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STUDY ON [illegible] IN MALAYSIA

FINAL REPORT

VOLUME I MAIN REPORT

GOVERNMENT OF MALAYSIA

STUDY ON KELANTAN RIVER BASIN-WIDE FLOOD MITIGATION

FINAL REPORT

PART I

MASTER PLAN STUDY

(MAIN REPORT)

NOVEMBER, 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

A List of Reports

1. Executive Summary

2. Master Plan Study
   (Main Report)

3. Master Plan Study
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4. Pre-feasibility Study on Combination Plan
   of Lebir Dam, Kemubu Dam and River Improvement
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5. Pre-feasibility Study on Combination Plan
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6. Additional Survey for 1988 Flood

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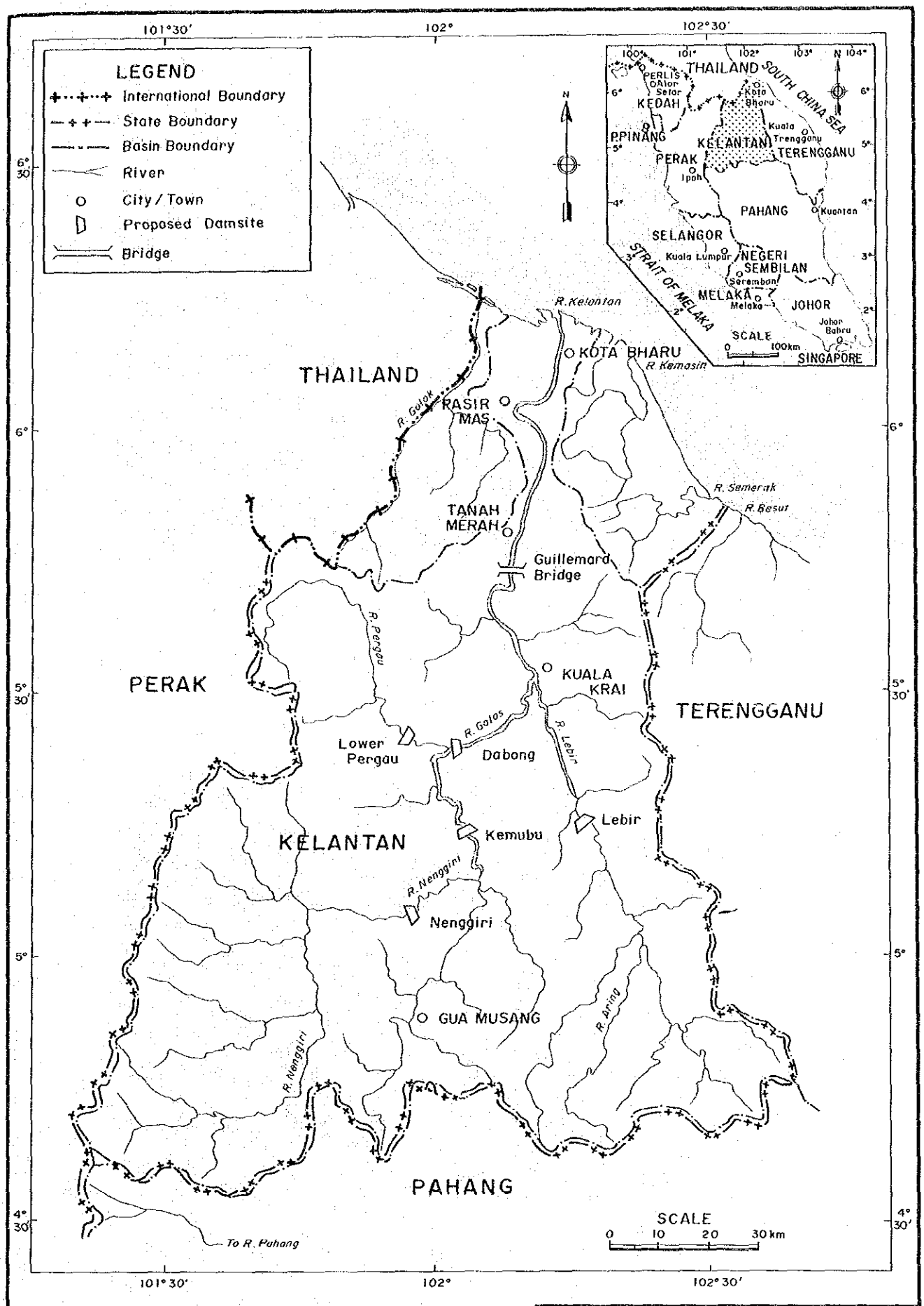
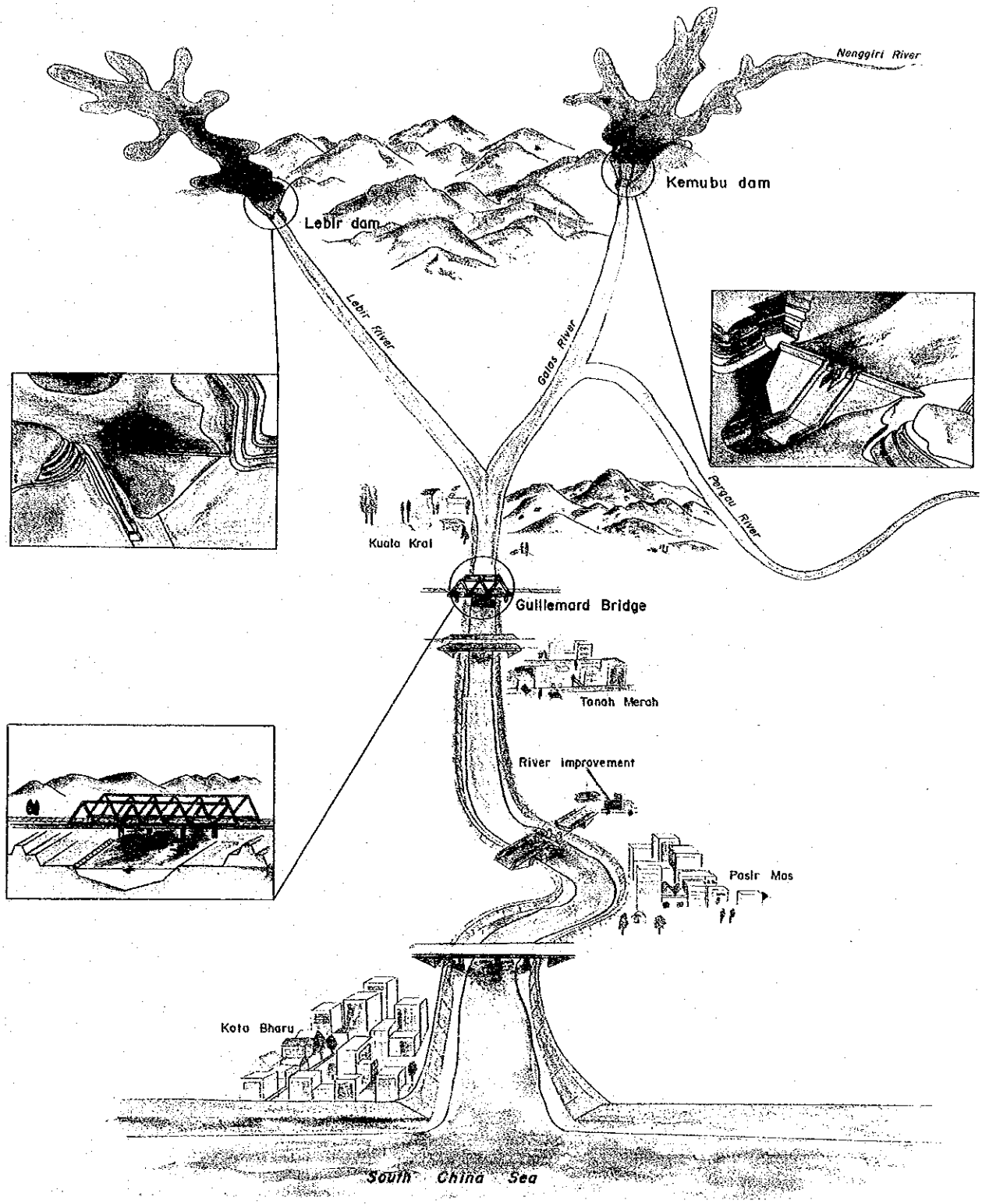


LOCATION OF PROJECT AREA

GOVERNMENT OF MALAYSIA
STUDY
ON
KELANTAN RIVER BASIN - WIDE FLOOD MITIGATION
JAPAN INTERNATIONAL COOPERATION AGENCY

Guillemard Bridge (November 26, 1988)

Kota Bharu Town (November 26, 1988)



