GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

STATE REPORT

VOL. 7

TRENGGANU

OCTOBER 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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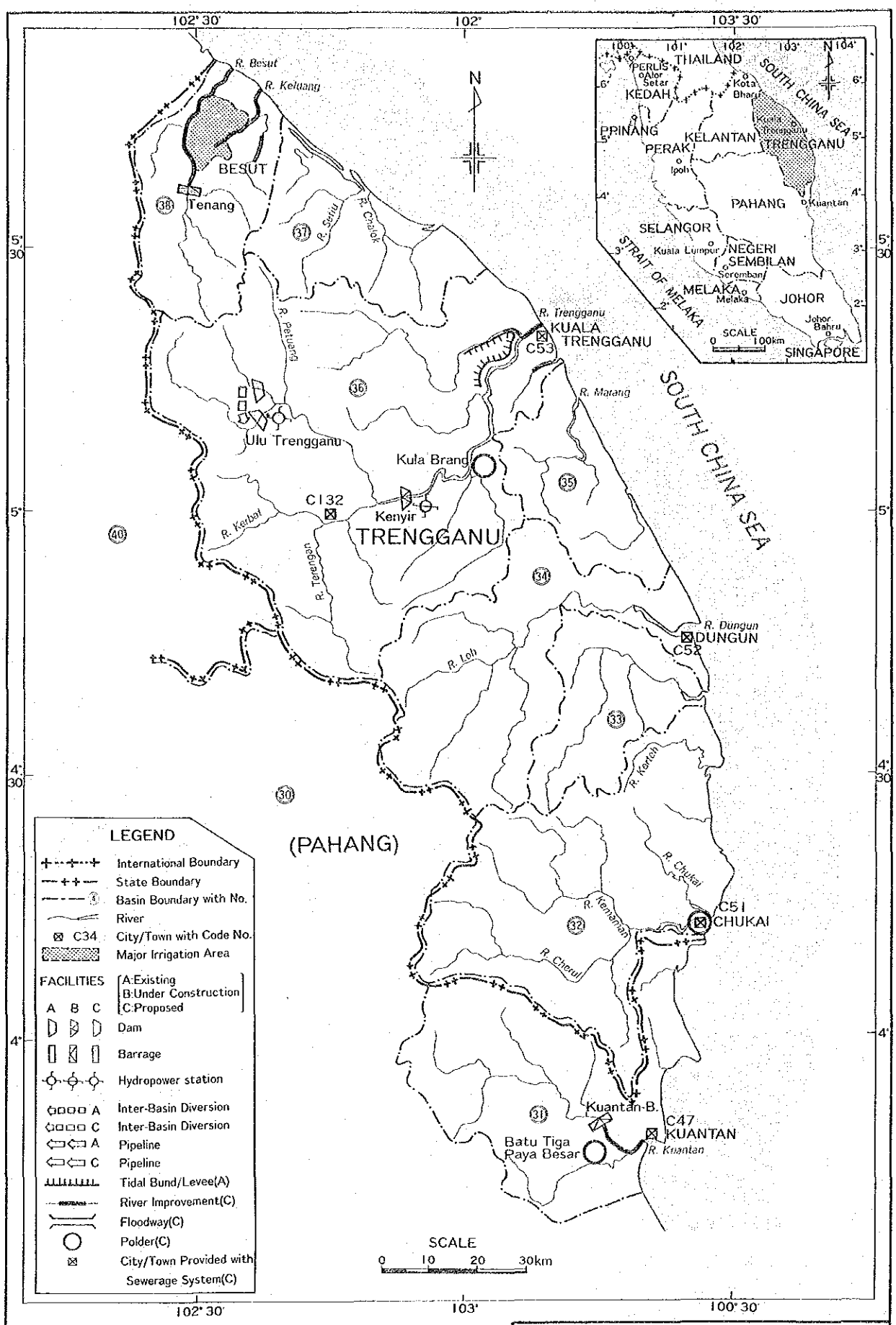

Recommended Plan
for the State of Trengganu

GOVERNMENT OF MALAYSIA
NATIONAL WATER RESOURCES STUDY MALAYSIA
JAPAN INTERNATIONAL COOPERATION AGENCY

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FIGURES

ABBREVIATIONS

(1) Plan

FMP	:	First Malaysia Plan
SMP	:	Second Malaysia Plan
TMP	:	Third Malaysia Plan
4MP	:	Fourth Malaysia Plan
5MP	:	Fifth Malaysia Plan
6MP	:	Sixth Malaysia Plan
7MP	:	Seventh Malaysia Plan
NEP	:	New Economic Policy
OPP	:	Outline Perspective Plan
RESP	:	Rural Environmental Sanitation Program

(2) 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
ICU	:	Implementation and Coordination Unit
MARDI	:	Malaysian Agricultural Research and Development Institute
MIDA	:	Malaysian Industrial Development Authority
MLRD	:	Ministry of Land and Regional Development
MMS	:	Malaysian Meteorological Service
MOA	:	Ministry of Agriculture
MOF	:	Ministry of Finance
MOH	:	Ministry of Health
MOPI	:	Ministry of Primary Industries

MRRDB	:	Malaysia 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
SEB	:	Sabah Electricity Board
SEBC	:	State Economic Development Corporation
S(E)PU	:	State (Economic) Planning Unit
SESCO	:	Sarawak Electricity Supply Croporation
UDA	:	Urban Development Authority

(3) International or Foreign Organization

ADAA	:	Australian Development Assistance Agency
ADB	:	Asian Development Bank
ASCE	:	American Society of Civil Engineers
FAO	:	Food and Agriculture Organization of the United Nations
IBRD	:	International Bank for Reconstruction and Development
ILO	:	International Labour Organization
IMF	:	International Monetary Fund
IRRI	:	International Rice Research Institute
JICA	:	Japan International Cooperation Agency
JSCE	:	Japan Society of Civil Engineers
MOC	:	Ministry of Construction, Japan
OECD	:	Organization for Economic Cooperation and Development
OECF	:	Overseas Economic Cooperation Fund, Japan
UK	:	United Kingdom
UNDP	:	United Nations Development Program
UNSF	:	United Nations Special Fund
US or USA	:	United States of America
US/AID	:	United States Agency for International Development
USBR	:	United States Bureau of Reclamation
WHO	:	World Health Organization
WMO	:	World Meteorological Organization

(4) Others

B	:	Benefit
BOD	:	Biochemical Oxygen Demand
C	:	Cost
CIF	:	Cost, Insurance and Freight
COD	:	Chemical Oxygen Demand
D&I	:	Domestic and Industrial
dia	:	Diameter
EIRR	:	Economic Internal Rate of Return
El.	:	Elevation above mean sea level
Eq.	:	Equation
Fig.	:	Figure
FOB	:	Free on Board
FSL	:	Full Supply Level
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
H	:	Height, or Water Head
HWL	:	Reservoir High Water Level
LWL	:	Reservoir Low Water Level
O&M	:	Operation and Maintenance
Q	:	Discharge
Ref.	:	Reference
SITC	:	Standard International Trade Classification
SS	:	Suspended Solid
V	:	Volume
W	:	Width

ABBREVIATIONS OF MEASUREMENT

Length

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

Area

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

Volume

cm^3 = cu.cm = cubic centimeter
l = lit = liter
kl = kiloliter
m^3 = cu.m = cubic meter
gal.= gallon

Weight

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

Time

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

Electrical Measures

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

Other Measures

% = percent
PS = horsepower
° = degree
' = minute
" = second
°C = degree centigrade
10^3 = thousand
10^6 = million
10^9 = billion (milliard)

Derived Measures

m^3/s = cubic meter per second
cusec = cubic feet per second
mgd = million gallon per day
kWh = Kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
kWh/y = kilowatt hour per year
kVA = kilovolt ampere
BTU = British thermal unit
psi = pound per square inch

Money

M$ = Malaysian ringgit
US$ = US dollar
¥ = Japanese Yen

CONVERSION FACTORS

	From Metric System	To Metric System
Length	1 cm = 0.394 inch 1 m = 3.28 ft = 1.094 yd 1 km = 0.621 mile	1 inch = 2.54 cm 1 ft = 30.48 cm 1 yd = 91.44 cm 1 mile = 1.609 km
Area	1 cm^2 = 0.155 sq.in 1 m^2 = 10.76 sq.ft 1 ha = 2.471 acres 1 km^2 = 0.386 sq.mile	1 sq.ft = 0.0929 m^2 1 sq.yd = 0.835 m^2 1 acre = 0.4047 ha 1 sq.mile = 2.59 km^2
Volume	1 cm^3 = 0.0610 cu.in 1 lit = 0.220 gal.(imp.) 1 kl = 6.29 barrels 1 m^3 = 35.3 cu.ft 10^6 m^3 = 811 acre-ft	1 cu.ft = 28.32 lit 1 cu.yd = 0.765 m^3 1 gal.(imp.) = 4.55 lit 1 gal.(US) = 3.79 lit 1 acre-ft = 1233.5 m^2
Weight	1 g = 0.0353 ounce 1 kg = 2.20 lb 1 ton = 0.984 long ton = 1.102 short ton	1 ounce = 28.35 g 1 lb = 0.4536 kg 1 long ton = 1.016 ton 1 short ton = 0.907 ton
Energy	1 kWh = 3,413 BTU	1 BTU = 0.293 Wh
Temperature	°C = (°F − 32) · 5/9	°F = 1.8°C + 32
Derived Measures	1 m^3/s = 35.3 cusec 1 kg/cm^2 = 14.2 psi 1 ton/ha = 891 lb/acre 10^6 m^3 = 810.7 acre-ft 1 m^3/s = 19.0 mgd	1 cusec = 0.0283 m^3/s 1 psi = 0.703 kg/cm^2 1 lb/acre = 1.12 kg/ha 1 acre-ft = 1,233.5 m^3 1 mgd = 0.0526 m^3/s
Local Measures	1 lit = 0.220 gantang 1 kg = 1.65 kati 1 ton = 16.5 pikul	1 gantang = 4.55 lit 1 kati = 0.606 kg 1 pikul = 60.6 kg

Exchange Rate
(As average between July and December 1980)

$1 = M$2.22
¥100 = M$1.03

1. INTRODUCTION

Malaysia's rapid development has begun to strain her water resources. Increasingly water stress has occurred in places where previously water was found abundant for use. The responsibility for water resources development and management in Malaysia has traditionally been fragmented among various departments and agencies in accordance with their respective functions and activities related to water. In the absence of a comprehensive system to coordinate the multifarious activities in water resources development and management, these activities tend to take place in isolation. This may lead to competition in water use and even duplication of activities and functions. An integrated approach to water resources development and management is therefore necessary to ensure future efficient use of water and other resources, and a study in this regard has become necessary.

The National Water Resources Study, Malaysia, has been carried out by the Study Team of the Japan International Cooperation Agency (JICA) in collaboration with officials of the Government of Malaysia for 3 years since October, 1979 in order to establish a basic framework for the orderly planning and implementation of water resources development programs and projects and for rational water resources management consistent with the overall national socio-economic development objective.

The Final Report submitted now comprises Volume 1 Master Action Plan and Volume 2 Water Resources Development and Use Plan, being supported by the State Reports and Sectoral Studies.

The Master Action Plan contains recommendations on actions to be taken by the Federal and State Governments to ensure efficient and effective execution of water resources development and management in the future, including the national water policy, implementation program, financial system, water administration, institutional framework, legal provisions and further study.

The Water Resources Development and Use Plan is a translation of the national water policy into a long-term national master plan for water resources development, reflecting the needs based on socio-economic goals and also the availability of water and other resources as well as the extent and distribution of water stress.

Each volume of the State Reports is a version of the Water Resources Development and Use Plan compiled for a State or a group of States, including more information regarding the specific State or States. The State Report Volume 7 herein presented describes the matters for the State of Trengganu.

The Water Resources Development and Use Plan was prepared to show general direction of water resources development in Malaysia, identifying future problems and needs and availability of water and other resources, based on analysis and interpretation of readily available data and information. Individual projects indicated are, therefore, only notional and no intention has been made to define any of their details.

2. BACKGROUND

2.1 The Land

The State of Trengganu of 12,950 sq.km is located in the northern part of east coast of Peninsular Malaysia, between 102°23′ and 103°30′ east in longitude and between 3°53′ and 5°51′ north in latitude. It faces the South China Sea in the east and adjoins the States of Kelantan and Pahang across the watershed of the east ridge in the west.

Western half of the State is mountainous. Mt. Mandi Angin (El. 1,460 m) is the highest peak of the east ridge. Eastern half is featured by low hills, rolling plains and swamps. Rivers run parallel or perpendicular to the geological trend. They are the Kemaman, Kerteh, Chukai, Paka, Dungun, Marang, Trengganu, Chalok, Setiu, Keluang, Besut and small coastal rivers.

Major geological members in the State are meta-sedimentary rocks of Carboniferous to Triassic and intrusive granitic rocks which form north-south trending zones of exposure among the former. The intrusive granitic rocks are predominantly composed of granodiorite and granite. Meta-sedimentary facies consists of shales, some calcareous and tuffaceous, sandstones and quartzites. Alluvial deposits are formed in the 5 km wide coastal belt.

Soils are mostly sedentary soils occurring on undulating plains and mountains. The areal extent of alluvial soils on coastal plains, riverine flood plain and low riverine terraces is 3,072 sq.km, accounting for 24% of the total for the State. Out of it, 1,039 sq.km are evaluated as suitable for paddy, 805 sq.km for coconut, 633 sq.km for oil palm and cocoa, and 506 sq.km for rubber, respectively. In the sedentary soil area, 1,240 sq.km are suitable for rubber, and 601 sq.km are suitable to marginal for rubber, and 1,204 sq.km for oil palm and coconut. The extent of area suitable to marginal for coconut totals 1,780 sq.km among which 1,524 sq.km extend over the sedentary soil area.

Climate is usually hot and wet. Average annual rainfall is high of 2,500 mm - 3,000 mm, of which 50% occurs in November to January being strongly affected by the northeast monsoon. Meteorological data at Kuala Trengganu (El.35.1 m) are summarized in Table 1.

2.2 The Rivers

Run-off in rivers wholly or partially located in the State of Trengganu is estimated based on 1961 - 1979 records at the hydrological station No.5130432 in the Trengganu river. The surface run-off is 25 billion cu.m/y or 58% of rainfall of 43 billion cu.m/y. Evapotranspiration is 16 billion cu.m/y and groundwater recharge is 2 billion cu.m/y.

Organic pollution in the rivers is caused by domestic and industrial sewage, effluent from rubber factories, palm oil millls and animal husbandries. Biochemical oxigen demand (BOD) concentration of less than 5 mg/lit was measured during 1978/1979 in the Setiu and Kelang rivers.

Operation of mines, opening-up of residential areas, road construction and logging are major causes of high concentration of suspended solid (SS). In the 1978 observation, SS concentration was more than 500 mg/lit in some stretches of the Keluang river.

Alluvial aquifers occur in the flood plain of the Trengganu river. Rock aquifers may be found in the sedimentary rocks of carboniferous.

The river characteristics in terms of river morphology, estuary, sediment and sea water intrusion in Trengganu is as shown in Tables 2 through 4.

2.3 Watershed

Natural vegetation occupies 6,888 sq.km comprising hill forest of 5,787 sq.km, scrub forest of 741 sq.km, swamp forest of 80 sq.km and grassland of 280 sq.km. The varieties range from the mangroves on coastal fringes to the mixed dipterocarp forests in lowlying and hilly areas and the montane forests of the highlands.

The total forest area decreased from 10,093 sq.km or 78% of the whole State in 1966 to 6,608 sq.km or 51% in 1979 by forest exploitation not only for logging purpose but also for execution of agricultural land development schemes.

Through the soil erosion potential evaluation in the Study, it was preliminarily estimated that the concentration of suspended solid was less than 50 mg/lit in all rivers of the State showing less effect by the surface soil loss occurred in the catchment areas.

2.4 Present Socio-economic Condition

As illustrated in Fig.1, the State of Trengganu is administratively divided into six districts. Towns having population of more than 10,000 in 1980 were Kuala Trengganu, Chukai and Dungun.

Population of Trengganu was 0.6 million in 1980 with the average annual growth rate of 3.2% during the period from 1970 to 1980. Population density increased from 33 persons/sq.km in 1970 to 45 persons/sq.km in 1980.

Gross regional product (GRP) increased from M$261 million in 1971 to M$737 million in 1980 in factor cost at 1970 constant price with the average annual growth rate of 12.2%. GRP of manufacturing sector shared M$12 million or 4.6% of the total in 1971 and M$50 million or 6.8% in 1980. Per capita GRP was M$1,278 in 1980 in factor cost at 1970 constant price and its average annual growth rate between 1971 and 1980 was 8.8%.

Major land use patterns in 1979 were forest of 6,608 sq.km, grassland of 280 sq.km, annual and perennial crop land of 1,777 sq.km, swamp of 1,080 sq.km and miscellaneous land of 3,218 sq.km. The land use in 1974 is shown in Fig.2.

Rubber, oil palm, coconut and cocoa are planted for earning of foreign currency by export. The total planted area as of 1979 was 54,400 ha for rubber, 67,600 ha for oil palm, 11,900 ha for coconut and 1,500 ha for cocoa. During the last five years since 1975, newly planted area under FELDA and FELCRA schemes totaled 1,800 ha for rubber and 28,200 ha for oil palm. RISDA replanted 6,400 ha of rubber in the existing smallholders' rubber areas during the said period, while private estates reduced by 1,200 ha their planted area of rubber mainly for the purpose of conversion to oil palm. The annual production in 1979 totaled 19,500 tons of rubber as dry rubber content, 418,700 tons of oil palm as fresh fruit bunch and 28,800 tons of coconut as copra and 200 tons of cocoa as dry beans. Out of the above harvests, private estates produced 3,000 tons of rubber and 270,000 tons of oil palm and 200 tons of cocoa. The remaining ones were put out from RISDA, FELDA and FELCRA schemes as well as smallholders.

In five mills located within the State, 88,600 tons of crude palm oil and 20,000 tons of palm kernel were extracted from oil palm through processing 396,600 tons of fresh fruit bunch brought in the mills throughout 1979.

In 1979/80, paddy was planted in 34,200 ha comprising main season wet paddy of 26,200 ha, main season dry paddy of 3,800 ha and off-season wet paddy of 4,200 ha. As the whole paddy field was 34,100 ha, the crop intensity in 1979/80 became 1.00. The total rice production in 1979/80 was 55,200 tons among which 47,500 tons were harvested in the main season including 3,400 tons of dry paddy rice and the remaining 7,700 tons were off-season wet paddy rice. This production met 14% of the estimated local consumption of 54,900 tons in the State in 1979/80.

During the period from 1970/71 to 1979/80, rice production fluctuated between 38,600 tons in 1976/77 and 55,200 tons in 1979/80 largely affected by climatic condition, even though paddy field which was provided with irrigation facilities increased from 11,000 ha to 16,300 ha.

3. PRESENT CONDITION OF WATER RESOURCES DEVELOPMENT AND USE

3.1 Domestic and Industrial Water Supply

Public water supply in Trengganu is administered by the Water Supply Division of Public Works Department (PWD) of the State Government.

