GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

STATE REPORT

VOL. 9

SABAH

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GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

STATE REPORT

VOL. 9

SABAH

OCTOBER 1982

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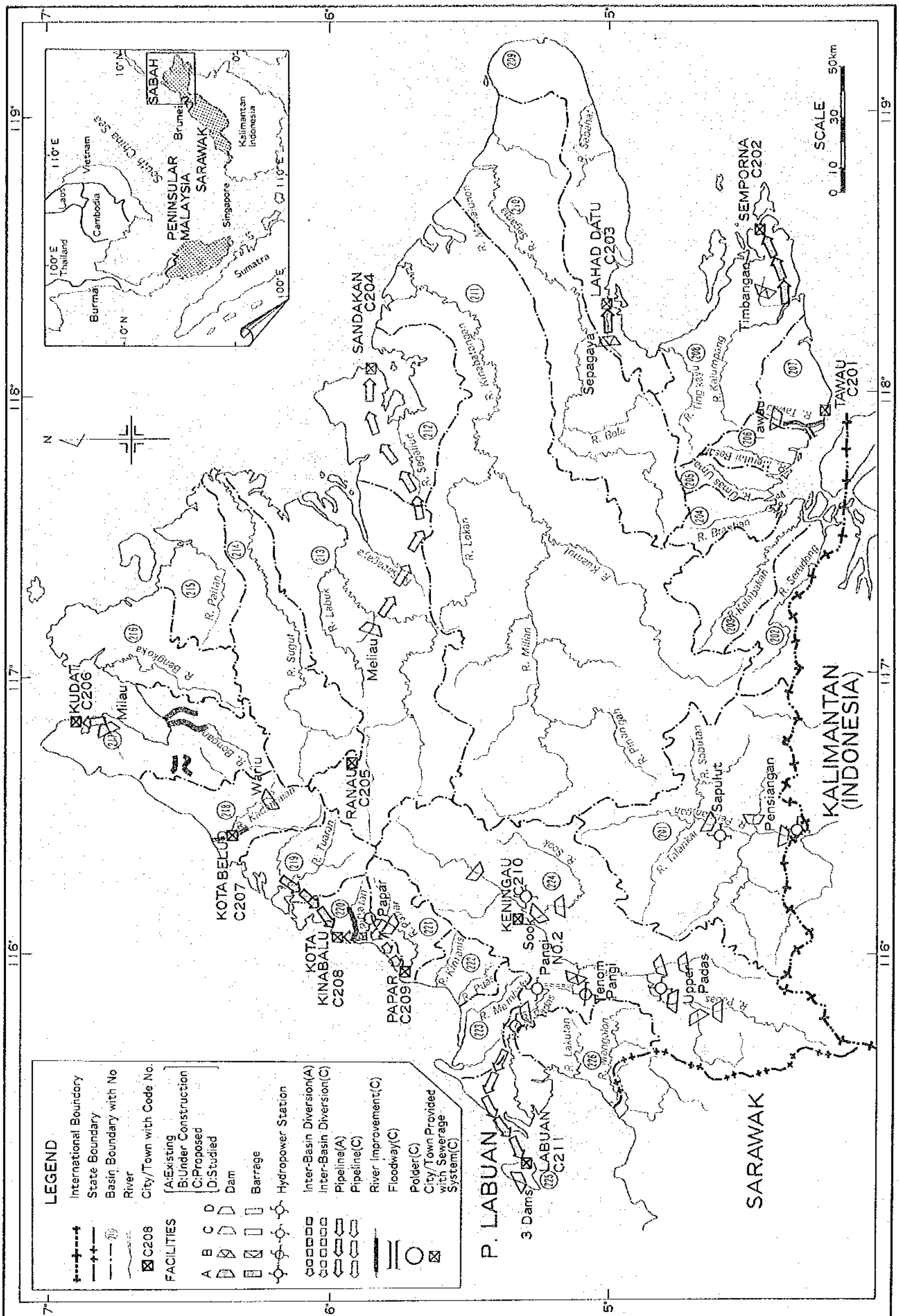

Recommended Plan
for the State of Sabah

GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY MALAYSIA

JAPAN INTERNATIONAL COOPERATION AGENCY

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FIGURES

ABBREVIATIONS

(1) Plan

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

(2) Domestic Organization

DID (JPT)	:	Drainage and Irrigation Department
DOA	:	Department of Agriculture
DOE	:	Division of Environment
DOF	:	Department of Forestry
DOFS	:	Department of Fishery
DOM	:	Department of Mines
DOS	:	Department of Statistics
EPU	:	Economic Planning Unit
FAMA	:	Federal Agricultural Marketing Authority
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
ICU	:	Implementation and Coordination Unit
MARDI	:	Malaysian Agricultural Research and Development Institute
MIDA	:	Malaysian Industrial Development Authority
MLRD	:	Ministry of Land and Regional Development
MMS	:	Malaysian Meteorological Service
MOA	:	Ministry of Agriculture
MOF	:	Ministry of Finance
MOH	:	Ministry of Health
MOPI	:	Ministry of Primary Industries

MRRDB	:	Malaysia Rubber Research and Development Board
NDPC	:	National Development Planning Committee
NEB (LLN)	:	National Electricity Board
PORIM	:	Palm Oil Research Institute of Malaysia
PWD (JKR)	:	Public Works Department
RDA	:	Regional Development Authority
RISDA	:	Rubber Industry Small-holders Development Authority
RRIM	:	Rubber Research Institute of Malaysia
SEB	:	Sabah Electricity Board
SEBC	:	State Economic Development Corporation
S(E)PU	:	State (Economic) Planning Unit
SESCO	:	Sarawak Electricity Supply Croporation
UDA	:	Urban Development Authority

(3) International or Foreign Organization

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

(4) Others

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

ABBREVIATIONS OF MEASUREMENT

Length

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

Area

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

Volume

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

Weight

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

Time

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

Electrical Measures

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

Other Measures

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

Derived Measures

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

Money

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

CONVERSION FACTORS

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

Exchange Rate
(As average between July and December 1980)

$1 = M$2.22
¥100 = M$1.03

1. INTRODUCTION

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

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

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

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

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

Each volume of the State Reports is a version of the Water Resources Development and Use Plan compiled for a State or a group of States, including more information regarding the specific State or States. The State Report Volume 9 herein presented describes the matters for the State of Sabah.

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

2. BACKGROUND

2.1 The Land

Sabah occupies the northern part of Borneo Island. The State of Sabah is located between 4° 05′ and 7° 30′ north in latitude and 115° 10′ and 119° 39′ east in longitude, adjoining to the State of Sarawak in the west and Indonesia's Kalimantan in the south. Its coast line faces the South China Sea in the northwest, the Sulu Sea in the north and northeast, and the Celebes Sea in the east. Sabah covers an area of 73,700 sq.km.

Sabah consists of two geological regions; Eastern Sabah sedimentary basin and Northwest Borneo Geosyncline covering west Sabah. Palaeogene sandstones and shales of the Northwest Borneo Geosyncline are good foundation for high dams.

The topography is featured by four physiographic regions; western lowland, western ranges, interior highlands and eastern lowlands. The western ranges are named as the Crocker Range which culminates in Mt. Kinabalu of El.4,100 m being the highest peak in Malaysia.

Alluvial soils occur in coastal plains, riverine, flood plains, lower riverine terrace, and intermediate and high terraces with a total coverage of 13,500 sq.km. Sedentary soils cover mountains to undulating plains totalling an area of 60,900 sq.km.

Climate is generally characterized by the northeast monsoon from November to January and the southwest monsoon from May to July. Air temperature and relative humidity are usually high with little variation.

Average annual rainfall is 2,664 mm. It is more than 3,000 mm in the northeastern part facing the Sulu Sea and in the southwestern part of the northwest coastal area and Labuan island. Some parts of the interior highlands are low rainfall regions of less than 2,000 mm in annual rainfall. Meteorological data at Kota Kinabalu and Sandakan are summarized in Table 1.

Alluvial aquifers are recognized mainly in sandy layers of Quaternary sediments. Rock aquifers are located in the limestone of crystalline and Karst type as well as Neogene sandstone. The estimated total safe yield is 4.2 million cu.m. for alluvial aquifers and 4.1 million cu.m for rock aquifers. Excellent to good alluvial aquifers are found in the Kadamaian and Padas river basins, while excellent to good rock aquifers are located in the Silibukan, Labuk and Bongan river basins.

2.2 The Rivers

There exist more than 50 river systems in Sabah. Surface run-off was estimated to be 1,517 mm/y or 112.8 billion cu.m/y on an average. Low flow and flood discharge are high in river systems which are located in the northernmost part of the northwest coastal areas of Sabah.

Bank erosion is observed in many rivers but it is only local and of a minor extent with the exception that riverains suffer from the bank erosion during floods of the Kadamaian, Papar and Pegalan rivers.

Specific annual yield of sedimentation was estimated to be 30 to 230 cu.m/sq.km/y and its average was 114 sq.m/sq.km/y.

Rivers in the eastern part of Sabah meander in their lower reaches. The estuaries of rivers in the west coast of Sabah are affected by drifting sand of the South China Sea. Problems of sea water intrusion are insignificant in Sabah.

Flood occurs from December to January in most areas of Sabah. The river characteristics in terms of river morphology, estuary, sediment and sea water intrusion in Sabah is as shown in Tables 2 and 3.

Self-purification mechanismm of river is greatly reduced and the aquatic ecosystem is also affected if the biochemical oxygen demand (BOD) concentration in the river is more than 5 mg/lit. Odour occurs if the BOD concentration is over 10 mg/lit. Observation records of BOD concentration in the river have not been accumulated sufficiently in Sabah.

Operation of copper mines, opening-up of residential areas and road construction are major causes of high concentration of suspended solid (SS) in some rivers. The aggradation and degradation occur in the river channel resulting in that some kinds of fishes become extinct. In Sabah, the Segama, Kinabatangan and Labuk rivers sometimes show the SS level of 500 to 1,000 mg/lit, while no river has been found to have the SS level of more than 1,000 mg/lit in the past three years.

2.3 Watershed

Natural vegetation covers an area of 30,900 sq.km or 42% of the State, comprising undisturbed high forest of 20,200 sq.km, montane forest, mangrove and transitional beach and swamp forest of 9,800 sq.km and grassland of 900 sq.km. The varieties range from the mangroves on coastal fringes to the mixed dipterocarp forests in low-lying and hilly areas and the mountain forests of the highlands.

The total forest area reduced from 63,600 sq.km or 86% of the State's land in 1971/72 to 39,300 sq.km or 53% in 1980 as a result of logging activities. The forest area includes immature and disturbed forests of 9,300 sq.km.

Through the soil erosion potential evaluation in the Study, it was preliminarily identified that the sediment load is high at present due to the surface soil loss occurred in the catchment areas of the Kadamaian, Tuaran, Putatan and Kimanis rivers.

2.4 Present Socio-economic Condition

As illustrated in Fig.1, the State of Sabah is administratively divided into five Divisions and subdivided into 24 Districts. Towns having population of more than 10,000 in 1980 are Kota Kinabalu, Sandakan, Tawau, Lahad Datu, Labuan and Kudat.

Population of Sabah was 1.1 million in 1980 with the average annual growth rate of 5.3% during the period from 1970 to 1980. Population density increased from 9 persons/sq.km in 1970 to 15 persons/sq.km in 1980.

Gross regional product (GRP) increased from M$848 million in 1971 to M$1,944 million in 1980 in factor cost at 1970 constant price with the average annual growth rate of 9.7%. GRP of manufacturing sector shared M$21 million or 2.5% of the total in 1971 and M$45 million or 2.3% in 1980. Per capita GRP was M$1,771 in 1980 in factor cost at 1970 constant price being nearly equal to the national average and its average annual growth rate between 1971 and 1980 was 4.2%.

Major land use patterns and their coverage in 1980 comprised forest land of 39,300 sq.km, grassland of 900 sq.km, annual and perennial crop land of 3,600 sq.km, shifting cultivation land of 800 sq.km and miscellaneous land of 29,800 sq.km including urban and associated areas and unalienated State's land. The land use in Sabah is presented in Fig.2.

Major export-orientated crops are rubber, oil palm, cocoa and coconut. During SMP and TMP periods, the total planted area went up from 105,000 to 106,900 ha for rubber, from 43,100 to 86,700 ha for oil palm and from 4,500 to 38,000 ha for cocoa, while it reduced from 57,200 to 53,600 ha for coconut. The exported products of these crops in 1980 were 30,800 tons in rubber, 143,600 tons in palm oil, 22,900 ton in palm kernel, 12,400 tons in cocoa beans and 43,200 tons in copra.

Present paddy cultivation area amounts to 44,300 ha comprising wet paddy field of 31,600 ha and hill and dry paddy fields of 12,700 ha. Among the wet paddy field, 20,800 ha are provided with irrigation facilites and 9,900 ha out of the irrigated paddy field are operated for double cropping of wet paddy.

Domestic production of rice in 1976 was 55,800 tons comprising wet paddy rice of 47,900 tons and hill and Kendinga paddy rice of 7,900 tons and it met 66% of the total consumption. In 1980, Sabah provided consumers with rice of 123,900 tons by purchasing domestic rice of 65,800 tons and by importing rice of 58,100 tons. The present self-sufficiency rate is 51%.

3. PRESENT CONDITION OF WATER RESOURCES DEVELOPMENT AND USE

3.1 Domestic and Industrial Water Supply

Public water supply in Sabah is administered by the Public Works Department (PWD) of the State Government and the Medical and Health Services of the Ministry of Health (MOH) of the Federal Government.

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

As shown in Table 4, the twenty five PWD waterworks delivered 105,600 cu.m/d of water on an average to 345,100 people in 1980. Corresponding daily per capita consumption is estimated to be 210 lpcd. Most waterworks depend on river water but groundwater or spring is the substantial water source for Sandakan, Semporna, Kota Belud, Beaufort, Kuala Penyu, Labuan and Tenom. A rain storage reservoir is the sole water source for Kudat.

In the interior and isolated rural areas, untreated water supply system has been developed by the State Government by either withdrawing water from small river connections or digging shallow wells equipped with hand pumps with materials and technical advices from MOH, under the Rural Environmental Sanitation Program. It was estimated that 146,500 people were served water by the untreated water supply system in 1980. The water users are suggested to boil water before drinking.

In consequence, 491,600 people out of the total State population of 1.10 million were served water through PWD and RESP, corresponding to the service factor of 45% in 1980.

3.2 Irrigation

The present wet paddy field totals 31,600 ha among which 20,800 ha are irrigated and the rest are rainfed. Fig.3 portrays areal distribution of wet paddy field in the State. 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 coastal area, sharing 70% of the whole irrigation area in the State. Irrigated double cropping of wet paddy is possible in 8,100 ha. The notale 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 extends along the Labuk and Bengkoka rivers.

The Tempasuk North Irrigation Scheme of 2,590 ha is the largest gravity schemes in the State with a total double cropping area of 1,050 ha. The intake structure consisting of 4-cell gates is located on the Tempasuk river. The canal is fully lined by precast concrete but its density is 5 m/ha.

The Papar Irrigation Scheme is the largest pumping irrigation scheme in the State. Total irrigation area is 2,430 ha and double cropping area is 2,020 ha. Two pump stations are constructed on the Papar river and equipped with eight pumps having the whole capacity of 1,417 lit/s. The canal length is 0.6 km in the earth main canal and 26.3 km in the concrete-lined secondary canals. The canal density is 11 km/ha.

The Trusan Sapi Pumping Irrigation Scheme was developed as the first sizeable irrigation scheme in the east of Sabah in 1976. Its irrigation area of 1,700 ha including double cropping area of 570 ha is located in a freshwater swamp area sandwiched by the Labuk and Sapagaya rivers. There are coastal bund of 8 km, one tidal control structure, internal drains of 22 km and one pumping station equipped with five pumps of 850 lit/s in total capacity. The canal density is 9 m/ha and most canals are lined by precast concrete.

3.3 Flood Mitigation

The flooded area, affected population and estimated damage by the recorded maximum floods are listed up in Table 5. The flooded areas by the recorded maximum floods are illustrated in Fig.4.

