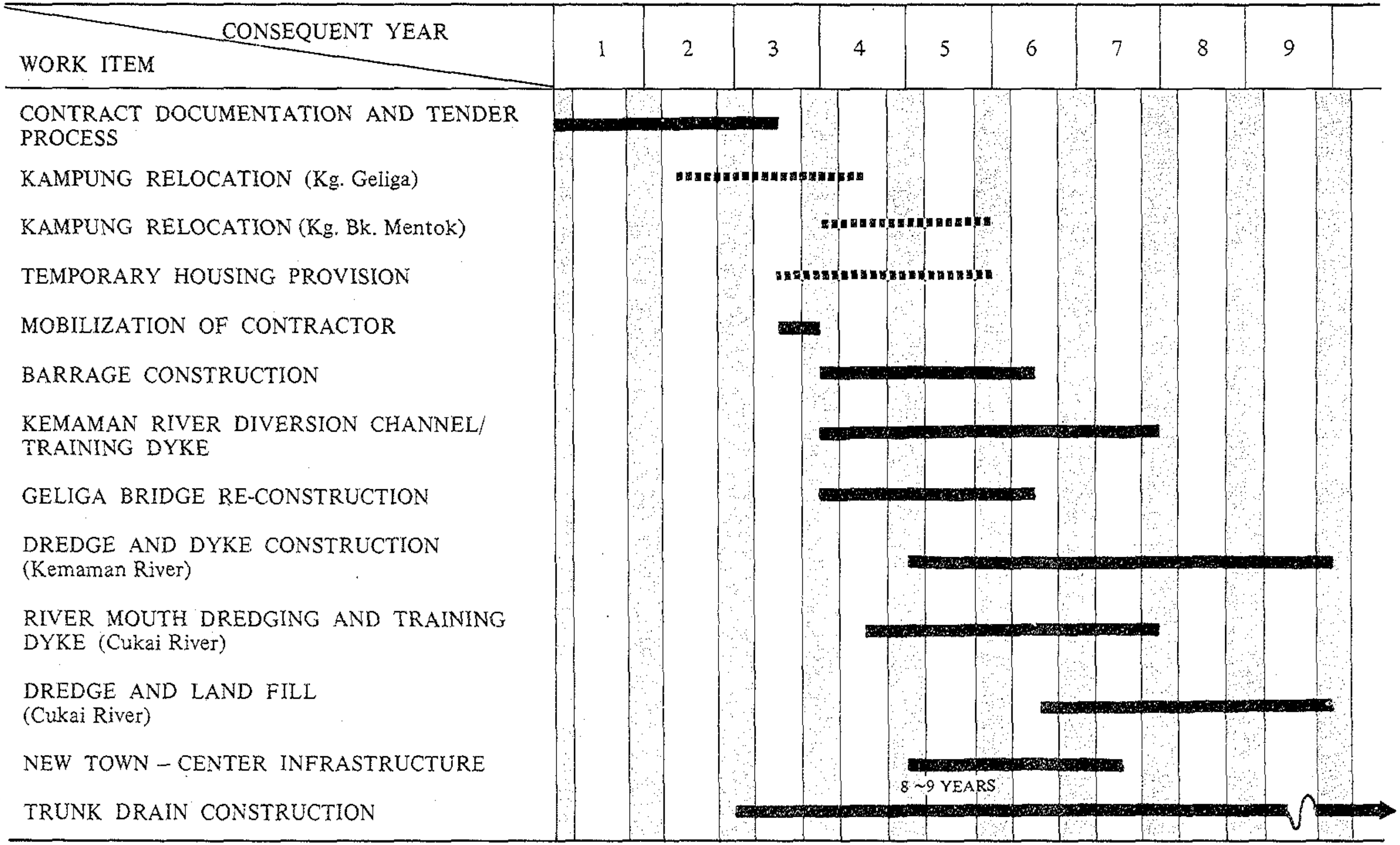


Fig. 5 FUTURE LANDUSE (ALTERNATIVE–3)

4.4 Integrity

No component part of the flood control works shll be taken out of the alternative to be performed alone or a differing sequence. Each alternative is designed as a linked unit, and to remove a link destroys the integrity of the design and prevents the achievement of the objectives.

Proposed implementation schedule for Alternative 3 is shown in Fig. 6.



Note: ▪▪▪▪▪▪▪▪ Indicating the work executed by direct involvement of the Government
[shaded box] Indicating "Monsoon season" period

Fig. 6 FLOOD CONTROL AND DRAINAGE PROJECT IMPLEMENTATION SCHEDULE ALTERNATIVE – 3

1.1 BACKGROUND

Development policies of the Terengganu State emphasizes the growth and distribution of its regional economy. In this context a number of industrial projects have been implemented in the Cukai town area resulting in a rapid growth or urbanization. Under these circumstances the regional study on the South Terengganu in Phase II was conducted in order to find priority projects within the framework of the recommended strategies.

The regional study recommended that Cukai town should be developed as a core town of the area accompanying urbanization and industrialization. Accordingly, improvement of the infrastructure becomes mandatory in order to provide adequate amenities. The road system has been improving and will be improved in the coming Fifth Plan period. Water supply, electricity, telecommunication are also in similar positions . However no actions against flooding have been conducted.

The area is easily flooded during the monsoon season, and in 1972 the town area suffered a heavy flood. This raised the necessity for a study and development of counter-measures, however, no substantial investment for improvement has been made. In 1983 another heavy flood caused much damage and inconvenience because during those eleven years there had been a number of developments and urbanization along the rivers. The flooding is mostly caused by overflowing of the Kemaman River, where the flood flow velocity is not large and the flood duration is rather long.

It is recognized there is necessity to prepare a plan which would mitigate the damages and inconveniences caused by flood. Implementation of the plan is a prerequisite for the development of the town.

1.2 STUDY OBJECTIVES

The objectives of the study is the presentation of the most viable solution in mitigating the flood damages in the Cukai town area, which can be concluded by comparing alternative plans of urban drainage mains and flood control works. Alternative solutions shall be studied technically, economically and through various viewpoints within the context of a prefeasibility study.

1.3 THE STUDY AREA

This prefeasibility study covers the downstream areas of Kemaman and Cukai Rivers encircling not only the existing town but also the planned year 2000 urbanized areas. It is shown in Figure 1.2.

1.4 CONDITIONS

This study has been conducted under the following pre-conditions:

- Topographic data used was provided by Malaysian agencies and included the 1:40,000 1983 aerial photographs
- An overall Kemaman River plan is not included
- The conceptual urban structure plan which was proposed in the Phase II study is to be used as the basic framework for the urban development.
- Population in study area is as follows.

Year	Drainage study area	Population
1985	5571 ha.	31,600*
2000	5571 ha.	58,000

* include 19,900 urban and 11,700 rural population
(Source: Kemaman District Office)

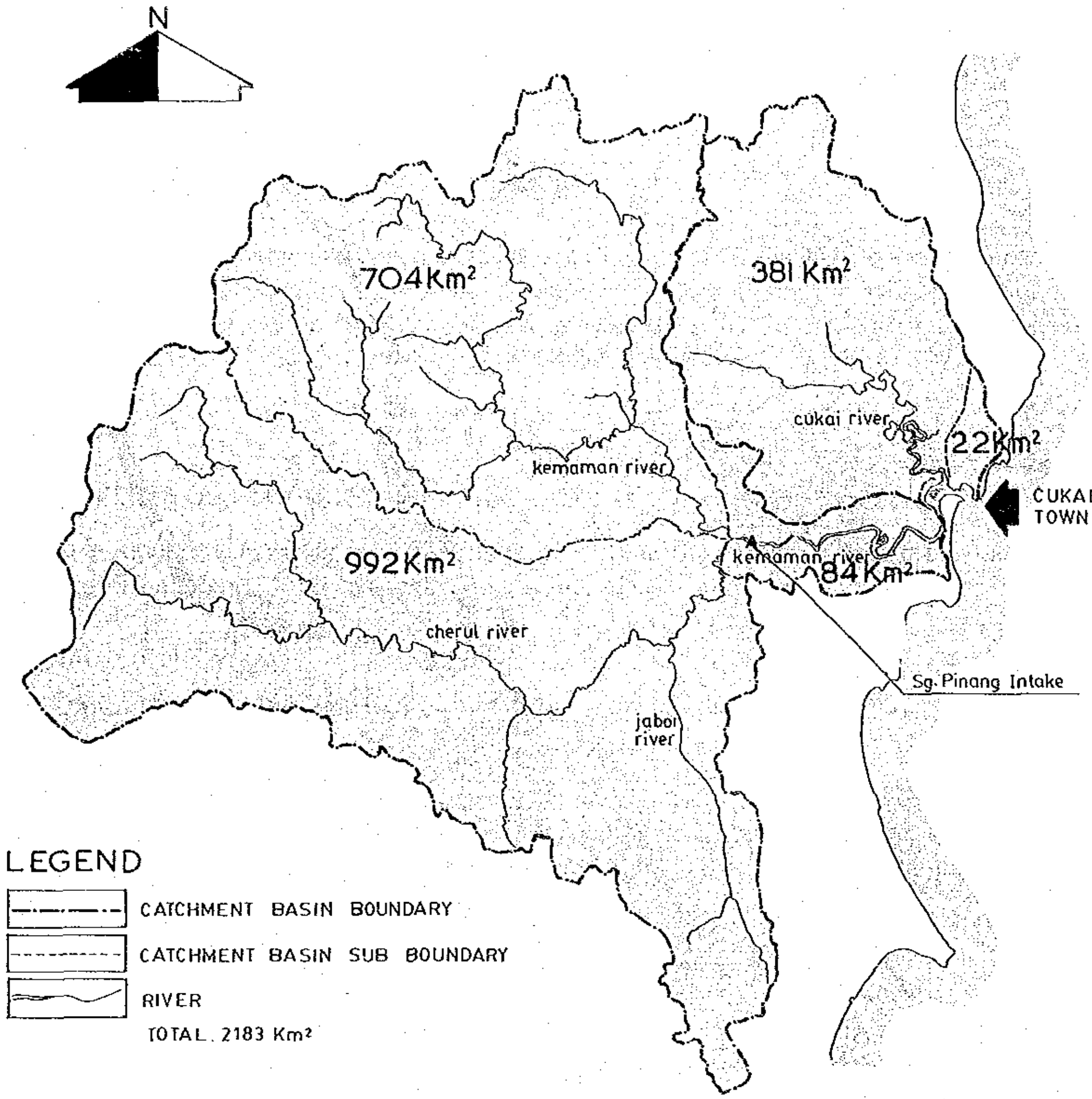


Fig. 1.1 KEMAMAN RIVER CATCHMENT

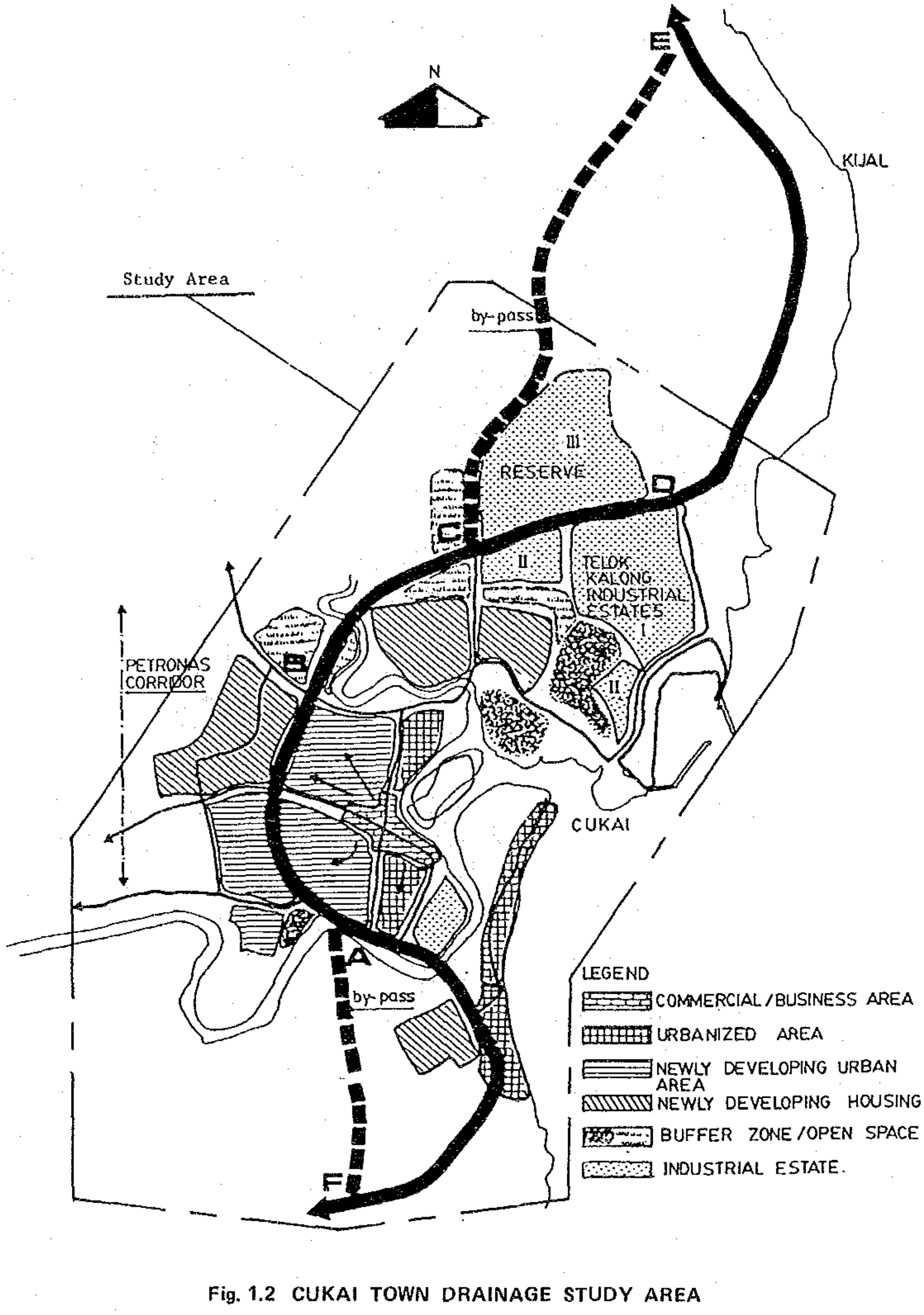


Fig. 1.2 CUKAI TOWN DRAINAGE STUDY AREA

CHAPTER 2 EXISTING CONDITIONS OF CUKAI TOWN

2.1 INTRODUCTION

Cukai has suffered many floods in its history those of 1972 and 1983 being the most recent and best recorded. These floods were extensive and lasted a lengthy period. The disruption caused by the 1983 was greater than that of 1972 because in the intervening time the town had developed significantly, even though the 1972 flood was deeper than that of 1983.