Master Plan of the Kelantan River Flood Mitigation

STUDY

ON

KELANTAN RIVER BASIN-WIDE

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ABBREVIATIONS

Domestic Organization

DID (JPT)	:	Drainage and Irrigation Department
DOA	:	Department of Agriculture
DOE	:	Division of Environment
DOF	:	Department of Forestry
DOFS	:	Department of Fishery
DOM	:	Department of Mines
DOS	:	Department of Statistics
EPU	:	Economic Planning Unit
FAMA	:	Federal Agricultural Marketing Authority
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
GSD	:	Geological Survey Department
ICU	:	Implementation and Coordination Unit
JOA	:	Orang Asli Department
KADA	:	Kelantan Agricultural Development Authority
KESEDAR	:	South Kelantan Development Authority
MARDI	:	Malaysian Agricultural Research and Development Institute
MHA	:	Ministry of Home Affairs
MIDA	:	Malaysian Industrial Development Authority
MLRD	:	Ministry of Land and Regional Development
MMS	:	Malaysian Meteorological Service
MNRD	:	Ministry of National & Rural Development
MOA	:	Ministry of Agriculture
MOE	:	Ministry of Education
MOF	:	Ministry of Finance

MOH	:	Ministry of Health
MOPI	:	Ministry of Primary Industries
MPE	:	Ministry of Public Enterprises
MPKB	:	Majilis Perbandaran Kota Bharu
MRRDB	:	Malaysian Rubber Research and Development Board
NDPC	:	National Development Planning Committee
NEB (LLN)	:	National Electricity Board
PORIM	:	Palm Oil Research Institute of Malaysia
PWD (JKR)	:	Public Works Department
RDA	:	Regional Development Authority
RISDA	:	Rubber Industry Small-holders Development Authority
RRIM	:	Rubber Research Institute of Malaysia
SEDC	:	State Economic Development Corporation
S(E)PU	:	State (Economic) Planning Unit
UDA	:	Urban Development Authority

International and Foreign Organizations

ADB	:	Asian Development Bank
IBRD	:	International Bank for Reconstruction and Development
JICA	:	Japan International Cooperation Agency
MOC	:	Ministry of Construction, Japan
WMO	:	World Meteorological Organization

Others

BOD	:	Biochemical Oxygen Demand
CIF	:	Cost, Insurance and Freight
COD	:	Chemical Oxygen Demand
DFWL	:	Reservoir Design Flood Water Level
El.	:	Elevation above Mean Sea Level

Eq.	:	Equation
Fig.	:	Figure
FSL	:	Reservoir Full Supply Level
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
Kg.	:	Kampung
NHWL	:	Reservoir Normal High Water Level
O&M	:	Operation and Maintenance
PMF	:	Probable Maximum Flood
PMP	:	Probable Maximum Precipitation
Ref.	:	Reference
SWL	:	Reservoir Surcharge Water Level

ABBREVIATIONS OF MEASUREMENT

Length

mm = millimetre
cm = centimetre
m = metre
km = kilometre
ft = foot
yd = yard

Area

cm^2 = square centimetre
m^2 = square metre
ha = hectare
km^2 = square kilometre
sq.km = square kilometre
$mile^2$ = square mile

Volume

cm^3 = cubic centimetre
l = lit = litre
kl = kilolitre
m^3 = cubic metre
gal. = gallon
MCM = million cubic metre

Weight

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

Time

s = sec = second
min = minute
h = hr = hour

Electrical Measures

V = Volt
A = Ampere
Hz = Hertz (cycle)
W = Watt
kW = Kilowatt
MW = Megawatt
GW = Gigawatt
kWh = kilowatt hour
GWh = Gigawatt hour

Other Measures

% = percent
° = degree
′ = minute
″ = second
^oC = degree in centigrade
10^3 = thousand
10^6 = million
10^9 = billion (milliard)

Derived Measures

m/s = metre per second
m^3/s = cubic metre per second
cms = cubic metre per second
cusec = cubic feet per second
mg/l = milligram per litre
Mld = million litre per day
kWh = kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
kWh/y = kilowatt hour per year
kVA = kilovolt ampere

Money

M$ = Malaysian ringgit
US$ = US dollar

LIST OF ANNEX

I. INTRODUCTION

1.1 Background

The Kelantan River located in the north-eastern part of Peninsular Malaysia originates from the mountain ridge which is the border with the State of Perak (refer to Location Map). A total catchment area is 13,100 km^2. Meandering the hilly areas in the upper and middle reaches northwardly and collecting major tributaries of the Pergau and Lebir rivers, the Kelantan River comes in the plain where the majority of Kelantan people reside practising agriculture.

Although the Kelantan River brings enormous benefits to the people as a water source of water supply, irrigation, power generation and so on, the people lived in the downstream reaches on the other hand suffer from habitual flooding.

Especially, rainstorms occurred in January, 1967 caused an overflow of the Kelantan and its adjacent rivers including tributaries, resulting in inundation of the entire coastal area of the Kelantan State. According to the Flood Report of 1967, the inundation area spreads over 3,000 km^2 which is equivalent to 20 percent of the Kelantan State area. Inhabitants of 540,000, 85 percent of state population of 637,000, including the evacuated persons of 125,000 suffered from flooding, and damages were estimated to be a historical maximum.

Furthermore, the floods with double peaks hit the downstream area on November and December of 1988, causing the evacuation of 36,800 people with 19 death toll and the damage of M$27 million according to the survey carried out in this study.

Annually repeating floods of the Kelantan River bring not only extensive economic losses and human sufferings, but also the threat of floods contributes to such negative psychological attitudes that farmers tend to be reluctant to adopt modern agricultural technology, and industrialists would refrain from investing in flood-prone areas.

In this circumstance, the Government of Malaysia requested to the Government of Japan technical assistance to formulate a basin-wide flood mitigation plan of the Kelantan River. In response to the request of Government of Malaysia, the Government of Japan sent a mission to Malaysia on November, 1987, and it was agreed by both governments that the study to formulate a basin-wide flood mitigation of the Kelantan River would be carried out under the Japanese technical assistance.

The study to formulate a basin-wide flood mitigation plan was commenced in April, 1988 under the cooperative work of Drainage and Irrigation Department (DID) and Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of technical cooperation programmes of the Government of Japan.

1.2 Objectives of the Study

The objectives of the study consist of the following:

(i) To formulate a basin-wide flood mitigation plan for the Kelantan River basin in the State of Kelantan, and

(ii) To perform pre-feasibility study for the major structures selected in the basin-wide flood mitigation plan.

In formulating the basin-wide flood mitigation plan for the Kelantan River basin, the study is approached by two ways; that is, one is to search the flood mitigation plan of the Kelantan River basin by giving the even weight between the flood mitigation plan and water resources development. The other way is to look for the flood mitigation plan placing high priority on itself. The selection of former or latter plan as the basin-wide flood mitigation plan for Kelantan River basin is based on the comprehensive judgment taking into account the social impact, flood mitigation efficiency and budgetary constraint as well as project viability.

Another implicit objective of the study is transfer of technology, which could be effected through field work in Malaysia and the invitation of a few key Malaysian staff concerned in the study to Japan for training. In view of the technical cooperation policies of Japan, this is in fact an essential objective of the study.

The basic concept for tackling the flood mitigation study of the Kelantan River was discussed in the seminar on flood mitigation held on November 1988 under the sponsors of DID and JICA as part of transfer of technology. Furthermore, a workshop was held on June 1989 to learn the application of hydrological model used in this study.

1.3 Work Progress

The study to formulate a basin-wide flood mitigation plan for the Kelantan River was initiated in April, 1988 with a dispatch of the JICA study team to Malaysia. After the arrival, a meeting was held in Kuala Lumpur to discuss the Inception Report, which outlines the methodology and time schedule for the study.

The study team moved and stationed at DID Kota Bharu office for carrying out field work, in which basic data and information on topography, hydrology, geology, socio-economy, environment and so on were collected and analysed for the formulation of basin-wide flood mitigation plan. Furthermore, basic ideas for the flood mitigation were studied considering water resources development of the Kelantan River. During the field work, Progress Reports 1 and 2 were submitted on July and September 1988, respectively.

The study team returned to Japan at the end of September 1988, and subsequently home work was commenced to formulate the basin-wide flood mitigation plan of the Kelantan River availing all the data and information collected in Malaysia. The Interim Report, which discusses the flood mitigation plan of the Kelantan River taking into account its water resources development stressing on hydropower generation as well, was submitted to the Government of Malaysia on March 1989.

During the discussion of the Interim Report, a problem to minimize the social problem caused by the creation of reservoirs was raised in formulating the flood mitigation plan for the Kelantan River basin, so that an additional study was carried out placing the high priority to formulate the flood mitigation plan itself.

Progress Report No. 3, submitted on May 1989, deals with the additional study for the formulation of flood mitigation plan in the Kelantan River basin. During the discussion of Progress Report No. 3, a plan combining the Lebir and Kemubu dam schemes and river improvement was selected as the one for the flood mitigation of the Kelantan River basin.

The pre-feasibility study for those schemes was carried out for assessing the project viability in more detail. This Final Report deals with the formulation of basin-wide flood mitigation in the Kelantan River as well as the pre-feasibility study for the Lebir and Kemubu dam schemes and river improvement.

