GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

MAIN REPORT

VOL. 2

WATER RESOURCES DEVELOPMENT AND USE PLAN

OCTOBER 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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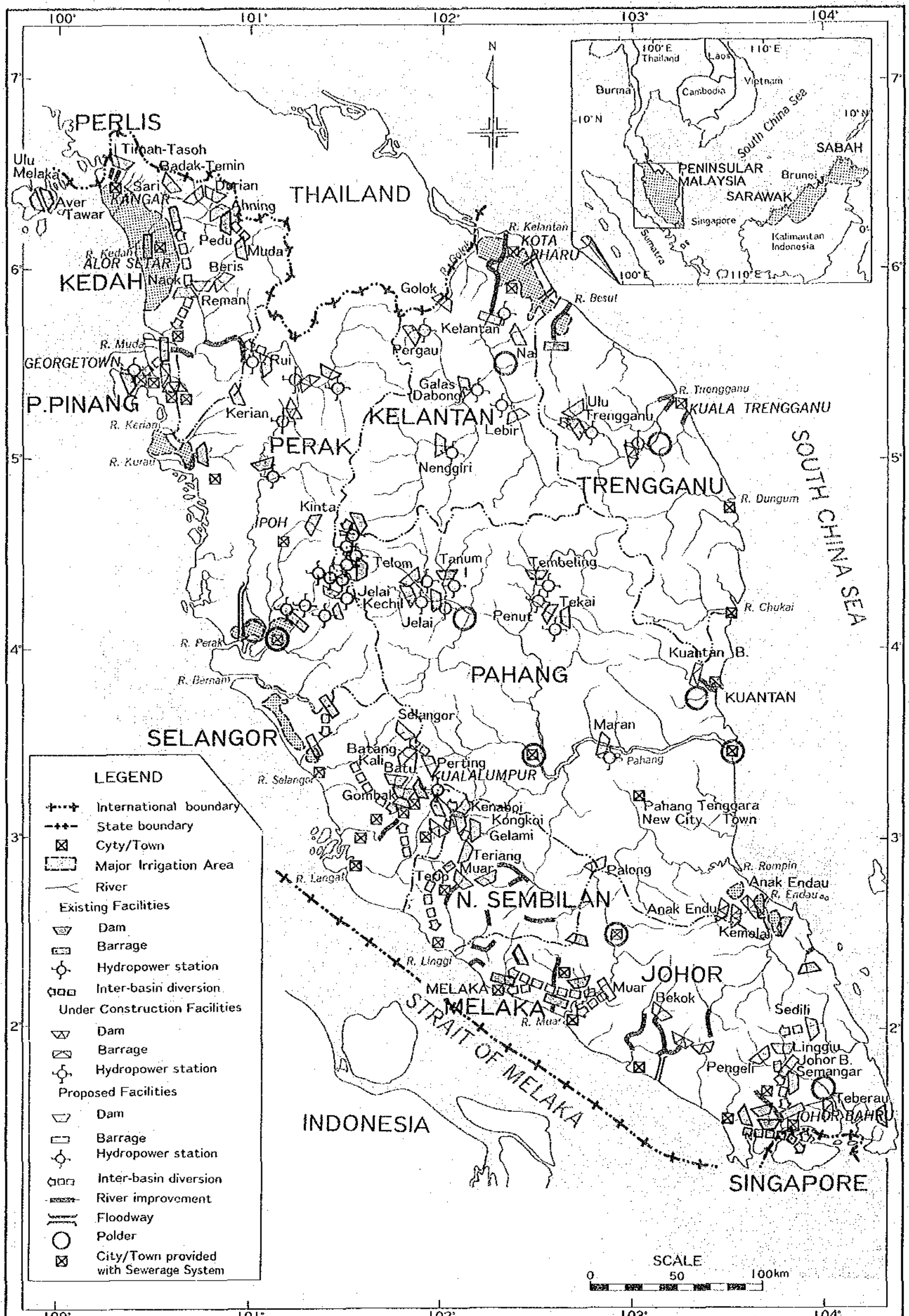

Recommended Plan
for Peninsular Malaysia

GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY MALAYSIA

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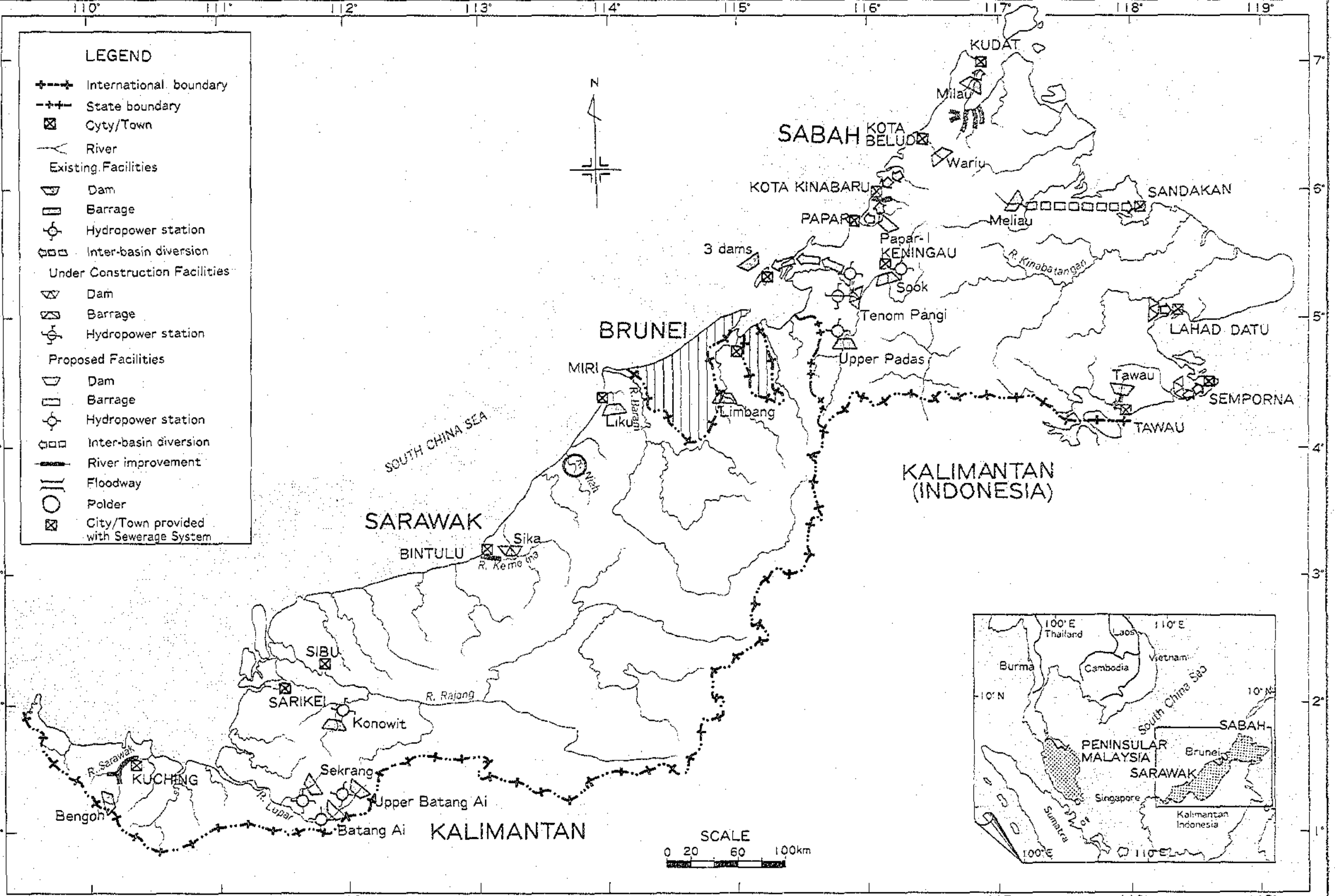

Recommended Plan
for Sabah and Sarawak

GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY MALAYSIA

JAPAN INTERNATIONAL COOPERATION AGENCY

SUMMARY

1. STUDY OBJECTIVE

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.

2. RATIONALE OF THE WATER RESOURCES DEVELOPMENT AND USE PLAN

The Master Action Plan in Volume 1 of the Final Report 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 studies.

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.

The Water Resources Development and Use Plan is 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, rather than dealing with specific projects. Individual projects indicated are, therefore, only notional and no intention has been made to define any of their details.

The Water Resources Development and Use Plan indicates that it is the time to expedite greatly the development of water resources, which are the most important natural resources for production and people's life, if Malaysia should continue the social and economic development as directed by the Malaysia Five Years Development Plans.

3. PRESENT AND FUTURE CONDITION OF WATER RESOURCES

Annual rainfall over the land of Malaysia is 990 billion m^3. Out of this, 360 billion m^3 returns to atmosphere as a result of evaporation and transpiration. The rest forms surface runoff of 566 billion m^3 and groundwater recharge of 64 billion m^3.