2.2 EFFECTS OF FLOODING

It is therefore convenient at this point to outline the problems caused by floods both from physical and socio-economic points of view.

a) Increase in damage

The urban area of Cukai is increasing as a result of industrial development, thus there is an increase in the value of property at risk.

The inhabitants of Cukai are experiencing an increase in living standards and thus the value of property and assets at risk is also increasing. The increase in the numbers of commercial properties and the value of the contents of the premises has increased the value of the flood risk.

b) Socio-economic activities

Land flooding is restricting on traffic and there are delays in the movement of people and cargos. These restrictions have an effect by making activity interruptions to commerce and industry which can be valued. These costs are included as part of the economic evaluation. These is also the normal human reaction to the inconveniences caused to normal daily activities. Whilst this is intangible in cost, there is a real psychological effect that can be observed.

c) Land use

Land flooding at regular intervals with big floods occasionally create a poor image for an important town. This is inhabiting to private and commercial development. Land which is flood prone has low value and consequently the higher ground has proportionally a more unreal higher value. The lack of flood free areas restricts the development of the town by reducing the area for development.

2.3 IMPACTS OF FLOODING

Flooding has a direct cost effect upon the economy of the town, the State and the Nation, and also affects the socio-economic development of the area.

a) Wealth related

The first obvious effect is in physical damage to private property, to factories and installed equipment, to shops and inventories.

Damage also occurs to the infrastructure, drains, sewers, buried utilities and to road surfaces, and other public facilities. Restoration by repair or replacement is a direct cost.

Flooding, by creating accessibility problems, can cause a reduction in family income due to loss of work days or cuts in operations by short time working.

Relief work by the town, State and National authorities incurs direct extra expenditure which could otherwise be used on other work.

There are results a loss of disposable income by the residents as they pay for repairs and replacements, and commerce and industry have a loss of investment funds.

b) Socio-economic related

The flooding of the drains and sewers results in a deterioration in health standards, and this in addition to general inconvenience of the flood has a destabilizing effect on the livelihood of the population.

There are transportation inadequacies during the flood period which inhabit spatial development due to access and the shortage of suitable land.

This inhibition for development is a handicap to the State, as it already has inferior competitive power when compared with other States, and loss of potential is a serious matter. The State cannot afford to suppress the dynamism of economic activities by not providing the adequate infrastructure.

2.4 LAND USE

Cukai town has to expand to absorb the effects of the industrial estate being constructed at Telok Kalong, and over the past five years this has been rapid.

Due to the lack of high ground development must take place in areas which are flood-prone.

a) Present development

The present land use situation is shown in Figure 2.1. This drawing gives the area presently built up by town or kampung, and the area which is currently under development for industry and housing.

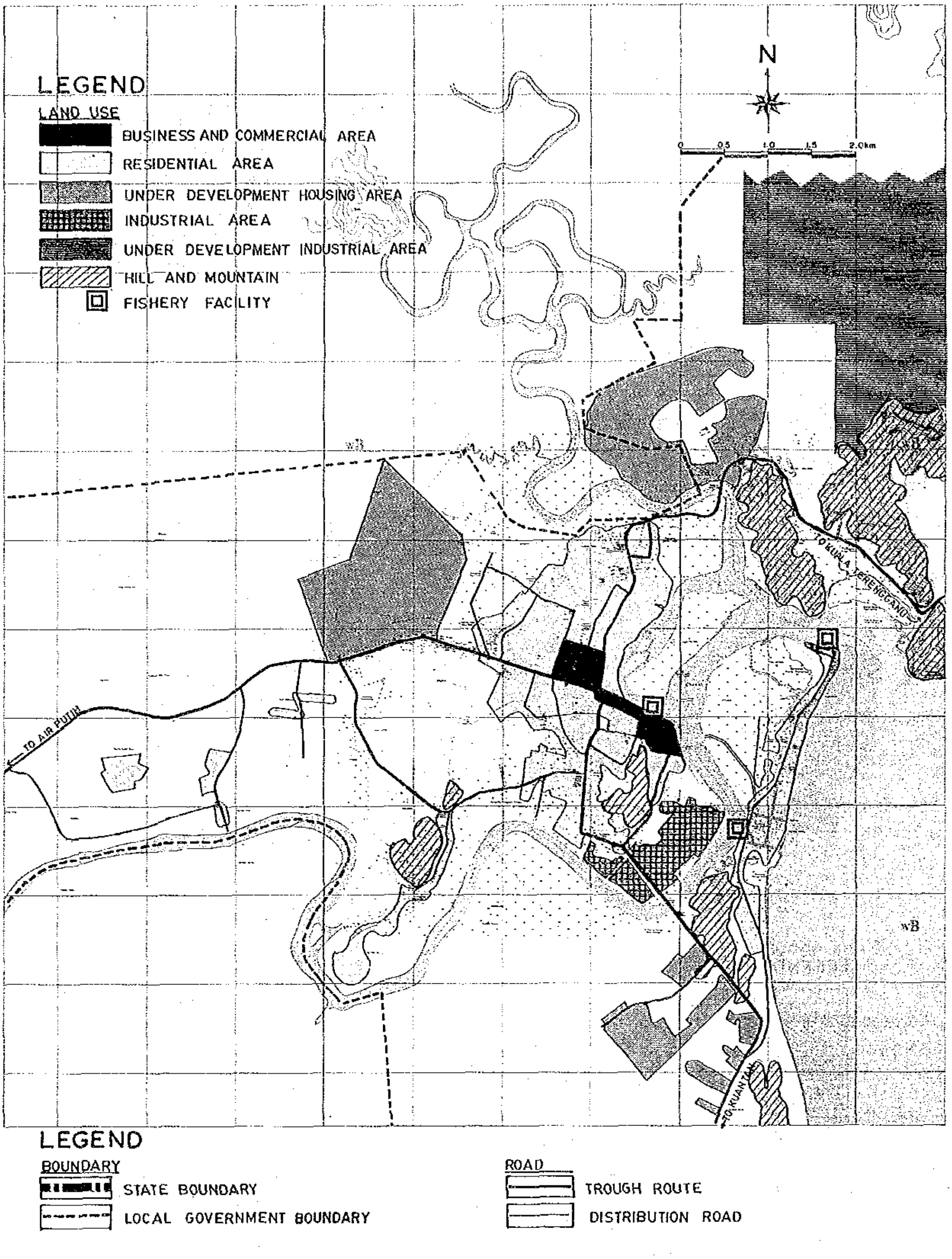


Fig. 2.1 PRESENT DEVELOPMENT CONDITION

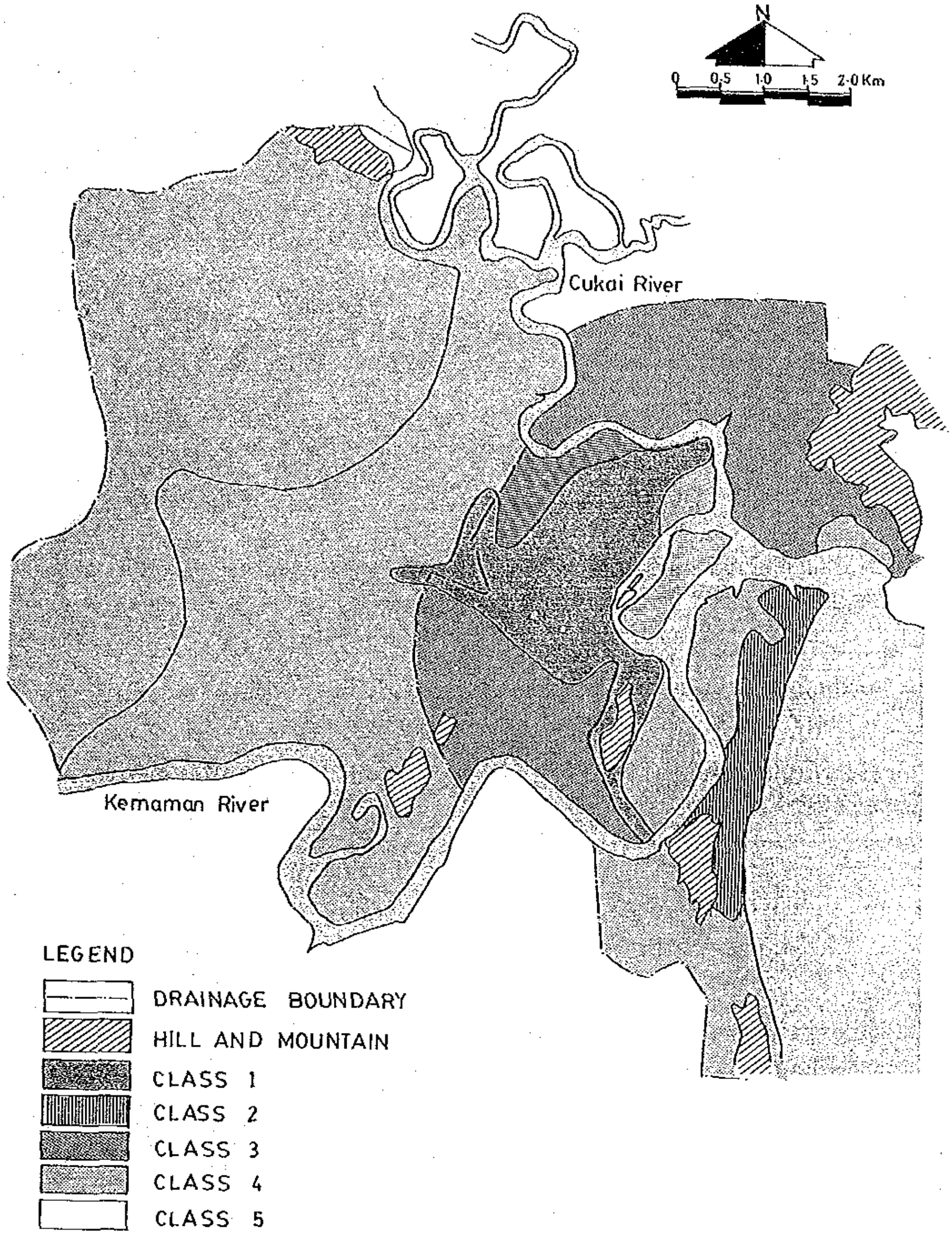


Fig. 2.2 LAND CLASSIFICATION MAP
(Present Condition for Urban Development)

The second Figure 2.2 shows the present land classification for urban development in terms of access and flood potential due to river water. Access was considered relative to the District Office and the Commercial Centre and the flooding based on ground level relative to the 1972 flood level.

The classification is shown in the following matrix.

	Accessibility [1]		
Flood Condition	Good	Moderate	Poor
No	1	2	4
Yes	3	4	5

Notes: 1/ Each number indicates the class in classification.

It should be noted that Class 4 is given two sub-classifications but is still marginal land.

The land classification map is re-drawn to show improvements that occur after the work is carried out and is shown as Figure 4.13. The pre-dominance of class 1 land should be noted.

Property deveopment has occured on land class 1 and 2 and very little undevelopable land remains. As a result new development is occuring in class 3 and 4 land.

The theme that is constantly appearing in this study is the conclusion obtained from these two maps.

(i) There is a shortage of flood-free land.

(ii) Development is taking place in flood-prone areas.

b) Surface water drainage

The surprising fact about the higher and developed land is that it floods, and that is due to surface water run-off.

The drainage system is not established in the town area to cater for the increased run-off due to development and consequently the areas become flooded due to shortcomings in the system. See the photographs and Figure 2.3.

There is currently only one trunk surface water drain under construction in the town area. This is the Gong Limau. Aspects of the drain are being redesigned but no other trunk drainage system is in design stage. There is a secondary drain under construction around the District Office.

There are two factors affecting the existing surface water drainage and influencing flooding of the system. The present system is inadequate, with culverts under roads of less diameter than the required needs of the rainfall. The drains are obstructed with sediment, grass and solid waste. A contributing factor is that the ground level at the drain outlets is below flood level causing water to back up the drains.