1.4 Content of Report

The report in this study consists of five parts. Part I consisting of main and supporting reports deals with the formulation of a basin-wide flood mitigation plan in the Kelantan River basin.

Part II consisting of main and supporting reports discusses the pre-feasibility study of Lebir and Kemubu dam schemes as well as river improvement. The specification on the study of river mouth treatment, which will be carried out in future, is also mentioned in ANNEX VII of Part II. Part III deals with the survey for 1988 flood.

Part IV contains the survey result of geological investigation carried out at the Kemubu and Dabong damsites. Meanwhile, the result of longitudinal and cross-sectional survey carried out between Kuala Krai and the estuary is compiled in the Data Book (Part V). The Executive Summary briefs the major outcomes in this study.

II. PROJECT AREA

2.1 The Kelantan River Basin

The Kelantan River basin with a catchment area of 13,100 km^2 locates in the northeastern part of Peninsular Malaysia, occupying more than 85% of the Kelantan State (refer to Location Map). The basin is bounded by the State of Perak and Thailand on the west, by the State of Pahang on the south and by the State of Terengganu on the east. The northern part of the basin faces the South China Sea.

The Kelantan River is divided into the Galas and Lebir rivers just at the upstream reach of Kuala Krai, about 100 km upstream from the river mouth. The Galas River is further divided into the Nenggiri and Pergau rivers. The Nenggiri River originates from the central mountain range in the southwestern part of the State of Kelantan, and flows down northeastward collecting many tributaries and changing its name to the Galas River.

The Galas River joins the Pergau River near Dabong, flows down eastward and joins with the Lebir River which originates from the Taban mountain range. After joining the Lebir River with the Galas River, the river changes its name to Kelantan and flows down northward passing along such major towns as Kuala Krai, Tanah Merah, Pasir Mas and Kota Bharu, finally debouching to the South China Sea near Kota Bharu. A total river length is about 360 km.

2.2 Natural Conditions

2.2.1 Meteorology and hydrology

(1) Meteorology

The climate in the State of Kelantan is characterized by the seasonal monsoon. The north-east monsoon, which prevails mainly from October to December, brings heavy rainfall in the coastal plain. Around 50 percent of annual rainfall, which is about 2,700 mm, occurs in the coastal plain on an average during these three months. This downpour in this period causes habitual flooding in the downstream areas of the Kelantan River, resulting in suffering from flood damages.

In the upstream river basin, however, there is no distinctive rainy season because of the rain shadow effect under the lee of coastal plain and the south-west monsoon which is generally less vigorous than the north-east monsoon, prevailing from May to September.

The mean annual temperature at Kota Bharu (5m a.m.s.l) is 26.7°C on January to 27.9°C on May. The variation of temperature depends upon a diurnal change ranging from 23°C at 6 o'clock in the morning to 30°C at 2 o'clock in the afternoon.

According to the data at Tanah Rata meteorological gauging station (1,470 m a.m.s.l) which locates in the State of Pahang about 20 km south from the state boundary of Kelantan and Pahang, the mean annual temperature is 18.1°C on an average and there is also a slight seasonal change ranging from 17.4°C on January to 18.8°C on May.

As well as the pattern of monthly average temperature, there is no significant change of relative humidity throughout the year. The annual mean relative humidity at Kota Bharu is 81% ranging from 79% on March to 86% on November, whilst 87% varying from 83% on February to 90% on November at the Tanah Rata station.

Daily sunshine hours have been recorded at the Kota Bharu and Tanah Rata stations. The annual mean daily sunshine hours are about five hours at Tanah Rata and about seven hours at Kota Bharu.

Average surface wind velocity is relatively low ranging from 0.24 m/sec at Kg. Lalok and 1.1 m/sec at Tanah Rata. The fastest instantaneous wind velocity of 45.9 miles/hour (20.5 m/sec) was recorded during the flood in 1967 at Kota Bharu on January 5, 1967.

According to the data collected in and around the State of Kelantan, the annual pan evaporation amount is 961 mm at Tanah Rata and 1,749 mm at Kota Bharu.

(2) Hydrology

The Kelantan River is generally characterized as the river with ample flow replenished by abundant rainfall of the basin. The mean flow of the Kelantan River is 540.6 m^3/sec at Guillemard Bridge, a stream gauge located just upstream of Tanah Merah, over the period of 1961 to 1984, which is equivalent to the annual runoff of 1,411.3 mm for the catchment area of 12,080 km^2.

The seasonal variation of flow shows the lowest level in April with an average of 282.2 m^3/sec, whilst the north-east monsoon occurred between November and December brings the highest rate of runoff with an average of 1,121,8 m^3/sec. The period of July and August has slightly high flow of 315.0 m^3/sec.

2.2.2 Geology

The topographic features of the Kelantan River basin are characterized by geological strata running from the south to the north direction as shown in Fig. 2.1. High mountain ranges located at the eastern, western and southern sides of the basin make a border with the State of Terengganu and the State of Perak and Thailand, respectively.

A geological map of the Kelantan River basin is given in

Fig. 2.2. High mountains running from east to west through the southern part of the basin consist mainly of granites which are intruded at the Palaeozoic-Tertiary age. The massive and sound granites shape the steep mountain slopes.

The hilly areas extended in the middle reaches are predominated by the Palaeozoic-Mesozoic rocks comprising sandstones, shales, limestones, tuffs and volcanics, which are very often metamorphosed regionally into phyllites and slates and further into crystalline schists. Thermal metamorphism due to the granite intrusion is often observed in the formation of hornfels. Particularly, phyllites, slates and schists are deeply weathered because of plenty of cracks and foliations.

Limestones with strong resistance to weathering form the high pinnacles with some caves in these bodies. Granitic masses intruded sporadically in the hilly areas are generally small in size and without tendency to expand.

Geological structure runs north-south or northwest-southwest. The axes of folding and major faults also orient these directions, but are sometimes intersected by other groups of faults tending northeast to southwest.

The flat areas of downstream reaches situated in about 40 km long endmost river stretches consist of the alluvial deposits comprising mainly sand, silt and clayey soil, and form the soft ground. Dunes formed with coarse sands carried by the westward littoral current are developed with the 10 km wide band from the coastline, especially at the estuary of the Kelantan River.

(1) Upstream Reaches

Most parts of the upstream reaches forming high mountainous ranges (refer to Figs. 2.1 and 2.2) consist mainly of granites except for the southern part dominated by the Palaeozoic-Mesozoic rocks. These granites are massive and sound, shaping the steep mountain slopes with waterfalls and rapids.

Granitic activities have been indicated in four periods at least by Rb/Sr radiometric datings. The earliest one is in the Late Carboniferous (300-285 million years), followed by two granite emplacements occurred in the Triassic; the Early Triassic (230 $\pm$ 6 million years) and Late Triassic (199 $\pm$ 2 million years). The latest granites intruded at the beginning of the Tertiary (75 $\pm$ 1 million years) occur as isolated stocks and dykes.

The granite is often sheared and gneissic, particularly near its contact with the adjoining rocks. Sheared planes generally strike in a northerly direction. On the other hand, weathering of the granites is not supposed to develop intensively except for the gentle slopes around the border with the hilly areas.

(2) Mid-stream Reaches

The hilly area extended in the middle reaches consists mainly of the Permian and Triassic rocks, comprising phyllite, slate, shale, limestone, tuff, volcanics and metamorphic rocks. Due to metamorphism widely spread in the region, most of the Permian and Triassic rocks are deformed slightly to moderately. In general, the older rocks show a greater degree of metamorphism than the younger ones.

The distribution of Permian and Triassic rocks is complicated. These strata, however, have almost same direction of north-south or northwest-southeast.

The Permian rocks are classified into four groups; arenaceous rocks, argillaceous rocks, volcanic rocks, and metamorphic rocks. Metamorphic rocks consisting mainly of schists with developed foliation are distributed in the strip area from the vicinity of Terowong 20 km southeast of Dabong to Tanah Merah 30 km downstream of Kuala Krai. These schists named "Taku schists" comprise mica-garnet schist, quartz schists and amphibole schists.

Volcanics consist of acid volcanics and basic volcanics. Acid volcanics comprising tuffs, agglomerates and rhyolites together with subordinately intercalated shale and quartzite predominate in the southeastern part of mid-stream reaches. Basic volcanics consisting mainly of tuffs, andesite and agglomerate with minor interbedded shale are distributed in the western part of hilly area and form long and narrow strips.

Argillaceous and arenaceous rocks occur mainly in the centre of hilly areas with limestones. These rocks due to metamorphism develop many foliations.

Limestones predominating in the area between the Lebir and Galas rivers form spectacular cliffs standing vertically or overhanged. Near the contact with granite masses, limestones are changed to crystalline marbles showing considerable variation in the grain size.

On the other hand, the Triassic rocks consist mainly of shales with mudstones. Sandstones/metasandstones, conglomerates, tuffaceous varieties and limestones are sporadically included in these Triassic rocks. The shales with grey to black colour are generally thinly laminated and strongly fissile.