PWD supplies piped and treated water to the major towns in urban area and also to the minor towns and villages in rural area. The urban water supply system also commands some suburban rural areas nearby. The pipeline is connected to individual taps.

In 1978, thirteen PWD waterworks delivered 19,200 cu.m/d of water on an average. The population served water through PWD networks was estimated at 323,200 in 1980.

In the interior and isolated rural areas, untreated water supply system has been developed by the State Government by either withdrawing water from small river or digging shallow wells equipped with hand pumps with materials and technical advices from MOH, under the Rural Environmental Sanitation Program. It was estimated that 73,000 people were served water by the untreated water supply system in 1980. The water users are suggested to boil water before drinking.

In consequence, 396,200 people out of the total State population of 576,900 were estimated to be served water through PWD and RESP, corresponding to the service factor of 69% in 1980.

3.2 Irrigation

There are 34,100 ha of paddy fields: 18,700 ha are irrigated and 15,400 ha are rainfed. Major scheme is the Besut Irrigation project of 5,058 ha, being fed water from the Teneng dam in the Besut river. Location of irrigation areas is shown in Fig.3. The sowing is carried out in June - November and harvest time is December - May for the main season. Off-season cropping is carried out between April - June and September - October, but only on 9,500 ha. Paddy yield is 1.8 - 2.2 tons/ha in the main season and 1.5 - 2.4 tons/ha in the off-season.

3.3 Flood Mitigation

Flood occurs between November and January, mostly in December. The damage by the recorded maximum flood in the State is estimated to be M$38.9 million at 1980 price level. Table 5 lists the inundated area and estimated damage by the recorded maximum flood by Basin. The inundated area is illustrated in Fig.4.

3.4 Power Generation

In Trengganu, the Kenyir multipurpose dam project is now under way in the Trengganu river. The project aims at 400 MW hydropower generation and flood mitigation of the Trengganu river. The commission is scheduled around 1984 - 85. The dam with the height of 150 m, the dam volume of 16.5 million cu.m of rockfill type and the active storage of 7,400 million cu.m will be the largest one in Peninsular Malaysia.

3.5 Inland Fishery

There are 48 ha of constructed ponds and 14 ha of tin mining pool used for fish culture. The water use of the constructed ponds in 1979 was 650,000 cu.m/y.

3.6 Inland Navigation

Navigation is recognized in rivers to some extents but most rivers have the problem of estuary clogging by drift. Some cargo boat transport sawn timber in 5 km stretch near the mouth of the Kemaman river. River traffic has been replaced by road transportation in the Dungun and Marang rivers. Passenger boats are operated in the Trengganu and Besut rivers. Estuaries are navigated by marine fishing boat.

3.7 Sewerage System

No sewerage system is installed in Trengganu. The installation of septic tank is compulsory by regulations in urban areas, while domestic sewage is directly discharged into nearby water course or onto land in rural area.

3.8 Water Purification System in Private Sector

The Federal DOE started to monitor the river water quality since 1978 in Trengganu with the frequency ranging from twice a year to once a month in 9 river water quality control regions.

There is a rubber factory in the State. This factory produces SMR, latex concentrate and conventional grade of 21 tons/day and discharge effluent of 271,000 cu.m/y to nearby watercourses. The water quality at outlets of the factory is 113 mg/lit in BOD concentration and 120 mg/lit in SS concentration.

There are 4 oil palm mills in operation of which total milling capacity amounts to 1,590 tons/hr in fresh fruit bunch (FFB). The volume of effluent from these mills is 213,000 cu.m/y. The treated or raw effluent is and will be discharged from 4 mills into watercourses. The water quality ranges from 500 to 14,000 mg/lit in BOD concentration and SS concentration is recorded at 12,000 mg/lit.

3.9 Watershed Management

The State Forestry Department is responsible for administration and regulation of forest exploitation, forest revenue collection, management and development of the State's forest resouces, and for planning and coordinatinng the development of wood-based industries.

At the end of 1979, the forest land was categorized into forest reserves of 1,997 sq.km, wild life and other reserves of 817 sq.km and Crown or State land of 3,794 sq.km. Out of the forest reserves, 1,701 sq.km was classified as productive forests comprising 1,679 sq.km of inland forests and 22 sq.km of mangrove forests. The remaining 296 sq.km were unproductive forests consisting of 288 sq.km of protective hill forest and 8 sq.km of mangrove forests. In the inland forest reserves, there remain 1,411 sq.km of unexploited forests which have been committed or licenced for development. The actual area opened for harvesting during 1979 was 57 sq.km corresponding to 4% of the unexploited forests.

Besides forest exploitation, execution of large scale land development schemes for tree crop plantations, housing estates and construction of highway in mountainous and hilly areas have caused sheet and gully erosion problems on steeply dissected land.

All the activities mentioned above are also sources of man-made sedimentation. In the future, the suspended solid concentration of river flow will range between 100 and 200 mg/lit in the lower reach of the Trengganu river, if all the present forest lands having a slope of less than 2 degrees and non-erodable soils are converted to tree crop plantations and those located on slope lands ranging from 3 to 6 degrees and on erodable soil areas with a slope of less than 2 degrees are exploited for logging purpose. In case that regeneration of the existing exploited forests will be artificially accelerated by conducting enrichment planting and regular planting in parallel with the above-mentioned development, the suspended solid concentration will not be substantially reduced.

3.10 Dams

Table 6 lists three dams in operation in Trengganu.

A big scale dam, the Kenyir dam, for the purposes of hydropower and flood control is now under construction in the State. Its major dimensions are as described in 3.4.

Two small weirs are now in operation for irrigation purpose and for water supply respectively.

4. FUTURE WATER DEMAND AND ASSOCIATED PROBLEMS

4.1 Projected Socio-economic Condition

The socio-economic framework was projected based on the planned values of 4MP and the Outline Perspective Plan (OPP) as well as the latest figures of 1980 Population Census as the preliminary field count. For the projection, an assumption was made that the 4MP/OPP target of GDP be achieved by 1990 and thereafter the growth rate be 7.5% between 1990 and 2000. Outcome for the State of Trengganu is described hereunder.

The average annual growth rate of population in the period from 1980 to 2000 was estimated to be 2.5%. Projected population is 760,000 in 1990 and 940,000 in 2000, respectively. Table 7 shows the projected population by urban and rural area in the State of Trengganu. In the Study, the urban area includes cities/towns each of which population in 2000 was estimated to be not less than 10,000.

GRP in factor cost at 1970 constant price was projected to be M$1,333 million in 1985, M$2,179 million in 1990 and M$4,751 million in 2000 with the average annual growth rate of 9.8% between 1980 and 2000.

Projected gross value of output in manufacturing sector will increase from M$163 million in 1980 to M$426 million in 1985, M$814 million in 1990 and M$2,678 million in 2000 at factor cost in 1970 prices as shown in Table 8.

The future rice consumption in the State was estimated to be 91,400 tons in 1990 and 113,100 tons in 2000. To raise the average rice self-sufficiency rate in Peninsular Malaysia up to 85% in 1990 and in 2000 as well, implementation of the following irrigation development plans is indispensable: (1) provision of irrigation system for the existing rainfed paddy field of 6,300 ha, (2) stabilization of irrigation water supply during the wet season to the existing irrigated paddy field of 5,000 ha and (3) development of new irrigation water resources during the dry season to increase by 4,400 ha double cropping area among the existing irrigated paddy field. The total rice production anticipated under the above plans will be 71,000 tons in 1990 and 75,000 tons in 2000.

Oil palm planting area was projected to increase to 72,740 ha in 1990 and 82,040 ha in 2000. The prospected processing volume of oil palm in the State will be 1.16 million ton as fresh fruit bunch in 1990 and 1.25 million tons in 2000.

Rubber planting area was projected to be kept in the present hectarage of 43,600 ha in 1990 and 2000. The total processing amount was projected to be 10,000 ton as dry rubber content in 1990 and 2000.

4.2 Basin Division

For the purpose of the Study, the land was divided into Basins each being a river basin or a group of river basins as shown in Fig.5. Each Basin is further divided into effective area and ineffective area. The former is the upper part of the Basin in which part of the water uses was assumed to return into lower stretches of the river. The latter is the remainder of the Basin, in which water used and surface flow originating therefrom were assumed to run totally into the sea. The boundary of the two areas is normally located below the lowest intake site, herein called the balance point, in the major river in the Basin. The total catchment area, effective area, the location of balance point and assumed river maintenance flow (see Section 5.2) are as shown in Table 9.

As shown in Fig.5, eight Basins are wholly or partly located in the State of Trengganu: located within the State are whole of the Kemaman, the Paka, the Dungun, the Merchang, the Trengganu and the Setiu Basins, most part of the Besut Basin and a part of the Semarak Basin.

4.3 Domestic and Industrial Water Demand

Domestic and industrial water demand was projected based on the projected population and gross value of output in manufacturing sector for 1990 and 2000.

For the domestic water supply, it was assumed that the entire population in the State would be fully served by piped water supply in 2000. Assumption was made that 50% of the total industrial water demand would be served by piped water supply. Table 10 shows the assumed per capita daily use of domestic water and service factor. The unit net manufacturing water use per gross value of manufacturing output by commodity group was assumed as shown in Table 11.

In Trengganu, the total water demand will reach 82 million cu.m/y in 1990 and 222 million cu.m/y in 2000 as shown in Table 12. Major demand centers are Kuala Trengganu, Chukai and Dungun among which Kuala Trengganu has the largest demand for both the industrial water and domestic water in 2000.

All the urban water demand was assumed to be supplied by surface water both in 1990 and 2000. However, in Kota Bharu in the State of Kelantan and in Sandakan and Labuan in the State of Sabah, groundwater use was assumed. For rural water supply, the share of groundwater use was assumed based on the estimated safe yield for each district.

The location of demand centers of domestic and industrial water is shown in Fig.5.

4.4 Irrigation Water Demand

The irrigated land development was projected taking into account information obtained from DID and the assumed rate of self-sufficiency in domestic rice production in the State. As shown in Table 13, the projected irrigation area will increase from 18,700 ha in 1980 to 23,800 ha in 1990 and 25,300 ha in 2000. The ratio of double cropping area to

the total irrigation area is 51% in 1980 and will be 51% in 1990 and 56% in 2000.

The irrigation water demand was calculated for 1990 and 2000 as shown in Table 14. Irrigation efficiency applied is 55% for both major and minor irrigation projects. The annual irrigation water demand will be 468 million cu.m in 1990 and 520 million cu.m in 2000, respectively.

4.5 Fish Pond Water Demand

The future hectarage of freshwater fish pond was projected to increase from 57 ha in 1980 to 398 ha in 1990 and 754 ha in 2000. The total water demand for freshwater fish culture will rise from 780,000 cu.m/y in 1980 to 5.42 million cu.m/y in 1990 and 10.19 million cu.m/y in 2000.

4.6 River Utilization Ratio and Water Deficit

The relative burden of water use on a river is indicated by the river utilization ratio, which is the ratio of water demand to natural run-off. All natural flow cannot meet water demand, because it mostly runs to the sea as flood flow. It was estimated that natural flow would often fail to meet all water demand if the river utilization ratio is not less than 10% under the hydrological condition in Malaysia. The area with river utilization ratio of not less than 10% is, therefore, herein called the water stress area. Table 15 shows the estimated long-average natural run-off, projected water demand and river utilization ratio.

The river utilization ratio was calculated for each basin for 1990 and 2000 as shown in Table 15. In the State of Trengganu, all the concerned seven Basins were estimated to have a river utilization of less than 10% in 2000; the Besut Basin having a little less than 10% of the ratio.

In order to determine the total requirement for storage supply and water diversion, the water deficit at the balance point was calculated for each Basin, assuming the hydrological condition in the recorded period.

Natural runoff in each basin was estimated on 5-day basis, based on daily hydrological records prepared by DID. The recorded period was 19 years from 1961 to 1979 for the Peninsular Malaysia and ranged from 10 to 15 years for Sabah and Sarawak.

Groundwater potential is still to be clarified. Groundwater development will be essential especially for the villages with difficulty of access of clean surface water. Groundwater use is assumed for some rural domestic water supplies based on the estimated safe yield in each district.

A part of water taken from a river returns to the river. It is herein called the return flow. The return flow from irrigated paddy was assumed to be 20% of irrigation water demand within the effective area. The return flow from domestic and industrial water use within the effective area was estimated depending on the purpose of water use ranging from 8 to 100%.

The water withdrawal is herein defined as the net reduction in river flow which is required to meet the water demand and it was calculated by the water demand deducted by the return flow and groundwater use.

Certain discharge is necessary to sustain normal water use and environmental condition in the river. It is herein called the river maintenance flow as will be explained in more detail in Section 5.2. The rate of river maintenance flow was assumed as shown in Table 9.

All the water demand can be met and all the water use can be sustained if river flow is more than the sum of water withdrawal and river maintenance flow, and if otherwise river flow is in deficit. The water deficit was calculated by the water withdrawal plus river maintenance flow less the natural run-off in each 5-day period.

The estimated water deficit varies depending on the assumed hydrological condition. Among the hydrological conditions in the recorded period of N years, that resulting the largest annual volume of water deficit is herein regarded as the driest condition and called 1/N drought, that resulting the second largest annual volume of water deficit is called 2/N drought, and so on. The estimated water deficit by Basin under 1/N to 5/N drought is as shown in Table 15.

The water deficit shown in Table 15 was calculated under without-dam condition. If the estimated supply capacity of the existing and under-construction dams listed up in Table 6 is taken into account, the above-mentioned water deficit will be reduced in Basins where dam is located. It is noted that the water deficit in each Basin was calculated only at the balance point and it indicates an overall balance in the Basin. There may be the cases that river flow is in deficit in some section upstream of the balance point if major demand is located upstream.

4.7 Water Quality

To estimate BOD concentration in the river, BOD load flowing into a river was calculated based on the water use by pollution source. Major pollution sources are the domestic and industrial water users comprising 4 urban areas, 4 palm oil mills, one rubber factory, animal husbandry in the rural areas. However, waste water from the following cities was assumed to be directly discharged to the sea: Chukai, Dungun and Kuala Trengganu.

It was assumed that BOD concentration in the effluent remains at the present level, except that the land disposal system is progressively applied in the palm oil mills and rubber factories as shown in Table 16. BOD concentration along the main streams of rivers was calculated for the condition that the rate of run-off at just downstream of each outlet of effluent was equal to the assumed rate of river maintenance flow at that point, and the residual purification ratio varies in the range of 0.7 to 0.9 according to the characteristics of the rivers.

Discharge ratio, run-off ratio and BOD concentration assumed by type of pollution source for 1990 and 2000 are as shown in Table 17. A portion of water is consumed by being incorporated in products, by evaporation and by leakage in the process it is used and treated. The ratio of water after consumption to that before consumption is called the discharge ratio. A portion of water is again lost during the travel that water is released by the consumer and it enters into a river. The ratio of water reaching the river to that discharged by the consumer is the run-off ratio.

The projected maximum BOD concentration in Trengganu will not be more than 5 mg/lit except for the Kemaman river in 1990 and 2000. This projection states that most rivers are little polluted presently and will be still clean in 1990 and 2000.

4.8 Watershed Problems

Annual rate of soil erosion ranges from about 30 tons/sq.km in natural forest to over 6,000 tons/sq.km in cleared land shifting cultivation land. Soil erosion reduces productivity in soil and also causes sedimentation in rivers. Erosion potential was studied in relation with soil erodability, slope and land use. Present annual erosion rate is estimated to be 300 tons/sq.km.

If all natural forest on slope of less than 6 degrees is disturbed, erosion rate will increase to 2,000 tons/sq.km. An exercise indicates that erosion rate is 900 tons/sq.km, if natural forest on slope of less than 2 degrees is cleared and converted to rubber farm. Reforestration in the disturbed forest can reduce erosion in a long run.

Based on these considerations, the following conclusions are preliminarily drawn:

(1) Forest clearing should be limited within the land of 2 degrees in slope.

(2) After clearing forest, such land use as appropriately protecting soils against erosion should be undertaken.

(3) As a long-term program for preservation of productive forest and soil conservation, reforestation should be undertaken in the disturbed forest.

It has been believed that forest clearing results in reduction of low river flow and increase of flood discharge. Experimental records in this respect in other countries are inadequate to draw conclusions applicable to Malaysia. There are also some experimental data in Malaysia but they are still insufficient for quantification. This aspect has not been analysed, but this does not mean that the importance of forest conservation in water resources conservation can be neglected.

5. STRATEGIES FOR WATER RESOURCES DEVELOPMENT AND USE

5.1 Problem Areas

Water resources use can be classified into instream uses, consumptive uses and energy potential use. Instream uses include navigation, fish catch and recreation. Consumptive uses are domestic and industrial water supply and irrigation. Energy potential use is hydropower generation. Water resources are liable to be deteriorated by man-made actions. Rivers are polluted by sewage and industrial effluent. Mining, logging, urban area development and road construction increases sedimentation in the rivers. Water resources have adverse characteristics such as drought and flood. Drought may constrain ordinary water uses. Rivers inundate vast lands and causes damages even loss of life.

Engineering measures are envisaged, corresponding to the characteristics of water resources and their use. Maintenance of low flow is required for sustaining not only instream water use but consumptive water use and environmental quality. Domestic and industrial water supply system and irrigation system and fishponds are provided to give consumptive water users access to water, also adjusting water quality to the use. When consumptive water use increases, competition may take place among the instream water users and consumptive water users, especially in the dry spell. Dams and basin transfer facilities are source development measures to augment low flow in the river so that all water uses can be sustained. Hydropower station is a measure to develop hydroelectric potential. Pollution abatement is to adjust water quality to water uses and requirement from the viewpoint of environmental quality.

The strategies for the water resources development and use are set for the following categories:

(1) maintenance of low flow necessary for sustaining various water uses and environmental quality;

(2) development of water supply and irrigation systems;

(3) source development for balancing water demand and supply;

(4) hydropower development;

(5) conservation of water quality; and

(6) flood mitigation.

5.2 Maintenance of Low Flow

Water has been utilized as need arises without causing any hazard yet to other water use in most rivers in Malaysia. The reduction of river flow due to intensified water use will, however, hurt various water users. The adverse effect of a small reduction of river flow may not be hazardous, but hazard becomes significant and irretrievable if small reductions accumulate.

It is proposed to establish the concept of river maintenance flow. The river maintenance flow is the minimum discharge which is required to maintain water depth, flow velocity, water quality, channel stability, aquatic eco-system and scenery to the extent necessary for navigation, fish catch, operation and maintenance of intakes, maintenance of river facilities, sea water repulsion, prevention of estuary clogging, conservation of groundwater, preservation of riparian land and people's amenity.

The river maintenance flow is the indicator of the allowable limit of water withdrawal from the river and is to be considered in allocating and developing water resources. Water withdrawal should not be increased, if it is expected to impair the river maintenance flow frequently. Source development such as construction of dam and inter basin water diversion system will be conducted, if it is necessary to augment low flow in the river to allow expected increase in water withdrawal, while sustaining the river maintenance flow. An estuary barrage will be constructed, if it contributes to the reduction of the required rate of river maintenance flow through preventing sea water intrusion and through maintaining water level for the intakes located in the estuary area.

