GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

STATE REPORT

VOL. 1

PERLIS KEDAH P. PINANG

OCTOBER 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

STATE REPORT

VOL. 1

PERLIS/KEDAH/P. PINANG

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JAPAN INTERNATIONAL COOPERATION AGENCY

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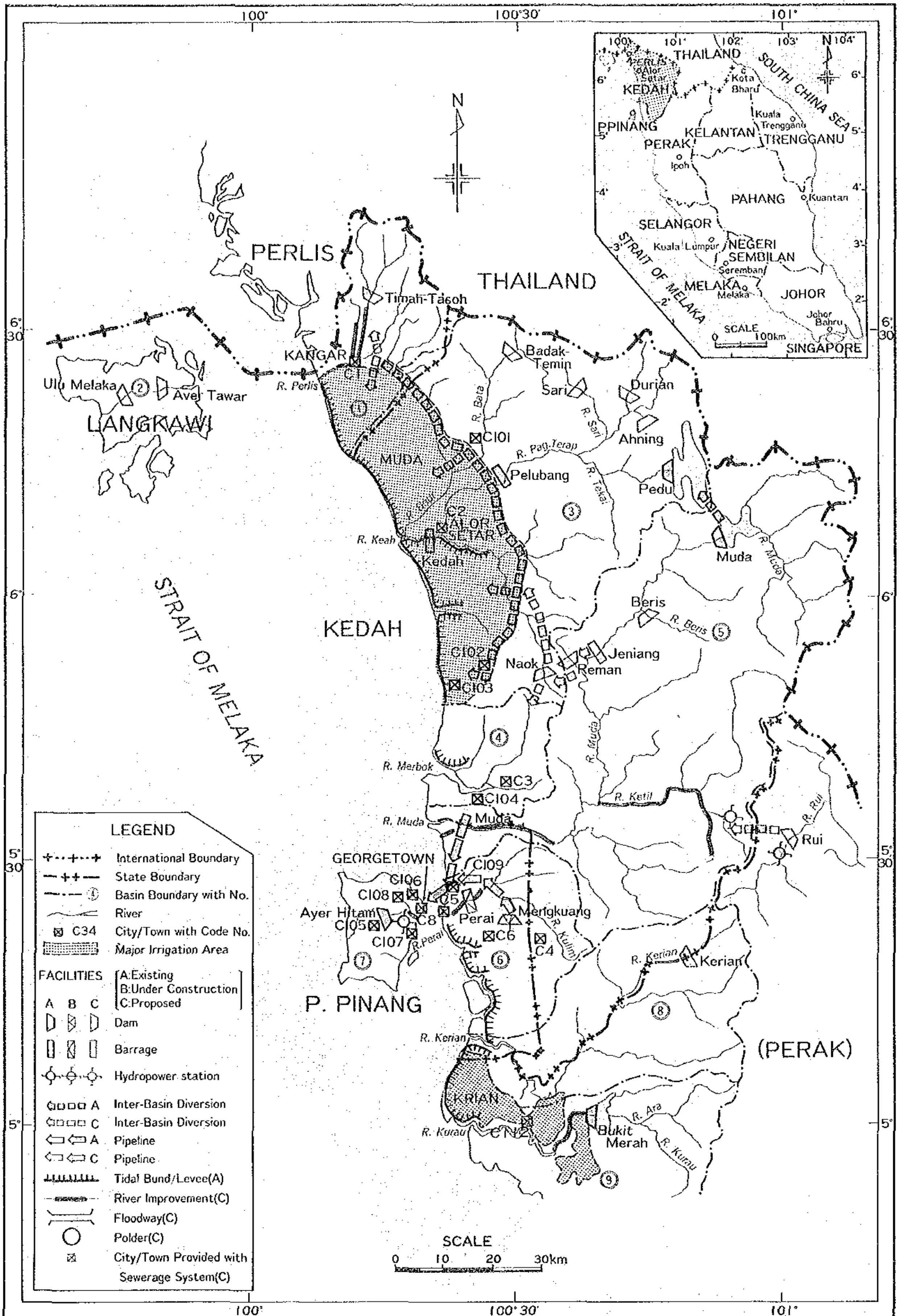

Recommended Plan
for the States of Perlis, Kedah & P. Pinang

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

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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 1 for the States of Perlis, Kedah and Pulau Pinang herein presented describes the matters for the three States together, because the entire area of the States need to form one region from the viewpoint of balancing water demand and supply.

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

(1) Perlis

The State of Perlis of 810 sq.km is located in the northernmost part of the west coast of Peninsular Malaysia, between $100^{\circ}7'$ and $100^{\circ}22'$ east in longitude and between $6^{\circ}15'$ and $6^{\circ}44'$ north in latitude. It faces the Strait of Melaka in the west and adjoins the State of Kedah in the south and Thailand in the north and east.

The State consists mainly of plains. Rivers run almost perpendicular to the geological trend. They are the Perlis, Arua, Terap and other small rivers belonging to the Perlis river system.

Geology of Perlis is characterized by Ordovician limestone which forms the western watershed of the Perlis river and extends to Langkawi island across the sea. The other major geological units are upper Devonian - Triassic sediments and alluvial deposits. In the former sediments, dark coloured crystalline limestones are thick in the western part but gradually thinning replaced by shale and sandstone alternations eastward. The latter occupies nearly half of the area in the State.

Soils are mostly alluvial soils occurring on coastal, riverine flood plains and terraces. Their areal extent is 597 sq.km, accounting for about three fourth of the total for the State. Out of it, 557 sq.km are evaluated as suitable for paddy, 359 sq.km for coconut and 218 sq.km for oil palm and cocoa. Suitable area for rubber is only 71 sq.km in the State.

Climate is usually hot and wet. Average annual rainfall is about 2,000 mm. Rainfall has the peaks during both the post-equinoctial transition periods between the monsoons. Meteorological data at Alor Star (El.4.6 m) are summarized in Table 1.