Dykes formed from quarts, porphry, aplite, pegmatite and microgranite sporadically occur in the schists and sedimentary rocks, being massive and sound in general. Faulting is common in all rocks.

Major faults strongly trending in the north-south or northwest-southeast direction are sometimes intersected by other groups of faults trending in the northwest to southwest direction. One of long-ranged major faults with a north-northwesterly trend is located on the right bank of the Lebir River, running parallel to the river course. Minor faults are commonly found in association with foldings.

(3) Downstream Reaches

The downstream reaches shown in Figs. 2.1 and 2.2 are characterized by lower hilly area from Kuala Krai to Kg. Kemubu and flat alluvial plain area from Kg. Kemubu to the river mouth. The lower hilly area consists of Permian-Triassic sedimentary rocks and granites which have same geological conditions as the rocks distributed in the mid-stream reaches.

Flat alluvial plain area consists of alluvial deposits classified into marine deposits and fluviatile deposits, although it is not always possible to demarcate two types of deposits. The underlying bedrock consists mainly of the Permian sedimentary rocks and granites. The depth from the ground surface to the bedrocks is in 100 to 200 m at the estuary of the Kelantan River and gradually shallow towards the upstream area of the river.

Marine deposits are composed of coarse sand containing shell fragments. Raised beaches and dunes, which are one of marine deposits and characterize the coastline, are formed by the westward littoral current. Around the mouth of the Kelantan River, many swamps are formed behind the ranging dunes due to poor drainage. Clayey soils with soft ground are predominant as the top soil of swamp areas.

On the other hand, fluvial deposits are composed of gravel, sand, silt, clay and their alternation. Medium-coarse sand with gravel is occasionally observed at the dunes in the riverbed or at the inner bank where the Kelantan River largely bends, but the river alluvium is more commonly represented by bands of stiff clay, thinner bands of silt and irregular beds of decayed vegetation. The change of river courses due to flooding causes the considerable complication in the river alluvium.

2.3 Socio-economy

2.3.1 Administrative divisions

Malaysia with a land area of 329,745 km^2 is composed of Peninsular Malaysia and the two Regions of Sabah and Sarawak. Peninsular Malaysia is divided into Northern, Central, Eastern and Southern Regions. The State of Kelantan belongs to Eastern Region and is one of eleven States in Peninsular Malaysia.

The State of Kelantan normally divided into North and South Kelantan is composed of ten Districts as shown in Fig. 2.3; Bachok, Kota Bharu, Machang, Pasir Mas, Pasir Puteh and Tumpat in North Kelantan and Tanah Merah, Jeli, Gua Musang and Kuala Krai in South Kelantan. Each District comprises several Daerahs, the number of which reaches 67 in the whole of the State. Under each Daerah there are several Mukims.

There is a District Office in each District. Kota Bharu is the capital of Kelantan as well as the development centre of

North Kelantan. Gua Musang is on the other hand the development centre of South Kelantan. Other major towns are Bachok, Machang, Pasir Mas, Pasir Puteh, Tanah Merah, Rantau Panjang, Jeli, Tumpat, Kuala Krai, Chiku, etc. Six Daerahs including Bandar Kota Bharu in Kota Bharu District are under the jurisdiction of MPKB (Majilis Perbandaran Kota Bharu) or Kota Bharu Municipal Council.

2.3.2 Population

The population of Kelantan is estimated at 1,091,756 in 1988 as shown in Table 2.1. District-wise, Kota Bharu District has the biggest population of 357,995, accounting for 32.8% or almost one third of the State population. Out of them, the population under the jurisdiction of Kota Bharu town council, MPKB, is estimated at 224,719 in 1988, constituting 20.6% or one fifth of the population of Kelantan. The population of Pasir Mas District is 142,867, which is placed second and accounts for 13.1%. The third place is occupied by Tumpat District, whose population of 104,492 accounts for 9.6% of the State population. Gua Musang District has the smallest population of 28,198, corresponding to 2.8% of the total population in Kelantan. The population of Jeli District is 37,120, which is the second smallest, sharing 3.4% of the State population.

The population of Kelantan grew during the last inter-censal period of 1970 to 1980 at the average annual rate of 2.6% (refer to Table 2.1). It is estimated that population is growing at the average annual rate of 2.5% since 1980.

Applying the average annual growth rate for population of 2.5%, the State population is forecasted to grow from 893.8 thousand in 1980 to 1,147.0 thousand in 1990, 1,468.3 thousand in 2000 and 1,879.5 thousand in 2010.

There is a difference in the pace of population growth among Districts. The population of Jeli District is growing at the fastest average annual rate of 5.4% since 1980. The population of Gua Musang District is also growing fast at the annual rate of 4.8%. Population growths in all Districts in South Kelantan are greater than the State average. Thus, the average annual growth rate in the whole of South Kelantan works out at 3.8% from 1980 to 1988.

In contrast, population of all Districts in North Kelantan except Kota Bharu District is growing at a lesser rate than the State average. Especially low growths of population are witnessed for Machang and Pasir Puteh Districts in these two decades: Average annual growth rates are 1.5% and 1.6% respectively. The population in the whole of North Kelantan is growing at the average annual rate of 2.2% since 1980. The population of Kota Bharu District has grown at an average annual rate of 2.8% from 1980 to 1988, while a slightly higher rate of 2.9% for the area under MPKB.

The population of Districts and Daerahs was forecasted based

on the growth rates of population by Daerah during the last inter-censal period of 1970 to 1980. The population of North Kelantan will increase from 859.4 thousand in 1988 to 1,354.4 thousand in 2010, whilst 232.4 thousand in 1988 to 525.0 thousand in 2010 for South Kelantan. The population of Kota Bharu District is estimated to reach 658.2 thousand in 2010 from 358.0 thousand in 1988. During the same period the population of area under MPKB which forms the core of the District population will grow from 224.7 thousand to 429.6 thousand.

2.3.3 Gross domestic product

The Gross Domestic Product (GDP) of Kelantan for 1988 is estimated at M$2,684.4 million at market prices, while GDP of Malaysia is estimated at M$78,458 million at market prices for the same year. Therefore, the State GDP as percentage of the national GDP is 3.4%. This ratio is much smaller than the populational ratio of 6.4% as well as the areal ratio of 4.5%. Kelantan is implied to be economically a "developing" State in Malaysia.

Sector-wise, the agricultural, forestry and fishery sectors will produce an amount of M$772.3 million in 1988, accounting for 28.8% of the State GDP. This sector is the single biggest contributor to the economy of the State. The government services sector is placed second, producing M$677.9 million and sharing 25.2% of the State GDP. The third and fourth places are occupied by the banks, insurance and real estates sector and the transport, restaurants and storage sector, respectively. The added value of the former will be M$334.0 million, accounting for 12.4% of the State GDP. And that of the latter will be M$273.3 million, accounting for 10.2% of the State GDP. The manufacturing sector's contribution to the economy of Kelantan is confined to 4.5%.

Summing up, the industrial structure of Kelantan is estimated at 28.8% for the primary industry, 11.0% for the secondary industry and 60.2% for the tertiary industry in 1988, while 21% for the primary industry, 37% for the secondary industry and 42% for the tertiary industry in the nation in the same year. One striking feature of the State economy is that the secondary sector is in the low level compared with the primary sector.

The contribution of primary industry to the State employment is 48.3%, while the same sector's contribution to the State economy is 28.8%. It means that the labour productivity of the primary industry in the State is in a great degree lower than the State average. Also, the secondary industry's share in the State employment is 15.5%, while the same sector's share in the State GDP is 11.0%. It implies that labour productivity of the secondary industry in the State is markedly lower than the State average. The tertiary industry is estimated to produce the added value corresponding to 60.2% of the State GDP with an employment constituting 36.2% of the State workforce.

In a nutshell, the economy of Kelantan is characterized by two aspects; that is, a primary industry which is given a priority in the State economy as well as a secondary industry which is not given a proper place in the State economy suffers from low productivity.

Looking back to the past, economy of Kelantan grew from M$679.9 million to M$1,668.6 million during the last decade of 1970 to 1980 at an average annual rate of 9.4%. Malaysian economy made a remarkably rapid progress amidst favourable international environment for external trade during that period. Now that the circumstances have changed, it is neither reasonable, nor practical to expect a growth rate of the same order.

According to the SEPU forecast in "5th Malaysia Plan for Kelantan", the state economy will grow from M$1,668.6 million to M$3,060.0 million during the period of 1980 to 1990 at an average annual rate of 6.25%. The JICA Study Team assumed that the slightly lower growth rate of 6.0% would be appropriate from 1990 onward. Applying this assumption, economy of Kelantan is forecasted to grow from M$2,684.4 in 1988 to M$9,816.8 million in 2010.