The total flooded areas estimated are 2,700 sq.km with affected population of 82,000.

Several facilities have been constructed in the Papar, the Talipok and the Api-Api rivers, but most of them are rather on ad hoc basis.

3.4 Power Generation

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 total power demand in SEB power supply system was 79 MW in 1980. According to a preliminary projection provided by SEB in June, 1982, the future power demand will be 344 MW in 1990 and 1,035 MW in 2000.

The Tenom Pangi hydropower project 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 combined cycle power station is being planned by Sabah Energy Corporaton (SEC) which was recently established in relation to the estabishment of sponge iron plants and methanol and LPG plants in Labuan.

3.5 Inland Fishery

Three types of inland fishery activities such as riverine fishing, freshwater pond culture and brackish water pond culture are observed in the State. The freshwater ponds are presently about 4,000 in number and 339 ha in surface area. 290 ha are concentrated in the Divisions of Kudat and West Coast. The estimated water use of the freshwater pond is 11 million cu.m/y in total.

3.6 Inland Navigation

The Kinabatangan and Labuk rivers are main inland navigation routes in the east of Sabah. In the Kinabatangan river, there are about 200 tug boats for towing logs with 25 gross weight tons and 1 or 1.25 m of draft on an average. There are about 100 tug boats of similar size for towing logs in the Labuk river. Besides, considerable navigation has been observed for 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.

3.7 Sewerage System

The sewerage system is installed in seven towns; 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 sewage is directly discharged into nearby water course or onto land in rural area.

3.8 Water Purification System in Private Sector

The Federal DOE started to monitor the river water quality since November, 1981 in Sabah with the frequency ranging from twice a year to once a month in 29 river water quality control regions.

There are three rubber factories in the State. Two of them located in Tawau and Tenom discharge effluent of 90,000 cu.m/y to nearby watercourses. Another factory at Putatan, discharging raw effluent of 131,000 cu.m/y, is located adjacent to housing area of Kota Kinabalu, but it will be relocated to Tuaran. The water quality at outlets of factories ranges from 20 to 50 mg/lit in BOD concentration and from 26 to 500 mg/lit in SS concentration.

The number of oil palm mills is 10 in operation and three under construction. The total milling capacity nf the 13 mills is 295 tons/hr in fresh fruit bunch (FFB). Treated or raw effluent is and will be discharged from five mills into watercourses, from four mills into sea and from four mills onto land. Among 10 existing mills, biological treatment is applied to seven mills and land disposal method of treated effluent is taken up by four mills. The water quality ranges from 90 to 22,800 mg/lit in BOD concentration and is between 500 and 35,400 mg/lit in SS concentration.

Mamut copper mine, operated since 1975, is now yielding copper concentrate of 10,000 tons a month. The ore processing area and the tailing dam are major sources of sedimentation. The effluent from the 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 cu.m/min containing a significant amount of inorganic SS.

3.9 Watershed Management

The Forest Department of Sabah controls all the existing forests under its management system established for proper utilization of forest resources in the State. Sabah has a potential area of 16,700 sq.km as exploitable at present and is planning to develop 8,000 sq.km out of the potential area up to 2000.

Besides forest exploitation, a hill paddy growth in shifting cultivation areas has caused sheet and gully erosion problems on steeply dissected land. The present area recognized as shifting cultivation area is about 800 sq.km, out of which 140 sq.km are grown with hill paddy.

The above-mentioned activities as well as execution of land development schemes are also sources of man-made sedimentation. To reduce the adverse effects, the Sabah Forest Development Authority started to undertake reafforestation and reforestation works at Bengkoka in the Division of Kudat.

3.10 Dams

Table 6 lists ten dams at various stages in Sabah.

The Kudat rain storage reservoir is operated for domestic and industrial water supply in Kudat. The Timbangan dam and Sepagaya dam are under construction for domestic and industrial water supply in Semporna and Lahad Datu, respectively. Tenom weir is being constructed as the intake weir for the Tenom Pangi hydropower project. Detailed design is being conducted for three dams for domestic and industrial water supply in Labuan. Four other dams are at the stage of planning.

4. FUTURE WATER DEMAND AND ASSOCIATED PROBLEMS

4.1 Projected Socio-economic Condition

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

The average annual growth rate of population was estimated to be 3.2%. Projected population is 1.51 million in 1990 and 2.08 million in 2000, respectively. Table 7 shows the projected population by urban and rural area in Sabah. In the Study, the urban area includes cities/towns each of which the population in 2000 was estimated to be not less than 10,000.

GRP in factor cost at 1970 constant price was projected to be M$2,767 million in 1985, M$4,107 million in 1990, M$6,239 million in 1995 and M$9,704 million in 2000 with the average annual growth rate of 8.4% between 1980 and 2000.

Projected gross value of output in manufacturing sector will increase from M$155 million in 1980 to M$337 million in 1985, M$638 million in 1990 and M$4,042 million in 2000 at factor cost in 1970 prices as shown in Table 8.

The future rice consumption in the State was estimated to be 181,200 tons in 1990 and 249,600 tons in 2000. To raise the average rice self-sufficiency rate in Malaysia up to 85% in 1990 and in 2000 as well, implementation of the following irrigation development plans is indispensable: (1) provision of irrigation system for the existing rainfed paddy field of 9,200 ha and the newly reclaimed paddy field of 9,400 ha, (2) stabilization of irrigation water supply during the wet season to the existing irrigated paddy field of 2,000 ha and (3) development of new irrigation water resources during the dry season to increase by 1,500 ha of double cropping area among the existing irrigated paddy field. The total rice production anticipated under the above plans will be 98,500 tons in 1990 and 128,000 tons in 2000.

Oil palm planting area was projected to increase from 90,500 ha in 1980 to 124,800 ha in 1990 and 164,500 ha in 2000. The prospected production of oil palm will rise from 1.26 million FFB tons in 1980 to 1.54 million FFB tons in 1990 and 2.24 million FFB tons in 2000.

Rubber planting area was projected to be kept in the present hectarage of 107,000 ha in 1990 and 2000. The total processing amount was projected to be 210,000 million ton as dry rubber content in 1990 and 400,000 million ton in 2000.

4.2 Basin Division

For the purpose of the Study, Sabah was divided into 26 Basins each being a river basin or a group of river basins as shown in Fig.5. Each Basin is further divided into effective area and ineffective area. The former is the upper part of the Basin in which part of the water uses was assumed to return into lower stretches of 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 5.2) are as shown in Table 9.

4.3 Domestic and Industrial Water Demand

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

For the domestic water supply, it was assumed that the entire population in urban area would be fully served by piped water supply. While in rural area, 60% of the total population in 1990 and 90% of the total population in 2000 were assumed to be served by piped water supply. Assumption was made that 50% of the total industrial water demand will be served by piped water supply. Table 10 shows the assumed per capita daily use of domestic water and service factor. The unit net manufacturing water use per gross value of manufacturing output by commodity group was assumed as shown in Table 11.

The total water demand will reach 103 million cu.m/y in 1990 and 259 million cu.m/y in 2000 as shown in Tables 12 and 13. Major demand centers are Labuan, Kota Kinabalu, Sandakan, Tawau and Lahad Datu among which Labuan has the largest demand for industrial water and Kota Kinabalu shows the maximum domestic water demand. In 2000, the total water demand in five Basins in which the above-mentioned cities/towns are located will share 106.1 million cu.m/y or 63% of the State's domestic water demand and 77.9 million cu.m/y or 85% of the industrial water demand.

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

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

4.4 Irrigation Water Demand

The irrigated land development was projected taking into account information obtained from DID and the assumed rate of self-sufficiency in domestic rice production in the State. As shown in Table 14 the projected irrigation area will increase from 20,800 ha in 1980 to 32,400 ha in 1990 and 39,500 ha in 2000. The ratio of double cropping area to the total irrigation area will rise from 47% in 1980 to 51% in 1990 and to 50% in 2000.

The irrigation water demand was calculated for 1990 and 2000 as shown in Table 15. Irrigation efficiency applied is 55% for both major and minor irrigation projects. The annual irrigation water demand will be 649 million cu.m in 1990 and 644 million cu.m in 2000, respectively.

4.5 Fish Pond Water Demand

The future hectarage of freshwater fish pond was projected to increase from 339 ha in 1980 to 608 ha in 1990 and to 878 ha in 2000. The total water demand for freshwater fish culture will rise from 10.9 million cu.m/y in 1980 to 19.5 million cu.m/y in 1990 and 28.1 million cu.m/y in 2000.

4.6 River Utilization Ratio and Water Deficit

The relative burden of water use on a river is indicated by the river utilization ratio, which is the ratio of water demand to natural run-off. All natural flow cannot meet water demand, because it mostly runs to the sea as flood flow. It was estimated that natural flow would often fail to meet all water demand if the river utilization ratio is not less than 10% under the hydrological condition in Malaysia. The area with river utilization ratio of not less than 10% is, therefore, herein called the water stress area. Table 16 shows the estimated long-average natural run-off, projected water demand and river utilization ratio in 26 Basins in Sabah for 1990 and 2000.

The river utilization ratio was calculated for each basin for 1990 and 2000 as shown in Table 16. Putatan (Kota Kinabalu) and Labuan Basins are the only Basins of which river utilization ratio is larger than or equal to 10% in a whole basin in 2000. The ratio of Sub-basins are also projected because water utilization is locally concentrated in the specified Sub-basins. In the Sub-basins of Tawau, Sandakan, Kudat, Kota Belud (Kadamaian) and Kota Kinabalu (Moyog), it is projected to be larger than 10% in the year 2000.

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

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

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

A part of water taken from a river returns to the river. It is herein called the return flow. The return flow from irrigated paddy was assumed to be 20% of irrigation water demand within the effective area. The return flow from domestic and industrial water use within the effective area was estimated depending on the purpose of water use; 5% to 90% of demand.

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 as the water demand deducted by the return flow and groundwater use.

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

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

The estimated water deficit varies depending on the assumed hydroloical condition. Among the hydrological conditions in the recorded period of N years, that resulting the largest annual volume of water deficit is herein regarded as the driest condition and called 1/N drought, that resulting the second largest annual volume of water deficit is called 2/N drought, and so on. The estimated water deficit by Basin under 1/N to 5/N drought is shown in Table 17.

The water deficit as shown in Table 17 was calculated under without-dam condition. If the estimated supply capacity of the existing and under construction dams listed up in Table 6 is taken into account, the above-mentioned water deficit will be reduced in Basins where dam is located. It is noted that the water deficit in each Basin was calculated only at the balance point and it indicates an overall balance in the Basin. There may be the cases that river flow is in deficit in some section upstream of the balance point if major demand is located upstream.

4.7 Water Quality

To estimate BOD concentration in the river, BOD load flowing into a river was calculated based on the water use by pollution source. Major pollution sources are the domestic and industrial water users comprising 17 urban areas, 10 palm oil mills, three rubber factories, animal husbandry and the rural areas. However, waste water from the following cities was assumed to be directly discharged to sea; Tawau, Semporna, Lahad Datu, Sandakan, Kudat, Kota Kinabalu and Labuan.

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 18. BOD concentration along the main streams of rivers was calculated for the condition that the rate of run-off at just downstream of each outlet of effluent was equal to the assumed rate of river maintenance flow at that point, and the residual purification ratio varies in the range of 0.7 to 0.9 according to the characteristics of the rivers.

Discharge ratio, run-off ratio and BOD concentration assumed by type of pollution source for 1990 and 2000 are shown in Table 19. A portion of water is consumed by being incorporated in products, by evaporation and by leakage in the process it is used and treated. The ratio of water after consumption to that before consumption is called the discharge ratio. A portion of water is again lost during the travel that water is released by the consumer and it enters into a river. The ratio of water reaching the river to that discharged by the consumer is the run-off ratio.

The projected maximum BOD concentration in Sabah will not be more than 5 mg/lit except for minor portions of the Silibukan and Bongan rivers in 1990 and 2000. This projection states that most rivers are little polluted presently and will be still clean in 1990 and 2000.

4.8 Watershed Problems

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

Present annual erosion rate is estimated to be 500 tons/sq.km. This erosion rate is generally high, because soils are erodable and natural forest has been converted to other land to a large extent. Relatively high erosion rate in Sabah is attributable to wide area of disturbed and cleared forest occupying 13% of land.

It is estimated that reforestration for all disturbed forest in Sabah can reduce erosion rate to 80 tons/sq.km. Reforestration in the disturbed forest can reduce erosion in a long run.

If all natural forest on slope of less than 6 degrees is disturbed, erosion rate will increase to 2,150 tons/sq.km. An exercise indicates that erosion rate is 700 tons/sq.km, if natural forest on slope of less than 2 degrees is cleared and converted to rubber farm.

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

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

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

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

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

5. STRATEGIES FOR WATER RESOURCES DEVELOPMENT AND USE

5.1 Problem Areas

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

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

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

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

(2) development of water supply and irrigation systems;

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

(4) hydropower development;

(5) conservation of water quality; and

(6) flood mitigation.

5.2 Maintenance of Low Flow

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

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

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

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

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

5.3 Development of Water Supply and Irrigation Systems

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

Domestic and industrial water supply is conducted along with the objectives of national economic development, regional development and social well-being improvement. The service factor of urban water supply system is already high, and the development of rural water supply system has been forcefully promoted in the recent years. Taking into account the Government policy prevailing, it is assumed that the public water supply system will be developed to supply domestic water to all people by 2000 and to supply 50% of industrial water, except that 10% of rural people in Sabah and Sarawak will still not be publicly supplied, because of remoteness and non-availability of suitable water source.

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

5.4 Source Development

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

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

5.5 Water Pollution Abatement

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

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

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

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

5.6 Hydropower Development

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

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

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

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

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

5.7 Flood Mitigation

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

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

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

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

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

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

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

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

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

In addition to the above-mentioned measures, flood forecasting and warning system is proposed for some river basins having more than 5,000 inhabitants liable to flood hazard as shown in Table 20.

5.8 Inland Fishery

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

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

6. ALTERNATIVE STUDIES

6.1 Scope of Alternative Studies

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

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

6.2 Water Demand and Supply Balance Alternatives

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

These water stress Basins were further sub-divided and it was found that the river utilization ratio would be more than 10% in 2000 in seven Sub-basins as shown in Table 21.

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

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

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

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

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

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

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

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

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

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

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

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

6.3 Hydropower Development Alternatives

The projected power demand and SEB expansion schedule are illustrated for major power demand centers in Fig.7. The projected power demand up to 2000 is less than 100 MW in each demand center except for Kota Kinabalu. It is appropriate to install thermal power of around 10 MW, probably diesel, in unit capacity as an additional expansion plan to 2000 in these demand centers. On the other hand, in Kota Kinabalu, hydropower developmeent or thermal plant of larger unit capacity should be considered for the period after 1990, in which the power demand will be 250 to 300 MW. It is estimated that 140 MW of additional capacity including reserved capacity is necessary to meet the growing demand in Kota Kinabalu up to 2000, after the on-going Tenom Pangi, Phase I/II is completed.

The implementation of the Tenom Pangi, Phase III, is being considered by SEB, in order to increase the power generation of the Tenom Pangi Project with higher dependability. The Tenom Pangi, Phase I/II , of 66 MW is under construction as a run-of-river power station in order to meet the immediate power demand in Kota Kinabalu. By the nature of run-of-river development, it is estimated that the Pangi power station will reduce power generation in the dry period so that it will need certain supporting power plant. Phase III consists of the construction of the Sook dam with an active storage capacity of 480 million cu.m in an upstream tributary of the Padas river to augment the low flow from 40 cu.m/s to 116 cu.m/s, and expansion of the Pangi power station by 44 MW in installed capacity. The power generation of 40 MW is also contemplated at the Sook dam. If Phase III is implemented, annual energy production at the Pangi power station will increase from 475 to 684 GWh. Under the dry condition, the Pangi power station can generate 66 MW for four hours per day if Phase I/II only is completed, but it can generate 110 MW for 12 hours per day. The dependable output of the proposed Sook power station will not be large, but it can develop 100 GWh of potential.

