JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF IRRIGATION AND DRAINAGE
MINISTRY OF AGRICULTURE
MALAYSIA

COMPREHENSIVE MANAGEMENT PLAN OF MUDA RIVER BASIN

VOLUME 3

SUPPORTING REPORT

(FINAL REPORT)

DECEMBER 1995

CTI ENGINEERING CO., LTD.
IN ASSOCIATION WITH
INA CORPORATION

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CONTENTS OF SUPPORTING REPORT

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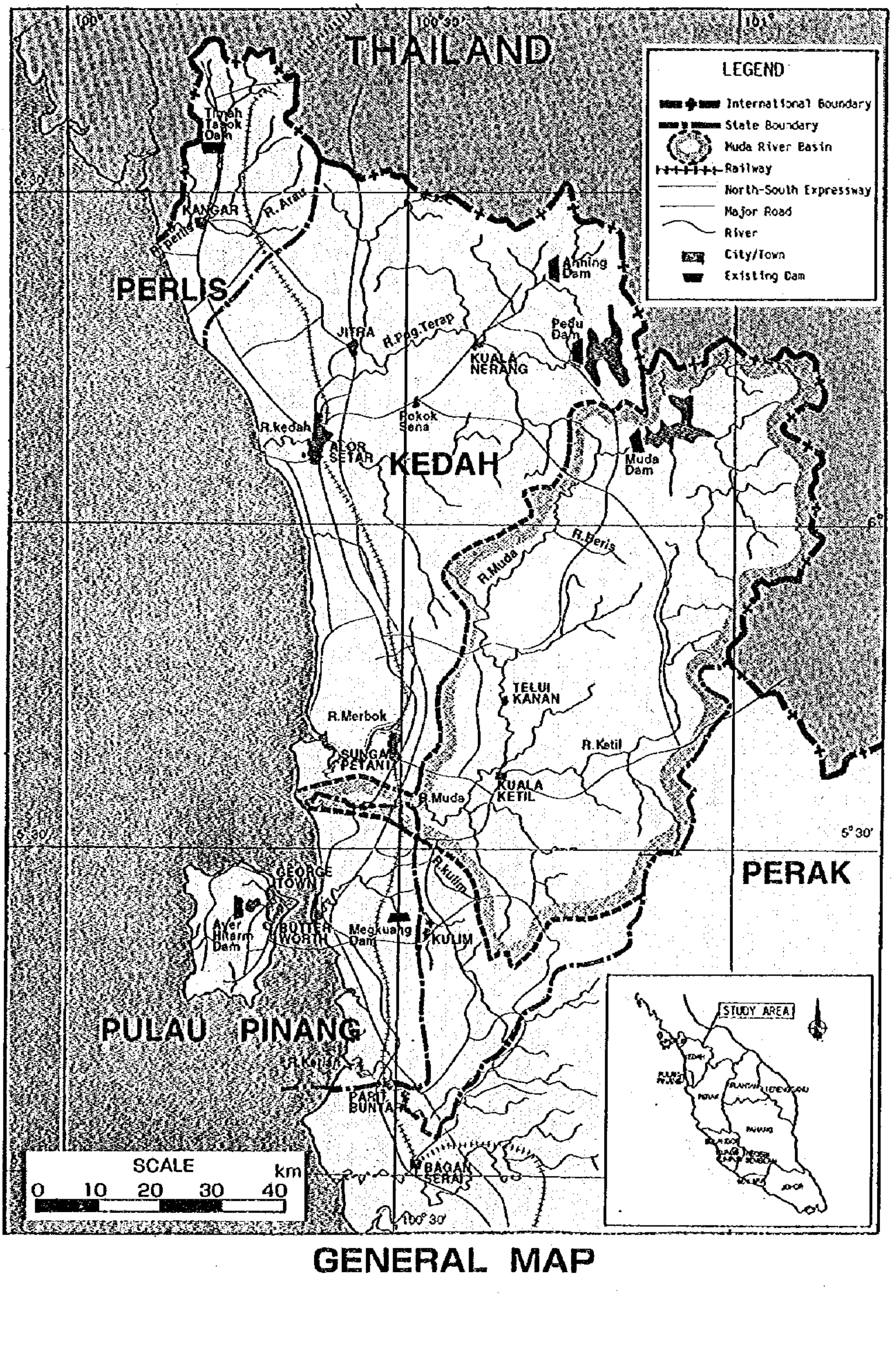
THAILAND
LEGEND
International Boundary
State Boundary
Muda River Basin
Railway
North-South Expressway
Major Road
River
City/Town
Existing Dam
PERLIS
KEDAH
PERAK
PULAU PINANG
KANGAR
JITRA
KUALA NERANG
ALOR SETAR
SUNGAI PETANI
KUALA KETIL
GEORGE TOWN
BUTTERWORTH
KULIM
PARIT BUNTAR
BAGAN SERAI
TELUI KANAN
Pokok Sena
Timah Tasoh Dam
Ahning Dam
Pedu Dam
Muda Dam
Megkuang Dam
Ayer Hitam Dam
R. Perlis
R. Arau
R. Kedah
R.Pdg.Terap
R.Muda
R.Beris
R.Merbok
R.Ketil
R.Kulim
R.Kerian
SCALE
km
0 10 20 30 40
STUDY AREA
100°
100°30'
101°
6°30'
6°
5°30'
GENERAL MAP

SECTOR I

HYDROLOGY

SECTOR I
HYDROLOGY

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1. OBJECTIVE RIVER BASINS AND CATCHMENT AREAS

This hydrological study covers low flow and flood runoff analyses. In the low flow analysis, the objective basins are Muda and Pdg. Terap river basins to generate natural runoff discharge from these basins. The results of this analysis are the basic data for the water resources management plan. On the other hand, in the flood runoff analysis the objective basin is solely Muda river basin to estimate flood runoff discharge from this basin. The results of this analysis are the basic data for the flood mitigation plan.

The catchment areas of these basins are essential in the analyses. Accordingly, the figures applied in the previous reports (Perlis-Kedah-Pulau Pinang Regional Water Resources Study, Feb. 1984, JICA, hereinafter referred to as PKP Study) were reviewed through the actual measurement on the topographic map with a scale of 1 to 50,000, and clarified as follows.

1.1 Catchment Areas of River Discharge Stations

PKP Study clarified the catchment areas of the existing river discharge stations. This present study justified and applied these catchment areas. This study also includes the discharge measurement at three (3) sites, Nami, Kg. Tiban and Pinang Tunggal. Table I.1.1.1 shows the catchment areas of these gauging stations.

1.2 Catchment Areas of Major Structures for Water Resource Development

In PKP Study the catchment area of Muda barrage was 4,054 km^2. This figure was revised to 4,201 km^2 based on the measurement in this present study. The present study justified and applied the catchment areas of the other structures indicated in PKP Study, as shown in Table I.1.2.1.

1.3 Catchment Areas of Entire Muda River Basin and Its Sub-Basins

Table I.1.3.1 shows the measured catchment areas of the entire Muda river basin and the divided sub-basins. In conclusion, the following two (2) revisions were made on the values estimated in PKP Study:

Particulars	PKP Study	This Study
Entire Muda River Basin	4,355 km^2	4,210 km^2
Entire Ketil River Basin	895 km^2	868 km^2

2. DISCHARGE MEASUREMENT

This study includes the discharge measurement at the three (3) sites (Nami, Kg. Tiban and Pinang Tunggal) to supplement the existing data and/or to verify their accuracy.

The installation of these staff gauges was completed in mid-May 1994, and since then the number of discharge measurement reached 38 to 40 times at each site until June 1995 (refer to Table I.2.1.1). The rating curves of these sites were prepared based on the measured data so as to clarify observed river discharge and to study river bed load (refer to Fig. I.2.1.1).

3. COLLECTED DATA

3.1 Meteorology

Meteorological data except for evaporation cover four (4) stations (Chuping, Alor Setar Airport, Butterworth Airport and Pinang International Airport), which are operated by MMS. The collected data consist of air temperature, relative humidity, wind rose summary, daily sunshine and so on. Table I.3.1.1 shows the inventory of these meteorological stations. On the other hand, evaporation data cover five (5) gauging stations which are operated by DID and MMS. Table I.3.1.2 indicates the inventory of the evaporation stations and Fig. I.3.1.1 shows the location of these stations.

3.2 Rainfall

The collected rainfall data are daily and hourly rainfall. The number of objective rainfall stations for the collection is 22, which are located in the states of Kedah and Pulau Pinang. DID operates these rainfall stations. Table I. 3.2.1 and Fig. I. 3.1.1 show the inventory and the location of these rainfall stations, respectively.