The river maintenance flow should be sustained to the extent possible, but its temporary reduction can be allowed to a certain extent. The river flow which corresponds to the subsistence level of water uses is herein called the essential river maintenance flow. The river maintenance flow may not be reduced to the essential river maintenance flow even if an extreme drought takes place. When the essential river maintenance flow is needed to be sustained under any drought, water withdrawal from the river should be reduced.

The river maintenance flow should be determined individually for each river, based on the conditions particular to the river. The river maintenance flow may require a costly development, if its rate is set considerably high. It should be determined based on the minimum requirement in each river. On the other hand, the river maintenance flow should not be so low as the recorded minimum flow, which is too small to sustain the existing water uses and environmental quality. It is preliminarily assumed that the rate of river maintenance flow is equal to the daily natural discharge of 97% in probability of exceedence as shown in Table 9 and that of essential river maintenance flow is equal to the daily natural discharge of 99% in probability of exceedence, referring to examples in several countries.

5.3 Development of Water Supply and Irrigation Systems

Water supply system and irrigation system have been developed, in order to transmit water from sources and to distribute it to the consuming ends.

Domestic and industrial water supply is conducted along with the objectives of national economic development, regional development and social well-being improvement. The service factor of urban water supply system is already high, and the development of rural water supply system has been forcefully promoted in the recent years. Taking into account the Government policy prevailing, it is assumed that the public water supply system will be developed to supply domestic water to all people by

2000 and to supply 50% of industrial water, except that 10% of rural people in Sabah and Sarawak will still not be publicly supplied, because of remoteness and non-availability of suitable water source.

Irrigation development on paddy, including the tertiary development is carried out along with the objectives of national economic development, improvement of food self-sufficiency and increase in farmers' real income. It is assumed that the irrigation facilities will be provided in accordance with the projected land development schedule.

5.4 Source Development

Balancing water demand and supply is the requisite for water resources development and use. The water demand projection was made assuming that concerned agencies would take appropriate measures for water saving such as recyclic use of water and increase in efficiency of facilities and utilization of sea water. Where frequent water deficit are foreseen even with these water saving measures, the development of source facilities such as water storage and/or interbasin diversion are proposed.

The strict adherence to the river maintenance flow will result in the construction of costly facilities even in the rivers in which water use is small compared with natural flow. Analysis showed that all the water demand could be met for more than 85% of time in the rivers of less than 10% in river utilization, if a temporary reduction in the river maintenance flow to a minor extent is permitted. With these considerations, it is proposed that the source development should be implemented only in the rivers in which the river utilization ratio will be more than 10%.

5.5 Water Pollution Abatement

Water pollution abatement is considered from the viewpoint of environmental quality and maintenance of water uses. River water can be treated ordinarily for domestic and industrial use, if its quality is on an adequate level from the viewpoint of environmental quality.

The concept of water quality standard in the river should be established as the indicator showing the target of water pollution abatement, which is performed by reducing pollution load discharged into the river.

The biochemical oxygen demand (BOD) is the oxygen used to meet the metabolic needs of aerobic micro-organisms in water rich in organic matter. Self-purification mechanism of river is greatly reduced and the aquatic ecosystem is also affected if BOD concentration in the rivers is more than 5 mg/lit. Odour occurs if the BOD concentration is over 10 mg/lit. Pre-treatment is necessary if BOD concentration in raw water is more than 2 mg/lit for domestic water supply and 5 mg/lit for industrial water supply. River water quality standards in terms of BOD concentration in several countries are illustrated in Fig.6. The target for water pollution abatement is set in terms of BOD concentration in the river, because BOD concentration is the most common and important parameter of man-made pollution of inland water.

The measures for organic pollution abatement in the river are the improvement of purification system of effluent from the palm oil mills and rubber factories as well as public sewerage development.

5.6 Hydropower Development

Power demand in Malaysia is growing at a high rate, while the existing power supply system largely depends on thermal power. Nation's energy policy directs the development of hydroelectric potential and the saving in fuel resources.

Hydroelectric potential in Sarawak has been estimated to be more than 20,000 MW. The Upper Rajang Hydroelectric Development is being studied in order to develop hydropower of 4,550 MW in the upper Rajang river in Sarawak. Power generated will be transmitted not only to Sabah and Sarawak but to Peninsular Malaysia by constructing submarine transmission line of 700 km. The total construction cost of the development has been estimated to be M$11 billion including the interconnection system. Further development including power supply to ASEAN countries has also been envisaged.

Due to uncertainties in the inter-connection systems for power transmission to Peninsular Malaysia and Sabah and also in the establishment of energy intensive industries in the State of Sarawak, this vast potential is, however, assumed to be made available only after the year 2000. The strategy of hydropower development is thus set to contribute to bridge power demand and supply balance up to 2000.

According to a recent projection by NEB, the maximum power demand in Peninsular Malaysia in 2000 will be 9,140 MW, while the installed capacity of existing and under construction hydropower totals only 1,206 MW at present. It is recommended that all known potential of economical hydropower of 1,026 MW in Peninsular Malaysia should be developed by 2000 for the maximum contribution in balancing power demand and supply.

There is a large power potential in Sabah and Sarawak, in addition to that in the Rajang river. The maximum power demand in 2000 has been projected to be a little over 1,000 MW each. Although power demand is generally fragmented into small isolated demand centers, hydropower development should be envisaged for such major demand centers as Kota Kinabalu in which the maximum power demand will be 460 MW in 2000 and Kuching in which the maximum power demand will grow to 295 MW by 2000. Such hydropower development should be capable of supplying to Tawau, Sandakan and Labuan if some or all of them are interconnected with Kota Kinabalu. It is recommended to develop hydropower in Sabah and Sarawak to such an extent that the incremental power demand in major demand centers can be met up to 2000.

5.7 Flood Mitigation

Flood mitigation contributes to the national economic development and social well-being by reducing flood damage and protecting people's life. The measures for flood mitigation should be provided in consonance with the socio-economic development.

The structural measures for the flood mitigation are channel improvement, bypass floodway, polder, flood control dam and their combinations as described below:

(1) Channel improvement: Channel improvement will increase the discharge capacity of river by reshaping the river channel and constructing levees including protection work against erosion and sedimentation in the river.

(2) Bypass floodway: Bypass floodway is a short-cut canal for flood where there are certain constraints for channel improvement. The discharge capacity of the floodway is usually determined to allow releasing the excess water of the original channel.

(3) Polder (Ring Bund): Polder is a ring bund to protect an area of high damage potential. It includes the construction of drainage canal and drainage pump for the protected area.

(4) Flood control dam: A flood control dam will retain flood temporarily. A single purpose flood control dam can hardly be justified, unless the flood damage is tremendous. The inclusion of flood control purpose into the dams proposed for other purposes is studied. The flood control space in the dam is determined to reduce the design flood discharge to 1/4, as a rule.

Non-structural measures are proposed for such river stretch as where structural measures are not applicable or where supplemental measures are required. They are the restriction of development and resettlement plan as described below:

(1) Restriction of development: The restriction of development is the control of damageable values in the flood vulnerable areas by restricting new development.

(2) Resettlement plan: The resettlement plan is also the restriction of development but it includes the resettlement of people.

In addition to the above-mentioned measures, flood forecasting and warning system is proposed for some river basins having more than 5,000 inhabitants liable to flood hazard as shown in Table 18.

5.8 Inland Fishery

Development of inland fishery contributes to the national economic development and social well-being by providing fish protein source and for eradicating poverty through providing employment opportunity in rural areas.

Inland fisheries activities comprise fishing and culturing in various waters such as rivers, lakes and reservoirs, tin mining pools, paddy fields, constructed ponds and mangrove areas. Along with the Government's policy for fish culture development presented in 4MP, the areal development was estimated in this Study. The beneficial and adverse effects of inland fishery development are shown in those of recommended plan for water demand and supply balance.

6. ALTERNATIVE STUDIES

6.1 Scope of Alternative Studies

In Chapter 5, the rate of river maintenance flow was provisionally assumed and the targets for domestic and industrial water supply, irrigation, water demand and supply balance and hydropower development were set. Herein presented are such alternative studies as those for water demand and supply balance plan by varying risks in supply, hydropower development plan by power supply system development plan, pollution abatement plan by target water quality standard, and flood mitigation plan for varying target of protection. Hydropower development alternatives are presented only for Sabah. For Peninsular Malaysia, it was assumed that all the known power potential should be fully developed by 2000 following the preliminary development schedule prepared by NEB. For Sarawak, as mentioned in 5.6, the hydropower potential was assumend to be so developed as to bridge demand and supply up to 2000.

The criteria for alternative setting and for comparison of the public expenditure and beneficial and adverse effects of alternatives are described hereunder, wherein, costs and effects were all estimated based on the criteria described in Chapter 7.

6.2 Water Demand and Supply Balance Alternatives

Both the instream water use and the consumptive water use can be sustained if river flow is more than the river maintenance flow. If otherwise, river flow should be augmented by developing source facilities such as dam for regulation of river flow or diversion facilities to transfer water from a river to another. A source development plan was proposed for each water stress Basin of which river utilization ratio in the projected year would be not less than 10% and the existing source facilities could not meet the estimated water deficit.

Natural flow varies not only seasonally but from year to year to a large extent. Any measures cannot meet all water demand under an extremely dry condition. In planning source facilities, water supply capacity is usually determined allowing a certain risk. If the risk is set considerably small, the source facilities are costly and if otherwise, adverse effects such as reduction in production and people's dissatisfaction may take place. The water demand and supply balance alternatives were proposed assuming different levels of risk.

Alternative sizes of the proposed source facilities were determined based on the following criteria:

Alternative B1: The supply capacity of source facilities is determined against the driest condition ever recorded; 1/N drought where N denotes the length of hydrological records in years.

Alternative B2: The supply capacity of source facilities is determined against the second driest condition ever recorded; 2/N drought.

Alternative B3: The supply capacity of source facilities is determined against the fourth driest condition (4/N drought) for Peninsular Malaysia and the third driest condition (3/N drought) for Sabah and Sarawak, ever recorded. This was proposed based on the difference in the length of hydrological records. (These conditions approximately correspond to 5-year drought according to Hazen's plotting method.)

A dam is constructed to retain water in the flood period and release it to augment river flow for the use in the dry period. Once a dam is constructed, inflow into the dam can be retained at any time, so far the storage capacity is available. It is required for a dam to release water at a rate which, together with the natural flow from the downstream catchment area, is sufficient to supply water demand while sustaining the river maintenance flow. In other words, the supply capacity of a dam is determined to supply all the water deficit. By doing so, the dam can develop water to meet the future water demand not affecting adversely on the existing water users.

The proposed dams were those either identified on 1/63,360 or 1/50,000 maps or proposed in previous studies. The water supply capacity of each dam was estimated based on hydrological record and on assumed storage capacity. The total water supply capacity of the proposed dams in a basin was determined to meet the total water deficit in the basin, allowing an operational loss which was assumed to be 10 to 20% of the water deficit.

If the total water supply capacity of all the proposed dams in a basin is not enough, diversion of water from other basin was proposed and, if necessary, the construction of a dam in the latter basin was further proposed.

The estimated public development expenditure and manpower requirement showed a large differences among the alternatives, indicating that a high guarantee of supply would be costly and requires a large manpower. A high guarantee of supply would bring a low value of internal rate of return, because benefit is little sensitive to the risk of supply. Alternative B1 can guarantee safe supply all the time even under the driest condition ever recorded but some interruption in safe supply have to be involved in the other alternatives. Considerations were made also of adverse effects such as removal of people from the proposed reservoir areas and change in fish fauna, and beneficial effects such as fish culture and recreation in a lake created.

It is recommended that Alternative B1 should be selected for the Basins where domestic and industrial water demand is predominant in accordance with the common understanding in Malaysia that domestic and industrial water supply should be sustained even under the serious drought.

Irrigation facilities have been designed against a drought of 5-year in return period in Malaysia, this criterion corresponds to the criteria in Japan, Korea, Indonesia and other countries in Southeast Asia. Under the condition that irrigation demand is already high, grading-up of the above-mentioned criterion will immediately require a large investment for source development. With these considerations, it is recommended to select Alternative B3 for the Basins where water is predominantly used for irrigation.

The location of potential and proposed water source facilities is shown in Fig.7 for Alternative B1.

6.3 Hydropower Development Alternatives

A hydropower development plan for Peninsular Malaysia was recommended without alternative study.

6.4 Water Pollution Abatement Alternatives

Two alternative plans for water pollution abatement were proposed setting target BOD concentration in the river as mentioned below.

Alternative P1: 5 mg/lit in BOD concentration in 1990 onwards

Alternative P2: 10 mg/lit in BOD concentration in 1990 onwards

If the reduction of BOD concentration in a stretch of a river is found necessary to attain the target, the improvement of purification method in all palm oil mills and rubber factories in the river was, first of all proposed. The Basin where the improvement was proposed for both the alternatives for 1990 and 2000 was the Kemaman Basin.

If there still remains a river stretch of higher BOD concentration than the proposed limit, the construction of a sewerage system in the urban area upstream of the river stretch was proposed: it is not the case in the State of Trengganu and therefore, the two alternatives are identical.

No treatment measures were assumed for the sewage from the towns of less than 50,000 in population and rural areas and for the effluent from animal husbandry. With these conditions, it was estimated that some river stretches in the west coast of Peninsular Malaysia would show higher BOD concentration than the target value.

The ordinary treatment method for the domestic water supply is the sedimentation, filtration and chlorination, if BOD concentration in raw water is not more than 2 mg/lit. The ordinary treatment method for the industrial water supply is the sedimentation, if BOD concentration in raw water is not more than 5 mg/lit. Pre-treatment facilities are needed to varying extent for raw water with BOD concentration above these limits. For BOD concentration in raw water more than the above-mentioned limit but not more than 20 mg/lit, pre-treatment is carried out by the rapid sand-filter bed and activated carbon absorption (secondary treatment). For BOD concentration between 20 and 200 mg/lit, an aerated lagoon

process such as aerated lagoon or maturing pond (primary treatment) is further needed. The cost for pre-treatment facilities was taken into account for the economic comparison of the alternatives.

The public development expenditure and manpower requirement were estimated in this Study to hardly vary between the two alternatives. The results of economic benefit cost analysis also showed little difference between the alternatives; although the economic cost is larger than the economic benefit, the water pollution abatement should be conducted from the viewpoint of environmental and social well-being impacts. Meanwhile, the problem is that the public development expenditure and manpower requirement would be largely concentrated in the earlier part of development, i.e., in 4MP and 5MP periods. In order to avoid this concentration, it is necessary to slow-down the rate of development up to 1990. With these considerations, it is recommended that the pollution in the river should be gradually abated by setting the target BOD concentration at 5 mg/lit for 2000.

6.5 Flood Mitigation Alternatives

Three alternatives are proposed for the flood mitigation:

Alternative F1: Structural measures are provided by 2000 for the entire river system to protect 90% of people within the flood prone area.

Alternative F2: Structural and non-structural measures are provided by 2000 for densely populated areas to protect 50% of people within the flood prone area.

Alternative F3: Structural and non-structural measures are provided by 2000 so far as such measures are economically viable.

The return period of design flood is assumed to be 20-year for the river stretch where the estimated annual flood damage is less than M$20,000/km and the population is 500 persons/km, and 50-year for the other river stretches, but 100-year if loss of life has been recorded.

The problem rivers were divided into stretches of 30 to 60 km in length. The measures explained in Section 5.7 were compared and the most economical measures was selected for each river stretch. The resulted alternative plans for the State are as outlined in Table 19.

Alternative F1 appeared to require a prohibitively large expenditure for the whole Malaysia. Alternative F3 should be implemented if considered from the viewpoint of national economic development, but it will increase the disparity between developed and underdeveloped areas. Taking into account the fact that social well-being objective has been emphasized through discussions between Malaysian Government officials and the Study Team, it is recommended that Alternative F2 should be taken up for the period up to 2000. The flood mitigation alternatives including Alternative F1, F2 and F3 are illustrated in Figs.8 through 10.

7. RECOMMENDED PLAN

A Water Resources Development and Use Plan is recommended, based on the comparison of alternatives. Its outline is illustrated in Cover Map.

7.1 Public Water Supply and Irrigation Development Plan

Public water supply system including PWD system and RESP system is recommended to be provided to meet all the urban and rural domestic water demands and 50% of industrial water demand by 2000 in accordance with the plan shown in Tables 20 through 22. However, 10% of the rural people in Sabah and Sarawak will still not be publicly supplied, because of the remoteness and non-availability of suitable water source.

Irrigation water supply system will be constructed in accordance with the schedule assumed in Table 13.

7.2 Source Development

The Kenyir dam will be completed in 1985 with the purposes of hydropower and flood mitigation. Its net supply capacity of 4,010 million cu.m/y will be well over the maximum rate of water deficit in 2000 in the downstream of the dam. Therefore, no source development plans are needed for the State by 2000.

7.3 Water Pollution Abatement Plan

The recommended plan for the water pollution abatement in the river is the improvement of purification method in the palm oil mills in the Kemaman Basin.

Although it is ineffective for the water pollution abatement in the river, sewerage development in Kuala Trengganu is assumed from the viewpoint of public health. The recommended plan for water pollution abatement is shown in Tables 23 to 25.

7.4 Flood Mitigation Plan

The recommended plan for flood mitigation is mentioned hereunder and is summarized in Table 26.

7.4.1 Kemaman river flood mitigation plan

The Kemaman river flooded 265 sq.km in 1971. The recommended plan is to protect 14,000 people by providing a ring bund for Chukai town.

7.4.2 Ibai river flood mitigation plan

The Ibai river located at south of Kuala Trengganu flooded 36 sq.km in 1967. Channel improvement of 12 km is recommended for the lowermost stretch of the river to protect 23,000 people in 20 sq.km.

7.4.3 Trengganu river flood mitigation plan

The Trengganu river flooded 290 sq.km in 1967, but no overbank flow will take place in the main stream under 50-year flood, if the Kenyir dam is completed. The recommended plan includes channel improvement of 12 km in the lowermost stretch of the main stream and 5 km in the Nerus river, one of the tributaries, to protect Kuala Trengganu of 199,000 in population from flood coming from the Nerus river, and ring bund to protect 3,900 people in Kuala Brang against flood originating from the Brang river which is also a tributary of the Trengganu river.

7.4.4 Setiu river flood mitigation plan

The Setiu river inundated 252 sq.km in 1967. The recommended plan is to protect 6,600 people by providing channel improvement for 9 km as a continuation of the on-going project.

7.4.5 Keluang Besar and Besut rivers flood mitigation plan

The Keluang Besar and Besut rivers, running across the Besut irrigation project area of 5,058 ha, flooded 266 sq.km in 1967. The recommended plan is to protect the irrigation area and 57,000 people by providing channel improvement for 12 km of the Kuluang Besar river and 21 km of the Besut river.

7.5 Hydropower Development Plan

The hydropower potential is high in the Trengganu river basin. The plan presented in Table 27 is recommended to match with the national energy policy.

The Ulu Trengganu dam is recommended for hydropower development with the installed capacity of 100 MW. The location of the dam is presented in Cover Map.

7.6 Cost Estimate

The construction costs of the proposed facilities were estimated at the constant price in December, 1980.

