GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA
PERLIS-KEDAH-PULAU PINANG
REGIONAL WATER RESOURCES STUDY
PART 1

VOL. 8
ANNEX

I. REGIONAL WATER DEMAND AND SUPPLY BALANCE SYSTEM

FEBRUARY 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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LIST OF VOLUMES

ABBREVIATIONS

(1) Organization/Plan

4MP	:	Fourth Malaysia Plan
DID (JPT)	:	Drainage and Irrigation Department
EPU	:	Economic Planning Unit
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
GSD	:	Geological Survey Department
JICA	:	Japan International Cooperation Agency
MADA	:	Muda Agricultural Development Authority
NEB (LIN)	:	National Electricity Board
NWRS	:	National Water Resources Study
PWD (JKR)	:	Public Works Department
RISDA	:	Rubber Industry Small-Holders Development Authority
WHO	:	World Health Organization

(2) Others

B	:	Benefit
BOD	:	Biochemical Oxygen Demand
C	:	Cost
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
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
H	:	Height, or Water Head
NHWL	:	Normal High Water Level
O&M	:	Operation and Maintenance
Q	:	Discharge
Ref.	:	Reference
SS	:	Suspended Solid

ABBREVIATIONS OF MEASUREMENT

Length

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

Area

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

Volume

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

Weight

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

Time

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

Electrical Measures

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

Other Measures

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

Derived Measures

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

Money

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

CONVERSION FACTORS

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

ANNEX I

REGIONAL WATER DEMAND AND SUPPLY BALANCE SYSTEM

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

1. INTRODUCTION

This report describes a summary of the study on the regional water demand and supply system carried out during the PART 1 STUDY.

The objectives of the study were:

(1) to calculate water deficit at any intake in the Region and to evaluate the total deficit in major rivers in the region on the basis of 5-day runoff data;

(2) to examine alternative combinations of source facilities to supplement the deficit;

(3) to evaluate the optimum scale of individual proposed dam; and

(4) to propose a preliminary reservoir operation rule of dams in the integrated river system.

2. DESCRIPTION OF THE REGION

2.1 The Region

The study of the integrated water resources development plan covers a region of the northern part of the west coast of Peninsula Malaysia where roughly corresponds to the land of the States of Perlis, Kedah and Pulau Pinang. The Region includes the Perlis, Kedah, Merbok, Muda and Perai river basins and small rivers in the south-east corner of the Region. Pulau Langkawi and the Kerian river basins are however not included. On the other hand it includes a part of the State of Perak because water transfer from a tributary of the Perak river is proposed in this study.

The total area of the Region is about 11,200 km^2.

2.2 River System

(1) Perlis river

The Perlis river has a catchment area of 880 km^2. The river bifurcates into several tributaries in the vicinity of Kangar. Major tributaries are the Temenggang and Korok rivers joining with the main stream from the north and the Gial river trending from the east to the west. The Gial river is joined by the Repoh and Arau rivers from the northeast.

The northern part of the MADA main irrigation canal runs from the east to the south utilizing the upstream portion of the Gial river and turns to the south from the confluence of the Gial and Arau rivers. The south running portion of the canal between the confluence and the sea is called the Arau canal.

The coastal plan in the south of the Gial river is mostly cultivated for paddy and the land along the middle reaches of the tributaries are developed for paddy and horticulture. Kangar has a population of 15,000.

The proposed Timah-Tasoh dam site is located in the upstream reaches of the Korok river.

(2) Kedah river

The Kedah river of 3,590 km^2 in catchment area bifurcates into 3 major tributaries above Alor Setar of 77,000 in population; the Pauh, Pdg. Terap and Pedang rivers. The Pdg. Terap river is the largest tributary, which has the Pelubang barrage of MADA in the lower reaches. The Pedu dam and the proposed Sari and Durian dams are located in the Pdg. Terap river.

The Pauh river flows into the northern part of the MADA main canal near Jitra. The Badak-Temin dam is located in the upstream reaches of the Pauh river.

The tributaries of the Pendang river are running to the west crossing the southern part of the MADA main canal and flow through the MADA irrigation area. They join with the main stream to the east of Alor Setar. The Pendang river has a function of drainage of the southern part of the MADA irrigation area.

(3) Muda river

The Muda river of 4,300 km^2 is the largest river in the Region. The most upstream reaches of 984 km^2 is shut down by the Muda dam and the water in the basin is diverted to the Kedah river through the Saiong tunnel. Thus the effective catchment area of the Muda river for a water balance study is 3,300 km^2.

The Ketil river is the largest tributary. It joins with the main stream in the middle reaches near Kuala Ketil. It is planned that the water diverted from the proposed Rui reservoir is released into a small tributary of the Ketil river.

(4) Perai river

The Perai river of 895 km^2 in catchment area bifurcates into the Kerah river and Kulim river at 20 km upstream from the estuary. There is a swamp between the above-mentioned confluence and 10 km upstream from the estuary. Below the swamp is the urban area of Butterworth populated by 82,000.

(5) Merbok river

The Merbok river of 410 km^2 lies between the Kedah and Muda rivers. The most parts of the main stream is a tidal river. Sungai Petani is located in the northern part of the basin.

(6) Rivers in the Pinang island

There are many small rivers in the Pinang island of 300 km^2 in area. The Pinang river of 60 km^2 is the largest among them. Most of the rivers are integrated through water supply systems in the island.

(7) Julu and southern rivers

There are three small rivers to the south of the Perai river. They are the Julu, Junjong and Jawi rivers. The catchment area of these rivers is 371 km^2 in total.

2.3 Demand Area

The MADA irrigation area is the largest water consumer in the Region. The area is 95,800 ha in 1982 and it is assumed to be reduced by 2,000 ha by the on-going tertiary development and by 800 ha with expansion of residential area by 2000.

The minor irrigation schemes are 33,000 ha in area, of which 7,000 ha is a control drainage scheme. The minor irrigation schemes excluding control drainage scheme will increase from 26,000 ha in 1982 to 41,000 ha in 2000.

The major demand centers of domestic and industrial water are cities of Kangar, Alor Setar, Butterworth and Georgetown. Bandar Bayan Baru and Bandar Seberang Jaya are new towns under construction in the State of Pulau Pinang. The population is planned to be 250,000 in each town by 2000.

3. SOURCE FACILITIES

3.1 Existing Source Facilities

Table 1 summarizes the principal features of the existing source facilities in the Region. There are three dams and four barrages across the major rivers in the Region.

The Muda and Pedu dams are operated to supply water to MADA area. The Muda dam completed in 1968 with an active storage capacity of 160 x 10^6 m^3 conveys water from its catchment area of 984 km^2 in the upper Muda river basin through the Saiong Tunnel to an upper tributary of the Pdg. Terap river, the major tributary of the Kedah river. The Pedu dam completed in 1969 with an active storage capacity of 1,049 x 10^6 m^3 regulates the water from the Muda dam and inflow from its own catchment area of 171 km^2 in the upper tributary of the Pdg. Terap river. The regulated outflow from the Pedu dam is discharged into the Pdg. Terap river. The Pelubang barrage completed in 1969 takes water in the Pdg. Terap river and supply MADA area.

The Ayer Hitam dam completed in 1962 in the Pinang island serves for water supply with its active storage capacity of 2 x 10^6 m^3.

The Kedah barrage completed in 1970 and Muda barrage completed in 1973 are tidal barrages to allow increased abstraction of river water by controlling sea water intrusion through the estuaries.

The Perai barrage was completed in 1981 for the purpose of checking flooding in Butterworth by retaining flood in the swamp located upstream. This barrage can also control sea water intrusion.

3.2 On-Going Projects

Herein explained are source development projects which are either committed for implementation or under construction (see Table 2).

The Timah-Tasoh dam is being investigated with the purposes of flood control and irrigation. The dam site is located just downstream of the confluence of the Timah and Tasoh rivers in the Perlis river system.

The Arau dam is also under study with the flood control and irrigation purposes. The dam site is located in the Arau river, a tributary of the Perlis river.

Detailed design is on-going for the Ahning dam in the Ahning river, a tributary of the Pdg. Terap river. Envisaged purposes are water supply, irrigation and hydropower. According to a feasibility study, the catchment area is 120 km^2, and the active storage capacity is 200 x 10^6 m^3.

The Mengkuang dam is under construction in the State of Pulau Pinang. It is a pumped-storage dam of 23.7 x 10^6 m^3 in active storage capacity. By utilizing water in the Kulim river and the River Muda Canal, the dam will contribute more water to the Sg. Dua waterworks.

A feasibility study is being carried out for the Jeniang diversion system which has been envisaged to supplement irrigation water in MADA area by diverting water from the Muda river. Surplus water in the Muda river will be taken at the Jeniang weir which will be located in the mid-stream of the Muda river and conveyed by a diversion canal by gravity to the Naok dam, where water is stored during wet season and released to MADA area through a feeder canal by gravity in dry season. The storage capacity of the Naok dam is small, being estimated to be 27 x 10^6 m^3. The Reman dam will be constructed in a tributary of the Muda river to provide more storage capacity in the system. It is a pumped-storage dam lifting water from the above-mentioned diversion canal and releasing water into the Naok reservoir. The implementation of Reman dam is, however, uncertain because of difficulties in land acquisition of the proposed reservoir area. Then the Reman dam is excluded from the Jeniang system and considered as one of the potential dams.

3.3 Potential Projects

In addition to the existing, on-going and proposed source development projects, three potential projects are incorporated in the Study. They are the Ma dam in the Muda river system and the Khlong Thepha dam in Thailand and the Merbok scheme in the Muda river system. Principal feature of these dams is shown in Table 3.

(1) The Ma dam

The Ma dam site was identified by the Jeniang Team in the Ma river 8 km upstream of the confluence of the Muda river and Ma river. It is located in the west of Kemajuan Tanah Lubok Merbau. The catchment area is 40 km^2. An active storage capacity of 35 x 10^6 m^3 is expected if a 50 m high dam is constructed.

(2) The Khlong Thepha dam

The Khlong Thepha dam site is identified through a study on 1/50,000 map. The dam site is located in Thailand 20 km to the north-east of the Pedu dam. Annual inflow from the catchment area of 173 km^2 is estimated to be 87 x 10^6 m^3. The active storage capacity is 78 x 10^6 m^3 between Els. 120 m and 125 m if a 50 m high dam is constructed. A basin transfer canal of 6 km in length is excavated to send water to the upper basin of the Pedu river.

(3) The Merbok scheme

The Merbok scheme is a pumped-storage project which was identified also by the Jeniang Team. A reservoir of 1,300 ha in surface area is created by constructing an earth dyke in the coastal mangrove swamp on the left bank of the Merbok river. A canal is excavated between the reservoir and the pond of the Muda barrage. Water is pumped up from the Muda river into the reservoir through the canal between June and August for the release to the Muda river during the rest of the year.

3.4 Proposed Dam Projects

Six dams are proposed in the Study. They are the Badak-Temin, Sari, Durian, Tawar-Muda and Beris dams in the State of Kedah and the Rui dam in the State of Perak. Tables 4 and 5 show the principal features of these dams.

The Badak-Temin dam site is located in the Temin river, a tributary of the Kedah river, 5 km east-northeast of Changlun. Annual inflow from the catchment area of 112 km^2 is estimated to be 58 x 10^6 m^3. The active storage capacity is 58 x 10^6 m^3 in a drawdown of 8.5 m, if the normal HWL is set at El. 45.0 m, which is the topographically maximum.

The Sari dam site is located in the Sari river, a tributary of the Kedah river, 7.5 m west-northwest of Padang Sanai. The catchment area is 61 km^2 and the annual inflow is estimated at 32 x 10^6 m^3. The active storage capacity is 56 x 10^6 m^3 if the normal HWL is assumed at El. 91 m.

The Durian dam site is located in the Durian river, a tributary of the Kedah river, 5 km to the north of Padang Sanai. The catchment area is 74 km^2 collecting 38 x 10^6 m^3 of annual runoff. The active storage capacity is 41 x 10^6 m^3 at the topographical maximum scale.

The Tawar-Muda dam site is located in the main stream of the Muda river, 2 km to the east-northeast of Nami or 17 km downstream of the Muda dam. Annual inflow from the catchment of 129 km^2 between the Muda dam and the Tawar-Muda dam site is estimated to be 123 x 10^6 m^3. The active storage capacity is 54 x 10^6 m^3 if the normal HWL is set at El. 77 m which is the allowable maximum height restricted by the elevation of the outlet structures of the Muda dam.

The Beris dam site is located in the Beris river, 1.6 km downstream of the confluence of the Muda river and the Beris river. The catchment area is 116 km^2 and the annual inflow is estimated to be 110 x 10^6 m^3. The active storage capacity is 101 x 10^6 m^3, if the normal HWL is set at El. 85 m.

The Rui dam has two alternative dam sites in the Rui river, a tributary of the Perak river. It is planned that the water of the Rui river regulated by the Rui reservoir is diverted to the Tiak river, a tributary of the Muda river through a transfer tunnel. The Rui 2 dam site is located 4 km to the southwest of Kg. Pahit near a bridge of the Keroh-Gerik road. The Rui 3 dam site is located 2 km downstream of the Rui dam site. The catchment area of Rui 2 is 278 km^2 and has 250 x 10^6 m^3 of annual runoff. The storage capacity is 245 x 10^6 m^3 if the normal HWL is set at El. 245 m. The Rui 3 dam site has the catchment area of 305 km^2 collecting 273 x 10^6 m^3 of annual inflow. The active storage capacity is 383 x 10^6 m^3 if the normal HWL is set at El. 250 m.

4. RIVER BASIN MODEL

4.1 General

The rivers in the Region are integrated each other and they can be grouped into three major river systems and two minor river systems from the viewpoint of water demand and supply balance. Major systems are the Perlis, Kedah and Muda-Perai river systems while minor systems are the Merbok and the Julu and the southern river systems.

These river systems are illustrated schematically in a diagram as shown in Plates 1 and 2. A river system consists of the main stream and tributaries on which one or more intakes are situated.

Intakes for irrigation and D&I water supply have been listed up all over the Region based on the studies in the ANNEXES B and D. They are all pointed on the diagram.

4.2 Perlis River System

The Perlis river system is located in the northern part of the Region. It is composed of the main stream of the Temanggang, Korok and other tributaries which feed the northwestern part of the State of Perlis including Kangar. In the southern part of the State, a part of the irrigation area of MADA is developing and it is excluded from the Perlis river system. Since the Arau and Gial rivers are integrated into the MADA canal system, their catchment areas are also excluded from the Perlis river system.

4.3 Kedah River System

The Kedah river system is defined as all the rivers flowing into the irrigation area of MADA which is developing in the northwestern part of the State of Kedah and southern part of the State of Perlis. It includes the above-mentioned Arau river and the Gial river, the whole Kedah river basin and local rivers flow into the southern MADA area. In addition, the catchment area of the Muda dam is also included in this system because the water of the Muda reservoir is transferred to the Pedu reservoir in the Kedah basin through the Saiong tunnel.

4.4 Muda-Perai River System

The irrigation area developing between the Muda and Perai rivers in their downstream reaches is fed by these two rivers through the River Muda canal and some other irrigation canals. These rivers are also interconnected by domestic and water supply systems which feed the Seberang Perai area and the Pinang island through a submarine pipeline system. A part of the Merbok basin is also fed by the Muda river for domestic and industrial water supply. The catchment area of the Muda dam is excluded from the river system because the Muda dam discharges insignificant volume of water downstream.

4.5 Merbok River System

Since most of the stretches of the main stream of the Merbok river has wide channel affected by sea water intrusion, no major water users are located along the stream while pollutant loads are discharged from outlets of sewerage system. The main concern of the water balance calculation is, therefore, a water quality problem of the main stream.

4.6 Juru and Southern River System

Juru river is located to the south of the Perai river system. Water quality is the major problem of the river system while water deficit is not significant.

4.7 Inter-Basin Transfer

(1) Jeniang transfer

The MADA irrigation area is the largest water user in the Region. The main sources of water supply to the area are the Kedah river system whose main stream is running through the area and Pedu-Muda integrated dam system. The supply capacity is, however, not enough to guarantee the demand in 1/5 drought level under the present condition.

On the other hand, the Muda river has abundant water throughout the year except for a few months a year. The excess water is transferable at Jeniang site to the MADA irrigation area by constructing an intake weir across the Muda main stream and a diversion canal.

With the Jeniang diversion system, water controlled by the proposed Beris and Tawar-Muda dams as well as the uncontrolled Muda river water can be transferred to the MADA area.

The Kedah river system and the Muda-Perai river system will be, therefore, interconnected each other if the Jeniang project is materialized.

(2) Rui dam diversion

The proposed Rui dam scheme is also a basin transfer plan. The catchment area of the Rui dam is adjacent to the Muda river basin. The water stored by the Rui dam is diverted to a branch of the Ketil river, a tributary of the Muda river through a diversion tunnel. The water is sent to the lower reaches of the Muda-Perai river system. Thus, the river system in the catchment area of the Rui dam is regarded as being integrated in the Muda-Perai river system, if the situation needs the Rui dam.

5. DATA

5.1 Runoff

(1) Runoff estimate

Runoff in the Region is analyzed in ANNEX E "METEOROLOGY AND HYDROLOGY" in the following manner.

The Region was divided into five river basins for the purpose of runoff estimate. They are the Perlis, Kedah, Muda and Perai and Rui river basins. The Merbok river is involved in the Muda river basin while the rivers in the Pinang Island are involved in the Perai river basin.

Each river basin is further divided into two to seven sub-basins as shown in Fig. 1.

The runoff in a river basin is represented by that of a key station selected for the river basin except for the Rui river basin whose runoff is represented by the Jeniang station runoff, which is the key station of the Muda river basin.

The natural runoff is defined as the runoff which is not significantly affected by water withdrawals in the catchment area. It is estimated at the key station for 20 years from 1961 to 1980 on the 5-day basis as tabulated in Tables 41 to 52 of the ANNEX E on the basis of runoff observed and partially supplemented by a simulation study.

The 5-day runoff data of a sub-basin is transposed from the key station of the river basin in which the sub-basin is involved by assuming that the rainfall loss on an average during the period of 1961 - 1980 evenly distributes in the river basin.

Runoff depth at an arbitrary location in a sub-basin is assumed to be uniform over the sub-basin.

The average annual runoff depth of the sub-basin thus calculated are summarized in Table 6.

(2) Available runoff

Annual runoff volume at major locations in the Region is summarized in Table 7. The total available water resources of the major rivers are 176 x 10^6 m^3 in the Perlis river, 2,209 x 10^6 m^3 in the Kedah river including Pedu-Muda dam system and 3,330 x 10^6 m^3 in the Muda river on an average condition, which are counted at the lowest point of the main stream for balance calculation.

(3) Drought spell

The critical period is normally between March and July in view of water demand and supply balance in the Region. The runoff during the critical period is calculated at the key stations for three river systems for 20 years period as shown in Table 8.

Judging from the table, there were two consecutive drought spells during the 20 years period in the Kedah river system. A spell from 1963 to 1965 is the severest drought for the period and the second one is a spell from 1977 to 1979.

In the Muda and Perai rivers, 1977 was the severest drought year while 1963 was the severest in the Perlis and Kedah rivers. 1977 was the fourth in the Kedah river.

5.2 Water Demand

(1) Cases of demand projection

Water demand of domestic and industrial water supply is projected in High and Low Growth Cases. The target years of the projection are 1982 (present condition), 1985, 1990 and 2000. However, 3 cases of target year of 1982, 1990 and 2000 are selected for water balance calculation. It is assumed that the demand is constant throughout the year.

In the case of irrigation water supply, the demand is projected for 3 cases of the target years on 10-day basis.

(2) Domestic and industrial water demand

The domestic and industrial water demand in the Region is studied in ANNEX B "DOMESTIC AND INDUSTRIAL WATER SUPPLY".

Table 9 shows the demand allocated to the surface water supply of the Perlis, Kedah and Muda & Perai river systems. The total demand is 164 x 10^6 m^3 in 1982, 337 x 10^6 m^3 in 1990 and 674 x 10^6 m^3 in 2000 in High Growth Case while 265 x 10^6 m^3 in 1990 and 408 x 10^6 m^3 in 2000 in Low Growth Case.

Table 10 shows the annual demand at each intake of the balance model. The water supply system of Pulau Pinang is integrated and water sources of the system are local rivers in the Pinang island, the Perai river and the Muda river as shown in the water demand and supply system diagram (Plate No. 2). Although all the demand of the system is indicated at Intake 20 in Table 10, actual intake volume at the intake is the demand less the supply by natural runoff of rivers in the Pinang island and the Perai river and by the regulated runoff of Ayer Hitam dam. The annual abstraction volume at the intake is calculated in Section 6.5.

(3) Irrigation water demand

The irrigation water requirement in the Region is estimated in ANNEX D "IRRIGATION DEVELOPMENT". Demand at an arbitrary intake in the Region is derived from the cropping schedule of the service area and the corresponding unit water requirement.

Tables 11 to 20 summarize the annual water demand at each intake of the balance model. In the Muda and Perai river system, the demand of Pinang Tungal system is supplied by both Perai and Muda river systems through the Sungai Muda canal. The annual abstraction volume from the Muda main river is assumed to be the demand in the Pinang Tungal system less natural runoff supply by the Perai river. The abstraction volume is calculated in Section 6.5.

The total irrigation water requirement of the Region is 2,152 x 10^6 m^3 in 1990 and 2,246 x 10^6 m^3 in 2000, as shown in Table 9.

6. WATER DEFICIT

6.1 General

The objective of the water deficit calculation is to examine the capability of the natural runoff to supply water for irrigation and D&I water demand in the Region under selected conditions of demand projection by means of a simulation method based on the past 20 years hydrological data.

The simulation model consists of a tributary model and a main stream model. The tributary model calculates deficit in a tributary basin and surplus runoff running into the main stream.

The main stream model is the major concern of this study because large water users are located along the downstream reaches of the main stream. The water supply and demand balance is calculated at several points along the main stream. The available runoff is the discharge from tributaries, the natural flow from own catchment area of the main stream and return flow from outlets along the main stream.

Users of the river runoff in this study are irrigation water supply, domestic and industrial water supply and maintenance flow for sustaining water quality of the river runoff.

The water deficit calculation is carried out for 1982, 1990 and 2000 of target years under conditions in High and Low Growth Cases.

6.2 Procedure

(1) Water demand and supply balance is calculated at every intake shown in the schematic diagram of the river systems on the 5-day basis for 20 years period from 1961 to 1980. (See Plates 1 and 2)

(2) In a tributary system water deficit (DF) at any intake is given as the difference between the available runoff (R) and water demand (D) at the intake. If the available runoff is larger than the water demand, the excess (S) is discharged downstream. The relationship is expressed as follows:

If $R > D$ then $DF = 0$
$S = R - D$

If $R \leq D$ then $DF = D - R$
$S = 0$

If there is no intake upstream of the objective intake, the available runoff is the natural runoff (Q) from the catchment area. On the other hand, if there is an intake or intakes upstream of the objective intake, the available runoff is the sum of the natural runoff from the intervening catchment area between upper intake(s) and the objective intake, the excess runoff released from the upper intakes and return flow discharged from outlet(s) located in the intervening catchment area.

The discharge from each tributary into the main stream is obtained by repeating the above-mentioned analysis for all the stretch of the tributary. Fig. 2 illustrates a simple model of a tributary.

(3) The main stream of each river system is divided into several stretches at just downstream of every confluence of tributaries and intake points along the stream.

The water balance of each stretch is given as follows. The runoff into a stretch is runoff from the immediate upstream stretch, runoff discharged from tributaries and the natural runoff and the return flow from the own catchment area of the stretch. The outflow from the stretch is water taken at intakes located along the stretch and runoff discharging to the downstream stretch. Then the deficit or excess in the stretch is calculated and the deficit is accumulated at the downstream end of the main stream.

Fig. 3 shows a simplified main stream model.

(4) Water quality of rivers in the Region is evaluated on the basis of the projected BOD load. It is assumed that the BOD concentration in a river should not be higher than 2 mg/l at domestic and industrial water supply intakes, 5 mg/l at irrigation intakes and 10 mg/l for preservation of environmental quality.

In case that the BOD concentration exceeds these limitations at any stretch of the river, pollutant loads are to be treated as much as economically possible. The rate of maintenance flow is that required to sustain the above-mentioned criteria after treatment at any stretch along the river.

If the river discharge is less than the rate of maintenance flow, the shortage is counted in the water deficit of the river stretch.

A balance calculation of BOD concentration is carried out in ANNEX G "WATER QUALITY" and it examines the rate of maintenance flow. Table 21 shows the rate of maintenance flow of five river systems for two cases of demand projection.

6.3 River Models

The Perlis river system has 6 tributary models and a main stream model which has 11 stretches. The outlet of the second stretch from upstream of the main stream model is set at the proposed Timah-Tasoh dam site. The downstream end of the main stream model is set at the confluence of the Tok river, the lowest tributary of the river system.

The main stream model of the Kedah river starts from the Pedu dam and ends at the Kedah barrage. The main stream is divided into 28 stretches. The river system has 16 tributaries of which 6 rivers are flowing into the MADA irrigation area. A balance in the MADA irrigation area which is fed mostly by the Kedah main stream through the MADA canal system is calculated by a model specified for the MADA area. A detailed explanation of the model is given in ANNEX D.

The Muda river has 11 tributaries and is connected with three tributaries of the Perai river and small rivers in the Pinang island through irrigation and water supply canals. The main stream of the Muda river is divided into 31 stretches including the Muda dam basin in the uppermost of the main stream. In the operation of the model, however, the water of the Muda river is shut down and no release from the dam is considered. The downstream end of the model is set at the Muda barrage. The location of Jeniang diversion weir corresponds to the 9th stretch from upstream.

The Merbok model has 7 tributaries. Water users of the river are minor irrigation schemes. The Julu and southern river system consists of three small rivers and main water users are also minor irrigation schemes. Water pollution control is main concern of these river systems.

6.4 Water Balance in Tributaries

Table 22 shows annual deficit of 20 years average and that in 1977 hydrological condition for every tributary of six river systems.

(1) Perlis river system

The natural river runoff is not sufficient to serve water to the tributaries over the Perlis river system. The proportion of deficit to water demand ranges 20 to 30 under 1977 hydrological condition.

Because of improvement of irrigation efficiency in 1990, the deficit is expected to be a little decreased and the situation continues up to 2000.

The total deficit in the tributary basins in Perlis river system is estimated at 4.1×10^6 m^3 in 1982, 3.2×10^6 m^3 in 1990 and 3.2×10^6 m^3 in 2000, respectively, under 1977 hydrological condition.

(2) Kedah river system

Under the present condition, water deficit is found in the northern part of the river basin, the Gial, Arau and Temin rivers.

With the progress of irrigation development in tributary basins, water deficit occurs all over the tributary basins. The water deficits, however, are mostly less than 10% of the demands except for the Gial, Arau and Temin rivers. The deficits in these rivers are expected to be covered by Arau and Badak-Temin dams.

Water demand of the MADA irrigation area is calculated at the Pelubang head work as shown in Table 12.

The total deficit in the tributaries of the river system is 8.1 x 10^6 m^3 in 1982, 15.5 x 10^6 m^3 in 1990 and 32.9 x 10^6 m^3 in 2000 in High Growth Case in 1977 hydrological condition.

(3) Muda-Perai river system

Irrigation water is taken in the Jemeri, Chepil, Ketil, Sedim and Kulim rivers under the present condition.

Water deficit is found in the Jemeri and Ketil rivers. The proportion of deficit to water demand is about 10% for these rivers in the fourth drought year.

The future development of the small irrigation scheme is planned at new intake points to take excess natural runoff and the water deficit is kept at less than 10% of the water demand.

The total deficit in the river system is estimated at 4.5 x 10^6 m^3 in 1982, 6.3 x 10^6 m^3 in 1990 and 10.6 x 10^6 m^3 in 2000, respectively.

(4) Merbok river system

Water deficit in the Merbok river system occurs almost every year but the proportion to water demand is about 8% on an average in 2000.

6.5 Water Balance in Main Stream

(1) Perlis river system

The annual deficit accumulated along the main stream is shown in Tables 23 and 24 for 1982, 1990 and 2000. Since there is no plan to take water for D&I water supply from the river system in 1990 and 2000, alternative projections in 1990 and 2000 are not examined.

Under the present condition, significant water deficit occurs in only a few years during the 20-year period and the situation will continue up to 1990.