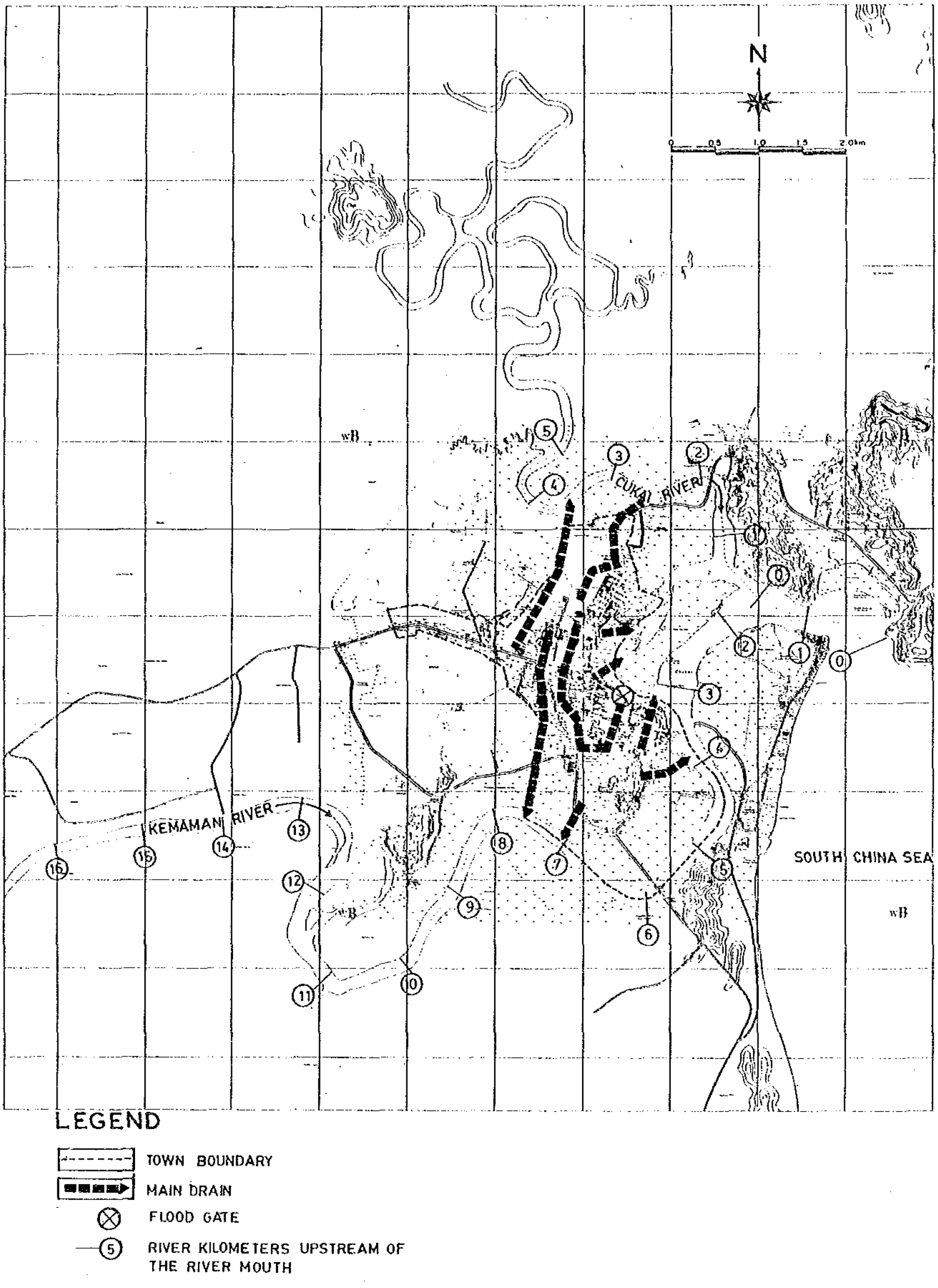
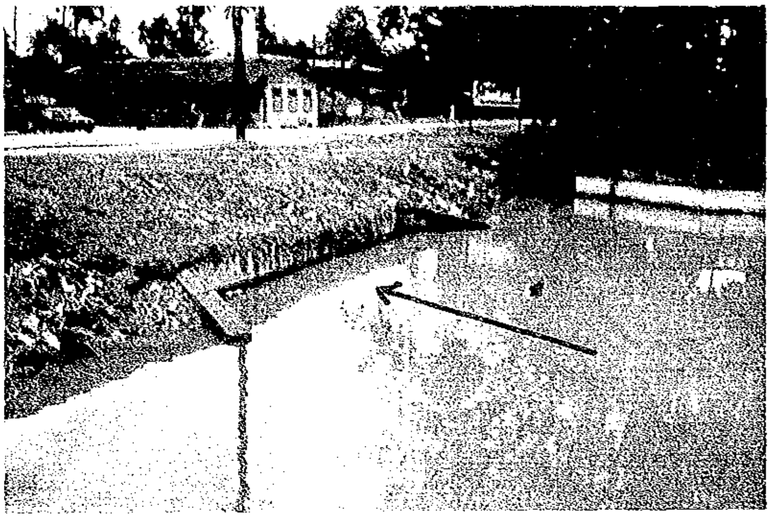


Fig. 2.3 EXISTING DRAINAGE SYSTEM IN CUKAI TOWN



Limbon River
Kg. Bunggol Kanan

Discharge capacity of pipe culvert is smaller than run-off

Source: Study Team, 1985

Limbong River
Kg. Bunggol Kanan
in 1983 Flood

Source: D.I.D

National Road
Route 3
Kg. Kubang Kurus in 1983 Flood

Source: D.I.D

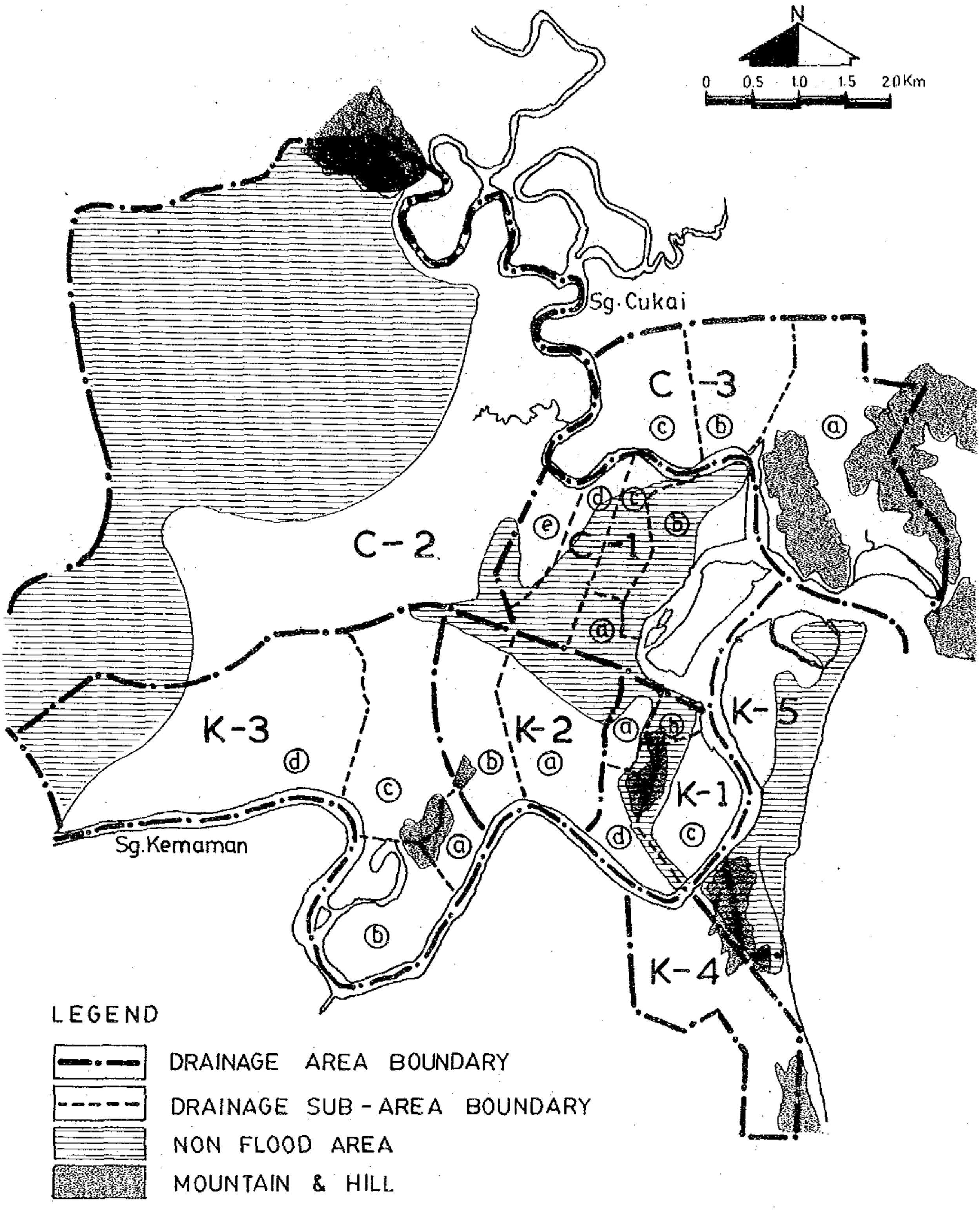


Fig. 2.4 DIVISION OF DRAINAGE AREA

The drainage area, by watershed, to each river is shown in Figure 2.4: C denotes the area draining to the Cukai River and K for that draining to the Kemaman River. The larger area of the C watershed should be noted and this is significant as will be discussed at the appropriate place in the report. These areas are subdivided into smaller watershed areas and then further subdivided by ground levels.

The large expanse between the two rivers are flood-prone area C2 and K3 should be noted, but in terms of surface drainage this has little significance. Only if the land is to be developed will it be necessary to provide surface water drainage, but in order for this area to be developed adequately it must be free of flooding from the river.

2.5 FLOOD OBSERVATIONS

Both the Kemaman River and the Cukai River are tidal and for the Kemaman River the tidal effect during floods is reduced to about 6km from the river mouth, approximately Geliga Bridge. (Normally more than 20km) This does not reflect on saline intrusion which extends further up to 10 - 15 kms from the mouth.

Both the 1972 flood and the 1983 flood were observed, the former one was more closely observed than the 1983 flood.

The effect of the river mouth sedimentation was obvious with the higher 1972 flood level, although it has a shorter duration of only 6 days compared with 2 weeks in 1983, which occured after river mouth dredging works.

From the studies made on the 1983 flood and from observed levels it was found that the flood waters flowed from the Kemaman River towards the Cukai River isolating the town from the west and also moved around to isolate the various elements of high ground along the river. This is shown in Figure 2.5.

It was noted that the flooding of the higher ground in the town was due to surface water run-off from the rainfall and not from river floodwater. This is an important distinction as there are live situations to consider.

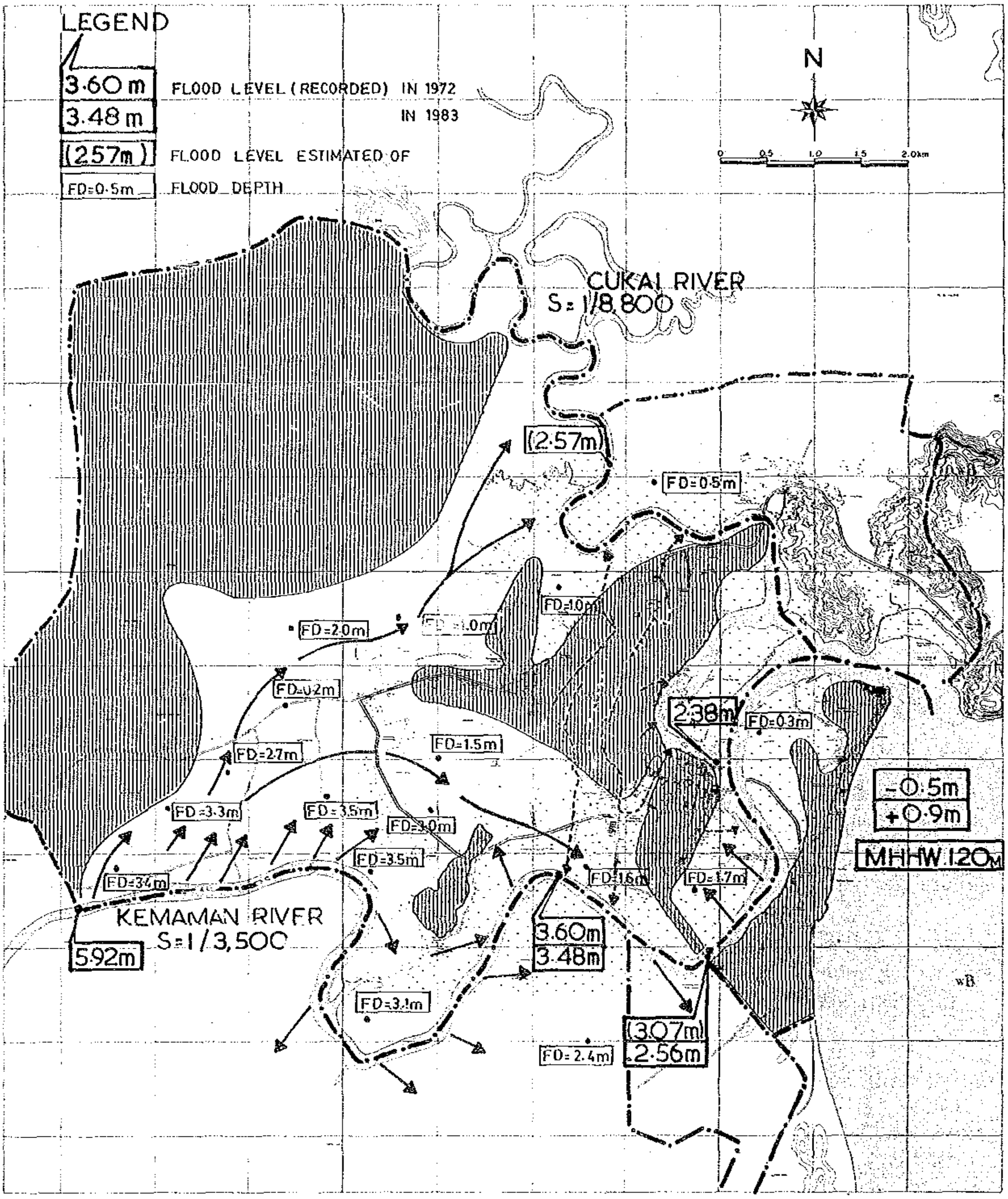
(i) River flood control

(ii) Surface water run-off

Whilest these two have no direct relationship they are lined, and the projects be carried out independently. As land areas are freed from flood threat they become available for development and thus need surface water drainage.