The construction costs consist of direct construction cost (contract amount), engineering and administration, land acquisition and physical contingency. The direct construction cost was estimated based on the actual costs and previous estimate for similar projects in Malaysia. Major unit costs assumed are listed in Tables 28 and 29. The physical contingency was assumed to be 30%. The construction cost is disbursed in five years antecedent to the year of commission of the proposed facilities. The construction cost of the untreated rural water supply, however, was assumed to be disbursed in one year exceptionally.

The construction costs were estimated for all the proposed facilities to be commissioned in 1985 onward, including storage and diversion facilities, domestic and industrial water supply system, irrigation system, flood mitigation facilities and public sewerage system, but the sunk cost was not estimated.

The purification facilities for the palm oil mills and rubber processing factories were assumed to be privately financed.

According to the present practice, it was assumed that the construction cost of sewerage system borne by private sector is the house connections in the existing town area, and branch sewers and house connections in the new town areas. In estimating the sewerage treatment capacity in the new town area, it was assumed that the population within the existing town area will remain unchanged and the treatment capacity is allocated in proportion to the population.

The development expenditure and recurrent expenditure in public and private sectors for the recommended plan was estimated as shown in Tables 30 and 31.

7.7 Beneficial and Adverse Effects

The beneficial and adverse effects of the recommended plans were evaluated from the viewpoints of national economic development, environmental quality and social well-being. The beneficial and adverse effects of the recommended plans comprising each aspect of national economic development, environmental quality and social well-being are presented in Table 32 for water demand and supply balance, in Table 33 for water pollution abatement, in Table 34 for flood mitigation and in Table 35 for hydropower development.

7.7.1 National economic development

The beneficial and adverse effects of the recommended plans for the national economic development account are calculated as the annual equivalent of economic benefits and costs, assuming a discount rate of 8% for an evaluation period of 50 years between 1981 and 2030.

The prices of internationally traded goods and services were estimated based on the World Bank projection up to 1990, or the international market price in December, 1980. The prices of locally traded goods and services were the normalized price in December, 1980. The transfer payments such as tax and local contractors' profit are deducted from all prices. The ratio of transfer payment to the financial cost was assumed to be 20% of financial cost referring to the ratio of tax revenue to GDP at purchasers' price in 1980 in 4MP.

The domestic and industrial water supply benefit was estimated based on the least-costly alternative facilities cost criteria. The cost of the above-mentioned alternative facilities including dams and the proposed intake, conveyance, treatment and distribution systems is regarded as the benefit of domestic and industrial water supply without drought damage.

There should be established a rule for the emergency operation against the drought in which both the rate of water withdrawal and rate of river maintenance flow should be sustained as much as possible and the river flow should be kept not below the essential river maintenance flow. Herein a simplified rule was assumed: water withdrawal for use continues until the river flow after the water withdrawal lowers to the essential river maintenance flow and thereafter the water withdrawal is reduced so that river flow no longer lowers. Consequently, the reduction in supply for domestic and industrial water and irrigation water is calculated through the period in which run-off record is available, allowing low flow after the water withdrawal to be equal to the essential river maintenance flow. The reduction in benefit is calculated assuming that it is proportional to the reduction in the supply.

The economic farmgate price of paddy during the evaluation period was estimated to be M$640/ton based on the projected price of 5% broken rice, FOB Bangkok. Estimated paddy yield, gross value, production cost and net value are estimated for 1990 and 2000 as shown in Table 36. The hectareage of newly reclaimed land and upgraded lands from rainfed paddy to irrigated or control drainaged paddies, single crop to double crop and minor scheme to major scheme were estimated for the future. Then the irrigation benefit is obtained as the incremental net production value.

The sewerage benefit is the willingness-to-pay by served people and saving in the cost of purification of industrial waste. It was herein assumed to be 0.6% of real income of served people and to be the same percentage of gross value of manufacturing production of served industries.

Pre-treatment facilities are necessary if BOD concentration in raw water is more than 2 mg/lit for domestic water supply and 5 mg/lit for industrial water supply. Its costs can be saved, if the proposed water pollution abatement measures reduce BOD concentration in the river below this limit. This saving in cost is counted as a part of water pollution abatement benefit.

Under the flood mitigation benefit, average value of reduction in annual damage by the proposed measures only is counted, while land enhancement benefit is counted in the irrigation benefit. It is assumed that the damageable value in the flood prone area will increase at a rate of gross regional product of the state.

The fish culture benefit was estimated to be M$2,000/ha for the fish pond and M$1.6 million/reservoir for the cage culture in the created reservoir.

Benefit of the created lake recreation is estimated by use of the concept of willingness-to-pay of the visitors to the lake. The willingness-to-pay is measured in terms of the travelling, or fuel cost of the vehicles to the recreation area. The said cost is assumed to be M$0.1/km.

The economic cost is calculated as the annual equivalent of the construction cost and OMR cost. It is noted that the private sector cost of industrial water supply facilities, purification facilities in palm oil mills and rubber factories and sewerage facilities are included in the economic cost of water pollution abatement measures.

The economic internal rate of return (EIRR) is calculated as the discount rate with which the present worth of benefit equals to that of cost.

7.7.2 Environmental quality

The beneficial and adverse effects of the recommended plans from the viewpoint of environmental quality are descriptively displayed.

The river maintenance flow is the requisite for the conservation of river environment and adequate water use. The effect on the river maintenance flow is evalpated as the number of days when the river maintenance flow can be sustained in the driest year ever recorded.

The water surface of created reservoir provides favorable scenery, place of recreation and enhancement of wildlife. The beneficial effect of created lake is counted by the water surface area.

The reduction in length of river stretches in which BOD concentration will be more than 5 mg/lit is regarded as the beneficial effect of water pollution abatement.

The channel improvement stabilizes the river channel and provides favorable condition for navigation and other instream water use. The length of improved river stretches is counted as a parameter showing the beneficial effect on environmental quality.

If a dam is constructed, some species of fish would probably disappear in certain length of river stretch immediately downstream of the dam showing an adverse effect on ecological system, though such adverse effect can be compensated by possible cage culture in the created reservoir.

7.7.3 Social well-being

The income increase, health improvement, life saving, and reduced risk in water supply are counted as the beneficial effect from the viewpoint of social well-being. The adverse effect is the inevitable removal of people for the purpose of construction of proposed facilities.

8. PLAN UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

8.1 Assumed GDP Growth Rate

The recommended plan mentioned in the foregoing Chapter 7 is based on an assumption that the growth rate of GDP is 7.7% in the period from 1980 to 1985, 8.4% from 1985 to 1990, and 7.5% from 1990 to 2000, in accordance with 4MP and OPP.

For reference, a plan under a lower economic growth was prepared, assuming that Malaysia's economy might be affected by a long-lasting world-wide economic depression. The growth rate of GDP assumed was 7% in the period from 1980 to 1985, 6% from 1985 to 1990, and 5% from 1990 to 2000.

8.2 Parameters Predominantly Related to GDP Per Capita

The parameters dominated by GDP per capita are the urbanization ratio, share of manufacturing sector in GDP, gross value of industrial output, power consumption per capita, domestic water consumption per capita and value of flood damage, so far related with the water resources development and use. These parameters under the condition of lower economic growth were estimated assuming a functional relationship with GDP per capita.

8.3 Assumed Targets

The service factor and per capita daily use (PCDU) in domestic water supply and rate of irrigation development may be affected by the economic growth and by the socio-economic policy as well. It is herein assumed that, in case of the lower economic development, the target service factor and PCDU in domestic water supply for 2000 is delayed by five years but the rate of irrigation development does not change even under the lower economic development. The estimated service factor and PCDU under the condition of lower economic growth are shown in Table 37. The domestic and industrial water demand estimated under the condition of lower economic growth is shown in Table 38.

8.4 Development Plan

The development plan under the condition of lower economic growth is tabulated in Tables 39 through 44.

8.5 Public Expenditure

The public development and recurrent expenditures are estimated for the case of lower economic growth as shown in Tables 45 and 46.

8.6 Beneficial and Adverse Effects

The beneficial and adverse effects of the water resources development and use plan for the case of lower economic growth are summarized in Tables 47 to 50.

TABLES

Table 1 METEOROLOGICAL DATA IN TRENGGANU

Kuala Trengganu, El 35.1 m

		Mean Air Temperature (°C)	Relative Humidity (%)	Sunshine Hours (hrs.)	Open Water Evaporation (mm)	Rainfall (mm)
Jan.		24.9	84.3	6.45	137	260
Feb.		25.5	83.3	7.55	142	124
Mar.		26.1	83.4	8.24	170	122
Apr.		27.0	83.6	8.82	177	94
May		27.2	84.7	8.03	163	118
June		26.8	85.2	6.88	150	180
July		26.5	84.8	7.04	150	142
Aug.		26.4	85.4	6.91	151	224
Sep.		26.2	85.8	6.23	151	256
Oct.		26.1	87.1	5.77	141	302
Nov.		25.3	89.5	4.36	119	610
Dec.		25.2	87.7	4.08	115	792
Annual		26.1	85.4	6.70	1,766	3,224
Daily	Max.	33.9	98.2			
	Min.	18.4	68.7			

Table 2 RIVER CHARACTERISTICS IN TRENGGANU (1/3)

Basin No.	Item	Description
32	Kemaman river	
	(A) River Morphology	Meanders in tidal swamp areas, especially in Chukai river. Minor erosions in tidal and middle reaches. But no adverse problems reported.
	(B) Estuary*	Show depth at river mouth due to coastal drift. Only small boats (3 m draft) navigable. Northern cape seems to prevent excessive intrusion of coastal sand into river mouth.
	(C) Sediment	Active sediment movement and sand deposit in lower reaches. Deposit being extracted for construction materials.
	(D) Sea Water Intrusion	Saline up to 19 km upstream. Tidal effect up to Cherul river confluence (25 km). No saline problem at existing PWD's water supply intake (21 km).
34	Dungun river	
	(A) River Morphology	No heavy meanders. Stable banks being formed by hard ground. Only localized erosion in upper reaches.
	(B) Estuary	Tanjung Dungun at northern part of river mouth seems to prevent excessive intrusion of coastal sands, but still sand bars existing in river mouth area. Sufficient navigation depth at present (fishermen). No immediate problem.
	(C) Sediment	Sand deposit/shoals in middle/lower reaches. Tin mining in Bukit Besi area yielding sediment.
	(D) Sea Water Intrusion	Possibly up to Kg. Kemudi. No saline problem at JKR Dungun Works (13 km from river mouth).

Remarks; *: Major problems requiring some improving measures

Table 3 RIVER CHARACTERISTICS IN TRENGGANU (2/3)

Basin No.	Item	Description
36	Trengganu river	
	(A) River Morphology	Some bank erosion at upstream of K. Brang and at meanders in downstream areas. After the completion of Kenyl Dam, erosion may further develop, being caused by riverbed degradation. But, no need of immediate protection.
	(B) Estuary*	Shallow river mouth causing the navigation of big ships difficult. Shoreline at river mouth changeable due to interaction between river flows and wave actions. In general, however, seems to be in a stable regime.
	(C) Sediment	150 $m^3/km^2/y$ before Kenyl Dam, 42 $m^3/km^2/y$ after Dam completion. At present, sand shoals upstream of K. Brang much contributing silting in lower reaches.
	(D) Sea Water Intrusion*	Up to Pulau Babi (17 km). Tidal effect up to 28 km. Saline problem existing at PWD's Pulau Musang Intake (2 weeks/year). 150 m^3/s release from Kenyir Dam may solve problem.
37	Setiu river	
	(A) River Morphology	Meanders existing in middle/lower reaches, but in stable regime at present. River appears to incise the banks at local places upstream from Kg. Buloh, but controlled by stable banks.
	(B) Estuary*	Sediment from sea forming extensive dunes along coast, with intrusion of sand into river mouth. Shallow river mouth causing navigation difficult.
	(C) Sediment*	No estimate of yield rate so far, but probably less. No sand bars and shoals observed in upper/middle reaches.
	(D) Sea Water Intrusion	Possibly not up to Kg. Guntong (17 km). No adverse problem reported.

Remarks; *: Major problems requiring some improving measures

Table 4 RIVER CHARACTERISTICS IN TRENGGANU (3/3)

Basin No.	Item	Description
38	Besut river	
	(A) River Morphology	Moderate meanders throughout reaches. River appears to incise the banks, but excessive erosion prevented by comparatively hard banks.
	(B) Estuary*	River mouth area silted by river-borne sediment as well as sediment from sea. Right bank coastal dune seems developing (remarkable change from the condition in 1967 - 1 : 63,360 map).
	(C) Sediment*	Sand bars/shoals at almost all meanders downstream from Kg. La. No detailed survey so far, but possibly high yield due to agricultural development in upper reaches.
	(D) Sea Water Intrusion	Possibly up to Kg. Baru (7 km). No adverse problem at present.

Remarks; *: Major problems requiring some improving measures

Table 5 FLOODED AREA BY RECORDED MAXIMUM FLOOD IN TRENGGANU

Basin No.	River Basin	Year	Flooded Area (km^2)	Population 1980 (10^3)	Estimated Damage at 1980 Condition (M$$10^6$)
32	Kemaman	1972	265	25	3.7
	Kemasik	1973	11	-	0.1
	Kerteh	1973	59	1	0.1
33	Paka	1973	47	1	0.1
34	Dungun	1973	220	8	1.3
35	Marang	1976	72	3	0.4
	Merchang	-	114	-	-
36	Ibai	1967	36	23	3.1
	Trengganu	1967	289	74	12.7
37	Merang	1967	102	1	0.1
	Setiu	1967	252	7	1.6
38	Keluang	1967	102	23	4.7
	Besut	1967	167	57	11.0
	Total		1,736	223	38.9

Table 6 LIST OF EXISTING AND PLANNED DAMS IN TRENGGANU

Name	River	Purpose/ Year of Commission	Organi-zation	Catchment Area (km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity (10^6 m^3/y)
Under Construction						
Kenyir Dam	Trengganu	HY + FM	NEB	2,600	7,400	4,010
Existing						
Besut Weir	Besut	IR	DID	-	-	0
Tenang Weir	Besut	-	PWD	-	-	0

Remarks; FM: Flood mitigation
HY: Hydropower

Table 7 HISTORICAL AND PROJECTED POPULATION OF DISTRICT BY CITY/TOWN AND RURAL AREA IN TRENGGANU

Unit: 10^3

District	City/Rural	Historical 1980	Projected 1985	1990	2000	Average Annual Growth (%) 1980-2000
64. Kemaman	51. Chukai	17	19	22	28	2.5
	Rural	53	58	69	53	1.0
	District Total	70	77	91	81	0.7
65. Dungun	52. Dungun	32	40	52	84	4.9
	Rural	33	29	16	3	-11.3
	District Total	65	69	68	87	1.5
66. Marang	Rural	28	30	35	33	0.8
67. Ulu Trengganu	132. Ulu Trengganu	5	7	10	17	6.3
	Rural	44	47	53	44	1.0
	District Total	49	54	63	61	1.1
68. Kuala Trengganu	53. Kuala Trengganu	199	281	377	611	5.8
	Rural	56	43	13	2	-15.4
	District Total	255	324	390	613	4.5
69. Besut	Rural	110	115	115	68	-2.4
Total	Urban Total	253	347	461	740	5.5
	Rural Total	324	322	301	203	-2.3
	State Total	577	669	762	943	2.5

Table 8 HISTORICAL AND PROJECTED GROSS VALUE OF MANUFACTURING OUTPUT BY COMMODITY GROUP IN TRENGGANU

Unit: M$10^6

Item	Year 1980	1985	1990	2000
Food	71	166	183	553
Textile	5	12	18	60
Wood	61	93	107	195
Paper	0	0	0	0
Publishing	1	2	6	72
Chemical	10	35	161	432
Rubber	7	19	35	201
Non-metal	1	3	6	55
Basic metal	0	70	239	653
Machinery	7	25	57	441
Others	0	1	2	16
Total	163	426	814	2,678

Remarks; In factor cost at 1970 prices

Table 9 BASIN AREA AND ASSUMED RIVER MAINTENANCE FLOW IN TRENGGANU

Basin No.	Basin	Total Catchment Area (km^2)	Effective Catchment Area (km^2)	Balance Point (km)	River Maintenance Flow (m^3/s)
32	Kemaman	2,570	2,245	5	23.1
33	Paka	850	815	2	7.4
34	Dungun	1,875	1,760	10	20.6
35	Marang	760	650	6	8.1
36	Trengganu	4,650	4,600	1	61.5
37	Setiu	1,035	875	6	10.0
38	Besut	1,230	940	17	10.5

Remarks; The location of balance point is the river length in km measured upstream from the estuary.

Table 10 ESTIMATED AND PROJECTED SERVICE FACTOR AND PER CAPITA DAILY USE OF DOMESTIC WATER IN TRENGGANU

City/Rural	Service Factor (%)				Per Capita Daily Use (lpcd)			
	Estimated	Projected			Estimated	Projected		
	1980	1985	1990	2000	1980	1985	1990	2000
1. Urban Area								
51 Chuka	80	85	90	100	160	175	190	220
52 Dungun	80	85	90	100	160	175	190	220
53 Kuala Trengganu	100	100	100	100	115	153	190	220
132 Ulutrengganu	100	100	100	100	170	185	200	250
2. Rural Area								
PWD Rural	25	43	44	45	75	100	125	175
MOH Rural	22	52	55	55	40	48	55	70
3. Non-Pipe-Served Area	-	-	-	-	40	40	40	40

Table 11 NET UNIT MANUFACTURING WATER USE PER GROSS VALUE OF MANUFACTURING OUTPUT BY COMMODITY GROUP

Unit: $m^3/d/M\$10^6/y$

	Commodity Group	Assumed/1 1975	Estimated/2 1980	Projected 1985/2	Projected 1990 & 2000
1.	Food	77.0	75.0	73.0	71.0
2.	Textile	79.0	77.0	75.0	73.0
3.	Wood Product	12.0	12.3	12.7	13.0
4.	Paper Product	581.0	560.7	540.3	520.0
5.	Publishing	10.0	10.0	10.0	10.0
6.	Chemicals	140.0	136.7	133.3	130.0
7.	Rubber Manufacturing	126.0	105.7	85.3	65.0
8.	Non-metal	88.0	86.7	69.3	68.0
9.	Basic Metal	53.0	51.7	50.3	49.0
10.	Machinery	16.0	17.3	18.7	20.0
11.	Miscellaneous	48.0	48.3	48.7	49.0

Remarks; /1: Assumed from data in Japan in 1970
/2: Obtained by interpolation

Note; The values indicated are net manufacturing water use (excluding the water used cyclically) per $M\$10^6$ of the gross value of manufacturing output at 1970 price.