Water is used for domestic and industrial water supply, irrigation, hydropower generation, navigation, fisheries and mining. Public water supply system serves 66% of total population. Self-sufficiency ratio of rice is 69%. Wet paddy field of 546,000 ha is subject to vagaries of climate, though 60% is irrigated. Installed capacity of hydropower is 614 MW, accounting for 29% of total power supply capacity. Man-made water pollution in rivers has begun to affect water uses and environmental quality adversely. Flood prone area amounts to 29,000 km^2.

High growth in population and economy will require an increased water for use. Domestic and industrial water demand of 1.3 billion m^3 in 1980 will grow to 4.8 billion m^3 by 2000. Irrigation water demand of 7.4 billion m^3 in 1980 will increase to 10.4 billion m^3 by 2000.

Although surface runoff seems to be abundant for use, water deficit takes place in regions of major water demand. This is due to wide variation in rainfall in time and space. Runoff reduces very low in dry season while it is mostly flood running to waste in wet season. It is estimated that only 10% of annual runoff in the river is available for use, unless regulated by storage dams.

4. STRATEGIES FOR WATER RESOURCES DEVELOPMENT AND USE

Based on the socio-economic objective and characteristics of water resources, the strategies for water resources development and use are set as follows:

(1) The river maintenance flow, which is the minimum river discharge required for ordinary water uses and environmental quality, should be sustained in major rivers.

(2) Public water supply system should be developed to supply domestic water to all people by 2000 and 50% of industrial water except for areas where water source is inaccessible. Irrigation development should be undertaken from the viewpoint of food self-sufficiency and increase in farmers' income.

(3) Water source should be developed to balance water demand and supply in water stress areas.

(4) Hydropower should be developed to contribute to energy self-reliance.

(5) Water pollution in rivers should be abated setting the standard concentration of biochemical oxygen demand at 5 mg/lit.

(6) Flood mitigation work should be provided to protect 50% of people in flood prone area.

5. PLAN FORMULATION

The Water Resources Development and Use Plan is recommended based on comparison of alternative plans from the viewpoint of national economic development, regional development, environmental quality and social well-being. The proposed alternative plans could be taken into account in the future in modifying the recommended plan if so required. The essential components of the recommended plan are:

(1) Development of public water supply system and irrigation system to provide water users with access to water;

(2) Development of water source including dam construction and inter-basin diversion of water to balance water demand and supply;

(3) Development of hydropower to contribute towards meeting nation's energy demand;

(4) Implementation of water pollution abatement measures including improvement of purification method of effluent from rubber factories and palm oil mills, and sewerage development; and

(5) Construction of flood mitigation works.

As readily available water has been entirely committed to the existing use in the water stress areas, it is necessary to construct dams so that water in wet season can be retained for the use in dry season. In the regions where no more damsite is available, it is further necessary to divert water from another region.

6. PUBLIC WATER SUPPLY SYSTEM AND IRRIGATION SYSTEM DEVELOPMENT PLAN

Population served by public water supply system is 9.5 million or 66% of total population at present. The service factor is 91% in urban area and 50% in rural area.

In urban area, many waterworks are overloaded under the high population pressure. It is also a serious problem that water supply systems are poorly maintained due to financial difficulties. Rural water supply, being promoted based on the New Economic Policy has often encountered with a difficulty in the areas where clean water source is inaccessible.

Development should be expedited to keep up with rapidly growing water demand arising from high growth in population and industries. Treated public water supply capacity of 2.6 million m^3/d at present should be expanded to 5.6 million m^3/d by 1990 and 10.3 million m^3/d by 2000 and untreated public water supply system should be developed from 19 million m^3/y at present to 60 million m^3/y by 1990 and 100 million m^3/y by 2000. By this development the service factor will increase to 97% by 1990 and 100% by 2000 in urban area, and to 83% by 1990 and 96% by 2000 in rural area.

Irrigation area of 302,000 ha will be increased to 455,000 ha by 1990 and 545,000 ha by 2000. Annual rice production will increase from 1.2 million tons in 1980 to 1.8 million tons by 1990 and 2.2 million tons by 2000, accounting for a rice self-sufficiency ratio of 69% in 1980 and 85% in 1990 and 2000.

7. SOURCE DEVELOPMENT PLAN

Source development is recommended for balancing water demand and supply in water stress areas including four regions and 13 areas.

It is recommended to construct nine dams within Perlis/ Kedah/Pulau Pinang region, and a dam in the State of Perak to meet the regional water demand represented by the Muda irrigation project, a number of minor irrigation projects and large towns, where water is already insufficient even with the flow regulation by the existing Muda and Pedu dams.

The construction of four dams, in addition to the Semenyih dam which is under construction, in three rivers within the State of Selangor, two dams in the State of Negeri Sembilan and a dam in the State of Pahang is recommended for domestic and industrial water supply in Federal Territory and large towns in the Kelang valley region, where the capacity of existing two dams is already insufficient.

The recommended plan for the Melaka/Muar region includes the construction of two dams in the Muar river basin, one in the State of Negeri Sembilan and the other on the boundary of the States of Negeri Sembilan and Johor, a barrage on the Muar river in the State of Johor and a diversion canal to convey water from the Muar river to Melaka and its environs.

The construction of four dams and two barrages is recommended to develop water in the Teberau, Johor and Sedili Besar rivers for domestic and industrial water supply in Johor Bahru and Singapore. Other problem areas needing immediate source development are Port Dickson, Kota Kinabalu, Labuan and the drought prone area of Sarawak.

8. HYDROPOWER DEVELOPMENT PLAN

Energy production in Malaysia largely depends on thermal power. Nation's energy policy directs the development of hydropower to promote self-reliance in energy supply.

According to a projection, the maximum power demand in Peninsular Malaysia will be 9,140 MW in 2000, 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 economic hydropower of 1,026 MW in Peninsular Malaysia should be developed by 2000 for the maximum contribution in energy supply.

There is a large potential in Sabah and Sarawak. Two hydropower stations of 158 MW in total installed capacity are under construction. Large scale hydropower projects in the Rajang river are under feasibility study. These projects could meet energy demand of the whole Malaysia if implemented. As these projects still have some aspects to be clarified, however, it is assumed that they will be commissioned after 2000. In Sabah and Sarawak, power demand centers are isolated. Hydropower development should focus on meeting incremental power demand in Kota Kinabalu, where power demand will grow to 460 MW by 2000, and Kuching, in which power demand in 2000 will reach 295 MW. The recommended hydropower projects of 374 MW for Sabah includes the Tenom Pangi Phase III and the Papar multipurpose project, the latter is also important for water supply to Kota Kinabalu. The total installed capacity recommended for Sarawak is 204 MW.

9. WATER POLLUTION ABATEMENT PLAN

Water pollution in rivers has become a problem. Organic pollution is caused by domestic and industrial sewage, effluent from rubber factories, palm oil mills and animal husbandry, while major causes of suspended solid in the rivers are operation of mines, opening-up of residential areas, road construction, logging and forest clearing. It is estimated that most rivers in the west coast of Peninsular Malaysia and some other rivers will be heavily affected by organic pollution in the future.

The recommended measures for water pollution abatement are the improvement of purification system in rubber factories and palm oil mills and sewerage development in eleven towns in problem areas, which are mostly located in the west coast of Peninsular Malaysia.

If the recommended plan is implemented, the concentration of biochemical oxygen demand in polluted rivers will be reduced to a significant extent and below 5 mg/lit in river stretches of 794 km in total length.

It is emphasized that the water pollution abatement plan should be implemented from the viewpoint of improving environmental quality and social well-being, though it may be difficult to be justified if economic criteria only are sticked to.

In addition to the above-mentioned, it is recommended that 20 sewerage projects which are presently in various stages of investigation should be implemented from the viewpoint of public health, though they are not effective to attain the river water quality target.

10. FLOOD MITIGATION PLAN

Population in the total flood prone area of 29,000 km^2 was 2.7 million in 1980. Flood problem over Malaysia is especially serious in densely populated areas such as Kelang valley and flood plain of the Kelantan river. Flooding by rivers coupled with poor drainage has been a problem in agriculture in the west Johor region. The floods in the Pahang river inundate a vast area of land. Habitual flood prone areas tend to be left unused but damage is caused to towns, villages and annual crop lands, which are generally developed along rivers. Long average of flood damage is estimated to be M$100 million/y.

The recommended flood mitigation plan involves structural measures such as channel improvement of 850 km in river length, excavation of bypass floodways in total length of 82 km, construction of ring bunds for twelve towns/villages, construction of twelve dams, to protect 50% of people in the flood prone areas.