Investigation of the flood mechanism showed that the surface water gradient of the Cukai River from the confluence of the Kemaman River was 1:8,800 that of the Kemaman River from the river mouth to 16km was 1:3,500. The bankfull capacity of the Kemaman River as determined by the Cukai Flood Mitigation Study is 1,123 cu.m/sec. at a 50 percent frequency flood. The flood frequency for 1972 and 1983 floods is estimated at between 5 and 10 percent.

The difference in river gradients is significant as it indicates the nature of the river catchment area. The Kemaman River has a mountainous forested catchment which



LEGEND

DRAINAGE AREA BOUNDARY

EXISTING MAIN DRAINAGE CHANNEL

FLOW OF FLOOD WATER

NON FLOOD AREA

Note: 1/ Data for Tide is Tide Table of TG. GELANG
2/ Data of Water Surface Slope of Cukai River is FL=+2.0m (the junction of Kemaman River) and FL=+5.0m (180K bridge, 26.4km from the junction) in 1983
3/ Data of Water Surface Slope of Kemaman River is FL=+2.38m (3.3km upstream of the river mouth) and FL=+5.92m (15.7km upstream of the river mouth) in 1972

Fig. 2.5 EXISTING FLOOD MECHANISM

gives high run-off and increased stream velocity. The Cukai River has a swampy low lying catchment basin with larger water containing capacity and low run-off. The flooding potential of the Cukai River is very low because of the vast water surface area and ability of the ground to retain water. This is significant in considering the proportions of the watersheds in the study area.

In inference from this data is extremely significant. If the water can be retained in the Kemaman River then the land subject to flooding will become flood free as the Cukai River does not frequently flood. It was also shown that the removal of sedimentation from the river mouth reduces the flood levels.

These facts support the theme:

(i) There is a shortage of flood-free land.

(ii) Development is taking place in flood-prone areas.

CHAPTER 3 STUDY APPROACH

3.1 PREVIOUS STUDIES AND AVAILABLE MATERIAL

Four principal sources of material are available for the preliminary work on the study.

a) Cukai Flood Mitigation Study conducted by the DID in 1978 after the 1972 flood.

Aspects of this study were rapidly outdated by the development since 1980 and consequently the role of flood mitigation in the area has changed considerably and now becomes important.

Material gathered for that study has been valuable for this study, but the conclusions derived are no longer applicable. A result of that study was topographic information of the area between the Kemaman River and Air Putih Road and 1 : 10,000 topographic map. These saved considerable time to this study.

b) Gong Limau (trunk drain) is being constructed, and whilst some aspects of it are under redesign the design criteria used and information obtained from DID has been of great assistance to this study.

c) The Terengganu Coastal Region Study Report prepared by Maunsell and Partners in 1980 provided data on the coastal phenomena and the particular problem of the river mouths. Whilst no conclusions applicable to this study were included in the report, considerable background information was given which was extremely usefull.

d) Flood discharges are analized in the reports of the "National Water Resources Study" and "Water Resources Development For Domestic and Industrial Uses in the South Terengganu Region". These documents were used in preparing information in this study.

The study team acknowledges the information made available through these studies and is grateful for being able to make use of the data.

Also available to the study was the design report on Telok Kalong Industrial Port.

Major reports and data used in this study are as follows:–

a) DID: Cukai Flood Mitigation Study, 1978.

b) DID: Rainfall Intensity – Duration Curves, Kuantan.

c) DID: Lapuran Banjir 1983 Untuk Negeri Terengganu.

d) Government of Malaysia, JICA; National Water Resources Study, Malaysia, Meteorology and Hydrology, etc., 1981.

e) EPU: Water Resources Development for Domestic and Industrial Water Uses in the South Coastal Terengganu Region, 1981.

f) Port Authority Terengganu, Marine Department: Tide Tables 1970 – 1985.

3.2 STUDY METHODOLOGY

The study was divided into 4 activities between inception and final report, and a flow network prepared to control the sequence and influence of the work.

The four stages are Preliminary, Investigation, Land Use Changes and Evaluation.

a) Preliminary

It is essential to become familiar with the background, the site, the relevant facts, local feelings, local opinions, local weather effects, national design standards and criteria.

The preliminary data provides an introduction to the project and establishes the necessary contracts with counterparts, government officers, officials and the communities affected.

b) Investigation

This is the detailed research period to examine and follow up the various activities required by the study. This study is a pre-feasibility study and thus its intent is to examine broad possibilities and to eliminate impractical schemes so that a feasibility study and detailed design can be undertaken on a defined scheme.

This study showed that there was no linkage between river flood control and urban surface water drainage thus the two matters could be studied independently except at the interface of the outlet at the river.

c) Land use changes

The influence of land use early in the investigation should be noted and the theme of the inveestigation was quickly formed.

When acceptable proposals had been formulated the effect on urban land use is researched and the changes analysed in terms of alternative proposals, and recommendations made.

d) Evaluation

The recommendations must be costed into accountable terms to show the value of return for the money invested in the works.

These are essential project indicators and are influencing factors for investors both governnment and private.

In projects involving disaster prevention the negative costs only, i.e. the damages saved can be used. Consequently the factors are much lower than are normally accepted for investment purposes. In this project however there are considerable financial returns which cannot be ignored and this is discussed in the appropriate chapter.

The requirements of a technical study are such that concepts and criteria must be established upon which the investigation is based and solutions formulated.

3.3 STRATEGIC CONCEPTS

a) General

To achieve the implementation of a smooth development for the Cukai urban area, the following items must be considered in the study.

- The minimization of socio-economic losses due to flooding.
- Co-ordination with suitable urban land-use and drainage system.
- To minimize the effects of flooding on other areas.
- The environmental impacts of porposed works and the maintenance of urban amenities.

b) River improvement

- In principle to improve the river from the river mouth in the upstream direction.
- The water flow principle is to achieve a quick drain in the lower reaches and for flood water to be stored in the upstream areas and to have slow drain.
- To take into consideration future flood control requirements to minimize total social cost.

c) Urban drainage

- The principle of natural gravity flow drainage will be adopted.
- Flood water storage in the drainage area are to be considered to minimize the effects in the downstream areas.

3.4 DESIGN STANDARDS

The urban surface water drainage is based on criteria contained in the DID Manual "Urban Drainage Design Standards and Procedures for Peninsular Malaysia 1975".

The flood control works are based on criteria established during the study process.

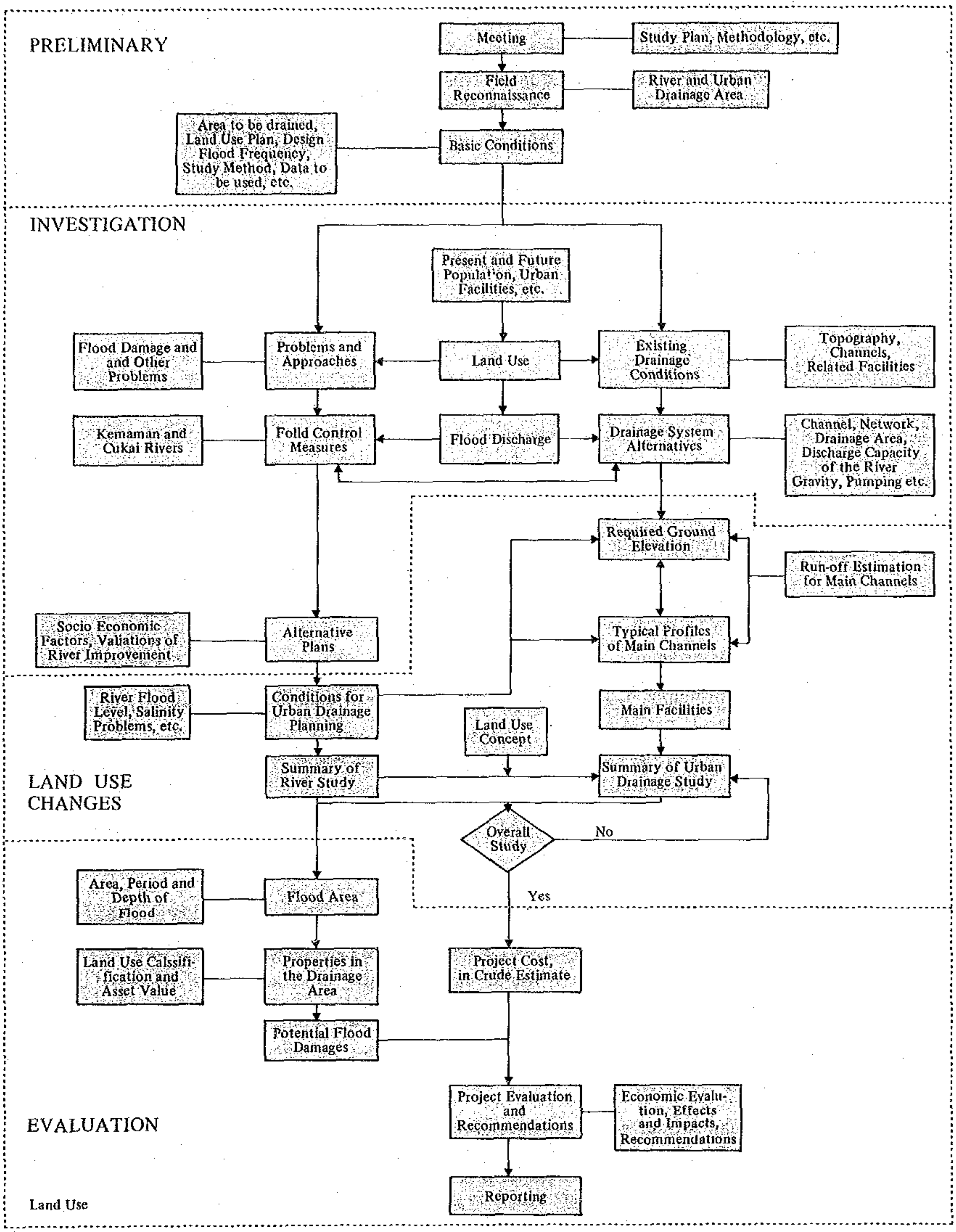


Fig. 3.1 FLOW CHART OF CUKAI DRAINAGE STUDY

Flood control measures:	2 percent (for the dyke)
Urban surface water drainage:	20 percent

The rationale used is described in the relevant section of the study.

CHAPTER 4 RIVER FLOOD CONTROL

4.1 INTRODUCTION

It was reported earlier that the dredging of the river mouth had significantly lowered flood levels for the 1983 flood, and this effect extended for a length of about 8km from the river mouth.

The second significant fact is that the storage capacity of the Cukai River is large and its run-off so slow that the Cukai River does not frequently flood from its own water.

The third significant fact is the distance from the river mouth to a point where there is significant difference between flood levels for different storm frequencies is about 5kms.

The second factor eliminated the need to carry out flood control works on the Cukai River. However river improvement works are required to remove narrows and sand banks which restrict flow.

The flood discharge is to equal that of the 2 percent storm within the limit of the area under study. However if river improvement works are carried out upstream of the area this will increase the run off and exceed the design capacity of the works increasing the risk of floods. Any river improvement works outside the area must include flood water storage facilities.

4.2 STUDY OPTIONS

The study examined several options available to control floods from the Kemaman River in particular and also the Cukai River.

There are three basic methods that could be used, dredging, building dykes or levees, and land reclamation or land-fill. The first two are for river control works and the latter for land improvements.

a) Dredging

Dredging is primarily considered for deepening rivers, but in this case it is also used for river widening and is a primary method for obtaining river improvement works of the quantity required to control the Kemaman River during flood.

In open waters it will be necessary to use marine dredgers of high capacity and installed horse power. Because of high costs for mobilization, crewing, and operation, 24 hour operation is to be expected. The soil nature would require a cutter suction dredger, and a pumping capacity of about 1km. The marine dredger should be able to operate within the estuary for a distance of 1 to 1½km inland.

In the river water the dredgers will have to be of shallow draught, have high capacity and only moderate installed capacity. Pumping capacity will be less and about 1km only will be required. For the Cukai River the Bukit Kuang bridge will not pass a dredger. The dredger must therefore be of a road transportable type, and be easily broken down into significant components. Since the requirements placed on this dredger are less it can be much smaller than that used for the Kemaman River.

In terms of production the volume of dredging in the Kemaman River is large and it is likely that two dredgers would be used.

The river is used by boat traffic and the dredged material has to be piped to the land. It is usual to use floating pipeline with flexible joints, however it is improbable that the boat traffic can be confined to a certain time, or that dredging be stopped to permit the pipe-line to be broken. A short length of submerged pipe under the river will probably be used.

b) Dyke building or levees

The use of walls or dykes is a traditional way of retaining water within a restricted area. These walls are usually above normal water level and are only reqired during flood conditions. These walls have to restrain considerable water infiltration and pressure and therefore are of some width. They are usually grassed but trees and bushes are not encouraged on the river face as their roots penetrate the structure of the dyke and considerably weaken it.

It is usual to construct the dykes from excavated material, the material being pumped ashore and allowed to settle in settling ponds or polders.

As the dyke is an earth structure it has to be formed with the beast earthwork practice and must be spread and compacted with earthwork machinery. End over tipping may be used for landfill but cannot be accepted for an earth structure. Final grading and shaping is done by bulldozer.