Table 12 ESTIMATED AND PROJECTED D&I WATER DEMAND BY BASIN IN TRENGGANU

Unit: 10^6 m^3/y

Basin No.		City/Rural	Estimated 1980 D&I	Projected 1985 D	1985 I	1985 Total	1990 D	1990 I	1990 Total	2000 D	2000 I	2000 Total
32	51	Chukai	1.3	1.5	1.9	3.4	1.8	4.6	6.4	3.0	23.4	26.4
		Rural	1.7	1.8	1.0	2.8	2.7	1.0	3.7	2.9	1.1	4.0
		Basin Total	3.0	3.3	2.9	6.2	4.5	5.6	10.1	5.9	24.5	30.4
33		Rural	0.4	0.3	0.2	0.5	0.2	0.5	0.7	0.0	0.2	0.2
34	52	Dungun	2.4	3.0	1.2	4.2	4.4	2.8	7.2	8.9	14.5	23.4
		Rural	0.8	0.6	0.5	1.1	0.4	0.6	1.0	0.1	0.7	0.8
		Basin Total	3.2	3.6	1.7	5.3	4.8	3.4	8.2	9.0	15.2	24.2
35		Rural	0.8	0.9	0.2	1.1	1.5	0.2	1.7	1.9	0.2	2.1
36	53	Kuala Trengganu	17.6	25.0	6.2	31.2	36.2	15.3	51.5	73.4	79.1	152.5
	132	Ulu Trengganu	0.2	0.3	0.2	0.5	0.8	0.5	1.3	1.8	2.7	4.5
		City Total	17.8	25.3	6.4	31.7	39.0	15.8	52.8	75.2	81.8	157.0
		Rural	3.1	2.8	1.4	4.2	2.6	1.1	3.7	2.4	1.7	4.1
		Basin Total	20.9	28.1	7.8	35.9	39.6	16.9	56.5	77.6	83.5	161.1
37		Rural	1.0	1.4	0.1	1.5	1.8	0.2	2.0	1.5	0.2	1.7
38		Rural	1.6	2.4	0.2	2.6	2.9	0.3	3.2	2.3	0.3	2.6
Total			30.9	40.0	13.1	53.1	55.3	27.1	82.4	98.2	124.1	222.3
(State Total for Trengganu)			(30.9)	(40.0)	(13.1)	(53.1)	(55.3)	(27.1)	(82.4)	(98.2)	(124.1)	(222.3)

Remarks; Water demand: Total source demand
D: Domestic water demand
I: Industrial water demand

Table 13 ESTIMATED AREA OF IRRIGATED PADDY FIELD IN TRENGGANU

Unit: ha

Basin No.	Basin Name	Scheme	1980 Main Season	1980 Off Season	1990 Main Season	1990 Off Season	2000 Main Season	2000 Off Season
32.	Kemaman+	Minor	635	379	671	415	671	415
33.	Paka	Minor	162	-	162	-	162	-
34.	Dungun	Minor	66	32	1,280	639	1,467	826
35.	Marang+	Minor	695	238	1,375	622	2,104	1,351
36.	Trengganu	Minor	9,195	3,811	11,177	4,744	11,177	5,181
37.	Setiu+	Minor	1,841	431	2,619	836	3,200	1,417
38.	Besut+	Major	5,058	4,047	5,058	4,047	5,058	4,047
		Minor	1,008	583	1,453	927	1,453	927
Total			18,660	9,521	23,795	12,230	25,292	14,164

Note; + marked after the name of Basin shows the inclusion of other Basin than the stated Basin.

Table 14 ESTIMATED IRRIGATION WATER DEMAND FOR PADDY IN TRENGGANU

Unit: 10^6 m^3/y

Basin No.	Basin Name	Scheme	1980	1990	2000
32.	Kemaman+	Minor	19	18	18
33.	Paka	Minor	3	3	3
34.	Dungun	Minor	2	31	37
35.	Marang+	Minor	13	26	47
36.	Trengganu	Minor	180	200	208
37.	Setiu+	Minor	29	42	59
38.	Besut+	Major	128	116	116
		Minor	23	32	32
Total			397	468	520

Note; + marked after the name of Basin shows the inclusion of other Basin than the stated Basin.

Table 15 RIVER UTILIZATION RATIO BY BASIN IN TRENGGANU FOR 1990 AND 2000

Basin No.	Basin Name	Surface* Runoff (1)	1990 Source Demand D&I	1990 Source Demand Irr.	1990 Source Demand Total (2)	1990 Ratio (2)/(1) (%)	2000 Source Demand D&I	2000 Source Demand Irr.	2000 Source Demand Total (2)	2000 Ratio (2)/(1) (%)
32	Kemaman	3,369	10	18	28	1	30	18	48	1
33	Paka	1,082	0	3	3	0	0	3	3	0
34	Dungun	3,013	8	31	39	1	24	37	61	2
35	Marang	1,181	2	26	28	2	2	47	49	4
36	Trengganu	8,974	57	200	257	3	161	208	369	4
37	Setiu	1,466	2	42	44	3	2	59	61	4
38	Besut	1,544	3	148	151	9.8	3	148	151	9.8

Remarks; *: Surface runoff in effective area

: The ratio of less than 0.1% was assumed to be zero.

Table 16 ASSUMED DEVELOPMENT OF LAND DISPOSAL IN PALM OIL MILLS AND RUBBER FACTORIES IN TRENGGANU

Unit: %

	1980	1990	2000
Palm oil mills	25	50	75
Rubber factories	0	10	20

Table 17 DISCHARGE RATIO, RUNOFF RATIO, INFILTRATION RATIO AND BOD CONCENTRATION OF EFFLUENT ASSUMED UNDER PRESENT PURIFICATION LEVEL IN TRENGGANU

Pollution Source	Year	Discharge Ratio	BOD Concentration (mg/lit)	Runoff Ratio	Infiltration Ratio
Domestic					
Urban sewerage	1999 & 2000	0.9	30	1.0	0.2
Urban non-sewerage	1990	0.9	160	0.6	0
	2000	0.9	140	0.6	0
Rural	1990 & 2000	0.8	200	0.1	0
Manufacture					
Urban sewerage	1990 & 2000	1.0	30	1.0	0.2
Urban non-sewerage }	1990	1.0	155	0.6	0
Rural }	2000	1.0	140	0.1	0
Palm Oil Mill					
With P.S./1	1990	0.55	50	0.6	0
	2000	0.3	50	0.6	0
Without P.S.	1990	0.55	22,000	0.6	0
	2000	0.3	22,000	0.6	0
Land disposal	1990	0.1	50	0.6	0
	2000	0.1	50	0.6	0
Rubber Factories					
With P.S.	1990	0.9	50	0.6	0
	2000	0.8	50	0.6	0
Without P.S.	1990	0.9	2,320	0.6	0
	2000	0.8	2,320	0.6	0
Land disposal	1990	0.1	50	0.6	0
	2000	0.1	50	0.6	0
Animal Husbandry	1990 & 2000	1.0	200/2	0.1	0

Remarks; /1: Purification System
/2: g/d/head

Table 18 PROPOSED FLOOD FORECASTING AND WARNING SYSTEM IN TRENGGANU

Basin No.	River Basin	People Rel'ved by F/F (10^3)	Construction Cost (M$$10^6$)	Construction Period
32	Kemaman	6.7	0.5	4MP
34	Dungun	2.6	0.6	4MP
36	Trengganu/1	20.5	0.4	4MP
38	Besut/1	15.1	0.2	4MP
Total		44.9	1.7	

Remarks; /1: Additional flood forecasting stations be recommended.

Table 19 OUTLINE OF FLOOD MITIGATION PROGRAM BY ALTERNATIVE IN TRENGGANU

Basin No.	Basin Name	R.I. (km)	Dam (nos)	F.W. (km)	Pold. (nos)	N.S. (10^3)	P.P. (10^3)	F.A. (10^3ha)	C.C. (M$$10^6$)
	ALTERNATIVE F1								
32	Kemaman	36	-	-	-	-	24	7	72
33	Paka	12	-	-	-	-	-	2	20
34	Dungun	50	-	-	-	-	9	16	113
36	Trengganu	162	-	-	-	-	145	30	276
37	Setiu	24	-	-	-	-	3	4	16
38	Besut	66	-	-	-	-	62	24	98
	Total	350	-	-	-	-	243	83	595
	ALTERNATIVE F2								
32	Kemaman	-	-	-	1	-	14	2	10
36	Trengganu	29	-	-	1	-	77	10	79
37	Setiu	9	-	-	-	-	2	1	8
38	Besut	33	-	-	-	-	55	18	58
	Total	71	-	-	2	-	148	31	155
	ALTERNATIVE F3								
32	Kemaman	-	-	-	1	-	14	2	10
36	Trengganu	5	-	-	1	34	35	3	33
38	Besut	66	-	-	-	-	62	24	98
	Total	71	-	-	2	34	111	29	141

Remarks;
- R.I. : River improvement,
- F.W. : Floodway,
- Pold.: Polder,
- N.S. : Non-structural measure, in person
- P.P.: Population protected (the year 2000)
- F.A.: Flood area relieved
- C.C.: Construction cost

Table 20 RECOMMENDED WATER SUPPLY DEVELOPMENT PLAN FOR CITIES/TOWNS IN TRENGGANU

Basin No.	Code No.	City/Town	1985 TC	1985 SF	1985 SP	1990 TC	1990 SF	1990 SP	2000 TC	2000 SF	2000 SP
32	51	Chukai	7.1	85	16.2	12.3	90	19.8	44.4	100	28.0
34	52	Dungun	10.7	85	34.0	17.3	90	46.8	48.8	100	84.0
36	53	Kuala Trengganu	84.7	100	281.0	132.3	100	377.0	340.5	100	611.0
	132	Ulu Trengganu	1.1	85	6.0	3.3	90	9.0	9.6	100	17.0
	Total		103.6	97	337.2	165.2	98	452.6	443.3	100	740.0

Remarks; TC: Treatment capacity required in the corresponding year in 10^3 m^3/d

SF: Service factor in %

SP: Served population in 10^3

Table 21 RECOMMENDED TREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN TRENGGANU

Basin No.	Basin Name	1985 TC	1985 SF	1985 SP	1990 TC	1990 SF	1990 SP	2000 TC	2000 SF	2000 SP
32	Kemaman	4.2	42.6	24.7	6.0	44.3	30.6	6.9	44.7	23.7
33	Paka	0.9	42.7	4.1	0.9	43.4	2.3	0.3	40.0	0.4
34	Pungun	1.5	42.8	8.3	1.2	44.9	4.8	0.9	45.0	0.9
35	Marang	1.8	42.7	13.8	3.0	44.3	16.7	3.9	44.9	15.8
36	Trengganu	6.6	42.4	36.8	6.6	44.3	28.5	6.6	44.7	19.6
37	Setiu	2.7	42.6	18.6	3.9	44.4	19.4	3.3	45.0	11.6
38	Besut & Keluang	4.8	42.5	30.3	6.0	44.3	31.6	5.1	44.8	18.9
Total		22.5	-	136.6	27.6	-	133.9	27.0	-	90.9
Trengganu		22.6	42.5	136.6	28.0	44.4	133.9	27.1	44.8	90.7

Remarks; TC: Treatment capacity required in the corresponding year in 10^3 m3/d
SF: Service factor in %
SP: Served population in 10^3 persons

Table 22 RECOMMENDED UNTREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN TRENGGANU

Unit: 10^6 m^3/y

Basin No.	Basin Name	1985 SD	1985 SF	1985 SP	1990 SD	1990 SF	1990 SP	2000 SD	2000 SF	2000 SP
32	Kemaman	0.6	52.4	30.4	0.9	54.6	37.7	0.9	55.3	29.3
33	Paka	0.1	52.1	5.0	0.1	54.7	2.9	0.0	50.0	0.5
34	Dungum	0.2	52.6	10.2	0.1	55.1	5.9	0.0	55.0	1.1
35	Marang	0.3	52.3	16.9	0.5	54.6	20.6	0.6	55.1	19.4
36	Trengganu	1.0	52.4	45.4	0.9	54.7	35.2	0.7	55.3	24.2
37	Setiu	0.5	52.4	22.9	0.6	54.7	23.9	0.5	55.4	14.3
38	Besut & Keluang	0.8	52.5	37.4	1.0	54.7	39.0	0.7	55.2	23.3
Total		3.5	-	168.2	4.1	-	165.2	3.4	-	112.1
Trengganu		3.5	52.4	168.2	4.1	54.7	165.1	3.4	55.2	112.1

Remarks; SD: Source demand in the rural area in the corresponding year in 10^6 m^3/y
SF: Service factor in the rural area in %
SP: Served population in the rural area in 10^3 persons

Table 23 RECOMMENDED PLAN FOR IMPROVEMENT OF PURIFICATION SYSTEM IN PALM OIL MILLS AND RUBBER FACTORIES IN TREATMENT CAPACITY IN TRENGGANU

Unit: m^3/d

Basin		1981 - 1990			1991 - 2000		
No.	Name	Palm Oil	Rubber	Total	Palm Oil	Rubber	Total
32	Kemaman	1,904	0	1,904	176	0	176
Total		1,904	0	1,904	176	0	176

Table 24 ASSUMED PUBLIC SEWERAGE DEVELOPMENT NOT AFFECTING RIVER WATER QUALITY IN TRENGGANU

Basin	City/Town		1990			2000		
No.	No.		Treatment Capacity ($10^3 m^3/d$)	Service Factor (%)	Served Population (10^3)	Treatment Capacity ($10^3 m^3/d$)	Service Factor (%)	Served Pipulation (10^3)
36	C53	Kuala Trengganu	60	50	189	218	60	367
Total			60	-	189	218	-	367

Table 25 POLLUTION LOAD IN 2000 BY BASIN UNDER WITH-AND-WITHOUT IMPLEMENTATION OF RECOMMENDED PLAN IN TRENGGANU

Basin No.	Basin Name	Without Project: BOD Load into River (ton/d) PR	UI	RA	Total	Max. BOD in River (mg/lit)	With Project: BOD Load into River (ton/d) PR	UI	RA	Total	Max. BOD in River (mg/lit)
32	Kemaman	8	5	0	13	10	0	5	0	5	0
33	Paka	0	0	0	0	0	0	0	0	0	0
34	Dungun	3	0	0	3	2	3	4	0	7	2
35	Marang	0	0	0	0	0	0	0	0	0	0
36	Trengganu	3	1	0	4	1	3	1	0	4	1
37	Setiu	0	0	0	0	0	0	0	0	0	0
38	Besut	0	0	0	0	0	0	0	0	0	0
	Total	14	6	0	20	-	6	10	0	16	-

Remarks; PR: Palm oil mill and rubber factory effluent
UI: Urban sewer and industrial effluent
RA: Rural sewer and animal husbandry

Table 26 RECOMMENDED FLOOD MITIGATION PROGRAM IN TRENGGANU

Basin No.	Name of River	R.I. (km)	F.W. (km)	Dam (nos)	Pold. (nos)	N.S. (10^3)	P.P. (10^3)	F.A. (10^3ha)	C.C. (M$$10^6$)
By 1990									
32	Kemaman	-	-	-	1	-	14	2	10
36	Trengganu	-	-	-	-	-	-	-	-
37	Setiu	9	-	-	-	-	2	1	8
38	Besut	-	-	-	-	-	-	-	25
	Total	9	-	-	1	-	16	3	43
By 2000									
32	Kemaman	-	-	-	1	-	14	2	10
36	Trengganu	29	-	-	1	-	77	10	79
37	Setiu	9	-	-	-	-	2	1	8
38	Besut	33	-	-	-	-	55	18	58
	Total	71	-	-	2	-	148	31	155

Remarks; R.I. : River improvement,
F.W. : Floodway,
Pold.: Polder,
N.S. : Non-structural measure, in population (2000)
P.P.: Population protected (the year 2000)
F.A.: Flood area relieved
C.C.: Construction cost

Table 27 RECOMMENDED HYDROPOWER DEVELOPMENT PLAN IN TRENGGANU

Basin No.		36
Project		Ulu Trengganu
Catchment Area	(km^2)	420
Active Storage	(10^6 m^3)	600
Surface Area	(km^2)	46
Install. Capacity	(MW)	100
Annual Energy	(GWh)	360
Purpose		Hydropower
Regulated Outflow	(m^3/s)	22
Construction Cost	(M$$10^6$)	221
Year of Commission		1988

Remarks; Construction cost is financial cost at 1980 constant price.

Table 28 ASSUMED UNIT CONSTRUCTION COST (1/2)

1. Compensation on Land (M$10^6/km^2)

Irrigated paddy	2.5	Urban area class S	100
Rainfed paddy	1.5	Urban area class A	10
Tree crop field classes A & B	1.5	Urban area class B	5
Tree crop field class C	0.5	Village area class A	5
Forest class A	0.5	Village area class B	1
Forest class B	0.1		

S: very good access, A: good access
B: poor access, C: very poor access

2. Resettlement (M$10^3/household)

Urban	30	Rural	10

3. Civilwork

Dam	M$48-66 per m^3 of embankment volume
Canal	M$50-94/m per m^3/s of discharge capacity
Tunnel	M$160-182/m per m^3/s of discharge capacity
Pipeline	M$990-1,980/m per m^3/s of discharge capacity
Barrage/Weir	M$1,320/m per m^3/s of 100-y maximum capacity
Pumping station	M$7,700-14,300 m^3/s of discharge capacity

4. River Facilities

Channel improvement (M$10^6/km)

200 m^3/s	0.2 - 0.4
500 m^3/s	0.3 - 0.6
1,000 m^3/s	0.4 - 0.8
10,000 m^3/s	1.2 - 2.9

Floodway (M$10^6/km)

200 m^3/s	0.2 - 0.5
500 m^3/s	0.4 - 0.9
1,000 m^3/s	0.5 - 1.2
2,000 m^3/s	0.7 - 1.8

Polder

Protection bund	M$150-700 x 10^3/km
Drainage system	M$540 x 10^3/km
Drainage pump	M$150-380 x 10^3 per m^3/s

Remarks; Unit construction costs include the engineering and administration cost, but the physical contingency is not included.

Table 29 ASSUMED UNIT CONSTRUCTION COST (2/2)

5. D&I Water Supply System

Pipeline	M$430/m per m^3/s of discharge capacity
Treatment plant	M$710 per m^3/d of capacity
Distribution system	M$1,300 per m^3/d of capacity

6. Sewerage System M$157 x 10^6 per 100 x 10^3 m^3/d

7. D&I Pre-treatment System

Aerated lagoon	M$38 x 10^6 per 100 x 10^3 m^3/d
Rapid sandfilter bed	M$112 x 10^6 per 100 x 10^3 m^3/d

8. Power Facilities

Generating equipment

Rated head more than 140 m	M$275-440 per kW
Rated head 20 - 80 mm	M$550-880 per kW
Rated less than 30 m	M$1,320-1,540 per kW
Transmission line	M$162-194 x 10^3 per km

9. Irrigation Facilities

From rainfed paddy to irrigated paddy	M$11,370 per ha
From new reclaimed land to irrigated paddy	M$12,300 per ha
From irrigated single cropped paddy to double	M$6,150 per ha
Tertiary development and rehabilitation	M$5,470 per ha

Remarks; Unit construction costs include the engineering and administration cost, but the physical contingency is not included.

Table 30 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE OF RECOMMENDED PLAN IN TRENGGANU

Unit: M10^6

Sector	4MP	5MP	6MP	7MP	Total
Source Development	–	–	–	–	–
Irrigation	29	48	19	17	113
Inland Fishery	0	0	0	0	0
Public Water Supply	90	211	249	100	650
Public Water Supply; Pre-treatment facilities	0	0	0	0	0
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	40	63	61	25	189
Flood Mitigation	3	41	54	58	156
Total	162	363	383	200	1,108

Remarks; (1): At 1980 constant price
(2): The amount shown for 4MP is the additional budget, assuming that the original budget can provide the capacity necessary up to 1985.