The recommended Bekok dam in west Johor and Limbang and Bengoh dams in Sarawak are proposed for flood mitigation as major purpose, and the remaining nine dams are those recommended for either source development or hydropower generation as major purpose.

Far less than 50% of affected people can be protected by structural measures in the State of Pahang because floods are large. The resettlement of people seriously affected by flood should be considered, in relation to the new town development in the Pahang Tenggara region.

11. EXPENDITURE AND MANPOWER REQUIREMENT

A large amount of investment and manpower will be required to implement water resources development to the extent that the socio-economic development can successfully be conducted along with the policy directed in the Malaysia Five Years Development Plans. To show the order of magnitude, costs and manpower requirement up to 2000 for the implementation of the Water Resources Development and Use are estimated.

The public development expenditure will be of the order of M$6 billion in the Fourth Malaysia Plan, M$16 billion in the Fifth Malaysia Plan, M$13 billion in the Sixth Malaysia Plan and M$6 billion in the Seventh Malaysia Plan. The above-mentioned amount for the Fourth Malaysia Plan represents an additional requirement to the present budget in case of public water supply. The total of M$41 billion up to 2000 gives an order of magnitude equal to the total development expenditure of the Fourth Malaysia Plan. The development cost to be privately financed up to 2000 is estimated to be of the order of M$15 billion. The public recurrent expenditure up to 2000 will be about M$8 billion.

Manpower requirement will be of the order of 2,000 persons in the Fourth Malaysia Plan, 20,700 persons in the Fifth Malaysia Plan, 26,000 persons in the Sixth Malaysia Plan and 29,300 persons in the Seventh Malaysia Plan. The requirement in the Fifth Malaysia Plan will comprise 800 engineers, 1,100 technical assistants, 2,800 technicians and other 16,000 persons.

12. PLAN UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

The Water Resources Development and Use Plan has been formulated based on an assumption that the growth rate of gross domestic product (GDP) is 7.7% from 1980 to 1985, 8.4% from 1985 to 1990 according to the Fourth Malaysia Plan and 7.5% between 1990 and 2000 projected by the Study.

For reference, a plan under a lower economic growth is prepared, assuming that Malaysia's economy might be affected by a long-lasting world-wide economic depression. The growth rate of GDP is assumed to be 7% between 1980 and 1985, 6% between 1985 and 1990 and 5% between 1990 and 2000. With this assumption, GDP in 2000 is estimated to be M$78 billion, or 69% of the original estimate of M$113 billion.

Domestic and industrial water demand estimated with the above-mentioned assumption is 89% for 1990 and 75% for 2000, compared with the original estimate. Overall service factor in 2000 is 96% or 3 points below the original estimate of 99%.

The required size of water resources development is accordingly reduced and the estimated public development expenditure up to 2000 of M$32 billion is 77% of the original estimate.

These estimates indicate that water resources development should be expedited, even if future economic growth is lower than the expected.

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

Volume

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

Weight

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

Time

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

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 in 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 1sq.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 = 1,233.5 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.

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The Final Report submitted herein 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.

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2. BACKGROUND

2.1 Land

Malaysia of 330,000 km^2 consists of Peninsular Malaysia of 131,900 km^2, Sabah of 73,700 km^2 and Sarawak of 124,400 km^2. Peninsular Malaysia occupies the southern half of Malay Peninsula. Sabah and Sarawak are located in the north and northwest, respectively, of the Borneo Island.

Malaysia belongs to the circumpacific folded mountain belts with principal mountain trend of north-south in Peninsular Malaysia and northeast-southwest in Sabah and Sarawak. Coastal areas are featured by low hills, rolling plains and swamps. The mountainous feature in the north of Peninsular Malaysia is formed by the Main Range and East Range with the highest peak of Mt. Tahan (El. 2,188 m), in contrast to the flat topography of the Pahang and Muar river basins in the south. Topography of Sabah is mostly highland of more than El. 500 m with the Crocker range along the west coast, culminated in Mt. Kinabalu of El. 4,100 m, the highest peak in Malaysia. The Kinabatangan river cuts the interior highland and runs to the northeast coast. The borderline between the State of Sarawak and Indonesian Kalimantan approximately conforms to the watershed of the Kapuas Hulu, Iran and other mountains which are the continuation of the Crocker range. Interior area of Sarawak is formed of ranges and plateaus in Els. 500 and 2,000 m. The Rajang river draining the central mountainous area develops a vast flood plain in the southern part of the coastline.

Peninsular Malaysia and Borneo Island are situated on a tectonically stable cratonic block which is composed of meta-sedimentary rocks of Palaeozoic and Mesozoic systems.

Extensive Tertiary sedimentary system of Northwest Borneo Geosyncline is developed along the northwest coastal region of Borneo, occupying large part of Sabah and Sarawak, while Peninsular Malaysia is for the most part composed of Silurian to Lower Jurassic meta-sedimentary rocks and intrusive granites with only scattered patches of Tertiaries.

Alluvial soils occur in coastal plains, riverine flood plains, low riverine terraces, and intermediate and high terraces and sedentary soils cover mountains to undulating plains. The proportion of alluvial soil is 27% in Peninsular Malaysia, 18% in Sabah and 21% in Sarawak. Alluvial soils on coastal plains of Sarawak are dominated by peat and subject to poor drainage or periodic flooding by brackish water.

Natural vegetation covers an area of 226,300 km^2, or 69% of the total land area, comprising high forest of 184,600 km^2, scrub, mangrove and transitional beach and swamp forest of 37,800 km^2 and grassland of 3,900 km^2. Forests are mostly dominated by the families of dipterocarpaceae and leguminosae. Other typical species are mountain oak growing in highlands, mangrove in lowlands on the coasts and peaty bog stands.

2.2 Climate

The climate in Malaysia is tropical, characterized by the maritime monsoon winds with obvious interference by mountains in Borneo Island, Malay Peninsula and Smatra Island.

The northeast monsoon prevailing between November and January brings heavy rainfall over Malaysia especially the east coast of Peninsular Malaysia, north Sabah and south Sarawak, but less rainfall in the west coast of Peninsular Malaysia. This period is wettest and coolest. Subsequent inter-monsoon period of 2 to 3 months is driest with increasing air temperature. The southwest monsoon prevails in April and May in Peninsular Malaysia and between May and July in

Sabah and Sarawak, but with less rainfall than the northeast monsoon. Air temperature is highest at the beginning of this period. Heavy rainfall often occurs in the northern part of the west coast of Peninsular Malaysia and east coast of Sabah during the inter-monsoon period between June and October in Peninsular Malaysia and August to October in Sabah and Sarawak.

Monthly mean air temperature little varies through the year ranging between 25° and 28°C in the coastal lowland and monthly mean relative humidity is usually high of 75 to 90%.

Average annual rainfall is more than 2,000 mm except for a part of the Pahang and Muar river basins. It is more than 3,000 mm in the northern half of the east coast and Cameron Highlands of Peninsular Malaysia, the entire coast of Sabah and entire Sarawak. Annual rainfall exceeds even over 4,000 mm in the mountainous area of Sarawak. Average annual rainfall was estimated to be 2,420 mm for Peninsular Malaysia, 2,630 mm for Sabah and 3,830 mm for Sarawak.

2.3 Hydrology

There are a number of hydrological stations in Malaysia, but data are generally interrupted and with low accuracy. The Study estimated runoff record at 11 key stations in Peninsular Malaysia for the 19-year period from 1961 to 1979, at 12 key stations in Sabah and Sarawak for varying period of 10 to 17 years. The runoff record at a key station was transposed to a river basin which is regarded as belonging to the same hydrological region as the key station, based on the difference in long-average basin rainfall. Average annual runoff was thus estimated to be 1,110 mm, or 147 billion m^3 for Peninsular Malaysia, 1,530 mm, or 113 billion m^3 for Sabah and 2,460 mm, or 306 billion m^3 for Sarawak.

Annual variation in river flow is rather small, especially in the Selangor, Padas and Rajang rivers, but it is high in the Melaka and Perak rivers and coastal rivers in Sarawak.

Bank erosion is observed in many rivers but it is only local and to a minor extent except for the Perak river near Teluk Anson, some rivers in the west coast of Sabah and coastal stretch of rivers affected by tidal bore in Sarawak. Rivers meander in the tidal reaches. Estuaries are affected by drifting sand especially in the east coast of Peninsular Malaysia, west coast of Sabah and north Sarawak. Coastal stretches of rivers in Sarawak are deeply intruded by sea water due to slow gradient.

Data pertaining to sedimentation in rivers are few, but they indicate that specific annual sediment yield is low of 10 to 400 tons/km^2 in Peninsular Malaysia, 30 to 230 tons/km^2 in Sabah. No reliable data could be found for Sarawak. It seems that silting is reducing the discharge capacity of some rivers in Peninsular Malaysia.