Water drains off the pumped material and this must be trained back into the river. It has a high content of fine silt or clay and must not be permitted to flow on to the land area that is not to be reclaimed.

c) Land reclamation or land-fill

A usual method for raising property above local flooding is to fill the site with earth up to 1 to 1.5 metres above ground level.

For a house site this can usually be achieved by lorry hauling the fill. However for large areas near to water the use of reclamation by dredger is normal. The same methods as that of the dykes is used, except that levelling and grading by bulldozer only need by carried out. The same water run-off conditions apply.

When used as landfill over agricultural land at least 12 months interval between placing of fill and bringing into cultivation is needed to ensure any salts in the fill are leached out.

Reclamation can be used to bring swampy land up to a flood free level or to crate new land from the river bed or sea bed. Marine reclamation can be used for agricultural land provided that all water is drained back into the river, and then the soil is left to permit sales to leach out.

4.3 FLOOD CONTROL FOR CUKAI AREA

The theme of this Study is that there is a shortage of flood-free land and that development is taking place in flood prone areas.

It is therefore necessary that development should take place in an orderly arrangement and the C2 and K3 areas between the rivers provide the logical space. The land on the right bank of the Kemaman River is swampy low-intensive agricultural land, and is close to the State Boundary.

a) Protection by dyke or landfill

The flood flow from the Kemaman River is across K3 and C2 and cuts off Cukai It is therefore necessary to provide a raised bank protection on the left bank of the Kemaman River to keep the flood waters out of K3 and C2 areas. The height of this protection is discussed later. The significance of this is shown in Figure 2.5.

When considering the Cukai River, the river does not have the same characteristics and dyke protection is not required and the basis for protection is land-fill in the lower areas.

b) River dredging and widening

River improvement works are classified into three groups deepening, widening and straightening. The effect is to increase the speed of run-off by reducing the obstructions to river flow. An improved run-off reduces the level of the water. However any improvement works must be balanced between flood-water flow and low-water flow.

The criteria used for designing the river channel improvements are:

River bed	:	From river mouth to end of area - same gradient as floodwater surface level i.e. 1 : 3,500 for the Kemaman River and 1 : 8,800 for the Cukai River.
Low flow channel's width	:	Bankfull capacity for 50 percent flood
Landfill	:	Ground height to give bankfull capacity of 10 percent flood
River reservation	:	To give bankfull capacity for 2 percent flood

There is little dredging to be carried out in the main stream, and the bulk of dredging work is in river widening. This is a major improvement as it is retained within the new banks of the river. In general river widening will be carried out on the right bank or on state land where there is no or little development and compensation is simipler.

The material to be recovered from dredging work is used as a landfill, this is used to raise the river banks such that the height will prevent over topping by a 10 percent flood. This is set back from the existing channel bed by varying distances.

c) River mouth

It was recorded earlier the effects of dredging at the river mouth in particular in the esturary it had a large effect on flood levels. Therefore river mouth works have a significant effect.

By dredging the river estuary and mouth such that the river bed profile is smooth, but finished above the sea bed level the required effect is obtained.

However to obtain the best effect the river dredging has to be carried out to some distance from the shoreline. To protect this channel from littoral drift and siltation it is necessary to construct training banks or dykes out to sea alongside the channel.

The channel under these conditions is usually narrower than the river to increase velocity of the water and so to make the bed self-cleaning to reduce maintenance.

d) Short-Cuts

A meandering river can be improved by cutting across a neck of land and so eliminate a bend in the river. This reduces distance, and hence flood level.

However this technique has its limitations as it involves considerable land compensation, and displacement of people and kempongs. Consequently it can only be carried out where substantial achievements can be obtained with only small increases in costs.

e) Associated works

The only physical obstructions across the rivers are Geliga Bridge on the Kemaman River and Bukit Kuang Bridge over he Cukai River.

The river at Geliga Bridge will be widened and consequently a completely new structure is required.

This bridge must be completed and open before dredging works reach the site. This bridge will be a major new structure and should be designed to the best standards. The number of piers in the river should be kept to a minimum and the total width of piers facing upstream should not be more than 6 percent of the overall width of the river between banks. The bridge abutments must be set back to the outside the river flood flow area.

The Bukit Kuang Bridge is not affected by river works and no work is contemplated.

There are three sets of moorings and wharves on the Kemaman River which will be affected by dredging operations. Temporary relocation and permament re-siting will be necessary. During this process dredging operations may have to be phased around this work.

There is a saine intrusion into the river due to the tidal effects. River will increase this risk, and the water intakes for domestic, agricultural and industrial use must be protected. Upstream of the area under study a submerged barrier may be required to hold back the dencer saline water. This water is close to the river bottom in the upper reaches and is not mixed with fresh water. This must be closely studied at the feasibility stage.

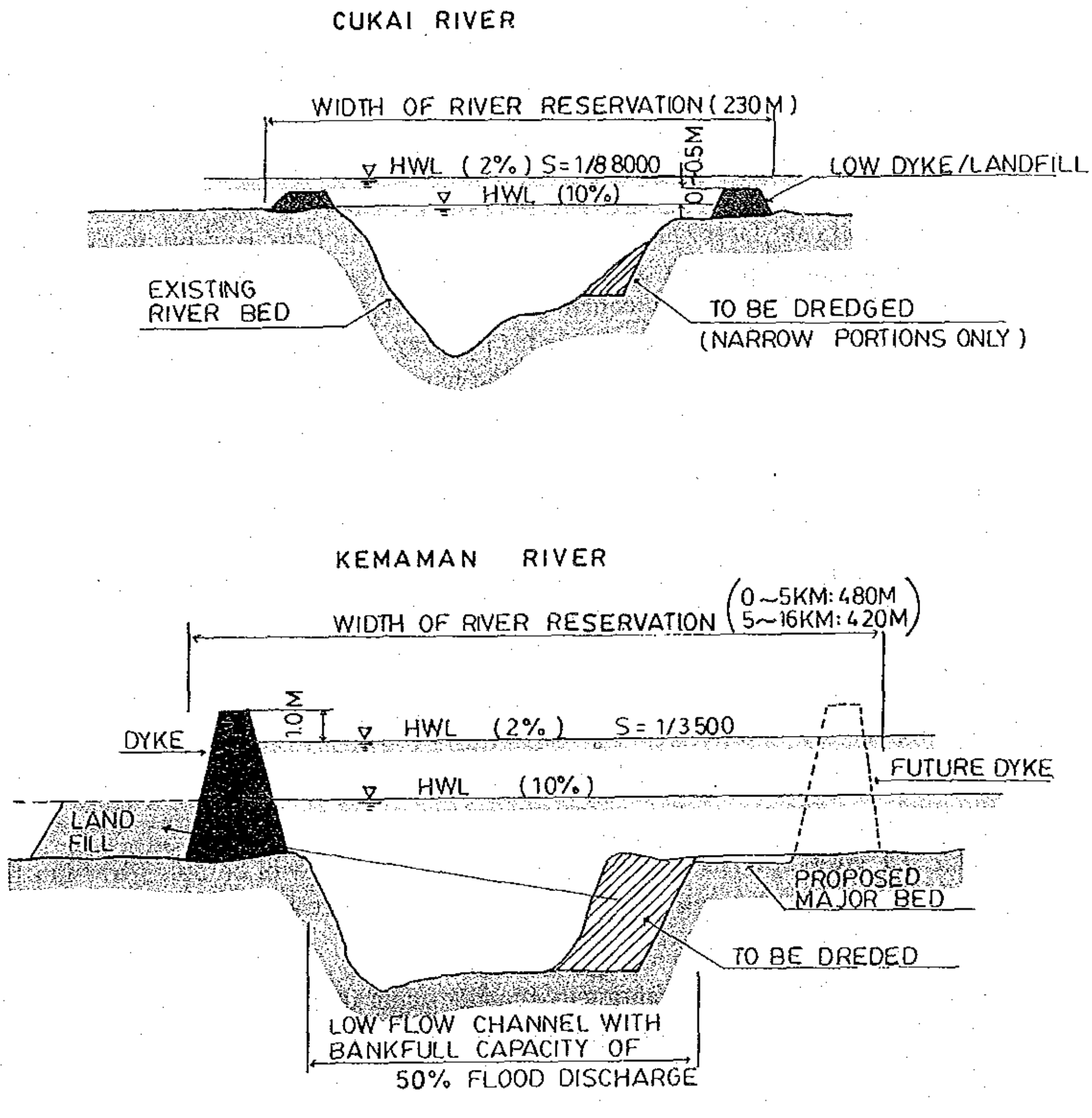


Fig. 4.1 CONCEPT OF RIVER PROFILE DECISION

4.4 ALTERNATIVE RIVER IMPROVEMENT

By assessing the date given in Section 4.1 and 4.2 a straight forward river improvement scheme was prepared. This is Alternative 1.

a) Alternative 1 or basic case

The plan of these works is shown in Figure 4.2 and the longitudinal profile in Figure 4.3.

The works are to extend from a new river mouth 600m out to sea to the 16km mark up the Kemaman River and to a point 5km upstream on the Cukai River from the oonfluence of the two rivers.

River widening for the Kemaman is carried out as shown in Figure 4.1 and landfill and a dyke built to give protection against a 2 percent flood. The dyke will have a one metre freeboard.

The surplus dredged material is used to from a 2 metre to 2.5 metre high flood free area. A significant factor in these works is the width of the land-fill and the necessary changes this will bring. However this constitutes land improvement and houses occupying land which is subsequently improved can be re-built on flood-free land. Similarly the width makes it suitable for highway construction and also for planting with fruit trees and similar crops, and the improvement will enhance the standard of living of the inhabitants. Access over the dyke to the river must be provided for activities centred on the river.

Cukai River presents a different condition and much of the flooding is local and is caused by lower swampy banks associated with river narrows. Consequently much of the work is of a local nature and consists of widening the river to average profile and using the recovered material for landfill. The height of the landfill would average 1 metre to 1.5 metres, the width of fill being related to the volume of material dredged and the length to be protected.

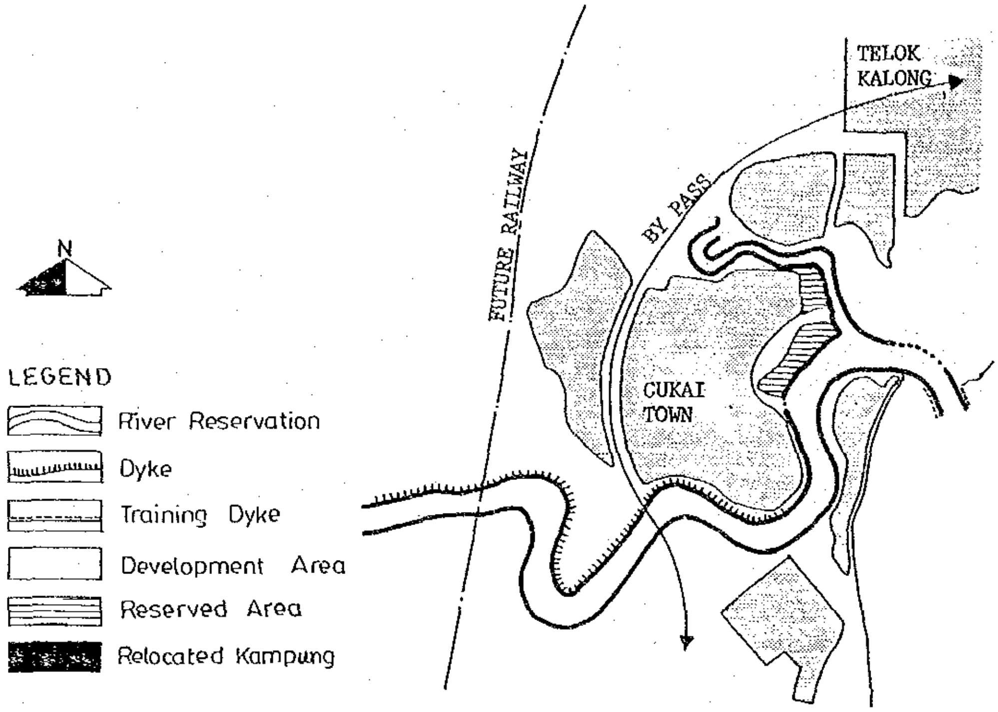
The river mouth improvements would consist of dredging the channel and using this material to form sand mounds which would be protected by rock or concrete mouring.

Table 4.1 gives in chart form the improvements which will be obtained from the river mouth improvements and the river improvement related to two points on the river.

The 10 percent frequency represents the landfill height condition and the 2 percent frequency the dyke design. The 5 percent frequency is used for comparison purposes as both the 1972 and 1983 floods were of between 10 and 5 percent. The "1972 Flood" column is used for comparison purposes.

The "without project" case is the calculated level of flood water as now existing at two points on the Kemaman River and one point on the Cukai River.

Alternative 1 shows the river level after the works described. The reduction in water levels is significant on the Kemaman, but not much for the Cukai River.



River improvement along the existing low flow channel.