Table 31 ESTIMATED ANNUAL RECURRENT EXPENDITURE OF RECOMMENDED PLAN IN TRENGGANU

Unit: M10^6

Sector	4MP	5MP	6MP	7MP	Total
Source Development	–	–	–	–	–
Irrigation	0	2	6	7	15
Inland Fishery	0	0	0	0	0
Public Water Supply	0	17	40	61	118
Public Water Supply; Pre-treatment facilities	0	0	0	0	0
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	0	13	26	36	75
Flood Mitigation	0	2	22	49	73
Total	0	34	94	153	281

Remarks; (1): At 1980 constant price
(2): Recurrent expenditure on the capacity, which is to be constructed by the original budget for 4MP, is not included.

Table 32 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER DEMAND AND SUPPLY BALANCE IN TRENGGANU

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Irrigation	($M\$10^6$)	6
D&I water supply	($M\$10^6$)	49
Fish culture	($M\$10^6$)	1
Reservoir recreation	($M\$10^6$)	1
Total	($M\$10^6$)	57
1.2 Economic Cost		
Irrigation	($M\$10^6$)	4
D&I water supply	($M\$10^6$)	49
Fish culture	($M\$10^6$)	1
Dams, barrages & diversion facilities	($M\$10^6$)	0
Total	($M\$10^6$)	54
1.3 EIRR	(%)	10
2. Environmental Quality		
2.1 Beneficial Effect		
Safe maintenance flow period (2000)		See Table
Surface area of lake created	(km^2)	-
2.2 Adverse Effect		
Possible reduction in kind of fish immediately downstream of dams and barrages	(nos. of site)	-
3. Social Well-being		
3.1 Beneficial Effect		
Number of farm households benefited by proposed irrigation in 2000	(10^3)	9
Number of people served by proposed public water supply in 2000	(10^3)	943
Safe supply period (2000)		See Table
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^2)	-

Remarks; All effects by proposed hydropower project are not shown except irrigation, D&I water supply and lake recreation benefit.

Table 33 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER POLLUTION ABATEMENT IN TRENGGANU

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Sewerage	($M\$10^6$)	4
Saving in pre-treatment for D&I water supply	($M\$10^6$)	0
Total	($M\$10^6$)	4
1.2 Economic Cost		
Sewerage	($M\$10^6$)	10
Private purification facilities	($M\$10^6$)	0
Pre-treatment for D&I water supply	($M\$10^6$)	0
Total	($M\$10^6$)	10
2. Environmental Quality		
2.1 Beneficial Effects		
Length of river stretch where BOD concentration is not more than 10 mg/lit in 2000 compared with without project condition (Study length = 267 km)	(km)	267/267/1
Length of river stretch where BOD concentration is not more than 5 mg/lit in 2000 compared with without project condition (Study length = 267 km)	(km)	267/249/1
2.2 Adverse Effect		-
3. Social Well-Being		
3.1 Beneficial Effects		
Number of people served by proposed sewerage system in 2000	(10^3)	367
3.2 Adverse Effect		-

Remarks; /1: (Length of river stretch with Project)/ (Length of river stretch without Project)

Table 34 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR FLOOD MITIGATION IN TRENGGANU

Item		Recommended Plan
1. National Economic Development		
1.1 Economic Benefit		
Damage reduction	($M\$10^6$)	4.8
1.2 Economic Cost		
Flood mitigation work	($M\$10^6$)	4.5
1.3 EIRR	(%)	8.4
2. Environmental Quality		
2.1 Beneficial Effect		
Length of improved stretch	(km)	71
2.2 Adverse Effect		-
3. Social Well-Being		
3.1 Beneficial Effect		
Number of protected people by proposed facilities in 2000	(10^3)	148
Population served by proposed flood warning system in 2000	(10^3)	45
Area relieved from flood hazards	(10^3 ha)	31
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	6

Table 35 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR HYDROPOWER DEVELOPMENT FOR PENINSULAR MALAYSIA

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Power generation	($M\$10^6$)	344
1.2 Economic Cost		
Dam & power facilities	($M\$10^6$)	107
1.3 EIRR	(%)	22
2. Environmental Quality		
2.1 Beneficial Effect		
Surface area of reservoir created	(km^2)	1,170
2.2 Adverse Effect		
Number of sites where kind of fish might be reduced being located immediately downstream of dam	(nos. of site)	13
3. Social Well-being		
3.1 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	23

Remarks; (1): Figures in this table cover 3 States, i.e. Pahang, Trengganu and Kelantan.

(2): Economic benefit other than power generation benefit is not shown here, but included in the water demand and supply account.

Table 36 SUMMARY OF FUTURE ECONOMIC NET VALUE OF WET PADDY BY TYPE OF SCHEME IN TRENGGANU

	Yield (ton/ha)	Unit Price (M$/ton)	Gross Value (M$/ha)	Production Cost (M$/ha)	Net Value (M$/ha)
(1) Major Irrigation Scheme (Besut)					
Double cropping	7.7	640	4,928	1,679	3,249
Single cropping	3.6	640	2,304	784	1,520
(2) Minor Irrigation Scheme					
Double cropping	6.8	640	4,352	1,492	2,860
Single cropping	3.2	640	2,048	703	1,345
(3) Rainfed Scheme					
Single cropping	1.7	640	1,088	645	443

Table 37 ESTIMATED AND PROJECTED SERVICE FACTOR AND PER CAPITA DAILY USE OF DOMESTIC WATER IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

City/Rural	Service Factor (%)				Per Capita Daily Use (lpcd)			
	Estimated	Projected			Estimated	Projected		
	1980	1985	1990	2000	1980	1985	1990	2000
1. Urban Area								
51 Chuka	80.0	85.0	90.0	95.0	160.0	170.0	185.0	210.0
52 Dungun	80.0	85.0	90.0	95.0	160.0	170.0	185.0	210.0
53 Kuala Trengganu	100.0	100.0	100.0	100.0	170.0	180.0	195.0	240.0
132 Ulutrengganu	47.4	94.9	99.0	95.0	75.0	95.0	115.0	210.0
2. Rural Area								
PWD Rural	25.0	42.5	44.4	44.6	75.0	95.0	115.0	155.0
MOH Rural	22.4	52.4	54.6	54.9	40.0	45.0	55.0	65.0
3. Non-Pipe-Served Area	-	-	-	-	40.0	40.0	40.0	40.0

Table 38 ESTIMATED AND PROJECTED D & I WATER DEMAND BY BASIN IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: 10^6 m^3/y

Basin No.		City/Rural	Estimated 1980 D&I	Projected 1985 D	1985 I	1985 Total	1990 D	1990 I	1990 Total	2000 D	2000 I	2000 Total
32	51	Chukai	1.3	1.4	1.7	3.1	1.7	3.2	4.9	2.3	9.8	12.1
		Rural	1.7	1.6	1.0	2.6	1.9	0.9	2.8	2.1	0.9	3.0
		Basin Total	3.0	3.0	2.7	5.7	3.6	4.1	7.7	4.4	10.7	15.1
33		Rural	0.4	0.3	0.2	0.5	0.5	0.2	0.7	0.6	0.1	0.7
34	52	Dungun	2.4	2.9	1.1	4.0	4.0	2.0	6.0	6.7	6.0	12.7
		Rural	0.8	0.6	0.5	1.1	0.9	0.5	1.4	1.2	0.5	1.7
		Basin Total	3.2	3.5	1.6	5.1	4.9	2.5	7.4	7.9	6.5	14.4
35		Rural	0.8	0.8	0.2	1.0	1.2	0.2	1.4	1.3	0.2	1.5
36	53	Kuala Trengganu	17.6	24.0	5.8	29.8	33.4	10.6	44.0	58.3	33.1	91.4
	132	Ulu Trengganu	0.2	0.3	0.2	0.5	0.5	0.3	0.8	1.3	1.1	2.4
		City Rural	17.8	24.3	6.0	30.3	33.9	10.9	44.8	59.6	34.2	93.8
		Rural	3.1	2.9	1.3	4.2	4.1	1.2	5.3	6.4	1.3	7.7
		Basin Total	20.9	27.2	7.3	34.5	38.0	12.1	50.1	66.0	35.5	101.5
37		Rural	1.0	1.2	0.1	1.3	1.6	0.1	1.7	1.8	0.1	1.9
38		Rural	1.6	2.1	0.2	2.3	2.5	0.2	2.7	3.0	0.2	3.2
Total			30.9	38.1	12.3	50.4	52.3	19.4	71.7	85.0	53.3	138.3
Trengganu			30.9	38.1	12.3	50.4	52.3	19.4	71.7	85.0	53.3	138.3

Remarks: D: Domestic water demand
I: Industrial water demand
Total: Total source demand

Table 39 RECOMMENDED WATER SUPPLY DEVELOPMENT PLAN FOR CITIES/TOWNS IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Code No.	City/Town	1985 TC	1985 SF	1985 SP	1990 TC	1990 SF	1990 SP	2000 TC	2000 SF	2000 SP
32	51	Chukai	6.6	85	16.2	9.9	90	18.9	21.6	95	22.8
34	52	Dungun	10.1	85	34.0	14.8	90	44.1	29.0	95	65.6
36	53	Kuala Trengganu	81.1	100	278.0	116.7	100	357.0	225.8	100	506.0
	132	Ulu Trengganu	1.1	85	6.0	2.2	90	8.1	5.8	95	13.3
	Total		98.9	97	334.2	143.6	98	428.1	282.2	99	607.7

Remarks; TC: Treatment capacity required in the corresponsing year in 10^3 m^3/d

SF: Service facotr in %

SP: Served population in 10^3

Table 40 RECOMMENDED TREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Basin Name	1985			1990			2000		
		TC	SF	SP	TC	SF	SP	TC	SF	SP
32	Kemaman & Others	3.6	42.5	22.5	4.2	44.3	22.6	4.8	44.5	18.7
33	Paka	0.9	47.2	4.6	1.2	44.6	5.0	1.2	44.8	5.6
34	Dungun	1.5	42.5	9.4	2.1	44.3	10.1	2.7	44.3	11.3
35	Marang & Others	1.5	42.4	12.8	2.4	44.2	12.9	2.7	44.4	11.5
36	Trengganu	6.9	42.5	42.0	9.0	44.3	46.5	14.2	44.6	57.6
37	Setiu & Others	2.4	42.6	17.8	3.0	44.2	18.0	3.6	44.7	16.3
38	Besut & Kelang	4.2	42.5	29.0	5.1	44.3	29.4	6.3	44.5	26.5
Total		21.0	-	138.1	27.0	-	144.5	35.5	-	147.5
Trengganu		21.0	42.5	138.1	27.1	44.4	144.5	35.9	44.6	147.5

Remarks; TC: Treatment capacity required in the corresponding year in 10^3 m^3/d
SF: Service factor in %
SP: Served population in 10^3 persons

Table 41 RECOMMENDED UNTREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Basin Name	1985			1990			2000		
		SD	SF	SP	SD	SF	SP	SD	SF	SP
32	Kemaman	0.6	52.5	27.8	0.7	54.7	27.9	0.7	55.0	23.1
33	Paka	0.1	52.3	5.7	0.2	54.5	6.1	0.2	55.2	6.9
34	Dungun	0.2	52.5	11.6	0.3	54.4	12.4	0.4	54.9	14.0
35	Marang	0.3	52.3	15.8	0.4	54.5	15.9	0.4	54.8	14.2
36	Trengganu	1.0	52.4	51.8	1.5	54.6	57.3	2.1	54.9	70.9
37	Setiu	0.4	52.4	21.9	0.6	54.5	22.2	0.6	54.8	20.0
38	Besut & Keluang	0.7	52.3	35.7	0.9	54.8	36.3	1.0	55.0	32.7
Total		3.3	-	170.3	4.6	-	178.1	5.4	-	181.8
Trengganu		3.3	52.4	170.4	4.6	54.6	178.1	5.4	54.9	181.8

Remarks; SD: Source demand in the rural area in the corresponding year in 10^6 m^3/y
SF: Service factor in the rural area in %
SP: Served population in the rural area in 10^3 persons

Table 42 RECOMMENDED PLAN FOR IMPROVEMENT OF PURIFICATION SYSTEM IN PALM OIL MILLS AND RUBBER FACTORIES IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: m^3/d

Basin		1981 - 1990			1991 - 2000		
No.	Name	Palm Oil	Rubber	Total	Palm Oil	Rubber	Total
32	Kemaman	1,904	0	1,904	176	0	176
Total		1,904	0	1,904	176	0	176

Table 43 ASSUMED PUBLIC SEWERAGE DEVELOPMENT NOT AFFECTING RIVER WATER QUALITY IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin	City/Town		1990			2000		
No.	No.	Name	Treatment Capacity ($10^3m^3/d$)	Service Factor (%)	Served Population (10^3)	Treatment Capacity ($10^3m^3/d$)	Service Factor (%)	Served Population (10^3)
36	C53	Kuala Trengganu	41	40	143	139	65	329
Total			41	-	143	139	-	329

Table 44 RECOMMENDED FLOOD MITIGATION PROGRAM IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Name of River	R.I. (km)	F.W. (km)	Dam (nos)	Pold. (nos)	N.S. (km^2)	P.P. (10^3)	F.A. (10^3ha)	C.C. (M$$10^6$)
By 1990									
32	Kemaman	-	-	-	1	-	14	2	10
36	Trengganu	-	-	-	-	-	-	-	-
37	Setiu	9	-	-	-	-	3	1	8
38	Besut	-	-	-	-	-	-	-	25
	Total	9	-	-	1	-	17	3	43
By 2000									
32	Kemaman	-	-	-	1	-	14	2	10
36	Trengganu	29	-	-	1	-	76	10	79
37	Setiu	9	-	-	-	-	3	1	8
38	Besut	33	-	-	-	-	51	18	58
	Total	71	-	-	2	-	144	31	155

Remarks;
R.I. : River improvement,
F.W. : Floodway,
Pold.: Polder,
N.S. : Non-structural measure,
P.P.: Population protected (the year 2000)
F.A.: Flood area relieved
C.C.: Construction cost

Table 45 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE FOR RECOMMENDED PLAN IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: M10^6

Sector	4MP	5MP	6MP	7MP	Total
Source Development	-	-	-	-	-
Irrigation	29	48	19	17	113
Inland Fishery	0	0	0	0	0
Public Water Supply	72	144	156	63	435
Public Water Supply; Pre-treatment facilities	0	0	0	0	0
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	28	45	44	18	135
Flood Mitigation	3	41	54	58	156
Total	132	278	273	156	839

Remarks; (1): At 1980 constant price
(2): The amount shown for 4MP is the additional budget, assuming that the original budget can provide the capacity necessary up to 1985.

Table 46 ESTIMATED ANNUAL RECURRENT EXPENDITURE FOR RECOMMENDED PLAN IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: M10^6

Sector	4MP	5MP	6MP	7MP	Total
Source Development	-	-	-	-	-
Irrigation	0	2	6	7	15
Inland Fishery	0	0	0	0	0
Public Water Supply	0	13	28	41	82
Public Water Supply; Pre-treatment facilities	0	0	0	0	0
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	0	9	18	26	53
Flood Mitigation	0	2	22	49	73
Total	0	26	74	123	223

Remarks; (1): At 1980 constant price
(2): Recurrent expenditure on the capacity, which is to be constructed by the original budget for 4MP, is not included.

Table 47 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER DEMAND AND SUPPLY BALANCE IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Irrigation	($M\$10^6$)	6
D&I water supply	($M\$10^6$)	27
Fish culture	($M\$10^6$)	1
Reservoir recreation	($M\$10^6$)	0
Total	($M\$10^6$)	34
1.2 Economic Cost		
Irrigation	($M\$10^6$)	4
D&I water supply	($M\$10^6$)	27
Fish culture	($M\$10^6$)	1
Dams, barrages & diversion facilities	($M\$10^6$)	0
Total	($M\$10^6$)	32
1.3 EIRR	(%)	10
2. Environmental Quality		
2.1 Beneficial Effect		
Safe maintenance flow period (2000)		See Table
Surface area of lake created	(km^2)	-
2.2 Adverse Effect		
Possible reduction in kind of fish immediately downstream of dams and barrages	(nos. of site)	-
3. Social Well-being		
3.1 Beneficial Effect		
Number of farm households benefited by proposed irrigation in 2000	(10^3)	9
Number of people served by proposed public water supply in 2000	(10^3)	938
Safe supply period (2000)		See Table
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^2)	-

Remarks; All effects by proposed hydropower project are not shown except irrigation, D&I water supply and lake recreation benefit.

Table 48 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER POLLUTION ABATEMENT IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Sewerage	(M$10^6)	2
Saving in pre-treatment for D&I water supply	(M$10^6)	0
Total	(M$10^6)	2
1.2 Economic Cost		
Sewerage	(M$10^6)	7
Private purification facilities	(M$10^6)	0
Pre-treatment for D&I water supply	(M$10^6)	0
Total	(M$10^6)	7
2. Environmental Quality		
2.1 Beneficial Effects		
Length of river stretch where BOD concentration is not more than 10 mg/lit in 2000 compared with without project condition (Study length = 267 km)	(km)	267/267 /1
Length of river stretch where BOD concentration is not more than 5 mg/lit in 2000 compared with without project condition (Study length = 267 km)	(km)	267/250 /1
2.2 Adverse Effect		-
3. Social Well-Being		
3.1 Beneficial Effects		
Number of people served by proposed sewerage system in 2000	(10^3)	329
3.2 Adverse Effect		-

Remarks; /1: (Length of river stretch with Project)/ (Length of river stretch without Project)

Table 49 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR FLOOD MITIGATION IN TRENGGANU UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Damage reduction	(M$10^6)	3.6
1.2 Economic Cost		
Flood mitigation work	(M$10^6)	4.5
1.3 EIRR	(%)	6.1
2. Environmental Quality		
2.1 Beneficial Effect		
Length of improved stretch	(km)	71
2.2 Adverse Effect		-
3. Social Well-Being		
3.1 Beneficial Effect		
Number of protected people by proposed facilities in 2000	(10^3)	144
Population served by proposed flood warning system in 2000	(10^3)	44
Area relieved from flood hazards	(km^2)	31
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	6

Table 50 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR HYDROPOWER DEVELOPMENT FOR PENINSULAR MALAYSIA UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Power generation	($M\$10^6$)	270
1.2 Economic Cost		
Dam & power facilities	($M\$10^6$)	81
1.3 EIRR	(%)	23
2. Environmental Quality		
2.1 Beneficial Effect		
Surface area of reservoir created	(km^2)	1,064
2.2 Adverse Effect		
Number of sites where kind of fish might be reduced being located immediately downstream of dam	(nos. of site)	11
3. Social Well-being		
3.1 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	23

Remarks; (1): Figures in this table cover 3 States, i.e. Pahang, Trengganu and Kelantan.

(2): Economic benefit other than power generation benefit is not shown here, but included in the water demand and supply account.