Flood occurs in the northeast monsoon period in general, but also in the southwest monsoon period in the southern part and in September and October in the northern part of west coast of Peninsular Malaysia. Rivers inundate vast areas, when flood occurs.

Organic pollution in the rivers is caused by domestic and industrial sewage, effluent from palm oil mills and rubber factories and animal husbandries. Biochemical oxygen demand (BOD) concentration of more than 5 mg/lit was measured during 1978/1979 in the Kedah, Merbok, Jaru, Jawi, Kinta, Buloh, Kelang, Langat, Linggi, Johor, Endau and Pahang rivers in Peninsular Malaysia and the Samarahan river in Sarawak.

Operation of tin/copper mines, opening-up of residential areas, road construction, logging and forest clearing are major causes of high concentration of suspended solid (SS) in some rivers. It is estimated that the average SS concentration is 50 to 500 mg/lit in natural rivers in Malaysia. In the 1978/1979 observation in Peninsular Malaysia, SS concentration was more than 500 mg/lit in some stretches of the Perai, Kinta, Bernam, Selangor, Buloh, Kelang, Langat, Melaka, Kuantan and Keluang rivers. SS concentration of more than 500 mg/lit has been sometimes observed in the Segama, Kinabatangan and Labuk rivers in Sabah and the Lupar and Samarahan rivers in Sarawak.

Alluvial aquifer is found in Quarternary sediments of loose sand and gravels. Excellent to good aquifers are recognized in the flood plains of large rivers such as the Kelantan, Trengganu, Pahang, Perak and Rajang rivers. Alluvial aquifers are often intruded by sea water especially in the coastal plains of west coast and southern part of east coast of Peninsular Malaysia, and entire coast of Sabah and Sarawak. Perched water develops in natural levees and coastal dunes, suggestive small scale groundwater development possibility even in areas of poor groundwater potential. Rock aquifer occurs in cracks and fissures of limestones, sandstones, conglomerates, shales and their alternations in limited hilly or mountain areas in the States of Perlis, Perak, Selangor and Pahang in Peninsular Malaysia, in the vicinity of Sandakan, and coastal mountains between Kota Belud and northern watershed of the Rajang river in Sabah and Sarawak. Groundwater storage potential was estimated to be 63 billion m^3 for Peninsular Malaysia, 14 billion m^3 for Sabah and 22 billion m^3 for Sarawak. Groundwater recharge depends on rainfall, soils and geology. Assuming that recharge rate is 1 to 2.5 mm/d for alluvium and 0.1 to 0.4 mm/d for rocks, groundwater recharge was calculated to be

20 billion m^3/y for Peninsular Malaysia, 14 billion m^3/y for Sabah and 30 billion m^3/y for Sarawak.

The yield of a well is determined by the transmissivity of aquifer. Pumping may have to be interrupted if groundwater storage is small. Aquifer will be, sooner or later, depleted, if pumpage is usually larger than recharge. A well can be productive only if it hits an aquifer, of which areal distribution is complex. Based on these considerations, safe yield of groundwater was preliminarily estimated to be 5.7 billion m^3/y for Peninsular Malaysia, 2.2 billion m^3/y for Sabah and 3.9 billion m^3/y for Sarawak.

Rainfall reaching on the ground surface partly becomes surface runoff in streams or temporarily stored in lakes and swamps. The remainder infiltrates underground and forms soil moisture or recharges groundwater. Part of water returns to the air as evaporation from stream, lake, swamp and soil surface or as transpiration by vegetation which abstructs soil moisture. Surface runoff and groundwater finally discharges into the sea. In a long run, rainfall less evapotranspiration is equal to surface runoff and groundwater recharge. The hydrological balance by state was estimated as shown in Table 1.

2.4 Present Socio-economic Condition

Malaysia is a federation of 13 states; States of Perlis, Kedah, Pulau Pinang, Perak, Selangor, Negeri Sembilan, Melaka, Johor, Pahang, Trengganu and Kelantan in Peninsular Malaysia and the States of Sabah and Sarawak. Each state in Peninsular Malaysia is administratively divided into several districts, but the States of Sabah and Sarawak are each divided into several divisions, each of which is further subdivided into some districts. The Federal Capital is Kuala Lumpur having population of 998,000.

Population in Malaysia was 14.3 million, consisting of 11.9 million in Peninsular Malaysia, 1.1 million in Sabah and 1.3 million in Sarawak, in 1980 and its average annual growth rate was 2.84% between 1970 and 1980. Population density was 90 persons/km^2 in Peninsular Malaysia, 15 persons/km^2 in Sabah and 11 persons/km^2 in Sarawak.

Gross domestic product (GDP) at factor cost at 1970 constant price grew from M$12.6 billion in 1971 to M$25.4 billion in 1980 with an average annual growth rate of 8.1%. These values correspond to GDP per capita of M$1,140 in 1971 and M$1,780 in 1980 with an average growth rate of 5.1%. The share of the manufacturing sector in GDP rose from 14.7% to 21.2% while the share of the agriculture, forestry and fishing sector reduced from 30.5% to 22.8% between 1971 and 1980.

Major export commodities are rubber, tin, saw logs, palm oil, crude oil and manufactured goods. Total commodity export value was M$28.4 billion in 1980 at current price. Rubber and tin has been traditionally important export commodities. Their export, accounted for 53% of the total export in 1970, has largely gained export value owing to increasing international market price, but the share in the total export value was reduced to 26% in 1980. Instead, the share of crude petroleum and manufactured goods increased from 14% in 1970 to 46% in 1980. Major imported commodities are machinery and transport equipment, manufactured goods, food, beverages and tobacco. The total commodity import amounted to M$23.5 billion in 1980 at current price.

Labor force was 5.4 million and 5.3% was unemployed in 1980. Composition of employment was 41% in agriculture, forestry and fishing sector, 16% in manufacturing sector and 43% in the other sectors.

Land use is 226,300 km^2 for forest and grassland, 71,900 km^2 for agricultural land and 31,800 km^2 for the other land. The agricultural land comprises perennial crop land of 34,500 km^2 and mixed horticulture, annual crop and shifting cultivation areas and fishponds of 37,400 km^2.

Major export crops are rubber, oil palm, coconut and pepper. Production in 1980 was 1.6 million tons of rubber, 2.6 million tons of palm oil, 330,000 tons of copra and 36,000 tons of pepper.

3. PRESENT CONDITION OF WATER RESOURCES DEVELOPMENT AND USE

3.1 Domestic and Industrial Water Supply

Public water supply system in Malaysia is generally administered by the Public Works Department (PWD) of the state except that it is under the State Waterworks Department in Perak, Negeri Sembilan and Selangor and the Water Authority, a state statutory body, in Pulau Pinang and Melaka. The Kuching and Sibu Water Boards are statutory bodies of the State of Sarawak for the water supply in the two towns and their environs. Sabah Water Authority is going to be established under the Sabah Water Authority Enactment, April, 1982.

Treated water supply by public system in 1978 in Peninsular Malaysia was 598 million m^3/y, of which 429 million m^3/y was metered. The pipe-served population was 6.54 million in total, of which 3.92 million lived in urban area and 2.62 million was in rural area. The corresponding service factor was 88% in urban area and 40% in rural area. Per capita water consumption was 180 lit/d and per capita water supply was 250 lit/d. In 1980, treated water of 39 million m^3/y was delivered to 345,000 people in Sabah corresponding to 210 lit/d in per capita in water consumption. Service factor was 86% for urban area and 7% for rural area. In Sarawak, treated water of 38 million m^3 was delivered to 475,000 people corresponding to 194 lit/d in per capita water consumption. Service factor was 93% for urban area and 12% for rural area.

Untreated water supply system has been constructed in isolated rural areas either conveying water from small streams to individual houses or digging shallow wells equipped with hand pumps with materials and advices by MOH under the

Rural Environmental Sanitation Program. MOH suggests to boil water before drinking. At present, 1 million people are supplied by untreated system.

Population served by public water supply system in Malaysia in 1980 is estimated to be 5.0 million in urban area and 4.5 million in rural area, including 1.0 million served by untreated supply, corresponding to a service factor of 91% in urban area and 50% in rural area. In overall, the service factor is 66%. The supply capacity in Malaysia in 1980 is estimated to be 2.6 million m^3/d in treatment capacity and 19 million m^3/y of untreated supply in source demand.

Most water supply systems depend on water in rivers, but groundwater or spring is the substantial source for Kota Bahru, Sandakan, Labuan, Jerijeh and rural areas and rain storage reservoir is major source of water in Kudat in the State of Sabah.

In urban areas, many waterworks are overloaded under the high population pressure. It is also a serious problem that water supply systems are poorly maintained due to financial difficulties. Rural water supply, being promoted based on the New Economic Policy has often encountered with a difficulty in the areas where clean water source is inaccessible.