Living standard of Kelantan in terms of per capita GDP for 1988 is calculated at M$2,459 at 1988 prices. The amount is almost equal to US$1,000 at the exchange rate of M$2.50 to US$1.00. It is equal to or higher than per capita GDP's in most of other ASEAN countries. However, it may be about one half of the national average. It is expected to grow from M$2,459 in 1988 to M$5,223 in 2010 (1.8 times) at an average annual rate of 3.4%.

2.3.4 Agriculture and other sectors

(1) Agriculture sector

Supporting 70% of population, employing 50% of workforce, producing 30% of GDP and using 20% of land area, the agricultural sector plays and will continue to play a major role for the socio-economy of the State.

There are four main crops, i.e. paddy, tobacco, rubber and oil palm. Paddy is the most important crop in the State with the annual planted area of around 70,000 ha and the annual production of about 200,000 tons. The State's share to national paddy production with around 1.5 million tons a year is therefore as much as 13.5%. Paddy is not only consumed within the State, but also exported to other States.

Tobacco is grown under the Federal guidance to lift the economic status of the farmers concerned. Green tobacco leaves of 7 to 9 million tons are annually produced with the planted area of around 10,000 ha. National quota is more or less 10 million tons, resulting in the Kelantan's share of 80% or so to the total production of tobacco.

Rubber is one of traditional crops in the State. Now replanting of the crop is in progress, and 60% out of 130,000 ha has been replaced with young plants. The State shares about 30% to the total production of rubber with the annual average production of 45,000 tons.

Oil palm is grown like rubber mainly for export. For the past 20 years the planted area of oil palm has grown to 60,000 ha at an average annual rate of 24%: In 1988, Kelantan is estimated to produce 84,000 tons of palm oil, which will correspond to 1.7% of the total production in Malaysia.

Paddy and tobacco are mostly grown in North Kelantan. Whereas major plantations of rubber and especially oil palm are found in South Kelantan. Other important crops are coconut, cocoa, groundnut, vegetables, fruits and so on.

Livestocks, a non-crop product belonging to the primary industry, are important as a supplementary income source to the farmers in Kelantan. In 1988, the State is estimated to have cattle and buffalo population of around 130,000, which will correspond to 15% of the said population over the whole Malaysia. Up to 1988, grazing reserves of 4,178 ha have been developed.

(2) Industry, and commerce and service sectors

In 1988 the manufacturing industry in Kelantan is expected to produce the added value of M$120.9 million and to employ workforce of 23,954. GDP and employment of the manufacturing industry are estimated to be 4.5% and 7.3% for the State total respectively.

Most of the manufacturing industries in the State fall under the category of the so-called agro-industry or the like, i.e. wood, rubber, food and tobacco industries. Undergoing only a primary processing, the resultant products are not high in terms of the added value.

The number of registered industrial establishments in the State is estimated at 624 for 1988 and the average number of workers per such an establishment is 25. Actually, it is estimated that there exist about 5,000 establishments when the so-called cottage industries are taken into account. Then, the average number of workers per establishment is reduced to 5.

In 1988 commerce and service industries in Kelantan are expected to produce the added value of M$824.5 million with the total employment of 50,537. The industries comprise wholesale, retail, transport, restaurant, storage, banks, insurance and real estate. GDP and employment are estimated to be 30.7% and 15.4% for the State total respectively. The estimated number of establishments under this sector is 8,854 and the number of workers per establishment works out at 6.

(3) Infrastructure

Infrastructural deficiency in both quantity and quality has been habitually cited as one of major factors retarding the economic growth of the State. It is said that isolation of the State is confined to the traditional agriculture-based self-sufficient economy. The Government has persistently placed the highest priority on infrastructural development against such background.

Road length in 1987 is 2,004 km, out of which 1,225 km is State roads and 749 km is Federal roads. Noteworthy events for the last a few years are the development of the Kuala Krai-Gua Musang-Kuala Lipis Highway, Jeli-Dabong-Gua Musang road and East-West Highway. The Kuala Krai-Gua Musang-Kuala Lipis Highway links the northern sub-region with the southern sub-region as well as with other States. The construction of the Jeli-Dabong-Gua Musang road connects the Sg. Pergau - Sg. Galas Valley with the new growth centre of Gua Musang, and the opening of the East-West Highway links not only Kelantan but also the East Coast with the northern West Coast of Peninsular Malaysia.

Railway runs in parallel with the Kelantan River starting from Tumput down to Gua Musang and beyond. The total length within the State is 207 km. Besides the highway and railway networks, there is a air system, which connects Kota Bharu with major cities in Malaysia with several daily flights.

Out of the urban population of 216,000 in the State, 140,887 or 65.2% were served with urban water supply in 1985. Likewise, out of the rural population of 789,480, 189,392 or 24.0% were served. The total average service ratio works out at 32.8%. Per capita daily consumption was 137 litres. The existing water sources are groundwater and the Kelantan River water.

An electricity supply network is linked to the National Grid. The ratio of households with electricity supply in Kelantan was 62.8% in 1985. The number of electricity consumers was 186,110 as of 1987.

2.4 Land Use

2.4.1 Present land use

Present land use is depicted in Fig. 2.4. As of 1988, 74.4% of the State, 1,504,009 ha, is covered with forest, and another 21.3% is planted with agricultural crops; that is, 95.7% of the State area is occupied by forest and agricultural lands.

Out of 320,583 ha of agricultural land areas in 1988, 129,413 ha or 40.4% is the rubber plantation area, followed by 71,248 ha or 22.2% of paddy fields and 61,261 ha or 19.1% of oil palm plantations. The combined acreage of these three major crops works out at 261,922 ha, accounting for 81.7% of the total State agricultural land area.

During the period of 1966 to 1981, rubber acreage grew from 91,285 ha to 142,209 ha at an average annual growth rate of 3.0%. Since 1981, however, the outward expansion of rubber land has stopped. And now an emphasis is placed upon the intensive utilization of the existing rubber areas by replanting. Now 60% of the total State rubber area has been replanted with young trees. Even distributed all over Kelantan, rubber areas are especially concentrated in the three southern Districts of Kuala Krai, Tanah Merah and Gua Musang. 65% of the total State rubber area is located in South Kelantan.

During 22 years from 1966 to 1988, oil palm plantations have multiplied 123 times from 497 ha to 61,261 ha. This trend will be kept up into future. District-wise, 74.6% of the total oil palm areas in the State are only shared by Gua Musang District. South Kelantan's share of oil palm acreage reaches 96.9%.

Paddy as well as timber and livestocks has an important role in the agricultural economy of the nation. Paddy area is rather on the decrease in statistics, because agricultural policy towards paddy has revolved around intensive use of the existing areas through modern agricultural technology such as irrigation, fertilizers, pesticide and improved variety of seeds. Paddy fields are distributed all over Kelantan, but three Districts of Pasir Mas, Kota Bharu and Pasir Puteh distinguish themselves with more than 10,000 ha of paddy areas. North Kelantan shares 89.5% of total paddy areas in the State.

Tobacco is normally grown in paddy areas. The acreage of tobacco for 1988 is 8,219 ha. Although there are fluctuations in the yearly acreage of tobacco, a trend is rather upward. District-wise, Bachok, Pasir Puteh and Pasir Mas have the acreage of more than 1,000 ha. North Kelantan dominates in tobacco planting areas with the share of 95.8%.

The Government is making a great effort to develop grazing reserves considering the important place of Kelantan in livestock farming. As of 1988, 4,178 ha has been developed, of which 2,385 ha or 57.1% belongs to Pasir Mas District. North Kelantan shares 89.9% of pasture reserves.

The rather even distribution of agricultural land as a whole over the ten Districts is striking. Also, it is noteworthy that agricultural land is almost evenly shared by North and South Kelantan, although the comparative position of agriculture between two sub-regions is different. The area for agricultural land has grown at an average annual rate of 1.9% during the period of 22 years from 1966 to 1988.

Forest is decreasing along with grasslands and swamps at an average annual rate of 0.4% since 1966. The trend will be maintained or intensified in future as the economic development of Kelantan progresses. As of 1988, South Kelantan possesses 95.6% of the total forest and related area in the State, most of which falls under Gua-Musang District.

Urban and associated areas composed of urban, estate

buildings, mining and power line and other associated areas are estimated at 5,365 ha as of 1988, accounting for 0.4% of the total State land area. They have grown at an average annual rate of 2.2% from 1966 to 1981. It is assumed that the same rate can be applied since 1981. The rate is a little lower than 2.5%, which is the estimated average annual growth rate of the State population during the same period. Population density in the urban areas may be rising. District-wise, Kota Bharu with 2,381 ha occupies 44.4% of the total State urban and associated area.

2.4.2 Future land use plan

(1) Urban development

Urban areas will continue to expand in future due to the migration of rural population seeking better employment opportunities as well as to the natural increase of urban population.

The jurisdiction of MPKB only covered Bandar Kota Bharu (Kota Bharu Town) was extended in 1978 by absorbing five neighbouring Daerahs (Sub-district) of Badang, Kemunin, Panji, Lundang, and Kota. The area managed by MPKB was at the same time declared to be urbanized as the development centre of the State.