On the other hand a large deficit appears in 2000 balance. This is because irrigation schemes are to be developed along the main stream following to the development plan of Timah-Tasoh dam whose operation is expected to be started in early 1990's. Thus the deficit in 2000 is to be filled by the water released from Timah-Tasoh dam.

(2) Kedah river system

Tables 25 to 27 show the annual deficit along the main stream for the selected cases of demand projection.

In this balance calculation, outflow from the Pedu-Muda dam system is not counted. Since the dam system has 830 x 10^6 m^3 of average annual inflow and 1,209 x 10^6 m^3 of storage capacity, the regulated outflow would cover about 70% of the deficit of 1,014 x 10^6 m^3 in an average year under the present condition as stated in the next chapter.

Thus, it is found that water shortage is usual in the Kedah river system under the present condition and the situation will become worse with the increase of domestic and industrial water demand and small irrigation development along the main stream.

(3) Muda-Perai river system

The Muda river is integrated with the Perai river by the Sungai Dua canal for irrigation purpose and also with the Perai river and local rivers in the Pinang island for water supply purpose. The abstraction volume from the Muda river is given as the deficit accumulated along the canal systems which is the demand less natural runoff supply by the Perai and the local rivers. Table 28 shows the annual abstraction volume for the Sungai Dua canal and Table 29 shows that at Intake 20 in the water demand and supply diagram (Plate 2) for Pulau Pinang water supply.

The annual accumulated deficit along the main stream is shown in Tables 30 to 32 for the selected cases of demand projection.

Under the present condition significant water deficit occurs five years during the 20-year period and the deficit will be mostly covered by the pumped up storage of Mengkuang dam whose completion is expected in 1985.

The domestic and industrial demand, however, is growing rapidly. Water deficit will appear more frequently with the increase of the D&I demand. It is expected that more than 100 x 10^6 m^3 of deficit occurs three years during the 20-year period in 2000 under both cases of demand projection.

6.6 Summary of Deficit

Figs. 4 to 16 illustrate the balance of natural runoff and water demand at the lowest stretch for the Perlis river, at the lowest intake near Alor Setar for the Kedah river and at Muda barrage for the Muda river, respectively, for 1982, 1990 and 2000 demand projections in High and Low Growth Cases.

7. RESERVOIR OPERATION STUDY

7.1 General

Net water output is defined as regulated outflow from a dam less compensation discharge to the downstream which is taken in the downstream if the dam is not built. The compensation discharge is also herein called as shutdown discharge.

The purposes of this chapter are to evaluate net water output of the existing and on-going dam projects and to examine net water output of the proposed dams as a function of storage capacity.

Net water output of a dam is examined by a simulation study of reservoir operation for the 20-year period. As a preliminary operation rule, outflow from the dam is assumed to have the same temporal pattern with deficit in the contemplated demand area, i.e., the proportion of outflow to the corresponding deficit is constant throughout the 20-year period.

For a given reservoir storage of a dam, the maximum proportion of outflow to deficit is determined by trials and errors method as follows. For a reservoir having a large carry-over space for dry years, the whole space of the reservoir is used only once during the 20-year period. This is applied to the operation of the Pedu-Muda dam system, Ahning dam and Rui dam. On the other hand, operation of smaller reservoirs allows the reservoir water level to drop to the low water level three times during the 20-year period.

7.2 Procedure of Reservoir Water Balance

(1) The water balance of reservoir during a 5-day period is given by the following equation:

$$S_{end} = S_b + I - O - E - SP \quad \text{.......................} \quad (4)$$

where, S_{end}: Reservoir storage at the end of the 5-day period
S_b : Reservoir storage at the beginning of the period
I : Inflow to the reservoir during the period
O : Outflow from the reservoir during the period
E : Evaporation from the reservoir surface during the period
SP : Spillout discharge during the period, if any

(2) Inflow to the reservoir consists of two sources. One is the surface runoff from the catchment area of the dam site less the reservoir surface area and the other is rainfall on the reservoir surface.

(3) The temporal pattern of outflow from the reservoir coincides with that of the water deficit in the contemplated downstream demand area.

(4) The minimum rate of outflow from a reservoir is defined as the lowest runoff for the 20-year period for the proposed dams except for the Rui dam. For the Rui dam, it is the 20-year average of 99% exceedence discharge. Table 33 shows the minimum flow for the proposed dams.

The outflow from a reservoir shall be larger than the minimum rate throughout the year, even if no water is required in the downstream.

(5) Evaporation loss is given as potential evaporation depth multiplied by the average surface area of a reservoir during the objective period. The potential evaporation rate is based on the open water evaporation data near the reservoir. Table 34 shows the monthly evaporation data applied to the calculation.

(6) Spillout discharge is the excess water released through a spillway when the reservoir water level is not lower than the high water level.

(7) The stage-storage-surface area relationship is shown in Tables 35 and 36 for the existing and the proposed dams.

(8) The carry-over storage at the beginning of 1961 is determined assuming a circular hydrological series; the reservoir operation study is carried out for 40 years by repeating 1961 to 1980 period twice in the manner that the end of 1980 of the first 20-year period is followed by the beginning of 1961 of the other 20-year period.

Plate 3 shows the mass curves in proportion to average discharge of the key stations of three river basins. The peak of the mass curve is found at the end of 1976 for the key stations of the Kedah and Muda rivers while it is in 1973 for the Perlis river. Then it is assumed that the reservoir water surface is at HWL at the end of 1976 for the Kedah and Muda rivers and in 1973 for the Perlis river. With this assumption, the storage requirement is the largest for obtaining the maximum outflow.

7.3 Supply Capacity of Existing Dams and On-Going Dam Projects

(1) The Pedu-Muda dam system

The Pedu-Muda dam system is an integrated dam system. The water stored in Muda reservoir is sent to Pedu reservoir through Saiong diversion tunnel and the regulated discharge in these two reservoirs is released from the Pedu dam in normal operation and excess water is released through spillway facilities of these dams.

The amount of diversion water through the tunnel is estimated by the equations shown in Table 37 for three different hydraulic conditions in the tunnel, as given in "Muda Irrigation Project Operating and Maintenance Instructions".

The net water output of the Pedu-Muda dam system is calculated following to the procedure given in the previous section using the above equations for integrating two dams. In the case of existing Pedu-Muda system, the catchment water has been shut down in the water balance calculation. The outflow pattern of the system is the accumulated deficits along the Kedah main stream below the Pedu dam, in which the largest user is MADA irrigation area.

The calculated net water output of the system is 718 x 10^6 m3/y on an average for the 20-year period. The supply capacity can cover 72% of water deficit in 1982, 62% in 2000 in High Growth Case and 65% in Low Growth Case.

Table 38 shows annual supply capacity of the system and the remaining deficit of the Kedah river system.

(2) Ayer Hitam dam

The net water output of Ayer Hitam dam is estimated at 2 x 10^6 m^3/y and it is assumed to be constant every year. The output has been deducted from the demand of the Pinang island. Thus, the effect of Ayer Hitam dam has been taken into account in estimating the water deficit in the Muda-Perai river system.

(3) Mengkuang dam

The water pumped up in Mengkuang reservoir is released in a drought spell, which usually occurs for a continuous few months once a year. The net water output of the dam is estimated at 24 x 10^6 m^3/y at maximum, which is equal to the active storage.

(4) Ahning dam

Ahning dam is planned to supply water to domestic and industrial water uses in the downstream reaches of the Kedah river, mostly located below Pulbang barrage and along the MADA canal. The Ahning dam is characterized by its large active storage of 200 x 10^6 m^3 which is about three times of annual average inflow volume. Thus, the reservoir has a large carry-over capacity, but the average regulated flow is only 51 x 10^6 m^3/y which is about 82% of the average annual inflow and the net water output is 31 x 10^6 m^3/y on an average as shown in Table 39.

(5) Timah-Tasoh and Arau dams

The net water output of Timah-Tasoh dam is estimated at 14 x 10^6 m^3/y assuming 37 x 10^6 m^3 of active storage.

The water output of Arau dam is estimated at 13 x 10^6 m^3/y assuming 25 x 10^6 m^3 of active storage. The contemplated demand area of the dam is irrigation areas along the Arau river.

Their annual output is summarized in Table 40.

7.4 Supply Capacity of Proposed Dams

(1) Demand areas

The contemplated supply area of Badak-Temin, Sari and Durian dams is located along the main stream of the Kedah river, mainly in the lower reaches.

Beris and Tawar-Muda dams can supply the southern MADA irrigation area below Guar Kepayang regulator through Jeniang diversion system and also can supply the lower reaches of the Muda-Perai river system and the Pinang island.

Rui dam will supply only the Muda-Perai system.

The deficit in the Kedah river system occurs every year while that of the Muda-Perai river system does not occur every year but a large deficit occurs in a few years during the 20-year period.

Thus a dam for the Muda-Perai demand area is less effective than for the Kedah demand area.

The proposed dams in the Kedah river basin can also be alternatives for water supply to the Muda-Perai demand area if Jeniang diversion system is in operation because it allows to increase available water to be supplied by storages in the Muda-Perai river system. The supply capacity of these dams for Muda-Perai system is estimated for the use of economic evaluation of D&I water supply.

(2) Supply capacity

Supply capacity of the proposed dams is calculated by the procedures described in the previous section.

Although annual shutdown discharge of a proposed dam is different between High and Low Growth Cases, the difference is negligibly small for the proposed dams. Thus, annual shutdown discharge of the proposed dams under the demand pattern in 2000 in Low Growth Case only is shown in Table 41.

Table 42 shows net water output for selected cases of dam height. The pattern of outflow used for the calculation is similar to the deficit along the Kedah main stream for the Badak-Temin, Sari and Durian dams. Remaining deficit in the southern MADA irrigation area with the Jeniang diversion system is used for the operation of the Beris and Tawar-Muda dams.

Rui dam is operated for the deficit pattern of the Muda-Perai river system.

7.5 Supply Capacity of Jeniang Diversion System

Jeniang diversion system will take river water in the middle reaches of the Muda river and divert to the southern MADA irrigation area through a diversion canal and Naok dam. The capacity of the diversion canal is 40 m^3/s at maximum and the Naok dam has 27×10^6 m^3 of active storage.

It is assumed that the system can take river water so far as that does not cause increased water deficit in the main stream of the Muda river below the Jeniang weir.

As for the river maintenance flow immediately downstream of the weir, the minimum requirement to release over the weir to the downstream is determined at 2 m^3/s which is the lowest discharge at the weir site in the 1961 - 1980 period.

The water diverted from the Jeniang weir is assumed to be sent to the Central canal of the MADA main canal just upstream of the Guar Kepayang regulator. The command area of the canal at the regulator is 33,400 ha in the southern MADA area.

In the balance calculation of the Jeniang system, the water demand along the MADA main canal except the above southern MADA area is firstly supplied by uncontrolled river flow taken at the Pelubang weir and the excess water, if any, is supplied to the southern MADA area. The water from the Jeniang system can cover only the deficit of the southern MADA area of 33,400 ha.

Table 43 shows the available amount of water to be diverted by the system in which the demand of the northern MADA area, deficit in the southern MADA area, the natural runoff of the Muda river at the weir site, the amount of uncontrolled diversion water and the amount of controlled water by Naok dam are summarized on annual basis for High Growth Case. Table 44 shows those for Low Growth Case.

Tables 45 to 50 show the balance of diversion water on the 5-day basis under the 1976 and 1977 hydrological condition. The uncontrolled river flow is not effective in January and October when no water demand occurs in the MADA area. The active storage of Naok dam can be used averagely twice a year by storing the excess water.

In this calculation, the effect of the spillout from the Pedu dam is not counted. If the Pedu dam were full at the end of the wet season, the excess water through spillway could be used for supplying the deficit in MADA area and reversely, supply by the Jeniang system could be reduced. However this situation would rarely occur. The simulation study shows that spillout from the Pedu dam occurs in January to February and the demand in the MADA area is quite low in this period. No diversion water from this Jeniang system is expected during the period. On the other hand the demand in March in the Muda-Perai river system is so large that no excess water is available from the Kedah river system to the MADA south area. Then the Jeniang system is effective in and after March. Thus it is assumed that the spillout effect of the Pedu dam is negligible.

The supply area of the Jeniang system may be extended to 43,600 ha which corresponds to command area of the Central canal of the MADA area developing in the left bank of the Kedah river below the Pelubang weir. For this purpose, a new feed canal would be necessary to be constructed from the Guar Kepayang to the northern part of the command area. The incremental water volume of the Jeniang system is about 60 x 10^6 m^3 due to the extension.

8. OPTIMIZATION STUDY

8.1 Optimum Scale of Dam

The optimum scale of dam is determined by applying the least cost criteria for producing unit net water output.

The relation between dam cost and corresponding storage volume is obtained in the dam study given in ANNEX L "PROPOSED DAM PROJECTS". On the other hand, storage capacity - net water output curves are prepared in the previous section.

Unit construction cost of dam is defined as the investment cost of a dam divided by corresponding net water output. A curve showing the relation between storage capacity and unit construction cost is obtained for each proposed dam by combining above-mentioned curves. Figs. 17 to 19 show storage capacity and unit cost curves, in which the point of least unit cost is indicated. Because the physical maximum scale for dam construction is smaller than the scale of least unit cost for the Badak-Temin, Durian, Tawar-Muda and Beris dams, their optimum scale is determined to be the physical maximum scale. In the case of the Rui and Sari dams, their optimum scales are determined by the least unit cost.

8.2 Supply Capacity of Optimum Scale

Annual supply capacity of proposed dams at their optimum scale is summarized in Tables 51 and 52 for the 20-year period. The variation of annual supply capacity coincides with that of deficit of the contemplated demand area.

Since the proposed dams in the Kedah river system can be alternatives for water supply of the Muda-Perai river system after Jeniang diversion system is in operation, supply capacity for the deficit pattern of the Muda-Perai river system is also calculated.

8.3 Reservoir Operation Rule

In evaluating supply capacity of a reservoir, the outflow discharge from the reservoir is determined to have the same temporal pattern with the water deficit to which the reservoir supplys its stored water.

The proportion of outflow discharge to the contemplated water deficit has been optimized by a simulation study based on 1961 - 1980 hydrological condition.

This operation rule will guarantee to release 100 percent of the assigned outflow till the dam uses up its full space of the active storage and if the reservoir is empty, inflow discharge only can be released from the reservoir until the inflow exceeds the assigned outflow discharge.

The illustration in the top of Fig. 20 shows the case of shortage of supply for Beris dam in which the shortage occurs concentratedly in the later part of the dry season. This situation may occur four times during the 1961 - 1980 period under the operation condition in this study for Beris dam.

For avoiding the concentration of the shortage of supply in a short duration, an appropriate operation method shall be introduced.

In this study, water level rule curve method and maximum allowable discharge method are examined.

For a reservoir having carry-over storage for a few or less consecutive years, the rule curve method is applicable as shown in Figs. 20 and 21 for Beris and Tawar-Muda dams, respectively.

A water level rule curve is constructed by trials and errors method by a simulation study. The recommended rule curve is shown in the bottom illustration in Figs. 20 and 21. If the reservoir water level is lower than a broken line at the beginning of any 5-day period, the outflow of the period shall be reduced by 10 percent from the assigned outflow discharge.

The second illustration in the figures shows the shortage of supply resulted from the application of the rule curves. It is obviously shown in the figures that the shortage of supply is almost evenly distributed for the supply period and the maximum proportion of shortage to the assigned outflow in a 5-day period is largely reduced.

By applying this method, the drought damage due to shortage of supply could be significantly decreased in an extreme drought year but average output will be a little reduced.

On the other hand a reservoir having a large carry-over storage for a consecutive years, water level rule curves are usually provided for firm output and for secondary output of carry-over. In the case of Pedu dam, the reservoir has about 650 x 10^6 m^3 of firm output and about 100 x 10^6 m^3/y of average carry-over capacity.

However the method is not effective for such a dam as Pedu dam having 9 consecutive dry years in this simulation study from 1977 to 1980 and return to 1961 to 1965 as shown in Fig. 22.

The maximum outflow requirement of 885 x 10^6 m^3 occurs in 1977. It requires to release three times of annual average carry-over storage and it is possible to release 100 percent of the requirement if no restriction is introduced because the reservoir is full in the beginning of 1977. In this situation, the outflow in 1977 is to be restricted to 750 x 10^6 m^3 if the use of carry-over capacity is restricted to 100 x 10^6 m^3 for each one year.

As an alternative operation method, a combinational use of the maximum allowable discharge method and water level rule curve is preliminarily examined in this study.

In the bottom of Fig. 22, a proposed maximum allowable outflow pattern and a water level rule curve are illustrated.

If outflow from the reservoir is restricted within the above limitation, the reservoir will not be empty for the 1961 - 1980 hydrological condition and shortage of supply is insignificant. The reservoir water level rule curve is effectively applied only for the critical condition of the reservoir when carry-over storage capacity has been already used in the preceding years.

Because the proportion of outflow assigned for Pedu dam is determined under the condition that no shortage of supply occurs during the 1961 - 1980 hydrological year, the above-mentioned operation rule effectively works only in an extreme dry spell severer than the 1977 - 1965 dry spell.

If a bigger proportion of outflow is assigned for Pedu dam, average output will be increased but shortage of supply may occur in a drought year or in the last year of a consecutive dry years. The operation rule will be more effective in this situation for distributing shortage of supply for a longer period of the drought spell.

In the further study of the recommended source facility plan, a simulation study shall be carried out for an integrated system, in which Pedu-Muda dam system, Mengkuang, Ahning, Beris and Tawar-Muda dams and Jeniang system are simultaneously operated following to the operation rules given in advance. Then the operation rule shall be optimized in economic and technical viewpoints.

9. WATER SUPPLY PLAN

9.1 General

Water demand and supply balance plans are studied for the Perlis, Kedah and Muda-Perai river systems under 1977 hydrological condition.

As discussed in the previous section 5.1, 1977 is one of the severest dry years over the Region and it is selected as the design drought year in this study.

9.2 Perlis River System

Annual water deficit of the main stream of the Perlis river system is estimated at 3 x 10^6 m^3 by 1990 and 29 x 10^6 m^3 by 2000 under the design drought year (1977).

The on-going Timah-Tasoh dam project is a multipurpose project for flood mitigation, irrigation, domestic and industrial water supply. The dam having 37 x 10^6 m^3 of storage capacity is located in the upstream reaches of the Perlis river.

Since the deficit of 29 x 10^6 m^3 in 2000 can be met by 29 x 10^6 m^3 of storage, the deficit can be fully covered by the storage of Timah-Tasoh dam. No additional source facility is necessary by 2000.

9.3 Kedah-Muda-Perai Integrated River System

9.3.1 General

Although Pedu-Muda dam system can supply 885 x 10^6 m^3 of water in the design drought year, the remaining deficit of the Kedah river system is 312 x 10^6 m^3 in 1982 and it increases to 463 x 10^6 m^3 in 2000 in High Growth Case or 398 x 10^6 m^3 in Low Growth Case.

The on-going Jeniang diversion system will cover a part of the deficit by its supply capacity of 209 x 10^6 m^3 in High Growth Case or 214 x 10^6 m^3 in Low Growth Case. Still 254 x 10^6 m^3 of deficit remains in 2000 in High Growth Case. It is 184 x 10^6 m^3 in Low Growth Case.

On the other hand, the water deficit of the Muda-Perai river system is 28 x 10^6 m^3 in 1982 but it is expected to increase to 157 x 10^6 m^3 in 2000 in High Growth Case or 107 x 10^6 m^3 in Low Growth Case.

Since dams proposed in the Muda river upstream of the Jeniang weir can supply directly to both the Kedah and Muda-Perai river systems through Jeniang diversion weir, supply plans of new source facilities are prepared for the integrated Kedah-Muda-Perai river system.

9.3.2 Source development projects

Possible new source facilities for the integrated river system are as follows:

On-going project

The Ahning dam	Kedah river
The Mengkuang dam	Muda river
The Jeniang and Naok system	Muda river

Proposed dam project

The Badak-Temin dam	Kedah river
The Durian dam	Kedah river
The Sari dam	Kedah river
The Tawar-Muda dam	Muda river
The Beris dam	Muda river
The Rui dam	Perak river

Potential dam project

The Ma dam	Muda river
The Khlong Thepha dam	Thailand
The Reman dam	Muda river
The Merbok dam	Muda river

Although Arau dam project is on-going in the Kedah river basin, it is assumed that the controlled water by Arau dam is used only for development of the minor irrigation schemes along the Arau river and it does not contribute to the integrated system because the supply capacity just meets the requirement of the Minor irrigation.

The Rui dam and the potential dams involve some uncertainties:

The Rui dam; The State Government of Perak cannot make a decision to go on a feasibility study unless a mineral potential study in the proposed reservoir area is conducted.

The Ma dam; The plan is only notional.

The Khlong Thepha dam; The plan is only notional. The site is located in Thailand.

The Reman dam; A feasibility study has been completed but a land development project has been implemented in the proposed reservoir area.

The Merbok dam; The plan is only notional.

Net water output and preliminary value of EIRR of the Jeniang system, proposed dams and potential dams are summarized in Table 53.

Assuming that the marginal value of discount rate as the opportunity cost of capital is 8%, only the Beris and Tawar-Muda dams are justifiable among the proposed dams except the Rui dam. Water output of these dams is not enough to meet all the water deficit. On the other hand, the potential dams including the Rui dam are generally large in net water output and favorable in the value of EIRR.

9.3.3 Source development involving potential projects

Overall source development plans for the Kedah-Muda-Perai river system are formulated assuming all the cases between 2 extremes; any of the potential projects including the Rui dam can be implemented in one extreme case and no potential dam can be implemented in the other.

For all the cases, it is assumed that the on-going Mengkuang dam, Ahning dam and Jeniang system, and the proposed Beris dam are implemented.

The optimum plan for each case is formulated based on the net benefit maximization criteria. The proposed and potential dams, higher than 8% in the value of EIRR, are selected in the descending order of EIRR, except the potential dams which are not implemented by some non-economic reason, until the total net supply capacity exceeds the water deficit.

The optimum plans for all the possible cases are illustrated in Fig. 23 for High Growth Case and Fig. 24 for Low Growth Case.

9.4 Recommended Source Development Plan

(1) Development plan

As discussed in ANNEX N "ECONOMIC ANALYSIS OF PROPOSED SOURCE FACILITIES", the economic optimum combination of source development includes Jeniang system, Beris dam and Tawar-Muda dam. The other proposed dams except for Rui dam are not economically feasible in this plan up to 2000, while Rui dam is not included because of uncertainty in implementation of the project and studied only as an alternative source facility in technical viewpoint.

Fig. 25 shows a sketch of the recommended combination of source facilities and their supply area.

(2) Water output distribution at Jeniang weir

If the Beris and Tawar-Muda dams only are implemented and the other proposed dams will not come in, the deficit in the integrated river system cannot be fully covered by the water output of these two dams. Since the water released from the Beris and Tawar-Muda dams is distributed to the Kedah and Muda-Perai river systems at the Jeniang weir, the deficit remained in each river system depends on the operation rule of the Jeniang weir.

In this Study, three typical cases of water allocation at the Jeniang weir is examined. In the first case of the allocation, the Muda river system has a priority to receive the water output of the Beris and Tawar-Muda dams. If there is a deficit in the Muda-Perai river system, the scheduled output of these two dams is supplied to fulfill the deficit and the surplus water output, if any, is diverted to the Kedah river system. This operation is technically possible by observing the water level at the Muda barrage. Actually deficit in the Muda-Perai river system will occur once in a few years in 2000 demand condition. Then the water output is mostly diverted to the Kedah river system in a normal year. Tables 54 and 55 show the annual demand and supply balance of the Muda priority case for the 1961 - 1980 period in which balance of deficit and net water output of source facilities and a ratio of remaining deficit to demand are shown.

In the second case of allocation, the water output is allocated so that the rate of the remaining deficit to demand is evenly distributed in both the Kedah and Muda-Perai river systems after the two dams are operated. For obtaining this condition, a simple operation rule is introduced that discharge from the weir to the downstream of the Muda river is restricted between selected maximum and minimum rate of discharge. If there is a water deficit in the Muda-Perai river system below the weir, water is released from the Jeniang weir but the rate is restricted below the selected maximum rate of discharge while the minimum rate of 2 m^3/s shall be maintained even if there is no deficit in the downstream. The maximum discharge from the Jeniang weir shall be set at 8.5 m^3/s for High Growth Case and 9 m^3/s for Low Growth Case for obtaining even deficit distribution if two dams are operated. If the Beris dam only is implemented the rate shall be 6.5 m^3/s and 7 m^3/s for High and Low Growth Cases, respectively. Tables 56 and 57 show the water balance for the second allocation case.

In the third case of allocation, the priority is given to the Kedah river. The maximum discharge at the Jeniang weir is set at 3 m^3/s and only 1 x 10^6 m^3/y of water output is allocated to the Muda-Perai river system and the remaining water output of two dams are diverted to the Kedah river system through the Jeniang diversion system. In this allocation, the Muda river system will gain few benefit from the source development but will not suffer from the development. Tables 58 and 59 show the water supply and balance of the third allocation case.

In the economic evaluation discussed in ANNEX N, it is found that the first allocation case of Muda priority gives the biggest B - C among these three alternatives.

9.5 Analysis of Water Deficit

(1) Cause of water deficit

For the purpose of economic analysis of the proposed source development plan, the cause of water deficit in Kedah and Muda-Perai river systems is analysed. In the analysis water deficit and water output is expressed by means of average of 20-year period.

Water users of river runoff are classified into MADA and minor irrigation projects and domestic water supply for Kedah river system and minor irrigation projects and domestic and industrial water supply for Muda-Perai river system.

The minor irrigation projects are further classified into those in the main stream and tributary. They are called as the main minor and tributary minor. The minor irrigation project in the main stream are those taking water from a river stretch or a canal which is located downstream of the outlet of the existing or assumed source project and the others are the minor irrigation project in tributary. The existing and future minor irrigation projects in the Kedah river system are either located in the river stretch between the Pedu dam and Pelubang barrage or taking water from the MADA canal system. There is no development plan of minor irrigation projects in the main stream in the Muda-Perai river system.

The causes of water deficit and areas affected by water deficit is examined under the condition that Ahning and Mengkuang dams are put into operation but Jeniang and the proposed dams are not included. The water deficit already existing in 1982 cannot be physically divided into causes and it is regarded as caused by the existing projects in proportion to water demand. For the future years, the difference between total incremental water deficit after 1982 and deficit calculated assuming that water demand in a purpose does not increase is the incremental water deficit caused by the purpose. The water deficit which affects a purpose is assumed to be proportional to water demand of the purpose. The resulted average annual water deficit by cause of water deficit by area affected by water deficit is summarized in Tables 60 and 61.

(2) Allocation of water deficit for source facilities

Water deficit by cause is allocated to the source facilities, in accordance with the correlation between the source facilities and cause of water deficit as shown in Table 62.

The Jeniang system is constructed to supply water deficit within its net water output in MADA, minor irrigation projects in the main stream and domestic and industrial water supply which are existing and to be developed in the Kedah river system up to 2000.

The Beris dam is constructed to supply water deficit caused by increase in domestic and industrial water supply demand in the Muda-Perai river system, by minor irrigation development in tributaries in both the Kedah and Muda-Perai river system, and a part of remaining water deficit in MADA, minor irrigation projects and domestic and industrial water supply in the Kedah river system. The Tawar-Muda dam is constructed to supply water deficit caused by increase in domestic and industrial water demand in the Muda-Perai river system and a part of water deficit in the MADA area, minor irrigation projects in the Kedah river system.

It is assumed that the Sari, Durian, Badak-Temin, Khlong Thepha, Ma and Reman dams supply the Kedah river system and the Merbok and Rui dams supply the Muda-Perai river system.

Average net water output of source facilities by cause of water deficit is calculated as summarized in Tables 63 to 67.

10. WATER DEMAND AND SUPPLY BALANCE IN PERAK RIVER

10.1 General

The purpose of this chapter is to preliminarily examine the effect of shutdown of Rui dam to the water users of the Perak river.

The catchment water of the proposed Rui dam is to be diverted to the Muda river and the dam is planned to release 1.4 m^3/s of constant discharge throughout the year as compensation discharge to the Rui river downstream of the dam site.

The average annual discharge at the proposed Rui 2 dam site is estimated at 7.9 m^3/s. The reduction of 6.5 m^3/s (7.9 - 1.4 m^3/s) will decrease 20 GWh of secondary energy of Chenderoh and Kenering power station.