Peculiar to Sarawak, especially in the First, Second and Sixth Divisions is drought prone area, which is mainly located on the coastal plain. Rain tubs or small streams only are the means to collect drinking water in these areas, because rivers are deeply intruded by sea water. In 1981 when the drought was hardest during the last 10 years, the total population of 102,600 living in 227 villages was suffered from an extreme water shortage. PWD transported potable water to these areas by water tankers, barges, launches and trucks, and even by helicopter. The similar drought occurred in 1972 and 1979 as well. Not a few people were suffered from epidemics such as cholera and dysentery in these areas during the drought years. To cope with the situation, PWD Sarawak has been making efforts extensively to construct the public water supply system in the drought prone areas.

The Public Utility Board of Singapore takes raw water for domestic and industrial water supply from the Pontian Kechil, Sekudai, Pulai, Teberau and Johor rivers, based on Agreements made between the State of Johor and City Council of Singapore. There are the Pontian Kechil dam in the Pontian Kechil river, Gunong Pulai and Pulai III dams in the Pulai river for this purpose. The raw water is partly diverted to Johor Bahru. The water demand in 1980 is estimated to be 37 million m^3 for Johor Bahru and 198 million m^3 for Singapore. According to the above-mentioned agreement, Singapore may extract raw water of 414 million m^3/y from rivers in the State of Johor.

3.2 Irrigation

Among 428,000 ha of paddy fields in Peninsular Malaysia, 302,000 ha are irrigated and the rest are rainfed. The major irrigation schemes are the Muda, Krian, Sg. Manik, Tanjong Karang, Besut, Kemubu and North Kelantan Irrigation Projects. The area of the major schemes totals 180,000 ha. There are 772 small scale irrigation schemes consisting of 492 gravity irrigation, 96 pumping irrigation, 135 control drainage and 49 inundation schemes. Average size of small-scale schemes for whole Peninsular Malaysia is 387 ha.

Wet paddy field in Sabah totals 30,200 ha among which 20,800 ha are irrigated. DID Sabah maintains 25 irrigation schemes each having an irrigated area larger than 100 ha. The irrigated paddy field of 14,700 ha is concentrated in the west coast accounted for 70% of the whole irrigation area in the State. The notable irrigation schemes are the Tempasuk North, Tuaran, Penampang and Papar Irrigation Schemes. The irrigated paddy field in the interior area totals 3,400 ha and the largest scheme is the Binkor Irrigation Scheme with irrigated area of 1,200 ha. In the northeast of Sabah, 2,700 ha extend along the Labuk and Bengkoka rivers.

DID Sarawak maintains 28 irrigation schemes with a total area of 6,100 ha, comprising 17 control drainage schemes of 4,400 ha, 10 pumping irrigation schemes of 1,600 ha and a gravity irrigation scheme of 100 ha. The irrigated double cropped area is 1,600 ha. There remains rainfed wet paddy field of 64,800 ha in total. The notable schemes are the Tanjong Bijat Control Drainage Scheme and Paya Selanyan Irrigation Scheme, Stage II.

Rice demand in Malaysia is estimated to be 1.71 million tons, while the domestic rice production is 1.17 million tons, or 69% of the demand, under the normal climatic condition, but liable to reduce depending on unfavorable climate. Hill paddy of shifting cultivation estimated to be 7,000 ha in Peninsular Malaysia 12,000 ha in Sabah and 74,000 ha in Sarawak is of very low yield.

3.3 Hydropower

The responsible agency for hydropower is the National Electricity Board (NEB) for Peninsular Malaysia, Sabah Electricity Board (SEB) for Sabah and Sarawak Electricity Supply Corporation (SESCO) for Sarawak.

The generating capacity of NEB system in 1979 was 1,796 MW, of which 614 MW was hydropower plants. Major cities, towns and villages in the west coast and Kuantan in the east coast have been connected by NEB transmission lines. Major cities in the east and west coast will be linked by NEB power supply system if the on-going construction is completed. The Cameron Highlands scheme is a series of hydropower station, involving diversion of water from tributaries of the Kelantan and Pahang rivers to the Perak river basin. The Temengor dam (348 MW) was recently completed in the Perak river. The Kenyir dam (400 MW) in the Trengganu river is under construction for the power generation. When this dam is completed, water in the lower reaches of the Trengganu river will be substantially regulated. The Bersia (72 MW) and Kenering (120 MW) dams are being constructed downstream of the Temengor dam. With these dams completed by 1985, the total installed capacity of hydropower will reach 1,206 MW.

SEB power supply system of 144 MW in total installed capacity consists of isolated distribution system wholly depending on diesel power. Major power stations are located in Kota Kinabalu (63.3 MW), Sandakan (25.7 MW), Tawau (23.9 MW), Labuan (13.1 MW), Lahad Datu (3.8 MW) and Kudat (2.4 MW). The Tenom Pangi Hydropower Project, Phase I/II of 66 MW in the Padas river and a 132 kV transmission line connecting the Pangi power station, Beaufort, Kota Kinabalu and Inanam is going to be completed in 1984. In addition to this project, a gas turbine power plant (2 x 14 MW) in Kota Kinabalu and some diesel power stations are included in the expansion plan of SEB. These power stations will meet the power demand in major towns by 1990. Apart from SEB's plan, installation of a thermal power station is being planned by Sabah Energy Corporation (SEC), which was recently established in relation to the establishment of sponge iron plant and methanol and LPG plant in Labuan.

SESCO power supply system of 148 MW in total installed capacity also comprises entirely isolated systems depending on diesel and gas turbine power. Major power stations are located in Kuching (77.7 MW), Sibu (31.6 MW), Miri (14.5 MW), Bintulu (11.4 MW) and Sarikei (2.6 MW). Gas turbine units installed are 1 x 3.8 MW in Miri and 2 x 19 MW in Bintulu. The Batang Ai hydropower station of 92 MW including a 2-circuit 275 kV transmission line between the power station and Kuching is going to be completed in 1984. In addition to this project, SESCO includes the construction of some gas turbine plant and diesel power plant in its short-term expansion plan which can meet the power demand in major towns up to 1990, if the energy-intensive industries are not established. The Upper Rajang River Hydroelectric Development is being studied by SESCO for a long-term power balance not only in the State of Sarawak but in the whole Malaysia.

3.4 Inland Fishery

Freshwater fisheries are pond culture in constructed ponds and tin mine pools of 2,300 ha in total surface area and riverine fishing. Brackish water pond culture is also observed in Sabah and Sarawak.

3.5 Inland Navigation

River traffic in Peninsular Malaysia is found to a limited extent. Fishermen catch fish and prawns in the rivers using small sampans or outboard engine boats with less than 0.9 m draft. Passenger boats with drafts of 0.6 to 0.9 m ply between villages or across the rivers. Cargo boats navigate the rivers, carrying various goods mainly agricultural products and their inputs, sawn timber, palm oil and petroleum. The biggest cargo boats in operation are oil tankers of about 4,000 GWT with 7.5 m draft. A number of marine fishing boats have their bases in estuaries or upstream jetties. They go for fishing through river mouths and go upstream for unloading their fish at markets along the rivers. In 1979, 8,110 powered boats and 2,085 non-powered boats were registered at the Fisheries Department at jetties located along 55 major rivers. The largest boat was 795 tons in GWT with 2.6 m draft.

The Kinabatangan and Labuk rivers are main inland navigation routes in the east of Sabah. In the Kinabatangan river, there are about 200 tugboats for towing logs with 25 gross weight tons and 1 or 1.25 m of draft on an average. There are about 100 tugboats of similar size for towing logs in the Labuk river. Besides, considerable navigation has been observed in the Kalabakan, Segama, Sugut, Bengkoka, Klias and Padas rivers. The main usage of these rivers is for the movement of logs from the point adjoining the felling area to the ports of loading.

Inland navigation plays very important role in transportation networks of Sarawak, especially in the Lawas, Limbang, Baram, Miri, Kemena, Mudah, Igan, Paloh, Rajang, Saribas, Lupar, Sadong and Sarawak rivers. The river ports of Kuching along the Sarawak river and Tanjung Mani along the Rajang river have been the major ports in the State for import and export. In 1978, 39,000 tons of cargo were loaded and 0.40 million tons were unloaded at the Kuching port. Timber exports recorded in 1980 through the Tanjung Mani deep anchorage point was about 1.7 million tons as logs and sawn timber. At present, there are 161 jetties along 55 rivers serving for various purposes including loading and unloading of daily necessities, agricultural goods, fish, construction materials and others and daily communication of villagers.

3.6 Sewerage System

Major policy for sewerage development is to provide sewerage system to populated areas especially state capitals for the purpose of public health. The sewerage development in new town areas is conducted at the cost of developers.