3.2.1 Daily Rainfall

The daily rainfall data comprise those of 21 rainfall stations which are located in and around the objective river basins of the low flow analysis. These stations are shown in Table I.3.2.1 excluding 5504035 Lahar Ikan Mati. The collected data are the basis for the clarification of the aerial and seasonal distribution of rainfall.

3.2.2 Hourly Rainfall

Collected hourly rainfall data cover the following five (5) rainfall stations, at which automatic recorders are installed. These stations are located in and around the aforementioned objective river basin of the flood runoff analysis. Table I.3.2.2 shows the collected storm data, which present 11 major storm patterns.

Station No.	Station Name
5504035	Lahar Ikan Mati, Kepala Batas, P. Pinang
5507076	Batu 27 Jln. Baling, Kedah
5806066	Jeniang Klinik, Kedah
5808001	Batu 61 Jln. Baling, Kedah
6108001	Komplek Rumah Muda, Kedah

3.3 River Discharge

The collected discharge data are observed daily average discharge and observed flood discharge. The number of discharge stations for collection is six (6), and they are operated by DID. Table I.3.3.1 shows the inventory of these stations, and Fig. I.3.1.1 shows the location of these stations.

3.3.1 Daily Discharge

The daily discharge data comprise those of the aforementioned six (6) stations, which are five (5) stations (Nami, Jeniang, Jam. Syed Omar, Ldg. Victoria and Kuala Pegang) along Muda River and one (1) station (Lengkuas) along Pdg. Terap River, as shown in Table I.3.3.1. These data are the basis for the low flow analysis.

3.3.2 Flood Discharge

As mentioned before, the objective river basin of the flood runoff analysis is solely Muda river basin. Consequently, collected flood discharge and water level data cover the following four (4) automatic recorder stations which are located along the Muda river system:

Station No.	Station Name
5806414	Jeniang
5505412	Ldg. Victoria
5606410	Jam. Syed Omar
5608418	Kuala Pegang

The collected flood discharge and water level data are instantaneous values with one hour interval. Table I.3.3.2 shows the dates of the collected discharge data, whose periods correspond to the collected hourly rainfall data.

3.4 Tide

There are two (2) tidal stations in the states of Perlis, Kedah and Pulau Pinang and these are the Pulau Langkawi and Pulau Pinang stations. Pulau Langkawi Station is located on the north of Langkawi Island and is about 110 km northwest of the Muda river mouth. On the other hand, Pulau Pinang Station is located on the northeast of Pinang Island and is about 20 km south of the Muda river mouth. Considering their locations, Pulau Pinang Station was chosen as the reference station of this study. This tidal station operates a magnetic tape tide gauge (float type). The description of this station is, as follows:

Station Name	Pulau Pinang
Locality	Kedah Pier
Latitude	05 25.3
Longitude	100 20.8
Date Established	Nov. 1984

The data collection from Pulau Pinang Station covers nine (9) years from 1985 to 1993. The collected data, observed tidal heights and levels, are referred to zero of tide gauge. The zero of tide gauge of this station is 5.331 m below Survey Department brass BM P0241 or 2.535 m below Land Survey Datum (LSD). Fig. I.3.1.1 shows the location of this station.

4. METEOROLOGY

4.1 Wind

The study area has two typical monsoons; namely, the northeast monsoon and southwest monsoon. The northeast monsoon usually occurs from November to February. During this monsoon, the northeasterly winds prevails The southwest monsoon reaches the west coast of Peninsular Malaysia from the Indian Ocean and prevails over Peninsular Malaysia from May to August causing the westerly and/or northwesterly winds. In the transition period between the two monsoons, from September to November, the western wind prevails and the equatorial trough tends to lie over Malaysia.

4.2 Rainfall

The northeast monsoon unloads its moisture contents over the east coast of Peninsular Malaysia. However, the study area located in the west coast receives a little rain during this monsoon due to the sheltering effect of the central mountain range running from north to south in Peninsular Malaysia. On the other hand, the southwest monsoon usually contains heavy moisture and causes the fairly heavy rainfall in the study area from April to May. In the transition period between the above two monsoons, from September to November, the western wind causes the heaviest rainfall in the study area in a year.

Thus, the study area tends to have two rainy seasons in a year; one is from April to May and another, from September to November (refer to Fig. I.4.2.1).

The annual rainfall depth in the Study Area is about 2,000 to 3,000 mm. The heavy annual rainfall is observed around the central mountain of Gunong Jerai and the southern mountainous areas declining northward and to the river mouth (refer to Fig. I.4.2.1).

4.3 Temperature

At Alor Setar and Pinang, the average values of daily temperature reach 27.1°C, while those at Butterworth and Chuping reach 27.3°C and 26.9°C, respectively. Over these stations, the annual variation is less than 2°C. In this area, March to April are the months with the highest average monthly temperature. On the other hand, September to December are the months with the lowest average monthly temperature at Pinang and Butterworth, while November to December are the ones at Alor Setar and Chuping (refer to Table I.4.3.1).

4.4 Relative Humidity

The minimum range of the mean monthly humidity is found in Butterworth where the mean relative humidity varies from a low of 74.6% in January to a high of 86.2% in October. The maximum range is found in Chuping where the mean relative humidity varies from a low of 74.1% in February to a high of 88.6% in October (refer to Table I.4.4.1).

4.5 Sunshine Hours

Alor Setar receives 7.3 hours per day of sunshine while Pinang and Chuping receive 6.9 hours on the average. On the extreme, Pinang receives a minimum of 5.4 hours per day on the average in September. On the other end of the scale, Alor Setar receives a maximum of 8.8 hours per day on the average in February (refer to Table I.4.5.1).

4.6 Evaporation

Alor Setar has an annual average evaporation of 1,635 mm (4.5 mm/day). On the extreme, Alor Setar has the lowest average evaporation rate of 3.6 mm/day in November, while Padang Katong has the highest one of 6.7 mm/day in February (refer to Table I.4.6.1).

5. LOW FLOW ANALYSIS

5.1 Simulation Model

5.1.1 Model Configuration

Among various runoff simulation models, selected was the Tank Model which was developed to generate long term discharge data from observed rainfall. In this model, a river basin is regarded as a series of four (4) tanks (refer to Fig. I.5.1.1). In the model, the outlets on the right hand side of each tank represent runoff holes, while the outlets at the bottoms represent infiltration holes.

Basin rainfall $R(t)$ is firstly reserved in the top tank, and runs off through the side holes or infiltrates through the bottom hole into the second upper tank. This process is repeated up to the last tank. Evapotranspiration loss $E(t)$ is subtracted from the water reserved in the top tank at first, and then from the water in the second upper tank. This subtraction process is repeated in the lower tanks until the whole depth of evapotranspiration loss is subtracted from the tanks.

The total of runoff discharge from the outlets of all tanks is the value of runoff depth from the river basin. Here, surface runoff is by the top tank, subsurface runoff by the second tank, and ground water runoff by the third and the fourth tanks.

5.1.2 Reference Points

The following five (5) river discharge stations were selected as the reference points of the low flow analysis from the viewpoint of discharge generation. Fig. I.5.1.2 shows the location of these reference points.

River Basin	Station Name	Station No.	Catchment Area (km^2)	Location
Muda	Nami	6007415	1,220	Upper Reach
Muda	Jeniang	5806414	1,740	Middle Reach
Muda	Ldg. Victoria	5505412	4,010	Lower Reach
Muda	Kuala Pegang	5608418	704	Ketil River
Pdg. Terap	Lengkuas	6204421	1,270	Lower Reach

5.1.3 Hydrological Year

The Tank Model starts and ends at the end of drought period in every year. This simulation cycle (hereinafter referred to as a hydrological year) aims at minimizing basin storage effects on the initial conditions of the Model. Accordingly, this study adopted this hydrological year instead of a calendar year. In this study, the hydrological year starts in April 1 and ends in March 31, which corresponds to the end of the northeast monsoon season.

5.2 Input Data

5.2.1 Natural Runoff Discharge

Natural runoff discharge is a value not affected by any water use in catchment area. The Tank Model analysis requires the data of such natural runoff discharge in order to calibrate the constant parameters of the model.

In Muda River except for its tributaries, Muda Dam significantly controlled the river discharge after its construction during 1966-1969. As to Pdg. Terap River, the construction period of Pedu Dam and Saiong Tunnel was also 1966-1969 and the construction of Pelubang Barrage terminated in 1969. Ahning Dam was completed in 1991. Moreover, there was not any dominant intake facility along these rivers before 1966. Therefore, in the lower reaches of these facilities, the record before 1966 could present the natural runoff discharge.