The energy reduction is to be compensated by the output of a power station newly constructed at the outlet of the transfer tunnel to the Muda river basin. The average output is expected at 60 GWh. A detailed study of the compensation of energy is discussed in ANNEX M.

Hence the major concern of this chapter is effect to water withdrawals in the downstream of Rui river and the main stream of the Perak river.

10.2 Runoff of the Perak River

The natural runoff of the Perak river is estimated in NWRS based on the runoff records at Lanjot in the Kinta river, one of the major tributary of the Perak river.

Although there are three runoff gauging stations along the main stream of the Perak river, no reliable records are available because of significant effect of construction work of three large dams in the upper reaches of the river.

Thus the runoff data studied in NWRS is only the reliable one available for this preliminary water balance study.

10.3 Water Demand

Fig. 26 shows the water demand and supply diagram of the Perak river which is affected by the proposed Rui dam project.

A minor irrigation scheme along the Rui dam has 400 ha of service area and the demand can be fully covered by the intervening catchment water for the 1961 - 1980 hydrological condition.

The demand along the main stream is mainly located downstream of Chenderoh dam. In NWRS, the water demand is estimated at 698 x 10^6 m^3/y for irrigation and 42 x 10^6 m^3/y for domestic and industrial water supply in 2000.

10.4 Water Demand and Supply Balance Calculation

The natural runoff of the upstream reaches of the Perak river is largely controlled by a huge storage of Temengor dam. The regulated outflow is roughly estimated at 93 m^3/s, which is 80% of average annual inflow of 116 m^3/s on the basis of the storage-draft curve of the catchment runoff as shown in Fig. 27.

The constant outflow is added in the dry season on the uncontrolled runoff below the Temengor dam site less the withdrawn discharge from Rui dam. Fig. 29 shows the resulting runoff at the confluence of the Kinta river and the main stream.

It is obviously shown in the figure that the river runoff does not draw below 100 m^3/s in the driest year while the peak of demand is only 50 m^3/s in maximum.

The Perak river still has sufficient water for water withdrawal. The proportion of the demand to the annual river runoff is about 7% in 2000.

Thus it is concluded that the construction of Rui dam will not cause any damage in the downstream water withdrawals by 2000.

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4. FEASIBILITY STUDY FOR PROPOSED JENIANG DIVERSION, NAOK RESERVOIR AND TRANSFER CANAL, DRAFT FINAL REPORT, Aug. 1983

5. FEASIBILITY STUDY FOR PROPOSED STORAGE SCHEME, FINAL REPORT, 1979

6. FEASIBILITY STUDY OF REMAN RESERVOIR PROJECT, DRAFT FINAL REPORT, Nov. 1983

TABLES

Table 1 PRINCIPAL FEATURES OF EXISTING SOURCE FACILITIES

(1) Dams

Name of Dam	Muda	Pedu	Ayer Hitam
River System	Muda	Kedah	Ayer Hitam
Year of Completion	1968	1969	1962
Purpose	Irrigation	Irrigation	Water supply
Reservoir			
Catchment area (km^2)	984	171	25
Surface area (km^2)	26	65	
Normal HWL (El. m)	100.6	97.6	235
Active storage capacity (10^6 m^3)	160	1,049	2
Dam			
Type	Concrete buttress	Rockfill	Central core earth-rock
Crest elevation (El. m)	106	101	236
Crest length (m)	250	220	219
Dam height (m)	37	61	48
Dam volume (10^3 m^3)	30	580	

(2) Barrages

Name of Barrage	Pelubang	Kedah	Muda	Perai
River System	Kedah	Kedah	Muda	Perai
Year of Completion	1969	1970	1973	1981
Purpose	Irrigation	Tidal control	Tidal control	Flood control
Gate Type	Overshot leaf gates	Roller gates	Radial gates	Double stage roller gates
Normal HWL (El. m)	7.71		4.57	

Table 2 PRINCIPAL FEATURES OF ON-GOING PROJECTS

(1) Dam

Name of Dam	Timah-Tasoh	Arau	Ahning	Mengkuang
River System	Perlis	Perlis	Kedah	Mengkuang
Purpose	Flood control & irrigation	Flood control	Water supply, irrigation & power	Water supply
Reservoir				
Catchment area (km^2)	150	58	120	3.6
Surface area (km^2)	12.2	5.5	9	1.7
Normal HWL (El. m)	27.4	23.6	113	43.3
Active storage capacity (10^6 m^3)	37	25	200	24
Dam				
Type	Earthfill	Earthfill	Concrete-faced Rockfill	Earthfill
Crest length (m)	4,300	900		792
Dam height (m)	10			27
Dam volume (10^3 m^3)			750	

(2) Jeniang Diversion System

	Jeniang	Naok	Reman	Remarks
Catchment area (km^2)	667		32	Reman
Normal HWL (El. m)	34	30	57	Pumping Capacity
Capacity				20 m^3/s
Active storage capacity (10^6 m^3)		27	240	Head 28 m
Dam type	Concrete Barrage	Earthfill	Earthfill	Diversion Canal
Dam volume (10^3 m^3)		2,160	1,030	Capacity 40 m^3/s
Dam height (m)			40	Length 10 km

Table 3 PRINCIPAL FEATURES OF POTENTIAL DAMS

		Ma	Khlong Thepha	Merbok
River system		Muda	Khlong Thepha	Merbok
Reservoir				
Catchment area	km^2	40	173	
Annual inflow	10^6 m^3	38	87	
Normal HWL	El. m	75	125	8.5
LWL	El. m	60	120	0
Surface area	km^2	4	16	13
Active storage capacity	10^6 m^3	35	78	110
Regulated outflow	10^6 m^3	30	73	118
Dam				
Type		Rockfill	Rockfill	Dyke
Maximum height	m	30	50	10
Crest length	m	500	600	14,400
Dam volume	10^3 m^3	700	800	10,000
Transfer Canal				
Discharge capacity	m^3/s	-	5	20
Length	km		6	5
Construction cost at 1982 price level	M$$10^6$	80	90	132

Table 4 PRINCIPAL FEATURES OF PROPOSED DAMS WITH OPTIMUM SCALE (1/2)

	Unit	Badak-Temin	Sari	Durian
1. Reservoir				
1.1 Catchment area	km^2	112	61	74
1.2 Annual inflow	10^6 m^3	58	32	38
1.3 Maximum WL	El. m	47	93	76
1.4 Normal HWL	El. m	45	91	74
1.5 LWL	El. m	36.5	69	60
1.6 Surface area	km^2	9.4	4.5	4.6
1.7 Active storage capacity	10^6 m^3	58	56	41
1.8 Net water output (1977)	10^6 m^3	30	23	21
2. Main Dam				
2.1 Crest elevation	El. m	50	95	79
2.2 Maximum height	m	29	47	39
2.3 Crest length	m	1,075	170	903
2.4 Type		Rockfill & concrete	Concrete gravity	Rockfill
2.5 Dam embankment volume	10^3 m^3	929	-	1,084
2.6 Dam concrete volume	10^3 m^3	67	62	-
3. Subordinate and Saddle Dams				
3.1 Number		3	1	-
3.2 Total crest length	m	2,106	270	-
3.3 Embankment volume	10^3 m^3	462	30	-
4. Spillway				
4.1 Discharge capacity	m^3/s	310	402	270
4.2 Overflow crest length	m			
5. River Outlet Facilities				
5.1 Tributary		Badak	Sari	Durian
5.2 Discharge capacity	m^3/s			
6. River Diversion Facilities for Construction				
6.1 Tunnel No. x diameter (m) x length (m)		Multi-stage channel diversion	1x5.9x173	2x4.7x217
7. Power Station				
7.1 Installed capacity	MW	-	-	-
7.2 Energy output	GWh	-	-	-
8. Basin Transfer Tunnel				
8.1 Diameter (m) x length (m)		-	-	-
8.2 Discharge capacity	m^3/s	-	-	-
9. Investment Cost (at 1982 Price Level)				
9.1 Construction work	M10^6	94.64	40.2	85.7
9.2 Land acquisition	M10^6	20.1	15.6	1.4
9.3 Physical contingency	M10^6	34.4	16.7	26.2
Total	M10^6	149.2	72.5	113.3

Table 5 PRINCIPAL FEATURES OF PROPOSED DAMS WITH OPTIMUM SCALE (2/2)

	Unit	Tawar-Muda	Beris	Rui 2	Rui 3
1. Reservoir					
1.1 Catchment area	km^2	129	116	278	305
1.2 Annual inflow	10^6 m^3	123	110	250	273
1.3 Maximum WL	El. m	79	87	248	253
1.4 Normal HWL	El. m	77	85	245	250
1.5 LWL	El. m	65.5	69	202.5	201.5
1.6 Surface area	km^2	9.1	12.6	9.7	16.0
1.7 Active storage capacity	10^6 m^3	54	101	245	383
1.8 Net water output (1977)	10^6 m^3	41	92	241	269
2. Main Dam					
2.1 Crest elevation	El. m	82	89	251	256
2.2 Maximum height	m	34	42	77	85
2.3 Crest length	m	338	145	460	300
2.4 Type		Rockfill	Concrete gravity	Rockfill	Rockfill
2.5 Dam embankment volume	10^3 m^3	281	-	2,714	2,594
2.6 Dam concrete volume	10^3 m^3	-	58	-	-
3. Subordinate and Saddle Dams					
3.1 Number		3	1	-	-
3.2 Total crest length	m	1,520	150	-	-
3.3 Embankment volume	10^3 m^3	913	104	-	-
4. Spillway					
4.1 Discharge capacity	m^3/s	430	410	1,530	1,640
4.2 Overflow crest length	m				
5. River Outlet Facilities					
5.1 Tributary		Muda	Beris	Tiak and Rui	
5.2 Discharge capacity	m^3/s				
6. River Diversion Facilities for Construction					
6.1 Tunnel No. x diameter x length (m)		2x5.4x248	1x5.6x202	2x6.6x513	2x6.9x383
7. Power Station					
7.1 Installed capacity	MW	-	-	26 + 0.88	26 + 0.88
7.2 Energy output	GWh	-	-	64 + 4.4	74 + 4.4
8. Basin Transfer Tunnel					
8.1 Diameter (m) x length (m)		-	-	3.5x9,000	
8.2 Discharge capacity	m^3/s	-	-	30	
9. Investment Cost (at 1982 Price Level)					
9.1 Construction work	M$$10^6$	79.8	34.8	301.2	306.4
9.2 Land acquisition	M$$10^6$	8.3	22.3	0.3	5.6
9.3 Physical contingency	M$$10^6$	26.5	17.1	90.5	93.6
Total	M$$10^6$	114.6	74.2	392.0	405.6

Table 6 ANNUAL RUNOFF DEPTH BY SUB-BASIN

River Basin	Sub-basin	Catchment Area (km^2)	Annual Runoff Depth (mm) Average (1961 - 1980)	Annual Runoff Depth (mm) Drought Year (1977)
Perlis	PL1	341	522	284
	PL2	317	480	262
	PL3	225	620	338
Kedah	KD1	1,343	514	316
	KD2	365	677	416
	KD3	345	914	562
	KD4	503	790	486
	KD5	974	1,051	646
	KD6	63	1,607	988
Muda	MD1	984	756	623
	MD2	756	949	782
	MD3	812	1,053	868
	MD4	895	1,007	830
	MD5	569	1,440	1,186
	MD6	559	1,007	830
	MD7	263	1,346	1,109
Perai	PR1	258	1,179	992
	PR2	453	942	793
	PR3	300	1,276	1,074
Rui	RU1	611	761	627
	RU2	278	898	740

Table 7 ANNUAL RUNOFF AT MAJOR WATER SOURCE FACILITIES

Water Source Facility	River Basin	Catchment Area (km^2)	Annual Runoff (10^6 m^3) Average (1961 - 1980)	Drought Year (1977)
Timah Tasoh Dam Site	Perlis	150	78	43
Arau Dam Site	Perlis	58	28	15
Ahning Dam Site	Kedah	120	62	38
Pedu Dam	Kedah	173	89	55
Pelubang Barrage	Kedah	1,076*	613	377
Kedah Barrage	Kedah	1,961*	1,377	846
Muda Dam	Muda	984	743	612
Jeniang Diversion Site	Muda	667**	633	521
Muda Barrage	Muda	3,070**	3,330	2,741
Perai Barrage	Perai	411	449	377
Badak-Temin Dam Site	Kedah	112	58	35
Sari Dam Site	Kedah	61	32	20
Durian Dam Site	Kedah	74	38	23
Tawar-Muda Dam Site	Muda	129	123	102
Beris Dam Site	Muda	116	110	91
Rui Dam Site	Rui	278	250	206

Remarks; * : The catchment area of the Pedu dam is not included.
**: The catchment area of the Muda dam is not included.

Table 8 DRY SEASON RUNOFF
(March to July)

Unit: 10^6 m^3

Year	Perlis	Kedah	Muda	Perai
1961	13.0	108.8	360.3	63.0
1962	24.4	140.8	408.0	87.8
1963	3.1	22.0	350.3	46.5
1964	16.3	50.7	388.9	56.4
1965	10.3	60.8	319.9	36.5
1966	23.8	119.7	493.5	69.9
1967	36.2	211.1	464.3	90.5
1968	10.3	179.2	128.0	62.2
1969	26.7	90.7	442.5	61.8
1970	22.0	111.5	585.3	72.0
1971	24.7	243.0	299.6	52.8
1972	13.2	245.6	198.4	55.9
1973	15.5	336.6	349.1	74.9
1974	7.2	245.3	219.9	55.1
1975	14.5	69.5	341.5	83.4
1976	22.1	334.7	568.7	46.3
1977	4.7	58.6	116.9	31.7
1978	15.3	114.8	332.9	48.0
1979	33.1	129.5	310.5	32.8
1980	15.6	27.9	286.1	36.0

Table 9 ANNUAL DEMAND

Unit: 10^6 m^3

Basin	1982 D&I	1982 Irri-gation	1990 D&I High Growth	1990 D&I Low Growth	1990 Irri-gation	2000 D&I High Growth	2000 D&I Low Growth	2000 Irri-gation
Perlis River								
Tributary	0	11.8	0	0	10.9	0	0	12.4
Main	0	11.7	0	0	10.8	0	0	49.3
Total	0	23.5	0	0	21.7	0	0	61.7
Kedah River								
Tributaries								
(1) Upstream of Pelubang	0	2.2	0	0	8.9	0	0	20.0
(2) Temin, Arau, Gial	0.7	34.3	1.2	1.0	35.3	1.7	1.3	62.6
(3) Downstream of Pelubang	0.9	1.0	0	0.8	13.7	0	1.0	21.1
Sub-total	1.6	37.5	1.2	1.8	57.9	1.7	2.3	103.7
Main								
(1) MADA	9.7	1,621.1	17.4	15.9	1,543.0	45.6	22.2	1,484.7
(2) Others	19.1	6.1	44.7	31.5	61.4	112.5	47.1	84.9
Sub-total	28.8	1,627.2	62.1	47.4	1,604.4	158.1	69.3	1,569.6
Total	30.4	1,664.7	63.3	49.2	1,662.3	159.8	71.6	1,673.3
Muda-Perai River								
Tributaries								
(1) Muda river	6.3	28.5	9.5	7.7	64.3	13.9	9.9	97.5
(2) Perai others	1.2	6.9	4.1	2.7	6.0	11.3	4.3	10.5
Sub-total	7.5	35.4	13.6	10.4	70.3	25.2	14.2	108.0
Main/Perai/Pinang	126.0	357.6	260.5	205.2	357.8	488.7	322.4	359.2
Total	133.5	393.0	274.1	215.6	428.3	513.9	336.6	467.2
Other Rivers	0	38.7	0	0	39.8	0	0	44.0
Grand Total	163.9	2,119.9	337.4	264.8	2,152.1	673.7	408.2	2,246.2

Table 10 D&I WATER DEMAND BY INTAKE

Unit: 10^6 m^3

Basin	Intake No.	1982	1990 High Growth	1990 Low Growth	2000 High Growth	2000 Low Growth
Kedah						
Tributaries						
(1) Temin, Arau, Gial	2/102	0.7	1.2	1.0	1.7	1.3
(2) Others	6	0	0	0	0	0
	7	0	0	0	0	0
	10003	0.9	0	0.8	0	1.0
Sub-total		1.6	1.2	1.8	1.2	2.3
Main						
(1) MADA	1/101	7.1	10.8	9.3	25.7	15.2
	5	2.6	6.6	6.6	19.9	7.0
(2) Others	4/105	1.3	3.0	2.4	4.2	3.3
	104	0	0.1	0.2	0.3	0.2
	3/103/10001	16.6	37.9	25.9	101.8	38.8
	10002	1.2	3.7	3.0	6.2	4.8
Sub-total		28.8	62.1	47.4	158.1	69.3
Total		30.4	63.3	49.2	159.8	71.6
Muda-Perai						
Tributaries						
(1) Perai others	113	0	2.9	1.6	9.5	3.0
	114/10005	1.2	1.2	1.1	1.8	1.3
(2) Others	8	1.3	0	0	0	0
	9	0.7	0	0	0	0
	17	0	0	0	0	0
	18/112	2.0	0.8	0.7	1.1	0.8
	19	0.3	0.5	0.3	0.8	0.5
	108	0	1.7	1.4	2.4	1.8
	110	2.0	3.6	3.0	5.6	3.9
	111	0	2.9	2.3	4.0	2.9
Sub-total		7.5	13.6	10.4	25.2	14.2
Main	16/109	14.7	23.3	16.5	62.1	25.0
	20/Perai/Pinang	111.3	233.4	185.5	421.2	293.2
	106	0	0.9	0.8	1.3	1.0
	107	0	2.9	2.4	4.1	3.2
Sub-total		126.0	260.5	205.2	488.7	322.4
Total		133.5	274.1	215.6	513.9	336.6
Grand Total		163.9	337.4	264.8	673.7	408.2

Remarks; Refer to Tables 53 to 56 in ANNEX B.

Table 11 PROJECTED IRRIGATION WATER DEMAND BY RIVER SYSTEM (1/10)

Unit: 10^6 m^3

River Basin	Name of Tributary	No. of Scheme	1982	1990	2000
I. Perlis River System					
I-1 Main Stream					
Perlis		(P) 15	2.13	1.98	5.71
"		(P) 6	9.54	8.86	25.54
"		(P) 29	0	0	10.64
"		(P) 30	0	0	7.44
Total of I-1			11.68	10.84	49.33
I-2 Tributary					
Perlis	Sg. Timah	(P) 15	2.00	1.86	1.86
Perlis	Sg. Tasoh	(P) 12	0.74	0.68	0.68
"	"	(P) 23	0	0	0.58
"	"	(P) 24	0	0	0.47
	Sub-total		0.74	0.68	1.74
Perlis	Sg. Jejawi	(P) 7	2.47	2.29	2.29
Perlis	Sg. Kechor	(P) 1	1.59	1.48	1.48
"	"	(P) 3	0.64	0.59	0.59
"	"	(P) 2	2.36	2.19	2.19
"	"	(P) 14	0.95	0.89	0.89
"	"	(P) 4	0.66	0.62	0.62
	Sub-total		6.20	5.76	5.76
Perlis	Sg. Temenggong	(P) 5	0.35	0.32	0.32
"	"	(P) 28	0	0	0.39
	Sub-total		0.35	0.32	0.71
Total of I-2			11.76	10.91	12.36
Total of I			23.44	21.75	61.69

Remarks; Refer to Tables 67 to 71 in ANNEX D.

Table 12 PROJECTED IRRIGATION WATER DEMAND BY RIVER SYSTEM (2/10)

Unit: 10^6 m^3

River Basin	Name of Tributary	No. of Scheme	1982	1990	2000
II. Kedah River System					
II-1 Main Stream					
Kedah	(U/S of Pelubang)	(K) 126	0	0	1.26
"		(K) 127	0	0	2.25
"		(K) 128	0	0	0.84
"		(K) 77	0	1.31	1.31
	Sub-total		0	1.31	5.66
Kedah		MADA	1,621.06	1,543.02	1,484.65
Kedah	(Muda Northern Canal)	(K) 55	0	4.51	4.51
"	"	(K) 135	0	0	0.46
"	"	(K) 54	0	6.95	6.95
"	"	(K) 45	0	6.74	6.74
"	"	(P) 31	0	0	13.36
	Sub-total		0	18.19	32.02
Kedah	(Muda Central Canal)	(K) 136	0	0	0.43
"	"	(K) 64	0	3.83	3.83
"	"	(K) 56	0	1.36	1.36
"	"	(K) 50	0	11.56	11.56
"	"	(K) 49	0	4.80	4.80
"	"	(K) 48	0	3.24	3.24
"	"	(K) 32	1.51	2.16	2.16
	Sub-total		1.51	26.95	27.38
Kedah	(Muda Southern Canal)	(K) 36	4.62	4.29	7.93
"	"	(K) 137	0	0	0.82
"	"	(K) 138	0	0	0.43
"	"	(K) 67	0	1.02	1.02
"	"	(K) 39	0	9.62	9.62
	Sub-total		4.62	14.93	19.82
Total of II-1			1,627.19	1,604.40	1,569.53

Remarks; Refer to Tables 67 to 71 in ANNEX D.

Table 13 PROJECTED IRRIGATION WATER DEMAND BY RIVER SYSTEM (3/10)

Unit: 10^6 m^3

River Basin	Name of Tributary	No. of Scheme	1982	1990	2000
II-2 Tributary					
Kedah	Sg. Kesai	(K) 98	0	0	0.32
Kedah	Sg. Tok-Khamis	(K) 99	0	0	0.32
Kedah	Sg. Tekai	(K) 100	0	0	0.32
"	"	(K) 101	0	0	0.49
"	"	(K) 102	0	0	0.41
"	"	(K) 103	0	0	0.32
"	"	(K) 104	0	0	0.47
"	"	(K) 68	0	0.54	0.54
"	"	(K) 69	0	0.47	0.47
	Sub-total		0	1.01	3.01
Kedah	Sg. Jelutang	(K) 70	0	0.48	0.48
Kedah	Sg. Bdg. Terap	(K) 106	0	0	1.17
"	"	(K) 107	0	0	0.58
"	"	(K) 71	0	0.66	0.66
"	"	(K) 73	0	0.56	0.56
"	"	(K) 108	0	0	2.01
"	"	(K) 105	0	0	0.32
"	"	(K) 72	0	0.84	0.84
"	"	(K) 109	0	0	1.12
"	"	(K) 110	0	0	1.50
	Sub-total		0	2.06	8.76
Kedah	Sg. Janing	(K) 111	0	0	0.32
"	"	(K) 6	2.17	2.02	2.02
	Sub-total		2.17	2.02	2.34
Kedah	Sg. Kejai	(K) 47	0	0.86	0.86
Kedah	Sg. Perik	(K) 46	0	2.46	2.46
"	"	(K) 112	0	0	0.82
	Sub-total		0	2.46	3.28
Kedah	Sg. Alor Yai	(K) 113	0	0	0.64
Perlis	Sg. Gial	(P) 25	0	0	0.52
"	"	(P) 13	1.46	1.36	0.36
"	"	(P) 26	0	0	0.54
	Sub-total		1.46	1.36	2.42

Remarks; Refer to Tables 67 to 71 in ANNEX D.

Table 14 PROJECTED IRRIGATION WATER DEMAND BY RIVER SYSTEM (4/10)

Unit: 10^6 m^3

River Basin	Name of Tributary	No. of Scheme	1982	1990	2000
Perlis	Sg. Arau	(P) 27	0	0	0.80
"	"	(P) 8	2.70	2.50	7.22
"	"	(P) 9	1.33	1.23	3.55
"	"	(P) 10	2.91	2.70	7.78
	Sub-total		6.93	6.43	19.34
Kedah	Sg. Temin	(K) 78	0	0.47	0.47
"	"	(K) 79	0	0.80	0.80
"	"	(K) 129	0	0	0.41
"	"	(K) 130	0	0	0.32
"	"	(K) 131	0	0	0.48
"	"	(K) 5	1.58	1.47	1.47
"	"	(K) 132	0	0	0.58
"	"	(K) 81	0	0.47	0.47
"	"	(K) 80	0	0.32	0.32
"	"	(K) 133	0	0	2.43
"	"	(K) 21	5.38	5.00	7.58
"	"	(K) 33-U/S	2.61	3.78	10.34
"	"	(K) 33-D/S	16.33	15.16	15.16
	Sub-total		25.90	27.47	40.83
Kedah	Sg. Timas	(K) 114	0	0	0.68
Kedah	Sg. Pendang	(K) 115	0	0	0.31
"	"	(K) 116	0	0	0.50
"	"	(K) 117	0	0	0.41
"	"	(K) 118	0	0	0.56
"	"	(K) 122	0	0	1.08
"	"	(K) 119	0	0	0.30
"	"	(K) 32	1.02	2.38	2.38
"	"	(K) 120	0	0	0.38
"	"	(K) 74	0	0.59	0.59
"	"	(K) 75	0	0.77	0.77
"	"	(K) 76	0	1.71	1.71
"	"	(K) 121	0	0	0.52
"	"	(K) 123	0	0	1.18
"	"	(K) 48-U/S	0	3.19	3.19
"	"	(K) 124	0	0	0.89
"	"	(K) 48-D/S	0	5.08	5.08
"	"	(K) 125	0	0	0.53
	Sub-total		1.02	13.72	20.39
Total of II-2			37.48	57.87	103.67
Total of II			1,664.67	1,662.27	1,673.20

Remarks; Refer to Tables 67 to 71 in ANNEX D.

Table 15 PROJECTED IRRIGATION WATER DEMAND BY RIVER SYSTEM (5/10)

Unit: 10^6 m^3

River Basin	Name of Tributary	No. of Scheme	1982	1990	2000
III. Muda & Perai River System					
III-1 Main Stream					
Muda	U/S of Pinang Tungal	(K) 53	0	1.28	1.68
"	"	(K) 184	0	0	0.48
"	"	(K) 185	0	0	0.50
"	"	(K) 66	0	0.75	0.75
"	"	(K) 59	0	1.21	1.21
"	"	(K) 65	0	1.14	1.14
"	"	(K) 2	4.71	5.49	5.49
"	"	(K) 1	9.72	10.18	10.18
"	"	(K) 25	0.60	0.56	0.56
"	"	(K) 51	0	5.17	5.17
	Sub-total		15.03	25.78	27.16
Muda	Pinang Tungal System	(P.P) 2	32.77	29.76	29.76
"	"	(P.P) 4-U/S	1.29	1.40	3.83
"	"	(P.P) 4-D/S	3.45	3.83	1.40
"	"	(P.P) 3-Kerah	11.52	10.44	10.44
"	"	(P.P) 3-Jarak	5.76	5.21	5.21
"	"	(P.P) 6	80.47	68.65	68.65
	Sub-total		135.27	119.29	119.29
Muda	D/S of Pinang Tungal	(K) 31	5.17	5.57	5.57
"	"	(P.P) 1	164.63	141.63	141.63
"	"	(K) 4	37.54	36.43	36.43
"	"	(K) 38	0	29.14	29.14
	Sub-total		207.34	212.77	212.77
Total of III-1			357.64	357.84	359.22
III-2 Tributary					
Muda	Sg. Sok	(K) 139	0	0	0.64
"	"	(K) 140	0	0	0.50
"	"	(K) 141	0	0	0.49
"	"	(K) 82	0	0.73	0.73
"	"	(K) 83	0	0.54	0.54
	Sub-total		0	1.27	2.90
Muda	Sg. Beris	(K) 84	0	0.62	0.62
"	"	(K) 142	0	0	0.60
	Sub-total		0	0.62	1.22

Remarks; Refer to Tables 67 to 71 in ANNEX D.