(2) Kedah

The State of Kedah of 9,480 sq.km, including Pulau Langkawi, is located in the northern part of the west coast of Peninsular Malaysia, between 99"40' and 101"8' east in longitude and between 5"5' and 6"33' in latitude. It faces the Strait of Melaka in the west and adjoins the State of Perlis in the north and the States of Pulau Pinang and Perak in the south.

Eastern part of the State is mountainous. Major portion is plains with limited area of swamps in the southern most part. Rivers run perpendicular or parallel to the geological trend. They are the Kedah, Merbok, Muda, Kerian and other small rivers.

Kedah is situated on a complicated mosaic of various geological facies. Granites occur in the vicinity of the eastern border along the Main Range as well as in some isolated small areas around Mt. Koh Mai on the northern border and around the town of Kulim. Provinces of Silurian meta-sediments, comprising variegated shales and quartzites interbedded locally with cherts and limestones, are developed adjacent to the granite zones. Shales, mudstones and sandstones of Carboniferous - Triassic ages form a north-south trending belt in the northern Kedah. Also, Triassic sandstones interbedded with shales siltstones and cherts are developed extensively in the northern Kedah and in isolated patches in the southern Kedah. The only exposure of Cambrian bed in the Peninsula, composed of quartzites and mica schists, is located around Mt. Jerai near the west coast. Coastal alluvial plain is approximately 15 km wide. Isolated hills of Permian limestone are scattered in the northern Kedah. Faults of northwesterly and northeasterly trends are intensively developed in the central part of the State.

Soils are mostly sedentary soils occurring on undulating plains and mountains. The areal extent of alluvial soils on coastal plains and riverine flood plain or low riverine terraces is 2,149 sq.km, accounting for 23% of the total for the State. Of this, 1,416 sq.km are evaluated as suitable for paddy, 1,135 sq.km for coconut and 799 sq.km for oil palm and cocoa. Suitable area for rubber totals 742 sq.km among which 70% extends over the sedentary soil area.

Climate is usually hot and wet. Average annual rainfall is about 2,000 mm. Rainfall has the peaks during both the post-equinoctial transition periods between the monsoons. Meteorological data at Alor Setar (El.4.6 m) are summarized in Table 1.

(3) Pulau Pinang

The State of Pulau Pinang of 1,040 sq.km, composed of Seberang Perai and Pulau Pinang, is located in the northern portion of the west coast of Peninsular Malaysia, between 100"11′ and 100"33′ east in longitude and 5"8′ and 5"35′ north in latitude. It faces the Strait of Melaka in the west and adjoins the State of Kedah in the north and the east and the State of Perak in the south.

Seberang Perai of 740 sq.km is mostly alluvial plain being occurred by low hills. The southern part of eastern boundary is featured by hills of intruded granite. Major rivers are the Muda, Perai and Kurian. They all run into Seberang Perai across the state boundary. A minor part of the Kurau river basin belongs to Seberang Perai.

Pulau Pinang of 300 sq.km is mountainous wholly composed of coarse granitic rock of upper Carboniferous and upper Triassic. Coastal alluvium thinly develops in limited areas in the southeast and southwest.

Soils are mostly alluvial soils occurring on coastal plains, riverine, flood plain and terraces. Their areal extent is 684 sq.km, accounting for 66% of the total for the State. Out of it, 356 sq.km are evaluated as suitable for paddy, 212 sq.km for coconut, and 153 sq.km for oil palm and cocoa. Suitable area for rubber is only 17 sq.km in the whole State.

Climate is usually hot and wet. Average annual rainfall is 2,000 mm - 2,500 mm. Rainfall has the peaks during both the post-equinoctial transition periods between the monsoons. Meteorological data at Bayan Lepas (El.33.0 m) are summarized in Table 1.

2.2 The Rivers

Run-off in all rivers which are wholly or partly located in the States of Kedah and Pulau Pinang is estimated based on 1961 - 1979 records at the hydrological station No.5007421 in the Kuran river. In Kedah, the surface run-off is 16 billion cu.m/y. Evapotranspiration is 51 billion cu.m/y and groundwater recharge is 1 billion cu.m/y. In Pulau Pinang, the surface run-ooff is 10 billion or about 56% of rainfall of 18 billion cu.m/y. Evapotranspiration is 7 billion cu.m/y and groundwater recharge is 1 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 more than 5 mg/lit was measured during 1978/1979 in the Kedah, Merbok, Juru and Jawi rivers. Effluent from industrial estate in Butterworth is the major cause of high concentration of suspended solids (SS). In the 1978 observation, SS concentration was more than 500 mg/lit in the downstream of the Perai river.

Alluvial aquifers occur in the limited area of the coastal plain along the sea coast in Perlis and in the coastal plain along the sea coast and rolling plain in Kedah and Pulau Pinang. Sea water intrudes evidently near the seashore in these coastal States.

Rock aquifers may be found in the limestone and the sedimentary rocks of Silurian to Triassic in Perlis, in the sedimentary rocks of Silurian to Triassic in Kedah and in some granites in Pulau Pinang.

The river characteristics in terms of river morphology, estuary, sediment and sea water intrusion in the States of Perlis, Kedah and Pulau Pinang is as shown in Table 2 through 4.

2.3 Watershed

(1) Perlis/Kedah

Natural vegetation occupies 4,266 sq.km comprising hill forest of 3,235 sq.km, scrub forest of 627 sq.km, swamp forest of 195 sq.km and grassland of 209 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 decreased from 4,575 sq.km or 44% of the whole States in 1966 to 4,057 sq.km or 39% 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 (SS) was less than 100 mg/lit at present in all rivers of both the States, showing less effect by surface soil loss occured in the catchment areas.

(2) Pulau Pinang

Natural vegetation occupies 95 sq.km comprising hill forest of 65 sq.km, scrub forest of 5 sq.km, swamp forest of 4 sq.km and grassland of 21 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 slightly decreased from 116 sq.km or 11% of the whole State in 1966 to 74 sq.km or 7% in 1979.