5.2.2 Basin Average Rainfall

The adopted method was the Thiessen Method in the estimation of daily basin average rainfall for the catchment area of each reference point. The rainfall records at 21 stations are the basis of this estimation. Regarding the missing data in the records, they were filled in through correlation and linear regression analyses. The period of this estimation is 33 years from 1959 to 1991. The daily basin average rainfall is the input data of the Model to generate the natural runoff discharge.

Fig. I.5.2.1 shows the Thiessen Polygon Network together with the location of the applied rainfall stations, and Table I.5.2.1 indicates the coefficients of Thiessen Polygon. Table I.5.2.2 and Fig. I.5.2.2 show the basin average rainfall on monthly basis. Based on the estimation results, the annual basin average rainfall of each reference point is, as follows:

Reference Point	Basin Average Rainfall (mm/year)
Nami	2,128
Jeniang	2,197
Ldg. Victoria	2,355
Kuala Pegang	2,266
Lengkuas	1,898

5.2.3 Basin Evapotranspiration Loss

(1) Annual Evapotranspiration Loss

The annual evapotranspiration loss is the difference between the basin average rainfall and the observed natural runoff discharge in each hydrological year (refer to Table I.5.2.3). As shown in this Table, the annual evapotranspiration losses are rather constant except for a few extraordinary years. These extraordinary years were judged to contain certain significant errors in the data.

Adopted values as the annual evapotranspiration losses are the averages of the annual values except for the extraordinary years, and the hydrological years other than the extraordinary years are the calibration period of the Model.

(2) Daily Evapotranspiration Loss

The annual evapotranspiration loss was distributed to each month according to the proportions of the observed evaporation. A daily loss was then assumed as a constant value by month. Based on the assumption, the monthly loss was divided by the number of days in the month and thus, converted into the daily loss.

The observed monthly evaporation data were obtained from the average of two (2) gauging stations, Alor Setar (Sta. No. 48603) and Komplek Rumah Muda (Sta. No. 6108301). Table I.5.2.4 shows the calculated daily evapotranspiration losses.

5.3 Model Calibration and Generation of Natural Runoff

The trial and error method was the way of the model calibration. Table I.5.3.1 shows the determined model parameters and Fig. I.5.3.1 indicates the observed and simulated hydrographs. Using the determined Tank Model, the natural runoff discharge was generated at five (5) reference points for 33 hydrological years from 1959 to 1991. Table I.5.3.2 shows the annual runoff and loss of the generated natural flow. Tables I.5.3.3 and I.5.3.4 show the monthly averages and the flow-duration table of the generated discharge, respectively.

6. FLOOD RUNOFF ANALYSIS

6.1 Rainfall Analysis

6.1.1 Reference Points and Basin Division

The flood runoff analysis aims at estimating the probable basin average rainfall and the probable runoff discharge for selected reference points in Muda river basin. In this study, the following five (5) reference points were selected:

Reference Point	Station No.	Catchment Area (km^2)	Remarks
Jeniang	5806414	1,740	Gauging Station
Jam. Syed Omar	5606410	3,330	Gauging Station
Ldg. Victoria	5505412	4,010	Gauging Station
Kuala Pegang	5608418	704	Gauging Station
Sik	---	153	Confluence of Chepir and Sik Rivers

The maximum number of divided sub-basins in the catchment areas of the reference points is 32. The basin division was made on the topographic map with a scale of 1 to 50,000, considering the locations of the river discharge stations, the major structures (dam and barrage) and confluence of tributaries. Fig. I.6.1.1 shows the location of the reference points and this basin division.

6.1.2 Rainfall Duration

The dominant rainfall duration was estimated through the actual 11 storms recorded at five (5) rainfall stations (refer to Table I.3.2.2). Based on the Thiessen coefficients shown in Table I.6.1.1, the hourly basin average rainfalls of these 11 storms were estimated for each reference point (refer to Fig. I.6.1.2). Using these hourly basin average rainfalls, the dominant rainfall duration was studied through rainfall mass curves (refer to Fig. I.6.1.3).

As shown in Fig. I.6.1.3, the rainfall duration at the reference points along Muda Main River (Jeniang, Jam. Syed Omar and Ldg. Victoria) varies from 20 to 70 hours approximately. On the other hand, it is less than 24 hours for the reference points along the tributaries of Muda River (Kuala Pegang and Sik). In due consideration of these figures and the flood conditions of Muda River, the rainfall duration for each reference point was determined, as follows:

Reference Point	Rainfall Duration
Jeniang	3-day
Jam. Syed Omar	3-day
Ldg. Victoria	3-day
Kuala Pegang	1-day
Sik	1-day

6.1.3 Probable Basin Rainfall

A series of the basin average annual maximum rainfall for the above 1-day and 3-day duration was estimated by the Thiessen Method for each reference point based on the daily rainfall records at 21 rainfall stations. These rainfall data were also used for the foregoing low flow analysis. The period of the series is 34 years from 1959 to 1992, as shown in Table I.6.1.2. Table I.6.1.3 and Fig. I.6.1.4 show the study results of the probable basin rainfall, which was estimated by Logarithmic Normal Distribution based on these series.

As shown in Table I.6.1.2, the 1988 flood caused the largest 3-day rainfall during 34 years along the Muda main stream. The 3-day rainfall amounted to 182.1 mm at Jeniang, 157.3 mm at Jam. Syed Omar and 145.3 mm at Ldg. Victoria, and these figures correspond to 30 to 50-year return period in recurrence probability. In the flood of 1988, however, the smallest rainfall occurred in the catchment area of Ketil River, 1-day rainfall of 80.5 mm at Kuala Pegang corresponding to a 10-year return period. Consequently, the 1988 flood was evaluated to have caused the heavier rainfall along the Muda main stream rather than Ketil River.

6.2 Configuration of Simulation Model

Applied model is the Storage Function Model to convert the basin rainfall into flood discharge. This Model includes the following two (2) components:

(a) Basin model to calculate flood runoff discharge generated from effective rainfall in sub-basins; and

(b) Channel model to calculate channel flow discharge from sub-basins.

The basin model includes 32 sub-basins in accordance with the basin division described in Subsection 6.1.1. To connect these sub-basins under "with Muda dam" condition, 20 river channels were assumed as the channel model. Fig. I.6.2.1 shows the configuration of the Model. The salient features of the model components are, as follows:

(1) Basin Model

The basic equations of the Basin Model consist of continuity equation and storage equation, as follows:

$$dS(t+Tl = f \cdot r(t) \cdot A / 3.6 - Q(t+Tl)$$
$$S(t+Tl = K \cdot Q(t+Tl)^{P}$$

where,

$S(t+Tl)$	:	Storage volume of basin at time $t+Tl$ [(m^3/s) hr]
f	:	Runoff ratio
$r(t)$	:	Average rainfall depth of basin at time t (mm/hr)
A	:	Basin area (km^2)
$Q(t+Tl)$	:	Runoff discharge at time $t+Tl$ (m^3/s)
Tl	:	Constant parameter of lag time (hr)
K, p	:	Constant parameters

(2) Channel Model

The basic equations of the Channel Model are continuity equation and storage equation, as follows:

$$dS(t+Tl)/dt = I(t) - Q(t+Tl+Tlz)$$
$$S(t+Tl) = K \cdot Q(t+Tl)^{P}$$

where,

$S(t+Tl)$	:	Storage volume of channel at time $t+Tl$ [(m^3/s) hr]
I	:	Inflow discharge to channel (m^3/s)
$Q(t)$	:	Outflow discharge from channel at time t (m^3/s)
Tl	:	Constant parameter of lag time (hr)
Tlz	:	Constant parameter of apparent lag time (hr)
Kp	:	Constant parameters

6.3 Model Calibration

The constant parameters in the above formulas were calibrated using the storm runoff hydrographs and the hourly rainfall recorded in the following dominant floods:

Station Name	Selected Floods
Jeniang	27/11/1985, 5/10/1986 and 19/11/1988
Jam. Syed Omar	27/11/1985 and 5/10/1986
Ldg. Victoria	27/11/1985, 5/10/1986 and 19/11/1988
Kuala Pegang	14/9/1983, 30/9/1985 and 20/11/1988

The calibrated parameters and the simulated hydrographs are as shown in Table I.6.3.1 and Fig. I.6.3.1.