The Papar dam project proposed for the domestic and industrial water supply to Kota Kinabalu will incidentally create a water head between the Papar dam site and the Kinalut river. Power generation of 30 MW will be possible, if the size of the Papar dam is increased.

The water head below the Pangi power station can be developed for power generation. The Lower Halogilat project of 144 MW has been proposed as a storage development. The cost of power is expected to be quite low. Flooding of the existing railway is the constraint, but the development of road network seems to be reducing the importance of this problem. One of the alternatives in this area is the Pangi No. 2 power station of 90 MW, which is a run-of-river development below the Pangi power station.

There are some possible sites for hydropower development in the upper basin of the Padas river, according to a map study.

The Pensiangan river flows from southern part of Sabah to the territory of Indonesia. The catchment area is 5,200 sq.km at the borderline. Large potential in this river system can be developed at a low cost for the power supply to the west coast and probably to the east Sabah. An example is the Pensiangan Project of 190 MW near the borderline.

Above-mentioned potential sites are illustrated in Fig.8 and outline of some alternatives are shown in Table 25.

6.4 Water Pollution Abatement Alternatives

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

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

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

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

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

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

The ordinary treatment method for the domestic water supply is the sedimentation, filtration and chlorination, if BOD concentration in raw water is not more than 2 mg/lit. The ordinary treatment method for the industrial water supply is the sedimentation, if BOD concentration in raw water is not more than 5 mg/lit. Pre-treatment facilities are needed to varying extent for raw water with BOD concentration above these limits.

For BOD concentration in raw water more than the above-mentioned limit but not more than 20 mg/lit, pre-treatment is carried out by the rapid sand-filter bed and activated carbon absorption (secondary treatment). For BOD concentration between 20 and 200 mg/lit, an aerated lagoon process such as aerated lagoon or maturing pond (primary treatment) is further needed. The cost for pre-treatment facilities was taken into account for the economic comparison of the alternatives.

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

6.5 Flood Mitigation Alternatives

Three alternatives are proposed for the flood mitigation:

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

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

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

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

The problem rivers were divided into stretches of 30 to 60 km in length. The measures explained in Section 5.7 were compared and the most economical measures was selected for each river stretch. The resulted alternative plans for the State are as outlined in Table 26.

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

The flood mitigation alternatives including Alternative F1, F2 and F3 are illustrated in Fig.9 through 11.

7. RECOMMENDED PLAN

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

7.1 Public Water Supply and Irrigation Development Plan

Public water supply system including PWD system and RESP system is recommended to be provided to meet all urban domestic water demand, 90% of rural domestic water demand and 50% of industrial water demand by 2000 in accordance with the plan as shown in Tables 27 through 29.

Irrigation water supply system will be constructed in accordance with the schedule assumed in Table 14.

7.2 Source Development

The recommended water source development plan for balancing water demand and supply is summarized in Table 30. The water source development plan in the problem area is mentioned hereunder.

Fig.12 illustrates the recommended water demand and supply balance program for the State.

7.2.1 Tawau dam project

Tawau has a population of 50,000. There are two waterworks of PWD with the total treatment capacity of 11,380 cu.m/d in the Tawau river. Water demand has already exceeded the supply capacity, and water rationing has been conducted since 1979. In 1980, PWD delivered 4.9 million cu.m of water to 35,200 people. The Tawau Water Supply Extension Project, Stage I, of 20,000 cu.m/d in treatment capacity depending also on the Tawau river, is going to be completed by 1983.

Population in Tawau is projected to be 82,000 for 1990 and 150,000 for 2000. The corresponding domestic and industrial demand was estimated to be 8 million cu.m/y in 1990 and 26 million cu.m/y in 2000. It is foreseen that supply will often fail in the future, because the projected water demand is large compared with natural flow in the Tawau river.

The recommended source facilities is the Tawau dam in the upper reaches of the Tawau river, in order to regulate the run-off in the river.

7.2.2 Meliau dam and diversion project

Sandakan has a population of 80,800. Water supply system depends on 21 boreholes and two river intakes. Groundwater supply is 75% of total supply. There are two treatment plants, their total capacity being 20,880 to 22,320 cu.m/d. PWD delivered 7.5 million cu.m of water to 64,700 people in 1980. Failure in supply often takes place, because of high demand. The Sandakan Stage I - Interim will be completed by 1983, as the interim measure until a new surface supply is made available. It consists of the construction of 13 boreholes and extension of treatment plant capacity by 18,000 cu.m/d.

Population in Sandakan is projected to be 127,000 for 1990 and 222,000 for 2000. The corresponding domestic and industrial water demand is estimated to be 15 million cu.m/y in 1990 and 50 million cu.m/y in 2000. A study has been carried out for the Sandakan Water Supply Extenson Project, Stage I, which envisages to draw water either from the Labuk river or the Kinabatangan river.

The recommended plan herein assumes that water will be taken from the Labuk river. A pipeline system is constructed in stages in a distance of 120 km between the Meliau river and Sandakan, and the Meliau dam is constructed in order to regulate the Meliau river flow.

7.2.3 Milau river source development plan

Kudat has a population of 12,000. PWD public water supply is conducted with a rain storage reservoir of 2.7 million cu.m in storage capacity. The treatment capacity is 4,550 cu.m/d. PWD delivered 900,000 cu.m of water to 7,500 people in 1980.

Population in Kudat is projected to be 21,000 for 1990 and 43,000 for 2000. The corresponding water demand is estimated to be 2.2 million cu.m in 1990 and 8.1 million cu.m in 2000. Little water resources are available near Kudat for the future water supply.

The recommended source development comprises a 30 km long pipeline between the Milau river and Kudat to convey water, and the Milau dam to augment low flow in the Milau river.

7.2.4 Wariu dam project

There are 5,400 ha of irrigation schemes including the Tempasuk North Irrigation schemes in the surrounding area of Kota Belud in the Kadamaian and Wariu river Basin. It is estimated that additional 1,000 ha will be developed by 2000.

The Wariu dam is recommended in the upstream reaches of the Wariu river, in order to regulate river flow for irrigation and domestic and industrial water supply in the above-mentioned area.

7.2.5 Papar dam and diversion project

Kota Kinabalu has a population of 71,000. There are two intakes of PWD in the Moyog river (Basin 220). The total treatment capacity is 45,500 cu.m/d. PWD, delivered 15.6 million cu.m of water to 119,000 people including those living in suburban area. The Kota Kinabalu Water Supply Extension Project, Stage I, is going to be completed by 1983. This project envisages to install 54,000 cu.m/d of additional capacity by diverting water from the Tuaran river to Kota Kinabalu.

Population in Kota Kinabalu including suburban area is projected to be 134,000 for 1990 and 271,000 for 2000. The corresponding domestic and industrial water demand is estimated to be 23 million cu.m in 1990 and 62 million cu.m in 2000.

Water supply from the Moyog river has to be often interrupted, because the water demand in the existing irrigation area of 1,822 ha is more than what can be totally supplied by natural flow in the Moyog river. Water supply from the Tuaran river will also be interrupted, if the natural flow only is depended on. It is necessary to construct a dam in order to sustain the safe supply. There are several sites suitable for the dam constructon in the upstream reaches of the Tuaran, Moyog and Papar rivers. Herein the Papar dam site is preliminarily selected.

The Papar dam is proposed in the upstream reaches of the Papar river (Basin 221) in order to provide safe water supply to Kota Kinabalu, while augmenting downstream flow for the purpose of irrigation and domestic and industrial water supply within the Papar river basin. The diversion of water includes the regular supply to the incremental water demand and temporary supply when the intakes in the Moyog and Tuaran rivers are encountered with drought. This project can integrate hydropower generation at the outlet of the diversion tunnel.

7.2.6 Padas river diversion project

Labuan island has a population of 29,000. PWD water supply system of 9,100 cu.m/d entirely depends on 31 boreholes. In 1980, PWD delivered 1.8 million cu.m of water to 14,900 people in Labuan. The expansion plan of water supply includes tubewells, three dams and artificial recharging system.

Population in Labuan island is projected to be 52,000 for 1990 and 105,000 for 2000. Correspoinding domestic and industrial water demand is high of 13 million cu.m/y in 1990 and 24 million cu.m/y in 2000, because large scale industries will be established.

Total exploitable water resources within Labuan island are estimated at 11 million cu.m/y including 7 million cu.m/y of groundwater and 4 million cu.m/y of surface water. Further water source has to be sought from the main land.

The recommended source development is diversion of water from the Padas river by means of submarine pipelines, which will be commissioned by stages.

7.3 Water Pollution Abatement Plan

The recommended plan for the water pollution abatement in the river is the improvement of purification method in the palm oil mills in the Silibukan and Bongan Basins.

Although it is ineffective for the water pollution abatement in the river, sewerage development in Tawau, Lahad Datu, Sandakan and Kota Kinabalu is assumed from the viewpoint of public health. The recommended plan for water pollution abatement is shown in Tables 31 through 33.

7.4 Flood Mitigation Plan

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

7.4.1 Tawau river flood mitigation project

Tawau, populated by 50,000, is located at the estuary of the Tawau river. The town is often flooded, because the river, stretching for 9 km in the town, is not capable of discharging flood. For example, a flash flood in January, 1981 flooded 18 sq.km and affected 6,000 people, mostly within the town. The recommended flood mitigation plan consists of the excavation of a bypass floodway of 3 km in length and improvement of existing river channel of 9 km in length. Although incorporation of flood control storage was preliminarily discarded in the proposed Tawau dam, it should be further studied in the stage of feasibility study.

7.4.2 Bandau plain flood mitigation project

The Langkon, Bongan, Kota Marudu and Tandek rivers run through the Bandau plain where several villages are located. A flood associated with high tide in January, 1981 inundated 109 sq.km including Langkon and Kota Marudu towns. A budget has been allocated under 4MP for the flood mitigation in the Bandau plain. The recommended flood mitigation plan is river channel improvement of 56 km in length in order to protect Bandau plain.

7.4.3 Kadamaian river channel improvement project

The flood of January, 1981 affected the low-lying area of Kota Belud town and the irrigation scheme. A comparatively large scale irrigation scheme is carried out and will be expanded in the flood prone area. The banks were eroded in several places by floods. The recommended flood mitigation plan is the river channel improvement of 16 km in length in the most downstream stretch.

7.4.4 Putatan river channel improvement project

The Moyog river distributes into small channels of small discharge capacity in the south of Kota Kinabalu. The major distributary is the Putatan river causing drainage problem in the surrouning area. The Putatan river inundated 7 sq.km and affected 7,000 people in a flood in 1974.

The recommended flood mitigation plan is river channel improvement of 12 km in length in the town area.

7.5 Hydropower Development Plan

The implementation of the Tenom Pangi, Phase III, is first of all recommended, because the firming-up of power production and increase in the installed capacity will be needed soon after the Tenom Pangi, Phase I/II, is completed in 1984.

The implementation of the Papar dam is urgently needed for the purpose of domestic and industrial water supply in Kota Kinabalu. Papar power, if multipurpose development is justified, should be commissioned in accordance with the program for Kota Kinabalu water supply.

Further hydropower will be developed either in the Padas river basin or in the Pensiangan river basin. A run-of-river development below the Pangi power station and thereafter a storage development in the Pensiangan for the supply to Kota Kinabalu are herein assumed. It is noted that this schedule is only a provisional assumption to be elaborated based on further study.

The recommended hydropower development plan is as shown in Table 35.

7.6 Cost Estimate

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

The construction costs consist of direct construction cost (contract amount), engineering and administration, land acquisition and physical contingency. The direct construction cost was estimated based on the actual costs and previous estimate for similar projects in Malaysia. Major unit costs assumed are listed in Tables 36 and 37. The engineering and administration costs were assumed to be 10% of the direct construction cost. The physical contingency was assumed to be 30% of the construction costs. The construction cost is disbursed in five years antecedent to the year of commission of the proposed facilities. The construction cost of the untreated rural water supply, however, was assumed to be disbursed in one year exceptionally.

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

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

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

The development expenditure and recurrent expenditure in public sector for the recommended plan was estimated as shown in Tables 38 and 39.

7.7 Beneficial and Adverse Effects

The beneficial and adverse effects of the recommended plans were evaluated from the viewpoints of national economic development, environmental quality and social well-being. The beneficial and adverse effects of the recommended plans comprising each aspect of national economic development, environmental quality and social well-being are presented in Tables 40 and 41 for water demand and supply balance, in Table 42 for water pollution abatement, in Table 43 for flood mitigation and in Table 44 for hydropower development.

7.7.1 National economic development

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

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

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

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

The economic farmgate price of paddy during the evaluation period was estimated to be M$640/ton based on the projected price of 5% broken rice, FOB Bangkok. Estimated paddies yield, gross value, production cost and net value are estimated for 1990 and 2000 as shown in Table 45. The hectarage of newly reclaimed land and upgraded lands from rainfed paddy to irrigated or control drainaged paddies, single crop to double crop and minor scheme to major scheme were estimated for the future. Then the irrigation benefit is obtained as the incremental net production value.

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

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

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

The fish culture benefit was estimated to be M$2,200/ha for the fish pond and M$1.7 million/reservoir for the cage culture in the created reservoir.

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

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

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

7.7.2 Environmental quality

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

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

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

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

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

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

7.7.3 Social well-being

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

8. PLAN UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

8.1 Assumed GDP Growth Rate

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

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

8.2 Parameters Predominantly Related to GDP Per Capita

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

8.3 Assumed Targets

The service factor and per capita daily use (PCDU) in domestic water supply and rate of irrigation development may be affected by the economic growth and by the socio-economic policy as well. It is herein assumed that, in case of the lower economic development, the target service factor and PCDU in domestic water supply for 2000 is delayed by five years but the rate of irrigation development does not change even under the lower economic development. The estimated service factor and PCDU under the condition of lower economic growth are shown in Table 46. The domestic and industrial water demand estimated under the condition of lower economic growth is shown in Tables 47 and 48.

8.4 Development Plan

The development plan under the condition of lower economic growth is tabulated in Tables 49 through 56.

8.5 Public Expenditure

The public development and recurrent expenditures are estimated for the case of lower economic growth as shown in Tables 57 and 58.

8.6 Beneficial and Adverse Effects

The beneficial and adverse effects of the water resources development and use plan for the case of lower economic growth are summarized in Tables 59 through 62.

TABLES

Table 1 METEOROLOGICAL DATA IN SABAH

Station	Month	Air Temperature (°C) Max.	Min.	Mean	Relative Humidity (%)	Daily Sunshine (hrs.)	Pan Evaporation (mm)	Rainfall (mm)
Kota Kinabalu								
	Jan.	29.6	22.7	25.8	83.3	6.3	148	143
	Feb.	29.8	22.7	26.0	82.9	7.0	145	68
	Mar.	30.7	23.2	26.7	81.1	7.5	175	73
	Apr.	31.5	23.9	27.3	80.7	8.2	179	99
	May	31.6	24.1	27.4	80.6	7.4	177	204
	June	31.2	23.8	27.1	80.2	6.6	165	306
	July	31.0	23.6	26.9	79.9	6.6	167	260
	Aug.	31.1	23.6	26.9	79.2	6.3	167	239
	Sep.	30.8	23.5	26.7	81.2	6.1	156	294
	Oct.	30.6	23.5	26.6	82.7	6.1	162	349
	Nov.	30.4	23.4	26.4	83.3	6.4	145	282
	Dec.	30.3	23.2	26.3	83.1	6.2	148	242
	Annual	30.7	23.4	26.7	81.5	6.7	1,933	2,559
Sandakan								
	Jan.	29.3	22.9	26.2	85.2	5.3	109	541
	Feb.	29.6	22.8	26.3	83.9	5.9	108	487
	Mar.	30.5	23.1	26.9	82.4	7.1	131	262
	Apr.	31.5	23.4	27.5	82.9	8.0	147	158
	May	32.4	23.4	27.5	83.9	8.1	161	252
	June	32.1	23.1	27.2	84.5	6.7	139	268
	July	32.3	22.8	27.1	83.7	7.0	141	242
	Aug.	32.2	22.8	26.9	84.0	7.0	145	269
	Sep.	32.0	22.9	26.9	85.0	6.3	139	268
	Oct.	31.6	23.0	26.9	85.0	6.0	139	321
	Nov.	30.8	23.0	26.6	86.4	5.6	120	328
	Dec.	29.9	23.1	26.4	87.1	5.0	113	455
	Annual	31.2	23.0	26.9	84.5	6.5	1,593	3,851

Remarks; Temperature, humidity and sunshine data are the average for 13 years (1968 - 1980).
Pan evaporation data are the average for 14 years (1967 - 1980).
Rainfall data are the average for 20 years (1960 - 1980).