Table 16 PROJECTED IRRIGATION WATER DEMAND BY RIVER SYSTEM (6/10)

Unit: 10^6 m^3

River Basin	Name of Tributary	No. of Scheme	1982	1990	2000
Muda	Sg. Kerik	(K) 143	0	0	0.50
Muda	Sg. Jemeri	(K) 144	0	0	0.60
"	"	(K) 85	0	0.56	0.56
"	"	(K) 12	4.48	3.99	3.99
	Sub-total		4.48	4.55	5.15
Muda	Sg. Begia	(K) 145	0	0	0.44
Muda	Sg. Chepil	(K) 86	0	1.14	1.14
"	"	(K) 146	0	0	1.16
"	"	(K) 149	0	0	1.55
"	"	(K) 147	0	0	0.99
"	"	(K) 148	0	0	0.81
"	"	(K) 87	0	2.29	2.29
"	"	(K) 15	2.12	1.89	1.89
"	"	(K) 150	0	0	1.03
"	"	(K) 52	0	1.48	1.48
"	"	(K) 44	0	3.58	3.58
	Sub-total		2.12	10.38	15.93
Muda	Sg. Cajad	(K) 88	0	0.54	0.54
"	"	(K) 151	0	0	0.49
	Sub-total		0	0.54	1.03
Muda	Sg. Tembak	(K) 152	0	0	0.65
"	"	(K) 153	0	0	0.41
"	"	(K) 58	0	1.63	1.63
"	"	(K) 154	0	0	0.42
"	"	(K) 63	0	2.77	2.77
	Sub-total		0	4.40	5.86
Muda	Sg. Ketil	(K) 155	0	0	0.42
"	"	(K) 156	0	0	0.62
"	"	(K) 158	0	0	0.47
"	"	(K) 159	0	0	0.36
"	"	(K) 26-U/S	0.65	0.56	0.56
"	"	(K) 91	0	0.71	0.71
"	"	(K) 160	0	0	0.57
"	"	(K) 89	0	0.95	0.95
"	"	(K) 10	0.65	0.58	0.58
"	"	(K) 164	0	0	0.38
"	"	(K) 167	0	0	0.49
"	"	(K) 165	0	0	0.38
"	"	(K) 166	0	0	0.54

Remarks; Refer to Tables 67 to 71 in ANNEX D.

Table 17 PROJECTED IRRIGATION WATER DEMAND BY RIVER SYSTEM (7/10)

Unit: 10^6 m^3

River Basin	Name of Tributary	No. of Scheme	1982	1990	2000
Muda	Sg. Ketil	(K) 169	0	0	0.54
"	"	(K) 90	0	0.96	0.96
"	"	(K) 172	0	0	0.51
"	"	(K) 168	0	0	0.27
"	"	(K) 162	0	0	2.06
"	"	(K) 173	0	0	1.01
"	"	(K) 9	1.05	0.94	0.94
"	"	(K) 174	0	0	0.33
"	"	(K) 175	0	0	0.49
"	"	(K) 40	0	2.08	2.08
"	"	(K) 26-D/S	1.05	1.46	1.46
"	"	(K) 170	0	0	1.00
"	"	(K) 8	4.34	3.87	3.87
"	"	(K) 163	0	0	0.92
"	"	(K) 157	0	0	1.21
"	"	(K) 41	0	1.98	2.27
"	"	(K) 92	0	0.58	0.58
"	"	(K) 161	0	0	1.16
"	"	(K) 171	0	0	0.62
"	"	(K) 93	0	2.41	2.41
"	"	(K) 3	5.58	4.97	4.97
"	"	(K) 60	0	1.60	1.60
"	"	(K) 34	0.93	0.83	0.83
"	"	(K) 94	0	1.31	1.31
	Sub-total		14.25	25.79	40.43
Muda	Sg. Sedim	(K) 176	0	0	0.98
"	"	(K) 178	0	0	0.71
"	"	(K) 179	0	0	1.32
"	"	(K) 27	0.32	0	0
"	"	(K) 35	0.79	0.96	0.96
"	"	(K) 11	1.45	1.34	1.34
"	"	(K) 29	1.31	1.46	1.46
"	"	(K) 182	0	0	1.02
"	"	(K) 19	0.94	0	0
"	"	(K) 183	0	0	0.81
"	"	(K) 43	0	2.66	2.66
"	"	(K) 177	0	0	0.94
"	"	(K) 18	1.64	1.53	1.53
"	"	(K) 180	0	0	0.94
"	"	(K) 62	0	1.89	1.89
"	"	(K) 42	0	2.51	2.51
"	"	(K) 181	0	0	0.61
"	"	(K) 57	0	1.63	1.63

Remarks; Refer to Tables 67 to 71 in ANNEX D.

Table 18 PROJECTED IRRIGATION WATER DEMAND BY RIVER SYSTEM (8/10)

Unit: 10^6 m^3

River Basin	Name of Tributary	No. of Scheme	1982	1990	2000
Muda	Sg. Sedim	(K) 30	1.22	1.13	1.13
"	"	(K) 61	0	1.60	1.60
	Sub-total		7.67	16.71	24.05
Perai	Sg. Jarak	(K) 189	0	0	0.96
"	"	(K) 190	0	0	0.86
"	"	(K) 191	0	0	0.60
"	"	(K) 14	0.60	0	0
"	"	(K) 20	1.58	0	0
"	"	(K) 96	0	1.26	1.26
"	"	(P.P) 5	2.25	1.96	1.96
	Sub-total		4.43	3.21	5.63
Perai	Sg. Kulim	(K) 97	0	0.54	0.54
"	"	(K) 24-U/S	1.16	1.08	1.21
"	"	(K) 24-D/S	1.30	1.21	1.08
"	"	(K) 192	0	0	2.00
	Sub-total		2.47	2.83	4.83
Total of III-2			35.42	70.30	107.97
Total of III			393.06	428.14	467.19
Total of I - III			2,081.17	2,112.16	2,202.08

Remarks; Refer to Tables 67 to 71 in ANNEX D.

Table 19 PROJECTED IRRIGATION WATER DEMAND BY RIVER SYSTEM (9/10)

Unit: 10^6 m^3

River Basin	Name of Tributary	No. of Scheme	1982	1990	2000
IV. Other Rivers					
IV-1 Perlis					
	Sg. Perlis (I)	(P) 11	1.93	1.80	1.80
IV-2 Kedah					
	Sg. Perlis (II)	(K) 134	0	0	0.52
	"	(K) 45	0	0.68	0.68
	Sub-total		0	0.68	1.20
	Sg. Berida	(K) 28	1.03	1.60	1.60
Total of IV-2			1.03	2.28	2.80
IV-3 Muda					
	Sg. Ruai	(K) 22	0.64	1.03	1.03
	Sg. Singkir	(K) 23	2.87	2.66	2.66
	Sg. Merbok	(K) 186	0	0	1.18
	"	(K) 187	0	0	0.30
	"	(K) 95	0	0.95	0.95
	"	(K) 37	1.79	1.66	1.66
	"	(K) 188	0	0	0.60
	"	(K) 7	3.95	3.67	3.67
	Sub-total		5.74	6.29	8.37
Total of IV-3			9.25	9.98	12.06
IV-4 Perai					
	Sg. Jawi	(K) 13	0.41	0.55	0.55
	"	(K) 195	0	0	0.52
	Sub-total		0.41	0.55	1.07
	Sg. Junjong (I)	(P.P) 8	4.09	3.81	3.81
	Sg. Junjong (II)	(K) 193	0	0	0.40
	"	(K) 194	0	0	0.70
	"	(P.P) 7	2.92	2.71	2.71
	"	(P.P) 12	0	1.32	1.32
	"	(P.P) 9	0.43	0.40	0.40

Remarks; Refer to Tables 67 to 71 in ANNEX D.

Table 20 PROJECTED IRRIGATION WATER DEMAND BY RIVER SYSTEM (10/10)

Unit: 10^6 m^3

River Basin	Name of Tributary	No. of Scheme	1982	1990	2000
	Sg. Junjong (II)	(P.P) 11	4.18	3.33	3.33
	"	(P.P) 10	0.39	0.48	0.48
	Sub-total		7.92	8.24	9.34
(Pinang Island)					
	Sg. Pinang	(P.P) 13	4.09	3.83	3.83
	Sg. Ruso	(P.P) 13	1.63	1.52	1.52
	Sg. Kongs	(P.P) 14-U/S	5.53	1.89	1.89
	"	(P.P) 14-D/S	0	3.27	3.27
	Sg. Burong	(P.P) 14	2.46	2.30	2.30
	Sg. P. Petong	(P.P) 14	0.34	0.32	0.32
	Sub-total		14.05	13.13	13.13
Total of IV-4			26.47	25.73	27.35
Total of IV			38.68	39.79	44.01
Total of I - IV			2,119.85	2,151.95	2,246.09

Remarks; Refer to Tables 67 to 71 in ANNEX D.

Table 21 RIVER MAINTENANCE FLOW

Unit: m^3/s

River System	1990		2000	
	High Growth	Low Growth	High Growth	Low Growth
Perlis	0.5	-	1.5	-
Kedah	2.2	2.0	6.1	2.3
Muda	0	0	0	0
Merbok	0	0	0	0
Perai	0	0	0	0
Julu	0	0	0	0

Table 22 ANNUAL DEFICIT BY TRIBUTARY

Basin	Tributary	1982 Average Deficit (10^6 m^3)	1982 Deficit in 1977 (10^6 m^3)	1982 No. of Deficit Year	1990 Average Deficit (10^6 m^3)	1990 Deficit in 1977 (10^6 m^3)	1990 No. of Deficit Year	2000 Average Deficit (10^6 m^3)	2000 Deficit in 1977 (10^6 m^3)	2000 No. of Deficit Year
Perlis	Tasoh	0.33	0.64	20	0.03	0.27	9	0.03	0.27	10
	Timah	0.25	0.96	16	0.20	0.85	14	0.21	0.88	14
	Jejawi	0.78	1.40	20	0.78	1.40	20	0.68	1.27	19
	Kechor	1.36	2.82	20	1.16	2.57	19	1.17	2.57	19
	Temenggong	0.11	0.32	19	0.00	0.03	2	0.00	0.04	3
	Tok Nin	0	0	0	0	0	0	0	0	0
Kedah	Kesai	0	0	0	0	0	0	0.02	0.01	8
	Tok Khamis	0	0	0	0	0	0	0.02	0.02	10
	Tekai	0	0	0	0.03	0	7	0.12	0.04	10
	Jelutang	0	0	0	0.03	0.02	9	0.03	0.02	9
	Bdg. Terap	0	0	0	0.01	0	3	0.32	0.24	13
	Pdg. Langet	0	0	0	0	0	0	0	0	0
	Janing	0.08	0.01	10	0.07	0	7	0.09	0.02	10
	Berau	0	0	0	0	0	0	0	0	0
	Kejai	0	0	0	0.04	0	5	0.04	0	5
	Perik	0	0	0	0.57	0.95	20	0.62	1.01	20
	Alor Yai	0	0	0	0	0	0	0.03	0.02	9
	Tok Yan	0	0	0	0	0	0	0	0	0
	Rimba	0	0	0	0	0	0	0	0	0
	Temas	0	0	0	0	0	0	0.03	0	7
	Pendang	0.03	0.01	7	1.04	0.97	18	1.35	1.27	18
	Gial	0.36	0.80	19	1.30	1.97	20	1.31	2.00	20
	Arau	0.39	2.66	12	2.33	7.15	19	8.29	16.11	20
	Temin	2.82	4.63	18	2.76	4.46	18	7.31	12.12	20
Muda	Sok	0	0	0	0.00	0	1	0.01	0.06	5
	Beris	0	0	0	0	0	0	0.00	0.02	3
	Kerik	0	0	0	0	0	0	0	0	0
	Pokeh	0	0	0	0	0	0	0	0	0
	Jemeri	0.36	1.15	19	0.39	1.23	19	0.50	1.47	20
	Begia	0	0	0	0	0	0	0.01	0.02	5
	Keduak	0	0	0	0	0	0	0	0	0
	Chepil	0.01	0.04	2	0.04	0.12	2	0.15	0.76	6
	Cajad	0	0	0	0.01	0.02	5	0.01	0.05	5
	Tembak	0	0	0	0.02	0.09	5	0.05	0.27	5
	Ketil	1.15	2.26	20	2.10	3.50	20	1.52	3.61	20
	Sedim	0.03	0.07	6	0.03	0.09	5	0.07	0.25	5
	Jerong	0	0	0	0	0	0	0	0	0
Perai	Kerah	0.30	1.01	20	0.39	1.23	20	0.39	1.23	20
	Jarak	0.00	0	2	0.00	0	1	0.01	0	1
	Kulim	0.00	0	1	0.00	0	1	1.90	2.82	20
Merbok	Merbok	0.45	1.45	17	0.47	1.52	18	0.70	2.05	20
Julu	Julu	0.00	0.01	5	0	0	0	0	0	0

Table 23 MONTHLY DEFICIT OF PERLIS RIVER BASIN IN 1982

1982

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	0	0	0	0	0	0	0	0.20	0	0	0	0.20
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	1.70	0	0	0	1.70
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0.95	0	0	0	0.95
1975	0	0	0	0	0	0	0	0	0.24	0	0	0.02	0.25
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	1.17	2.52	3.70
1978	0	0	0	0	0	0	0	0	0	0	0.18	0	0.18
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Mean													0.35

Table 24 MONTHLY DEFICIT OF PERLIS RIVER BASIN IN 1990 AND 2000

1990

UNit: 10^6 m^3

Year	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	0	0	0	0	0	0	0	0.09	0	0	0	0.09
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0.03	0.05	0.05	0.03	0	0.05	0	0	0	0	0.22
1964	0	0	0.01	0.05	0	0	0.02	0.05	1.52	0	0	0	1.65
1965	0	0	0.03	0.32	0.21	0	0	0	0	0	0	0	0.56
1966	0	0	0	0.02	0	0	0	0	0	0	0	0	0.02
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0.80	0	0	0	0.80
1975	0	0	0	0	0	0	0	0	0.20	0	0	0	0.20
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0.01	0.05	0.02	0	0	0	0	0	1.04	2.24	3.35
1978	0	0	0	0	0	0	0	0	0	0	0.12	0	0.12
1979	0	0	0.02	0.02	0	0	0	0	0	0	0	0	0.03
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Mean													0.35

2000

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	0	4.24	4.29	1.12	3.17	0.10	0	1.04	0	0	0	13.97
1962	0	0	4.46	4.96	0	1.64	0.32	0	0	0	0	0.12	11.50
1963	0	0.01	6.41	5.97	5.37	6.10	3.09	1.11	0	0	0	0	28.06
1964	0	0	5.75	5.97	0.17	3.10	4.62	1.11	3.42	0	0	0	24.14
1965	0	0	6.41	6.24	4.09	5.52	0.94	0	0	0	0	0	23.21
1966	0	0	4.12	5.09	0.60	0.06	0.10	0	0	0	0	0	9.97
1967	0	0	3.03	2.97	0	0	0	0	0	0	0	0	6.01
1968	0	0	3.92	1.57	1.82	6.62	4.40	0	0	0	0	0.06	18.38
1969	0	0	4.88	0	0	0.20	0	0	0	0	0	0	5.08
1970	0	0	3.90	3.57	0.16	0.68	0	0	0	0	0	0	8.32
1971	0	0	1.16	2.66	0.82	0.15	0	0	0	0	0	0	4.79
1972	0	0	4.93	2.10	0.77	4.07	2.59	0.02	0	0	0	0	14.48
1973	0	0	3.58	2.20	0.44	1.05	0.10	0	0	0	0	0	7.36
1974	0	0	4.76	5.09	2.79	2.66	2.00	0	1.91	0	0	0	19.21
1975	0	0	3.86	3.06	0.42	0.54	3.26	0	0.48	0.03	0	0.25	11.89
1976	0	0	5.38	4.83	0.20	2.78	0.85	0	0.06	0	0	0.06	14.16
1977	0	0	5.88	5.97	2.96	3.88	3.53	0	0	0	2.03	4.60	28.87
1978	0	0.01	2.88	1.83	0.67	4.64	0.85	0	0	0	0.40	0.19	11.47
1979	0	0	6.06	3.91	0	0.79	0	0	0	0	0	0.22	10.98
1980	0	0	2.88	0.77	0	0.93	0	0	0	0	0	0	4.58
Annual Mean													13.82

Table 25 MONTHLY DEFICIT OF KEDAH RIVER BASIN IN 1982

1982 Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	215.20	71.60	0	6.93	111.40	183.60	148.69	154.23	125.09	19.26	37.37	154.55	1227.92
1962	183.27	73.00	0.64	19.89	73.63	195.45	101.81	117.84	56.59	13.69	42.23	206.09	1084.13
1963	228.48	78.96	4.64	28.87	145.56	210.33	156.43	164.92	104.76	14.89	9.83	183.46	1331.13
1964	232.34	81.37	4.52	28.30	119.17	200.49	145.09	155.56	71.23	53.61	6.04	181.08	1278.81
1965	231.67	80.46	1.43	18.63	133.80	205.78	141.52	105.34	39.38	4.43	6.38	4.48	973.28
1966	184.65	63.59	0	19.57	102.36	153.49	145.25	147.61	96.77	4.29	5.49	81.11	1004.18
1967	124.10	64.33	0	15.13	67.79	131.70	82.00	100.80	57.83	0	7.08	102.52	753.27
1968	204.78	69.04	1.65	4.59	118.06	193.67	135.18	122.09	61.61	2.02	15.83	108.17	1036.70
1969	176.49	60.82	0	24.43	140.41	174.61	117.83	68.07	62.47	6.69	0	88.96	920.77
1970	181.91	57.28	0	27.02	109.70	180.40	109.26	86.87	51.97	0.80	1.59	88.41	895.19
1971	149.58	44.36	0	15.09	138.27	139.09	104.62	69.39	48.04	4.54	0	86.55	799.52
1972	168.72	50.95	0	0	90.82	188.91	150.69	153.91	13.44	1.19	0	59.80	878.42
1973	154.21	45.09	0	7.69	46.16	95.91	109.25	76.87	74.68	0	0.48	72.36	682.69
1974	162.75	46.16	0	23.91	33.09	157.56	125.82	106.36	55.31	2.46	7.21	149.94	870.58
1975	159.02	60.78	0	23.60	141.71	192.60	134.17	131.04	79.82	30.11	23.47	87.58	1063.90
1976	176.33	59.43	0	15.01	52.01	159.12	58.11	101.13	58.42	0	0	115.18	794.74
1977	189.20	60.39	0	27.20	117.32	204.68	158.88	130.42	78.42	7.45	29.66	178.02	1181.65
1978	219.43	75.82	3.16	27.25	139.03	160.58	95.06	118.60	52.00	30.26	48.25	152.44	1121.87
1979	219.06	76.05	4.22	20.72	89.01	180.65	108.61	124.31	40.70	49.40	7.28	139.29	1059.31
1980	204.57	68.88	1.54	24.38	145.82	205.70	149.82	111.43	68.35	0	0	75.02	1055.51
Annual Mean													1000.68

Table 26 MONTHLY DEFICIT OF KEDAH RIVER BASIN IN 1990

1990 High Growth

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	26.52	324.35	206.71	142.08	192.96	78.29	61.41	115.70	6.09	81.61	45.34	1281.06
1962	0	26.74	333.36	222.64	99.33	204.76	33.49	29.80	41.99	8.54	91.88	53.14	1145.67
1963	0	28.52	342.43	234.46	176.90	221.59	86.95	73.63	99.46	4.28	35.33	30.51	1334.06
1964	1.63	33.04	342.98	233.27	150.05	209.99	77.67	62.88	58.75	32.89	25.90	28.68	1257.73
1965	0.40	30.47	334.62	218.67	164.85	215.37	71.02	18.36	39.76	0	34.93	0	1128.45
1966	0	22.36	327.66	221.43	133.14	162.47	74.71	55.73	96.71	0	24.83	0	1119.04
1967	0	24.94	328.95	215.33	98.02	143.28	22.76	24.82	59.91	0	30.66	1.57	950.25
1968	0	26.40	311.71	138.06	149.20	203.08	65.97	38.28	58.46	0	57.48	7.67	1056.33
1969	0	24.81	332.33	214.83	171.59	183.71	47.20	6.06	44.77	1.31	5.38	0	1031.99
1970	0	23.89	331.12	229.88	140.32	189.81	43.16	20.34	57.64	0	38.04	2.87	1077.08
1971	0	11.33	225.58	206.98	169.18	147.62	40.19	9.28	57.89	0	6.15	0	874.19
1972	0	21.51	318.52	110.06	121.21	198.24	80.19	61.27	20.53	0	3.67	0	935.21
1973	0	20.67	323.36	168.63	71.97	99.90	39.32	7.76	64.42	0	30.53	3.91	830.47
1974	0	21.47	324.57	225.61	48.93	166.24	55.10	37.40	67.74	0	61.44	16.28	1024.77
1975	0	24.22	327.27	225.57	172.98	201.80	68.36	45.12	62.66	14.35	75.58	19.60	1237.51
1976	0	24.31	332.14	210.02	73.93	168.06	22.41	28.87	65.06	0	10.05	2.95	937.80
1977	0	24.57	332.88	230.63	147.91	214.06	88.19	42.97	77.03	2.15	85.77	29.67	1275.83
1978	0	28.26	339.66	232.26	170.46	169.06	37.53	38.65	37.10	13.53	108.37	15.54	1190.41
1979	0	28.37	342.30	204.40	119.60	189.89	46.75	37.29	28.24	20.03	30.59	9.71	1057.16
1980	0	26.33	337.38	229.22	177.12	215.14	79.41	22.33	67.74	0	16.42	0	1171.11
Annual Mean													1095.81

1990 Low Growth

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	26.22	323.18	205.61	141.23	191.98	77.13	60.25	114.60	5.73	80.96	44.59	1271.48
1962	0	26.44	332.19	221.51	98.50	203.63	32.71	29.00	41.42	8.35	91.24	51.98	1136.98
1963	0	28.23	341.35	233.45	175.75	220.58	85.87	72.57	98.56	4.09	35.10	29.58	1325.12
1964	0.97	32.10	341.94	232.23	148.93	208.86	76.77	61.71	58.13	32.15	25.82	27.85	1247.45
1965	0.07	29.53	333.45	217.54	163.68	214.24	69.86	17.66	39.65	0	34.85	0	1120.53
1966	0	22.06	326.50	220.30	132.12	161.55	73.55	54.94	95.92	0	24.67	0	1111.59
1967	0	24.64	327.79	214.22	97.44	142.63	22.42	24.21	59.41	0	30.57	1.53	944.85
1968	0	26.10	310.72	137.51	148.04	201.96	65.00	37.50	57.98	0	57.27	7.63	1049.71
1969	0	24.51	331.17	213.70	170.42	182.74	46.37	5.87	44.52	1.27	5.30	0	1025.86
1970	0	23.59	329.95	228.76	139.41	188.69	42.36	20.13	57.13	0	37.82	2.83	1070.66
1971	0	11.14	224.98	205.85	168.01	146.93	39.61	9.23	57.53	0	6.07	0	869.35
1972	0	21.21	317.36	109.60	120.37	197.11	79.03	60.29	20.46	0	3.63	0	929.05
1973	0	20.37	322.19	167.84	71.73	99.68	38.78	7.33	63.83	0	30.41	3.87	826.02
1974	0	21.17	323.41	224.48	48.66	165.45	53.93	36.61	67.18	0	61.18	16.19	1018.27
1975	0	23.92	326.11	224.44	171.81	200.67	67.42	44.33	61.88	13.93	75.37	19.51	1229.40
1976	0	24.01	330.97	209.04	73.62	167.15	22.08	28.12	64.49	0	9.97	2.91	932.36
1977	0	24.27	331.71	229.50	147.04	212.93	87.11	42.13	76.22	2.08	85.50	28.98	1267.45
1978	0	27.96	338.61	231.25	169.33	168.11	36.87	37.86	36.79	13.13	107.56	15.17	1182.62
1979	0	28.08	341.26	203.50	118.62	188.76	45.85	36.67	28.01	19.43	30.38	9.62	1050.18
1980	0	26.03	336.28	228.17	175.96	214.08	78.24	21.93	67.12	0	16.29	0	1164.10
Annual Mean													1088.65

Table 27 MONTHLY DEFICIT OF KEDAH RIVER BASIN IN 2000

2000 High Growth

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	28.97	327.59	211.84	149.33	201.67	89.42	71.99	122.05	8.17	85.87	50.90	1347.81
1962	0	28.74	337.94	228.76	105.91	214.90	42.47	38.78	46.06	9.60	96.27	65.05	1214.47
1963	5.82	37.84	349.36	243.41	184.36	231.76	99.77	89.03	106.31	6.11	37.20	42.85	1433.81
1964	14.90	43.68	349.93	242.40	159.17	218.40	87.55	73.23	63.77	36.80	27.31	38.74	1355.90
1965	12.41	41.07	338.55	223.71	170.95	224.26	81.36	25.53	41.25	0	36.74	0	1195.82
1966	0	22.51	330.62	225.73	139.94	171.60	85.60	65.04	101.54	0	27.28	0	1169.86
1967	0	25.09	331.57	220.25	105.05	150.08	29.46	32.15	63.58	0	32.50	2.55	992.27
1968	0	26.56	317.33	142.81	156.05	210.39	73.96	45.61	62.74	0	61.76	8.73	1105.95
1969	0	24.94	335.90	223.13	180.50	192.93	58.18	7.66	50.22	2.29	6.15	0	1081.90
1970	0	24.05	334.52	238.51	149.18	199.88	52.42	24.59	61.27	0	41.18	3.78	1129.38
1971	0	11.38	230.61	212.72	176.28	156.62	47.89	12.79	60.61	0.07	6.73	0.42	916.11
1972	0	21.66	321.83	112.51	128.12	206.49	89.81	71.41	21.35	0	3.92	0.46	977.55
1973	0	20.80	326.23	172.61	76.99	106.71	49.36	13.00	70.49	0	32.81	4.98	873.96
1974	0	21.60	327.08	230.14	51.79	175.31	65.41	44.72	70.16	0	66.21	18.60	1071.02
1975	0	24.37	329.67	230.84	180.65	210.55	76.58	52.44	68.10	17.21	80.09	21.85	1292.37
1976	0	24.46	335.35	216.74	78.94	176.92	25.64	36.29	67.73	0	11.28	3.85	977.21
1977	0	24.72	336.32	239.09	155.78	223.30	102.51	53.93	82.00	3.13	91.04	35.72	1347.53
1978	0	32.22	347.37	242.12	178.79	175.41	45.91	46.02	41.48	16.37	114.64	18.45	1258.79
1979	0	32.91	349.02	212.24	127.01	199.61	56.09	44.61	32.20	25.61	33.40	11.76	1124.46
1980	0	26.56	344.33	238.61	187.60	227.13	90.80	29.37	72.70	0	17.70	0.10	1234.91
Annual Mean													1155.55

2000 Low Growth

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	25.27	322.15	206.57	143.41	195.24	83.25	66.17	116.48	6.41	82.16	47.22	1294.34
1962	0	25.45	329.93	221.64	101.43	207.14	37.44	33.91	42.89	8.72	92.47	56.60	1157.62
1963	0	28.60	338.70	233.00	177.52	221.35	90.31	78.53	99.93	4.40	35.48	34.15	1341.97
1964	4.15	33.96	339.18	231.99	152.01	211.59	80.30	67.50	59.56	33.29	26.19	32.52	1272.25
1965	2.47	31.35	331.52	217.85	165.50	215.76	75.91	21.36	39.53	0	35.18	0	1136.44
1966	0	21.11	325.05	220.34	134.83	167.06	79.96	59.62	97.15	0	25.21	0	1130.34
1967	0	23.68	326.12	214.98	100.38	145.95	26.38	28.46	60.26	0	30.94	1.95	959.11
1968	0	25.15	309.19	138.94	150.61	205.12	69.10	41.93	58.84	0	58.00	7.91	1064.79
1969	0	23.53	329.26	214.78	173.19	187.65	52.74	6.79	45.97	1.41	5.58	0	1040.90
1970	0	22.64	328.15	228.68	142.51	194.61	48.03	22.52	57.94	0	38.62	3.15	1086.86
1971	0	10.50	226.75	207.45	170.84	152.06	44.02	10.94	57.98	0	6.38	0	886.92
1972	0	20.26	316.39	109.94	123.02	201.22	84.24	65.85	20.47	0	3.68	0	945.07
1973	0	19.39	320.78	168.58	73.42	103.16	44.01	10.38	65.67	0	31.13	4.28	840.80
1974	0	20.19	321.64	224.31	49.52	170.04	59.97	41.03	67.53	0	62.21	16.91	1033.35
1975	0	22.96	324.23	224.79	174.46	205.21	72.19	48.75	63.71	14.61	76.01	20.10	1247.04
1976	0	23.06	328.87	208.77	75.48	171.79	23.89	32.60	65.10	0	10.30	3.24	943.10
1977	0	23.32	329.52	229.07	148.90	215.03	91.76	47.00	77.61	2.25	86.29	32.11	1282.85
1978	0	27.01	336.61	231.71	171.63	170.94	41.89	42.33	38.03	13.74	109.38	16.70	1199.97
1979	0	27.20	338.26	203.30	121.89	194.34	51.70	40.92	29.05	20.78	31.10	10.32	1068.87
1980	0	25.06	334.32	228.95	178.95	217.05	84.16	25.69	68.46	0	16.79	0	1179.43
Annual Mean													1105.60