The development plan of MPKB toward year 2000 as given in Fig. 2.5 consists of three development centres with corridors; Bandar Kota Bharu, Kubang Kerian and Pengkalan Chepa. Bandar Kota Bharu will have a function as a pivot of these three development centres as well as the centre of commerce and trading.

The development of Kubang Kerian includes the residential and industrial areas as well as Istana Negeri (State Palace) and the campus and hospital of Science University of Malaysia. The development centre of Pengkalan Chepa area will be an airport with the industrial estate, army camp and residential area.

According to the information from the Town and Country Planning Department there is no definite development plan at this moment for the major riverine towns of Pasir Mas, Tanah Merah and Kuala Krai besides Kota Bharu.

(2) Rural development

The persistent policy of the Government is to narrow down the gap in the standard of living and basic amenities existing between Kelantan and other States.

Agriculture and forestry sectors form the nuclei to achieve socio-economic parity for the Kelantan people. The centerpiece for the development of North Kelantan is more intensive use of agricultural land along with diversification of crops. The development strategy for South Kelantan centres on more extensive use of land for agriculture as well as more systematic approaches

for the preservation and utilization of forest.

According to the government policy, rice production will be concentrated on the granary areas; that is, paddy lands in Kelantan will be developed only in the KADA project area as one of eight granary areas in Malaysia. KADA's policy target during the 5th Malaysia Plan period is to increase paddy yields by 0.1 ton per ha per year. Furthermore, the development of KADA granary area is still in progress with the target level of 500 ha a year.

Development of oil palm plantations in South Kelantan will be further stepped up, and oil palm acreage will jump up from 61,261 ha in 1988 to 140,013 ha in 2010 along such rivers as the Galas and Lebir rivers, which would be almost maximum. Thus, the share of oil palm acreage in the total State areas will rise from 4.1% to 8.0%.

2.5 Floods and Damages

2.5.1 Present river conditions and characteristics

After the confluence of the Galas and Lebir rivers (refer to Location Map), the Kelantan River flows down to the flood-prone area. The riverbed slope in these stretches is about 1:6,000. The river channel forms a single cross-section with the width of about 300 m to 900 m and bankful depth of about 5 m to 15 m as shown below and further details are given in Fig. 2.6:

Section	River width,m	Bankful depth,m
Estuary to Pasir Mas (25 km upstream from the estuary)	600 to 900	5 to 10
Pasir Mas to Tanah Merah (55 km upstream from the estuary)	500	10 to 12
Tanah Merah to Kuala Krai (101 km upstream from the estuary)	300	10 to 15

Flow capacity of the Kelantan River was computed by means of non-uniform flow calculation using the cross-sectional maps with an interval of 1 km newly prepared in this study. There are several places in the downstream reaches of Pasir Mas with the bankful flow capacity of less than 5,000 m^3/sec as illustrated in Fig. 2.7, and the present bankful flow capacity at several major points is summarized as follows:

River stretch	Flow capacity (m^3/sec)
Kota Bharu	4,500
Pasir Mas	6,600
Tanah Merah	10,200
Guillemard Bridge	11,000
Kuala Krai	10,500

It is noted that the bankful flow at Kuala Krai shows the capacity of the other bank, since the inundation takes place at the other bank of Kuala Krai at first. Thus, Kuala Krai is free from the bigger flood than 10,500 m^3/sec.

Probable peak discharges at Guillemard Bridge, a railway bridge spanned the Kelantan River upstream of Tanah Merah, were estimated using annual maximum peak discharges observed in the period of 1941 to 1986 as given in Table 2.2 and the Gumbel's probable distribution function as follows:

Return Period (year)	Probable Peak Discharge (m^3/sec)
200	20,700
100	18,500
50	16,300
30	14,700
20	13,400
10	11,000
5	8,700
2	5,100

It can be said in the comparison of probable peak discharge and bankful flow capacity of the Kelantan River that inundation takes place with the frequency more than once in two years in the downstream reaches.

An isohyetal map of the rainstorm occurred in November to December 1986 is given in Fig. 2.8 as a typical rainfall pattern in the Kelantan River basin. This rainfall pattern implies that flooding in the downstream reaches of the Kelantan River is caused not only by overtopping of flood water from the Kelantan River, but also by the local rainfall in the downstream area;

that is, treatment of interior water is another problem to tackle for the basin-wide flood mitigation in the Kelantan River.

2.5.2 Past large scale floods and damages

Floods with a magnitude of more than 5,000 m^3/sec occur almost once in two years in the downstream reaches of the Kelantan River. Among them, the floods occurred in 1967 and 1983 caused severe damages.

On 2nd January 1967, heavy rainfall occurred and lasted up to 7th January in the entire Kelantan River basin. The recorded maximum daily rainfall was 585 mm at JPT store, Kota Bharu and 420 mm at Machang P.S. Flood peak discharges at the major gauges were 3,400 m^3/sec at Chegar Atas, 8,700 m^3/sec at Dabong, 4,200 m^3/sec at Tualang and 16,000 m^3/sec at Guillemard Bridge. On 4th January, flood water overtopped the bank of the Kelantan River and the entire coastal plain was inundated. Most of the Kota Bharu town was under water at night time on 4th January.

The flood damages by 1967-flood exert not only to the destruction of houses and infrastructures, and losses of properties, but also to the loss of lives especially in the riparian area.

The inundation area in 1967-flood spread over 300,000 ha, which is equivalent to 20 percent of the Kelantan State area as delineated in Fig. 2.9. The flood report, January 1967 states that about 537,000 persons were affected by the flood, about 125,000 persons evacuated from the lowland area and death toll went up to 38 persons in total. It is reported that flood damages in 1967 were about M$30 million in total in the State of Kelantan. Among them, the damage for agricultural crop is estimated at around M$14 million. Among about 17,400 ha of irrigation schemes, 2,800 ha of the acreage corresponding to about 16% of the scheme areas was damaged.

On 1st December 1983, rain started and lasted up to 15th December in the entire basin area. The maximum rainfall occurred during 3rd to 5th December. The recorded maximum daily rainfall was 290 mm at Machang and 270 mm at Kuala Krai. Flood water overtopped the river bank, and the Kota Bharu town inundated on 5th December. Flood peak discharges were about 1,900 m^3/sec at Chegar Atas, 6,000 m^3/sec at Dabong, 4,000 m^3/sec at Tualang and 12,000 m^3/sec at Guillemard Bridge.

The flood occurred in December 1983 also caused severe damages in the downstream area of the basin. According to the flood report, the inundation area amounted to about 60,700 ha in the basin, and about 27,000 persons along the Kelantan River were affected by the flood. The flood damage in the basin is estimated at around M$11.4 million comprising M$3.5 million for agricultural crops, M$0.5 million for livestocks and poultry, M$1.0 million for houses, properties and business and M$6.4 million for public services and facilities.

The floods with double peaks hit the downstream area on November and December of 1988, and caused considerable damage. A detail survey for these floods is discussed in the separate volume (Part III).

2.6 Existing Flood Mitigation Facilities and Plans

2.6.1 Existing flood mitigation facilities

The downstream reaches of the Kelantan River have suffered from habitual inundation mainly due to overtopping of flood water from the Kelantan River as discussed in the preceding Section 2.5. To cope with such repeating inundation, DID has implemented the flood mitigation works at several places as given in Fig. 2.10.

An about 10.5 km long trapezoidal levee was constructed in the right bank downstream from the Kemubu pumping station in 1971. Although the levee is cut in several places to make access roads to the Kelantan River, the levee is in a good condition at present. Following this work, an about 1.8 km long revetment was constructed in 1972 to protect Pasir Mas located at the place where the Kelantan River sharply bends. This revetment seems to effectively work for the prevention of bank erosion in this sharp bend.

An about 3 km long levee was constructed at the other side of Kota Bharu in 1984 to protect the Lemal irrigation scheme from flooding. In 1986, river protection work comprising the stone pitching groyne and revetment with stone piling was carried out to protect Kedai Buloh from the bank erosion.

Temporary river bank protection work by means of sand bag piling was executed in 1987 for the sandy bank located at the left river bank of about 3 to 4 km downstream from Kota Bharu, followed by permanent protection work.

The river mouth of the Kelantan River is shifting westward due to the closure by sand bar. In order to secure the navigation canal, DID carried out about 200 m long open-cut work at the estuary in 1983. However, this open-cut canal was buried by a westward littoral current at present.

2.6.2 Flood mitigation plans

Several flood mitigation plans were proposed for the Kelantan River basin in past. The basin-wide flood mitigation study was carried out by ENEX in 1977. In this study, conceivable damsites for flood mitigation were selected and flood mitigation effect was studied by combining several promising dams. To mitigate flood damages in the downstream plain area of the basin, it was recommended to implement the Dabong multipurpose dam scheme and about 60 km long levee embankment work in the upstream stretches from the river mouth. However, a concept for the design flood scale and a relation between the dam

and river improvement on the flood mitigation effect are not made clear.