Table 2 RIVER CHARACTERISTICS IN SABAH (1/2)

Basin No.	Item	Description
211	Kinabatangan river	
	(A) River Morphology	Remarkable meanding in the middle and the lower reaches. Bank erosion is still active at the concave of river.
	(B) Estuary	Sand dune along river makes the haul distance of timber vessels longer.
	(C) Sediment	Water contains much mud and fine sand. Sediment yield of 200 m/km/y is adopted.
	(D) Sea Water Intrusion	No survey data available, but water reached at least 50 km from the river mouth. Tidal back water effect was reported at Lamag.
217	Bongan river	
	(A) River Morphology	Rivers are no stable. Meandering/ bank erosions assaulted houses, padi and irrigation facilities.
	(B) Estuary	River mouths are silted up but it seems not affect much to fishermen since activity become less.
	(C) Sediment	S. Bandau, S. Bongon are silted up because of sediment yielded banked erosion and development of road.
	(D) Sea Water Intrusion	S. Langkong, S. Bandau used for domestic water supply observed salt water intrusion. But the salt water intrusion does not affect padi field.

Table 3 RIVER CHARACTERISTICS IN SABAH (2/2)

Basin No.	Item	Description
218	Kadamaian river	
	(A) River Morphology	Bank erosions threaten houses and crop field, river bed is not stable.
	(B) Estuary	River mouth is shifting towards south-west due to sea current.
	(C) Sediment	Sediment situation is deteriorated at S. Kadamayan blue to road construction.
	(D) Salt Water Intrusion	S. Bira-Biraan is affected by salt water intrusion. Tidal gate at S. Bira-Biraan is under planning.
	(E) Flood	Flood assaulted mainly irrigation scheme. Flood damage on Jan. 1981 amounted M$130,000 to irrigation scheme and crops.
	(F) Other Items	Adjustment of river gradient by means of sabo dam at Kg. Rangalau or up-stream of the irrigation intake be considered.
224	Padas river	
	(A) River Morphology	Heavy meanderings exist in the down-stream reach and upstream of the confluence of S. Padas and S. Pegalan. Banks are eroded near Beaufort. DOA's Pumping station at Cocoa Research Station, Tenom was washed away due to bank erosion.
	(B) Sediment	Bolders and gravel are deposited at the river bed, which accelerates bank erosion.
	(C) Sea Water Intrusion	Salt water intrusion has not investi-gated yet. The most downstream intake is just downstream of Beaufort town.

Table 4 PWD WATER SUPPLY IN SABAH IN 1980

Water Works	Type of Supply /1	Design Capacity (m^3/d)	Estimated Served Popu- lation	Water Delivered (m^3/d)	Daily Per Capita Supply (lpcd)	No. of Connec- tion
Kota Kinabalu	R.A.B.D.	45,500	118,991	42,725	359	19,049
Sandakan	R.H.A.B.D.	20,475	64,709	20,475	316	10,641
Tawau	R.A.B.D.	13,650	35,245	13,332	378	6,640
Labuan	H.A.B.D.	9,100	14,928	5,005	335	2,379
Papar	R.A.B.D.	2,275	14,616	1,638	112	2,436
Lahad Datu	R.A.B.D.	4,550	11,076	2,503	226	1,651
Keningau	R.A.B.D.	1,365	8,618	1,775	206	1,082
Semporna	W.R.A.B.D.	3,413	5,350	1,684	315	775
Ranau	R.A.B.D.	683	5,213	1,047	201	728
Kota Belud	W.D.	2,730	7,245	1,729	239	1,505
Kudat	I.A.C.D.	3,276	7,526	2,594	345	1,416
Urban Total		107,017	293,517	94,507	322	48,302
Tamparuli	R.A.B.D.	3,185	7,954	3,640	458	1,337
Beaufort	R.S.A.B.D.	1,638	11,316	2,230	197	1,589
Tenom	R.S.A.B.D.	1,638	5,507	956	174	704
Sipitang/Mesapol	R.A.B.D.	455	2,990	455	152	481
Westom/Lingungan	R.A.B.D.	728	1,326	228	172	175
Tuaran	R.A.C.D.	2,275	6,082	1,047	172	941
Kuala Penyu	H.A.D.	455	1,000	137	137	200
Kunak	S.C.D.	455	1,787	319	179	320
Membakut	R.A.C.D.	2,275	4,725	319	68	748
Tambunan	R.A.C.D.	546	4,029	319	79	665
Nabawan	R.B.D.	546	722	137	190	263
Bingkor	R.A.B.D.	1,138	2,188	728	333	420
Kota Marudu	R.A.B.D.	1,138	1,512	546	361	301
Beluran	R.A.B.D.	1,138	480	46	96	80
Rural Total		17,610	51,618	11,107	215	8,224
Total		124,627	345,135	105,614	306	56,526

Remarks; /1 : Type of Supply
A - Coagulation & Sedimentation
B - Rapid Gravity Filters
C - Pressure Filters
D - Chlorination
S - Spring
W - Well
I - Impounded Reservoir
R - River
H - Boreholes

Source; PWD Headquarters, Kota Kinabalu, Sabah State

Table 5 FLOODED AREA BY RECORDED MAXIMUM FLOOD IN SABAH

Basin No.	River Basin	Year	Flooded Area (km^2)	Population 1980 (10^3)	Estimated Damage at 1980 Condition (M$$10^3$)
201	Pensiangan	1981	67	1	41
207	Tawau	1981	18	6	678
210	Segama	1981	255	5	618
211	Kinabatangan	1981	1,032	6	677
212	Segaliud	1977	9	6	593
213	Labuk	1976	259	4	122
214	Sugut	1981	162	0	14
216	Bengkoka	1981	44	0	21
217	Bongan	1977	369	21	556
218	Kadamaian	1977	63	9	2,352
219	Tuaran	1981	35	4	401
220	Putatan	1981	7	7	653
221	Papar	1967	23	7	873
222	Kimanis	1981	14	1	250
224	Padas	1981	352	5	835
	Total		2,709	82	8,684

Table 6 LIST OF EXISTING AND PLANNED DAMS IN SABAH

Name	River	Purpose/Year of Commission	Organization	Catchment Area(km^2)	Active Storage Capacity (10^6 m^3)	Net Supply Capacity (10^3 m^3/d)
Existing						
Kudat rain storage reservoir	Bongan	WS	PWD	-	2.73	4.55
Under Construction						
Timbangan dam	Kalumpang	WS/1983	PWD	27.7	0.82	9.12
Sepagaya dam	Silibukan	WS/1984	PWD	23.2	1.91	9.12
Tenom weir	Padas	HY: 66MW/1984	SEB	7,815	4.7	-
Under Detailed Design						
Bukit Kuda dam	Labuan	WS	PWD	0.2	3.64)	12.29 by 3 dams
Kerupang dam	Labuan	WS	PWD	0.5	0.28)	
Pagar dam	Labuan	WS	PWD	0.8	0.36)	
Under Planning						
Balat dam	Kinabatangan	FM, HY: 34MW	(DID)	10,730	5,000	-
Meliau dam	Labuk	WS	PWD	58	18	-
Sook dam	Padas	HY: 35MW	SEB	1,770	400	-
Papar dam	Papar	HY: 45MW	SEB	350	-	-

Remarks; WS: Domestic and industrial water supply
FM: Flood Mitigation
HY: Hydropower

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

Unit: 10^3

District		City/Rural	Historical 1980	Projected 1985	Projected 1990	Projected 2000	Average Annual Growth(%) 1980-2000
201. Pensiangan		Rural	9	10	11	12	1.4
202. Tawau	201.	Tawau	50	62	82	150	5.6
		Rural	82	101	122	140	2.7
		Total	132	163	204	290	4.0
203. Semporna	202.	Semporna	6	7	9	15	4.7
		Rural	56	70	85	101	3.0
		Total	62	77	94	116	3.2
204. Lahad Datu	203.	Lahad Datu	18	26	38	84	8.0
		Rural	41	47	53	59	1.8
		Total	59	73	91	143	4.5
205. Kinabatangan		Rural	29	35	41	47	2.4
206. Sandakan	204.	Sandakan	81	99	127	222	5.2
		Rural	49	54	58	62	1.2
		Total	130	153	185	284	4.0
207. Labuk/Sugut		Rural	36	38	39	41	0.7
208. Pitas		Rural	19	20	22	23	1.0
209. Kudat	206.	Kudat	12	16	21	43	6.6
		Rural	34	35	37	38	0.6
		Total	46	51	58	81	2.9
210. Kota Marudu		Rural	31	33	36	38	1.0
211. Kota Belud	207.	Kota Belud	5	7	9	18	6.6
		Rural	46	49	52	54	0.8
		Total	51	56	61	72	1.7
212. Ranau	205.	Ranau	5	7	9	19	6.9
		Rural	29	31	33	34	0.8
		Total	34	38	42	53	2.2
213. Tuaran		Rural	55	58	61	63	0.7
214. Kota Kinabalu	208.	Kota Kinabalu	71	97	134	271	6.9
		Rural	53	68	85	103	3.4
		Total	124	165	219	374	5.7
215. Penampang		Rural	43	48	53	58	1.5
216. Papar	209.	Papar	6	8	12	25	7.4
		Rural	40	42	43	44	0.5
		Total	46	50	55	69	2.0
217. Tambunan		Rural	16	18	18	19	0.9
218. Keningau	210.	Keningau	5	6	8	16	6.0
		Rural	43	49	56	62	1.8
		Total	48	55	64	78	2.5
219. Kuala Penyu		Rural	14	15	15	16	0.7
220. Beaufort		Rural	41	43	44	46	0.6
221. Tenom		Rural	30	32	33	34	0.6
222. Sipitang		Rural	14	14	15	16	0.7
223. Labuan	211.	Labuan	19	29	41	93	8.3
		Rural	10	11	11	12	0.9
		Total	29	40	52	105	6.6
		Urban Total	278	364	490	956	6.4
		Rural Total	820	921	1023	1122	1.6
		State Total	1098	1285	1513	2078	3.2

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

Unit: M$$10^6$

Item	Year 1980	1985	1990	2000
Food	59	99	145	1,023
Textile	1	2	2	17
Wood	33	55	80	564
Paper	0	0	0	0
Publishing	9	15	22	158
Chemical	23	74	173	1,016
Rubber	7	12	17	119
Non-metal	2	3	4	28
Basic metal	0	43	145	763
Machinery	14	23	34	238
Others	7	11	16	114
Total	155	337	638	4,040

Remarks; In factor cost at 1970 prices

Table 9 BASIN AREA AND ASSUMED RIVER MAINTENANCE FLOW IN SABAH

Basin No.	Basin	Total Catchment Area (km^2)	Effective Catchment Area (km^2)	Balance Point (km)	River Maintenance Flow (m^3/s)
201	Pensiangan	5,971	5,971	0	75.9
202	Serudong	1,308	1,155	11	10.3
203	Kalabakan	1,371	1,288	13	12.4
204	Brantian	741	678	10	5.9
205	Umas Umas	553	408	5	3.3
206	Merutai Besar	558	473	5	4.2
207	Tawau	888	683	10	7.2
208	Kalumpang	2,792	2,284	5	23.5
209	Silibukan	2,714	2,154	5	30.4
210	Segama	5,558	4,787	35	63.2
211	Kinabatangan	16,755	15,752	52	74.7
212	Segaliud	2,335	1,632	8	22.5
213	Labuk	6,829	5,969	15	86.0
214	Sugut	3,094	2,826	35	40.4
215	Paitan	1,474	1,086	10	17.3
216	Bengkoka	1,866	1,463	4	6.8
217	Bongan	2,126	1,823	1	7.7
218	Kadamaian	1,336	1,171	5	7.3
219	Tuaran	1,247	1,139	6	7.8
220	Putatan	629	494	3	2.9
221	Papar	805	785	3	4.8
222	Kimanis	607	547	3	3.2
223	Membakut	736	338	12	1.9
224	Padas	9,180	8,475	27	57.2
225	Labuan	86	46	2	0.3
226	Lakutan	1,291	1,173	5	6.1
	Total	72,850	64,600		

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

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

Item	Service Factor (%)				Per Capita Daily Use (lpcd)			
	Estimated	Projectd			Estimated	Projected		
	1980	1985	1990	2000	1980	1985	1990	2000
1. Urban Area								
201 Tawau	71	80	85	100	188	189	190	230
202 Semporna	89	90	95	100	136	138	140	220
203 Lahad Datu	61	70	80	100	135	163	190	220
204 Sandakan	80	85	90	100	139	170	200	230
205 Kudat	63	70	80	100	134	162	190	220
206 Kota Belud	100	100	100	100	106	123	140	220
207 Ranau	100	100	100	100	123	132	140	220
208 Kota Kinabalu	100	100	100	100	190	195	200	230
209 Papar	100	100	100	100	67	129	190	220
210 Keningan	100	100	100	100	124	132	140	220
211 Labuan	79	85	90	100	183	187	190	220
2. Rural Area								
PWD Area	7	16	23	35	75	100	125	175
MOH Area	19	23	35	53	40	45	55	70
3. Non-pipe-served Area	-	-	-	-	40	40	40	40

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

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

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

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

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

Table 12 ESTIMATED AND PROJECTED D&I WATER DEMAND BY BASIN IN SABAH (1/2)

Unit: 10^6 m^3/y

Basin No.	City/Rural	Estimated 1980	Projected 1985			1990			2000		
		D&I	D	I	Total	D	I	Total	D	I	Total
201	Rural	0.3	0.3	0.0	0.3	0.3	0.0	0.3	0.6	0.0	0.6
202	Rural	0.4	0.4	0.0	0.4	0.7	0.0	0.7	1.1	0.0	1.1
203	Rural	0.4	0.5	0.0	0.5	0.8	0.0	0.8	1.4	0.0	1.4
204	Rural	0.1	0.3	0.0	0.3	0.4	0.0	0.4	0.8	0.0	0.8
205	Rural	0.1	0.3	0.0	0.3	0.3	0.0	0.3	0.6	0.0	0.6
206	Rural	0.1	0.3	0.0	0.3	0.3	0.0	0.3	0.6	0.1	0.7
207	201 Tawau	5.5	5.9	1.1	7.0	6.6	1.3	7.9	16.6	9.2	25.8
	Rural	0.7	0.4	0.6	1.0	0.5	0.6	1.1	0.8	0.7	1.5
	Basin Total	6.2	6.3	1.7	8.0	7.1	1.9	9.0	17.4	9.9	27.3
208	202 Semporna	0.6	0.5	0.1	0.6	0.6	0.1	0.7	1.6	0.9	2.5
	Rural	1.8	2.2	0.1	2.3	3.1	0.1	3.2	5.7	0.1	5.8
	Basin Total	2.4	2.7	0.2	2.9	3.7	0.2	3.9	7.3	1.0	8.3
209	203 Lahad Datu	1.1	1.9	0.4	2.3	2.9	0.7	3.6	8.9	5.1	14.0
	Rural	0.4	0.4	0.1	0.5	0.5	0.1	0.6	0.8	0.3	1.1
	Basin Total	1.5	2.3	0.5	2.8	3.4	0.8	4.2	9.7	5.4	15.1
210	Rural	0.6	0.7	0.1	0.8	0.9	0.1	1.0	1.6	0.1	1.7
211	Rural	0.8	1.0	0.0	1.0	1.3	0.0	1.3	2.4	0.0	2.4
212	204 Sandakan	8.8	8.3	2.5	10.8	11.2	3.7	14.9	24.5	25.7	50.2
	Rural	1.1	1.1	0.2	1.3	1.5	0.3	1.8	2.6	0.3	2.9
	Basin Total	9.9	9.4	2.7	12.1	12.7	4.0	16.7	27.1	26.0	53.1
213	205 Ranau	0.4	0.5	0.1	0.6	0.6	0.3	0.9	2.0	1.6	3.6
	Rural	1.2	1.1	0.2	1.3	1.5	0.2	1.7	2.3	0.4	2.7
	Basin Total	1.6	1.6	0.3	1.9	2.1	0.5	2.6	4.3	2.0	6.3
214	Rural	0.4	0.4	0.0	0.4	0.6	0.0	0.6	1.0	0.0	1.0
215	Rural	0.1	0.1	0.0	0.1	0.3	0.0	0.3	0.4	0.0	0.4
216	Rural	0.5	0.7	0.0	0.7	0.9	0.0	0.9	1.4	0.0	1.4
217	206 Kudat	1.3	1.1	0.4	1.5	1.6	0.5	2.1	4.5	3.6	8.1
	Rural	1.1	1.5	0.1	1.6	1.8	0.1	1.9	3.1	0.4	3.5
	Basin Total	2.4	2.6	0.5	3.1	3.4	0.6	4.0	7.6	4.0	11.6
218	207 Kota Belud	0.8	0.7	0.1	0.8	0.7	0.3	1.0	2.1	1.6	3.7
	Rural	0.8	1.1	0.0	1.1	1.5	0.0	1.5	2.3	0.0	2.3
	Basin Total	1.6	1.8	0.1	1.9	2.2	0.3	2.5	4.4	1.6	6.0
219	Rural	2.6	3.3	0.2	3.5	4.4	0.5	4.9	4.8	0.5	5.3
220	208 Kota Kinabalu	16.4	17.2	2.2	19.4	19.9	3.2	23.1	39.7	22.6	62.3
	Rural	0.8	0.8	0.0	0.8	1.0	0.0	1.0	1.9	0.0	1.9
	Basin Total	17.2	18.0	2.2	20.2	20.9	3.2	24.1	41.6	22.6	64.2