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 at present in all rivers of the State showing less effect by surface soil loss occurred in the catchment areas.

2.4 Present Socio-economic Condition

As illustrated in Fig.1, the State of Perlis is administratively composed of one district, the State of Kedah of 11 districts and the State of Pulau Pinang of 5 districts. Towns having population of more than 10,000 in 1980 were Kangar in Perlis, Jitra, Alor Setar, Sg. Petani and Kulim in Kedah and Butterworth, Kg.PMTG Kuching, Bk. Mertojan, Perai, Georgetown, Air Itam, Tg.Tokong, Gelugor and Tg.Bunga in Pulau Pinang.

Population and gross regional product (GRP) of the State of Perlis, Kedah and Pulau Pinang are described hereunder.

(1) Perlis/Kedah

Population of Perlis/Kedah was 1.3 million in 1980 with the average annual growth rate of 1.8% during the period from 1970 to 1980. Population density increased from 109 persons/sq.km in 1970 to 129 persons/sq.km in 1980.

The GRP increased from M$806 million in 1971 to M$1,422 million in 1980 in factor cost at 1970 constant price with the average annual growth rate of 6.5%. GRP of manufacturing sector shared M$39 million or 4.8% of the total in 1971 and M$110 million or 7.7% in 1980. Per capita GRP was M$1,069 in 1980 in factor cost at 1970 constant price and its average annual growth rate between 1971 and 1980 was 4.7%.

Major land use patterns in 1979 were forest of 4,057 sq.km, grassland of 209 sq.km, annual and perennial crop land of 4,806 sq.km, swamp of 195 sq.km and miscellaneous land of 1,031 sq.km. Fig.2 shows the land use in 1974.

Rubber, oil palm, coconut and cocoa are planted for earning of foreign currency by export. The total planted area as of 1979 was 224,400 ha for rubber, 7,600 ha for oil palm, 12,700 ha for coconut and 200 ha for cocoa. During the last five years since 1975, newly planted area under FELDA and FELCRA schemes totaled 3,607 ha for rubber. RISDA replanted 11,464 ha of rubber in the existing smallholders' rubber areas during the said period, while private estates reduced by 4,100 ha their planted area of rubber mainly for the purpose of conversion to oil palm. The annual production in 1979 totaled 224,100 tons of rubber as dry rubber content, 95,700 tons of oil palm as fresh fruit bunch and 31,000 tons of coconut as copra. Out of the above harvests, private estates produced 99,900 tons of rubber and 95,700 tons of oil palm. The remaining ones were put out from RISDA, FELDA and FELCRA schemes as well as smallholders.

In one mill located within the State, 5,900 tons of crude palm oil and 1,300 tons of palm kernel were extracted from oil palm through processing 26,500 tons of fresh fruit bunch brought in the mills throughout 1979.

In 1979/80, paddy was planted in 262,800 ha comprising main season wet paddy of 149,000 ha, main season dry paddy of 600 ha and off-season wet paddy of 113,200 ha. As the whole paddy field was 167,700 ha, the crop intensity in 1979/80 became 1.57. The total rice production in 1979/80 was 654,900 tons among which 362,000 tons were harvested in the main season including 400 tons of dry paddy rice and the remaining 292,900 tons were off-season wet paddy rice. This production met 100% of the estimated local consumption of 126,500 tons in the two States and covered the supply shortage of rice in other States.

During the period from 1970/71 to 1979/80, rice production fluctuated between 309,600 tons in 1977/78 and 657,100 tons in 1978/79 largely affected by climatic condition, even though paddy field which was provided with irrigation facilities increased from 93,200 ha to 113,400 ha.

(2) Pulau Pinang

Population of Pulau Pinang was 1.0 million in 1980 with the average annual growth rate of 1.9% during the period from 1970 to 1980. Population density increased from 774 persons/sq.km in 1970 to 933 persons/sq.km in 1980.

The GRP increased from M$827 million in 1971 to M$2,221 million in 1980 in factor cost at 1970 constant price with the average annual growth rate of 11.6%. GRP of manufacturing sector shared M$174 million or 21.0% of the total in 1971 and M$825 million or 37.2% in 1980. Per capita GRP was M$2,289 in 1980 in factor cost at 1970 constant price and its average annual growth rate between 1971 and 1980 was 9.6%.

Major land use patterns in 1979 were forest of 74 sq.km, grassland of 21 sq.km, annual and perennial crop land of 737 sq.km, swamp of 60 sq.km and miscellaneous land of 155 sq.km. Fig.2 shows the land use in 1974.

Rubber, oil palm, coconut and cocoa are planted for earning of foreign currency by export. The total planted area as of 1979 was 24,000 ha for rubber, 4,600 ha for oil palm, 15,400 ha for coconut and 700 ha for cocoa. During the last five years since 1975, private estates reduced by 1,700 ha their planted area of rubber mainly for the purpose of conversion to oil palm. The annual production in 1979 totaled 44,300 tons of rubber as dry rubber content, 43,100 tons of oil palm as fresh fruit bunch and 36,400 tons of coconut as copra and 30 tons of cocoa as dry beans. Out of the above harvests, private estates produced 9,300 tons of rubber and 43,100 tons of oil palm and 30 tons of cocoa. The remaining ones were put out from RISDA, FELDA and FELCRA schemes as well as smallholders.

In four mills located within the State, 24,600 tons of crude palm oil and 5,600 tons of palm kernel were extracted from oil palm through processing 110,100 tons of fresh fruit bunch brought in the mills throughout 1979.

In 1979/80, paddy was planted in 22,800 ha comprising main season wet paddy of 11,400 ha and off-season wet paddy of 11,400 ha. As the whole paddy field was 18,000 ha, the crop intensity in 1979/80 became 1.27. The total rice production in 1979/80 was 35,500 tons among which 17,900 tons were harvested in the main season and the remaining 17,600 tons were off-season wet paddy rice. This production met 38% of the estimated local consumption of 92,300 tons in the State in 1979/80.