6.4 Probable Flood Runoff Discharge

The probable flood runoff discharge of 5, 10, 20, 50 and 100-year return period was estimated on the basis of the calibrated parameters for the flood simulation model.

6.4.1 Enlargement of Actual Rainfall

Based on the probable basin rainfall with 1- or 3-day rainfall duration, the actual hourly rainfall recorded in the 11 major floods was enlarged in the following manner:

$$T^N = R^N / Ra$$

Where,

T^N	:	Adjustment rate for N-year return period
R^N	:	Probable basin rainfall of N-year return period for fixed rainfall duration
Ra	:	Recorded rainfall in actual flood
N	:	Return period (5,10,20,50 and 100-year)

The recorded hourly rainfall enlarged as described above was assumed as the model hyetograph of N-year return period for each of the 11 actual major floods. Table I.6.4.1 shows the adjustment rate for each return period and each actual flood.

6.4.2 Probable Flood Runoff Discharge

The flood discharge hydrographs corresponding to each return period were estimated by applying the above model hyetographs and the flood runoff simulation model. The peaks of the estimated flood discharge hydrographs were provisionally assumed as the probable discharge enlarged from 11 actual major floods. In this estimation, the basin base flow was assumed to correspond to 0.06 $m^3/s/km^2$ in due consideration of the discharge records. The results of this runoff calculation are shown in Table I.6.4.2.

The typical probable flood discharge was then assumed as the value to cover 70% of the above peak discharge enlarged from 11 actual major floods. On the premises of the coverage rate of 70%, the fourth largest enlarged peak discharge was finally selected as the typical probable discharge. In Figs. I.6.4.1 and I. 6.4.2, shown are the hydrographs and the distribution of the typical probable flood discharge estimated for each return period.

Fig. I.6.4.3 shows the relationship between the specific peak discharge (50-year return period) and the catchment area in the west coastal area of Peninsular Malaysia, including the results of this study. These data were extracted from the "Hydrological Procedure No. 4, Magnitude and Frequency of Floods in Peninsular Malaysia (Revised and Updated) 1987 , and the Flood Frequency Region FF2 in this reference was the objective region. Based on this figure, it was deemed that the results of this analysis are reasonable.

7. NATURAL FLOOD REGULATION EFFECTS BY MUDA AND BERIS DAMS

Muda Dam is solely a water supply purpose dam. Beris Dam is also proposed as the indispensable water source to cope with the future incremental water demand, and its whole storage capacity needs to be used for water resources development. Thus, both Muda and Beris dams are not to have specific flood control capacities, and the flood regulation effects of these dams were not taken into consideration for the aforesaid estimated probable flood runoff discharge.

However, natural flood regulation effects could be expected by the retention volumes of both dams. In this connection, the extents of such natural regulation effects were calculated. The condition and the results of the calculation are described below:

7.1 Condition of Calculation

The dam inflow discharge is naturally regulated by the surcharge volume above the spillway crest. The crest level of each spillway is, as follows:

Dam	Spillway Type	Crest Level
Muda	Overflow Ogee	El. 100.58
Beris	Overflow Ogee with Side Channel	El. 84.00

The dam water level will increase as the dam inflow discharge increases, and the water impounded by the dam starts to overflow when the water level exceeds the crest level of the spillway. The overflow discharge could be calculated by the dam inflow discharge together with its reservoir storage capacity curve and its spillway discharge rating curve. The dam inflow discharge was assumed as the probable flood discharge of 50-year return period and obtained from the simulation model. The data of the reservoir storage rating curves and the spillway discharge rating curves were obtained from the related government agencies as shown in Fig. I.7.1.1.

It is noted that Muda and Pedu dams are connected with Saiong Tunnel, through which impounded water in Muda Reservoir is diverting into Pedu Reservoir. This diverting discharge is minimal compared with the dam flood inflow discharge, and therefore, not counted in the calculation for dam outflow discharge.

7.2 Results of Calculation

The flood mitigation effects were calculated at the reference points in their lower reaches as shown in Tables I.7.2.1 and I.7.2.2. As shown in Table I.7.2.1, Muda Dam has a considerable catchment area of 984 km^2 and could possess a certain effect to reduce the flood peak discharge for all years in a range 50 to 500 m^3/s at Jeniang, 30 to 400 m^3/s at Jam. Syed Omar and 50 to 300 m^3/s at Ldg. Victoria. On the other hand, Beris Dam was evaluated to have a minimal effect to reduce the flood peak discharge in the downstream except for a few years due to its small dam catchment area (116 km^2). Thus it is concluded that the natural dam regulation effect by Muda

Dam needs to be incorporated in the probable flood runoff discharge at the downstream reference points, while that of Beris Dam be neglected.

In line with these results, the flood mitigation effects of Muda Dam were further calculated. In this calculation, the dam inflow discharge was assumed as the probable flood discharge of 5- to 100-year return period. Among the regulated probable flood discharge by Muda Dam individually simulated for 11 years, the typical value was herein assumed to be the fourth largest corresponding to 70% coverage, as shown in Table I.7.2.3. Fig. I.7.2.1 shows the flood mitigation effect of Muda Dam for 50-year return period, and Fig. I.7.2.2 shows the distribution of the regulated probable flood discharge.

8. FLOOD REGULATION EFFECTS OF POTENTIAL FLOOD CONTROL DAMS

The potential flood control dams were selected at the following four (4) sites. In this study, calculated were the regulation effects by the flood control capacities of these dams for the downstream reference points. The locations of these dams are shown in Fig. I.8.1.1.

Potential Dam	Catchment Area (km^2)	Possible Max. Dam Active Storage Capacity (10^6m^3)	River System
Tawar Muda	1,113	54	Muda Main
Charok Tebar	38	73	Charok Tebar, Chepir
Weng	37	28	Weng, Ketil
Legong	44	38	Legong, Ketil

The above possible maximum dam active storage capacity is defined from the topographic conditions at the dam site and referred to hereinafter as the topo-max. capacity. The topo-max. capacity was estimated on the basis of the previous study results as well as the actual examination on the topographic map with a scale of 1 to 50,000. The condition and the results of the calculation are described as below:

8.1 Condition of Calculation

In this study, it is assumed that the dam inflow discharge can be regulated by the flood control capacity, and the constant ratio of dam outflow discharge to the dam peak inflow discharge is released from the dam site into the downstream. The dam inflow discharge was estimated as the natural probable flood runoff discharge of 50-year return period, and the estimation was made in accordance with the methodology described in Section 6.4.

The ratio of the dam outflow discharge to the peak inflow discharge was determined through the trial calculation until its corresponding necessary flood control capacity be equivalent to the hydrological upper limit of dam active storage capacity. The hydrological upper limit of dam active storage capacity was herein assumed as 80%

of the above topo-max. capacity and referred to hereinafter as the actual max. capacity.

The minimum ratio was, however, limited to 20%. When the necessary flood control capacity for the ratio of 20% is still less than the actual max. capacity, the ratio of 20% was applied for dam regulated discharge.

It is further noted that Tawar Muda Dam is located just downstream from the existing Muda Dam, and its dam inflow discharge is already regulated by Muda Dam. Accordingly, the dam regulation effect by Tawar Muda Dam was counted as the differences from the regulated discharge by Muda Dam.

8.2 Results of Calculation

The results of calculation on the dam regulation effects for 11 actual major floods are compiled in Tables I.8.2.1 to I.8.2.4. As shown in Table I.8.2.1, the potential flood control dam at Tawar Muda could provide a certain regulation effect for the reference point at Jeniang located just downstream from the dam site, while its effect was nil for the reference points such as Jam. Syed Omar and Ldg. Victoria that are located far from the dam site. As for other potential dams, the dam catchment areas are extremely small and, therefore, a minimal effect was also estimated for all reference points located downstream from the dam sites.