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

Table 13 ESTIMATED AND PROJECTED D&I WATER DEMAND BY BASIN IN SABAH (2/2)

Unit: 10^6 m^3/y

Basin No.	City/Rural	Estimated 1980 D&I	Projected 1985 D	1985 I	1985 Total	1990 D	1990 I	1990 Total	2000 D	2000 I	2000 Total
221	209 Papar	0.6	1.3	0.1	1.4	2.0	0.3	2.3	3.7	2.1	5.8
	Rural	0.8	0.9	0.0	0.9	1.1	0.0	1.1	1.9	0.0	1.9
	Basin Total	1.4	2.2	0.1	2.3	3.1	0.3	3.4	5.6	2.1	7.7
222	Rural	0.3	0.4	0.0	0.4	0.4	0.0	0.4	0.6	0.0	0.6
223	Rural	0.6	0.7	0.1	0.8	1.0	0.1	1.1	1.9	0.1	2.0
224	210 Keningau	0.7	0.8	0.1	0.9	0.8	0.1	0.9	2.2	1.4	3.6
	Rural	3.2	4.0	0.1	4.1	4.9	0.3	5.2	9.1	0.7	9.8
	Basin Total	3.9	4.8	0.2	5.0	5.7	0.4	6.1	11.3	2.1	13.4
225	211 Labuan	2.0	2.9	7.6	10.5	3.5	8.9	12.4	9.8	14.0	23.8
	Rural	0.1	0.3	0.0	0.3	0.3	0.0	0.3	0.5	0.0	0.5
	Basin Total	2.1	3.2	7.6	10.8	3.8	8.9	12.7	10.3	14.0	24.3
226	Rural	0.6	0.7	0.0	0.7	0.9	0.0	0.9	1.7	0.0	1.7
Total		58.1	65.0	16.5	81.5	81.6	21.8	103.4	167.5	91.5	259.0

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

Table 14 ESTIMATED AREA OF IRRIGATED PADDY FIELD IN SABAH

Unit: ha

Basin No.	Basin Name	Scheme	1980 Main Season	1980 Off Season	1990 Main Season	1990 Off Season	2000 Main Season	2000 Off Season
201-212	Tawau+	-	-	-	-	-	-	-
213	Labuk	Major/1	-	-	-	-	6000	3000
		Minor	2172	642	2510	690	730	120
214	Sugut	Minor	1068	324	1068	324	1068	324
215	Paitan	-	-	-	-	-	-	-
216	Bengkoka	Minor	238	199	766	617	1256	617
217	Bongan	Minor	1337	568	3406	2219	3406	2219
218	Kadamaian	Minor	5442	2423	6115	3108	6370	3581
219	Tuaran	Minor	1984	1206	1984	1206	1984	1206
220	Putatan	Minor	1419	628	1822	871	1822	871
221	Papar	Minor	2739	2055	3223	2539	3223	2539
222	Kimanis	Minor	60	60	2410	1610	2410	1610
223	Membakut	Minor	145	81	1319	667	1319	667
224	Padas	Minor	2962	1086	6563	2061	8718	2298
225	Labuan	-	-	-	-	-	-	-
226	Lakutan	Minor	1214	648	1214	648	1214	648
	Total		20780	9920	32400	16560	39520	19700

Remarks; /1: Lower Labuk Project. The Trusan Sapi Scheme of 1,780 ha will be incorporated into this project by 2000.

Table 15 ESTIMATED IRRIGATION WATER DEMAND FOR PADDY BY BASIN IN SABAH

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

Basin No.	Basin Name	Scheme	1980	1990	2000
201-212	Tawau	-	-	-	-
213	Labuk	Major	-	0	49
		Minor	29	32	9
214	Sugut	Minor	14	13	13
215	Paitan	-	-	-	-
216	Bengkoka	Minor	6	18	25
217	Bongan	Minor	27	76	76
218	Kadamaian	Minor	110	126	135
219	Tuaran	Minor	45	43	43
220	Putatan	Minor	30	37	37
221	Papar	Minor	36	45	45
222	Kimanis	Minor	1	31	31
223	Membakut	Minor	1	16	16
224	Padas	Minor	56	117	150
225	Labuan	-	-	-	-
226	Lakutan	Minor	15	15	15
	Total		370	569	644

Table 16 RIVER UTILIZATION RATIO BY BASIN IN SABAH FOR 1990 AND 2000

Unit: 10^6 m^3/y

Basin		Surface**	1990				2000			
		Runoff	Demand*			Ratio	Demand*			Ratio
No.	Name	(1)	D&I	Irr.	Total (2)	(2)/(1) (%)	D&I	Irr.	Total (2)	(2)/(1) (%)
201	Pensiangan	8,906	0.3	0	0.3	0***	0.6	0	0.6	0
202	Serudong	1,214	0.7	0	0.7	0	1.1	0	1.1	0.1
203	Kalabakan	1,460	0.8	0	0.8	0	1.4	0	1.4	0
204	Brantian	696	0.4	0	0.4	0	0.8	0	0.8	0.1
205	Umas Umas	393	0.3	0	0.3	0	0.6	0	0.6	0.1
206	Merutai Besar	490	0.3	0	0.3	0	0.7	0	0.7	0.1
207	Tawau	846	9.0	0	9.0	1.1	27.3	0	27.3	3.2
	C201 Tawau	103	8.0	0	8.0	7.8	25.8	0	25.8	25.0
208	Kalumpang	2,754	3.9	0	3.9	0.1	8.3	0	8.3	0.3
	C202 Semporna	80	0.8	0	0.8	1.0	2.6	0	2.6	3.3
209	Silibukan	3,566	4.2	0	4.2	0.1	15.1	0	15.1	0.4
	C203 Lahad Datu	162	3.5	0	3.5	2.2	14.1	0	14.2	8.7
210	Segama	7,447	1.0	0	1.0	0	1.7	0	1.7	0
211	Kinabatangan	20,988	1.3	0	1.3	0	2.4	0	2.4	0
212	Segaliud	3,714	16.7	0	16.7	0.4	53.1	0	53.1	1.4
	C204 Sandakan	82	14.8	0	14.8	18.0	50.1	0	50.1	61.1
213	Labuk	14,253	2.6	30	32.6	0.2	6.3	56	62.3	0.4
	C205 Ranau	344	0.8	9	9.8	2.8	3.6	9	12.6	3.7
214	Sugut	6,699	0.6	13	13.6	0.2	1.0	13	14.0	0.2
215	Paitan	2,850	0.3	0	0.3	0	0.4	0	0.4	0
216	Bengkoka	1,855	0.9	20	20.9	1.1	1.5	22	23.5	1.3
	Bengkoka irri-gation	952	0.3	20	20.3	2.1	0.7	22	22.7	2.4
217	Bongan	2,097	4.0	76	80.0	3.8	11.6	76	87.6	4.2
	C206 Kudat	80	2.2	0	2.2	2.8	8.1	0	8.1	10.1
	Minor irrigation	1,209	2.0	52	54.0	4.5	3.3	52	55.3	4.6
218	Kadamaian	1,985	2.5	126	128.5	6.5	6.0	135	141.0	7.1
	C207 Kota Belud	1,378	0.9	126	126.9	9.2	3.7	135	138.7	10.1
219	Tuaran	2,224	4.9	43	47.9	2.2	5.3	43	48.3	2.2
	Minor irrigation	1,464	1.3	43	44.3	3.0	2.0	43	45.0	3.1
220	Putatan	905	24.1	37	61.1	6.8	64.2	37	101.2	11.2
	C208 Kota Kina-balu	357	23.1	37	60.1	16.8	62.3	37	99.3	27.8
221	Papar	1,489	3.4	45	48.4	3.3	7.7	45	52.7	3.5
	C209 Papar	1,461	2.2	45	47.2	3.2	5.9	45	50.9	3.5
222	Kimanis	991	0.4	31	31.4	3.2	0.6	31	31.6	3.2
223	Membakut	598	1.1	16	17.1	2.9	2.0	16	18.0	3.0
224	Padas	8,708	6.1	117	123.1	1.4	13.4	150	163.4	1.9
	C210 Keningau	1,825	1.0	110	111.0	6.1	3.6	147	150.6	8.3
	Tambuan	538	0.7	23	23.7	4.4	1.5	45	46.5	8.6
225	C211 Labuan	96	12.4	0	12.4	12.9	23.8	0	23.8	24.8
226	Lakutan	1,879	0.9	15	15.9	0.8	1.7	15	16.7	0.9

Remarks; *: Source demand.
**: Surface runoff in effective area.
***: The ratio of less than 0.1% was assumed to be zero.

Table 17 ANNUAL DEFICITY BY BASIN IN SABAH FOR 1990 AND 2000

Unit: 10^6 m^3/y

Basin No.	Name of Sub-basin	Drought Level 1/N Deficit	1/N Year	2/N Deficit	2/N Year	3/N Deficit	3/N Year	4/N Deficit	4/N Year	5/N Deficit	5/N Year
1990											
207	Tawau	7.8	1973	1.5	1969	1.4	1968	0.8	1971	0.6	1977
218	Kota Belud	51.1	1973	31.4	1969	7.6	1966	3.8	1970	3.7	1975
219	Tuaran	9.9	1969	2.3	1975	1.8	1973	1.4	1967	1.3	1968
220	Kota Kinabalu	14.0	1973	8.7	1969	6.8	1966	4.8	1968	4.0	1965
221	Papar	12.1	1973	1.8	1969	1.4	1976	0.6	1968	0.5	1965
2000											
207	Tawau	15.3	1973	7.9	1969	5.6	1972	5.5	1971	5.1	1968
218	Kota Belud	54.5	1973	34.6	1969	8.9	1966	4.9	1975	4.8	1970
219	Tuaran	10.0	1969	2.3	1975	1.8	1973	1.4	1967	1.3	1968
220	Kota Kinabalu	23.7	1973	16.7	1969	12.4	1968	11.2	1965	10.6	1966
221	Papar	12.4	1973	1.9	1969	1.4	1976	0.7	1968	0.5	1965

Table 18 ASSUMED DEVELOPMENT OF LAND DISPOSAL IN PALM OIL MILLS AND RUBBER FACTORIES IN SABAH

Unit: %

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

Table 19 DISCHARGE RATIO, RUNOFF RATIO, INFILTRATION RATIO AND BOD CONCENTRATION OF EFFLUENT ASSUMED UNDER PRESENT PURIFICATION LEVEL IN SABAH

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

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

Table 20 PROPOSED FLOOD FORECASTING AND WARNING SYSTEM IN SABAH

Basin No.	River Basin	People Rel'ved by F/F (10^3)	Construction Cost (M\$$10^6$)	Construction Period
207	Tawau	8.5	2.4	6MP
210	Segama	3.5	4.1	7MP
211	Kinabatangan	4.3	4.2	4MP
217	Bongan	12.7	3.0	5MP
218	Kadamaian	6.5	2.2	6MP
221	Papar	14.2	2.1	5MP
224	Padas	3.0	5.4	7MP
Total		52.7	23.4	

Table 21 RIVER UTILIZATION RATIO BY SUB-BASIN IN SABAH

Unit: 10^6 m^3

Basin No.	Sub-Basin	C.A. (km^2)	Run-off	1990 Demand D&I	1990 Demand Irri.	1990 Utiliza-tion Ratio (%)	2000 Demand D&I	2000 Demand Irri.	2000 Utiliza-tion Ration (%)
207	Tawau	83	103	8	-	8	26	-	25
212	Sandakan	36	82	15	-	18	50	-	61
217	Kudat	70	80	2	-	3	8	-	10
218	Wariu	813	1,378	1	126	9	4	135	10
220	Moyog	195	357	23	37	17	62	37	28
225	Labuan	46	96	15	-	15	67	-	70

Remarks; C.A.: Catchment Area
D&I : Domestic and industrial water
Irri: Irrigation

Table 22 WATER SOURCE DEVELOPMENT PLANS FOR ALTERNATIVE B1 IN SABAH

Problem Basin No.	Facilities	Purpose	Catch-ment Area (km^2)	Active Storage Capacity (10^6m^3)	Net Supply Capacity ($10^6m^3/y$)	Construc-tion Cost (M10^6)	Construc-tion Period
207	Tawau dam	WS	38	7	21	88.7	1987-1991
212	Meliau diversion	WS	58	-			
	-Pipeline -1	WS		-	(8)	133.0	1983-1987
	-Pipeline -2	WS		-	(20)	223.0	1986-1990
	-Pipeline -3	WS		-	(20)	223.0	1991-1995
212	Meliau dam	WS	58	17	48	149.8	1986-1990
217	Milau diversion	WS	70	-	(12)	14.6	1983-1987
217	Milau dam	WS	70	5	12	8.3	1987-1991
218	Wariu dam	IR,WS	123	25	65	269.3	1985-1989
220	Papar diversion	WS	353	-	(62)	41.0	1985-1989
220	Papar dam	IR,WS	353	25	58	71.3	1985-1989
225	Padas diversion	WS					
	-Pipeline -1	WS	-	-	(10)	153.3	1983-1987
	-Pipeline -2	WS	-	-	(10)	153.3	1988-1992

Remarks; WS: Water Supply
IR: Irrigation
( ): Pipeline Capacity

Table 23 WATER SOURCE DEVELOPMENT PLANS FOR ALTERNATIVE B2 IN SABAH

Problem Basin No.	Facilities	Purpose	Catch-ment Area (km^2)	Active Storage Capacity (10^6m^3)	Net Supply Capacity ($10^6m^3/y$)	Construc-tion Cost (M$$10^6$)	Construc-tion Period
207	Tawau dam	WS	38	4	12	56.8	1987-1991
212	Meliau diversion	WS	58				
	-Pipeline -1	WS		-	(8)	133.0	1983-1987
	-Pipeline -2	WS		-	(20)	223.0	1986-1990
	-Pipeline -3	WS		-	(20)	223.0	1991-1995
212	Meliau dam	WS	58	17	48	149.8	1986-1990
217	Milau diversion	WS	70	-	(12)	14.6	1983-1987
217	Milau dam	WS	70	5	12	8.3	1987-1991
218	Wariu dam	IR,WS	123	17	42	178.7	1985-1989
220	Papar diversion	WS	353	-	(62)	41.0	1985-1989
220	Papar dam	IR,WS	353	15	35	66.7	1985-1989
225	Padas diversion	WS					
	-Pipeline -1	WS	-	-	(10)	153.3	1983-1987
	-Pipeline -2	WS	-	-	(10	153.3	1988-1992