Part of Kuala Lumpur including Petaling Jaya and Shah Alam, and Georgetown including Bandar Bayan Baru are served by sewerage systems. The served population is 150,000 in the Kuala Lumpur system, 220,000 in the Georgetown system and 5,000 in the Bandar Bayan Baru system. Even in these cities, the non-served people are a majority. Some of them have septic tank or Imhoff tank, but most people depend on night soil buckets, pit latrines and drains. There are continuation projects of sewerage development for Pulau Pinang, Butterworth/Bukit Mertajam, Ipoh, Kuala Lumpur and Shah Alam and new projects for other towns including master planning, feasibility study and implementation under 4MP.

The sewerage system is installed in seven towns in Sabah; Kota Kinabalu, Sandakan, Tawau, Lahad Datu, Semporna, Kudat and Labuan. Most sewage in these system is untreated and disposed to the sea. The installation of septic tank is compulsory by regulations in other unsewered urban areas, while domestic sewerage is directly discharged into nearby water course or onto land in rural area.

In Sarawak there is no sewerage system.

3.7 Water Treatment System in Factories and Mines

Effluent characteristics of manufacturing industries vary by the production process. DOE carried out an industrial effluent source survey in 1978 for 45 factories in Perai and Butterworth industrial estates and found that 26 factories had no purification system and no data was available for 9 factories. Only 10 factories had some purification facilities which are regarded to be pretreatment systems.

Rubber factories produce Conventional Grades Standard Malaysia Rubber (SMR) and Latex Concentrate. BOD concentration in untreated effluent is 1,500 mg/lit for the former and 2,340 mg/lit for the latter. There are 206 factories of more than 5 tons/d in processing capacity in Peninsular Malaysia, 3 factories in Sabah and 3 factories in Sarawak. According to a survey by DOE for Peninsular Malaysia in 1980, 110 factories treated effluent by biological ponding system, 28 factories had other types of purification system, 55 factories had no treatment facilities and no information was available for the remaining 13 factories. A factory near Kuching has a recycle-type treatment system.

Untreated effluent from palm oil mill has high BOD concentration of 22,000 mg/lit. Number of existing palm oil mills is 133 in Peninsular Malaysia, 10 in Sabah and 4 in Sarawak. Three mills in Sabah and 2 mills in Sarawak are being constructed. According to 1980 data in DOE, 63 mills apply biological treatment and oxidation pond system, 39 mills dispose the effluent on land and 2 mills use chemical treatment system. The use of palm oil mill effluent for fertilizer and animal feed is being investigated.

There are 889 tin mines in Peninsular Malaysia. They have been major source of man-made sedimentation. The Rule of the Mining Enactment sets the parameter limit of suspended solid in the mining effluent into the river to be 11,400 ppm, but actually the Inspector of Mines is guiding tin mines to limit it to 5,700 ppm. High sedimentation is generated due to overflow of water from tailing area and collapse of mining bund during heavy rainfall or flood.

Mamut copper mine in Sabah, operated since 1975, is now yielding copper concentrate of 10,000 tons a month. The effluent from the ore processing area and the overflow from the tailing dam are discharged into the nearby streams of the Langanan and Mirali rivers both of which are upper reaches of the Sugut river. The discharge amounts to about 10 m^3/min containing a significant amount of inorganic SS.

3.8 Watershed

Forest area in Peninsular Malaysia has been cleared mainly for agricultural purpose. Forest area including high forest, scrub forest and swamp reduced from 96,400 km^2, or

73% of total land area, in 1966 to 64,500 km², or 49%, in 1979. During the same period, agricultural land increased by 7,800 km² including oil palm farm of 6,700 km², coconut farm of 700 km² and cocoa farm of 1,400 km², and 2,300 km² was additionally cleared. Substantial area of forest must have been also districted or distributed due to logging, though quantitative data could not be analysed.

According to information obtained from Forest Department of Sabah, forest area in Sabah reduced from 63,600 km², or 86% of total land area, in 1971/72 to 39,300 km², or 53%, in 1980 as a result of logging mainly in undisturbed forest areas. A projection by the Forestry Department of Sabah indicates that 8,000 km² of forest will be exploited in 1981 to 2000. A reforestation program has been prepared by the Sabah Forestry Development Authority.

Forest area in Sarawak decreased from 100,300 km², or 81% of total land area, to 94,300 km², or 77%, mainly due to shifting cultivation and illegal felling in virgin forest areas. Shifting cultivation area of 28,500 km² accounts for 23% of total land area. Soil erosion is increasing problem in some districts especially in the Second and Sixth Divisions, because sufficient period for bush/fallow cannot be maintained due to increased population depending on the shifting cultivation. The State Government intends to develop irrigated paddy in order to resettle shifting cultivation farmers.

3.9 Flood

The flooded area by the recorded maximum flood is estimated to be 15,300 km² for Peninsular Malaysia, 2,700 km² for Sabah and 11,000 km² for Sarawak. Population in 1980 in the above-mentioned areas was 2.5 million in Peninsular Malaysia, 82,000 in Sabah and 134,000 in Sarawak. Habitual flood prone areas tend to be left unused, but damage takes place in towns, villages and annual croplands, which are generally developed along river. Long average of flood damage is estimated to be M$100 million/y.

Most river facilities including flood mitigation facilities have been constructed rather on ad hoc basis, mainly in relation with irrigation and drainage. Telemetric flood forecasting systems are installed in the Perak, Pahang, Trengganu and Kelantan river basins, and a flood warning siren system was established at Siniawan on the bank of the Sarawak river in 1976.

4. FUTURE WATER DEMAND AND ASSOCIATED PROBLEMS

4.1 Projected Socio-economic Condition

Socio-economic figures necessary for the projection of water demand and other parameters were estimated up to 2000, in conformity with 4MP including the Outline Perspective Plan (OPP).

The city/town is herein defined to be a town area of which the population size is estimated to be not less than 10,000 for 2000. The cities/towns are numbered for the purpose of the Study as shown in Table 2. The cities/towns in aggregate is called the urban area and the remaining area is named the rural area.

Population by state is shown in 4MP up to 1990, and that of Peninsular Malaysia, Sabah and Sarawak for 2000 has been estimated by EPU. The Study estimated population by state of the whole Malaysia for 2000 by means of ratio method. Projected population by state for 1980, 1985, 1990 and 2000 is as shown in Table 3. Population of Malaysia is estimated to be 14.3 million for 1980, 16.2 million for 1985, 18.1 million for 1990 and 22.1 million for 2000. Average annual growth rate of population will be 2.6% for 1980 - 1985, 2.3% for 1985 - 1990 and 2.0% for 1990 - 2000.

The population of each city/town was extrapolated to the future based on the trend between 1970 and 1980 censuses and then adjusted to the urbanization ratio (Total Cities/ Towns Population/Total Population) in whole Malaysia, which was assumed to be linearly related to gross domestic product (GDP) per capita. The same method was applied in estimating rural population by district. The urbanization ratio in Malaysia was estimated to be 37.7% for 1980, 41.1% for 1985, 45.4% for 1990 and 57.2% for 2000.

Gross domestic product (GDP) by state by sector at factor cost at 1970 constant price presented in 4MP indicates that average annual growth rate of GDP will be 7.7% for 1980 - 1985, 8.4% for 1985 - 1990. Gross regional product (GRP) of each state was extrapolated to 2000, assuming a functional relationship between GDP per capita of Malaysia and GRP of the state, but adjusted to GDP in 2000, which was estimated assuming an average annual growth rate for 1990 - 2000 to be 7.5% similar to those in rapidly growing countries such as Singapore and Korea in recent years. Projected GDP by state at factor cost at 1970 constant price is as shown in Table 4. The value of GDP is estimated to be M$25.4 billion for 1980, M$36.7 billion for 1985, M$54.9 billion for 1990 and M$113.1 billion for 2000.

The share of manufacturing sector in GRP in each state was derived from GDP by state by sector of 4MP up to 1990, and it was extrapolated to 2000 assuming a functional relationship with GRP per capita of the state. The share of manufacturing sector in GDP thus obtained was 21.2% for 1980, 24.6% for 1985, 27.6% for 1990 and 32.2% for 2000. Value added by manufacturing sector by state was then calculated as the product of GRP and share of manufacturing sector in GRP.

Value added by manufacturing sector by state was divided into those of 11 commodity groups. For the convenience of applying historical trend, value added by large scale industries such as iron-steel complex in Kemaman, sponge iron and methanol plants in Labuan and LNG industry in Bintulu was initially deducted from the projected value added by manufacturing sector by state, assuming that these industries would attain the planned production by 1990. Value added by these large scale industries was later on added to relevant element of value added by state by commodity group which was estimated excluding the large scale industries. Value added by manufacturing sector by state by commodity group in Peninsular Malaysia for 1974 was obtained from the Survey of Manufacturing Industries, Peninsular Malaysia, Vol. I, 1974, DOS. It was extrapolated to the projected years by means of the Frater Method using value added by manufacturing sector by state previously obtained for the projected years and based on the composition of value added by manufacturing sector by commodity group for 1980 and 1985 shown in 4MP. For Sabah and Sarawak, the composition of value added by manufacturing sector by commodity group excluding the large scale industries for the projected years was assumed to be the same as that derived for 1979 from the number of establishment in the Survey of Manufacturing Industries, Sabah, 1974, DOS and Directory of Approved Companies in Production (as at 30th June, 1979), MIDA, and that shown for 1978 in the Survey of Manufacturing Industries, Sarawak, 1978, DOS, respectively.