FIGURES

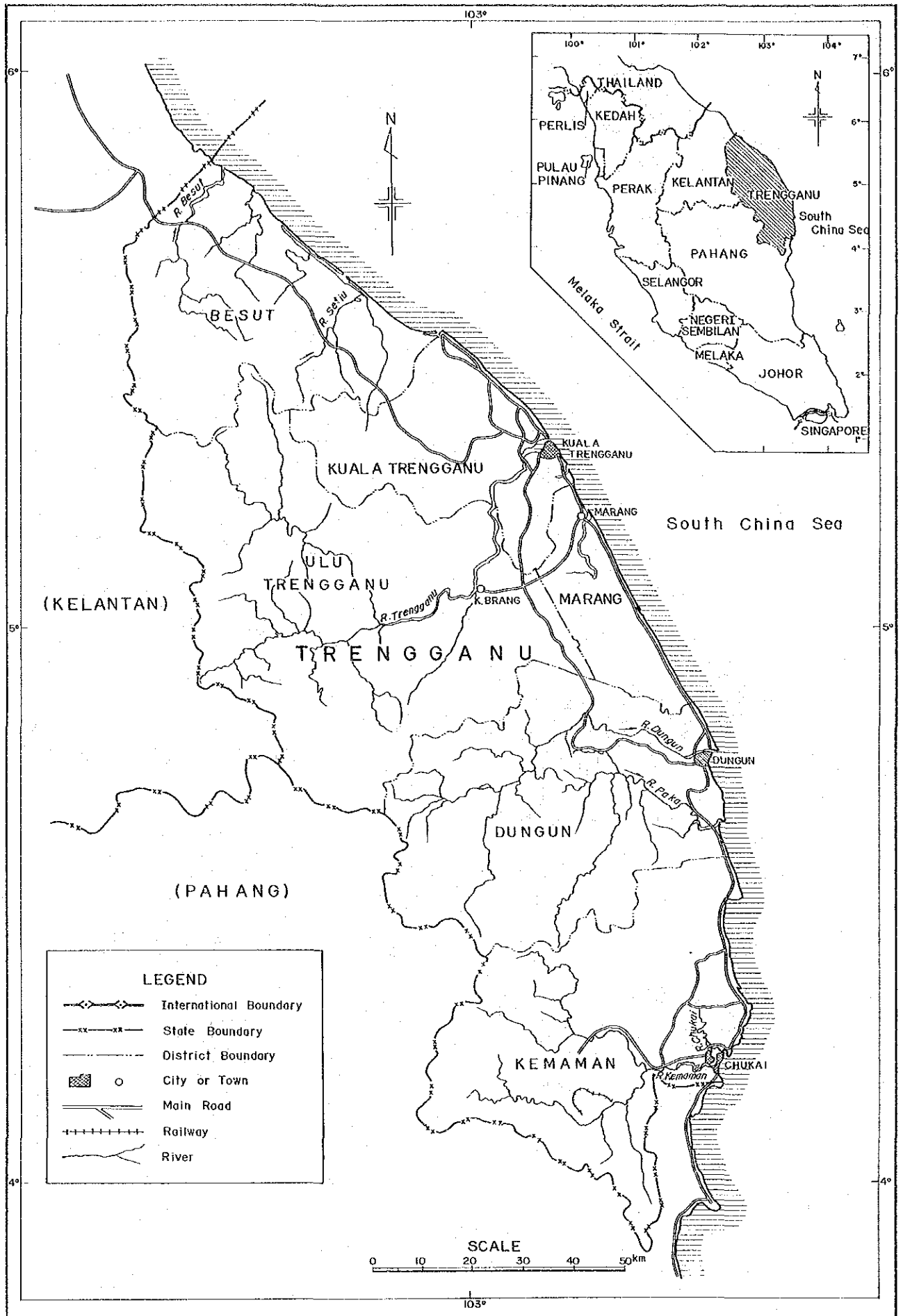

Fig.1 Map of the State of Trengganu

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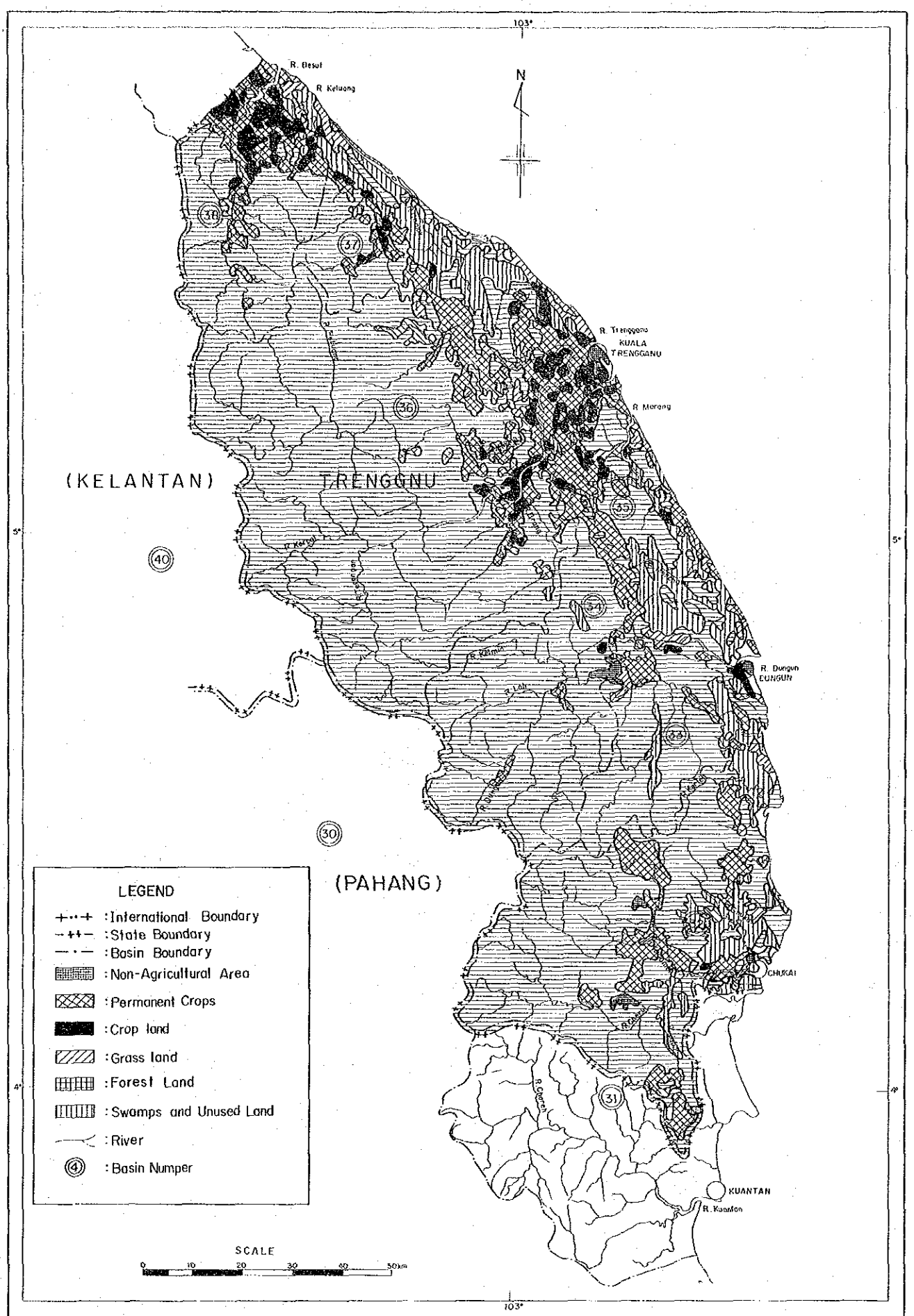

Fig. 2 Present Land Use

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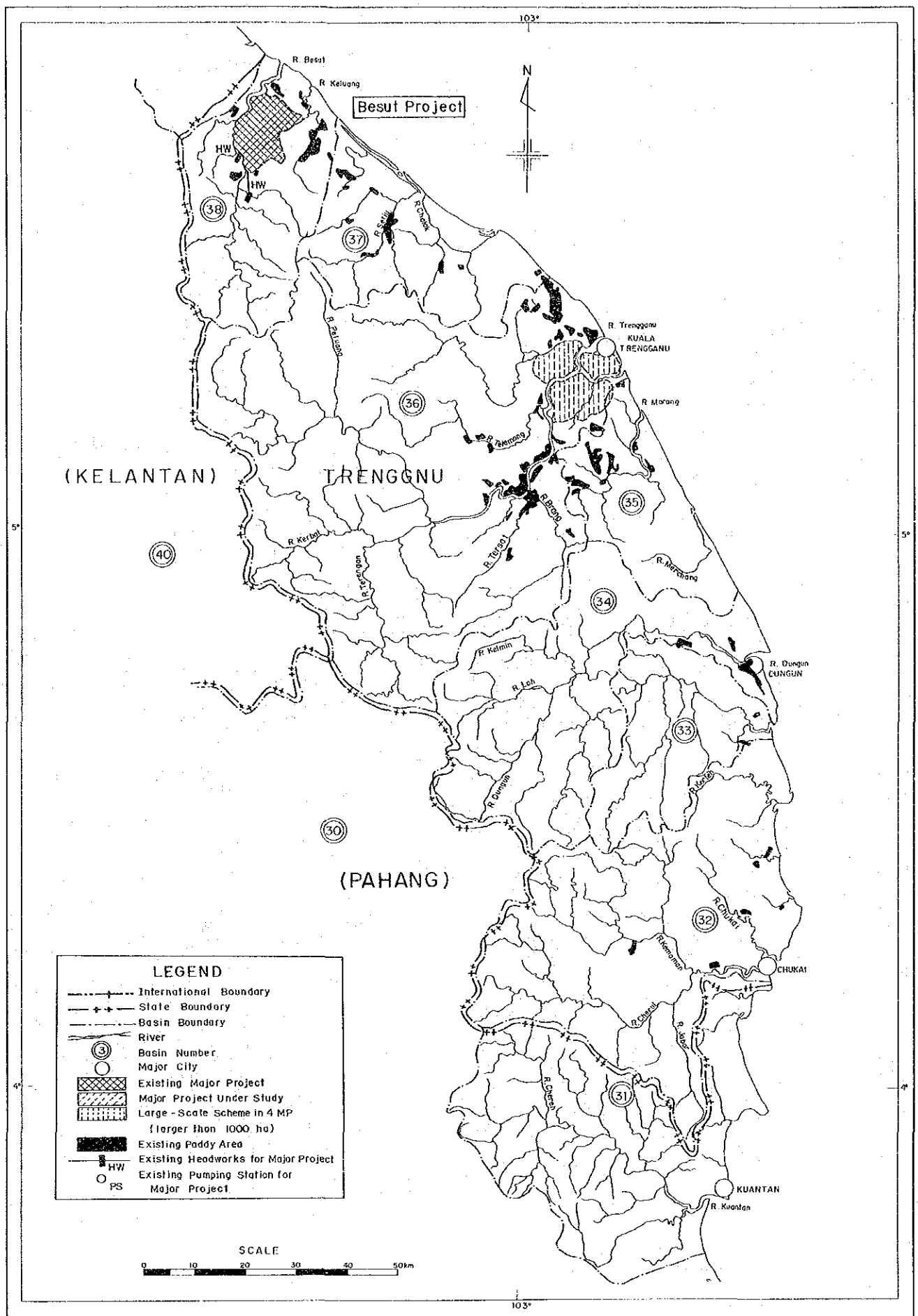

Fig. 3 Location of Paddy Field

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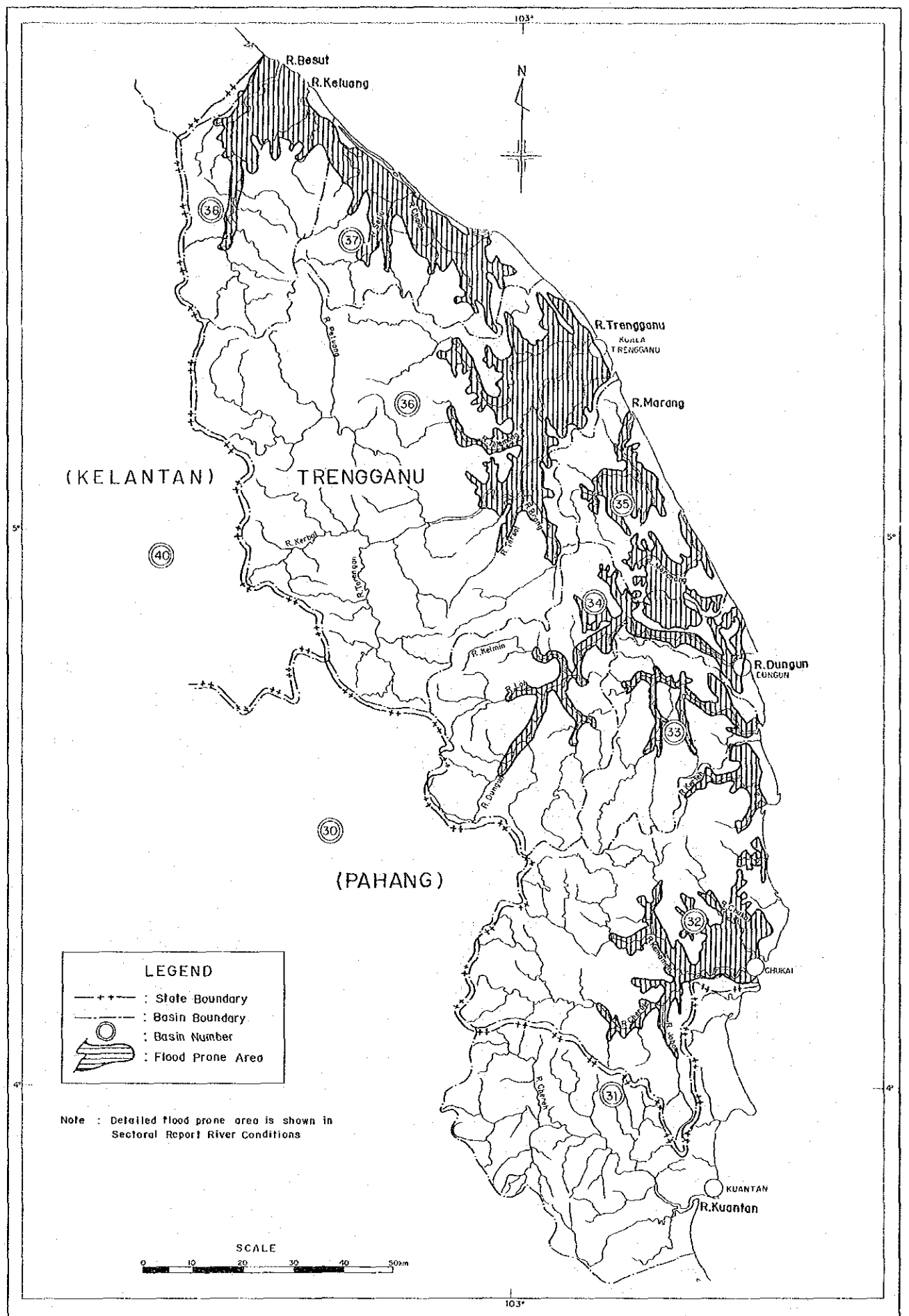

Fig. 4 Flood Prone Area in Trengganu

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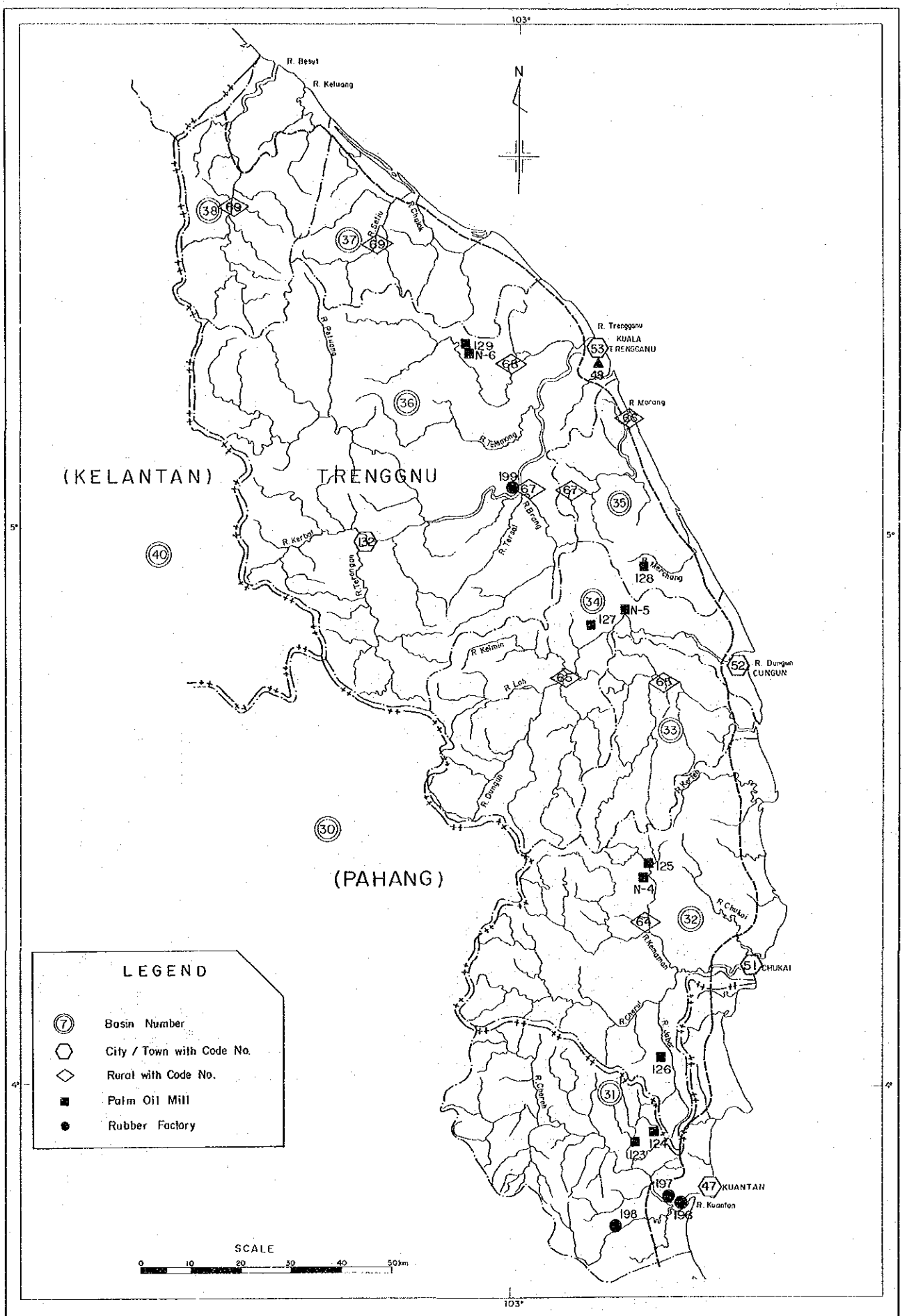