During the period from 1970/71 to 1979/80, rice production fluctuated between 35,500 tons in 1979/80 and 70,200 tons in 1973/74 largely affected by climatic condition, even though paddy field which was provided with irrigation facilities increased from 14,800 ha to 16,800 ha.

3. PRESENT CONDITION OF WATER RESOURCES DEVELOPMENT AND USE

3.1 Domestic and Industrial Water Supply

Public water supply in the States of Perlis and Kedah is administered by the Water Supply Division of Public Works Department (PWD) of the State Government. In Pulau Pinang, public water supply is administered by the Penang Water Authority (WA). The Penang Water Authority is a statutory body and is managed under a commercial accounting system.

In these three States, PWD and WA 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 Perlis, in 1978, the five PWD water works delivered 8,200 cu.m/d; in Kedah, the twenty three PWD water works delivered 87,700 cu.m/d; in Pulau Pinang, the water delivered from the Penang Water Authority amounted to 243,800 cu.m/d. The population served water through PWD and Water Authority pipeline networks was estimated at 118,200 in Perlis, 426,400 in Kedah and 819,400 in Pulau Pinang 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 8,000 people for Perlis, 158,000 for Kedah and 3,000 for Pulau Pinang were served water by the untreated water supply system in 1980. These water users are suggested to boil water before drinking.

Consequently, the service factor, the ratio of water-served population to the State total population, was estimated at 80% in Perlis, 50% in Kedah and 85% in Pulau Pinang in 1980.

3.2 Irrigation

(1) Perlis

There are 28,700 ha of paddy fields: 20,200 ha are irrigated and 8,500 ha are rainfed. The Muda irrigation scheme extends from the State of Kedah into this State occupying most of alluvial plain on the left bank of the Perlis river with an area of 13,400 ha. Except for the Muda scheme area, there are 6,800 ha of small-scale irrigation schemes. All area are served by gravity irrigation. The average size of small-scale schemes is 235 ha. Location of irrigation areas is shown in Fig.3. Paddy yield is 2.5 - 3.5 tons/ha in the main season and 3.2 - 4.2 tons/ha in the off-season acording to the records from 1973 to 1978.

(2) Kedah

There are 139,000 ha of paddy fields: 96,000 ha are irrigated and 43,000 ha are rainfed. The Muda irrigation scheme which is the nation's largest irrigation scheme occupies flat alluvial coastal plain about 20 km wide and 65 km long extending into the State of Perlis as shown in Fig.3. Irrigation area of the scheme is 95,900 ha, comprising 82,500 ha in the State and 13,400 ha in the State of Perlis. The water sources of irrigation for the Muda scheme are the controlled flow from the Pedu and the Muda reservoirs and the uncontrolled flow from the tributaries of the Kedah river. Tertiary irrigation and drainage developmet is being carried out in order to improve water management problems.

Except for the Muda scheme, 33 small-scale irrigation schemes of 13,600 ha in total exist mainly in the fringe area of the Muda scheme consisting of 25 gravity irrigation, 6 pumping irrigation and 2 control drainage schemes. The average size of small-scale irrigation scheme is 412 ha. Paddy yield is 3.1 - 3.6 tons/ha in the main season and 3.6 - 4.2 tons/ha in the off-season according to the records from 1973 to 1978.

(3) Pulau Pinang

There are 18,000 ha of paddy fields: 16,800 ha are irrigated and 1,200 ha are rainfed. Of the above irrigated area, some 1,500 ha are the northern part of the Kerian irrigation scheme as shown in Fig.3. There are 15 minor schemes in the State commanding 15,300 ha in total, comprising 7 gravity irrigation, 6 pumping irrigation and 1 control drainage schemes. The largest irrigation scheme is the Sungai Muda pumping irrigation scheme of 7,114 ha taking irrigation water from downstream of the Muda river. Paddy yield is 2.9 - 3.4 tons/ha in the main season and 2.8 - 3.7 tons/ha in the off-season according to the records for 1973 to 1978.

3.3 Flood Mitigation

(1) Perlis

Flood occurs between August and January, mostly in December. The damage by the recorded maximum flood in the State is estimated to be M$6.2 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.

(2) Kedah

Flood occurs between July and January, mostly in September to December. The damage by the recorded maximum flood in the State is estimated to be M$9.5 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) Pulau Pinang

Flood occurs between August and January, mostly in September and October. The damage by the recorded maximum flood in the State is estimated to be M$7.3 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 Inland Fishery

There are 9 ha, 88 ha and 19 ha of freshwater constructed ponds and 1 ha, 31 ha and 2 ha of tin mining pool used for fish culturing in 1979 in the States of Perlis, Kedah and Pulau Pinang respectively. The water use of the constructed ponds was 0.12, 1.19 and 0.26 million cu.m/y in the States of Perlis, Kedah and Pulau Pinang respectively.

3.5 Inland Navigation

Only limited number of sampans ascend the Perlis river up to Kg.Tebing Tinggi in Perlis.

In Kedah, river traffic is very seldom except for marine fishing boats in the Kedah river. Passage through the barrage lock is very limited at present. No commercial boats navigate the Muda river. Cargo boats ascend the Perai river to feed factories and warehouses located 8.5 km from the river mouth.

River traffic is quite limited except for marine fishing boats in the rivers in Pulau Pinang.

3.6 Sewerage System

The sewerage system is installed only in Georgetown. Most sewage in this system is untreated and disposed to the sea. The sewerage system in Alor Setar is under construction. This system has the treatment facilities and sewage is disposed to the river after treated. The installation of septic tank is compulsory by regulations in other unsewered urban areas, while domestic sewage is directly discharged into nearby water course or onto land in rural area.

3.7 Water Purification System in Private Sector

(1) Perlis

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

There are neither rubber factories nor palm oil mills in the State.