In 1982, National Water Resources Study, Malaysia was carried out by JICA aiming mainly at utilization of river water for irrigation use, hydroelectric power generation, municipal and industrial demands and so on. In this planning, a flood mitigation study in the Kelantan River basin was preliminarily carried out and the implementation of Dabong and Lebir dam schemes was recommended for the flood mitigation of the downstream reaches.

On the other hand, the hydroelectric power development study was performed for the Galas and Lebir rivers. In the Galas River, a feasibility study on Nenggiri dam project was made in 1986 by NEB incorporating flood mitigation effect to the downstream stretches. In the Lebir River, the feasibility study on the Lebir dam project including flood mitigation has been performed by JICA. However, flood mitigation effect for the river stretches up to Kota Bharu is not yet made clear in the study on the Nenggiri and Lebir dam projects as well as the Dabong dam project by ENEX.

In order to protect the Kota Bharu town from flood water overtopping the river bank of the Kelantan, a 44 km long levee embankment plan is being worked out by JPT. The design concept of this plan is as follows:

Design flood	;	10,000 m^3/sec
Location of levee	;	Kg. Semut Api (the Kelantan delta) to Kemubu
Type of levee	;	Earth embankment
Dimension	;	Trapezoid with the slope of 1:2 to 1:3 on both sides and top width of 3 m to 10.7 m
Freeboard	;	0.9 m
Construction cost	;	M$77.3 million (1981 price).

It is noted that this works is based on the premise that the Dabong and Lebir dams proposed by ENEX will be constructed in an early stage.

2.7 Existing River and Related Structures

The structures such as bridges, pumping stations, jetties for small fishing ships and so on are located along the Kelantan River and its tributaries as shown in Fig. 2.11.

There are three roadway bridges crossing over the Kelantan and Lebir rivers, connecting with the national road networks. They are Sultan Yahya Putra Bridge crossing at Kota Bharu, Tanah

Merah Bridge upstream of the Tanah Merah and a bridge crossing over the Lebir River at about 30 km upstream from the Galas confluence. The superstructures of these bridges are of concrete type and their substructures are constructed by concrete piles or concrete pier structures. A roadway bridge is under construction at Pasir Mas. Furthermore, JKR has a plan to build a roadway bridge at Dabong spanning over the Galas River.

There are four railway bridges crossing over the Kelantan River and its tributaries. They are Guillemard Bridge crossing over the Kelantan River at 15 km upstream of Tanah Merah: Others are on the Galas, Lebir and Nenggiri rivers. The superstructures of these railway bridges are steel truss type and their substructures are concrete pier structures. The scouring at the bottom of the substructures and at both banks in the up and downstream sides of the bridges is not found at present. The features of these bridges are given in Table 2.3.

To supply river water for irrigation use, four pumping stations connected with the main irrigation canals are provided in the downstream reaches of the Kelantan River (refer to Fig. 2.11). They are Kemubu and Lemal pumping stations in the right bank upstream from the Pasir Mas, and Salor and Pasir Mas pumping stations in the left bank up and downstream of the Pasir Mas. There exists a pumping station for water supply of Tanah Merah. The features of these pumping stations are listed in Table 2.4.

There are several wooden-made jetties on the downstream reaches near the estuary. Those are used for unloading the marine products carried by small ships. A jetty is under construction by the Fishery Development Board at Kg. Che Latiff near the estuary (refer to Fig. 2.11). The dredging works with a scale of 5 m deep and 90 m wide is included as part of the project to ensure the access of fishing ships from the sea to the jetty. Dredging of the clogged river mouth will have not only the ensurance of navigation canal, but also advantageous effect for flushing flood discharge.

2.8 Existing Flood Forecasting and Warning System

Considering the current situation of flood mitigation facilities in the Kelantan River basin, one of the most effective means of flood-damage reduction is the emergency evacuation of the threatened area. A flood forecasting and warning system to make ease the evacuation of the threatened area was introduced for the entire Kelantan River basin in 1971, and was renewed in 1986 as depicted in Fig. 2.12.

According to the flood reports, the warning required evacuation was issued eight times after the installation of flood forecasting and warning system in 1971 including 1988 flood, and inhabitants in the threatened area of flood evacuated to safe places such as schools following the guide of police without chaos.

2.9 Development Potential

2.9.1 Constraints to development

"The 5th Malaysia Plan for Kelantan" states as follows:

(1) There is still imbalance in the development of Kelantan as compared with that of other States.

(2) There is imbalance in the development between Sub-region I (North) and II (South) in Kelantan.

(3) There are insufficient basic amenities for the provision of services for socio-economic development.

(4) The State government cannot afford to support development projects with State revenue.

All the above statements can be boiled down to one expression, i.e. underdeveloped economy of the State.

2.9.2 Development potential and the project

Actually the State of Kelantan has rich and abundant potentials in terms of human, agricultural, forestry, mining, water and tourism resources. Only they have not been properly or fully developed.

The Federal and State Governments, cognizant of the socio-economic status of Kelantan, have strenuously and consistently taken the policy for elevating quantitative and qualitative levels of infrastructures in the State. As a result, discrepancies existing between Kelantan and other States are being rapidly narrowed; that is, the circumstances confining the State to the existing status are now being removed.

However, one major obstacle still remained is flooding in the Kelantan River. Habitual flooding of the coastal plain brings about extensive economic losses in terms of damages to crops and property, inhibiting the growth of the agricultural, industrial and commercial sectors. The damage to the economy caused by flooding must be grasped in broader perspective than from the viewpoint of direct economic cost; that is, farmers have no positive inclination towards the adoption of new agricultural technology, which contributes to perpetuating the traditional low productivity of the agricultural sector.

Also, flood threat has depressed and dampened the investment climate in the State. Entrepreneurs and businessmen are in no way willing to invest in flood-prone areas. Thus, flood mitigation is crucial for long-term industrial development and economic progress of Kelantan.

III. WATER RESOURCES DEVELOPMENT

3.1 Present Water Uses

3.1.1 Irrigation water use

Water of the Kelantan River is at present used for four major irrigation schemes, i.e. Kemubu, Salor, Lemal and Pasir Mas, all of which stretch out in the lower reaches of the Kelantan River as shown in Fig. 3.1. These major irrigation schemes were developed by DID from 1951 to 1973 to increase the yield by double paddy cropping. Operation and maintenance were transferred to KADA after completion. The present irrigable areas for these schemes sum up to about 31,800 ha which requires about 72 cumecs in maximum water use to realize the entire double cropping as shown in Table 3.1.

The water abstraction fully depends on the existing four pumping stations, all of which are located along the reaches downstream from Guillemard Bridge as illustrated in Fig. 3.1. The maximum capacity of the pumping stations was originally designed to be 52.9 cumecs in total as shown in Table 3.2. However, due to the over-age pumping facilities, the pumping capacity has considerably decreased. According to the recent pump tests carried out by KADA, the present available capacity is estimated at about 35 cumecs as referred to Table 3.2.

At present, the main season crop is usually planted in October/November and harvested by the end of March, while the off season crop is planted in April/May and harvested by September. Peak water demand required for the Kelantan River as a source occurs in May/June. Since the maximum irrigation demand is much larger than the existing available pumping capacity, the area actually irrigated has been limited within 60 to 70% of the total irrigable area both for main and off seasons as given in Table 3.3. Thereby, KADA implements the renovation of the existing pumping facilities as well as other irrigation facilities so as to realise the double cropping irrigation for the whole irrigable area by the end of 1990.

3.1.2 Domestic and industrial water uses

(1) Maximum supply capacity

Groundwater was a sole water source for public supply system in the State of Kelantan by 1982. Thereafter, the Kelantan River and other surface flows were sought as water sources to solve the quantitative and qualitative restriction of the groundwater use and to cope with the rapid increment of domestic and industrial water demand.

The present maximum demand sums up to about 134 Mld in the lower reaches of the Kelantan River covering the districts of Kota Bharu, Tumpat, Pasir Mas, Machang, Bachok, Pasir Puteh and Kuala Krai. The said maximum demand is met by the groundwater

(72 Mld), the Kelantan River (43 Mld) and other surface flows (19 Mld) as shown in Table 3.4.

Water from the Kelantan River is abstracted from two existing pumping stations; one located at Kg. Kelar in Pasir Mas district with its pumping capacity of 22.70 Mld and the other at Sg. Kelantan in Tanah Merah district with its capacity of 20.43 Mld. These pumping stations are located along the Kelantan River downstream from Guillemard Bridge as illustrated in Fig. 3.1.

(2) Daily average use of domestic water

The enlargement of maximum supply capacity starting from 1982 could increase the daily average domestic water supply from 39 Mld in 1980 to 76 Mld in 1985 as shown in Table 3.5. Daily average domestic water supply in 1985 corresponds to about 57% of maximum supply capacity. It is herein noted that the share of supply from the Kelantan River was nil in 1980 but increased to 24 Mld equivalent to 32% of total average supply in 1985.