When the design discharge (50-year return period) regulated by the potential dams was assumed as the value to cover 70% of those for 11 actual major floods, the dam regulation effects at the dam downstream points are summarized as below:

Flood Control Dam	Tawar Muda	Charok Tebar	Legong	Weng
Reference Point	Jeniang	Sik	Pulai	Pulai
Without Dam	680 m^3/s	126 m^3/s	479 m^3/s	479 m^3/s
With Dam	452 m^3/s	98 m^3/s	415 m^3/s	446 m^3/s
Reduction of Peak Discharge	228 m^3/s	28 m^3/s	64 m^3/s	33 m^3/s

9. TIDAL WATER LEVEL

Pulau Pinang Tidal Station is the reference station of this study. The data collected from this station are the observed tidal levels whose period is nine (9) years from 1985 to 1993. The average of Mean High Water Springs (MHWS) of the data is the design high water level at the downstream end of Muda River in the flood mitigation plan. The summary of the averaged tidal levels is, as follows (refer to Table I.9.1.1):

Tide Level	Reduced Level (LSD.m)
Extreme Low Water (ELW)	-1.53
Mean Low Water Springs (MLWS)	-0.93
Mean Low Water Neaps (MLWN)	-0.11
Mean Sea Level (MSL)	0.14
Mean High Water Neaps (MHWN)	0.40
Mean High Water Springs (MHWS)	1.10
Extreme High Water (EHW)	1.57

TABLES

SECTOR I

HYDROLOGY

TABLE I. 1.1.1 CATCHMENT AREAS OF RIVER DISCHARGE STATIONS

Station Number		Station Name	River Name	Catchment Area (km^2)
6007415	#	Nami	Muda	1,220
5806414		Jeniang	Muda	1,740
5606410		Jam. Syed Omar	Muda	3,330
5505412		Ldg. Victoria	Muda	4,010
	#	Pinang Tunggal	Muda	4,172
5608418		Kuala Pegang	Ketil, Muda	704
	#	Kg. Tiban	Ketil, Muda	825
6204421		Lengkuas	Pdg.Terap, Kedah	1,270

Note: Above catchment areas except for Kuala Pegang and Kg. Tiban include dam basins.
: Installed in this Study.

TABLE I. 1.2.1 CATCHMENT AREAS OF MAJOR WATER SOURCE FACILITIES

Facility Name	River Basin	Catchment Area (km^2)
[Existing Facilities]		
Muda Dam	Muda	984
Pedu Dam	Pedu, Pdg. Terap, Kedah	171
Ahning Dam	Ahning, Pdg. Terap, Kedah	120
Muda Barrage	Muda	4,201
Pelubang Barrage	Pdg. Terap, Kedah	1,247
[Planning Facilities]		
Beris Dam	Beris, Muda	116
Reman Dam	Reman, Muda	32.2
Naok Dam	Naok, Pendang, Kedah	15
Jenian Barrage	Muda	1,651

Note: Above barrage catchment areas include dam basins.

TABLE I. 1.3.1 SUB-BASIN AREAS OF MUDA RIVER

Sub-Basin Name	Area (km2)	Sub-Basin Name	Area (km2)	Sub-Basin Name	Area (km2)
MB1	236.0	DB1	365.1	KB1	147.6
MB2	96.7	DB2	275.5	KB2	162.0
MB3	211.8	DB3	269.8	KB3	79.1
MB4	89.0	DB4	73.6	KB4	86.7
MB5	63.8	(Muda Dam)	984.0	KB5	146.8
MB6	262.6			KB6	81.8
MB7	60.3			KB7	121.0
MB8	25.8	BB1	122.5	KB8	43.4
MB9	28.4	(Beris R.)	122.5	(Ketil R.)	868.4
MB10	162.0				
MB11	29.0	CB1	135.2	SB1	264.6
MB12	9.0	CB2	18.2	SB2	246.9
(Muda Main)	1274.4	CB3	57.3	(Sedim R.)	511.5
		CB4	22.0		
		CB5	68.4	RB1	114.3
		CB6	33.8	(Karangan R.)	114.3
		(Chepir R.)	334.9		
Total Basin Area :			4210.0	km2	

TABLE I. 2.1.1 RESULTS OF DISCHARGE MEASUREMENT

Station: Nami

Date	H(m)	Q(m3/s)
15/ 5/94	49 24	5.065
18/ 5/94	49.09	3 344
29/ 5/94	49.08	2.692
7/ 6/94	49.15	3.704
20/ 6/94	49.02	2.247
26/ 6/94	49.11	2.771
4/ 7/94	49.50	7.766
20/ 7/94	49.15	3 556
24/ 7/94	49.16	3.711
31/ 7/94	49.12	3.022
3/ 8/94	49.29	5.117
15/ 8/94	49.49	8.165
29/ 8/94	49.26	4.615
4/ 9/94	49.28	5.394
12/9/94	49.51	8.955
25/ 9/94	49.49	8.421
2/10/94	49.50	8.039
16/10/94	49.69	14.708
30/10/94	49.48	7.782
6/11/94	49.28	4.766
20/11/94	49.31	6 627
26/11/94	49 59	9.991
7/12/94	49.43	7.018
14/12/94	49.18	3.949
16/12/94	49.16	3.816
21/12/94	49.12	3.198
22/12/94	49.10	3.407
23/12/94	49.10	3.148
1/1/95	49.04	2.313
8/1/95	49.02	1.986
17/1/95	49.00	1.799
21/1/95	49.08	1.529
5/2/95	48.95	1.031
12/2/95	48.94	1.441
19/2/95	48.95	0.910
19/3/95	48.96	1.965
29/3/95	49.02	2.113
2/4/95	49.02	2.306
4/6/95	49.48	7.925
29/6/95	49.00	1.789

(Number=40)

Station: Kg. Tiban

Date	H(m)	Q(m3/s)
14/ 5/94	17.77	32.004
17/ 5/94	17.52	16.310
30/ 5/94	17.56	23.775
6/ 6/94	18.14	51.993
19/ 6/94	17.41	13.626
26/ 6/94	18 29	59.869
6/ 7/94	17.64	23.897
13/ 7/94	17.47	18.791
25/ 7/94	17.29	11.041
7/ 8/94	17.29	10.591
18/ 8/94	17.45	18 913
30/ 8/94	17.63	28.418
5/ 9/94	17.57	19.658
19/ 9/94	17.80	33.975
26/ 9/94	17.61	28.954
4/10/94	17.67	28.957
17/10/94	18.21	48.982
26/10/94	18.02	48.743
9/11/94	17.55	27.338
20/11/94	17.46	17.568
26/11/94	17.87	35.523
6/12/94	18.10	56.487
13/12/94	17.44	20.103
16/12/94	17.39	15.757
20/12/94	17.44	15.704
22/12/94	17.30	12.587
23/12/94	17.28	11.929
27/12/94	17.22	9.159
10/1/95	17.15	8.179
23/1/95	17.08	8 268
4/2/95	17.01	5.375
22/2/95	16 94	3.916
12/3/95	17.15	9.847
21/3/95	17.01	2.744
8/4/95	16.94	5.040
29/4/95	17.95	48.448
23/5/95	17.21	16.465
10/6/95	17.07	10.605
21/6/95	17.04	10.801

(Number=39)

Station: Pinang Tunggal

Date	H(m)	Q(m3/s)
14/ 5/94	2.06	115.470
17/ 5/94	1.99	105.478
30/ 5/94	1.91	67.014
6/ 6/94	1.81	50.365
19/ 6/94	1.65	46.605
26/ 6/94	2.08	124.094
2/ 7/94	2.13	145.265
13/ 7/94	1.87	68.062
25/ 7/94	1.85	38.744
7/ 8/94	1.93	39.140
18/ 8/94	2.06	84.612
30/ 8/94	1.91	37.399
10/9/94	1.85	55.660
19/ 9/94	2.38	188.780
26/ 9/94	1.95	58.343
4/10/94	2.24	147.984
17/10/94	2.39	169.342
22/10/94	3.05	356.696
26/10/94	2.31	200.680
9/11/94	2.00	129.111
20/11/94	1.92	57.652
26/11/94	2.05	133.097
5/12/94	2.37	179.083
13/12/94	1.91	74.435
16/12/94	1.99	57.300
20/12/94	1.87	50.650
22/12/94	1.84	43.770
23/12/94	1.83	38.653
27/12/94	1.79	41.444
18/1/95	1.63	14.426
25/1/95	1.63	16 230
18/2/95	1.67	24.422
26/2/95	1.60	14.652
8/3/95	1.69	26.139
26/3/95	1.89	36.455
9/4/95	1.56	22.969
17/4/95	1.98	53.810
27/6/95	1.72	55.089

(Number=38)

Note) H: Water level above M.S.L. (m).
Q: Discharge (m3/s).

TABLE I. 3.1.1 INVENTORY FOR METEOROLOGICAL STATIONS

Station Number	Station Name	Altitude (M.S.L. m)	State	Location Latitude	Location Longitude	Collected Data Period: Air Temp.	Relative Humidity	Daily Sunshine	Days with Thunderstorm
48604	Chuping	21.7	Perlis	06 29	100 16	1979 - 1993	1979 - 1993	1979 - 1993	1979 - 1993
48603	Alor Setar Airport	3.9	Kedah	06 12	100 24	1968 - 1993	1968 - 1993	1968 - 1993	1968 - 1993
48602	Butterworth Airport	2.8	P.Pinang	05 28	100 23	1985 - 1993	1985 - 1993	N.A.	1985 - 1993
48601	Pinag International Aairport	2.8	P.Pinang	05 18	100 16	1968 - 1993	1968 - 1993	1968 - 1993	1968 - 1993

Note) These stations are operated by MMS.