Table 28 ABSTRACTION FROM MUDA RIVER FOR PINANG TUNGAL SYSTEM

Unit: 10^6 m^3

	1982	1990	2000
1961	40.3	40.9	41.7
1962	34.8	32.5	32.9
1963	42.6	44.5	45.6
1964	45.8	45.8	46.7
1965	52.6	50.5	51.6
1966	34.4	33.2	33.5
1967	35.2	33.0	33.2
1968	42.2	42.6	43.3
1969	38.2	37.6	38.3
1970	41.8	39.1	39.7
1971	37.3	39.3	40.3
1972	40.4	41.6	42.5
1973	35.5	35.2	35.6
1974	40.6	43.0	44.1
1975	35.3	32.2	32.3
1976	40.5	41.9	42.8
1977	57.5	55.6	56.8
1978	53.7	51.8	53.2
1979	58.6	54.3	55.2
1980	52.3	50.6	51.6
	43.0	42.3	43.0

Table 29 ABSTRACTION AT INTAKE 20 FOR PULAU PINANG WATER SUPPLY

Unit: 10^6 m^3

	1982	High Growth 1990	High Growth 2000	Low Growth 1990	Low Growth 2000
1961	23.5	64.0	238.8	36.4	111.3
1962	8.7	22.0	194.0	3.9	65.2
1963	29.1	80.4	256.9	47.0	129.8
1964	24.2	66.4	242.8	34.8	115.1
1965	32.8	91.1	267.3	58.4	140.6
1966	14.0	36.2	215.0	12.4	86.1
1967	7.6	18.4	190.7	4.6	61.8
1968	23.2	62.3	246.3	28.3	117.4
1969	20.6	56.3	233.0	27.4	104.6
1970	15.8	42.3	212.9	19.4	85.1
1971	20.9	55.5	235.2	23.7	107.4
1972	23.8	65.0	243.0	33.9	114.7
1973	17.4	46.1	224.3	17.0	95.8
1974	27.7	75.0	260.9	37.7	132.8
1975	13.8	35.8	213.5	11.3	84.6
1976	27.7	76.1	255.4	42.7	127.6
1977	32.1	89.3	265.4	56.2	138.4
1978	37.2	102.6	288.0	61.5	160.7
1979	39.3	104.6	282.9	70.4	156.2
1980	28.3	79.5	252.3	52.4	124.9
	23.4	63.4	230.0	34.0	113.0

Table 30 MONTHLY DEFICIT OF MUDA RIVER BASIN IN 1982

1982

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0.20	0	0	0	0	0	0	0	0	0	0.20
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	6.84	5.91	0.46	7.43	0	0	0	0	0	0	20.64
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	12.81	15.04	0.19	0	0	0	0	0	0	0	28.04
1978	0	2.36	6.11	0	0	0	0	0	0	0	0	0	8.46
1979	0.75	4.06	24.83	4.57	0	0	0	0	0	0	0	0	34.21
1980	0	0.02	6.06	2.77	0	0	0	0	0	0	0	0	8.85
Annual Mean													5.02

Table 31 MONTHLY DEFICIT OF MUDA RIVER BASIN IN 1990

1990 High Growth

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	4.99	2.75	0	0	0	0	0	0	0	0	7.74
1964	0	0	10.51	2.21	0	0	0	0	0	0	0	0	12.73
1965	0	0	9.20	0	0	0	0	0	0	0	0	0	9.20
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	24.15	18.20	3.73	22.84	0	0	0	0	0	0	68.92
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	1.41	0	0	0	0	0	0	0	0	0	1.41
1971	0	0	0	0	0	1.10	0	0	0	0	0	0	1.10
1972	0	0	5.75	0	0	0	0	0	0	0	0	0	5.75
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	4.93	0	0	0	0	0	0	0	0	0	4.93
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	5.90	0	0	0	0	0	0	0	0	5.90
1977	0	0	30.31	34.75	5.48	2.93	6.02	0	0	0	0	0	79.49
1978	0	0	22.07	4.72	0	0	0	0	0	0	0	0	26.79
1979	0	0.43	44.88	12.14	0.22	0	4.47	0	0	0	0	0	62.15
1980	0	0	21.86	10.53	0	0	0.91	0	0	0	0	0	33.29
Annual Mean													15.97

1990 Low Growth

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	2.87	1.29	0	0	0	0	0	0	0	0	4.15
1964	0	0	8.14	0.68	0	0	0	0	0	0	0	0	8.82
1965	0	0	6.45	0	0	0	0	0	0	0	0	0	6.45
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	21.05	16.65	2.69	19.03	0	0	0	0	0	0	59.43
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0.67	0	0	0	0	0	0	0	0	0	0.67
1971	0	0	0	0	0	0.35	0	0	0	0	0	0	0.35
1972	0	0	4.07	0	0	0	0	0	0	0	0	0	4.07
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	3.38	0	0	0	0	0	0	0	0	0	3.38
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	4.40	0	0	0	0	0	0	0	0	4.40
1977	0	0	27.22	30.41	3.98	2.23	3.83	0	0	0	0	0	67.67
1978	0	0	18.27	3.46	0	0	0	0	0	0	0	0	21.73
1979	0	0	40.16	10.65	0	0	2.93	0	0	0	0	0	53.74
1980	0	0	18.68	8.99	0	0	0.12	0	0	0	0	0	27.79
Annual Mean													13.13

Table 32 MONTHLY DEFICIT OF MUDA RIVER BASIN IN 2000

2000 High Growth

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	0	1.43	0	0	0	0	0	0	0	0	0	1.43
1962	0	0	1.93	0	0	0	0	0	0	0	0	0	1.93
1963	0	0	21.44	23.66	0	0	0	0	0	0	0	0	45.10
1964	0	0	27.15	12.72	0	0	0	0	0	0	0	0	39.88
1965	0	0	26.40	0	0	3.46	1.87	0	0	0	0	0	31.73
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	41.79	38.55	22.92	45.05	1.22	0	0	0	0	0	149.53
1969	0	0	3.22	0	0	0	0	0	0	0	0	0	3.22
1970	0	0	5.80	0	0	0	0	0	0	0	0	0	5.80
1971	0	0	0	4.23	2.39	11.50	0	0	0	0	0	0	18.11
1972	0	0	18.54	2.30	4.29	6.19	0	0	0	0	0	0	31.33
1973	0	0	5.83	5.49	0	0	0	0	0	0	0	0	11.32
1974	0	0	16.92	4.12	0	2.22	6.27	0	0	0	0	0	29.53
1975	0	0	0	0	0	0	0.54	0	0	0	0	0	0.54
1976	0	0	0.99	19.09	0	0	0	0	0	0	0	0	20.09
1977	0	0	47.17	57.01	18.74	11.11	23.24	0	0	0	0	0	157.27
1978	0	10.98	42.89	12.24	0	0	0	0	0	0	0	2.27	68.38
1979	8.56	16.44	65.51	21.96	4.16	6.51	12.20	0	0	0	0	1.56	136.90
1980	0	4.23	38.84	21.10	0	0	8.27	0	0	0	0	0	72.44
Annual Mean													41.23

2000 Low Growth

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	11.97	10.12	0	0	0	0	0	0	0	0	22.09
1964	0	0	17.81	5.17	0	0	0	0	0	0	0	0	22.98
1965	0	0	17.01	0	0	0	0	0	0	0	0	0	17.01
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	31.18	24.88	8.76	31.51	0	0	0	0	0	0	96.34
1969	0	0	0.93	0	0	0	0	0	0	0	0	0	0.93
1970	0	0	3.35	0	0	0	0	0	0	0	0	0	3.35
1971	0	0	0	0	0	4.75	0	0	0	0	0	0	4.75
1972	0	0	10.01	0	0.09	1.59	0	0	0	0	0	0	11.69
1973	0	0	1.10	0	0	0	0	0	0	0	0	0	1.10
1974	0	0	9.05	1.37	0	0	0	0	0	0	0	0	10.42
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	10.28	0	0	0	0	0	0	0	0	10.28
1977	0	0	36.84	43.60	8.80	5.51	11.93	0	0	0	0	0	106.68
1978	0	0.30	30.24	7.73	0	0	0	0	0	0	0	0	38.27
1979	0	4.13	51.83	15.30	1.53	2.04	7.56	0	0	0	0	0	82.40
1980	0	0	29.36	14.40	0	0	2.61	0	0	0	0	C	46.37
Annual Mean													25.79

Table 33 MINIMUM OUTFLOW REQUIREMENT OF PROPOSED DAMS

Dam	Catchment Area (km^2)	Minimum Discharge (m^3/s)
Badak-Temin	112	0.02
Sari	61	0.01
Durian	74	0.01
Tawar-Muda	129	0.24
Beris	116	0.22
Rui	278	1.40*

Remarks; Minimum flow is defined as the lowest discharge at dam site except for Rui dam. The minimum flow of Rui dam is determined to be the average of annual 99% exceedance discharge for the 20-year period.

Table 34 EVAPORATION DATA FOR RESERVOIR OPERATION

Unit: mm

	JPT Kangar	Pedu Dam	Muda Dam	Batu Seketul	Baling
Jan	160	196	186	149	163
Feb	176	199	191	152	161
Mar	200	214	207	179	194
Apr	174	172	173	169	177
May	143	146	145	150	179
Jun	123	124	134	142	169
Jul	126	139	146	161	173
Aug	128	140	145	142	180
Sep	121	129	134	144	167
Oct	119	126	124	143	165
Nov	112	120	106	122	149
Dec	123	142	143	124	151
Total	1,705	1,847	1,834	1,777	2,028
Destined Dam Project	Arau Timah-Tasoh	Durian Sari Ahning Badak-Temin	Muda Tawar-Muda	Beris	Rui 2

Table 35 STAGE-STORAGE-SURFACE AREA RELATIONSHIP OF EXISTING AND ON-GOING DAMS

Muda

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
82.8	0	0
85.0	9.0	8.8
90.0	12.4	32.7
95.0	17.5	78.8
100.0	24.5	146.0

Pedu

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
67.8	0	0
70.0	23.0	20.6
75.0	31.9	98.4
80.0	43.6	227.5
85.0	51.7	424.7
90.0	56.0	654.1
95.0	61.5	907.8
100.0	68.2	1,192.3

Ahning

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
72.0	0	0
75.0	0.2	6.7
80.0	0.5	18.9
85.0	1.1	33.8
90.0	2.1	52.8
95.0	3.0	77.2
100.0	3.9	102.7
105.0	4.8	131.7
110.0	6.5	169.3
113.0	9.0	200.0

Timah-Tasoh

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
17.4	0	0
20.0	3.2	9.6
24.0	8.1	24.4
27.4	12.2	37.0

Arau

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
18.0	0	0
20.0	2.0	8.3
23.6	5.5	23.6

Remarks; The stage-storage curves of Timah-Tasoh and Arau dams are roughly estimated based on the descriptions of "Kedah-Perlis Water Resources Management Study".

Table 36 STAGE-STORAGE-SURFACE AREA RELATIONSHIP OF PROPOSED DAM

Badak-Temin

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
27.8	0	0
30.0	0.15	0.31
35.0	2.74	7.53
40.0	6.49	30.50
45.0	9.40	70.30
50.0	12.52	125.10

Tawar-Muda

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
54.5	0	0
55.0	0.08	0.02
60.0	0.50	1.46
65.0	1.47	6.39
70.0	3.51	18.80
75.0	6.83	44.70
80.0	11.28	90.00

Durian

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
45.0	0	0
50.0	0.06	0.07
55.0	0.52	1.42
60.0	1.47	6.37
65.0	2.36	16.00
70.0	3.55	30.70
75.0	4.78	51.50
80.0	6.26	79.10

Sari

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
51.7	0	0
55.0	0.05	0.07
60.0	0.24	0.78
65.0	0.52	2.68
70.0	1.04	6.58
75.0	1.65	13.30
80.0	2.47	23.60
85.0	3.28	37.90

Beris

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
50.5	0	0
60.0	0.09	0.43
65.0	0.81	2.69
70.0	2.28	10.40
75.0	4.44	27.20
80.0	7.95	58.20
85.0	12.61	109.50
90.0	17.40	184.60

Rui

Elevation (m)	Area (km^2)	Volume (10^6 m^3)
180.0	0.02	0.02
190.0	0.51	2.45
200.0	1.80	14.00
210.0	3.42	40.40
220.0	5.09	82.90
230.0	6.62	140.90
240.0	8.82	217.10
245.0	9.74	263.50

Table 37 FLOW CAPACITY OF SAIONG TUNNEL

(1) Submerged flow condition

$H_m > 86.87$ m

$H_p > 85.34$ m $\quad Q = 14.638\ (H_m - H_p)^{0.5}$

Q : Discharge through tunnel
H_m: Muda dam reservoir water level
H_p: Pedu dam reservoir water level

(2) Semi submerged flow condition

$H_m > 86.87$ m

$H_p \leqq 85.34$ m $\quad Q = 14.638\ (H_m - 85.34)^{0.5}$

(3) Free surface flow condition

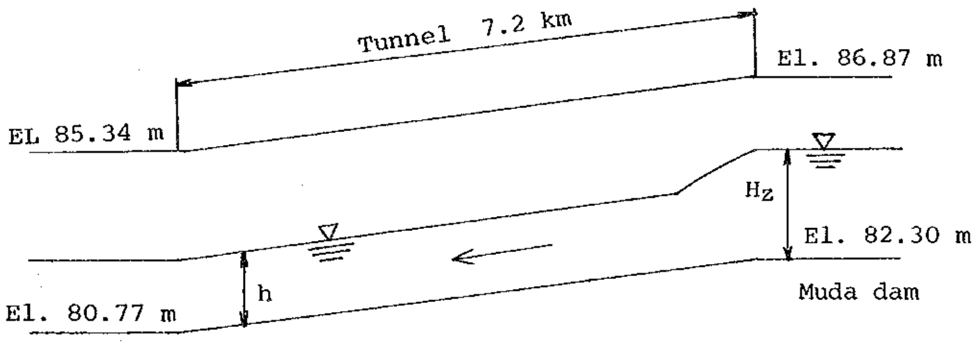
$H_m \leqq 86.87$ m

$H_p \leqq 85.34$ m $\quad Q = KS\sqrt{\frac{2g}{a}(H_z - h)}$

$$Q = K_s S R^{2/3}\, i^{1/2}$$

H_z: H_m - 82.30
K : 0.9
g : 9.8 m/s^2
a : 1.2
h : Water depth in tunnel

S : Metted section
R : Hydraulic radius
i : Slope 1/4,700
$K_s i^{1/2}$: 1.007
D : Tunnel diameter 4.57 m



Free surface flow condition

Table 38 WATER DEMAND AND SUPPLY BALANCE BY PEDU-MUDA DAM SYSTEM

Unit: 10^6 m^3

	High Growth Case in 2000			Low Growth Case in 2000		
Year	Deficit in Kedah (1)*	Pedu-Muda Supply (2)	Remaining Deficit (3) = (1) - (2)	Deficit in Kedah (4)	Pedu-Muda Supply (5)	Remaining Deficit (6) = (4) - (5)
1961	1,348	831	517	1,294	831	463
1962	1,214	750	464	1,158	750	408
1963	1,434	888	546	1,342	888	454
1964	1,356	836	520	1,272	836	436
1965	1,196	758	438	1,136	758	378
1966	1,170	695	475	1,130	695	435
1967	992	598	394	959	598	361
1968	1,106	731	375	1,065	731	334
1969	1,082	654	428	1,041	654	387
1970	1,129	630	499	1,087	630	457
1971	916	585	331	887	585	302
1972	978	670	308	945	670	275
1973	874	523	351	841	523	318
1974	1,071	678	393	1,033	678	355
1975	1,292	769	523	1,247	769	478
1976	977	593	384	943	593	350
1977	1,348	885	463	1,283	885	398
1978	1,259	780	479	1,200	780	420
1979	1,124	705	419	1,069	705	364
1980	1,235	793	442	1,179	793	386
Mean	1,155	718	437	1,106	718	388

Remarks; *: Deficit = Demand - Uncontrolled River Flow

Table 39 SUPPLY CAPACITY OF AHNING DAM

Unit: 10^6 m^3

Year	Regulated Water	Shut-down	Net Water Output
1961	60	19	41
1962	54	20	34
1963	64	10	54
1964	61	17	43
1965	53	11	42
1966	52	16	36
1967	44	24	21
1968	49	25	25
1969	48	17	31
1970	50	23	27
1971	41	26	15
1972	44	18	26
1973	39	33	6
1974	48	27	21
1975	58	18	39
1976	44	20	24
1977	60	18	42
1978	56	20	36
1979	50	30	20
1980	55	14	41
Mean	51	20	31

Table 40 SUPPLY CAPACITY OF TIMAH-TASOH AND ARAU DAMS

Unit: 10^6 m^3

Year	Timah-Tasoh Dam			Arau Dam		
	Regulated Water	Shut-down	Net Water Output	Regulated Water	Shut-down	Net Water Output
1961	36	22	14	24	7	17
1962	35	23	12	22	10	12
1963	41	13	28	26	10	16
1964	41	16	25	25	9	16
1965	38	14	24	13	5	8
1966	31	21	10	21	7	14
1967	30	24	6	19	16	3
1968	38	19	19	21	4	17
1969	31	26	5	20	8	12
1970	32	24	8	21	9	12
1971	32	27	5	17	6	11
1972	30	15	15	18	4	14
1973	33	25	8	17	6	11
1974	40	20	20	20	2	18
1975	36	23	13	23	5	18
1976	33	18	15	18	5	13
1977	43	12	31	24	6	18
1978	36	23	13	22	6	16
1979	34	22	12	21	11	10
1980	33	28	5	22	9	13
Mean	35	21	14	21	7	13

Table 41 ANNUAL SHUTDOWN DISCHARGE OF THE PROPOSED DAMS

Unit: 10^6 m^3

Year	Badak-Temin	Durian	Sari	Tawar-Muda	Beris	Rui 2
1961	13	11	8	47	43	44
1962	15	11	7	38	35	44
1963	6	4	2	37	33	44
1964	13	9	6	43	38	44
1965	5	4	1	38	34	44
1966	12	9	6	39	35	44
1967	19	13	9	33	29	44
1968	21	15	11	26	23	44
1969	11	7	4	39	35	44
1970	19	13	9	42	37	44
1971	20	12	9	26	24	44
1972	11	8	5	19	17	44
1973	28	19	14	33	29	44
1974	23	16	12	31	28	44
1975	14	11	8	42	38	44
1976	17	11	8	33	29	44
1977	14	10	7	28	25	44
1978	17	12	9	35	32	44
1979	27	18	14	25	22	44
1980	10	6	4	26	24	44
Mean	16	11	8	34	31	44

Table 42 RELATION BETWEEN NET WATER OUTPUT AND GROSS STORAGE OF PROPOSED DAMS

Badak-Temin						
H.W.L.	(m)	39	41	43	45	47
Gross Storage	(10^6 m^3)	25.0	37.0	54.0	70.3	90.0
1977 Net Water Output	(10^6 m^3)	4.3	17.0	25.4	30.3	35.3
Average Net Water Output	(10^6 m^3)	2.3	15.0	23.4	28.3	33.3
Durian						
H.W.L.	(m)	68	70	72	74	76
Gross Storage	(10^6 m^3)	24.0	30.7	38.0	47.0	57.0
1977 Net Water Output	(10^6 m^3)	12.8	16.5	18.6	20.5	23.0
Average Net Water Output	(10^6 m^3)	11.8	15.5	17.6	19.5	22.0
Sari						
H.W.L.	(m)	85	87	89	91	93
Gross Storage	(10^6 m^3)	37.9	45.0	53.0	62.0	71.0
1977 Net Water Output	(10^6 m^3)	18.3	20.0	21.3	22.8	24.5
Average Net Water Output	(10^6 m^3)	17.3	19.0	20.3	21.8	23.5
Tawar-Muda						
H.W.L.	(m)	70	73	75	77	80
Gross Storage	(10^6 m^3)	18.5	32.0	44.7	61.0	90.0
1977 Net Water Output	(10^6 m^3)	0	9.7	23.4	40.4	71.3
Average Net Water Output	(10^6 m^3)	0	3.7	17.4	34.4	65.3
Beris						
H.W.L.	(m)	80	82	85	88	90
Gross Storage	(10^6 m^3)	58.2	75.0	109.5	155.0	184.6
1977 Net Water Output	(10^6 m^3)	39.5	56.9	92.3	109.9	117.3
Average Net Water Output	(10^6 m^3)	33.5	50.9	86.3	103.9	111.3
Rui 2						
H.W.L.	(m)	235	239	241	243	245
Gross Storage	(10^6 m^3)	176.3	207.5	224.0	244.0	263.5
1977 Net Water Output	(10^6 m^3)	153.0	184.1	198.4	206.1	214.0
Average Net Water Output	(10^6 m^3)	149.7	180.8	195.1	202.8	210.7

Table 43 SUPPLY CAPACITY OF JENIANG SYSTEM IN 2000 IN HIGH GROWTH CASE

Unit: 10^6 m^3

Year	Kedah Natural Flow	MADA North Demand	MADA South Demand	MADA South Diversion Requirement	Muda River Diversion Natural Flow	Muda River Diversion Naok Dam	Remaining Deficit in MADA South	Natural Flow at Jeniang
1961	459	1,058	552	510	212	44	254	447
1962	801	1,058	552	455	190	66	199	540
1963	423	1,058	552	487	210	34	243	703
1964	451	1,060	553	491	210	38	243	547
1965	1,034	1,058	552	432	151	34	247	681
1966	911	1,058	552	454	220	59	175	771
1967	1,211	1,058	552	424	179	55	190	679
1968	766	1,060	553	460	109	35	316	409
1969	985	1,058	552	416	188	29	199	827
1970	780	1,058	552	456	247	50	159	772
1971	1,295	1,058	552	396	112	43	241	606
1972	1,455	1,060	553	380	64	32	284	639
1973	1,290	1,058	552	420	154	62	204	626
1974	1,047	1,058	552	455	135	54	266	435
1975	678	1,058	552	501	223	36	242	657
1976	1,289	1,060	553	403	164	73	166	941
1977	519	1,058	552	510	132	43	335	521
1978	595	1,058	552	479	179	49	251	484
1979	645	1,058	552	459	152	56	251	509
1980	855	1,060	553	451	148	29	274	859
Mean	874	1,059	552	452	169	46	237	633

Table 44 SUPPLY CAPACITY OF JENIANG SYSTEM IN 2000 IN LOW GROWTH CASE

Unit: 10^6 m^3

Year	Kedah Natural Flow	MADA North Demand	MADA South Demand	MADA South Diversion Requirement	Muda River Diversion: Natural Flow	Muda River Diversion: Naok Dam	Remaining Deficit in MADA South	Natural Flow at Jeniang
1961	460	1,047	539	499	213	44	242	447
1962	802	1,047	539	445	188	65	192	540
1963	424	1,047	539	477	211	33	233	703
1964	452	1,049	540	479	209	37	233	546
1965	1,035	1,047	539	424	158	33	233	681
1966	912	1,047	539	445	215	61	169	771
1967	1,212	1,047	539	415	173	54	188	679
1968	766	1,049	540	451	109	34	308	409
1969	986	1,047	539	408	184	29	195	827
1970	781	1,047	539	447	247	50	150	772
1971	1,296	1,047	539	389	117	41	231	606
1972	1,456	1,049	540	372	70	32	270	639
1973	1,291	1,047	539	412	157	62	193	626
1974	1,048	1,047	539	446	140	55	251	435
1975	679	1,047	539	492	218	35	239	657
1976	1,290	1,049	540	396	165	72	159	941
1977	520	1,047	539	500	136	41	323	521
1978	596	1,047	539	469	178	47	244	484
1979	646	1,047	539	448	153	56	239	509
1980	856	1,049	540	443	148	29	266	859
Mean	875	1,048	539	443	169	46	228	633

Table 45 5-DAY WATER BALANCE IN 1976 OF JENIANG SYSTEM IN 2000 FOR HIGH GROWTH CASE (JUL TO DEC)

Unit: 10^6 m^3

Period	Kedah Natural Flow	MADA North Demand	Surplus Flow	MADA South Demand	MADA South Diversion Requirement	Muda River Diversion Natural Flow	Muda River Diversion Naok Dam	Remaining Deficit in MADA South	Natural Flow at Jeniang	Surplus Flow to Downstream of Jeniang
(Jul)										
1 - 5	6.90	16.16	0	8.08	8.08	4.90	0	3.18	5.76	0.86
6 - 10	29.44	16.16	13.29	8.08	0	0	0	0	19.10	1.82
11 - 15	20.14	9.85	10.29	4.88	0	0	0	0	9.41	0.86
16 - 20	8.12	9.85	0	4.88	4.88	4.17	0.71	0	5.03	0.86
21 - 25	7.94	3.97	3.96	2.03	0	0	0	0	7.28	5.39
26-End	55.68	4.77	50.92	2.44	0	0	0	0	17.83	17.83
(Aug)										
1 - 5	16.29	1.77	14.52	0.99	0	0	0	0	9.11	9.11
6 - 10	9.69	1.76	7.91	0.99	0	0	0	0	5.45	5.45
11 - 15	8.07	6.61	1.46	3.02	1.56	1.56	0	0	4.27	2.71
16 - 20	7.21	6.61	0.60	3.02	2.42	2.42	0	0	4.96	2.54
21 - 25	13.11	15.47	0	7.13	7.13	7.13	0	0	11.54	4.42
26-End	10.31	18.56	0	8.55	8.55	8.35	0.20	0	9.39	1.04
(Sep)										
1 - 5	6.53	20.52	0	10.20	10.20	5.09	5.11	0	5.95	0.86
6 - 10	5.23	20.52	0	10.20	10.20	3.03	7.17	0	3.89	0.86
11 - 15	7.97	14.21	0	7.30	7.30	3.03	4.27	0	3.89	0.86
16 - 20	110.24	14.21	96.03	7.30	0	0	0	0	29.08	12.32
21 - 25	52.54	9.94	42.60	4.80	0	0	0	0	32.89	32.89
26-End	18.64	9.94	8.70	4.80	0	0	0	0	19.07	19.07
(Oct)										
1 - 5	60.74	9.12	51.62	4.45	0	0	0	0	27.79	27.79
6 - 10	32.94	9.12	23.82	4.45	0	0	0	0	31.02	31.02
11 - 15	76.48	9.12	67.36	4.45	0	0	0	0	63.84	63.84
16 - 20	37.00	9.12	27.88	4.45	0	0	0	0	33.46	33.46
21 - 25	23.62	10.07	13.55	4.92	0	0	0	0	28.31	28.31
26-End	30.66	12.08	18.58	5.91	0	0	0	0	33.12	33.12
(Nov)										
1 - 5	25.62	15.51	10.11	7.34	0	0	0	0	35.03	35.03
6 - 10	35.90	15.51	20.39	7.34	0	0	0	0	53.89	53.89
11 - 15	22.56	17.76	4.80	8.73	3.93	3.93	0	0	21.57	17.64
16 - 20	20.94	17.76	3.19	8.73	5.53	5.53	0	0	17.83	12.30
21 - 25	34.47	21.47	13.00	10.37	0	0	0	0	18.37	18.37
26-End	52.42	21.47	30.95	10.37	0	0	0	0	36.21	36.21
(Dec)										
1 - 5	22.87	13.39	9.48	7.00	0	0	0	0	20.99	20.99
6 - 10	17.23	13.39	3.83	7.00	3.15	3.15	0	0	13.79	10.64
11 - 15	15.25	4.80	10.46	2.64	0	0	0	0	10.22	10.22
16 - 20	13.63	4.80	8.83	2.64	0	0	0	0	8.85	8.85
21 - 25	12.51	1.38	11.13	0.65	0	0	0	0	8.53	8.53
26-End	12.89	1.66	11.23	0.78	0	0	0	0	11.70	11.70
Yearly Total	1289.35	1059.96	763.28	552.80	403.44	164.26	73.21	165.96	941.25	703.78