Fig. 4.2 ALTERNATIVE 1

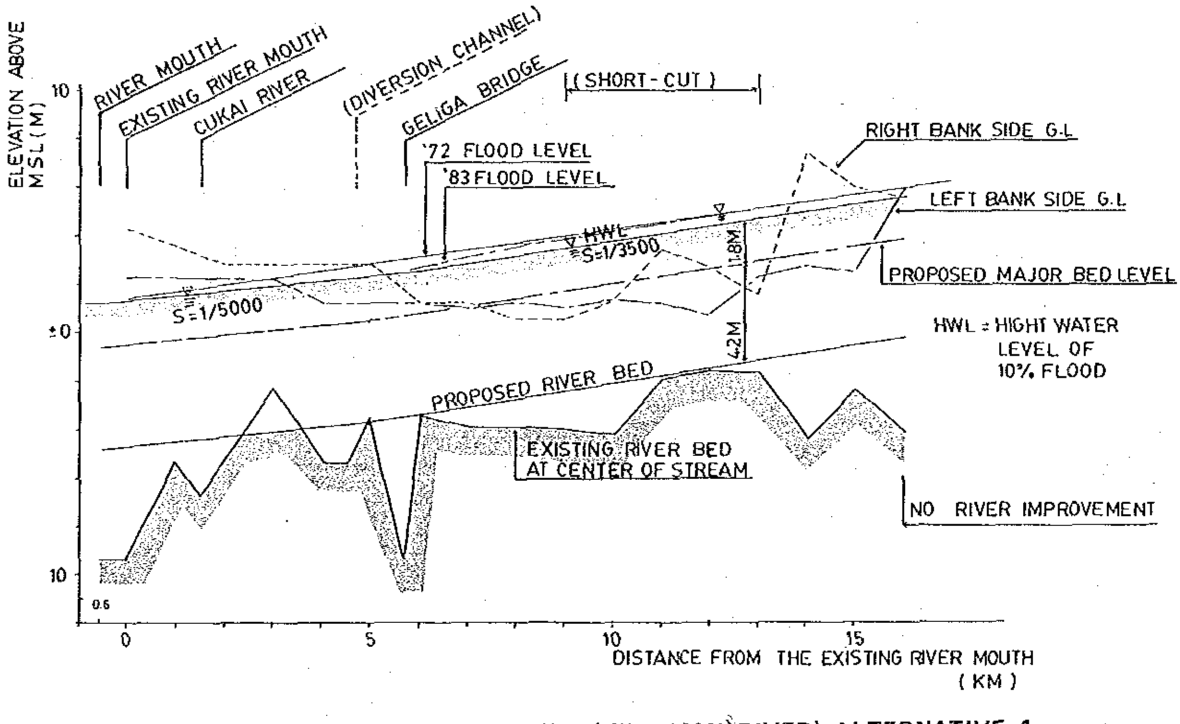


Fig. 4.3 LONGITUDINAL PROFILE (KEMAMAN RIVER) ALTERNATIVE 1

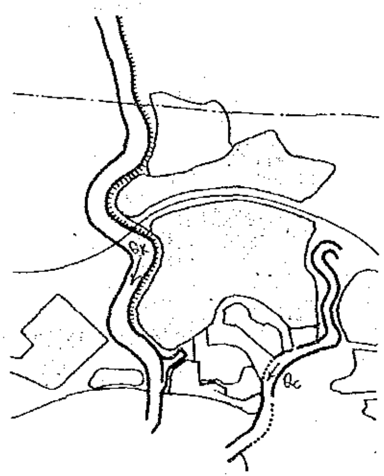
Table 4.1 Flood Level of the River by Frequency

UNIT: METERS ABOVE MSL

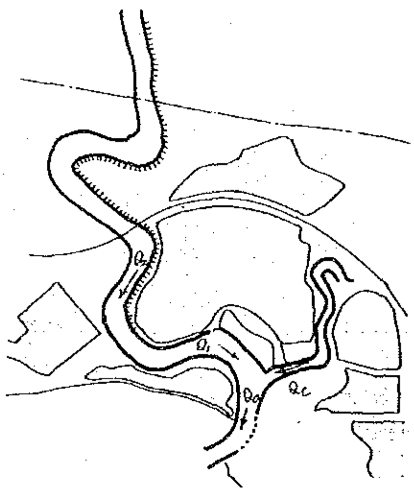
CASE		FREQUENCY	1972 FLOOD	10-YEAR (10%)	20-YEAR (5%)	50-YEAR (2%)
KEMAMAN RIVER	AT 8 KM	WITHOUT PROJECT	3.70	3.6	4.3	5.2
		ALTERNATIVE 1 and 4		3.2	3.6	4.5
		ALTERNATIVE 2 and 3		2.5	3.0	3.3
	AT 14 KM	WITHOUT PROJECT	5.43	5.3	6.0	6.9
		ALTERNATIVE 1		5.0	5.5	6.3
		ALTERNATIVE 2		4.3	4.7	5.5
		ALTERNATIVE 3		3.8	4.2	5.0
		ALTERNATIVE 4		4.5	5.0	5.8
CUKAI RIVER	AT 4 KM	WITHOUT PROJECT	2.45	2.3	2.7	3.2
		ALTERNATIVE 1 and 4		2.2	2.6	3.1
		ALTERNATIVE 2 and 3		2.0	2.4	2.9

FLOOD DISCHARGE BY FREQUENCY

ALT. 2 AND 3



ALT. 1, 4 AND EXISTING RIVER



UNIT: M³/S

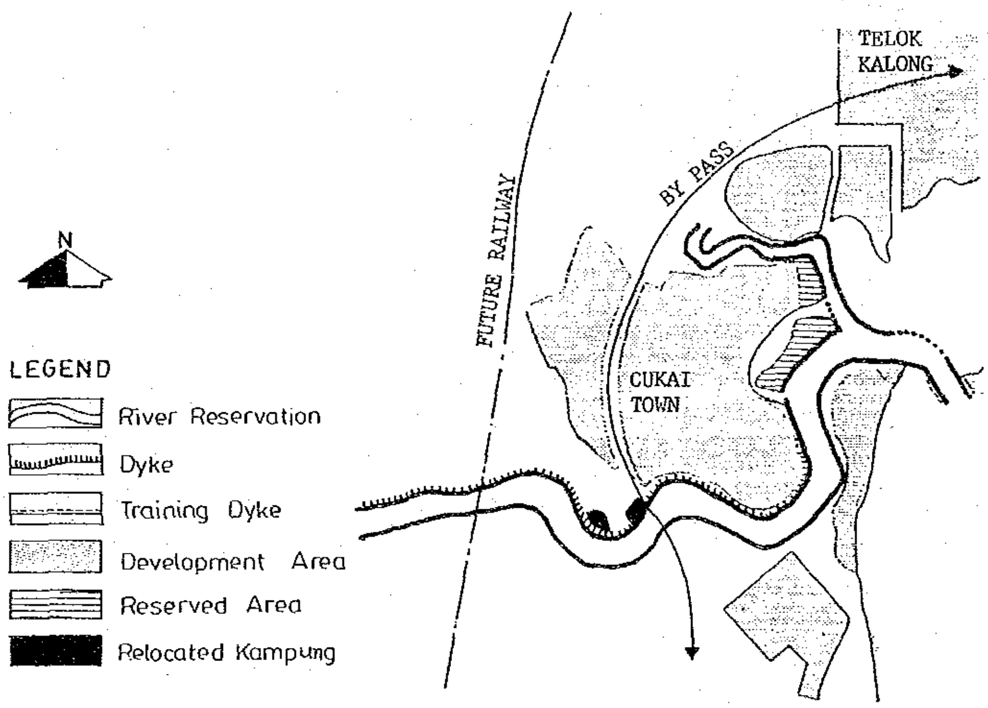
FLOOD FREQUENCY YEAR (%)	ALT. 2 & 3		ALT. 1, 4 & (EXISTING)			
	Qk	Qc	Q_0	Q_1	Q_2	Qc
2 (50)	1370	330	1400	1370	1370 (1180)	330
5 (20)	1930	485	2100	1930	1930 (1740)	485
10 (10)	(2400) 2350	607	2700	2350	2350 (2170)	607
20 (5)	2790	728	3150	2790	2790 (2600)	728
50 (2)	(3400) 3350	884	3800	3350	3350 (3160)	884
100 (1)	3720	1040	4500	3720	3720 (3720)	1040

Note: Estimated roughly using the results of discharge analysis in SCTWR and NWRSM. They are based on the existing conditions of the Kemamam River.

b) Alternative 4

This is a variation on the basic aternative 1. The whole of the works in alternative 1 are carried out except that a "short cut" is made at the 9km point across the neck of the bend. The original river length here was from 9 - 13kms, a length of 4kms. The new length is 2.4kms. The plan of this alternative is shown in Figure 4.4.

However this proposals bisects a kampung through the middle completely severing the community. It is therefore necessary to carry out a considerable inhabitants relocation programme which will include rehousing. An outline method of doing this is given in Figure 4.5. The delays involved to the dredging programme could amount to one year if alternative temporary housing is not provided. In addition the construction of the flood-free land behind the dyke may also affect other houses not directly displaced as a result of dredging.



River improvement with short-cut at Kg. Bukit Mentok but no diversion channel.

Fig. 4.4 ALTERNATIVE 4

On the positive side the reduction in flood levels over the basic or alternative 1 case is dramatic at 0.5 metres for all three cases. This is shown in Table 4.1. The reduction obtained over the "without project" is also dramatic. Alternative 4 represents a major improvement over the existing conditions.

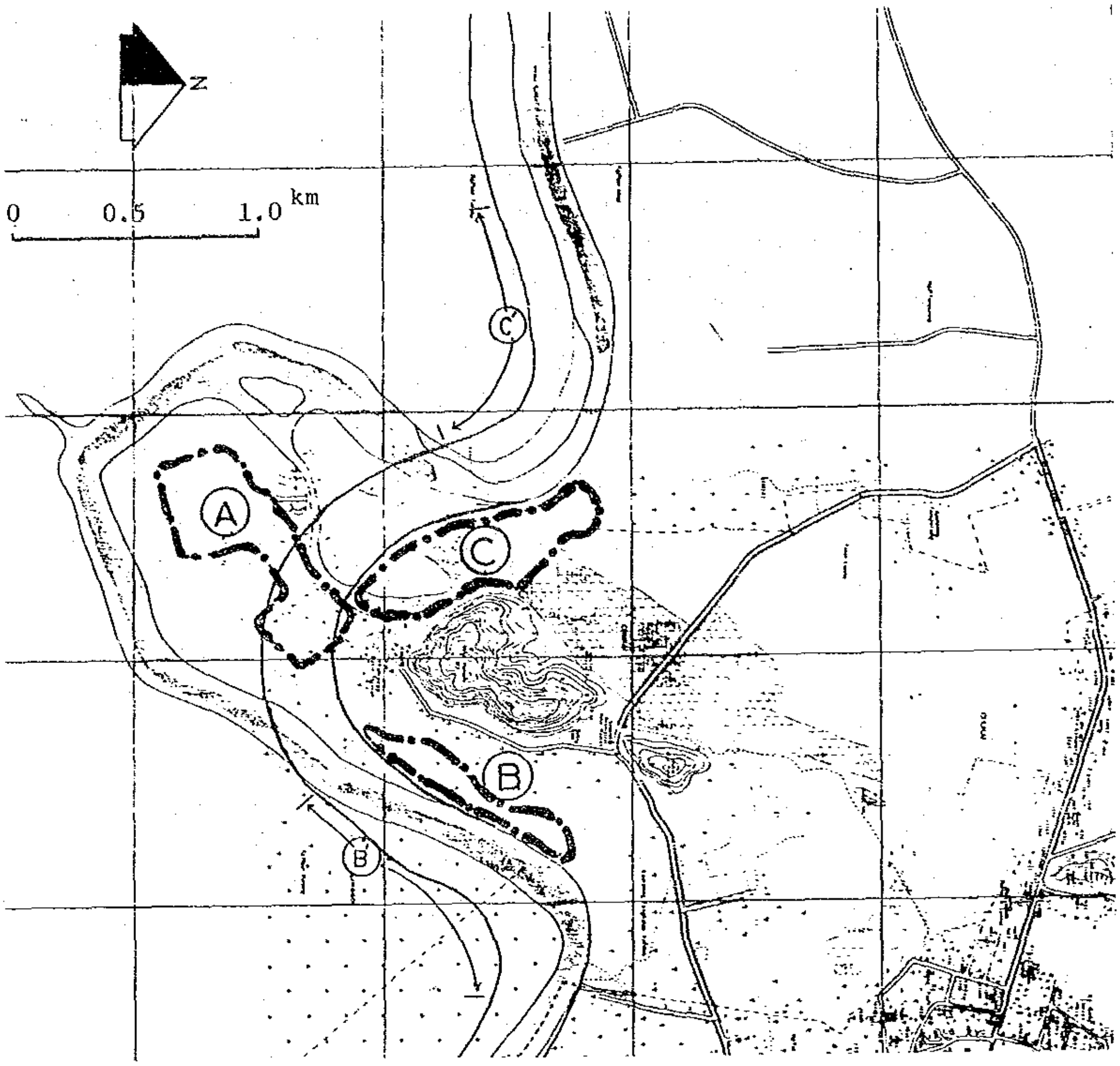


Fig. 4.5 KAMPUNG RELOCATION PROGRAM (Kg. Bukit Mentok)

NOTE:
1. Number of houses to be relocated: 65
2. Number of peoples to be relocated: 420
3. Area (Approx) (A) 30 ha/ (B) 10 ha/ (C) 20 ha
4. Relocation Schedule
   i) dredge the river section (B') and fill area (B)
   ii) dredge the river section (C') and fill area (C)
   iii) relocate the people living in area (A) to area (B) and (C).
   iv) dredge the new river reservation area and construct the dyke.