TABLE I. 3.1.2 INVENTORY FOR EVAPORATION STATIONS

Station Number	Station Name	Location Latitude	Location Longitude	State	Collected Data Period		No. of Years	Operation Authority
6401302	Padang Katong, Kangar	06 26 40	100 11 15	Perlis	1981 -	1990	10	DID
6108301	Komplek Rumah Muda	06 06 20	100 50 50	Kedah	1981 -	1990	10	DID
5903351	Pintu Kawalan P/S Kuala Sala	05 58 15	100 21 30	Kedah	1981 -	1990	10	DID
5504332	Rumah Pam Bombong Lima	05 33 25	100 26 10	Kedah	1966 -	1978	13	DID
48603	Alor Setar	06 12	100 24	Kedah	1974 -	1993	20	MMS

Note) Current instrumentation; Manual Station, American Class A Pan, Aluminium.

TABLE I. 3.2.1 INVENTORY FOR RAINFALL GAUGING STATIONS

Station Number	Station Name	State	Collected Data Period		No. of Years
5406083	Kelang Baharu, Kulim	Kedah	1959 -	1993	35
5407080	Ladang Dublin	Kedah	1959 -	1993	35
5505084	Ladang Henrietta	Kedah	1953 -	1993	41
5506082	Ladang Bukit Karangan	Kedah	1953 -	1993	41
5507076 #	Batu 27 Jln. Baling	Kedah	1963 -	1993	31
5606077	Ladang Lubok Segintah	Kedah	1959 -	1993	35
5608074	Pulai	Kedah	1959 -	1993	35
5609072	Hospital Baling	Kedah	1945 -	1993	49
5708071	Kg. Terabak	Kedah	1959 -	1993	35
5806065	Kg. Gajah Puteh	Kedah	1959 -	1993	35
5806066 #	Jeniang Klinik	Kedah	1953 -	1993	41
5807067	Sik	Kedah	1953 -	1993	41
5808001 #	Batu 61 Jln. Baling	Kedah	1974 -	1993	20
6106034 #	Naka	Kedah	1953 -	1993	41
6108001 #	Komplek Rumah Muda	Kedah	1975 -	1993	19
6204028	Ladang Tanjong Puah	Kedah	1953 -	1993	41
6205036	Kg. Paya	Kedah	1959 -	1990	32
6206035 #	Kuala Nerang	Kedah	1953 -	1993	41
6207032 #	Ampang Pedu	Kedah	1970 -	1993	24
6305029	Kg. Tengah	Kedah	1955 -	1993	39
6306031 #	Padang Sanai	Kedah	1953 -	1993	41
5504035 #	Lahar Ikan Mati, Kepala Batas	P.Pinang	1970 -	1993	24

Note) # : Stations with automatic recorders.

TABLE I. 3.2.2 COLLECTED HOURLY RAINFALL DATA (1/5)

BASIN NAME: JENIANG G.S.

	Rainfall Gauging Station				
Storm	6108001	5808001	5806066	5507076	5504035
25/11/1979	O	O	O	O	O
9/10/1980	O	O	O	O	O
12/11/1982	O	O	O	O	O
4/12/1983	O	O	O	O	O
14/ 7/1984	O	O	O	O	
27/11/1985	O	O	O	O	
5/10/1986	O	O	O	O	O
14/ 8/1987	O	O	O	O	O
19/11/1988	O	O	O	O	
19/ 9/1989	O	O	O	O	O
1/11/1990	O	O	O	O	O

TABLE I. 3.2.2 COLLECTED HOURLY RAINFALL DATA (2/5)

BASIN NAME: JAM. SYED OMAR G.S.

	Rainfall Gauging Station				
Storm	6108001	5808001	5806066	5507076	5504035
10/11/1979	O	O	O	O	O
9/10/1980	O	O	O	O	O
12/11/1982	O	O	O	O	O
4/12/1983	O	O	O	O	O
14/ 7/1984	O	O	O	O	
27/11/1985	O	O	O	O	
5/10/1986	O	O	O	O	O
14/ 8/1987	O	O	O	O	O
19/11/1988	O	O	O	O	
19/ 9/1989	O	O	O	O	O
19/10/1990	O	O	O	O	O

TABLE I. 3.2.2 COLLECTED HOURLY RAINFALL DATA (3/5)

BASIN NAME: LDG. VICTORIA G.S.

	Rainfall Gauging Station				
Storm	6108001	5808001	5806066	5507076	5504035
25/11/1979	O	O	O	O	O
4/10/1980	O	O	O	O	O
12/11/1982	O	O	O	O	O
15/ 9/1983	O	O	O	O	O
14/ 7/1984	O	O	O	O	
27/11/1985	O	O	O	O	
5/10/1986	O	O	O	O	O
14/ 8/1987	O	O	O	O	O
19/11/1988	O	O	O	O	
19/ 9/1989	O	O	O	O	O
31/10/1990	O	O	O	O	O

Note) These collected data (O) are indicated from the viewpoint of the entire Muda river basin.

TABLE I. 3.2.2 COLLECTED HOURLY RAINFALL DATA (4/5)

BASIN NAME: KUALA PEGANG G.S.

	Rainfall Gauging Station				
Storm	6108001	5808001	5806066	5507076	5504035
26/11/1979	O	O	O	O	O
14/10/1980	O	O	O	O	O
1/10/1982	O	O	O	O	O
14/ 9/1983	O	O	O	O	O
18/ 7/1984	O	O	O	O	
30/ 9/1985	O	O	O	O	
5/ 9/1986	O	O	O	O	O
27/10/1987	O	O	O	O	O
20/11/1988	O	O	O	O	
20/ 9/1989	O	O	O	O	O
1/11/1990	O	O	O	O	O

TABLE I. 3.2.2 COLLECTED HOURLY RAINFALL DATA (5/5)

BASIN NAME: SIK

	Rainfall Gauging Station				
Storm	6108001	5808001	5806066	5507076	5504035
15/11/1979	O	O	O	O	O
14/10/1980	O	O	O	O	O
2/10/1982	O	O	O	O	O
14/ 9/1983	O	O	O	O	O
18/ 7/1984	O	O	O	O	
28/10/1985	O	O	O	O	
5/ 9/1986	O	O	O	O	O
16/ 8/1987	O	O	O	O	O
13/11/1988	O	O	O	O	
20/ 9/1989	O	O	O	O	O
1/11/1990	O	O	O	O	O

Note) These collected data (O) are indicated from the viewpoint of the entire Muda river basin.

TABLE I. 3.3.1 INVENTORY FOR RIVER DISCHARGE STATIONS

Station Number	Station name	River Name	Catchment Area(km2)	Location Latitude	Location Longitude	State	Collected Data Period	No. of Years
5606410	Jam. Syed Omar	Muda	3330	05 36 35	100 37 35	Kedah	1975 - 1993	19
5608418	Kuala Pegang	Ketil, Muda	704	05 38 20	100 48 45	Kedah	1974 - 1993	20
5806414	Jeniang	Muda	1740	05 49 10	100 37 55	Kedah	1960 - 1993	34
6007415	Nami	Muda	1220	06 03 20	100 46 00	Kedah	1960 - 1973	14
6204421	Lengkuas	Pdg. Terap, Kedah	1270	06 12 45	100 27 15	Kedah	1961 - 1967	7
5505412	Ldg. Victoria	Muda	4010	05 31 55	100 34 20	P.Pinang	1960 - 1993	34

TABLE I. 3.3.2 COLLECTED FLOOD DISCHARGE DATA

Year	Discharge Gauging Station: Jeniang	J.S.Omar	Ldg.Victoria	Kuala Pegang
1979	25/11	10/11	25/11	26/11
1980	9/10	9/10	4/10	14/10
1983	4/12	4/12	16/ 9	14/ 9
1984	14/ 7	14/ 7	14/ 7	18/ 7
1985	27/11	27/11	27/11	30/ 9
1986	5/10	5/10	5/10	5/ 9
1988	19/11	19/11	19/11	20/11
1990	1/11	19/10	31/10	1/11

Note) Day/Month.