Table 46 5-DAY WATER BALANCE IN 1977 OF JENIANG SYSTEM IN 2000 FOR HIGH GROWTH CASE (JAN TO JUN)

Unit: 10^6 m^3

Period	Kedah Natural Flow	MADA North Demand	Surplus Flow	MADA South Demand	MADA South Diversion Requirement	Muda River Diversion Natural Flow	Muda River Diversion Naok Dam	Remaining Deficit in MADA South	Natural Flow at Jeniang	Surplus Flow to Downstream of Jeniang
(Jan)										
1 - 5	10.44	0.35	10.10	0.26	0	0	0	0	6.83	6.83
6 - 10	9.15	0.35	8.80	0.26	0	0	0	0	8.61	8.61
11 - 15	7.78	0.35	7.43	0.26	0	0	0	0	4.77	4.77
16 - 20	6.83	0.35	6.48	0.26	0	0	0	0	3.85	3.85
21 - 25	6.04	0.35	5.69	0.26	0	0	0	0	2.60	2.60
26-End	6.58	0.41	6.17	0.31	0	0	0	0	3.35	3.35
(Feb)										
1 - 5	4.99	0.35	4.64	0.26	0	0	0	0	2.64	2.64
6 - 10	4.59	0.35	4.24	0.26	0	0	0	0	2.25	2.25
11 - 15	4.09	0.35	3.75	0.26	0	0	0	0	2.32	2.32
16 - 20	3.56	0.35	3.21	0.26	0	0	0	0	1.65	1.65
21 - 25	3.12	10.84	0	6.26	6.26	0.35	5.91	0	1.22	0.86
26-End	1.72	6.51	0	3.76	3.76	0.32	3.43	0	0.84	0.52
(Mar)										
1 - 5	2.52	29.25	0	16.85	16.85	0.82	16.03	0	1.68	0.86
6 - 10	2.27	29.25	0	16.85	16.85	0.01	1.63	15.21	1.18	1.17
11 - 15	1.13	39.87	0	21.64	21.64	0.20	0	21.44	1.07	0.86
16 - 20	0.89	39.87	0	21.64	21.64	0.05	0	21.59	0.92	0.86
21 - 25	0.79	35.99	0	18.66	18.66	0	0	18.66	0.80	0.80
26-End	0.72	43.18	0	22.39	22.39	0	0	22.39	0.88	0.88
(Apr)										
1 - 5	0.51	29.25	0	15.64	15.64	0	0	15.64	0.69	0.69
6 - 10	0.42	29.25	0	15.64	15.64	0	0	15.64	0.65	0.65
11 - 15	0.42	24.67	0	13.69	13.69	0	0	13.69	0.65	0.65
16 - 20	0.42	24.67	0	13.69	13.69	0	0	13.69	0.77	0.77
21 - 25	0.47	20.48	0	11.06	11.06	0	0	11.06	0.69	0.69
26-End	0.47	20.48	0	11.06	11.06	0.13	0	10.93	1.68	1.56
(May)										
1 - 5	0.45	17.50	0	9.37	9.37	0.09	0	9.28	0.95	0.86
6 - 10	0.45	17.50	0	9.37	9.37	0.18	0	9.19	1.91	1.73
11 - 15	15.45	17.63	0	9.37	9.37	2.04	0	7.33	2.90	0.86
16 - 20	13.81	17.63	0	9.37	9.37	0.14	0	9.23	1.44	1.30
21 - 25	3.15	22.25	0	12.01	12.01	0.02	0	11.99	0.88	0.86
26-End	1.96	26.70	0	14.41	14.41	0.19	0	14.22	2.11	1.92
(Jun)										
1 - 5	1.20	25.66	0	13.61	13.61	0.21	0	13.40	1.98	1.77
6 - 10	0.93	25.66	0	13.61	13.61	2.92	0	10.69	3.78	0.86
11 - 15	0.74	24.62	0	13.00	13.00	3.63	0	9.37	4.49	0.86
16 - 20	0.72	24.62	0	13.00	13.00	4.77	0	8.23	5.63	0.86
21 - 25	0.80	21.30	0	11.02	11.02	0.24	0	10.78	2.36	2.12
26-End	0.41	21.30	0	11.02	11.02	0.16	0	10.86	1.37	1.21

Table 47 5-DAY WATER BALANCE IN 1977 OF JENIANG SYSTEM IN 2000 FOR HIGH GROWTH CASE (JUL TO DEC)

Unit: 10^6 m^3

Period	Kedah Natural Flow	MADA North Demand	Surplus Flow	MADA South Demand	MADA South Diversion Requirement	Muda River Diversion Natural Flow	Muda River Diversion Naok Dam	Remaining Deficit in MADA South	Natural Flow at Jeniang	Surplus Flow to Downstream of Jeniang
(Jul)										
1 - 5	0.36	16.16	0	8.08	8.08	0.19	0	7.89	1.40	1.21
6 - 10	0.40	16.16	0	8.08	8.08	0.16	0	7.92	1.07	0.91
11 - 15	0.40	9.85	0	4.88	4.88	1.64	0	3.24	2.51	0.86
16 - 20	0.31	9.85	0	4.88	4.88	0.16	0	4.72	1.37	1.21
21 - 25	0.32	3.97	0	2.03	2.03	0.12	0	1.91	1.07	0.95
26-End	0.38	4.77	0	2.44	2.44	0.17	0	2.27	1.73	1.56
(Aug)										
1 - 5	0.63	1.77	0	0.99	0.99	0.58	0	0.41	1.44	0.86
6 - 10	0.95	1.77	0	0.99	0.99	0.99	0	0	2.10	0.86
11 - 15	0.87	6.61	0	3.02	3.02	0.93	0.24	1.85	1.80	0.86
16 - 20	14.89	6.61	8.28	3.02	0	0	0	0	10.33	0.86
21 - 25	13.61	15.47	0	7.13	7.13	7.13	0	0	13.38	0.86
26-End	5.33	18.56	0	8.55	8.55	5.09	3.46	0	6.13	1.04
(Sep)										
1 - 5	7.79	20.52	0	10.20	10.20	8.73	1.46	0	9.60	0.86
6 - 10	11.14	20.52	0	10.20	10.20	10.20	0	0	12.89	0.86
11 - 15	5.03	14.21	0	7.30	7.30	4.39	2.91	0	5.26	0.86
16 - 20	10.96	14.21	0	7.30	7.30	7.30	0	0	8.38	0.86
21 - 25	8.97	9.94	0	4.80	4.80	4.80	0	0	7.82	0.86
26-End	22.84	9.94	12.90	4.80	0	0	0	0	12.72	0.86
(Oct)										
1 - 5	11.58	9.12	2.47	4.45	1.99	1.99	0	0	24.32	18.43
6 - 10	40.56	9.12	31.44	4.45	0	0	0	0	36.75	36.75
11 - 15	53.79	9.12	44.68	4.45	0	0	0	0	48.48	48.48
16 - 20	20.00	9.12	10.89	4.45	0	0	0	0	31.21	31.21
21 - 25	31.47	10.07	21.41	4.92	0	0	0	0	31.29	31.29
26-End	26.77	12.08	14.69	5.91	0	0	0	0	36.26	36.26
(Nov)										
1 - 5	18.20	15.51	2.69	7.34	4.67	4.67	0	0	22.57	17.90
6 - 10	14.65	15.51	0	7.34	7.34	7.34	0	0	30.50	23.16
11 - 15	13.52	17.76	0	8.73	8.73	8.73	0	0	19.07	10.34
16 - 20	12.50	17.76	0	8.73	8.73	8.73	0	0	12.50	3.77
21 - 25	10.29	21.47	0	10.37	10.37	10.37	0	0	12.13	1.76
26-End	8.99	21.47	0	10.37	10.37	7.56	2.81	0	8.42	0.86
(Dec)										
1 - 5	7.93	13.39	0	7.00	7.00	4.82	2.17	0	5.69	0.86
6 - 10	6.63	13.39	0	7.00	7.00	4.69	2.31	0	5.56	0.86
11 - 15	5.38	4.80	0.59	2.64	2.03	2.03	0	0	3.85	0.86
16 - 20	4.33	4.80	0	2.64	2.64	2.45	0.19	0	3.31	0.86
21 - 25	3.82	1.38	2.43	0.65	0	0	0	0	2.71	0.86
26-End	3.58	1.66	1.93	0.78	0	0	0	0	2.83	1.04
Yearly Total	519.18	1057.79	214.91	551.55	509.73	132.43	42.54	334.72	520.82	348.73

Table 48 5-DAY WATER BALANCE IN 1976 OF JENIANG SYSTEM IN 2000 FOR LOW GROWTH CASE (JUL TO DEC)

Unit: 10^6 m^3

Period	Kedah Natural Flow	MADA North Demand	Surplus Flow	MADA South Demand	MADA South Diversion Requirement	Muda River Diversion Natural Flow	Muda River Diversion Naok Dam	Remaining Deficit in MADA South	Natural Flow at Jeniang	Surplus Flow to Downstream of Jeniang
(Jul)										
1 - 5	6.91	15.98	0	7.91	7.91	4.90	0	3.01	5.76	0.86
6 - 10	29.46	15.98	13.47	7.91	0	0	0	0	19.10	1.82
11 - 15	20.16	9.72	10.44	4.71	0	0	0	0	9.41	0.86
16 - 20	8.13	9.72	0	4.71	4.71	4.17	0.54	0	5.03	0.86
21 - 25	7.95	3.84	4.11	1.81	0	0	0	0	7.28	5.57
26-End	55.70	4.61	51.09	2.18	0	0	0	0	17.83	17.83
(Aug)										
1 - 5	16.31	1.60	14.71	0.82	0	0	0	0	9.11	9.11
6 - 10	9.70	1.60	8.10	0.82	0	0	0	0	5.45	5.45
11 - 15	8.08	6.44	1.65	2.85	1.21	1.21	0	0	4.27	3.06
16 - 20	7.23	6.44	0.79	2.85	2.07	2.07	0	0	4.96	2.88
21 - 25	13.12	15.34	0	6.96	6.96	6.96	0	0	11.54	4.59
26-End	10.33	18.40	0	8.35	8.35	8.35	0	0	9.39	1.04
(Sep)										
1 - 5	6.54	20.39	0	10.02	10.02	5.09	4.94	0	5.95	0.86
6 - 10	5.24	20.39	0	10.02	10.02	3.03	6.99	0	3.89	0.86
11 - 15	7.98	14.08	0	7.13	7.13	3.03	4.10	0	3.89	0.86
16 - 20	110.25	14.08	96.17	7.13	0	0	0	0	29.08	13.05
21 - 25	52.55	9.81	42.75	4.62	0	0	0	0	32.89	32.89
26-End	18.65	9.81	8.84	4.62	0	0	0	0	19.07	19.07
(Oct)										
1 - 5	60.75	8.99	51.77	4.28	0	0	0	0	27.79	27.79
6 - 10	32.95	8.99	23.96	4.28	0	0	0	0	31.02	31.02
11 - 15	76.49	8.99	67.51	4.28	0	0	0	0	63.84	63.84
16 - 20	37.01	8.99	28.02	4.28	0	0	0	0	33.46	33.46
21 - 25	23.63	9.94	13.70	4.75	0	0	0	0	28.31	28.31
26-End	30.67	11.92	18.75	5.70	0	0	0	0	33.12	33.12
(Nov)										
1 - 5	25.63	15.34	10.30	7.17	0	0	0	0	35.03	35.03
6 - 10	35.91	15.34	20.58	7.17	0	0	0	0	53.89	53.89
11 - 15	22.57	17.63	4.95	8.51	3.54	3.54	0	0	21.57	18.03
16 - 20	20.95	17.63	3.33	8.51	5.18	5.18	0	0	17.83	12.65
21 - 25	34.49	21.34	13.15	10.20	0	0	0	0	18.37	18.37
26-End	52.44	21.34	31.10	10.20	0	0	0	0	36.21	36.21
(Dec)										
1 - 5	22.89	13.22	9.67	6.83	0	0	0	0	20.99	20.99
6 - 10	17.24	13.22	4.02	6.83	2.81	2.81	0	0	13.79	10.98
11 - 15	15.27	4.67	10.60	2.46	0	0	0	0	10.22	10.22
16 - 20	13.64	4.67	8.97	2.46	0	0	0	0	8.85	8.85
21 - 25	12.52	1.25	11.27	0.48	0	0	0	0	8.53	8.53
26-End	12.90	1.50	11.40	0.57	0	0	0	0	11.70	11.70
Yearly Total	1290.35	1049.43	769.66	539.97	396.25	165.21	72.14	158.90	941.25	703.90

Table 49 5-DAY WATER BALANCE IN 1977 OF JENIANG SYSTEM IN 2000 FOR LOW GROWTH CASE (JAN TO JUN)

Unit: 10^6 m^3

Period	Kedah Natural Flow	MADA North Demand	Surplus Flow	MADA South Demand	MADA South Diversion Requirement	Muda River Diversion Natural Flow	Muda River Diversion Naok Dam	Remaining Deficit in MADA South	Natural Flow at Jeniang	Surplus Flow to Downstream of Jeniang
(Jan)										
1 - 5	10.45	0.22	10.24	0.09	0	0	0	0	6.83	6.83
6 - 10	9.16	0.22	8.95	0.09	0	0	0	0	8.61	8.61
11 - 15	7.79	0.22	7.58	0.09	0	0	0	0	4.77	4.77
16 - 20	6.84	0.22	6.63	0.09	0	0	0	0	3.85	3.85
21 - 25	6.05	0.22	5.83	0.09	0	0	0	0	2.60	2.60
26-End	6.60	0.26	6.34	0.10	0	0	0	0	3.35	3.35
(Feb)										
1 - 5	5.00	0.22	4.78	0.09	0	0	0	0	2.64	2.64
6 - 10	4.60	0.22	4.39	0.09	0	0	0	0	2.25	2.25
11 - 15	4.11	0.22	3.89	0.09	0	0	0	0	2.32	2.32
16 - 20	3.57	0.22	3.36	0.09	0	0	0	0	1.65	1.65
21 - 25	3.13	10.67	0	6.09	6.09	0.35	5.74	0	1.22	0.86
26-End	1.72	6.40	0	3.65	3.65	0.32	3.33	0	0.84	0.52
(Mar)										
1 - 5	2.53	29.12	0	16.68	16.68	0.82	15.86	0	1.68	0.86
6 - 10	2.28	29.12	0	16.68	16.68	0.31	2.07	14.30	1.18	0.86
11 - 15	1.15	39.70	0	21.47	21.47	0.20	0	21.27	1.07	0.86
16 - 20	0.91	39.70	0	21.47	21.47	0.05	0	21.42	0.92	0.86
21 - 25	0.80	35.86	0	18.49	18.49	0	0	18.49	0.80	0.80
26-End	0.73	43.03	0	22.19	22.19	0	0	22.19	0.88	0.88
(Apr)										
1 - 5	0.53	29.12	0	15.47	15.47	0	0	15.47	0.69	0.69
6 - 10	0.43	29.12	0	15.47	15.47	0	0	15.47	0.65	0.65
11 - 15	0.43	24.49	0	13.52	13.52	0	0	13.52	0.65	0.65
16 - 20	0.43	24.49	0	13.52	13.52	0	0	13.52	0.77	0.77
21 - 25	0.48	20.30	0	10.89	10.89	0	0	10.89	0.69	0.69
26-End	0.48	20.30	0	10.89	10.89	0.82	0	10.07	1.68	0.86
(May)										
1 - 5	0.46	17.37	0	9.20	9.20	0.09	0	9.11	0.95	0.86
6 - 10	0.46	17.37	0	9.20	9.20	1.04	0	8.16	1.91	0.86
11 - 15	15.47	17.50	0	9.20	9.20	2.04	0	7.16	2.90	0.86
16 - 20	13.83	17.50	0	9.20	9.20	0.58	0	8.62	1.44	0.86
21 - 25	3.16	22.08	0	11.84	11.84	0.02	0	11.82	0.88	0.86
26-End	1.97	26.49	0	14.20	14.20	1.07	0	13.13	2.11	1.04
(Jun)										
1 - 5	1.21	25.49	0	13.44	13.44	1.12	0	12.32	1.98	0.86
6 - 10	0.94	25.49	0	13.44	13.44	2.92	0	10.52	3.78	0.86
11 - 15	0.75	24.45	0	12.83	12.83	3.63	0	9.20	4.49	0.86
16 - 20	0.73	24.45	0	12.83	12.83	4.77	0	8.06	5.63	0.86
21 - 25	0.82	21.17	0	10.84	10.84	1.49	0	9.35	2.36	0.86
26-End	0.42	21.17	0	10.84	10.84	0.50	0	10.34	1.37	0.86

Table 50 5-DAY WATER BALANCE IN 1977 OF JENIANG SYSTEM IN 2000 FOR LOW GROWTH CASE (JUL TO DEC)

Unit: 10^6 m^3

Period	Kedah Natural Flow	MADA North Demand	Surplus Flow	MADA South Demand	MADA South Diversion Requirement	Muda River Diversion Natural Flow	Muda River Diversion Naok Dam	Remaining Deficit in MADA South	Natural Flow at Jeniang	Surplus Flow to Downstream of Jeniang
(Jul)										
1 - 5	0.37	15.98	0	7.91	7.91	0.54	0	7.37	1.40	0.86
6 - 10	0.41	15.98	0	7.91	7.91	0.20	0	7.71	1.07	0.86
11 - 15	0.42	9.72	0	4.71	4.71	1.64	0	3.07	2.51	0.86
16 - 20	0.33	9.72	0	4.71	4.71	0.50	0	4.21	1.37	0.86
21 - 25	0.33	3.84	0	1.81	1.81	0.20	0	1.61	1.07	0.86
26-End	0.40	4.61	0	2.18	2.18	0.69	0	1.49	1.73	1.04
(Aug)										
1 - 5	0.65	1.60	0	0.82	0.82	0.58	0	0.24	1.44	0.86
6 - 10	0.96	1.60	0	0.82	0.82	0.82	0	0	2.10	0.86
11 - 15	0.89	6.44	0	2.85	2.85	0.93	0.41	1.51	1.80	0.86
16 - 20	14.91	6.44	8.47	2.85	0	0	0	0	10.33	0.86
21 - 25	13.62	15.34	0	6.96	6.96	6.96	0	0	13.38	0.86
26-End	5.35	18.40	0	8.35	8.35	5.09	3.25	0	6.13	1.04
(Sep)										
1 - 5	7.80	20.39	0	10.02	10.02	8.73	1.29	0	9.60	0.86
6 - 10	11.16	20.39	0	10.02	10.02	10.02	0	0	12.89	0.86
11 - 15	5.05	14.08	0	7.13	7.13	4.39	2.73	0	5.26	0.86
16 - 20	10.98	14.08	0	7.13	7.13	7.13	0	0	8.38	0.86
21 - 25	8.99	9.81	0	4.62	4.62	4.62	0	0	7.82	0.86
26-End	22.85	9.81	13.04	4.62	0	0	0	0	12.72	0.86
(Oct)										
1 - 5	11.60	8.99	2.61	4.28	1.68	1.68	0	0	24.32	19.98
6 - 10	40.57	8.99	31.58	4.28	0	0	0	0	36.75	36.75
11 - 15	53.81	8.99	44.82	4.28	0	0	0	0	48.48	48.48
16 - 20	20.01	8.99	11.03	4.28	0	0	0	0	31.21	31.21
21 - 25	31.49	9.94	21.55	4.75	0	0	0	0	31.29	31.29
26-End	26.78	11.92	14.86	5.70	0	0	0	0	36.26	36.26
(Nov)										
1 - 5	18.21	15.34	2.88	7.17	4.28	4.28	0	0	22.57	18.29
6 - 10	14.66	15.34	0	7.17	7.17	7.17	0	0	30.50	23.33
11 - 15	13.54	17.63	0	8.51	8.51	8.51	0	0	19.07	10.56
16 - 20	12.51	17.63	0	8.51	8.51	8.51	0	0	12.50	3.99
21 - 25	10.31	21.34	0	10.20	10.20	10.20	0	0	12.13	1.93
26-End	9.01	21.34	0	10.20	10.20	7.56	2.64	0	8.42	0.86
(Dec)										
1 - 5	7.94	13.22	0	6.83	6.83	4.82	2.00	0	5.69	0.86
6 - 10	6.64	13.22	0	6.83	6.83	4.69	2.13	0	5.56	0.86
11 - 15	5.40	4.67	0.73	2.46	1.73	1.73	0	0	3.85	0.86
16 - 20	4.35	4.67	0	2.46	2.46	2.45	0.01	0	3.31	0.86
21 - 25	3.83	1.25	2.58	0.48	0	0	0	0	2.71	0.86
26-End	3.60	1.50	2.10	0.57	0	0	0	0	2.83	1.04
Yearly Total	520.18	1047.30	218.24	538.76	499.85	136.81	41.47	321.61	520.82	344.43

Table 51 NET WATER OUTPUT OF PROPOSED DAMS FOR SUPPLY TO KEDAH RIVER

Unit: 10^6 m^3

Year	Tawar-Muda	Beris	Badak-Temin	Sari	Durian
1961	30	58	32	22	20
1962	30	55	26	20	17
1963	32	58	37	19	24
1964	28	55	15	11	11
1965	31	57	20	14	14
1966	23	47	27	20	18
1967	29	52	16	14	11
1968	36	85	17	15	11
1969	21	44	25	21	18
1970	12	34	19	17	14
1971	41	64	12	13	10
1972	54	79	22	17	15
1973	31	55	3	7	2
1974	44	71	14	13	9
1975	28	55	29	21	18
1976	27	50	27	15	12
1977	41	92	30	23	21
1978	37	59	25	19	17
1979	46	57	12	12	9
1980	46	60	31	23	22
Mean	33	59	22	17	15

Remarks; Net water output for the optimum scale

Table 52 NET WATER OUTPUT OF PROPOSED DAMS FOR SUPPLY TO MUDA RIVER

Unit: 10^6 m^3

Year	Tawar-Muda	Beris	Badak-Temin	Sari	Durian	Rui 2
1961	1	1	1	0	0	2
1962	1	1	1	1	0	3
1963	1	31	16	11	10	61
1964	15	28	11	7	8	54
1965	12	22	11	8	8	43
1966	0	0	0	0	0	0
1967	0	0	0	0	0	0
1968	50	81	32	28	22	204
1969	1	2	1	1	1	5
1970	2	4	2	2	1	8
1971	7	13	6	5	4	25
1972	12	22	11	8	8	43
1973	4	8	4	3	3	16
1974	11	20	10	8	7	40
1975	0	0	0	0	0	1
1976	8	14	7	5	5	28
1977	60	87	43	35	30	214
1978	26	26	7	9	5	93
1979	52	72	22	22	16	186
1980	27	50	16	15	12	99
Mean	15	24	10	8	7	56

Remarks; Net water output for the optimum scale

Table 53 EIRR OF SOURCE FACILITIES

	High		Low	
	B-C (M$10^6)	IRR	B-C (M$10^6)	IRR
Jeniang/Naok	186.1	12.2%	226.1	12.9%
Beris	39.2	14.4%	33.0	13.5%
Tawar-Muda	31.3	11.5%	7.2	9.0%
Sari	-5.6	7.1%	-6.1	7.0%
Badak-Temin	-31.1	4.5%	-32.9	4.2%
Durian	-30.6	3.7%	-32.2	3.5%
Rui	11.5	8.5%	-65.7	4.9%
Ma	-4.9	7.4%	-6.9	7.1%
Khlong Thepha	61.9	14.5%	57.7	13.9%
Reman	139.2	19.7%	107.3	17.8%
Merbok	43.6	12.0%	-24.9	4.1%

Remarks; B-C at 8% of discount rate

Table 54 WATER DEMAND AND SUPPLY BALANCE OF SOURCE DEVELOPMENT PLAN IN HIGH GROWTH CASE (ALTERNATIVE 1, MUDA PRIORITY)

Unit: 10^6 m^3

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Deficit in Kedah with Pedu-Muda Supply		517	464	546	520	438	475	394	375	428	499
Deficit in Muda		1	2	45	40	32	0	0	150	3	6
Mengkuang Supply		1	2	24	24	24	0	0	24	3	6
Ahning Supply		41	34	54	43	42	36	21	25	31	27
Remaining Deficit in Kedah		476	430	492	477	396	439	373	350	397	472
Proportion to Demand in Kedah		0.28	0.25	0.28	0.28	0.23	0.25	0.22	0.20	0.23	0.27
Remaining Deficit in Muda		0	0	21	16	8	0	0	126	0	0
Proportion to Demand in Muda		0	0	0.02	0.02	0.01	0	0	0.15	0	0
Jeniang & Naok Supply		255	257	243	247	185	279	234	145	217	297
Beris Supply	(Kedah)	58	55	45	45	52	47	52	0	44	34
	(Muda)	0	0	13	10	5	0	0	88	0	0
Tawar-Muda Supply	(Kedah)	30	30	24	22	28	23	29	0	21	12
	(Muda)	0	0	8	6	3	0	0	36	0	0
Remaining Deficit in Kedah		133	88	180	163	131	90	58	205	115	129
Proportion to Demand in Kedah		0.07	0.05	0.10	0.09	0.07	0.05	0.03	0.11	0.06	0.07
Remaining Deficit in Muda		0	0	0	0	0	0	0	2	0	0
Proportion to Demand in Muda		0	0	0	0	0	0	0	0.00	0	0

		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Deficit in Kedah with Pedu-Muda Supply		331	308	351	393	523	384	463	479	419	442
Deficit in Muda		18	31	11	30	1	20	157	68	137	72
Mengkuang Supply		18	24	11	24	1	20	24	24	24	24
Ahning Supply		15	26	6	21	39	24	42	36	20	41
Remaining Deficit in Kedah		316	282	345	372	484	360	421	443	399	401
Proportion to Demand in Kedah		0.18	0.16	0.20	0.22	0.28	0.21	0.24	0.26	0.23	0.23
Remaining Deficit in Muda		0	7	0	6	0	0	133	44	113	48
Proportion to Demand in Muda		0	0.01	0	0.01	0	0	0.15	0.05	0.13	0.06
Jeniang & Naok Supply		154	96	217	189	259	238	175	228	208	177
Beris Supply	(Kedah)	64	75	55	67	55	50	0	31	0	29
	(Muda)	0	4	0	4	0	0	92	28	57	31
Tawar-Muda Supply	(Kedah)	41	51	31	42	28	27	0	21	0	29
	(Muda)	0	3	0	2	0	0	41	16	48	17
Remaining Deficit in Kedah		57	60	42	74	143	29	246	163	191	166
Proportion to Demand in Kedah		0.03	0.03	0.02	0.04	0.08	0.02	0.14	0.09	0.11	0.09
Remaining Deficit in Muda		0	0	0	0	0	0	0	0	8	0
Proportion to Demand in Muda		0	0	0	0	0	0	0	0	0.01	0

Table 55 WATER DEMAND AND SUPPLY BALANCE OF SOURCE DEVELOPMENT PLAN IN LOW GROWTH CASE (ALTERNATIVE 1, MUDA PRIORITY)

Unit: 10^6 m^3

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Deficit in Kedah with Pedu-Muda Supply		463	408	454	436	378	435	361	334	387	457
Deficit in Muda		0	0	22	23	17	0	0	96	1	3
Mengkuang Supply		0	0	22	23	17	0	0	24	1	3
Ahning Supply		41	34	54	43	42	36	21	25	31	27
Remaining Deficit in Kedah		422	374	400	393	336	399	340	309	356	430
Proportion to Demand in Kedah		0.26	0.23	0.24	0.24	0.20	0.24	0.21	0.19	0.22	0.26
Remaining Deficit in Muda		0	0	0	0	0	0	0	72	0	0
Proportion to Demand in Muda		0	0	0	0	0	0	0	0.10	0	0
Jeniang & Naok Supply		257	254	244	247	191	276	227	143	213	297
Beris Supply	(Kedah)	58	55	58	55	57	47	52	46	44	34
	(Muda)	0	0	0	0	0	0	0	42	0	0
Tawar-Muda Supply	(Kedah)	30	30	32	28	31	23	29	6	21	12
	(Muda)	0	0	0	0	0	0	0	30	0	0
Remaining Deficit in Kedah		77	35	66	63	57	53	32	114	78	87
Proportion to Demand in Kedah		0.04	0.02	0.04	0.04	0.03	0.03	0.02	0.07	0.05	0.05
Remaining Deficit in Muda		0	0	0	0	0	0	0	0	0	0
Proportion to Demand in Muda		0	0	0	0	0	0	0	0	0	0