(2) Kedah

The Federal DOE started to monitor the river water quality since 1978 in Kedah with the frequency ranging from twice a year to once a month in 5 river water quality control regions.

There are 31 rubber factories in the State. These factories produce SMR, latex concentrate and conventional grade of 583 tons/day and they discharge effluent of 2.77 million cu.m/y to nearby watercourses. The water quality at outlets of factories ranges from 7 to 2,350 mg/lit in BOD concentration and from 6 to 1,000 mg/lit in SS concentration.

There is one oil palm mill in operation of which milling capacity amounts to 260 tons/hr in fresh fruit bunch (FFB). The volume of effluent from the mill is 33,000 cu.m/y. The treated or raw effluent is and will be discharged into watercourses. The water quality in BOD concentration is 80 mg/lit and SS concentration is 180 mg/lit.

(3) Pulau Pinang

The Federal DOE started to monitor the river water quality since 1978 in Pulau Pinang with the frequency ranging from twice a year to once a month in 2 river water quality control regions.

There are 9 rubber factories in the State. These factories produce SMR, latex concentrate and conventional grade of 316 tons/day and they discharge effluent of 2.19 million cu.m/y to nearby watercourses. The water quality at outlets of factories ranges from 20 to 50 mg/lit in BOD concentration and from 26 to 500 mg/lit in SS concentration .

There are 4 oil palm mills in operation of which milling capacity amounts to 210 tons/hr in fresh fruit bunch (FFB). The volume of effluent from these mills is 48,000 cu.m/y. The treated or raw effluent is and will be discharged from 2 mills into watercourses and from 2 mills onto land. The water quality ranges from 40 to 5,000 mg/lit in BOD concentration and SS concentration ranges from 500 to 2,500 mg/lit.

3.8 Watershed Management

(1) Perlis & Kedah

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 coordinating the development of wood-based industries.

At the end of 1979, the forest land was categorized into forest reserves of 3,504 sq.km, wild life and other reserves of 51 sq.km and Crown or State land of 502 sq.km. Out of the forest reserves, 2,007 sq.km was classified as productive forests comprising 1,929 sq.km of inland forests and 78 sq.km of mangrove forests. The remaining 1,497 sq.km were unproductive forests consisting of 1,484 sq.km of protective hill forest and 13 sq.km of mangrove forests. In the inland forest reserves, there remain 877 sq.km of unexploited forests which have been committed or licenced for development. The actual area opened for harvesting during 1979 was 82 sq.km corresponding to 9% of the unexploited forests.

Besides forest exploitation, execution of large-scaled 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 from 100 to 200 mg/lit in the lower reach of the Kedah river and from 100 to 300 mg/lit in the middle and lower reaches of the Muda river, if all the present forest lands having a slope of less than 2 degree and non-erodable soils are converted to tree crop plantations and those located on slope lands ranging from 3 to 6 degreeg 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.

(2) Pulau Pinang

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 coordinating the development of wood-based industries.

At the end of 1979, the forest land was categorized into forest reserves of 61 sq.km, wild life and other reserves of 8 sq.km and Crown or State land of 5 sq.km. Out of the forest reserves, 22 sq.km was classified as productive forests comprising 18 sq.km of inland forests and 4 sq.km of mangrove forests. The remaining 39 sq.km were unproductive forests consisting entirely of protective hill forest. In the inland forest reserves, there remain 4 sq.km of unexploited forests which have been committed or licenced for development. The actual area opened for harvesting during 1979 was 0.3 sq.km corresponding to 7% of the unexploited forests.

Besides forest exploitation, execution of large-scaled 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 be still less than 100 mg/lit in all rivers, even if all the present forest lands having a slope of less than 2 degree and non-erodable soils are converted to tree crop plantations and those located on slope lands ranging from 3 to 6 degree and on erodable soil areas with a slope of less than 2 degree 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.

3.9 Dams

There are no dams in the State of Perlis. In the State of Kedah, the Pedu-Muda dams and the Kedah and Muda barrages are in operation. In Pulau Pinang, the Ayer Hitam dam is in operation and the Perai barrage is under construction. The major features are shown in Table 6. The dam is for the purposes of water supply and hydropower generation.

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 States of Perlis/Kedah/Pulau Pinang is described hereunder.

(1) Perlis/Kedah

The average annual growth rate of population in the period from 1980 to 2000 was estimated to be 1.1%. Projected population is 1.52 million in 1990 and 1.64 million in 2000, respectively. Table 7 shows the projected population by urban and rural area in the States of Perlis and Kedah. 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$2,103 million in 1985, M$3,177 million in 1990 and M$6,901 million in 2000 with the average annual growth rate of 8.2% between 1980 and 2000.

Projected gross value of output in manufacturing sector will increase from M$404 million in 1980 to M$870 million in 1985, M$1,630 million in 1990 and M$5,987 million in 2000 at factor cost in 1970 prices as shown in Table 9.

The future rice consumption in the States was estimated to be 182,300 tons in 1990 and 196,600 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 28,200 ha, (2) stabilization of irrigation water supply during the wet season to the existing irrigated paddy field of 101,900 ha and (3) development of new irrigation water resources during the dry season to increase by 8,600 ha double cropping area among the existing irrigated paddy field. The total rice production anticipated under the above plans will be 656,300 tons in 1990 and 712,100 tons in 2000.

Oil palm planting area was projected to increase to 7,930 ha in 1990 and to 8,740 ha in 2000. The prospected processing volume of oil palm in the States will be 60,000 ton as fresh fruit bunch in 1990 and 2000.

Rubber planting area was projected to be kept in the present hectarage of 236,000 ha in 1990 and 2000. The total processing amount was projected to be 270,000 ton as dry rubber content in 1990 and 410,000 ton in 2000.