TABLE I. 4.3.1 24-HOUR MEAN TEMPERATURE

UNIT: °C

STATION NO.: 48603 STATION NAME: ALOR SETAR AIRPORT

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	26.3	27.5	28.3	27.6	27.6	27.8	27.1	27.2	26.7	27.0	26.2	26.0	27.1
1982	26.4	27.5	27.7	27.5	27.7	26.6	26.6	26.6	26.6	26.4	26.7	26.6	26.9
1983	27.1	28.0	28.5	28.8	28.0	27.9	27.1	27.0	26.5	26.8	26.5	26.0	27.4
1984	26.3	26.0	27.5	27.6	27.6	27.0	26.5	27.1	26.8	26.7	26.8	26.1	26.8
1985	26.9	27.2	27.3	27.9	27.6	27.3	26.5	27.0	26.4	26.3	26.2	26.4	26.9
1986	26.4	27.5	27.7	28.1	27.9	27.6	27.2	27.1	26.4	26.5	26.0	26.8	27.1
1987	27.0	27.8	28.3	28.9	27.5	28.0	27.5	26.8	26.9	27.2	26.7	26.5	27.4
1988	27.7	28.1	28.4	28.1	28.1	27.3	26.7	27.1	26.6	26.7	26.3	26.1	27.3
1989	27.3	27.4	27.5	27.6	27.7	27.1	27.2	26.7	26.5	26.4	27.1	27.1	27.1
1990	27.1	28.5	28.5	28.3	27.0	27.9	26.9	27.6	26.7	26.5	26.5	26.9	27.4
Ave.	26.9	27.6	28.0	28.0	27.7	27.5	26.9	27.0	26.6	26.7	26.5	26.5	27.1

STATION NO.: 48601 STATION NAME: PINANG INTERNATIONAL AIRPORT

YEAR	JAN	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	26.6	27.0	27.8	27.4	27.4	27.5	26.9	27.1	26.9	26.7	26.2	27.0	27.0
1982	27.5	27.7	27.6	27.3	27.5	27.6	26.6	26.7	26.5	26.3	26.5	27.1	27.1
1983	27.4	28.0	28.8	29.2	28.0	28.0	27.1	26.9	26.6	26.7	27.2	26.4	27.5
1984	26.3	26.2	26.9	27.1	27.4	27.2	26.5	26.9	26.5	26.4	26.8	26.4	26.7
1985	27.3	27.5	26.9	27.7	27.6	27.4	26.6	26.6	26.2	26.3	26.3	27.1	27.0
1986	26.9	27.5	27.4	27.7	27.7	27.5	27.3	27.4	26.0	26.1	26.3	27.1	27.1
1987	27.5	28.0	28.2	27.6	28.1	27.4	26.9	26.6	27.1	26.6	27.2	27.4	27.4
1988	27.8	27.7	28.0	28.0	28.0	27.4	27.1	26.9	26.0	26.7	26.3	26.1	27.2
1989	27.1	27.3	26.9	27.2	27.6	27.0	27.1	26.9	26.4	26.1	27.4	27.5	27.0
1990	27.1	28.2	28.1	28.0	27.5	28.0	26.9	27.4	26.5	26.7	26.7	27.2	27.4
Ave.	27.2	27.5	27.7	27.7	27.7	27.5	26.9	26.9	26.5	26.5	26.7	26.9	27.1

STATION NO.: 48602 STATION NAME: BUTTERWORTH AIRPORT

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1985	27.1	27.1	26.9	28.0	27.6	27.7	26.8	27.1	26.5	26.4	26.1	25.7	27.0
1986	26.8	27.7	27.6	27.8	28.0	27.9	27.7	27.7	26.2	26.3	26.2	26.9	27.2
1987	27.2	27.8	27.9	28.1	27.7	28.2	27.6	27.0	26.7	27.1	26.8	26.9	27.4
1988	27.7	27.7	28.0	28.0	28.2	27.8	27.3	27.2	26.7	27.1	26.9	26.6	27.4
1989	27.2	27.2	26.9	27.4	27.9	27.5	27.3	27.1	26.6	26.3	27.2	27.4	27.2
1990	27.1	28.1	28.1	28.2	27.6	28.3	27.2	27.6	26.7	26.6	26.7	27.0	27.4
Ave.	27.2	27.6	27.6	27.9	27.8	27.9	27.3	27.3	26.6	26.6	26.7	26.9	27.3

STATION NO.: 48604 STATION NAME: CHUPING

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	26.5	27.5	28.3	27.3	27.2	27.3	26.9	27.1	26.7	26.6	25.8	25.6	26.9
1982	26.5	27.8	28.0	27.2	27.2	27.1	26.1	26.4	26.3	26.0	26.2	26.1	26.7
1983	26.9	28.1	28.6	29.1	27.9	27.5	26.8	26.7	26.3	26.4	26.1	25.6	27.2
1984	26.1	26.5	27.2	27.2	27.4	26.5	26.1	26.9	26.2	26.2	26.4	25.9	26.6
1985	26.7	27.3	27.3	27.5	27.2	27.1	26.4	26.5	26.0	26.0	25.8	26.1	26.7
1986	26.1	27.4	27.9	27.9	27.4	27.2	27.1	27.1	26.1	26.1	25.7	26.4	26.9
1987	26.8	27.7	28.3	28.7	27.5	27.7	27.6	26.6	26.6	26.7	26.4	26.1	27.2
1988	27.4	28.0	28.2	27.9	27.6	26.9	26.5	26.8	26.2	26.3	25.9	25.8	27.0
1989	27.1	27.4	27.3	27.3	27.3	26.7	26.7	26.3	26.3	26.0	26.5	26.6	26.8
1990	26.8	28.2	28.3	28.0	27.1	27.5	26.7	27.3	26.3	26.4	26.1	26.3	27.1
Ave.	26.7	27.6	27.9	27.8	27.4	27.2	26.7	26.8	26.3	26.3	26.1	26.1	26.9

Source) Malaysian Meteorological Service (MMS).

TABLE I. 4.4.1 24-HOUR MEAN RELATIVE HUMIDITY

UNIT: %

STATION NO.: 48603 STATION NAME: ALOR SETAR AIRPORT

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	75.3	78.3	73.2	84.5	86.1	84.1	86.5	86.2	86.4	85.5	86.9	78.5	82.5
1982	71.8	73.5	77.5	84.1	85.6	84.9	87.1	87.8	87.9	87.1	85.6	80.5	82.8
1983	73.9	75.0	76.7	79.6	86.2	87.0	88.2	88.1	88.1	87.4	84.7	81.7	83.1
1984	77.3	76.8	79.4	85.0	86.7	86.2	87.5	85.7	84.2	85.0	82.4	82.9	83.3
1985	71.3	80.9	80.6	82.6	85.1	85.3	85.4	85.1	87.0	87.7	87.7	80.4	83.3
1986	75.3	70.6	75.7	81.1	85.0	84.9	85.2	85.3	86.6	87.1	87.3	76.8	81.7
1987	70.5	67.3	75.1	75.7	84.9	85.9	85.2	86.6	87.0	86.6	87.7	81.6	81.2
1988	71.8	74.6	77.9	83.0	84.5	85.6	86.8	84.8	86.8	86.4	86.1	76.4	82.1
1989	73.1	67.4	76.4	84.3	85.0	85.1	85.5	85.4	86.5	86.2	80.7	72.7	80.9
1990	71.7	69.1	70.8	80.3	85.7	84.7	85.2	82.6	85.9	87.4	86.1	75.7	80.4
Ave.	73.2	73.2	76.3	82.0	85.5	85.4	86.3	85.8	86.6	86.8	85.5	78.7	82.1

STATION NO.: 48601 STATION NAME: PINANG INTERNATIONAL AIRPORT

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	76.0	82.4	81.3	87.5	87.6	85.3	85.3	85.5	86.6	87.5	86.7	74.6	83.9
1982	68.7	77.3	82.9	87.2	88.0	85.7	87.1	87.4	87.6	88.3	88.4	80.2	84.1
1983	76.1	81.0	80.4	81.1	87.7	87.3	87.9	88.8	87.4	87.3	81.2	82.2	84.0
1984	81.4	85.8	85.4	87.7	86.0	85.8	88.0	87.0	86.2	87.6	85.4	83.7	85.7
1985	74.1	82.8	86.1	85.1	85.8	81.2	84.3	86.6	88.0	88.1	88.2	79.1	84.1
1986	75.8	74.4	80.7	85.3	85.0	84.4	83.1	83.5	89.6	89.5	85.6	77.3	82.9
1987	71.8	71.3	80.8	83.8	86.8	85.8	85.3	87.8	89.1	88.5	88.8	80.1	83.3
1988	76.6	82.4	83.5	84.8	83.9	84.5	84.2	85.2	85.7	83.4	80.8	72.7	82.3
1989	77.6	72.7	81.8	84.5	83.9	83.7	83.1	83.4	85.6	87.1	78.3	71.9	81.1
1990	74.3	74.7	78.1	82.8	84.9	81.7	83.1	81.9	85.5	86.7	84.6	75.3	81.1
Ave.	75.2	78.5	82.1	85.0	86.0	84.5	84.9	85.7	87.1	87.4	84.8	77.7	83.2