		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Deficit in Kedah with Pedu-Muda Supply		302	275	318	355	478	350	398	420	364	386
Deficit in Muda		5	12	1	10	0	10	107	38	82	46
Mengkuang Supply		5	12	1	10	0	10	24	24	24	24
Ahning Supply		15	26	6	21	39	24	42	36	20	41
Remaining Deficit in Kedah		287	249	312	334	439	326	356	384	344	345
Proportion to Demand in Kedah		0.17	0.15	0.19	0.20	0.27	0.20	0.22	0.23	0.21	0.21
Remaining Deficit in Muda		0	0	0	0	0	0	83	14	58	22
Proportion to Demand in Muda		0	0	0	0	0	0	0.12	0.02	0.08	0.03
Jeniang & Naok Supply		158	102	219	195	254	237	178	225	209	178
Beris Supply	(Kedah)	64	79	55	71	55	50	50	45	25	45
	(Muda)	0	0	0	0	0	0	42	14	32	15
Tawar-Muda Supply	(Kedah)	41	54	31	44	28	27	0	37	22	39
	(Muda)	0	0	0	0	0	0	41	0	26	7
Remaining Deficit in Kedah		24	14	7	24	102	12	128	77	88	83
Proportion to Demand in Kedah		0.01	0.01	0.00	0.01	0.06	0.01	0.07	0.04	0.05	0.05
Remaining Deficit in Muda		0	0	0	0	0	0	0	0	0	0
Proportion to Demand in Muda		0	0	0	0	0	0	0	0	0	0

Table 56. WATER DEMAND AND SUPPLY BALANCE OF SOURCE DEVELOPMENT PLAN IN HIGH GROWTH CASE (ALTERNATIVE 2, EVEN DISTRIBUTION)

Unit: 10^6 m^3

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Deficit in Kedah with Pedu-Muda Supply		517	464	546	520	438	475	394	375	428	499
Deficit in Muda		1	2	45	40	32	0	0	150	3	6
Mengkuang Supply		1	2	24	24	24	0	0	24	3	6
Ahning Supply		41	34	54	43	42	36	21	25	31	27
Remaining Deficit in Kedah		476	430	492	477	396	439	373	350	397	472
Proportion to Demand in Kedah		0.28	0.25	0.28	0.28	0.23	0.25	0.22	0.20	0.23	0.27
Remaining Deficit in Muda		0	0	21	16	8	0	0	126	0	0
Proportion to Demand in Muda		0	0	0.02	0.02	0.01	0	0	0.15	0	0
Jeniang & Naok Supply		255	257	243	247	185	279	234	145	217	297
Beris Supply	(Kedah)	58	55	45	46	50	47	52	41	44	34
	(Muda)	0	0	13	9	7	0	0	47	0	0
Tawar-Muda Supply	(Kedah)	30	30	24	21	30	23	29	0	21	12
	(Muda)	0	0	8	7	1	0	0	36	0	0
Remaining Deficit in Kedah		133	88	180	163	131	90	58	164	115	129
Proportion to Demand in Kedah		0.07	0.05	0.10	0.09	0.07	0.05	0.03	0.09	0.06	0.07
Remaining Deficit in Muda		0	0	0	0	0	0	0	43	0	0
Proportion to Demand in Muda		0	0	0	0	0	0	0	0.06	0	0

		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Deficit in Kedah with Pedu-Muda Supply		331	308	351	393	523	384	463	479	419	442
Deficit in Muda		18	31	11	30	1	20	157	68	137	72
Mengkuang Supply		18	24	11	24	1	20	24	24	24	24
Ahning Supply		15	26	6	21	39	24	42	36	20	41
Remaining Deficit in Kedah		316	282	345	372	484	360	421	443	399	401
Proportion to Demand in Kedah		0.18	0.16	0.20	0.22	0.28	0.21	0.24	0.26	0.23	0.23
Remaining Deficit in Muda		0	7	0	6	0	0	133	44	113	48
Proportion to Demand in Muda		0	0.01	0	0.01	0	0	0.15	0.05	0.13	0.06
Jeniang & Naok Supply		154	96	217	189	259	238	175	228	208	177
Beris Supply	(Kedah)	64	72	55	65	55	50	50	34	12	40
	(Muda)	0	7	0	6	0	0	42	25	45	20
Tawar-Muda Supply	(Kedah)	41	54	31	44	28	27	15	18	0	18
	(Muda)	0	0	0	0	0	0	26	19	48	28
Remaining Deficit in Kedah		57	60	42	74	143	29	181	163	179	166
Proportion to Demand in Kedah		0.03	0.03	0.02	0.04	0.08	0.02	0.10	0.09	0.10	0.09
Remaining Deficit in Muda		0	0	0	0	0	0	65	0	20	0
Proportion to Demand in Muda		0	0	0	0	0	0	0.09	0	0.03	0

Table 57 WATER DEMAND AND SUPPLY BALANCE OF SOURCE DEVELOPMENT PLAN IN LOW GROWTH CASE (ALTERNATIVE 2, EVEN DISTRIBUTION)

Unit: 10^6 m^3

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Deficit in Kedah with Pedu-Muda Supply		463	408	454	436	378	435	361	334	387	457
Deficit in Muda		0	0	22	23	17	0	0	96	1	3
Mengkuang Supply		0	0	22	23	17	0	0	24	1	3
Ahning Supply		41	34	54	43	42	36	21	25	31	27
Remaining Deficit in Kedah		422	374	400	393	336	399	340	309	356	430
Proportion to Demand in Kedah		0.26	0.23	0.24	0.24	0.20	0.24	0.21	0.19	0.22	0.26
Remaining Deficit in Muda		0	0	0	0	0	0	0	72	0	0
Proportion to Demand in Muda		0	0	0	0	0	0	0	0.10	0	0
Jeniang & Naok Supply		257	254	244	241	191	276	227	143	213	297
Beris Supply	(Kedah)	58	55	58	55	57	47	52	46	44	34
	(Muda)	0	0	0	0	0	0	0	42	0	0
Tawar-Muda Supply	(Kedah)	30	30	32	28	31	23	29	22	21	12
	(Muda)	0	0	0	0	0	0	0	14	0	0
Remaining Deficit in Kedah		77	35	66	63	57	53	32	98	78	87
Proportion to Demand in Kedah		0.04	0.02	0.04	0.04	0.03	0.03	0.02	0.06	0.05	0.05
Remaining Deficit in Muda		0	0	0	0	0	0	0	16	0	0
Proportion to Demand in Muda		0	0	0	0	0	0	0	0.03	0	0

		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Deficit in Kedah with Pedu-Muda Supply		302	275	318	355	478	350	398	420	364	386
Deficit in Muda		5	12	1	10	0	10	107	38	82	46
Mengkuang Supply		5	12	1	10	0	10	24	24	24	24
Ahning Supply		15	26	6	21	39	24	42	36	20	41
Remaining Deficit in Kedah		287	249	312	334	439	326	356	384	344	345
Proportion to Demand in Kedah		0.17	0.15	0.19	0.20	0.27	0.20	0.22	0.23	0.21	0.21
Remaining Deficit in Muda		0	0	0	0	0	0	83	14	58	22
Proportion to Demand in Muda		0	0	0	0	0	0	0.12	0.02	0.08	0.03
Jeniang & Naok Supply		158	102	219	195	254	237	178	225	209	178
Beris Supply	(Kedah)	64	79	55	71	55	50	54	45	25	45
	(Muda)	0	0	0	0	0	0	38	14	32	15
Tawar-Muda Supply	(Kedah)	41	54	31	44	28	27	27	37	40	39
	(Muda)	0	0	0	0	0	0	14	0	8	7
Remaining Deficit in Kedah		24	14	7	24	102	12	97	77	70	83
Proportion to Demand in Kedah		0.01	0.01	0.00	0.01	0.06	0.01	0.06	0.04	0.04	0.05
Remaining Deficit in Muda		0	0	0	0	0	0	31	0	18	0
Proportion to Demand in Muda		0	0	0	0	0	0	0.06	0	0.03	0

Table 58 WATER DEMAND AND SUPPLY BALANCE OF SOURCE DEVELOPMENT PLAN IN HIGH GROWTH CASE (ALTERNATIVE 3, KEDAH PRIORITY)

Unit: 10^6 m^3

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Deficit in Kedah with Pedu-Muda Supply		517	464	546	520	438	475	394	375	428	499
Deficit in Muda		1	2	45	40	32	0	0	150	3	6
Mengkuang Supply		1	2	24	24	24	0	0	24	3	6
Ahning Supply		41	34	54	43	42	36	21	25	31	27
Remaining Deficit in Kedah		476	430	492	477	396	439	373	350	397	472
Proportion to Demand in Kedah		0.28	0.25	0.28	0.28	0.23	0.25	0.22	0.20	0.23	0.27
Remaining Deficit in Muda		0	0	21	16	8	0	0	126	0	0
Proportion to Demand in Muda		0	0	0.02	0.02	0.01	0	0	0.15	0	0
Jeniang & Naok Supply		255	257	243	247	185	279	234	145	217	297
Beris Supply	(Kedah)	58	55	58	55	57	47	52	78	44	34
	(Muda)	0	0	0	0	0	0	0	10	0	0
Tawar-Muda Supply	(Kedah)	30	30	32	28	31	23	29	36	21	12
	(Muda)	0	0	0	0	0	0	0	0	0	0
Remaining Deficit in Kedah		133	88	159	147	123	90	58	91	115	129
Proportion to Demand in Kedah		0.07	0.05	0.09	0.08	0.07	0.05	0.03	0.05	0.06	0.07
Remaining Deficit in Muda		0	0	21	16	8	0	0	116	0	0
Proportion to Demand in Muda		0	0	0.03	0.02	0.01	0	0	0.15	0	0

		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Deficit in Kedah with Pedu-Muda Supply		331	308	351	393	523	384	463	479	419	442
Deficit in Muda		18	31	11	30	1	20	157	68	137	72
Mengkuang Supply		18	24	11	24	1	20	24	24	24	24
Ahning Supply		15	26	6	21	39	24	42	36	20	41
Remaining Deficit in Kedah		316	282	345	372	484	360	421	443	399	401
Proportion to Demand in Kedah		0.18	0.16	0.20	0.22	0.28	0.21	0.24	0.26	0.23	0.23
Remaining Deficit in Muda		0	7	0	6	0	0	133	44	113	48
Proportion to Demand in Muda		0	0.01	0	0.01	0	0	0.15	0.05	0.13	0.06
Jeniang & Naok Supply		154	96	217	189	259	238	175	228	208	177
Beris Supply	(Kedah)	64	79	55	71	55	50	86	59	50	60
	(Muda)	0	0	0	0	0	0	6	0	7	0
Tawar-Muda Supply	(Kedah)	41	54	31	44	28	27	41	37	48	46
	(Muda)	0	0	0	0	0	0	0	0	0	0
Remaining Deficit in Kedah		57	53	42	68	143	29	119	119	93	118
Proportion to Demand in Kedah		0.03	0.03	0.02	0.04	0.08	0.02	0.07	0.07	0.05	0.07
Remaining Deficit in Muda		0	7	0	6	0	0	127	44	106	48
Proportion to Demand in Muda		0	0.01	0	0.01	0	0	0.16	0.06	0.14	0.06

Table 59 WATER DEMAND AND SUPPLY BALANCE OF SOURCE DEVELOPMENT PLAN IN LOW GROWTH CASE (ALTERNATIVE 3, KEDAH PRIORITY)

Unit: 10^6 m^3

		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Deficit in Kedah with Pedu-Muda Supply		463	408	454	436	378	435	361	334	387	457
Deficit in Muda		0	0	22	23	17	0	0	96	1	3
Mengkuang Supply		0	0	22	23	17	0	0	24	1	3
Ahning Supply		41	34	54	43	42	36	21	25	31	27
Remaining Deficit in Kedah		422	374	400	393	336	399	340	309	356	430
Proportion to Demand in Kedah		0.26	0.23	0.24	0.24	0.20	0.24	0.21	0.19	0.22	0.26
Remaining Deficit in Muda		0	0	0	0	0	0	0	72	0	0
Proportion to Demand in Muda		0	0	0	0	0	0	0	0.10	0	0
Jeniang & Naok Supply		257	254	244	247	191	276	227	143	213	297
Beris Supply	(Kedah)	58	55	58	55	57	47	52	78	44	34
	(Muda)	0	0	0	0	0	0	0	10	0	0
Tawar-Muda Supply	(Kedah)	30	30	32	28	31	23	29	36	21	12
	(Muda)	0	0	0	0	0	0	0	0	0	0
Remaining Deficit in Kedah		77	35	66	63	57	53	32	52	78	87
Proportion to Demand in Kedah		0.04	0.02	0.04	0.04	0.03	0.03	0.02	0.03	0.05	0.05
Remaining Deficit in Muda		0	0	0	0	0	0	0	62	0	0
Proportion to Demand in Muda		0	0	0	0	0	0	0	0.11	0	0

		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Deficit in Kedah with Pedu-Muda Supply		302	275	318	355	478	350	398	420	364	386
Deficit in Muda		5	12	1	10	0	10	107	38	82	46
Mengkuang Supply		5	12	1	10	0	10	24	24	24	24
Ahning Supply		15	26	6	21	39	24	42	36	20	41
Remaining Deficit in Kedah		287	249	312	334	439	326	356	384	344	345
Proportion to Demand in Kedah		0.17	0.15	0.19	0.20	0.27	0.20	0.22	0.23	0.21	0.21
Remaining Deficit in Muda		0	0	0	0	0	0	83	14	58	22
Proportion to Demand in Muda		0	0	0	0	0	0	0.12	0.02	0.08	0.03
Jeniang & Naok Supply		158	102	219	195	254	237	178	225	209	178
Beris Supply	(Kedah)	64	79	55	71	55	50	85	58	50	60
	(Muda)	0	0	0	0	0	0	7	1	7	0
Tawar-Muda Supply	(Kedah)	41	54	31	44	28	27	41	37	48	46
	(Muda)	0	0	0	0	0	0	0	0	0	0
Remaining Deficit in Kedah		24	14	7	24	102	12	52	64	37	61
Proportion to Demand in Kedah		0.01	0.01	0.00	0.01	0.06	0.01	0.03	0.04	0.02	0.04
Remaining Deficit in Muda		0	0	0	0	0	0	76	13	51	22
Proportion to Demand in Muda		0	0	0	0	0	0	0.14	0.02	0.09	0.04

Table 60 AVERAGE ANNUAL WATER DEFICIT BY CAUSE BY AFFECTED AREA IN HIGH GROWTH CASE

Unit: 10^6 m^3

Cause of Water Deficit	Affected Area by Water Deficit						
	Kedah River System				Muda-Perai River System		
	MADA	Main Minor	D&I	Total	Main Minor	D&I	Total
1982							
Kedah System							
MADA	271			271			
Main minor		1		1			
Tributary minor	5.9		0.1	6			
D&I			5	5			
Total	276.9	1	5.1	283			
Muda-Perai System							
Main minor					3		3
Tributary minor					0.8	0.2	1
D&I						1	1
Total					3.8	1.2	5
1990							
Kedah System							
MADA	280.0	11.0	11.0	302			
Main minor	31.5	1.2	1.3	34			
Tributary minor	10.2	0.4	0.4	11			
D&I				0			
Total	321.7	12.6	12.7	347			
Muda-Perai System							
Main minor					2.3	0.7	3
Tributary minor					4.5	0.5	5
D&I						0	0
Total					6.8	1.2	8
2000							
Kedah System							
MADA	231.8	13.3	24.9	270			
Main minor	43.8	2.5	4.7	51			
Tributary minor	30.0	1.8	3.2	35			
D&I	26.6	1.5	2.9	31			
Total	332.2	19.1	35.7	387			
Muda-Perai System							
Main minor					1.5	1.5	3
Tributary minor					5.0	5.0	10
D&I					13.0	0	13
Total					19.5	6.5	26

Remarks; Supply by Ahning and Mengkuang dams is counted in D&I deficit in 1990 and 2000.

Table 61 AVERAGE ANNUAL WATER DEFICIT BY CAUSE BY AFFECTED AREA IN LOW GROWTH CASE

Unit: 10^6 m^3

Cause of Water Deficit	Affected Area by Water Deficit						
	Kedah River System				Muda-Perai River System		
	MADA	Main Minor	D&I	Total	Main Minor	D&I	Total
1982							
Kedah System							
MADA	271			271			
Main minor		1		1			
Tributary minor	5.9		0.1	6			
D&I			5	5			
Total	276.9	1	5.1	283			
Muda-Perai System							
Main minor					3		3
Tributary minor					0.8	0.2	1
D&I						1	1
Total					3.8	1.2	5
1990							
Kedah System							
MADA	282.0	11.2	8.8	302			
Main minor	25.2	1.0	0.8	27			
Tributary minor	10.3	0.4	0.3	11			
D&I				0			
Total	317.5	12.6	9.9	340			
Muda-Perai System							
Main minor					3		3
Tributary minor					3.0	0	3
D&I						0	
Total					6.0	0	6
2000							
Kedah System							
MADA	244.3	14.0	11.7	270			
Main minor	46.2	2.6	2.2	51			
Tributary minor	31.7	1.8	1.5	35			
D&I	0.8	0.1	0.1	1			
Total	323.0	18.5	15.5	357			
Muda-Perai System							
Main minor					2.0	1.0	3
Tributary minor					4.6	2.4	7
D&I					2.0	0	2
Total					8.6	3.4	12

Remarks; Supply by Ahning and Mengkuang dams is counted in D&I deficit in 1990 and 2000.

Table 62 ALLOCATION OF NET WATER OUTPUT

Source Facilit	Cause of Water Deficit: Kedah River	Cause of Water Deficit: Muda-Perai River
Jeniang/Naok	MADA Minor D&I Maintenance flow	
Beris	Tributary MADA Minor D&I Maintenance flow	Tributary Minor D&I
Tawar-Muda	MADA Minor D&I Maintenance flow	Minor D&I
Sari Durian Badak-Temin Khlong Thepha Ma	MADA Minor D&I Maintenance flow	
Reman	MADA Minor D&I Tributary (for cases of H-5, H-6, L-4) Maintenance flow	
Merbok		Tributary Minor D&I
Rui		Tributary Minor D&I Hydropower

Remarks;
- MADA = MADA irrigation
- Minor = Minor irrigation of main stream
- Tributary = Minor irrigation of tributary
- D&I = D&I water supply
- Maintenance flow = River maintenance flow only for High Growth Case
- Hydropower = Hydropower generation

Table 63 NET WATER OUTPUT OF SOURCE FACILITIES BY CAUSE OF WATER DEFICIT (ALTERNATIVE 1, MUDA PRIORITY) (1/5)

Unit: 10^6 m^3

	Low Growth Case			High Growth Case		
	Jeniang & Naok	Beris	Tawar-Muda	Jeniang & Naok	Beris	Tawar-Muda
1990						
Kedah System						
MADA	197.4	40.4	28.5	193.2	38.6	27.0
Main minor	17.6	3.6	2.5	21.8	4.4	3.0
Tributary minor	0	11.0	0	0	11.0	0
D&I	0	0	0	0	0	0
Sub-total	215.0	55.0	31.0	215.0	54.0	30.0
Muda-Perai System						
Main minor		1.0	2.0		0	3.0
Tributary minor		3.0	0		5.0	0
D&I		0	0		0	0
Sub-total		4.0	2.0		5.0	3.0
Total	215.0	59.0	33.0	215.0	59.0	33.0
2000						
Kedah System						
MADA	180.2	12.6	25.1	156.0	6.5	16.0
Main minor	34.1	2.4	4.8	29.5	1.2	3.0
Tributary minor	0	35.0	0	0	35.0	0
D&I	0.7	0.0	0.1	17.9	0.8	1.8
Maintenance flow	0	0	0	11.6	0.5	1.2
Sub-total	215.0	50.0	30.0	215.0	44.0	22.0
Muda-Perai System						
Main minor		0	3.0		0.9	2.1
Tributary minor		9.0	0		10.0	0
D&I		0	0		4.1	8.9
Sub-total		9.0	3.0		15.0	11.0
Total	215.0	59.0	33.0	215.0	59.0	33.0

Table 64 NET WATER OUTPUT OF SOURCE FACILITIES BY CAUSE OF WATER DEFICIT (ALTERNATIVE 2, EVEN DISTRIBUTION) (2/5)

Unit: 10^6 m^3

	Low Growth Case			High Growth Case		
	Jeniang & Naok	Beris	Tawar-Muda	Jeniang & Naok	Beris	Tawar-Muda
1990						
Kedah System						
MADA	197.4	40.4	29.4	193.2	38.6	28.5
Main minor	17.6	3.6	2.6	21.8	4.4	2.5
Tributary minor	0	11.0	0	0	11.0	0
D&I	0	0	0	0	0	0
Sub-total	215.0	55.0	32.0	215.0	54.0	31.0
Muda-Perai System						
Main minor		1.0	1.0		0	2.0
Tributary minor		3.0	0		5.0	0
D&I		0.0	0		0	0
Sub-total		4.0	1.0		5.0	2.0
Total	215.0	59.0	33.0	215.0	59.0	33.0
2000						
Kedah System						
MADA	180.3	14.2	26.0	156.0	9.4	17.4
Main minor	34.1	2.7	4.9	29.5	1.8	3.3
Tributary minor	0	35.0	0	0	35.0	0
D&I	0.7	0.1	0.1	17.9	1.1	2.0
Maintenance flow	0	0	0	11.6	0.7	1.3
Sub-total	215.1	52.0	31.0	215.0	48.0	24.0
Muda-Perai System						
Main minor		0	2.0		0.2	1.7
Tributary minor		7.0	0		10.0	0
D&I		0	0		0.8	7.3
Sub-total		7.0	2.0		11.0	9.0
Total	215.1	59.0	33.0	215.0	59.0	33.0

Table 65 NET WATER OUTPUT OF SOURCE FACILITIES BY CAUSE OF WATER DEFICIT (ALTERNATIVE 3, KEDAH PRIORITY) (3/5)

Unit: 10^6 m^3

	Low Growth Case			High Growth Case		
	Jeniang & Naok	Beris	Tawar-Muda	Jeniang & Naok	Beris	Tawar-Muda
1990						
Kedah System						
MADA	197.4	43.1	30.3	193.2	42.2	29.7
Main minor	17.6	3.9	2.7	21.8	4.8	3.3
Tributary minor	0	11.0	0	0	11.0	0
D&I	0	0	0	0	0	0
Sub-total	215.0	58.0	33.0	215.0	58.0	33.0
Muda-Perai System						
Main minor		0			0	
Tributary minor		1.0			1.0	
D&I		0			0	
Sub-total		1.0			1.0	
Total	215.0	59.0	33.0	215.0	59.0	33.0
2000						
Kedah System						
MADA	180.3	19.3	27.7	156.0	16.7	24.0
Main minor	34.1	3.6	5.2	29.5	3.2	4.5
Tributary minor	0	35.0	0	0	35.0	0
D&I	0.7	0.1	0.1	17.9	1.9	2.7
Maintenance flow	0	0	0	11.6	1.2	1.8
Sub-total	215.1	58.0	33.0	215.0	58.0	33.0
Muda-Perai System						
Main minor		0			0	
Tributary minor		1.0			1.0	
D&I		0			0	
Sub-total		1.0			1.0	
Total	215.1	59.0	33.0	215.0	59.0	33.0

Table 66 NET WATER OUTPUT OF SOURCE FACILITIES BY CAUSE OF WATER DEFICIT (4/5)

Unit: 10^6 m^3

	Low Growth Case			High Growth Case		
	Sari	Durian	Badak-Temin	Sari	Durian	Badak-Temin
Kedah System						
1990						
MADA	15.6	13.8	20.2	15.3	13.5	19.8
Main minor	1.4	1.2	1.8	1.7	1.5	2.2
Tributary						
D&I	0	0	0	0	0	0
Total	17.0	15.0	22.0	17.0	15.0	22.0
2000						
MADA	14.2	12.6	18.4	12.4	10.9	16.0
Main minor	2.7	2.4	3.5	2.3	2.0	3.0
Tributary						
D&I	0.1		0.1	1.4	1.3	1.8
Maintenance		0	0	0.9	0.8	1.2
Total	17.0	15.0	22.0	17.0	15.0	22.0

	Low Growth Case			High Growth Case		
	Ma	Khlong Thepha	Reman	Ma	Khlong Thepha	Reman
Kedah System						
1990						
MADA	19.3	52.3	67.0	18.9	51.2	66.5
Main minor	1.7	4.7	6.0	2.1	5.8	7.5
Tributary						
D&I						
Total	21.0	57.0	73.0	21.0	57.0	74.0
2000						
MADA	17.6	47.8	79.7	15.2	41.4	92.3
Main minor	3.3	9.0	15.0	2.9	7.8	18.4
Tributary						
D&I	0.1	0.2	0.3	1.8	4.8	11.2
Maintenance				1.1		
Total	21.0	57.0	95.0	21.0	57.0	134.0

Table 67 NET WATER OUTPUT OF SOURCE FACILITIES BY CAUSE OF WATER DEFICIT (5/5)

Unit: 10^6 m^3

	Low Growth Case		High Growth Case	
	Rui	Merbok	Rui	Merbok
Muda-Perai				
1990				
Main minor	3.0	3.0	4.3	4.3
Tributary	5.0	3.0	7.0	5.0
D&I	0.0	0.0	0.7	0.7
Total	8.0	6.0	12.0	10.0
2000				
Main minor	4.3	4.3	6.0	6.0
Tributary	9.0	7.0	12.0	10.0
D&I	2.7	2.7	0.7	16.0
Total	16.0	14.0	34.0	32.0