Value added by manufacturing sector by state by commodity group obtained for Peninsular Malaysia by the above-mentioned procedure was further adjusted based on the availability of water resources, because it showed such a high concentration of water intensive industries in Pulau Pinang, Kelang valley, Port Dickson and Johor Bahru that all water demand in these areas could not be met even if any technical measure is provided. It was assumed that water intensive industries such as paper and chemical industries in the above-mentioned areas would be kept at the projected 1985 production level by institutional measures. In the previously projected matrix of value added by manufacturing sector by state by commodity group for 1990 and 2000, the values for the paper and chemical industries for the States of Pulau Pinang, Selangor, Negeri Sembilan and Johor were replaced with those estimated for 1985, and then the other elements were adjusted so that the total value remained for each state and for each commodity group as was estimated previously.

The projected value added by manufacturing sector by state by commodity group was converted into gross value of manufacturing output by being divided by VA ratio which is an average ratio of value added to gross value of output in a commodity group. VA ratio applied in each commodity group was derived from data shown in the Surveys of Manufacturing Industries, 1974, DOS for Peninsular Malaysia, Sabah and Sarawak. In view that weighted average of VA ratio for the whole manufacturing sector remained at about 30% with no significant trend between 1969 and 1973, the projected gross values were adjusted assuming that this ratio would be maintained through the projection years. The projected gross value of manufacturing output at 1970 constant price is as shown in Table 5 by state and Table 6 by commodity group. It is M$17.9 billion for 1980, M$30.1 billion for 1985, M$50.2 billion for 1990 and M$114.3 billion for 2000. Average annual growth rate will be 11% for 1980 - 1985, 10.7% for 1985 - 1990 and 8.6% for 1990 - 2000.

4.2 Domestic and Industrial Water Demand

Domestic water demand up to 2000 was estimated based on the projected population of each city/town and the rural areas in each district. Per capita daily use for 1980, 1990 and 2000 was assumed by population size for urban area and by treated and untreated supply for rural area and to be 40 lit for non-served area as shown in Table 7. For each town in Sabah and Sarawak, per capita daily use was adjusted to actual ones which ranged between 67 lit and 197 lit in 1980. Service factor for urban areas was assumed that it increases from the present level to 100% by 2000. Served population of rural area in each state in Peninsular Malaysia was assumed to follow the sum of the target values by PWD and MOH up to 1985 and to increase further to all rural population by 2000. The proportion of rural population served by treated and untreated supply in Peninsular Malaysia was obtained by a ratio method. The service factor in rural area in Sabah and Sarawak was assumed to increase from the present level to 90% by 2000. The present proportion of rural population served by treated and untreated supply was assumed unchanged.

Industrial water demand in the future was estimated based on gross value of manufacturing output by state by commodity group. Net unit manufacturing water use per gross value of manufacturing output by commodity group was assumed as shown in Table 8. The values in the table are those in Japan in 1970 for 1975 and 1975 for 1990 and 2000 and they imply declining trend owing to water saving measures including recyclic water use. The estimated industrial water demand in each state was divided into cities/towns and rural areas by district, based on the gross value of manufacturing output by city/town in 1974 for Peninsular Malaysia and that by Division/Residency in 1974 and projected population by town for Sabah and Sarawak. Water demand by rubber factories and palm oil mills was separately estimated assuming a certain production increase based on the historical trend and added to the estimated industrial water demand. It was assumed that 50% of industrial water demand would be publicly supplied and the rest would depend on private system.

Source water demand was estimated assuming an unaccounted-for water demand would be 20% and treatment plant water use would be 5%.

Raw water to be supplied to Singapore was projected based on historical trend to be 198 million m^3/y in 1980, 250 million m^3/y in 1985, 316 million m^3/y in 1990 and 414 million m^3/y.

Mining water demand was not taken into account, because its hydrological effect would be limited locally.

The estimated domestic and industrial water demand is as summarized by purpose by type of supply in Table 9 and by state in Table 10. The total water demand is estimated to be 1.3 billion m^3 for 1980, 1.9 billion m^3 for 1985, 2.6 billion m^3 for 1990 and 4.8 billion m^3 for 2000. If water demand in 2000 is compared with that in 1980, the total water demand will be 3.7 times indicating an increased burden on water resources. The increase in total water demand will be especially high in the States of Perak, Selangor and Pahang. Domestic and industrial water demand depending on the public system will be 3.5 billion m^3 in 2000, accounting for 3.9 times the demand of 0.9 billion m^3 in 1980. This increase will require an incremental capacity of 7 million m^3/d (1,500 mgd) in public system by 2000.

4.3 Irrigation Water Demand

The irrigation land development was projected based on information obtained from DID and the assumed ratio of self-sufficiency in domestic rice production. As summarized in Tables 11 and 12, irrigated paddy will increase from 329,000 ha in 1980 to 393,000 ha in 1985, 455,000 ha in 1990 and 545,000 ha in 2000, while the total wet paddy area will little increase and dry and hill paddy area will be substantially reduced.

The irrigation water demand was calculated for the projected years as summarized by state in Table 13. Irrigation efficiency assumed was 65% for the Muda and Krian irrigation projects and 55% for other areas, taking into account the reduction in water losses by the on-going tertiary development. The estimated irrigation water demand is 7.4 billion m^3 for 1980, 8.2 billion m^3 for 1985, 9.0 billion m^3 for 1990 and 10.4 billion m^3 for 2000. Irrigation water demand will be more than doubled by 2000 in the States of Perlis, Johor, Pahang and Sarawak, but it will little increase or reduce in the States of Pulau Pinang, Negeri Sembilan and Melaka.

Fishpond water requirement is not taken into account, because it is quite minor compared with other water demand.

4.4 Basin Division

The total land area was divided into 41 Basins for Peninsular Malaysia, 26 Basins for Sabah and 21 Basins for Sarawak for the purpose of the Study. A basin is either a single river basin or a group of a few river basins. Each basin is further divided into effective area and ineffective area. The former is the upper part of the Basin in which part of water used was assumed to return into lower stretches of 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 from the estuary and assumed river maintenance flow (see Section 5.1) are as shown in Tables 14 and 15.

4.5 River Utilization Ratio and Water Deficit

Relative burden of water use on a river is indicated by the river utilization ratio, which is the ratio of water demand to natural runoff. 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 not less than 10% is, therefore, herein called the water stress area.

The river utilization ratio was calculated for each basin in Peninsular Malaysia for 1990 and 2000 as shown in Table 16. Most rivers in the west coast showed high river utilization ratio, indicating a need for augmentation of river flow. The same ratio was calculated for the Basins in Sabah and Sarawak but it was very low except for a few Basins. Hence, Sub-basins were defined by further subdividing the Basins, and Sub-basins of high river utilization ratio were identified for Sabah and Sarawak as listed in Table 17.

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 by DID. The recorded period ranged between 10 and 19 years.

Groundwater potential is still to be clarified, but groundwater development will be essential especially for the villages with difficult access to clean surface water. Groundwater use is assumed for rural domestic water supply 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 to range between 5% and 90% of demand varying depending on the purpose of water use.

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 to be the water demand deducted by the return flow and groundwater use.

Certain discharge is necessary to sustain normal water use and environmental condition in the river. It is herein called the river maintenance flow as will be explained in more detail in Section 5.1. The rate of river maintenance flow was assumed as shown in Tables 14 and 15.

All water demand can be met and all 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 as the water withdrawal plus river maintenance flow less the natural runoff 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 in the largest annual volume of water deficit is herein regarded as the driest condition and called 1/N drought, that resulting in the second largest annual volume of water deficit is called 2/N drought, and so on. The estimated water deficit by Basin/Sub-basin in which river utilization ratio is not less than 10%, under certain droughts is as shown in Table 18.

The water deficit as shown in Table 18 was calculated under without-dam condition. If the estimated supply capacity of the existing and under construction dams 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.

4.6 Water Quality

To estimate BOD concentration in the river, BOD load flowing into a river was calculated based on the water use by pollution source. Major pollution sources assumed were the domestic and industrial water users in urban and rural areas, and palm oil mills, rubber factories and animal husbandry in rural area. However, wastewater from the coastal cities/towns was assumed to be directly discharged to sea, not affecting river water quality.