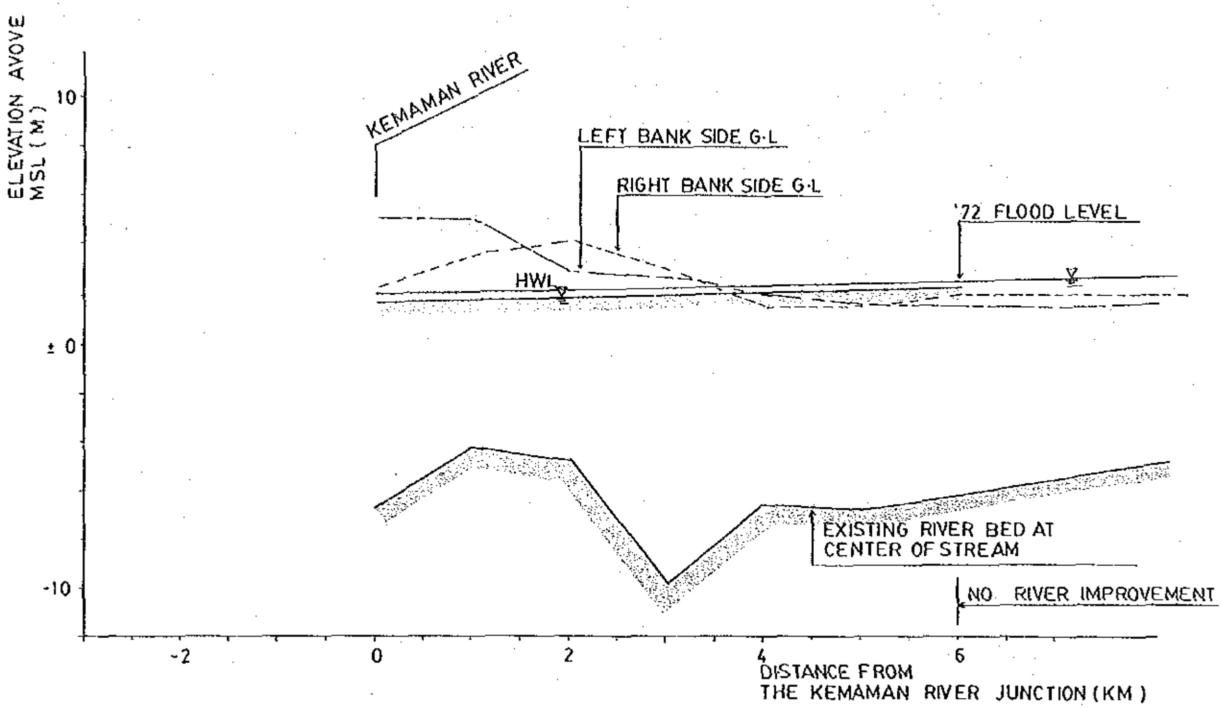


Fig. 4.6 LONGITUDINAL PROFILE (CUKAI RIVER) ALTERNATIVE–1 AND 4

c) Alternative 2

Alternative 2 is designed to take a "short cut" to the sea. This is the same as alternative 1 except that the river is diverted to the sea at the most suitable point.

About the 5km mark on the Kemaman the river bank is about 450 metres from the sea. The nearest point before the mouth. The plan for this is shown in Figure 4.7.

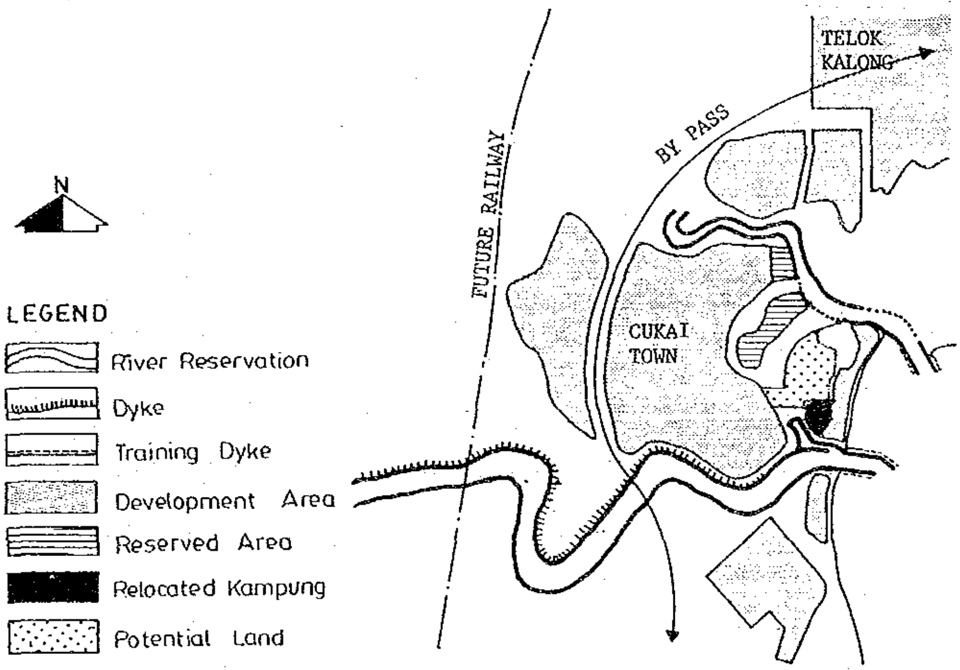
Alternative 2 was devised to "short cut" at this point and to provide a new outlet for the river. The new river mouth would be 2.4km from Geliga Bridge in place of 5.7kms at present this is a reduction of 3.3kms compared with 1.6kms of the alternative 4 reduction.

The reduction in flood water levels over the basic alternative 1 condition is greater than alternative 4. At 8km point the reduction is 0.7 for 10 percent and 0.6 and 1.2 for the 5 and 2 percent flood respectively. At the 14km point similar reductions are obtained. The effects on the Cukai River are 0.3 metres reduction in level and is shown in Figure 4.10.

The impacts of this alternative on Cukai town are dramatic and this is discussed in the relevant section of this study.

At the same time as the new outlet is provided for the Kemaman River the Cukai River shall flows out at the existing river mouth. Because of this river mouth works are still required as the reduction in water volume flowing to sea is very large. So whilst the river channel will be narrower the length of training banks must be longer to accommodate the new regime. The new river mouth is 2kms from the original confluence of the rivers.

Much of the dredged sand will go into the training banks, but there will be surplus. This will be pumped into the area between the two rivers to enhance the beach, as this material should not be used for construction purposes.



River improvement along the existing low flow channel and provision of diversion channel at Kg. Celiga Kechil.

Fig. 4.7 ALTERNATIVE 2

d) Alternative 3

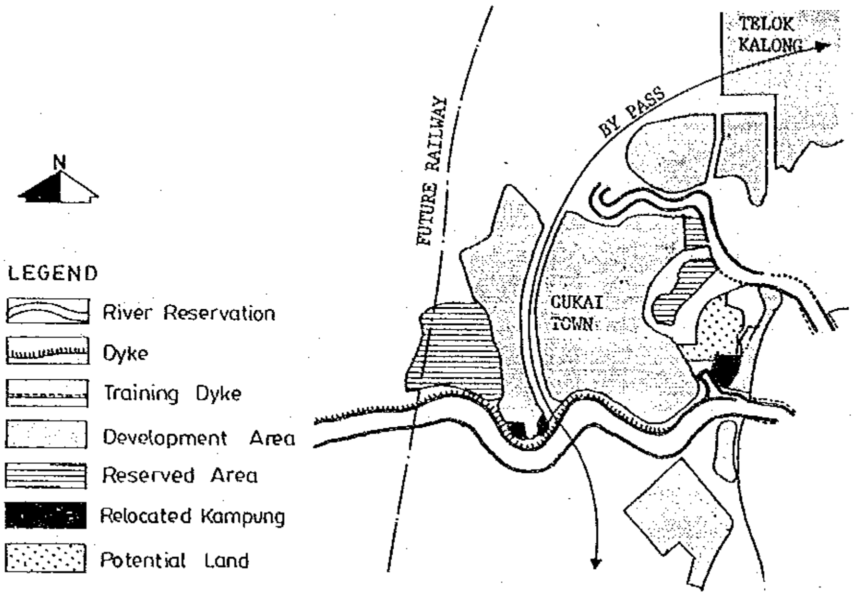
This alternative is alternative 2 with the same "short cut" described in alternative 4, and the plan is shown in Figure 4.8.

Exactly the same conditions apply for this short cut as in alternative 4 and Figure 4.5 should be referred to.

The effect on river levels upstream of the short cut are large and in comparison with the basic alternative 1 the reduction in water level is 1.2 metre, 1.3 metre and 1.3 metre for 10 percent 5 percent and 2 percent. Over the "without project" condition the reduction is 1.5 metre, 1.8 metre and 1.9 metre for 10, 5 and 2 percent floods respectively.

The longitudinal profile is shown in Figure 4.9.

Figure 4.10 shows the profile for the Cukai River which is the same as alternative 2.



River improvement with short-cut at Kg. Bukit mentok and provision of diversion channel at Kg. Geliga Kechil

Fig. 4.8 ALTERNATIVE 3

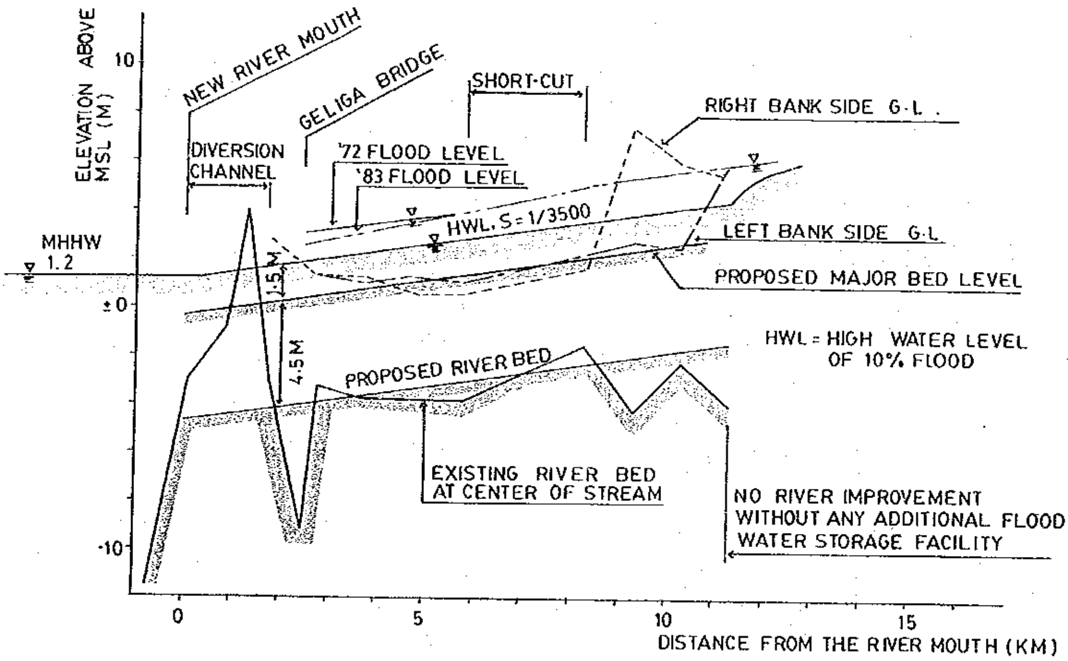


Fig. 4.9 LONGITUDINAL PROFILE (KEMAMAN RIVER) ALTERNATIVE – 3

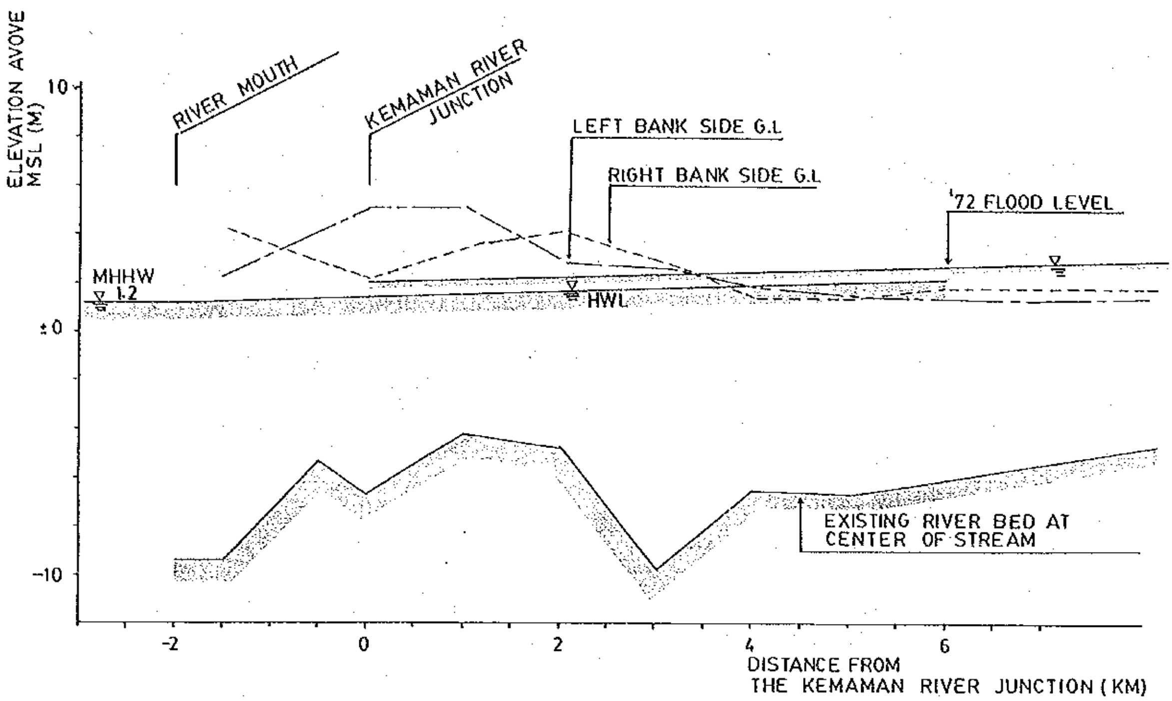


Fig. 4.10 LONGITUDINAL PROFILE (CUKAI RIVER) ALTERNATIVE–2 AND 3

4.5 COMPARISON OF ALTERNATIVES

There are two basic schemes considered alternative 1 and 2. Each has the same "short cut" variation giving alternatives 4 and 3 respectively.

a) Engineering comparisons

This comparison is made entirely on engineering judgement. The financial implications between the two projects is left to the appropriate place.