With the increment of daily average water supply, the population covered by the public water supply system has expanded from 147,000 (coverage rate of 19.5% to total population) in 1980 to 230,000 (coverage rate of 25.6%) in 1985. In this connection, the per capita consumption rate is estimated at 137 1/day.person in 1980. The values in recent years would be higher, but could not be assessed due to lack of available data (refer to Table 3.5).

The estimated per capita consumption in 1980 is deemed to be rather low compared with the usual consumption rate of some 200 1/day.person. This low consumption rate will be attributed to the high supply loss as estimated at 48.7% in Table 3.5 and the inadequately small supply capacity before 1982. It is however anticipated that the supply loss is gradually reduced and that the per capita consumption rate increases from 1982 onward due to the recent high supply capacity system.

(3) Potential use of industrial water

The potential use of industrial water in 1985 was estimated on the basis of following available information:

- The state gross industrial output as of 1985 expressed in monetary value, and
- Water use rate required to unit industrial output which was cited from the results of sampling survey carried out in the National Water Resources Study, 1982.

As shown in Table 3.6, the actual industrial output amounted to about M$300 million in 1985. The corresponding potential water use in 1985 is estimated at 16 Mld.

Judging from the water supply system enlarged after 1982,

most of present and future industrial water will be taken from the Kelantan River. In fact, as shown in Table 3.7, there are five major industrial estates in the State of Kelantan and the considerable part of their water use is projected to rely on the Kelantan River water.

(4) Total amount of present domestic and industrial water use

Domestic and industrial water use is computed at about 92 Mld on an average in 1985; 76 Mld for domestic water use and 16 Mld for industrial water use. The said daily average water use corresponds to about 70% of the maximum supply capacity.

Water sources for the daily average use are classified as follows:

- The Kelantan River: 24 Mld for domestic water use and 16 Mld for industrial water use, and

- Other sources; 52 Mld.

As estimated above, the present water use taken from the Kelantan River is to be about 40 Mld which corresponds to about 90% of the maximum supply capacity abstracted from the Kelantan River.

3.2 Future Water Demands

3.2.1 Irrigation water demand

The future irrigation water demand for the source of the Kelantan River is estimated in accordance with phasing development programmes of irrigation schemes. Thereby, the phasing development programmes are preliminarily assumed on the basis of the interview with the agencies concerned such as KADA and Kemasin-Semerak Project office, DID as well as the review on the previous study reports such as "KADA II Improvement Project, 1982 and "Kemasin-Semerak Integrated Rural Development Project, 1979". It is estimated as shown in Table 3.8 that the irrigation demand will increase from the present maximum use of 35 cumecs to the peak demand of 85 cumecs in 2010. It is herein noted that the future peak demand is assumed to occur on April from the result of the various study reports. The double cropping area of about 50,000 ha will be irrigated with maximum supply of 85 cumecs in 2010 as referred in Table 3.8.

The development programmes herein assumed are enumerated as below:

(1) Improvement of existing KADA irrigation areas

The existing irrigable area of 31,800 ha will be entirely used for double paddy cropping by the end of 1990 by improving existing irrigation facilities. In this connection, KADA is executing the plan to either replace or rehabilitate the existing

pumping facilities so as to increase the total pumping capacity from the present 35 cumecs to about 43 cumecs as referred to Table 3.2. Furthermore, a new pumping station with its capacity of about 37 cumecs is to be constructed by DID in 1990 near the existing Kemubu pumping station. Accordingly, the total pumping capacity will reach about 80 cumecs by 1990.

The peak water demand for the entire double cropping will be 72 cumecs which comes out on April by assuming that a 40-day presaturation period starts on March 11th (refer to "KADA II Improvement Project").

(2) Kemasin irrigation scheme

The Kemasin irrigation scheme is currently being implemented under "Kemasin-Semerak Integrated Rural Development Project" and to be completed by 1990. The area of 3,775 ha in the scheme is irrigated by taking the Kelantan River water from the new Kemubu pumping station during the off season. The peak water demand is to be 5.4 cumecs which comes out on May (refer to "Kemasin-Semerak Integrated Rural Development Project").

(3) Semerak irrigation scheme

Succeeding to the Kemasin irrigation scheme, the Semerak irrigation scheme will be developed during 1995 to 2000. Upon completion of the scheme, the new irrigation area of 7,745 ha will require the peak water demand of 10.4 cumecs on May. To meet this requirement, the Kelantan River water is abstracted from the new Kemubu pumping station (refer to "Kemasin-Semerak Integrated Rural Development Project").

(4) Other irrigation schemes

In line with the identification of DID, the following areas are assumed to require the water source of the Kelantan River by 2005:

- Existing single cropping areas of 3,620 ha to be changed into double cropping areas, and
- Ulu Lemal and Bagan II schemes with a total irrigation area of 2,940 ha.

The peak water demand is estimated at 3.2 cumecs which occurs on April (refer to "KADA II Improvement Project").

3.2.2 Domestic and industrial water demands

(1) Domestic water demand

The future gross demand of domestic water supply will increase as the increases of population, coverage rate of public

water supply system and per capita water consumption rate, which are estimated on the basis of the "1980 Population Census", "Fifth Malaysia Plan" and other available information from PWD as described hereinafter.

(i) Increase of population

Annual incremental rates were estimated to be 2.6% during a period from 1970 to 1980 and 2.5% from 1990 onward as described in Annex IV. Consequently, the population is projected to increase from 850,000 people in 1980 given in "1980 Population Census" to 1,680,000 people in 2010 in the lower reaches of the Kelantan River as shown in Table 3.9.

(ii) Coverage rate of public water supply system

The coverage rate is programmed to reach 100% by 2000 according to "Fifth Malaysia Plan". Although the coverage rate stayed at about 26% in 1985, water supply systems are being developed specially from 1982 onward so that it is not virtually difficult to achieve the assumed programme of coverage rate.

(iii) Per capita water consumption rate

The net per capita water consumption rate excluding system supply losses is assumed to be 200 l/day.person in 1990. The per capita rate is further to increase at 1.0% per year after 1990 taking account of the improvement of living standards. The gross per capita consumption rate is further assumed by adding the system supply loss to the above net consumption rate, so that the gross domestic water demand is estimated to increase from 44 Mld in 1980 to 576 Mld in 2010 as shown in Table 3.9.

In the above estimate, the system supply loss is assumed to decrease from 48.8% in 1980 to 30% after 1990. Furthermore, the gross domestic water demand is to be met not only from the Kelantan River water but also from other sources like groundwater. The water abstraction from the Kelantan River is estimated at 485 Mld in 2010 corresponding to 84% of gross demand by assuming that the water abstraction from other sources will not increase due to the quantative and qualitative restriction of the water sources. The study results are summarized in Table 3.9.

(2) Industrial water demand

The future industrial water demand is predicted in the premise that the potential demand in 1985 (refer to Table 3.6) will increase in proportion to the growth rate of gross state industrial product. The annual growth rate of GDP is projected to be 6.25% from 1985 to 1990 and 6.0% after 1991, while the percentage of industrial sector product to GDP is to increase from 12.9% in 1985 to 14.7% in 2010 as shown in Table 3.9 (refer to "Kelantan Regional and Township Development Project, 1987", prepared by SEPU). The industrial water demand in 2010 is thus

predicted to be about 80 Mld, which will substantially be taken from the Kelantan River. Further details are referred to Table 3.9.

3.2.3 River maintenance flow

The low-flow regime of the Kelantan River would be altered by the proposed dam reservoir and the river channel improvement, which is likely to cause the serious salinity intrusion in the river. To avoid the adverse effect, a certain measure of discharge is required as the river maintenance flow.

Should the river flow discharge be extremely low, the salinity water would intrude almost to the point where the river bed level lies at about high tide level. The point is estimated at about 24 km upstream from the river mouth. All existing intake points of the river surface flow are located beyond the limits of the salinity intrusion. Whilst the groundwater abstraction is presently made in and around the town area of Kota Bharu which is located along the Kelantan River about 10 km upstream from the river mouth and could be affected by the possible salinity.

According to the previous sample tests, the salinity of groundwater ranges from 41 to 155 ppm which is still allowable as the quality of potable water (refer to "Water Supply Study in Northern Kelantan, 1986"). Such rather small salinity of groundwater could be attributed to (1) the existing sand blockage of river mouth which prevents the salinity water intruding into the river channel and (2) the natural river flow discharge resisting the salinity intrusion. In this connection, the simulation study was made to find out the necessary river maintenance flow that can cope with the salinity intrusion under the river conditions altered by the proposed dam construction, the river channel improvement and the river mouth treatment.

Table below shows the relationship between the river flow discharge and the maximum length of the salt water intrusion:

River Flow Discharge (cms)	Length of Salt Water Wedge (km)
100	6.9
90	9.0
80	9.0
70	9.0
60	11.0
50	11.0

From the relationship above, the discharge of 70 cumecs is estimated as the necessary river maintenance flow that will not allow the salinity water to intrude upto the Kota Bharu town area which is located about 10 km upstream from the river mouth.