(2) Pulau Pinang

The average annual growth rate of population in the period from 1980 to 2000 was estimated to be 1.0%. Projected population is 1.13 million in 1990 and 1.17 million in 2000, respectively. Table 8 shows the projected population by urban and rural area in the State of Pulau Pinang. 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$3,011 million in 1985, M$4,364 million in 1990 and M$7,208 million in 2000 with the average annual growth rate of 6.1% between 1980 and 2000.

Projected gross value of output in manufacturing sector will increase from M$2,595 million in 1980 to M$3,914 million in 1985, M$6,324 million in 1990 and M$10,560 million in 2000 at in factor cost in 1970 prices as shown in Table 9.

The future rice consumption in the State was estimated to be 135,900 tons in 1990 and 140,500 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 500 ha, (2) stabilization of irrigation water supply during the wet season to the existing irrigated paddy field of 500 ha and (3) development of new irrigation water resources during the dry season to increase by 300 ha double cropping area among the existing irrigated paddy field. The total rice production is anticipated to decrease from 67,600 tons in 1990 to 67,500 tons in 2000 due to the conversion of the rainfed paddy to other farm land.

Oil palm planting area was projected to increase to 4,830 ha in 1990 and 5,320 ha in 2000. The prospected processing volume of oil palm in the State will be 90,000 ton as fresh fruit bunch in 1990 and 250,000 ton in 2000.

Rubber planting area was projected to be kept in the present hectarage of 52,200 ha in 1990 and 2000. The total processing amount was projected to be 140,000 ton as dry rubber content in 1990 and 220,000 ton in 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 10.

As shown in Fig.5, eight Basins in total are wholly or partly located in the States of Perlis, Kedah and Pulau Pinang. The State of Perlis is almost wholly covered by the Perlis Basin. In the State of Kedah, the Langkawi island constitutes an isolated basin of the Pulau Langkawi Basin. In the mainland Kedah, located are the whole area of the Merbok and the Kedah Basins, most part of the Muda Basin, and a part of the Kerian and the Perai Basins. In the State of Pulau Pinang, the Pinang island constitutes an isolated basin of the Pulau Pinang Basin. In the mainland Pulau Pinang, located are a part of the Perai Basin and the downstream area of the Muda 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 11 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 12.

In Perlis, the total water demand will reach 16 million cu.m/y in 1990 and 37 million cu.m/y in 2000 as shown in Table 13. Major demand center is Kangar, the State capital.

In Kedah, the total water demand will reach 113 million cu.m/y in 1990 and 260 million cu.m/y in 2000 as shown in Table 13. Major demand centers are Alor Setar, Kulang Pasu and Kulim among which Alor Setar has the largest demand for both the industrial water and domestic water demands in 2000.

In Pulau Pinang, the total water demand will reach 236 million cu.m/y in 1990 and 343 million cu.m/y in 2000 as shown in Table 13 and 14. Major demand centers are Butterworth, Georgetown, Perai, Air Itam and Bk.Mertajan among which Butterworth has the largest demand for industrial water and Georgetown has the largest domestic water demand 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

(1) Perlis/Kedah

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 15, the projected irrigation area will increase from 116,200 ha in 1980 to 135,500 ha in 1990 and 144,400 ha in 2000. The ratio of double cropping area to the total irrigation area will rise from 47% in 1980 to 52% in 1990 and 55% in 2000.

The irrigation water demand was calculated for 1990 and 2000 as shown in Table 16. Irrigation efficiency applied is 55% with the exception of Muda project (65%) for both major and minor irrigation projects. The annual irrigation water demand will be 2,466 million cu.m in 1990 and 2,688 million cu.m in 2000, respectively.

(2) Pulau Pinang

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 15, the projected irrigation area will increase from 16,800 ha in 1980 to 17,200 ha through 2000. The ratio of double cropping area to the total irrigation area will be 87% in 1980, 86% in 1990 and 87% in 2000.

The irrigation water demand was calculated for 1990 and 2000 as shown in Table 16. Irrigation efficiency applied is 55% for both major and minor irrigation projects. The annual irrigation water demand will be 465 million cu.m in 1990 and 466 million cu.m in 2000, respectively.

4.5 Fish Pond Water Demand

(1) Perlis and Kedah

The future hectarage of freshwater fish pond was projected to increase from 115 ha in 1980 to 354 ha in 1990 and to 664 ha in 2000. The total water demand for freshwater fish culture will rise from 1.57 million cu.m/y in 1980 to 4.86 million cu.m/y in 1990 and to 8.96 million cu.m/y in 2000.

(2) Pulau Pinang

The future hectarage of freshwater fish pond was projected to increase from 23 ha in 1980 to 109 ha in 1990 and to 205 ha in 2000. The total water demand for freshwater fish culture will rise from 310,000 cu.m/y in 1980 to 1.49 million cu.m/y in 1990 and to 2.83 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 source 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 17 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 17. In the States of Perlis, Kedah and Pulau Pinang, the seven Basins among the concerned eight were estimated to have a river utilization ratio of more than 10% in 2000; only the Kerian Basin to have the ratio of less than 10%.

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.

A certain amount of 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 10.

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 18.

The water deficit shown in Table 18 was calculated under without-dam condition. If the estimated supply capacity of the existing and under-construction dams listed up in Table 7 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. In the States of Perlis, Kedah and Pulau Pinang, major pollution sources assumed were the domestic and industrial water users comprising 17 urban areas, 5 palm oil mills, 40 rubber factories, animal husbandry in the rural areas. However, waste water from the following cities was assumed to be directly discharged to the sea; Georgetown, Butterworth, Yen, Tg.Tokong, Gelugor, Tg.Bunga, Kg.PMTG Kuching and Perai.

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 19. 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 20. 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 Perlis, Kedah and Pulau Pinang will be more than 5 mg/lit except for the Muda and Kerian rivers in 1990 and 2000. This projection states that rivers along which inland-cities/towns such as Kulim and SG. Petani are situated will be grossly polluted 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 500 and 950 tons/sq.km for Perlis/Kedah and Pulau Pinang respectively. This erosion rate is generally high, because soils are erodable and natural forest has been converted to other land to a large extent.