Remarks; WS: Water Supply
IR: Irrigation
( ): Pipeline Capacity

Table 24 WATER SOURCE DEVELOPMENT PLANS FOR ALTERNATIVE B3 IN SABAH

Problem Basin No.	Facilities	Purpose	Catch-ment Area (km^2)	Active Storage Capacity (10^6m^3)	Net Supply Capacity ($10^6m^3/y$)	Construc-tion Cost (M$$10^6$)	Construc-tion Period
207	Merotai Kanan diversion	WS	84	-	9	29.2	1987-1991
212	Meliau diversion	WS	58				
	-Pipeline -1			-	(8)	133.0	1983-1987
	-Pipeline -2			-	(20)	223.0	1986-1990
	-Pipeline -3			-	(20)	223.0	1991-1995
212	Meliau dam	WS	58	17	48	149.8	1986-1990
217	Milau diversion	WS	70	-	(12)	14.6	1983-1987
217	Milau dam	WS	70	5	12	8.3	1987-1991
218	Wariu dam	IR,WS	123	8	10	63.6	1985-1989
220	Papar diversion	WS	353	-	(62)	41.0	1985-1989
220	Papar dam	IR,WS	353	15	35	66.7	1985-1989
225	Padas diversion	WS					
	-Pipeline -1	WS	-	-	(10)	153.3	1983-1987
	-Pipeline -2	WS	-	-	(10)	153.3	1988-1992

Remarks; WS: Water Supply
IR: Irrigation
( ): Pipeline Capacity

Table 25 OUTLINE OF FLOOD MITIGATION PROGRAM BY ALTERNATIVE IN SABAH

Basin No.	Basin	Improved River Length (km)	Bypass Floodway (km)	Protected Population (10^3)	Protected Area (km^2)	Const. Cost ($M\$10^6$)
Alternative F1						
207	Tawau	-	3	17.1	18	8.0
210	Segama	8	-	2.8	10	24.1
213	Labuk	15	-	2.0	26	27.1
217	Bongan	56	-	25.3	315	60.8
218	Kadamaian	15	-	13.0	63	33.3
219	Tuaran	13	-	4.8	35	27.3
220	Putatan	12	-	21.9	7	12.0
221	Papar	17	-	25.0	23	21.3
222	Kimanis	15	-	1.4	14	15.4
224	Padas	16	-	2.7	87	58.4
	Total	167	3	116.0	598	287.7
Alternative F2						
207	Tawau	-	3	17.1	18	8.0
217	Bongan	56	-	25.3	315	60.8
218	Kadamaian	16	-	13.0	63	33.3
220	Putatan	12	-	21.5	7	12.0
	Total	84	3	76.9	403	114.1
Alternative F3						
207	Tawau	-	3	17.1	18	8.0
217	Bongan	5	-	3.1	56	1.1
220	Putatan	12	-	21.9	7	12.0
	Total	17	3	42.1	81	21.1

Remarks; Protected population: in 2000

Table 26 ALTERNATIVE HYDROPOWER DEVELOPMENT PLAN IN SABAH

Name	Dam Catchment Area (km^2)	Active Storage Capacity (10^6 m^3)	Installed Capacity (MW)	Annual Energy Output (GWh)	Construction Cost (M$$10^6$)
Tenom Pangi Stage III	(Sook) 1,770	480	84	309	300
Papar Multipurpose	353	147	30	130	180/1
Lower Halogilat	8,200	260	144	989	400/2
Pangi No. 2	(8,000)	-	90/3	547	290
Upper Padas	1,893	300	170	742	870
Pensiangan	5,106	4,342	370	1,639	1,070/4
Sapulut	2,594	2,865	150	1,324	410

Remarks; /1: M$70 x 10^6 for D&I water supply deducted.

/2: Cost for railway relocation not included.

/3: After Tenom Pangi, Stage III completed.

/4: Cost of transmission system to Tawau, Labuan & Sandakan included.

Table 27 RECOMMENDED WATER SUPPLY DEVELOPMENT PLAN FOR CITIES/TOWNS IN SABAH

Basin No.	Code No.	Town	1985 TC	1985 SF	1985 SP	1990 TC	1990 SF	1990 SP	2000 TC	2000 SF	2000 SP
207	201	Tawau	18.7	80	49.6	21.4	85	69.4	63.9	100	149.8
208	202	Semporna	1.8	90	6.3	2.1	95	8.7	6.3	100	15.3
209	203	Lahad Datu	6.0	70	18.2	9.3	80	30.2	34.7	100	83.8
212	204	Sandakan	28.0	85	84.2	38.6	90	114.2	112.4	100	221.6
213	205	Ranau	1.8	100	7.0	2.1	100	9.4	8.4	100	19.1
217	206	Kudat	3.6	70	11.2	5.4	80	17.1	19.0	100	42.6
218	207	Kota Belud	2.4	100	9.0	2.4	100	11.3	8.7	100	20.4
220	208	K. Kinabalu	55.2	100	159.0	64.8	100	210.7	153.7	100	364.1
221	209	Papar	4.2	100	17.0	6.3	100	21.6	14.5	100	35.4
224	210	Keningau	2.7	100	11.0	2.7	100	13.2	8.7	100	22.3
225	211	Labuan	31.3	85	24.7	37.1	90	36.6	71.7	100	93.3
Total			155.7	90	397.2	192.2	93	542.4	502.0	100	1067.7

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

SF: Service factor in %

SP: Served population in 10^3

Table 28 RECOMMENDED TREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN SABAH

Basin No.	Name	1985 TC	SF	SP	1990 TC	SF	SP	2000 TC	SF	SP
201	Pensiangan	0.3	40	1.2	0.3	60	1.9	0.9	90	3.2
202	Serudong	0.3	40	2.1	0.6	60	3.7	1.5	90	6.4
203	Kalabakan	0.3	40	2.5	0.9	60	4.4	2.1	90	7.7
204	Barantian	0.3	40	1.4	0.3	60	2.4	1.2	90	4.2
205	Umas-Umas	0.3	40	1.0	0.3	60	1.8	0.9	90	3.2
206	Merutai Besar	0.3	40	1.0	0.3	60	1.8	0.9	90	3.2
207	Tawau	0.3	40	1.6	0.6	60	2.8	1.2	90	4.9
208	Kalumpang	1.5	40	10.0	3.6	60	18.1	9.0	90	32.0
209	Silibukan	0.3	40	-	0.6	60	2.9	1.2	90	4.8
210	Segama	0.6	40	3.1	0.9	60	5.2	2.4	90	8.6
211	Kinabatangan	0.6	40	4.5	1.5	60	7.8	3.6	90	13.2
212	Segaliud	0.9	40	5.5	1.5	60	8.9	3.9	90	14.2
213	Labuk	0.9	40	5.2	1.5	60	8.0	3.6	90	12.6
214	Sugut	0.3	40	2.2	0.6	60	3.5	1.5	90	5.5
215	Paitan	0.0	40	0.7	0.3	60	1.1	0.6	90	1.8
216	Bengkoka	0.6	40	2.9	0.9	60	4.9	2.1	90	7.9
217	Bongan	1.2	40	6.6	2.1	60	10.5	4.5	90	16.4
218	Kadamaian	0.9	40	5.1	1.5	60	8.1	3.6	90	12.6
219	Tuaran	9.0	40	22.8	13.3	60	36.0	15.4	90	56.1
220	Putatan	0.6	40	3.6	1.2	60	6.1	3.0	90	10.3
221	Papar	0.6	40	4.1	1.2	60	6.4	3.0	90	10.3
222	Kimanis	0.3	40	1.6	0.3	60	2.5	0.9	90	3.8
223	Membakut	1.2	40	2.1	2.4	60	3.1	4.8	90	5.0
224	Padas	8.1	40	38.3	12.4	60	61.4	27.1	90	98.0
225	Labuan	0.3	40	1.2	0.3	60	1.8	0.6	90	2.9
226	Lakutan	1.2	40	1.7	2.1	60	2.6	4.2	90	4.2
Total		31.2	40	132.0	51.5	60	217.7	103.7	90	353.0

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

Table 29 RECOMMENDED UNTREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN SABAH

Basin No.	Name	1985			1990			2000		
		SD	SF	SP	SD	SF	SP	SD	SF	SP
201	Pensiangan	0.1	40	3.3	0.1	60	5.6	0.3	90	9.1
202	Serudong	0.1	40	5.5	0.3	60	9.9	0.6	90	17.4
203	Kalabakan	0.2	40	6.6	0.3	60	11.9	0.7	90	20.8
204	Barantian	0.1	40	3.7	0.2	60	6.5	0.4	90	11.4
205	Umas-Umas	0.1	40	2.7	0.1	60	4.9	0.3	90	8.5
206	Merutai Besar	0.1	40	2.7	0.1	60	4.9	0.3	90	8.5
207	Tawau	0.1	40	4.2	0.2	60	7.5	0.4	90	13.3
208	Kalumpang	0.6	40	27.0	1.2	60	48.9	2.8	90	86.5
209	Silibukan	0.1	40	-	0.2	60	7.8	0.4	90	13.1
210	Segama	0.2	40	8.2	0.4	60	13.9	0.8	90	23.4
211	Kinabatangan	0.3	40	12.1	0.4	60	21.0	1.2	90	35.6
212	Segaliud	0.3	40	14.9	0.6	60	24.0	1.3	90	38.5
213	Labuk	0.3	40	13.9	0.6	60	21.8	1.1	90	34.0
214	Sugut	0.1	40	6.0	0.2	60	9.5	0.4	90	14.7
215	Paitan	0.0	40	2.0	0.1	60	3.1	0.2	90	4.9
216	Bengkoka	0.2	40	8.0	0.3	60	13.1	0.7	90	21.4
217	Bongan	0.4	40	17.7	0.7	60	28.5	1.5	90	44.4
218	Kadamaian	0.3	40	13.7	0.6	60	21.9	1.1	90	34.2
219	Tuaran	0.4	40	0.8	0.7	60	1.3	1.4	90	2.0
220	Putatan	0.2	40	9.8	0.4	60	16.6	0.9	90	27.9
221	Papar	0.3	40	11.0	0.4	60	17.4	0.9	90	27.9
222	Kimanis	0.1	40	4.5	0.2	60	6.6	0.3	90	10.2
223	Membakut	0.1	40	-	0.2	60	-	0.4	90	-
224	Padas	0.8	40	8.3	1.4	60	13.4	2.9	90	21.3
225	Labuan	0.1	40	3.2	0.1	60	4.8	0.3	90	7.9
226	Lakutan	0.1	40	-	0.2	60	-	0.4	90	-
Total		5.7	40	189.8	10.2	60	324.8	22.0	90	536.9

Remarks; SD: Source demand (piped) in the corresponding year in 10^6 m^3/y

SF: Service factor in %

SP: Served population in 10^3

Table 30 RECOMMENDED WATER SOURCE DEVELOPMENT PLAN IN SABAH

Problem Basin No.	Facilities	Purpose	Catch-ment Area (km^2)	Active Storage Capacity (10^6m^3)	Net Supply Capacity ($10^6m^3/y$)	Construc-tion Cost (M$$10^6$)	Construc-tion Period
207	Tawau dam	WS	38	7	21	88.7	1987-1991
212	Meliau diversion	WS	58				
	-Pipeline -1	WS	-	-	(8)	133.0	1983-1987
	-Pipeline -2	WS	-	-	(20)	223.0	1986-1990
	-Pipeline -3	WS	-	-	(20)	223.0	1991-1995
212	Meliau dam	WS	58	17	48	149.8	1986-1990
217	Milau diversion	WS	70	-	(12)	14.6	1983-1987
217	Milau dam	WS	70	5	12	8.3	1987-1991
218	Wariu dam	IR,WS	123	8	10	63.6	1985-1989
220	Papar diversion	WS	353	-	(62)	41.0	1985-1989
220	Papar dam	IR,WS	353	15	35	66.7	1985-1989
225	Padas diversion	WS					
	-Pipeline -1	WS	-	-	(10)	153.3	1983-1987
	-Pipeline -2	WS	-	-	(10)	153.3	1988-1992

Remarks; WS: Water Supply
IR: Irrigation
( ): Pipeline Capacity

Table 31 RECOMMENDED PLAN FOR IMPROVEMENT OF PURIFICATION SYSTEM IN PALM OIL MILLS AND RUBBER FACTORIES IN TREATMENT CAPACITY IN SABAH

Unit: m^3/d

Basin		1981 - 1990			1991 - 2000		
No.	Name	Palm Oil	Rubber	Total	Plam Oil	Rubber	Total
209	Silibukan	0	360	360	0	0	0
217	Bongan	360	0	360	0	0	0
Total		360	360	720	0	0	0

Table 32 ASSUMED PUBLIC SEWERAGE DEVELOPMENT NOT AFFECTING RIVER WATER QUALITY IN SABAH

Basin	City/Town		1990			2000		
No.	No.	Name	Treatment Capacity ($10^3m^3/d$)	Service Factor (%)	Served Population (10^3)	Treatment Capacity ($10^3m^3/d$)	Service Factor (%)	Served Population (103)
207	C201	Tawau	13	70	57	48	80	120
209	C203	Lahad Datu	6	70	27	26	80	67
212	C204	Sandakan	26	75	95	93	80	178
220	C208	Kota Kinabalu	39	75	101	117	80	217
Total			84	0	280	284	-	582

Remarks; There are untreated sewerage systems in C201, C203, C204 and C208.

Table 33 POLLUTION LOAD IN 2000 BY BASIN UNDER WITH-AND-WITHOUT IMPLEMENTATION OF RECOMMENDED PLAN IN SABAH

Basin		Without Project					With Project				
		BOD Load into River (ton/d)				Max. BOD in River	BOD Load into River (ton/d)				Max. BOD in River
No.	Name	PR	UI	RA	Total	(mg/lit)	PR	UI	RA	Total	(mg/lit)
201	Pensiangan	0	0	0	0	0	0	0	0	0	0
202	Serudong	0	0	0	0	0	0	0	0	0	0
203	Kalabakan	0	0	0	0	0	0	0	0	0	0
204	Barantian	0	0	0	0	0	0	0	0	0	0
205	Umas-Umas	0	0	0	0	0	0	0	0	0	0
206	Merutai Besar	2	0	0	2	0	2	0	0	2	0
207	Tawau	0	0	0	0	0	0	0	0	0	0
208	Kalumpuang	0	0	0	0	0	0	0	0	0	0
209	Silibukan	5	0	0	5	4	5	0	0	5	4
210	Segama	0	0	0	0	0	0	0	0	0	0
211	Kinabatangan	0	0	0	0	0	0	0	0	0	0
212	Segaliud	0	0	0	0	0	0	0	0	0	0
213	Labuk	3	0	0	3	1	3	0	0	3	1
214	Sugut	0	0	0	0	0	0	0	0	0	0
215	Paitan	0	0	0	0	0	0	0	0	0	0
216	Bengkoka	0	0	0	0	0	0	0	0	0	0
217	Bongan	2	0	0	2	9	0	0	0	0	0
218	Kadamaian	0	1	0	1	0	0	1	0	1	0
219	Tuaran	0	0	0	0	0	0	0	0	0	0
220	Putatan	0	0	0	0	0	0	0	0	0	0
221	Papar	0	1	0	1	1	0	1	0	1	0
222	Kimanis	0	0	0	0	0	0	0	0	0	0
223	Membakut	0	0	0	0	0	0	0	0	0	0
224	Padas	0	1	0	1	0	0	1	0	1	0
225	Labuan	0	0	0	0	0	0	0	0	0	0
226	Lakutan	0	0	0	0	0	0	0	0	0	0
	Total	12	3	0	15	-	10	3	0	13	-

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

Table 34 RECOMMENDED FLOOD MITIGATION PROGRAM IN SABAH

Basin No.	Basin	Improved River Length (km)	Bypass Floodway (km)	Protected Population (10^3)	Protected Area (km^2)	Constr. Cost (M$$10^6$)
By 1990						
217	Bongan	47	-	21	269	50
By 2000						
207	Tawau	-	3	17	18	8
217	Bongan	56	-	25	315	61
218	Kadamaian	16	-	13	63	33
220	Putatan	12	-	22	7	12
Total		84	3	77	403	114

Remarks; Protected population: in 2000

Table 35 RECOMMENDED HYDROPOWER DEVELOPMENT PLAN IN SABAH

Name	Installed Capacity (MW)	Construction Cost (M$$10^6$)	Construction Period
Tenom Pangi Stage III			
- Sook dam & power	40	150	1985 - 1989
- Pangi extension	44	150	1985 - 1989
Papar Multipurpose	30	180 /1	1985 - 1989
Pangi No. 2	90	290	1989 - 1993
Upper Padas	170	870	1991 - 1995

Remarks; Construction cost at 1980 price.