Fig. 5 Location of Demand Centers and Pollution Sources

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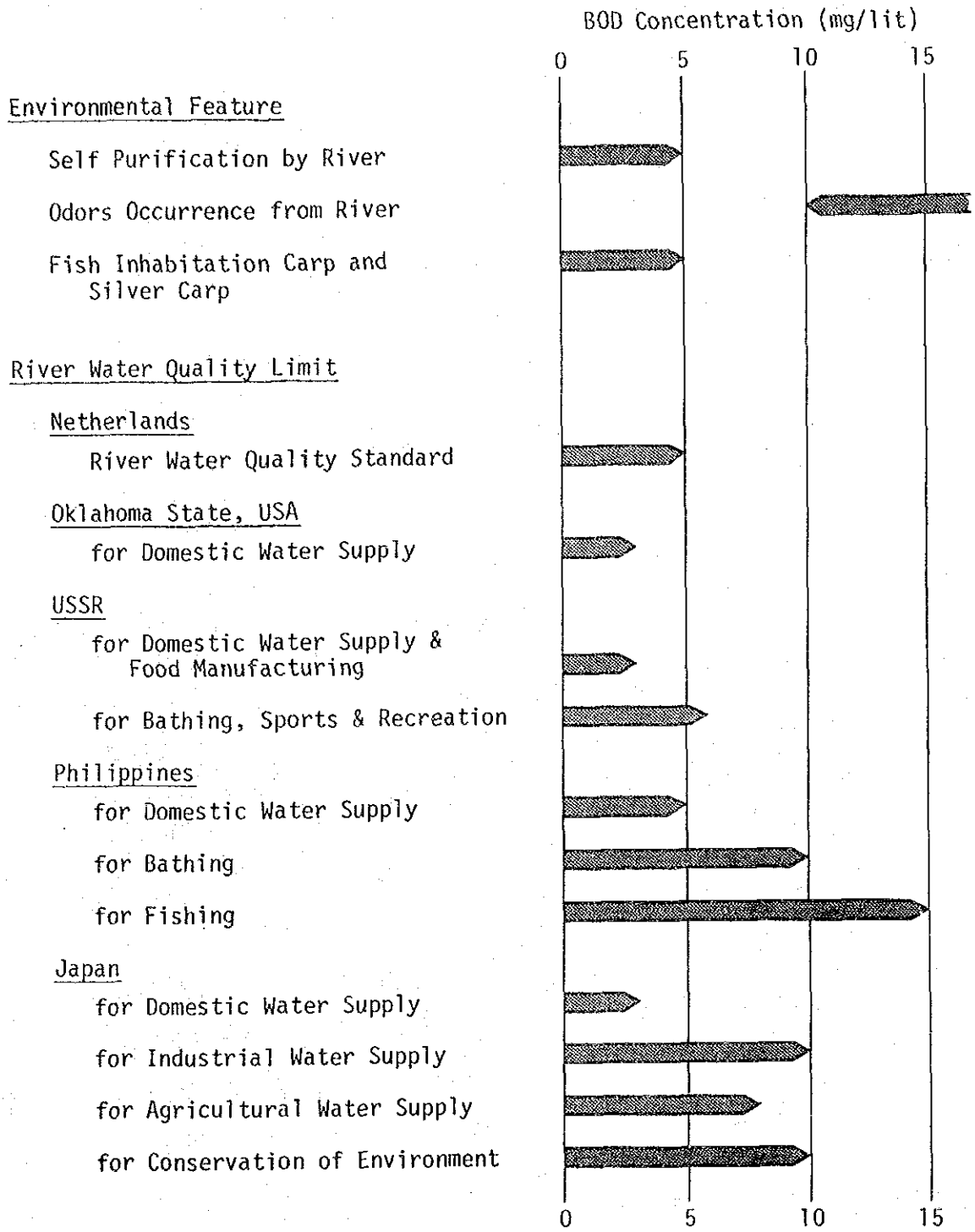

Fig. 6 Relationships between BOD Concentration and Environmental Feature and River Water Quality Limit

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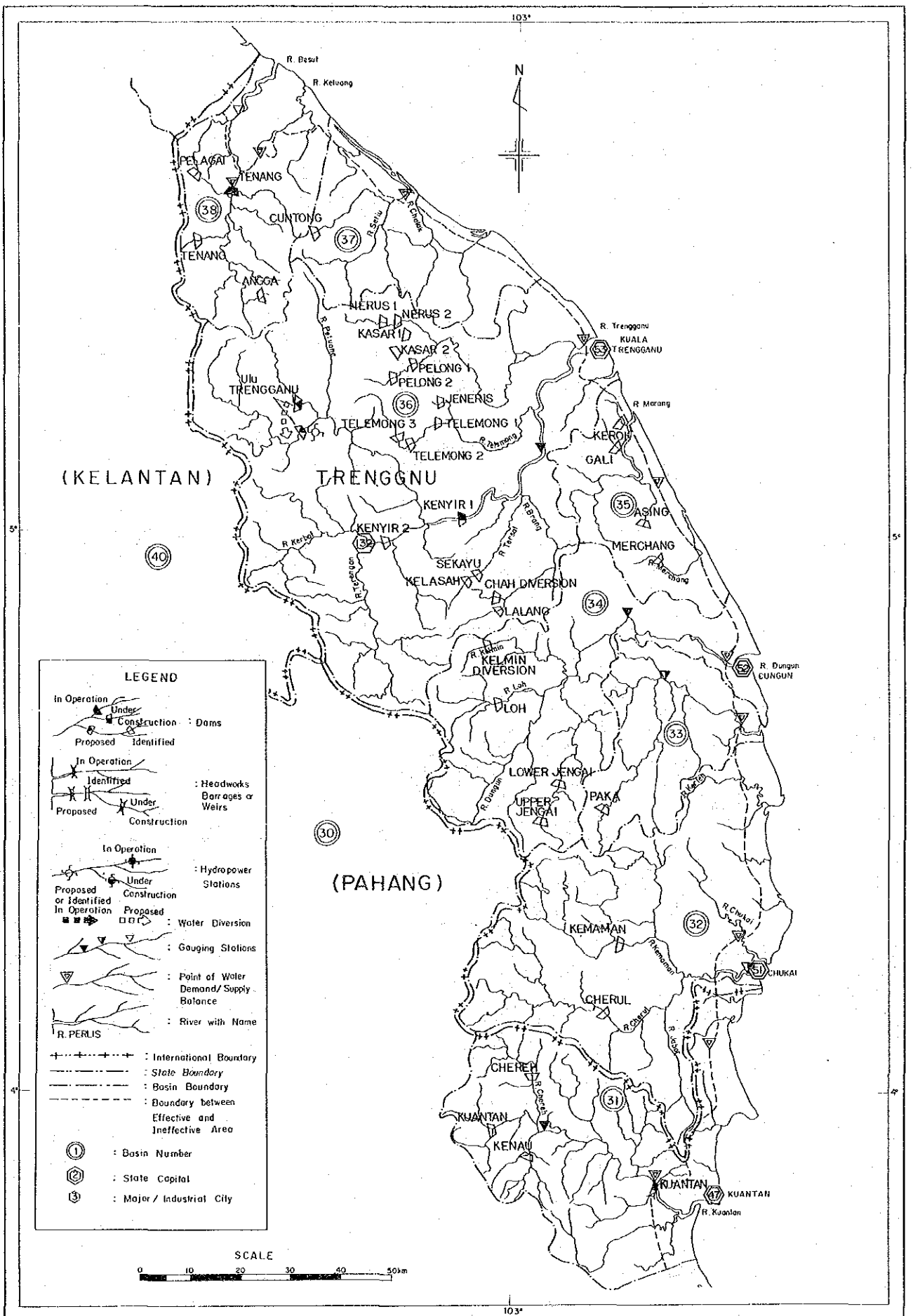

Fig. 7 Location of Potential and Proposed Water Source Facilities, Alternative B1

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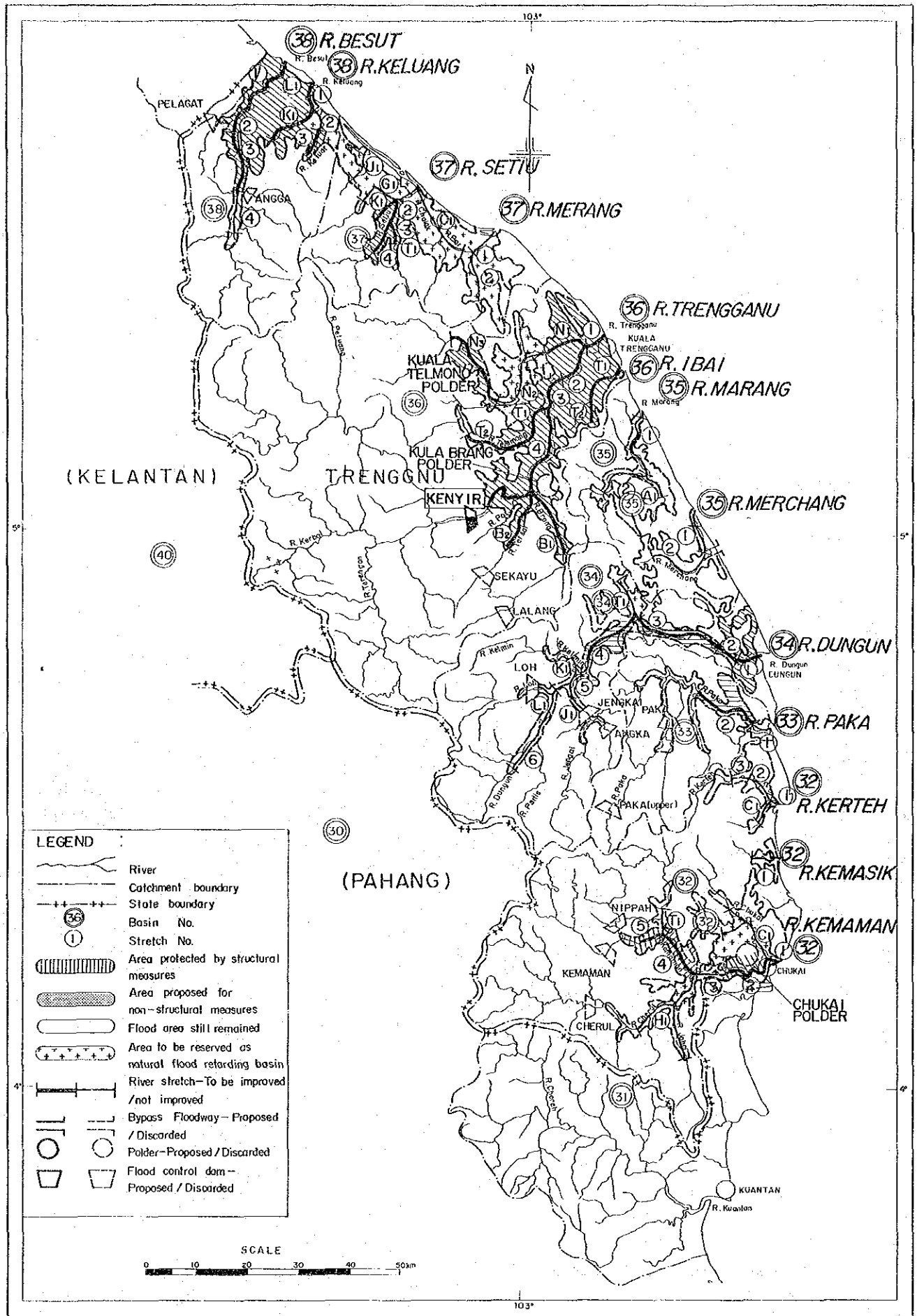

Fig. 8 Flood Mitigation Alternatives, Alternative F1

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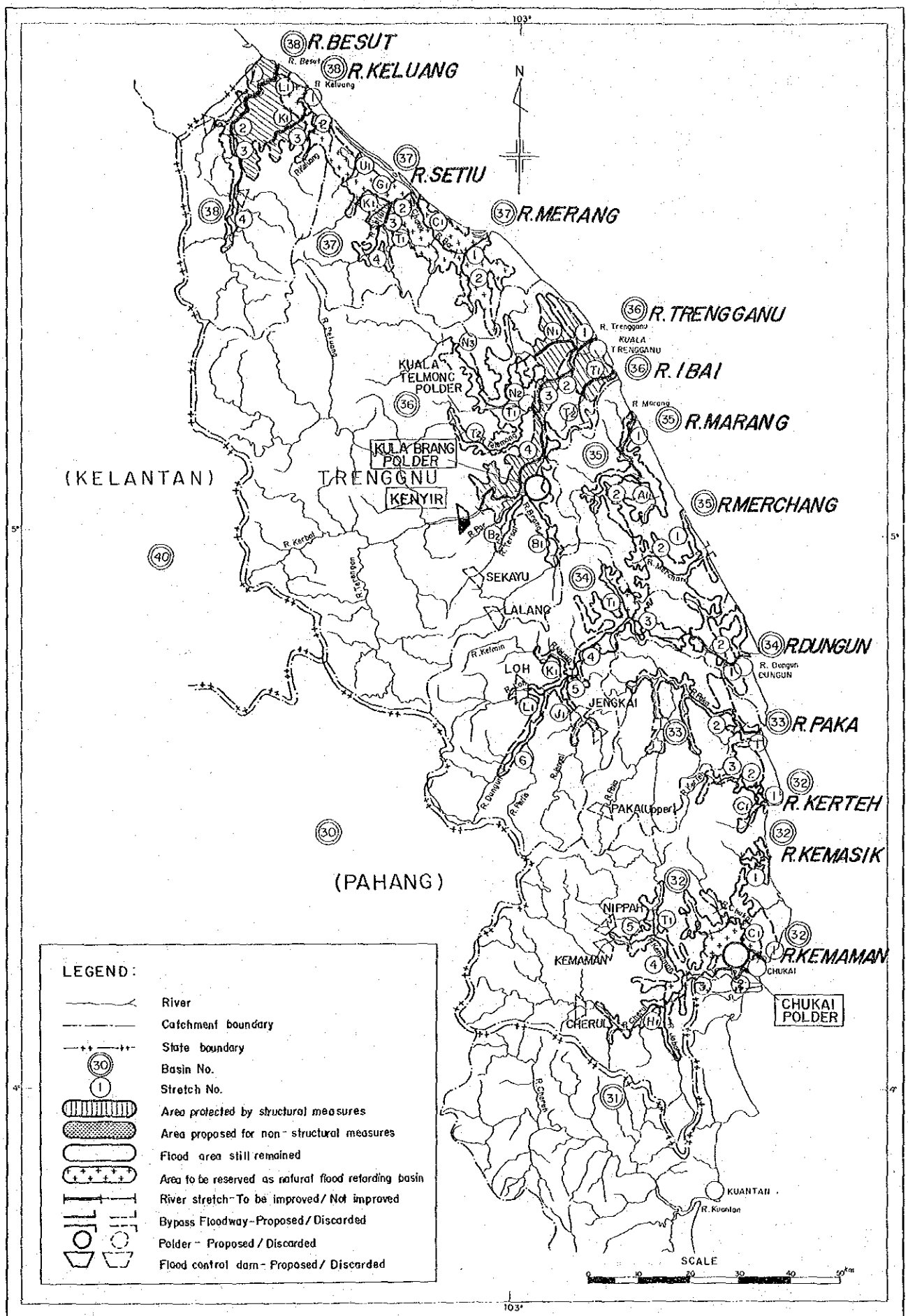

Fig. 9 Flood Mitigation Alternatives, Alternative F2

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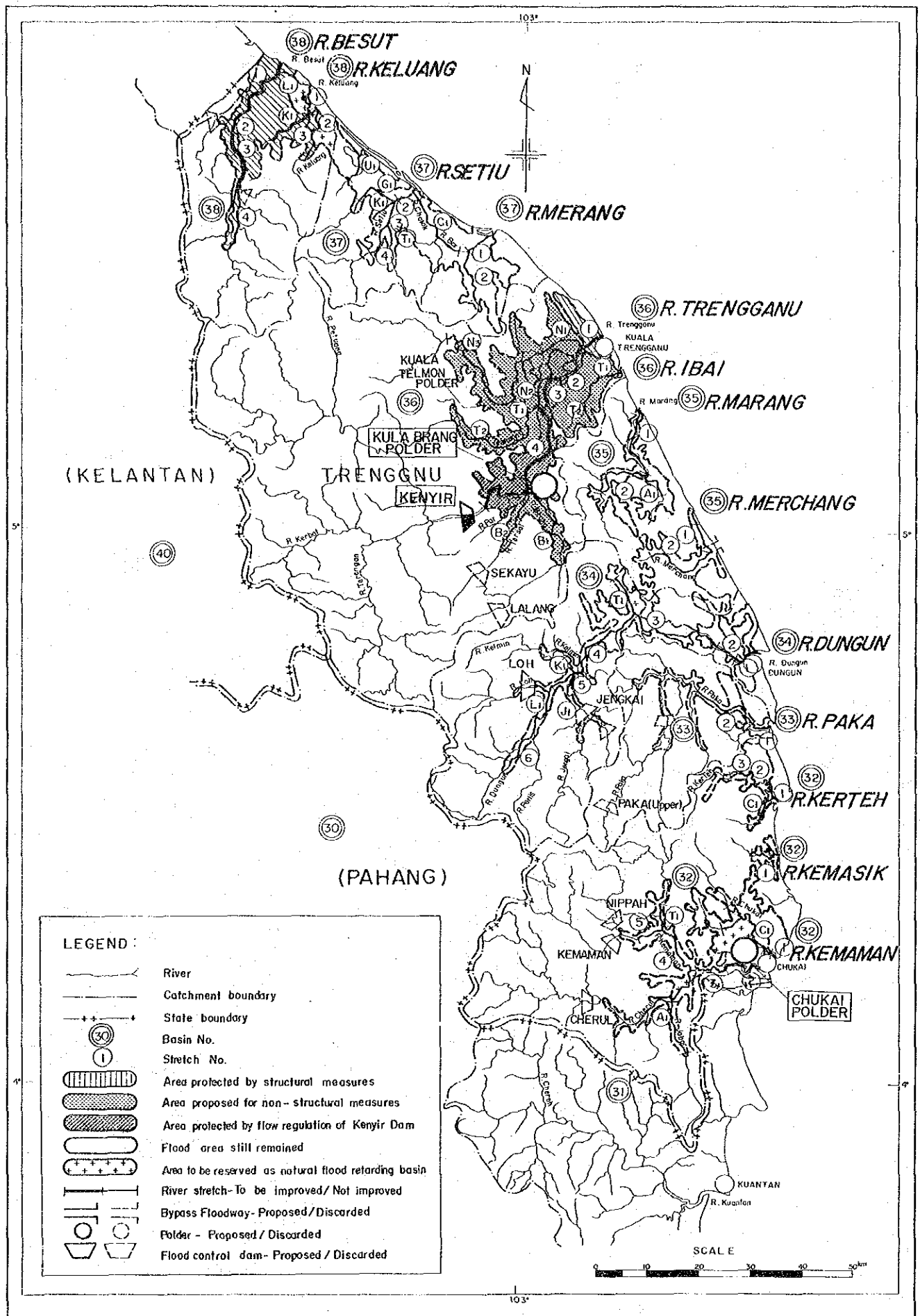

Fig.10 Flood Mitigation Alternatives, Alternative F3

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