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 river flow at just downstream of each effluent outlet 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 river flow.

Discharge ratio, runoff 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 volume after consumption to that before consumption is called the discharge ratio. Some amount of water is again lost by evaporation and seepage after water is released by the consumer. The ratio of water reaching the river to that discharged by the consumer is called the runoff ratio.

The projected BOD concentration in rivers in Peninsular Malaysia for 2000 is illustrated in Fig. 12. Rivers in the west coast, especially the southern half, will be largely polluted. On the other hand, most rivers in the east coast will be clean. The calculation for Sabah and Sarawak showed that BOD concentration would exceed 5 ppm in 2000 only in some stretches of the Merutai Besar, Silibukan and Bongan rivers in Sabah and the Suai river in Sarawak.

4.7 Watershed Problems

Annual rate of soil erosion ranges from about 30 tons/km^2 in natural forest to over 6,000 tons/km^2 in cleared land and 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 400 tons/km^2 for Peninsular Malaysia, 500 tons/km^2 for Sabah and 1,500 tons/km^2. In Peninsular Malaysia, erosion rate is generally high in the west coast, where soils are erodable and natural forest has been converted to other land to a large extent. Annual erosion rate estimated for Kedah, Pulau Pinang, Selangor and Johor is 480 - 950 tons/km^2. On the other hand, estimated erosion rate in the east coast is low ranging between 240 - 280 tons/km^2. Relatively high erosion rate in Sabah is attributable to wide area of disturbed and cleared forest occupying 13% of land. High erosion rate in Sarawak is mainly due to shifting cultivation, wherein disturbed and cleared forest including shifting cultivation land accounts for 24% of land.

Reforestation in the disturbed forest can reduce erosion in a long run. It is estimated that reforestation for all the disturbed forest in Sabah and Sarawak can reduce erosion rate to 60 - 80 tons/km^2. In Peninsular Malaysia especially in the west coast, substantial reduction in erosion is not expected from reforestation in the disturbed forest, because agricultural land occupying a large area is the major contributor to erosion.

If all natural forest on slope of less than 6° is disturbed, erosion rate will increase to 1,000 - 3,000 tons/km^2, except where natural forest has already converted to other land to a large extent. An exercise indicates that erosion rate is in the order of 400 - 900 tons/km^2 except that it is 1,600 tons/km^2 in Sarawak, if all natural forest on slope of less than 2° is cleared but it is 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° 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 accordingly 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

Surface runoff has been predominantly utilized among water resources in Malaysia. As described in Section 4.5, however, only a small portion of runoff can be practically utilized for consumptive purpose such as water supply and irrigation, because natural runoff largely varies from time to time. Actually, readily available water has been already committed for use in the regions of major water demand. It is necessary not only to develop water supply system and irrigation system to provide access to the consumptive water users but also to augment available runoff by constructing storage dams, and if no more storage site is available, it is further necessary to transfer water from another river. These source development undertakings have been done in the past but with inadequate rate resulting in the fact that water shortage is increasingly taking place in the regions of major water demand.

The water demand will grow to a large extent in pace with rapid socio-economic development as described in Chapter 5. It is the time to expedite water resources development to a great deal to keep up with the growing water demand if Malaysia should continue the social and economic development as directed by the Malaysia Five Years Development Plans.

Hydropower should be developed to support energy supply as it is renewable energy originating from water resources. Water resources are liable to deterioration by man-made pollution. Pollution abatement should be undertaken to sustain normal water uses and to conserve environmental quality. Water resouces have such an adverse effect as flooding on land. Flood mitigation should be carried out to protect people's life and to reduce flood damages.

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, not causing any hazard 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 recognized, but, if small reductions accumulate, hazard becomes significant and irretrievable.

It is proposed to establish the concept of the 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, to be considered in allocating and developing water resources. Increased water withdrawal should not be allowed, 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 for allowing expected increase in water withdrawal, while sustaining the river maintenance flow. An estuary barrage will be constructed, if it is feasible for the reduction of the required rate of river maintenance flow by preventing sea water intrusion and maintaining water level for the intakes located in the estuary area.

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

The river maintenance flow should be determined 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 generally 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 5, and that of essential river maintenance flow is equal to the daily natural discharge of 99% in probability of exceedence, referring to examples in some 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 to the consuming ends.

Domestic and industrial water supply is conducted with the objectives of national economic development, regional development and social well-being. 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 supplied by public system, because of remoteness and non-availability of suitable water source.

Irrigation development on paddy, including the tertiary development, is carried out 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 as shown in Tables 11 and 12.

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 and consumers would take appropriate measures for water saving such as recyclic use of water, 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. An analysis showed that the all water demand could be met for more than 85% of time in the rivers of less than 10% in river utilization ratio, if a temporary reduction in the river maintenance flow to the level of essential river maintenance flow 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 is more than 10%.

5.5 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 potential in Sabah and Sarawak, in addition to that in the Rajang river. The maximum power demand in 2000 has been projected to be on the order of 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 development should also be capable of supplying 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.

5.6 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 to be 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 river 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. 11. 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.

5.7 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 is the increase in 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 release 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 is to 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 the river stretches where structural measures are not applicable or 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.

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 alternative studies for water demand and supply balance plan for varying risk 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 by the reasons mentioned in Section 6.3.

The criteria for alternative setting and 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 consumptive water use can be sustained if river flow is more than the river maintenance flow. 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 of the water stress Basin/Sub-basin of which river utilization ratio in the projected year would be not less than 10% and the existing source facilities would not be capable of meeting the estimated water deficit.

Natural flow varies not only seasonally but from year to year to a large extent. Any measure 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 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.

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 at any time can be retained, so far as the storage capacity is available. It is the requirement for the 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 replenish all the water deficit. By doing so, the dam can develop water to meet the future water demand not adversely affecting on the existing water users.

The proposed dams were those 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 assumed storage capacity. The total water supply capacity of the proposed dams in a basin was made to meet the total water deficit in the Basin, allowing an operational surplus requirement which was assumed to be 10 to 20% of the water deficit.

If the total water supply capacity of all the proposed dam 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.

Outline of proposed source facilities for each alternative is summarized in Tables 21 to 28.

The public development expenditure by the Malaysia Five Years Development Plan period was estimated for each alternative at 1980 constant price as shown in Table 29. All the alternatives showed a high concentration of public development expenditure in 5MP. The total public development expenditure was estimated to be M$29 billion for Alternative B1, M$26 billion for Alternative B2 and M$23 billion for

Alternative B3, showing a large difference depending on the risk in supply in setting alternatives, though manpower requirement as shown in Table 30 showed little difference among alternatives. These results are suggestive that a higher guarantee of supply is more costly.

The results of economic analysis of the alternatives were as shown in Table 31. The economic benefit showed little difference among the alternatives, indicating that the economic loss due to temporary failure in irrigation and water supply would be relatively small to the total benefit so far as the risk remains within the assumed range. On the other hand, the economic cost was higher in Alternative B1 than in Alternative B2, and so on, reflecting the difference in the investment cost for the source development. As a result, the estimated value of internal rate of return (IRR) was lowest for Alternative B1 and highest for Alternative B3.

The safe supply period is herein defined as the period when the total water demand can be met not reducing the river flow below the assumed essential river maintenance flow under the driest condition (1/N drought), and the safe river maintenance flow period is the period when the assumed river maintenance flow can be sustained with the total water demand fully met under the driest condition. Approximate length of these periods were calculated as shown in Table 32. If Alternative B1 is selected, all water demand can be met and the river maintenance flow can be sustained all the time if the hydrological condition in the recorded period repeats. For Alternative B2, the safe river maintenance flow period is 238 to 365 days and the safe supply period is 268 to 365 days. In case of Alternative B3, the safe river maintenance flow period is 218 to 330 days and the safe supply period is 248 to 365 days. These figures show a large improvement compared with the safe river, maintenance flow period of 72 to 307 days and the safe supply period of 87 to 332 days under the without source facilities condition.

Construction of dams and other source facilities involves adverse effects such as change in fish fauna in some length of downstream river stretch and removal of people. These effects are indicated for each alternative as shown in Table 33. On the other hand created reservoir may be utilized for fish culture and recreation.

The above-mentioned considerations lead to the criteria that the risk in supply should be allowed as much as possible in view of saving cost and adverse effects, but it should be limited from the viewpoint of social well-being and environmental quality.

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 no matter how severe the drought is.

Irrigation facilities in Malaysia have been designed against a drought of 5 years in return period. This corresponds to the criteria in Korea, Indonesia and other countries in the southeast Asia. Grading-up of this standard will immediately require a large investment for source development, because irrigation demand is already high. It is recommended that Alternative B3, which approximately comply with the present standard for irrigation, should be selected for the Basins where irrigation water demand is predominant for the time being, stressing to provide irrigation facilities to more farmers.