In Perlis/Kedah/Pulau Pinang, however, substantial reduction in erosion is not expected from reforestration in the presently disturbed forest, because agricultural land occupying a large area is the major contributor to erosion. Reforestration in the disturbed forest can reduce erosion in a long run.

If all natural forest on slope of less than 6 degrees is disturbed, erosion rate will increase to 1,450 and 1,300 tons/sq.km for Perlis/Kedah and Pulau Pinang respectively. An exercise indicates that erosion rate is 900 and 1,000 tons/sq.km for Perlis/Kedah and Pulau Pinang respectively, if natural forest on slope of less than 2 degrees is cleared and converted to rubber farm.

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 10 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 21.

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. The alternative plans for water demand and supply balance are shown in Tables 22 through 24 for Alternatives B1, B2 and B3 respectively.

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 Basins where the improvement was proposed for both the alternatives for 1990 and 2000 were the Merbok, Perai, and Kurau Basins.

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: the public sewerage systems in SG.Petani and Kulim were proposed for the two alternatives.

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 each State are as outlined in Table 25.

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/WA systems 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 26 through 28. However, 10% of the rural people in Sabah and Sarawak will still not be publicly, because of the remoteness and non-available of suitable water source.

Irrigation water supply system will be constructed in accordance with the schedule assumed in Table 15.

7.2 Source Development

The recommended water source development plan for balancing water demand and supply is summarized in Table 29. The water source development plan in the problem area is mentioned hereunder.

Fig.11 illustrates the recommended water demand and supply balance programs for Perlis, Kedah and Pulau Pinang region, Pulau Langkawi, Kerian and Kurau river basins.

7.2.1 Perlis/Kedah/Pulau Pinang region source development plan

The Perlis/Kedah/Pulau Pinang region herein defined is 10,500 sq.km of water stress area covering the entire land of the States of Perlis/Kedah/Pulau Pinang, excluding Pulau Langkawi and Kerian areas. Major river systems are the Perlis, Kedah, Merbok, Muda and Perai river systems.

The Muda irrigation project of 95,860 ha encompasses entire coastal plain of the States of Perlis and Kedah. The Muda and Pedu dams are operated to supply water to the project. The Muda dam of 123 million cu.m in active storage capacity conveys water from its catchment area of 984 sq.km in the upper Muda river basin through a diversion tunnel to an upper tributary of the Kedah river. The Pedu dam of 864 million cu.m in active storage capacity regulate the water from the Muda dam and inflow from its catchment area of 171 sq.km in the upper tributary of the Kedah river. The regulated outflow of 780 million cu.m/y from the Pedu dam is discharged through the Kedah river and collected at the Pelubang barrage for the supply to the Muda irrigation project.

There are 10,000 ha of minor irrigation projects in the fringe area of the Muda irrigation project, depending on the Perlis, Kedah and Merbok river systems. Water resources in the Perlis, Kedah and Merbok river basins are insufficient to meet the present water demand of 2.1 billion cu.m/y, which is mostly for irrigation.

The above-mentioned minor irrigation area will increase to 21,500 ha by 1990 and 29,000 ha by 2000. Although irrigation efficiency in the Muda irrigation project will be improved by the on-going tertiary irrigation and drainage development under the Muda II Irrigation Project with a financial assistance by IBRD, increased minor irrigation projects and domestic and irrigation demand will push up the total water demand to 2.2 billion cu.m/y by 1990 and 2.5 billion cu.m/y by 2000, widening the imbalance between water demand and supply in the Perlis, Kedah and Merbok river basins.

Population in 1980 in the State of Pulau Pinang was 969,000, of which 480,000, or 50% were urban population living in Butterworth, Georgetown and other towns. The present sources of domestic and industrial water are the rivers in Pulau Pinang, the Muda river and the Perai river. The supply capacity within Pulau Pinang including that by the Ayer Hitam dam is estimated to be 30 million cu.m/y. The River Muda Water Scheme diverts water from the lower stretch of the Muda river through the River Muda Canal to the Sungei Dua Treatment Works on the right bank of the Perai river to feed the water supply system for the towns in Seberang Perai and Georgetown.

The Muda barrage was constructed to protect the intakes from sea water intrusion. The Mengkuang dam in a tributary of the Perai river is a pumped-storage reservoir project to increase the supply capacity of the River Muda Water Scheme. Stage I recently completed takes water from the Kulim river, a tributary of the Perai river and Stage II is envisaged further to pump water from the River Muda Canal. Total water supply capacity of Mengkuang dam Stages I&II is estimated to be 24 million cu.m/y.

The Muda and Perai rivers are also utilized for irrigation of 21,600 ha; 7,100 ha depending on the Muda river below the Muda dam, 13,500 ha utilizing both the Muda and Perai rivers and 1,000 ha taking water from the Perai river. The irrigation area in Pulau Pinang is 1,200 ha. The present irrigation water demand in these areas is estimated to be 709 million cu.m/y.

Population in the Muda and Perai river basins and Pulau Pinang is estimated to be 1.3 million for 1980, 1.5 million for 1990 and 1.6 million for 2000, and the corresponding domestic and industrial water demand is estimated to be 137 million cu.m for 1980, 263 million cu.m for 1990 and 390 million cu.m for 2000 including urban water demand within the State of Pulau Pinang of 85 million cu.m in 1980, 182 million cu.m in 1990 and 278 million cu.m in 2000, even if water intensive industries do not increase beyond 1985. Irrigation development will take place mainly in the areas wholly or partly depending on the Muda river. Irrigation area of 22,800 ha in 1980 will increase to 30,000 ha by 1990 and 31,200 ha by 2000. Total irrigation water demand is estimated to be 709 million cu.m for 1980, 738 million cu.m for 1990 and 815 million cu.m for 2000. These large water demand cannot be met by water resources in the Muda river below the Muda dam, Perai river and small rivers in Pulau Pinang.