/1: M$70 x 10^6 for D&I water supply deducted.

Table 36 ASSUMED UNIT CONSTRUCTION COST (1/2)

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

Irrigated paddy	2.5	Urban area class S	100
Rainfed paddy	1.5	Urban area class A	10
Tree crop field class A	1.5	Urban area class B	5
Tree crop field class B	1.0	Village area class A	5
Tree crop field class C	0.5	Village area class B	1
Forest class A	0.5		
Forest class B	0.1		

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

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

Urban	30	Rural	10

3. Civilwork

Dam	M$50-70 per m^3 of embankment volume
Canal	M$60-100 m per m^3/s of discharge capacity
Tunnel	M$180-200/m per m^3/s of discharge capacity
Pipeline	M$1,090-2,180/m per m^3/s of discharge capacity
Barrage/Weir	M$1,450/m per m^3/s 100-y maximum capacity
Pumping station	M$8,500-15,700 m^3/s of discharge capacity

4. River Facilities

Channel improvement (M$$10^6$/km)

200 m^3/s	0.2 - 0.4
500 m^3/s	0.3 - 0.7
1,000 m^3/s	0.4 - 0.9
10,000 m^3/s	1.3 - 3.2

Floodway (M$$10^6$/km)

200 m^3/s	0.2 - 0.6
500 m^3/s	0.4 - 1.0
1,000 m^3/s	0.6 - 1.3
2,000 m^3/s	0.8 - 2.0

Polder

Protection bund	M$170-770 x 10^3/km
Drainage system	M$590 x 10^3/km
Drainage pump	M$170-420 x 10^3 per m^3/s

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

Table 37 ASSUMED UNIT CONSTRUCTION COST (2/2)

5. D&I Water Supply System

Pipeline	M$470/m per m^3/s of discharge capacity
Treatment plant	M$780 per m^3/d of capacity
Distribution system	M$1,430 per m^3/d of capacity

6. Sewerage System M$173 x 10^6 per 100 x 103 m^3/d

7. D&I Pre-treatment System

Aerated lagoon	M$42 x 10^6 per 100 x 10^3 m^3/d
Rapid sandfilter bed	M$123 x 10^6 per 100 x 10^3 m^3/d

8. Power Facilities

Generating equipment

Rated head more than 140 m	M$300-480 per kW
Rated head 20 - 80 m	M$600-970 per kW
Rated less than 30 m	M$1,450-1,690 per kW
Transmission line	M$180-210 x 10^3 per km

9. Irrigation Facilities

From rainfed paddy to irrigated paddy	M$11,370 per ha
From new reclaimed land to irrigated paddy	M$12,300 per ha
From irrigated single cropped paddy to double	M$6,150 per ha
Tertiary development and rehabilitation	M$5,470 per ha
From rainfed to control drainage scheme	M$3,000

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

Table 38 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE OF RECOMMENDED PLAN IN SABAH

Unit: M$$10^6$

Sector	4MP	5MP	6MP	7MP	Total
Source Development	197	827	294	0	1,318
Irrigation	36	119	71	52	278
Inland Fishery	3	3	48	42	96
Public Water Supply	101	331	438	184	1,054
Public Water Supply; Pre-treatment facilities	0	0	0	0	0
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	49	84	83	33	249
Flood Mitigation	26	33	36	43	138
Hydropower	48	519	1,073	0	1,640
Total	460	1,916	2,043	354	4,773

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

Table 39 ESTIMATED ANNUAL RECURRENT EXPENDITURE OF RECOMMENDED PLAN IN SABAH

Unit: M$$10^6$

Sector	4MP	5MP	6MP	7MP	Total
Source Development	0	5	25	33	63
Irrigation	0	3	12	17	32
Inland Fishery	0	0	2	7	9
Public Water Supply	0	21	61	98	180
Public Water Supply; Pre-treatment facilities	0	0	0	0	0
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	0	17	33	47	97
Flood Mitigation	0	4	10	14	28
Hydropower	0	2	15	41	58
Total	0	52	158	257	467

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

Table 40 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER DEMAND AND SUPPLY BALANCE IN SABAH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Irrigation	(M$ 10^6)	18
D&I water supply	(M$ 10^6)	98
Fish culture	(M$ 10^6)	4
Reservoir recreation	(M$ 10^6)	3
Total	(M$ 10^6)	123
1.2 Economic Cost		
Irrigation	(M$ 10^6)	10
D&I water supply	(M$ 10^6)	58
Fish culture	(M$ 10^6)	4
Dams, barrages & diversion facilities	(M$ 10^6)	39
Total	(M$ 10^6)	111
1.3 EIRR	(%)	9
2. Environmental Quality		
2.1 Beneficial Effect		
Safe maintenance flow period (2000)		See Table
Surface area of lake created	(km^2)	10
2.2 Adverse Effect		
Possible reduction in kind of fish immediately downstream of dams and barrages	(nos. of site)	5
3. Social Well-being		
3.1 Beneficial Effect		
Number of farm households benefited by proposed irrigation in 2000	(10^3)	13
Number of people served by proposed public water supply in 2000	(10^3)	1,958
Safe supply period (2000)		See Table
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^2)	20

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

Table 41 SAFE SUPPLY PERIOD AND SAFE RIVER MAINTENANCE FLOW PERIOD IN 2000 WITH RECOMMENDED PLAN IMPLEMENTED IN SABAH

Unit: days

Basin No.	Basin Name	Safe Supply Period		Safe Maintenance Flow Period	
		Plan Implemented	Natural Flow	Plan Implemented	Natural Flow
207	Tawau	365	254	365	244
218	Kadamaian	298	265	290	260
221	Papar	350	330	330	296

Remarks; Natural Flow: Natural flow only is depended upon, with neither existing nor proposed facilities.

Table 42 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER POLLUTION ABATEMENT IN SABAH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Sewerage	($M\$10^6$)	6
Saving in pre-treatment for D&I water supply	($M\$10^6$)	0
Total	($M\$10^6$)	6
1.2 Economic Cost		
Sewerage	($M\$10^6$)	13
Private purification facilities	($M\$10^6$)	0
Pre-treatment for D&I water supply	($M\$10^6$)	0
Total	($M\$10^6$)	13
2. Environmental Quality		
2.1 Beneficial Effects		
Length of river stretch where BOD concentration is not more than 10 mg/lit in 2000 compared with without project condition (Study length = 1,600 km)	(km)	1,600/1,580 /1
Length of river stretch where BOD concentration is not more than 5 mg/lit in 2000 compared with without project condition (Study length = 1,600 km)	(km)	1,600/1,580 /1
2.2 Adverse Effect		-
3. Social Well-Being		
3.1 Beneficial Effects		
Number of people served by proposed sewerage system in 2000	(10^3)	582
3.2 Adverse Effect		-

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

Table 43 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR FLOOD MITIGATION IN SABAH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Damage reduction	(M$ 10^6)	3.4
1.2 Economic Cost		
Flood mitigation work	(M$ 10^6)	4.1
1.3 EIRR	(%)	7.1
2. Environmental Quality		
2.1 Beneficial Effect		
Length of improved stretch	(km)	87
2.2 Adverse Effect		-
3. Social Well-being		
3.1 Beneficial Effect		
Number of protected people by proposed facilities in 2000	(10^3)	77
Population served by proposed flood warning system in 2000	(10^3)	53
Area relieved from flood hazards	(10^3 ha)	40
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	9

Table 44 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR HYDROPOWER DEVELOPMENT IN SABAH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Power generation	(M$$10^6$)	101
1.2 Economic Cost		
Dam & power facilities	(M$$10^6$)	40
1.3 EIRR	(%)	16
2. Environmental Quality		
2.1 Beneficial Effect		
Surface area of lake created	(km^2)	43
2.2 Adverse Effect		
Possible reduction in kind of fish in immediately downstream of dam	(nos. of site)	4
3. Social Well-being		
3.1 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	4

Remarks; Economic benefit other than power generation benefit is not shown here, but included in the water demand and supply account.

Table 45 SUMMARY OF FUTURE ECONOMIC NET VALUE OF WET PADDY BY TYPE OF SCHEME IN SABAH

	Yield (ton/ha)	Unit Price (M$/ton)	Gross Value (M$/ha)	Production Cost (M$/ha)	Net Value (M$/ha)
(1) Major Irrigation Scheme (Lower Labuk)					
Double cropping	8.4	640	5,376	1,674	3,702
Single cropping	3.8	640	2,432	807	1,625
(2) Minor Irrigation Scheme					
Double cropping	7.7	640	4,928	839	1,849
Single cropping	3.5	640	2,240	782	1,458
(3) Rainfed Scheme					
Single cropping	2.0	640	1,280	609	671

Table 46 ESTIMATED AND PROJECTED SERVICE FACTOR AND PER CAPITA DAILY USE OF DOMESTIC WATER IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

	Service Factor (%)				Per Capita Daily Use (lpcd)			
	Estimated	Projected			Estimated	Projected		
Item	1980	1985	1990	2000	1980	1985	1990	2000
1. Urban Area								
201 Tawau	71	75	85	90	188	188	190	220
202 Semporna	89	90	95	100	136	136	140	210
203 Lahad Datu	61	70	75	90	135	160	185	210
204 Sandakan	80	85	90	95	139	167	195	220
205 Kudat	63	70	80	95	134	160	185	210
206 Kota Belud	100	100	100	100	106	118	130	210
207 Ranau	100	100	100	100	123	127	130	210
208 Kota Kinabalu	100	100	100	100	190	193	195	220
209 Papar	100	100	100	100	67	126	185	210
210 Keningan	100	100	100	100	124	127	130	210
211 Labuan	79	85	90	95	183	184	185	210
2. Rural Area								
PWD Area	7	16	19	29	75	95	115	155
MOH Area	19	20	31	47	40	45	55	65
3. Non-pipe-served Area	-	-	-	-	40	40	40	40

Table 47 ESTIMATED AND PROJECTED D&I WATER DEMAND BY BASIN IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH (1/2)

Unit: 10^6 m^3/y

Basin No.	City/Rural	Estimated 1980 D&I	Projected 1985 D	I	Total	1990 D	I	Total	2000 D	I	Total
201	Rural	0.3	0.3	0.0	0.3	0.3	0.0	0.3	0.6	0.0	0.6
202	Rural	0.4	0.4	0.0	0.4	0.6	0.0	0.6	1.1	0.0	1.1
203	Rural	0.4	0.6	0.0	0.6	0.7	0.0	0.7	1.5	0.0	1.5
204	Rural	0.1	0.3	0.0	0.3	0.3	0.0	0.3	0.8	0.0	0.8
205	Rural	0.1	0.3	0.0	0.3	0.3	0.0	0.3	0.6	0.0	0.6
206	Rural	0.1	0.3	0.0	0.3	0.3	0.0	0.3	0.6	0.1	0.7
207	201. Tawau	5.5	5.5	1.0	6.5	6.0	1.2	7.2	12.0	2.6	14.6
	Rural	0.7	0.3	0.6	0.9	0.5	0.6	1.1	0.9	0.7	1.6
	Sub-total	6.2	5.8	1.6	7.4	6.5	1.8	8.3	12.9	3.3	16.2
208	202. Semporna	0.6	0.5	0.2	0.7	0.5	0.2	0.7	1.3	0.2	1.5
	Rural	1.8	2.1	0.1	2.2	3.0	0.1	3.1	5.9	0.1	6.0
	Sub-total	2.4	2.6	0.3	2.9	3.5	0.3	3.8	7.2	0.3	7.5
209	203. Lahad Datu	1.1	1.6	0.4	2.0	2.5	0.6	3.1	6.4	1.4	7.8
	Rural	0.4	0.4	0.1	0.5	0.6	0.1	0.7	0.8	0.3	1.1
	Sub-total	1.5	2.0	0.5	2.5	3.1	0.7	3.8	7.2	1.7	8.9
210	Rural	0.6	0.7	0.1	0.8	0.8	0.1	0.9	1.5	0.1	1.6
211	Rural	0.8	1.0	0.0	1.0	1.2	0.0	1.2	2.3	0.0	2.3
212	204. Sandakan	8.8	8.1	2.4	10.5	10.3	3.0	13.3	18.7	7.4	26.1
	Rural	1.1	1.1	0.2	1.3	1.4	0.3	1.7	2.3	0.3	2.6
	Sub-total	9.9	9.2	2.6	11.8	11.7	3.3	15.0	21.0	7.7	28.7
213	205. Ranau	0.4	0.5	0.2	0.7	0.6	0.2	0.8	1.6	0.4	2.0
	Rural	1.2	1.1	0.2	1.3	1.3	0.2	1.5	1.9	0.4	2.3
	Sub-total	1.6	1.6	0.4	2.0	1.9	0.4	2.3	3.5	0.8	4.3
214	Rural	0.4	0.4	0.0	0.4	0.6	0.0	0.6	0.8	0.0	0.8
215	Rural	0.1	0.1	0.0	0.1	0.2	0.0	0.2	0.2	0.0	0.2
216	Rural	0.5	0.7	0.0	0.7	0.8	0.0	0.8	1.2	0.0	1.2
217	206. Kudat	1.3	1.0	0.4	1.4	1.5	0.4	1.9	3.4	1.0	4.4
	Rural	1.1	1.5	0.1	1.6	1.6	0.1	1.7	2.6	0.4	3.0
	Sub-total	2.4	2.5	0.5	3.0	3.1	0.5	3.6	6.0	1.4	7.4
218	207. Kota Belud	0.8	0.7	0.2	0.9	0.7	0.2	0.9	1.6	0.4	2.0
	Rural	0.8	1.1	0.0	1.1	1.3	0.0	1.3	1.9	0.0	1.9
	Sub-total	1.6	1.8	0.2	2.0	2.0	0.2	2.2	3.5	0.4	3.9
219	Rural	2.6	3.2	0.2	3.4	3.6	0.5	4.1	4.1	0.5	4.6

Table 48 ESTIMATED AND PROJECTED D&I WATER DEMAND BY BASIN IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH (2/2)

Unit: 10^6 m^3/y

Basin No.	City/Rural	Estimated 1980 D&I	Projected 1985 D	I	Total	1990 D	I	Total	2000 D	I	Total
220	208. Kota Kinabalu	16.4	16.8	2.2	19.0	19.2	2.6	21.8	36.6	6.4	43.0
	Rural	0.8	0.8	0.0	0.8	1.0	0.0	1.0	1.8	0.0	1.8
	Sub-total	17.2	17.6	2.2	19.8	20.2	2.6	22.8	38.4	6.4	44.8
221	209. Papar	0.6	1.3	0.2	1.5	1.9	0.2	2.1	3.1	0.6	3.7
	Rural	0.8	0.9	0.0	0.9	1.0	0.0	1.0	1.7	0.0	1.7
	Sub-total	1.4	2.2	0.2	2.4	2.9	0.2	3.1	4.8	0.6	5.4
222	Rural	0.3	0.4	0.0	0.4	0.4	0.0	0.4	0.6	0.0	0.6
223	Rural	0.6	0.6	0.1	0.7	1.0	0.1	1.1	1.8	0.1	1.9
224	210. Keningau	0.7	0.8	0.2	1.0	0.8	0.2	1.0	1.9	0.4	2.3
	Rural	3.2	3.9	0.1	4.0	4.4	0.3	4.7	8.1	0.7	8.8
	Sub-total	3.9	4.7	0.3	5.0	5.2	0.5	5.7	10.0	1.1	11.1
225	211. Labuan	2.0	2.9	7.6	10.5	3.2	8.0	11.2	7.5	11.6	19.1
	Rural	0.1	0.3	0.0	0.3	0.3	0.0	0.3	0.5	0.0	0.5
	Sub-total	2.1	3.2	7.6	10.8	3.5	8.0	11.5	8.0	11.6	19.6
226	Rural	0.6	0.7	0.0	0.7	0.8	0.0	0.8	1.6	0.0	1.6
Total		58.1	63.2	16.8	80.0	75.5	19.2	94.7	141.8	36.1	177.9