(i) The effect of the four alternatives is to produce 4 different water levels for set condition. This is shown in Figure 4.11 for two places. Upstream of Geliga Bridge and before the short cut the water level difference is about 0.5 between the basic alternative 1 proposal and the new outlet proposal of alternative 2.

(ii) Above the "short cut" alternatives 2 and 4 have virtually the same effect at a reduction of 1 metre below the 1972 flood. Alternative 1 has least effect with a reduction of 0.5 metres. Whilst alternative 3 has a reduction of about 1.5 metres, that is 1.0 metres below alternative 1.

To examine this effect Figure 4.12 is used. In this figure a cross-section of the Kemaman River is drawn showing the full effects of the different flood water

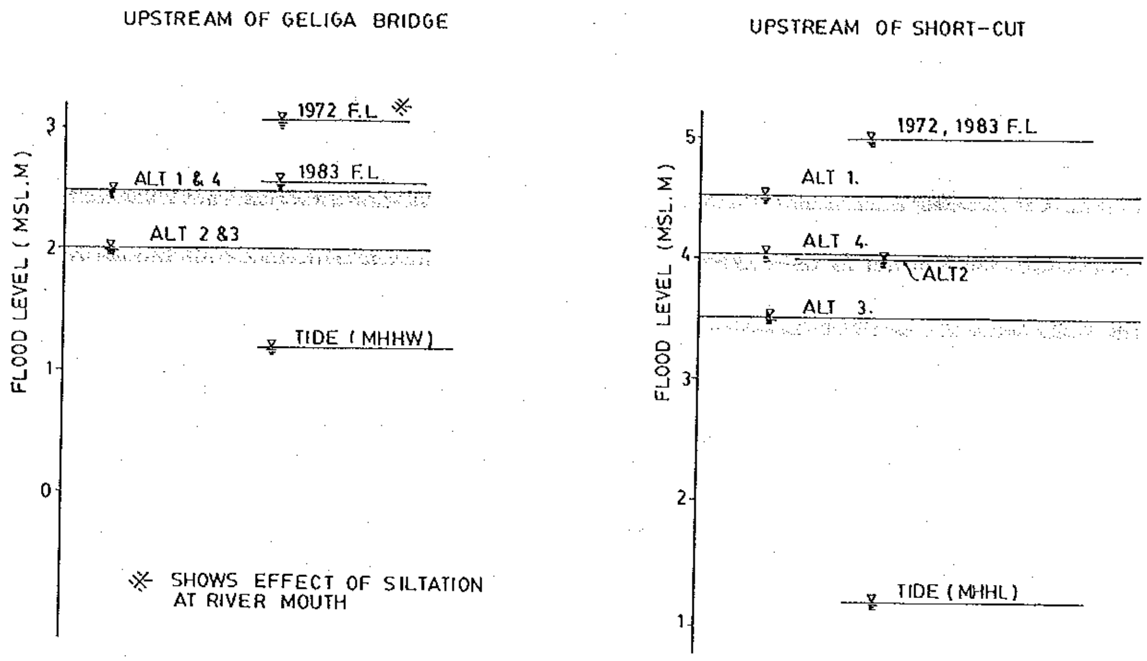


Fig. 4.11 WATER LEVEL OF THE KEMAMAN RIVER BY ALTERNATIVE (10-YEAR (10%) FLOOD))

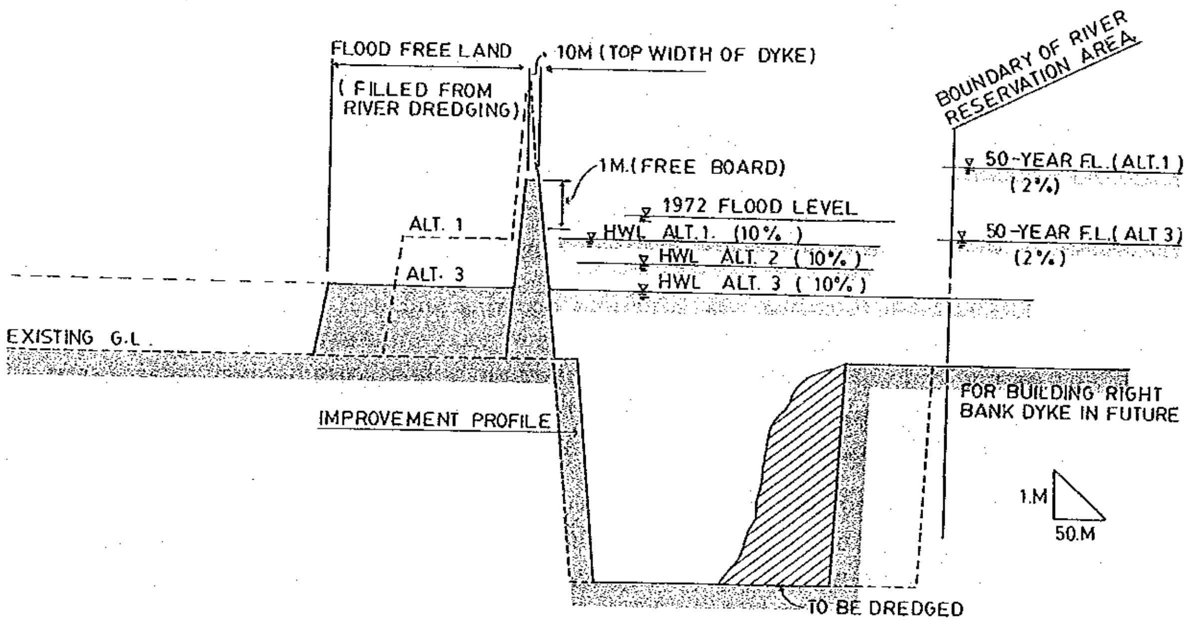


Fig. 4.12 STANDARD CROSS SECTION OF KEMAMAN RIVER

levels on the flood free area, the height of this above ground level and the size of the dyke. This difference is dramatic.

With the river level reduced to alternative 3 level any landfill need not exceed 1.5 metres to be flood-free of the 10 percent flood. This also applies to the right bank as well, and the 2 percent flood would only then flood an additional 1.2 metres, a big difference from the 2.7 metres over existing ground and the 4.0 metres over existing ground for alternative 1. This has a big impact on the right bank where development can now be considered.

The reduction in height of the dyke from above 5.25 metres to 3.75 metres above ground levels reduces the work involvement of creating and compacting 1.5 metres of earth dyke, a major saving in time and equipment, the fill can then be spread over the landfill portion by bulldozer without the need for the same compaction requirements. In this context the savings produced by alternative 3 over alternative 1 are significant. The distance involved over 3km from the end of the short cut and 5.5km including the short cut are long enough to require a significant effect upon the work programme.

(iii) Down stream of the "short cut" the effect are considerably reduced particularly as the dyke has to enter the town area. This is mitigated by moving the river channel away from the town bank towards the sea-side in alternative 1 and 4, though the higher land upon which the town stands helps in replacing the dyke and landfill.

(iv) The effect on the Geliga Bridge is not considered, though the possibility of reducing the level of the bridge soffite is considerable. The design of the bridge must permit the 2 percent flood to flow freely under it, and since the 2 percent flood is about 0.4m lower than 1972 flood and 1.2m lower than the alternative 1's 2 percent flood level, there is an opportunity to consider this design aspect.

(v) The river mouth condition in all alternatives is an interesting engineering problem, as even with alternative 1 the effects on the rigime at the river mouth are different. In addition the sea defence works at Telok Kalong will affect the tidal pattern and possibly the location and direction of the sandbar.

There are thus two new situations occuring and it is strongly recommended that a hydraulic model be constructed to make sure that the channel and training banks are correctly aligned. In the case of alternative 3 it may be necessary and even economic to make the deeper section a breakwater of caissons or concrete blocks.

In considering the engineering aspects the same type of works have to be performed but the alternative 3 river mouth is more exposed and will have to be more substantial. In this matter it would appear that alternative 1 has an advantage but it may be a spurious advantage.

(iv) Discussed in chapter 6 but summarized here for this examination is the question of drainage outfall for the surface water.

Alternative 1 requires pumping stations to be installed in the K2 and K3 area and flood gates in the Geliga Bridge only.

Alternative 3 requires only one set of flood gate at the upper most trunk drain on the Kemaman River.

This arrangement of alternative 3 reduces engineering requirements and maintenance considerably.

b) Land use

This is the significant factor in a flood control scheme and is the theme of the study:

(i) There is a shortage of flood-free land

(ii) Development is taking place in flood prone areas.

All alternatives provide the same defense against the 2 percent frequency flood, and in this respect render the same area of flood-prone land to be free from flood. In this respect all alternatives are equal.

In Chapter 7 land development is discussed and it is shown that land reclamation due to alternative 3 is large, and opens up area K5 to direct access from Cukai town. In this respect the alternative 2 and 3 is superior to alternative 1 and 4 which do not have any land reclamation projects.

The difference in land use classification between the existing situation Figure 2.2 and the land use classification for alternatives 3 is shown in Figure 4.13.

In terms of land use classification alternative 3 is superior to other alternatives (see Table 9.3).

c) Community impact

In alternative 1 the existing river only is improved and whilst there are impacts on individual properties there is no community disruption.

In alternative 4 the "short cut" completely severs the Kampung Bukit Mentok, and whilst as a result the kampung can be restored as one community there is dislocation involving temporary housing.

Alternative 2 involves a severance of the kampung Geliga Kechil. In this case only the southern portion is taken in addition to land which is free of houses. This only involves re-housing as the landfill to create a new community can be made of adjacent swamp land under another or early contract, and so the community can remain as one unit.

Alternative 3 has the combined effects of alternatives 2 and 4 and so has the greatest effect on the community.

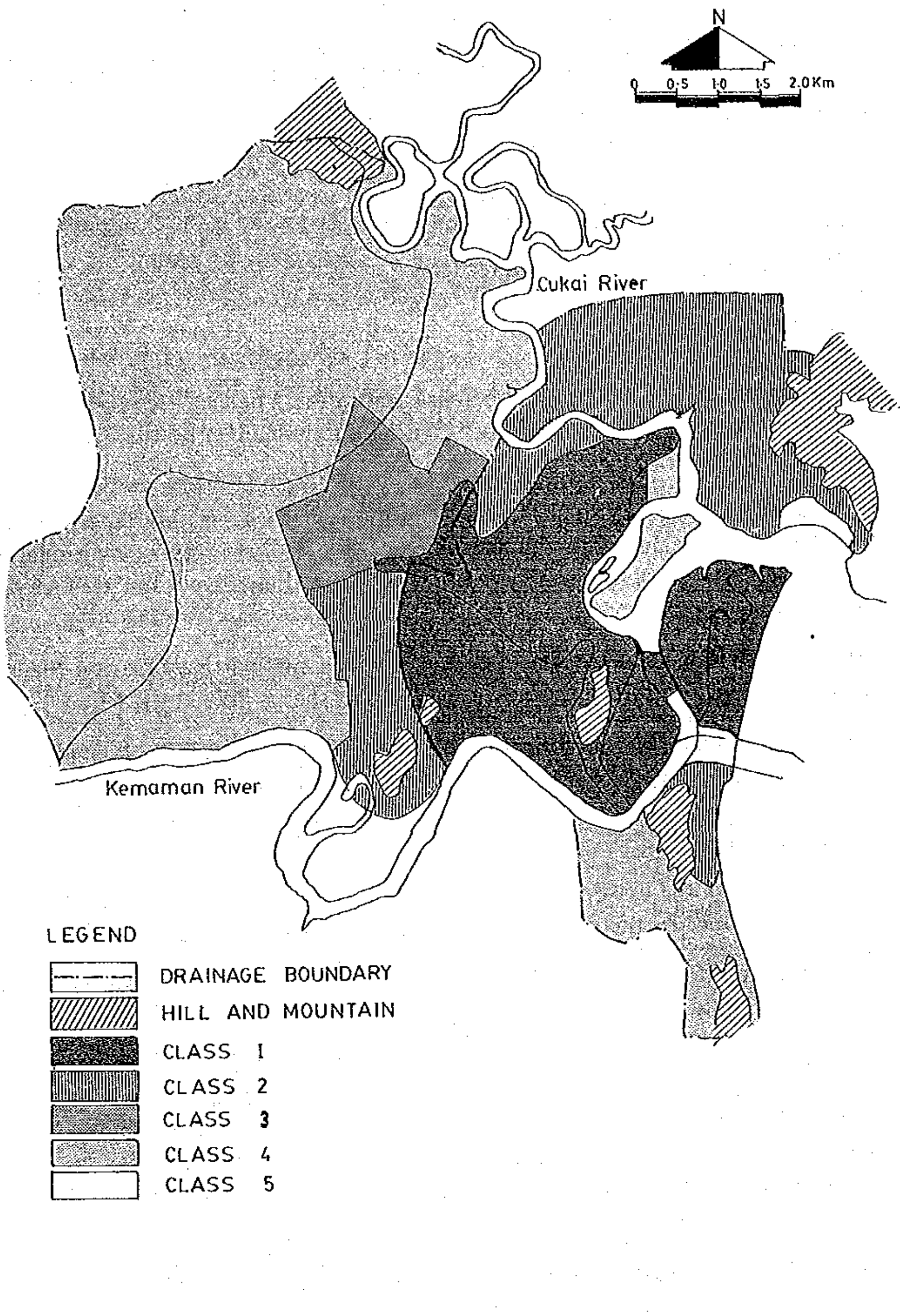


Fig. 4.13 LAND CLASSIFICATION MAP
(After Flood Mitigation Project Alt.3)