The water demand in the Perlis/Kedah/Pulau Pinang region altogether is estimated to be 2.9 billion cu.m for 1980, 3.2 billion cu.m for 1990 and 3.7 billion cu.m for 2000.

The recommended plan includes the construction of the Timah Tasoh dam in the Perlis river, the Badak-Temin, Sari, Durian and Ahning dams in the tributaries of the Kedah river, the Beris dam and Jeniang transfer including the Naok and Reman dams in the Muda river system and the Rui dam and diversion tunnel in a tributary of the Perak river.

The Jeniang transfer and the Rui dam and diversion tunnel are particularly important projects. The Jeniang transfer will consist of the Jeniang weir on the main stream of the Muda river, Naok and Reman dams and transfer canals to the Muda irrigation project and the Merbok river basin. It will collect flood flow at the Jeniang weir and store it in the Naok and Reman reservoirs. The water stored can be used either to augment the low flow in the Muda river or to supply water to the Muda irrigation project and the Merbok river basin in the dry season. The net supply capacity of the Jeniang transfer has been estimated to be as large as 350 million cu.m/y. The Rui dam will be located in the Rui river, an upper tributary of the Perak river within the State of Perak. Inflow from the catchment area of 215 sq.km will be regulated by the Rui dam and transferred to the upper stretch of the Kechil river, a tributary of the Muda river through a diversion tunnel, while certain river maintenance flow will be released into the Perak river. Net transferable water will be 140 million cu.m/y.

The proposed Rui reservoir will submerge a 2 MW hydropower plant of a private company and it will reduce secondary energy at the Kenering and Chenderoh power stations on the Perak river. On the other hand a potential of about 4 MW will be developed at the outlet of the diversion tunnel. These two projects together with the existing and recommended 6 dams can meet water demand which is expected up to 2000 and they will form a water resources system covering the Perlis, Kedah and Pulau Pinang region, in which any area suffering from drought can receive complemental water by coordinated operation of dams in other area.

7.2.2 Pulau Langkawi source development plan

Irrigation area in Pulau Langkawi of 2,700 ha will increase to 3,100 ha by 1990. Population is estimated to be 31,000 for 1980 and 38,000 for 2000. Natural flow in small rivers can not meet total water demand which is estimated to be 47 million cu.m for 1990 and 48 million cu.m for 2000.

It is recommended to construct the Aver Tawar dam and Ulu Melaka dam.

7.2.3 Kerian and Kurau river basins source development plan

The Kerian Irrigation Project of 23,490 ha is entirely located in the northwest coast of the State of Perak, but 1,504 ha out of the total area is located in the State of Pulau Pinang. It takes water from the Kerian and Kurau rivers. The Bukit Merah dam in the Kurau river and Kerian barrage serve for irrigation. The tertiary irrigation and drainage development is on-going as a part of Kerian-Sungei Manik Integrated Agricultural Development Project, assisted by IBRD. There are minor irrigation areas of about 3,600 ha, which will increase to 4,000 ha by 2000. Population of 350,000 will grow to 670,000 in the two river basins. It is estimated that these river basins will often suffer from water deficit in the near future. The construction of Kerian dam is recommended in the Kerian river, which is the boundary between the State of Kedah and State of Perak.

7.3 Water Pollution Abatement Plan

The recommended plan for the water pollution abatement in the river is the construction of public sewerage systems in Sungai Petani and Kulim and the improvement of purification method in the rubber factories in the Merbok, Perai and Kurau Basins.

Although it is ineffective for the water pollution abatement in the river, sewerage development in Alor Setar, Butterworth, Bukit Mertajam and Georgetown is assumed from the viewpoint of public health.

The recommended plan for water pollution abatement including the assumed sewerage development is shown in Table 30 through 33.

7.4 Flood Mitigation Plan

The recommended plan for flood mitigation is mentioned hereunder and is summarized in Table 34.

7.4.1 Perlis river flood mitigation plan

The Perlis river, bifurcating into many tributaries, flooded 49 sq.km in 1976. Population in 1980 in the flooded area was estimated to be 28,000 including 9,000 in Kangar. The recommended plan is the multipurpose development of the proposed Timah-Tasoh dam and channel improvement of 34 km to protect paddy field and Kangar.

7.4.2 Muda river flood mitigation plan

The Muda river flooded 99 sq.km in 1973. The recommended plan is channel improvement of 45 km along the Kechil river, a tributary where flush floods have endangered the inhabitants, and 27 km in the lower stretch of the main stream allowing flood retardation between the above-mentioned two river stretches. The plan also includes the on-going channel improvement to increase the discharge capacity in the lower reaches of the Tembus river which is a distributary of the Muda river.

7.4.3 Perai river flood mitigation plan

The estuary area of the Perai river located in the south of Butterworth is densely populated. The recommended plan is to provide channel improvement in the lowermost stretch of the Perai river for 4 km below the Perai barrage which is under construction.

7.4.4 Pinang river flood mitigation plan

The Pinang river flooded 1.4 sq.km in the south of Georgetown in 1980. The recommended plan is channel improvement of 2.5 km below Scotland road including the widening of existing river course. Occasional dredging of river-mouth mud will be necessary even after the recommended plan is implemented.

7.5 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 35 and 36. 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 sector for the recommended plan was estimated as shown in Tables 37 and 38.

7.6 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 Tables 39 and 40 for water demand and supply balance, in Table 41 for water pollution abatement and in Table 42 for flood mitigation.

7.6.1 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 43. The hectarage 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.

7.6.2 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 evaluated 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.

7.6.3 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 44. The domestic and industrial water demand estimated under the condition of lower economic growth is shown in Tables 45 and 46.

8.4 Development Plan

The development plan under the condition of lower economic growth is tabulated in Tables 47 through 54.

8.5 Public Expenditure

The public development and recurrent expenditures are estimated for the case of lower economic growth as shown in Tables 55 and 56.

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 57 through 59.