FIGURES

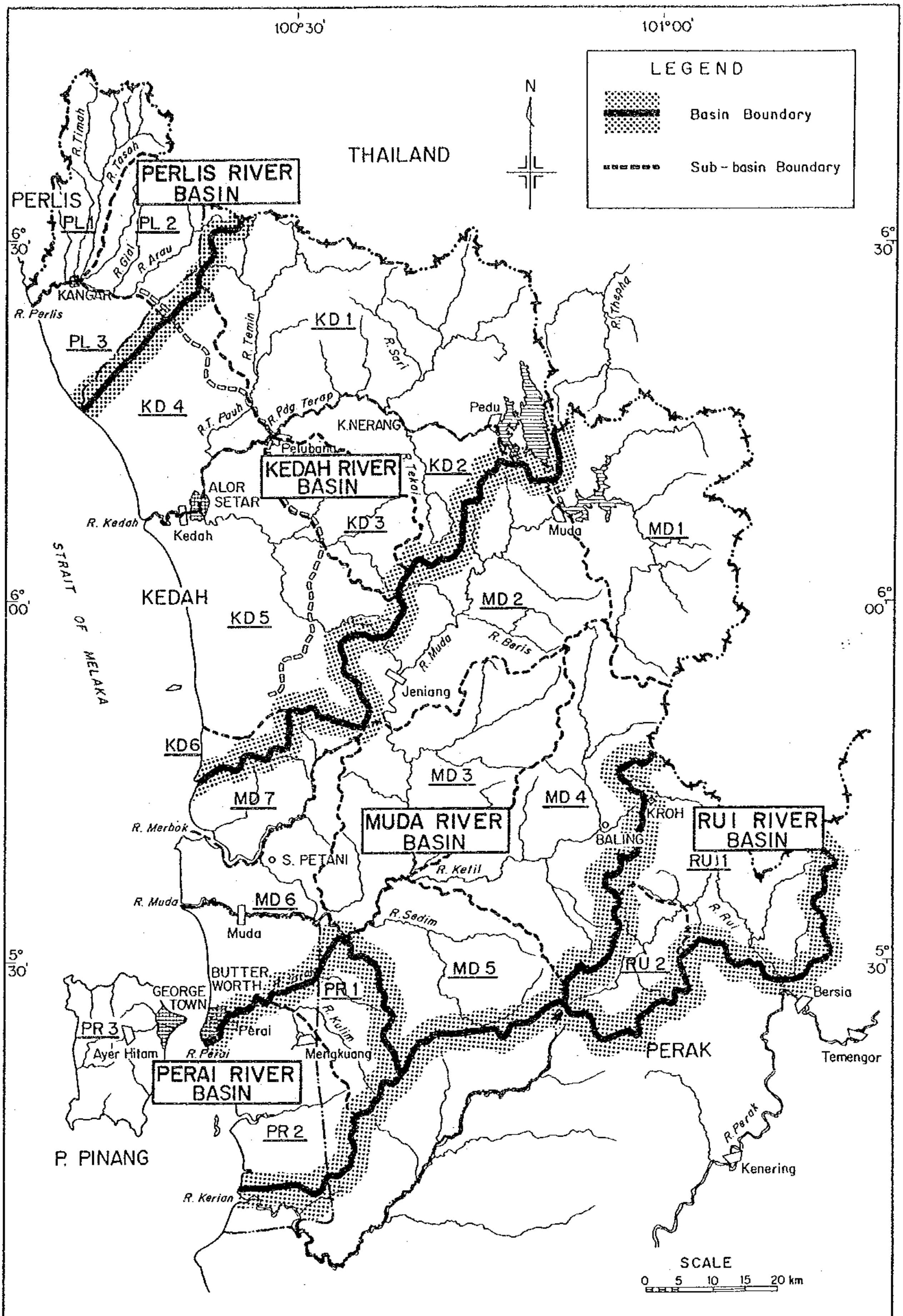


Fig. 1 Basin Division

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$R_1 = Q_1$

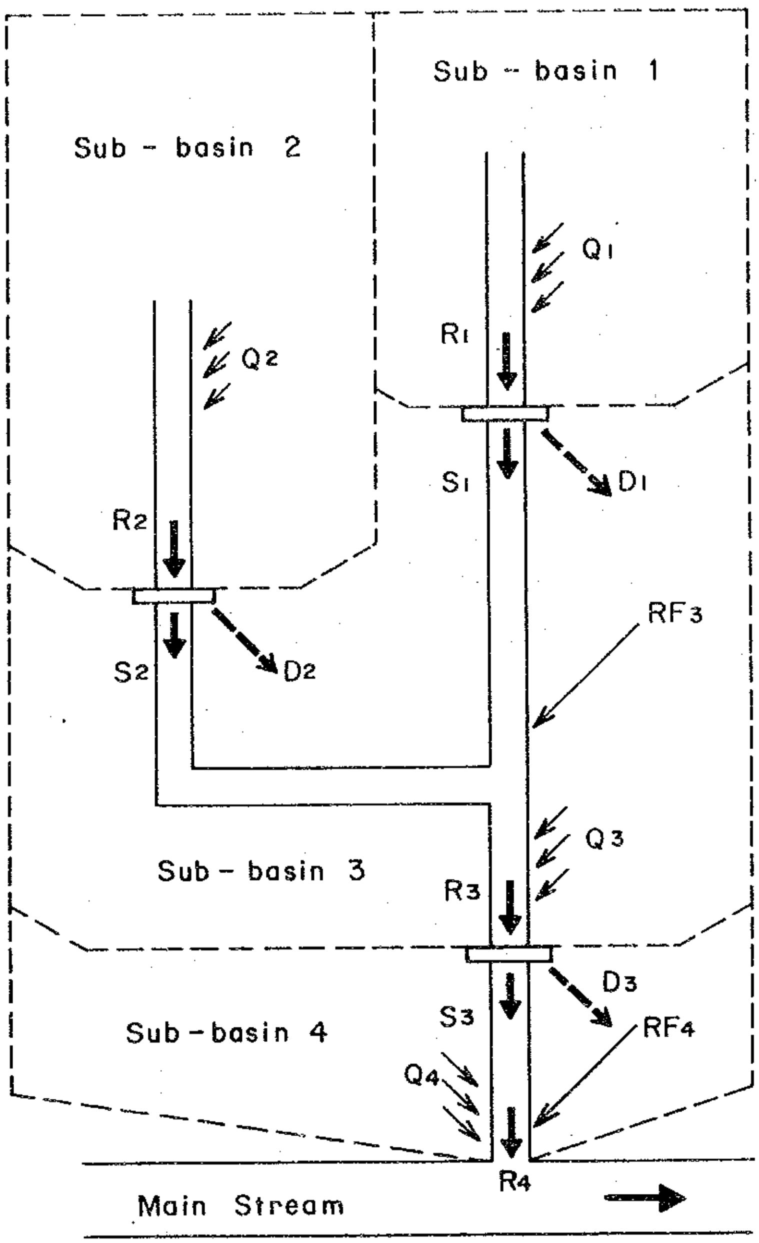
$R_2 = Q_2$

$R_3 = Q_3 + S_1 + S_2 + RF_3$

$R_4 = Q_4 + S_3 + RF_4$

IF ; $R_i > D_i$
$DF_i = 0$
$S_i = R_i - D_i$

IF ; $R_i \leq D_i$
$DF_i = D_i - R_i$
$S_i = 0$



R_i	Available runoff	at	intake i (i = 1 ~ 3)
D_i	Water demand	at	〃
S_i	Excess runoff	at	〃
DF_i	Water deficit	at	〃
Q_i	Natural runoff	in	Sub - basin i (i = 1 ~ 4)
RF_i	Return flow	in	〃
R_4	Runoff into the main stream		

Fig. 2 Tributary Model

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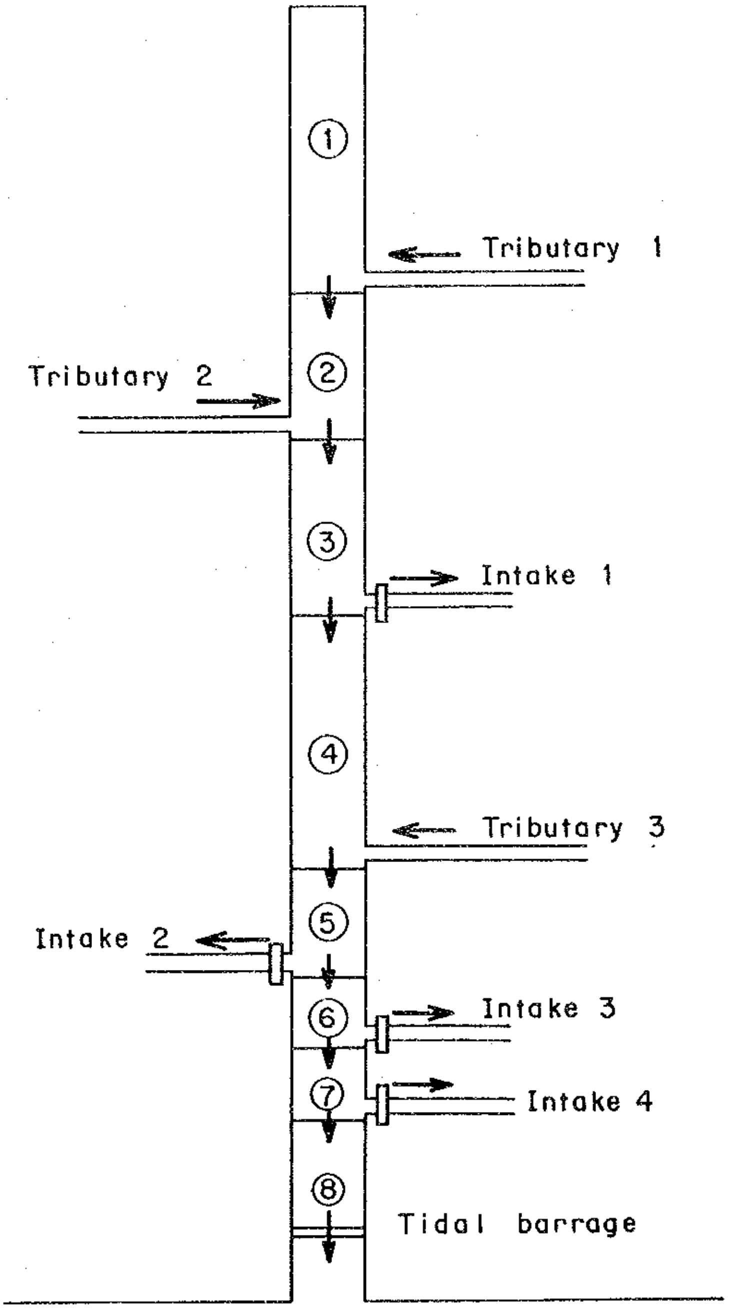

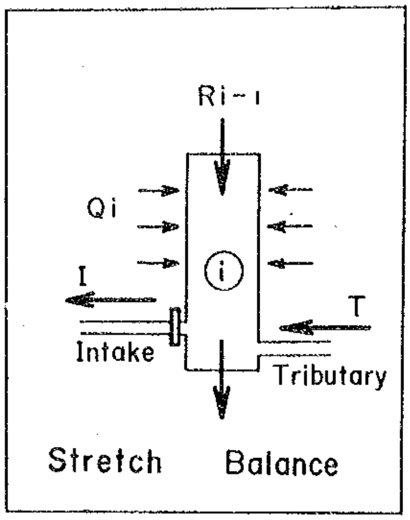

IF ; $R_{i-1} + Q_i + T - I \geq 0$

$R_i = R_{i-1} + Q_i + T - I$

$DF_i = 0$

IF ; $R_{i-1} + Q_i + T - I < 0$

$R_i = 0$

$DF_i = -(R_{i-1} + Q_i + T - I)$

R_{i-1}	Runoff from the upstream stretch
R_i	Surplus runoff to downstream
Q_i	Runoff from catchment of stretch
DF_i	Deficit at strech i
T	Tributary inflow
I	Intake outfrow

Fig. 3 Main Stream Model

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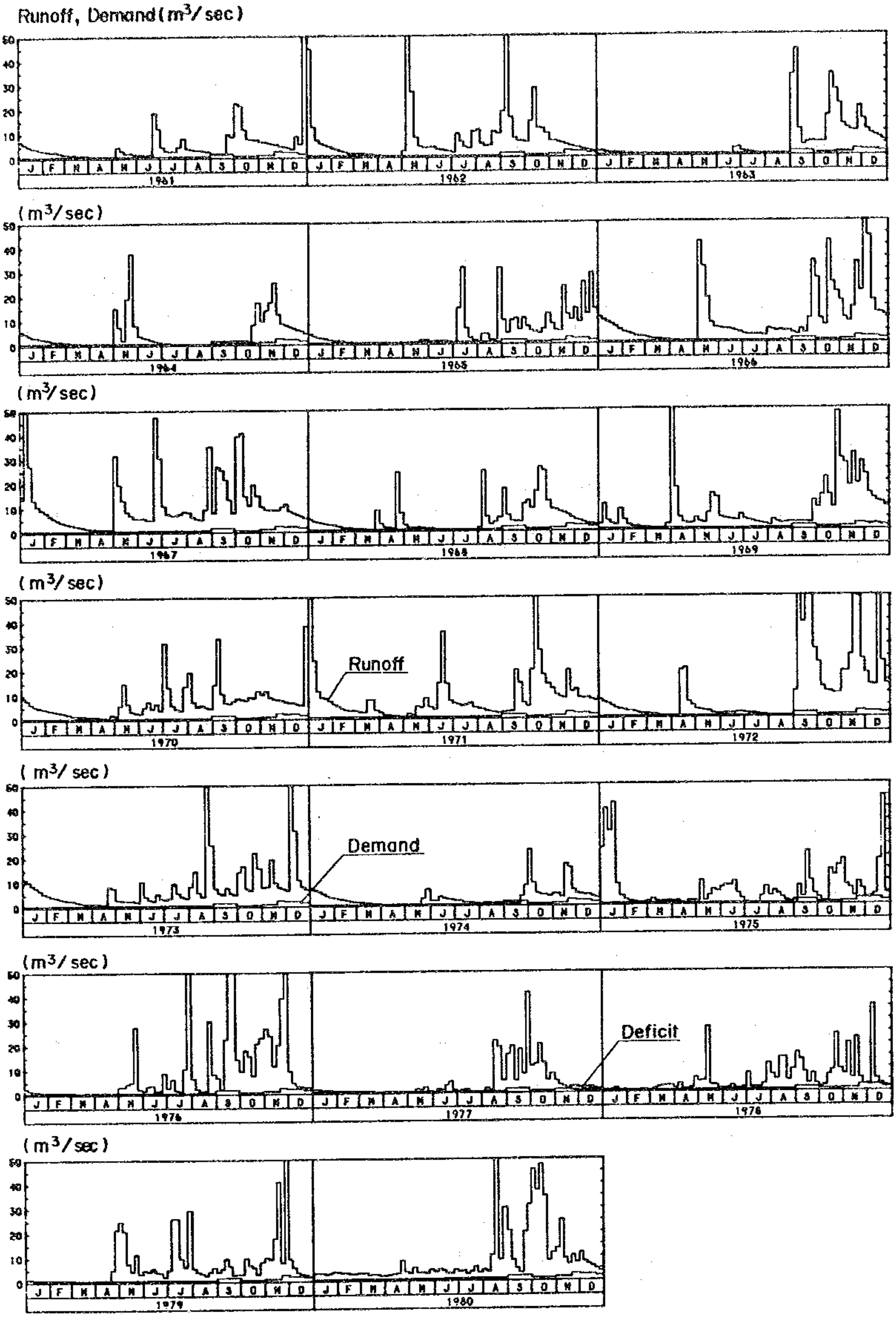

Fig. 4 Water Demand and Supply Balance of Perlis River System in 1982

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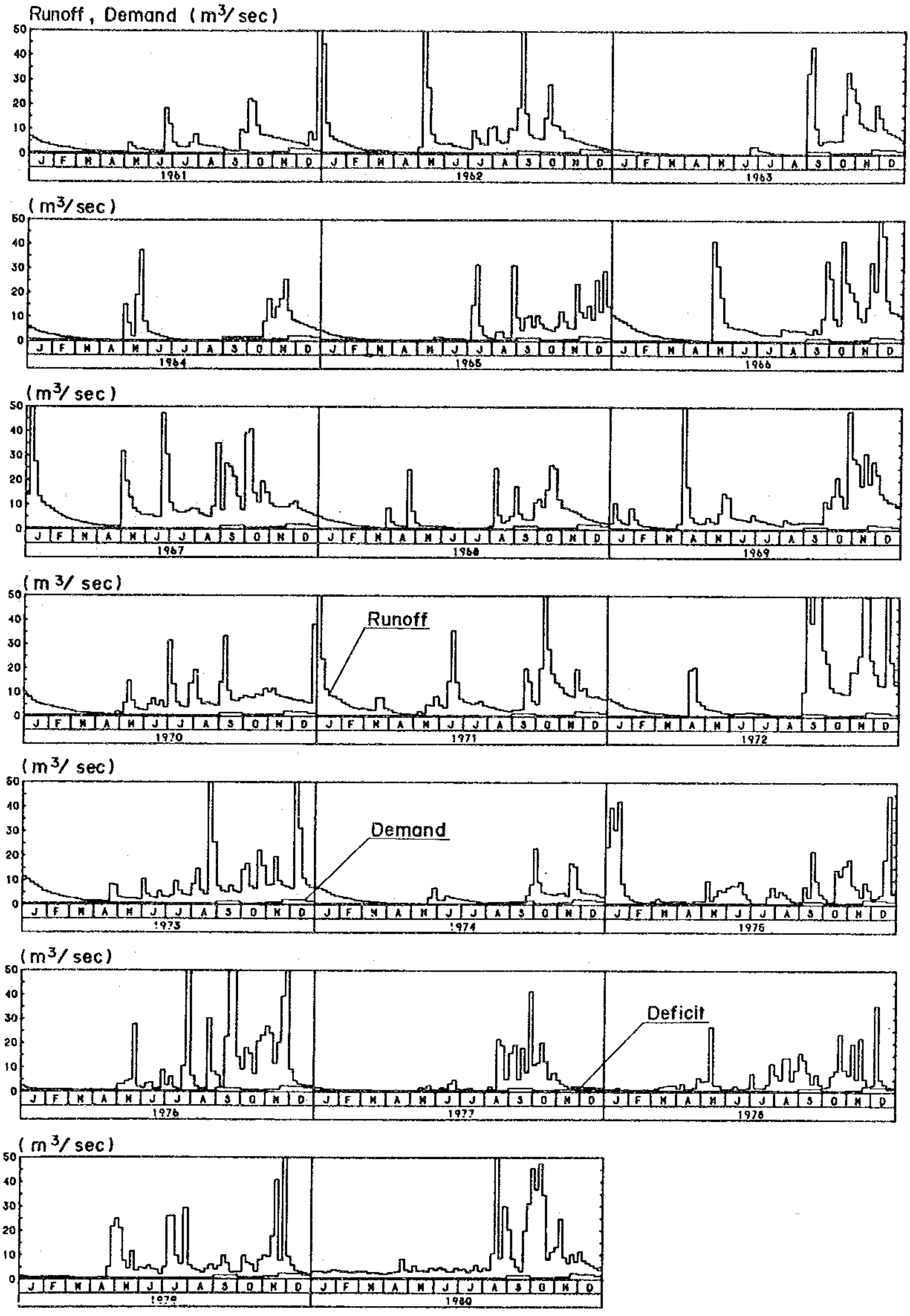

Fig. 5 Water Demand and Supply Balance of Perlis River System in 1990

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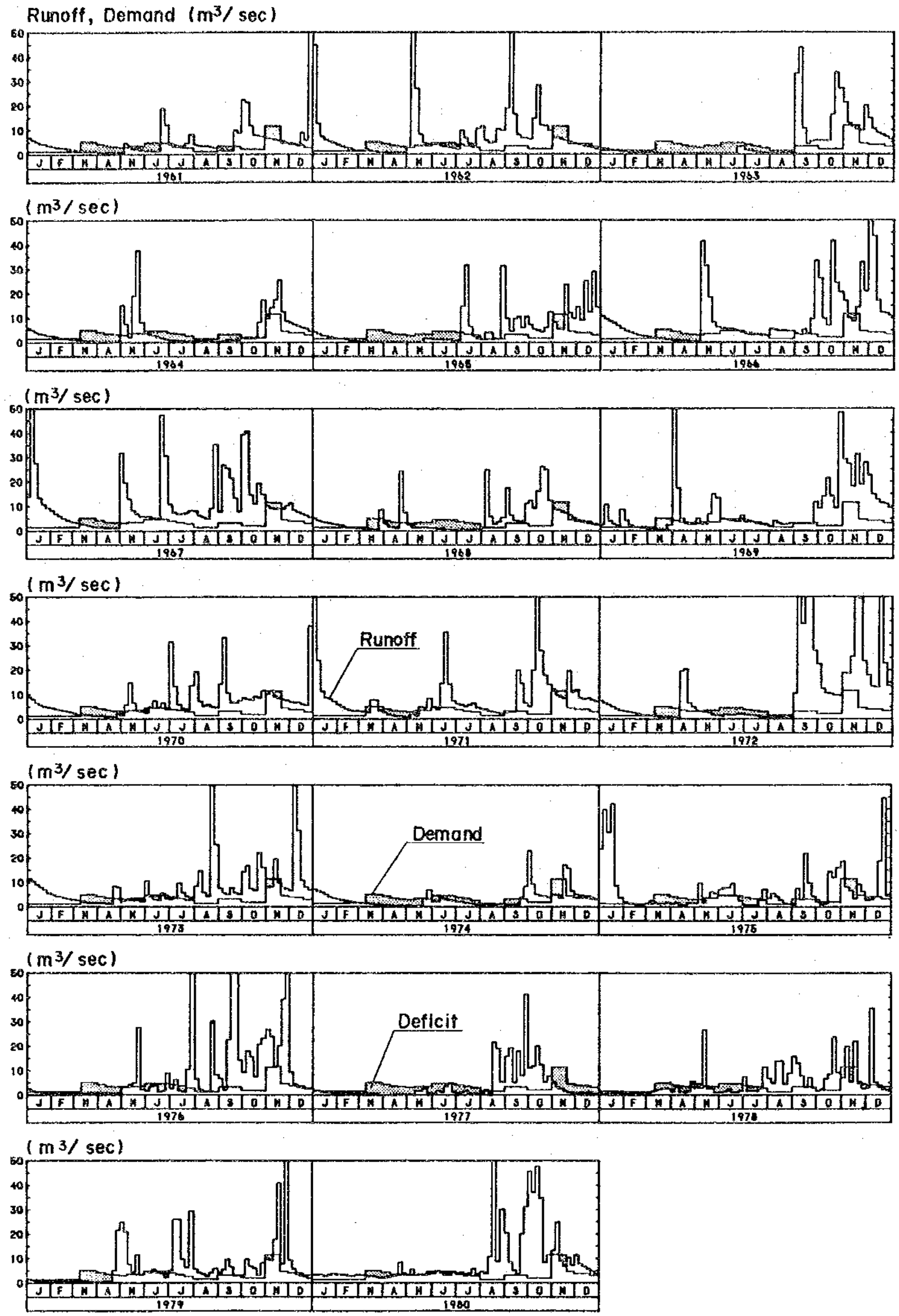

Fig. 6 Water Demand and Supply Balance of Perlis River System in 2000

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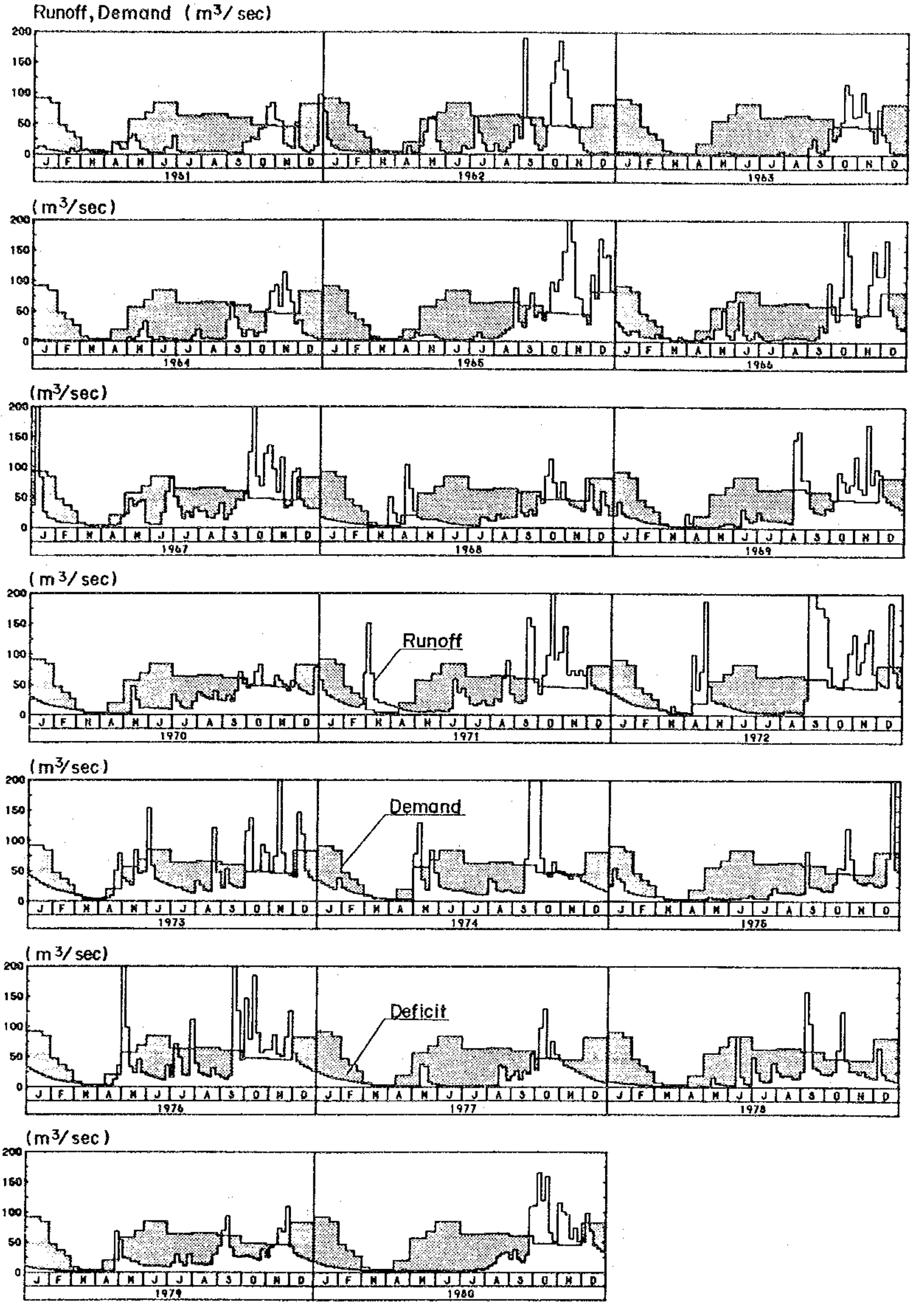

Fig. 7 Water Demand and Supply Balance of Kedah River System in 1982

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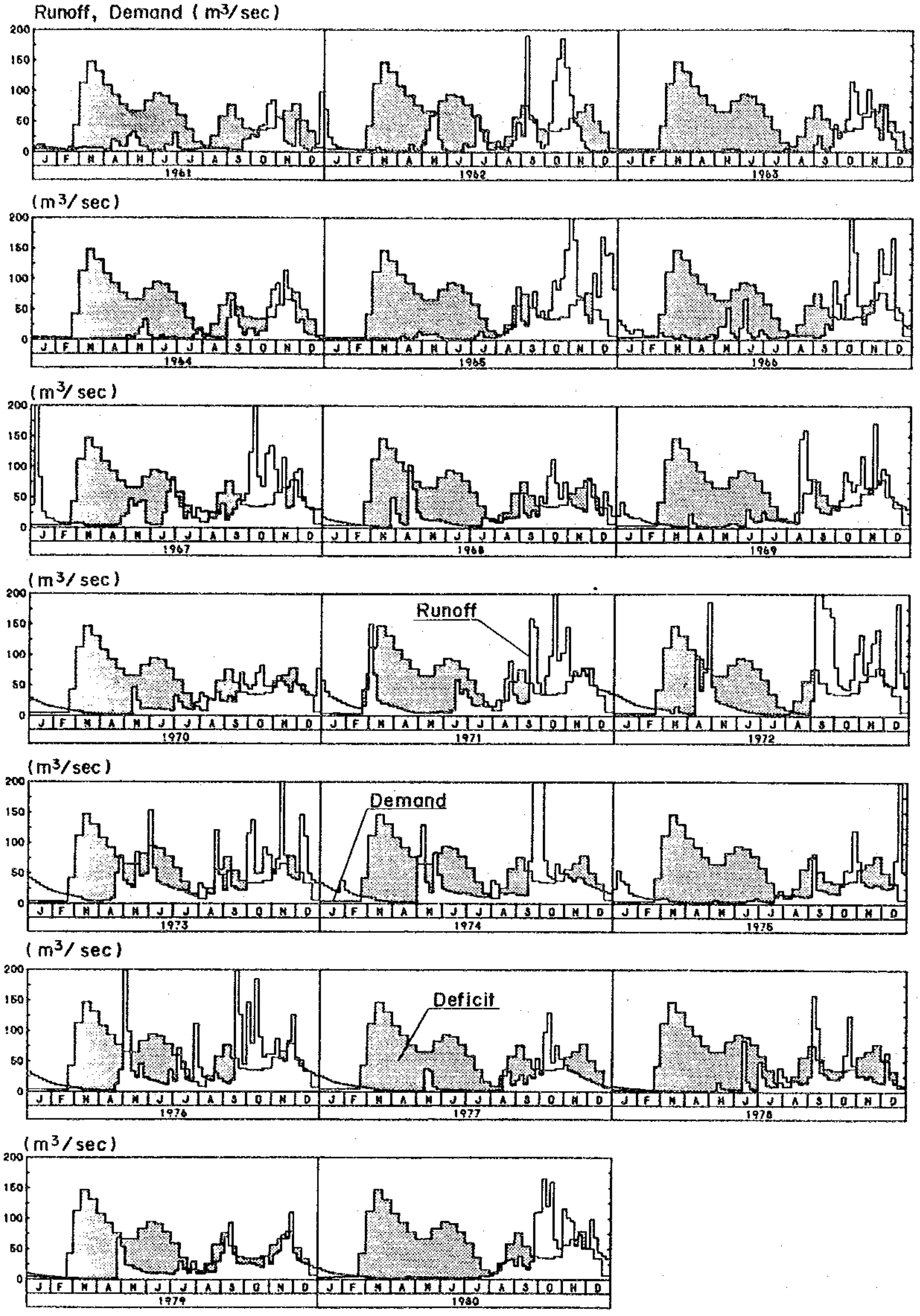

Fig. 8 Water Demand and Supply Balance of Kedah River System in 1990 in High Growth Case

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