Table 49 RECOMMENDED WATER SUPPLY DEVELOPMENT PLAN FOR CITIES/TOWNS IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Code No.	Town	1985 TC	1985 SF	1985 SP	1990 TC	1990 SF	1990 SP	2000 TC	2000 SF	2000 SP
207	201	Tawau	17.2	75	45.9	19.3	85	65.7	39.5	90	111.8
208	202	Semporna	1.8	90	6.5	1.8	95	8.3	4.2	100	12.7
209	203	Lahad Datu	5.1	70	17.7	8.1	75	26.9	21.1	90	62.5
212	204	Sandakan	27.1	85	83.0	35.0	90	108.2	66.9	95	174.6
213	205	Ranau	1.8	100	6.6	2.1	100	8.9	5.4	100	15.9
217	206	Kudat	3.3	70	10.8	4.8	80	16.2	11.8	95	33.5
218	207	Kota Belud	2.4	100	8.7	2.4	100	10.8	5.4	100	17.3
220	208	K. Kinabalu	53.9	100	157.5	61.8	100	208.6	119.9	100	345.8
221	209	Papar	4.2	100	16.9	6.0	100	21.0	10.2	100	31.1
224	210	Keningau	2.7	100	11.0	2.7	100	12.8	6.3	100	20.5
225	211	Labuan	31.3	85	24.3	33.5	90	34.7	57.3	95	73.5
Total			150.8	89	388.9	177.5	93	522.1	348.0	96	899.2

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

SF: Service factor in %

SP: Served population in 10^3

Table 50 RECOMMENDED TREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Name	1985 TC	1985 SF	1985 SP	1990 TC	1990 SF	1990 SP	2000 TC	2000 SF	2000 SP
201	Pensiangan	0.3	40	1.2	0.3	50	1.6	0.6	75	3.1
202	Serudong	0.3	40	2.1	0.6	50	3.2	1.5	75	6.7
203	Kalabakan	0.3	40	2.5	0.6	50	3.8	2.1	75	8.0
204	Barantian	0.3	40	1.4	0.3	50	2.1	0.9	75	4.4
205	Umas-Umas	0.3	40	1.0	0.3	50	1.6	0.6	75	3.3
206	Merutai Besar	0.3	40	1.0	0.3	50	1.6	0.6	75	3.3
207	Tawau	0.3	40	1.6	0.3	50	2.4	1.2	75	5.1
208	Kalumpang	1.5	40	10.1	3.0	50	15.7	8.1	75	33.8
209	Silibukan	0.3	40	1.7	0.3	50	2.5	0.9	75	4.7
210	Segama	0.6	40	3.1	0.6	50	4.4	2.1	75	8.4
211	Kinabatangan	0.6	40	4.5	1.2	50	6.8	3.3	75	13.3
212	Segaliud	0.9	40	5.5	1.2	50	7.5	3.3	75	12.9
213	Labuk	0.9	40	5.2	1.2	50	6.8	2.7	75	11.1
214	Sugut	0.3	40	2.2	0.6	50	2.9	1.2	75	4.8
215	Paitan	0.0	40	0.7	0.3	50	1.0	0.3	75	1.5
216	Bengkoka	0.6	40	3.0	0.6	50	4.1	1.5	75	6.9
217	Bongan	1.2	40	6.8	1.5	50	8.8	3.6	75	14.2
218	Kadamaian	0.9	40	5.1	1.2	50	6.8	2.7	75	10.9
219	Tuaran	8.4	40	22.8	9.9	50	30.0	12.4	75	49.3
220	Putatan	0.6	40	3.8	0.9	50	5.3	2.4	75	10.0
221	Papar	0.6	40	4.1	0.9	50	5.5	2.4	75	9.4
222	Kimanis	0.3	40	1.6	0.3	50	2.1	0.6	75	3.3
223	Membakut	0.9	40	2.1	2.4	50	2.7	4.5	75	4.2
224	Padas	7.8	40	38.6	9.6	50	52.2	22.0	75	88.1
225	Labuan	0.3	40	1.2	0.3	50	1.5	0.6	75	2.4
226	Lakutan	1.2	40	1.7	2.1	50	2.3	3.9	75	3.5
Total		30.0	40	134.6	40.8	50	185.2	86.0	75	326.6

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

Table 51 RECOMMENDED UNTREATED WATER SUPPLY DEVELOPMENT PLAN FOR RURAL AREA IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin		1985			1990			2000		
No.	Name	SD	SF	SP	SD	SF	SP	SD	SF	SP
201	Pensiangan	0.1	40	3.3	0.1	50	4.7	0.3	75	8.8
202	Serudong	0.1	40	5.5	0.2	50	8.6	0.4	75	18.1
203	Kalabakan	0.2	40	6.7	0.2	50	10.3	0.7	75	21.7
204	Barantian	0.1	40	3.7	0.1	50	5.6	0.4	75	11.8
205	Umas-Umas	0.1	40	2.8	0.1	50	4.2	0.3	75	8.9
206	Merutai Besar	0.1	40	2.8	0.1	50	4.2	0.3	75	8.9
207	Tawau	0.1	40	4.2	0.2	50	6.6	0.4	75	13.8
208	Kalumpang	0.6	40	27.4	1.0	50	42.6	2.7	75	91.3
209	Silibukan	0.1	40	4.7	0.2	50	6.7	0.4	75	12.6
210	Segama	0.2	40	8.2	0.3	50	11.9	0.7	75	22.7
211	Kinabatangan	0.3	40	12.1	0.4	50	18.3	1.1	75	35.8
212	Segaliud	0.3	40	14.9	0.4	50	20.4	1.0	75	34.7
213	Labuk	0.3	40	13.9	0.4	50	18.5	0.9	75	30.0
214	Sugut	0.1	40	6.0	0.2	50	8.0	0.4	75	13.1
215	Paitan	0.0	40	2.0	0.1	50	2.6	0.1	75	4.2
216	Bengkoka	0.2	40	8.0	0.3	50	11.0	0.6	75	18.5
217	Bongan	0.4	40	18.3	0.6	50	23.7	1.2	75	38.5
218	Kadamaian	0.3	40	13.7	0.4	50	18.3	0.9	75	29.6
219	Tuaran	0.4	40	0.8	0.4	50	1.1	1.1	75	1.7
220	Putatan	0.2	40	10.2	0.3	50	14.2	0.8	75	27.1
221	Papar	0.3	40	11.1	0.4	50	14.8	0.8	75	25.5
222	Kimanis	0.1	40	4.5	0.1	50	5.5	0.3	75	8.8
223	Membakut	0.1	40	5.5	0.2	50	7.2	0.3	75	11.4
224	Padas	0.8	40	8.4	1.1	50	11.4	2.4	75	19.2
225	Labuan	0.1	40	3.2	0.1	50	4.0	0.2	75	6.6
226	Lakutan	0.1	40	4.6	0.1	50	6.1	0.3	75	9.6
Total		5.7	40	206.5	8.0	50	290.5	19.0	75	532.9

Remarks; SD: Source demand (piped) in the corresponding year in 10^6 m^3/y.

SF: Service factor in %.

SP: Served population in 10^3.

Table 52 RECOMMENDED WATER SOURCE DEVELOPMENT PLAN IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Facilities	Purpose	Catchment Area (km^2)	Active Storage Capacity (10^6m^3)	Net Supply Capacity ($10^6m^3/y$)	Construction Cost (M$$10^6$)	Construction Period
207	Tawau dam	WS	38	3.7	13.2	58.8	1987-1991
212	Meliau diversion	WS	58	-	-	-	-
	-Pipeline -1	WS	-	-	(8)	133.0	1983-1987
	-Pipeline -2	WS	-	-	(20)	223.0	1988-1992
212	Meliau dam	WS	58	7	28	87.3	1988-1992
217	Milau diversion	WS	70	-	(4)	14.6	1983-1987
218	Wariu dam	IR,WS	123	8	10	63.6	1985-1989
220	Papar diversion	WS	353	-	(30)	25.0	1985-1989
220	Papar dam	IR,WS	353	20	33	61.1	1985-1989
225	Padas diversion	WS					
	-Pipeline -1	WS	-	-	14	214.2	1983-1987

Remarks; WS: Water Supply
IR: Irrigation
( ): Pipeline Capacity

Table 53 RECOMMENDER PLAN FOR IMPROVEMENT OF PURIFICATION SYSTEM IN PALM OIL MILLS AND RUBBER FACTORIES IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: m^3/d

Basin No.	Basin Name	1981 - 1990 Palm Oil	1981 - 1990 Rubber	1981 - 1990 Total	1991 - 2000 Palm Oil	1991 - 2000 Rubber	1991 - 2000 Total
209	Silibukan	0	360	360	0	0	0
217	Bongan	360	0	360	0	0	0
Total		360	360	720	0	0	0

Table 54 ASSUMED PUBLIC SEWERAGE DEVELOPMENT NOT AFFECTING RIVER WATER QUALITY IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	City/Town No.	City/Town Name	1990 Treatment Capacity ($10^3 m^3/d$)	1990 Service Factor (%)	1990 Served Population (10^3)	2000 Treatment Capacity ($10^3 m^3/d$)	2000 Service Factor (%)	2000 Served Population (10^3)
207	C201	Tawau	7	45	35	22	65	81
209	C203	Lahad Datu	3	35	13	12	65	45
212	C204	Sandakan	14	45	54	39	65	120
220	C208	Kota Kinabalu	25	50	64	64	65	146
Total			49	-	166	137	-	392

Remarks; There are untreated sewerage systems in C201, C203, C204 and C208.

Table 55 RECOMMENDED FLOOD MITIGATION PROGRAM IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	Basin	Improved River Length (km)	Bypass Floodway (km)	Protected Population (10^3)	Protected Area (km^2)	Constr. Cost ($M\$10^6$)
By 1990						
207	Tawau	-	3	14	18	8
217	Bongan	13	-	11	89	12
By 2000						
207	Tawau	-	3	14	18	8
217	Bongan	54	-	27	315	61
220	Putatan	12	-	20	7	12
Total		66	3	61	340	81

Remarks: Protected population: in 2000

Table 56 RECOMMENDED HYDROPOWER DEVELOPMENT PLAN IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Name	Installed Capacity (MW)	Construction Cost ($M\$10^6$)	Construction Period
Tenom Pangi Stage III			
- Sook dam & power	40	150	1985 - 1989
- Pangi extention	44	150	1985 - 1989
Papar Multipurpose	30	180/1	1985 - 1989
Pangi No. 2	90	290	1990 - 1994

Remarks; Construction cost at 1980 price.

/1: $M\$70 \times 10^6$ for D&I water supply deducted.

Table 57 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE OF RECOMMENDED PLAN IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: M$$10^6$

Sector	4MP	5MP	6MP	7MP	Total
Source Development	232	519	131	0	882
Irrigation	36	119	71	52	278
Inland Fishery	3	3	42	29	77
Public Water Supply	67	224	302	128	721
Public Water Supply; Pre-treatment facilities	0	0	0	0	0
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	23	41	44	17	125
Flood Mitigation	5	24	28	47	104
Hydropower	48	461	261	0	770
Total	414	1,391	879	273	2,957

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

Table 58 ESTIMATED ANNUAL RECURRENT EXPENDITURE OF RECOMMENDED PLAN IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: M$$10^6$

Sector	4MP	5MP	6MP	7MP	Total
Source Development	0	6	19	22	47
Irrigation	0	3	12	17	32
Inland Fishery	0	0	2	5	7
Public Water Supply	0	14	41	67	122
Public Water Supply; Pre-treatment facilities	0	0	0	0	0
Public Sewerage (Effective for river water pollution abatement)	0	0	0	0	0
Public Sewerage (Others)	0	8	16	24	48
Flood Mitigation	0	2	7	11	20
Hydropower	0	2	13	19	34
Total	0	35	110	165	310

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

Table 59 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER DEMAND AND SUPPLY BALANCE IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Irrigation	(M$$10^6$)	18
D&I water supply	(M$$10^6$)	61
Fish culture	(M$$10^6$)	3
Reservoir recreation	(M$$10^6$)	2
Total	(M$$10^6$)	84
1.2 Economic Cost		
Irrigation	(M$$10^6$)	10
D&I water supply	(M$$10^6$)	34
Fish culture	(M$$10^6$)	3
Dams, barrages & diversion facilities	(M$$10^6$)	28
Total	(M$$10^6$)	75
1.3 EIRR	(%)	10
2. Environmental Quality		
2.1 Beneficial Effect		
Safe maintenance flow period (2000)		See Table
Surface area of lake created	(km^2)	4
2.2 Adverse Effect		
Possible reduction in kind of fish immediately downstream of dams and barrages	(nos. of site)	4
3. Social Well-being		
3.1 Beneficial Effect		
Number of farm households benefited by proposed irrigation in 2000	(10^3)	13
Number of people served by proposed public water supply in 2000	(10^3)	1,759
Safe supply period (2000)		See Table
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^2)	20

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

Table 60 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR WATER POLLUTION ABATEMENT IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Sewerage	($M\$10^6$)	3
Saving in pre-treatment for D&I water supply	($M\$10^6$)	0
Total	($M\$10^6$)	3
1.2 Economic Cost		
Sewerage	($M\$10^6$)	6
Private purification facilities	($M\$10^6$)	0
Pre-treatment for D&I water supply	($M\$10^6$)	0
Total	($M\$10^6$)	6
2. Environmental Quality		
2.1 Beneficial Effects		
Length of river stretch where BOD concentration is not more than 10 mg/lit in 2000 compared with without project condition (Study length = 1,600 km)	(km)	1,580/1,580 /1
Length of river stretch where BOD concentration is not more than 5 mg/lit in 2000 compared with without project condition (Study length = 1,600 km)	(km)	1,600/1,580 /1
2.2 Adverse Effect		-
3. Social Well-Being		
3.1 Beneficial Effects		
Number of people served by proposed sewerage system in 2000	(10^3)	391
3.2 Adverse Effect		-

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

Table 61 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR FLOOD MITIGATION IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Damage reduction	($M\$10^6$)	2.8
1.2 Economic Cost		
Flood mitigation work	($M\$10^6$)	2.3
1.3 EIRR	(%)	9.3
2. Environmental Quality		
2.1 Beneficial Effect		
Length of improved stretch	(km)	71
2.2 Adverse Effect		-
3. Social Well-Being		
3.1 Beneficial Effect		
Number of protected people by proposed facilities in 2000	(10^3)	61
Population served by proposed flood warning system in 2000	(10^3)	50
Area relieved from flood hazards	(km^2)	340
3.2 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	7

Table 62 BENEFICIAL AND ADVERSE EFFECTS OF RECOMMENDED PLAN FOR HYDROPOWER DEVELOPMENT IN SABAH UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Power generation	($M\$10^6$)	70
1.2 Economic Cost		
Dam & power facilities	($M\$10^6$)	22
1.3 EIRR	(%)	20
2. Environmental Quality		
2.1 Beneficial Effect		
Surface area of lake created	(km^2)	34
2.2 Adverse Effect		
Possible reduction in kind of fish in immediately downstream of dam	(nos. of site)	3
3. Social Well-being		
3.1 Adverse Effect		
Number of people to be removed for construction of facilities	(10^3)	4

Remarks; Economic benefit other than power generation benefit is not shown here, but included in the water demand and supply account.