STATION NO.: 48602 STATION NAME: BUTTERWORTH AIRPORT

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1985	72.5	83.0	83.4	81.6	83.8	79.2	81.8	82.6	84.9	85.8	86.9	79.4	82.1
1986	74.8	71.6	77.6	82.6	82.2	81.4	79.9	81.2	86.7	87.2	85.1	77.4	80.6
1987	71.7	70.8	78.3	81.8	84.4	83.4	82.5	84.6	86.9	86.6	86.9	81.1	81.6
1988	75.5	80.7	81.5	84.3	83.5	83.0	83.5	84.2	86.7	84.2	83.2	75.2	82.1
1989	78.1	73.5	82.1	84.7	83.0	82.8	83.0	83.1	84.7	87.1	80.3	73.7	81.3
1990	75.2	76.1	78.3	81.8	85.0	81.2	82.7	81.3	84.4	86.3	84.7	76.1	81.1
Ave.	74.6	76.0	80.2	82.8	83.7	81.8	82.2	82.8	85.7	86.2	84.5	77.2	81.5

STATION NO.: 48604 STATION NAME: CHUPING

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	75.0	76.1	74.3	85.9	87.7	86.2	85.3	84.2	85.7	85.9	88.4	81.9	83.1
1982	73.6	73.4	75.1	85.9	88.3	87.7	89.9	89.5	89.2	90.1	88.5	85.0	84.7
1983	77.4	73.7	76.9	76.3	86.4	87.1	87.5	88.6	89.1	88.9	86.2	85.0	83.6
1984	79.3	78.8	80.0	85.0	85.2	88.6	88.4	85.7	86.9	87.8	85.1	84.2	84.6
1985	74.3	80.7	81.2	84.4	87.1	84.8	85.7	87.0	88.3	88.7	89.4	82.9	84.5
1986	77.7	70.9	74.9	81.9	86.5	85.9	84.7	85.7	88.8	89.4	88.8	80.0	82.9
1987	73.8	68.6	75.8	78.4	86.0	88.0	82.9	87.6	89.3	89.1	89.6	84.7	82.7
1988	76.3	77.0	79.0	84.6	87.7	87.3	87.4	88.8	89.7	88.9	87.8	78.3	84.2
1989	76.3	69.2	78.7	88.1	86.5	85.3	86.6	87.7	88.3	89.7	83.6	77.1	82.9
1990	74.8	72.3	73.9	81.1	87.4	85.0	84.8	82.0	86.1	87.1	86.3	79.5	81.7
Ave.	75.9	74.1	77.0	83.0	86.9	86.4	86.3	86.5	88.1	88.6	87.4	81.9	83.5

Source) Malaysian Meteorological Service (MMS).

TABLB I. 4.5.1 MEAN DAILY SUNSHINE HOURS

UNIT: hr

STATION NO.: 48603 STATION NAME: ALOR SETAR AIRPORT

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	8.8	8.6	9.7	7.6	7.0	7.9	7.3	8.3	6.1	6.7	4.8	6.9	7.5
1982	9.9	9.3	8.7	8.4	7.7	6.8	6.5	5.8	5.6	6.7	6.9	6.3	7.4
1983	9.1	9.4	8.8	8.9	7.0	6.5	6.6	5.6	5.7	5.9	6.9	5.3	7.1
1984	7.0	5.4	7.5	7.9	7.1	6.6	6.2	6.7	6.5	6.4	6.6	5.1	6.6
1985	9.5	7.5	7.4	7.7	7.2	7.6	7.6	7.0	5.5	5.7	5.8	7.4	7.2
1986	6.8	10.0	8.5	9.1	7.3	7.7	7.5	6.8	5.5	6.0	5.6	8.3	7.4
1987	8.7	10.6	8.2	8.8	7.0	6.9	8.7	6.4	5.7	7.0	5.4	6.4	7.5
1988	9.3	8.9	8.3	9.0	6.9	6.7	6.1	7.4	4.9	5.2	5.2	7.9	7.2
1989	8.7	9.5	8.4	7.5	7.1	7.7	7.4	6.6	6.3	4.7	7.9	9.0	7.6
1990	8.5	9.2	9.2	8.7	7.2	7.4	7.0	7.5	5.3	6.7	6.5	8.1	7.6
Ave.	8.6	8.8	8.5	8.4	7.2	7.2	7.1	6.8	5.7	6.1	6.2	7.1	7.3

STATION NO.: 48601 STATION NAME: PINANG INTERNATIONAL AIRPORT

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	8.1	7.8	8.8	7.1	6.8	7.8	6.9	7.9	5.9	6.3	4.6	7.7	7.1
1982	9.8	8.8	7.3	6.6	6.9	6.5	6.7	6.1	5.3	6.7	6.9	6.9	7.0
1983	8.4	9.1	8.7	7.9	5.9	6.8	6.1	5.7	5.9	5.8	7.3	5.4	6.9
1984	5.9	5.2	7.3	6.8	6.6	7.1	6.8	6.0	6.0	4.9	7.1	5.6	6.3
1985	9.2	8.0	6.8	7.0	6.5	8.1	6.7	5.9	5.0	5.7	6.1	8.0	6.9
1986	6.3	9.5	7.6	6.9	6.8	7.3	7.5	7.0	4.7	5.1	5.4	7.0	6.8
1987	8.1	10.4	7.8	7.7	6.3	7.0	8.1	4.9	4.7	6.2	4.9	6.6	6.9
1988	8.2	8.2	7.8	7.9	6.3	6.8	6.9	7.1	5.2	5.5	5.4	7.5	6.9
1989	8.0	8.7	7.0	7.3	6.9	7.7	6.9	6.3	6.6	4.2	8.2	8.5	7.2
1990	7.7	9.0	9.1	8.1	6.3	7.3	6.6	7.2	4.9	6.4	6.3	8.2	7.3
Ave.	6.2	8.5	7.8	7.3	6.5	6.5	6.9	6.4	5.4	5.7	6.2	7.1	6.9

STATION NO.: 48604 STATION NAME: CHUPING

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	8.6	8.5	8.8	6.6	6.5	6.7	7.5	8.2	5.9	6.4	4.5	6.6	7.1
1982	9.4	8.9	8.3	6.8	6.9	6.1	5.9	5.4	5.5	6.2	5.8	6.2	6.8
1983	8.9	9.0	8.3	8.6	6.7	5.9	6.0	5.3	5.4	5.6	6.2	5.2	6.8
1984	7.0	5.5	7.5	7.6	7.3	5.3	5.9	7.1	6.0	5.7	6.3	5.0	6.4
1985	9.1	7.5	7.1	7.1	6.6	6.9	7.7	6.9	5.5	5.1	5.3	7.1	6.8
1986	6.6	9.7	8.1	8.2	6.1	7.1	7.2	6.5	5.4	5.9	4.9	8.2	7.0
1987	8.6	10.3	7.9	8.2	7.0	6.4	8.0	6.3	5.3	6.4	5.2	6.4	7.2
1988	9.3	8.7	7.6	8.4	5.9	6.3	6.7	7.4	4.7	5.0	4.9	8.0	6.9
1989	8.7	9.2	8.2	7.1	6.4	7.4	7.3	6.1	6.5	4.8	7.2	9.2	7.3
1990	8.3	8.9	9.1	8.1	6.7	6.7	7.0	7.3	4.9	6.4	6.0	7.7	7.3
Ave.	8.5	8.6	8.1	7.7	6.6	6.5	6.9	6.7	5.5	5.8	5.6	7.0	6.9

Source) Malaysian Meteorological Service (MMS).

TABLE I. 4.6.1 MONTHLY PAN EVAPORATION

UNIT: mm

STATION NO. 6401302 STATION NAME: PADANG KATONG, KANGAR, PERLIS

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	171.8	164.4	182.7	153.9	161.7	141.7	134.5	148.9	134.4	146.9	133.4	156.1	1835.4
1982	196.1	184.7	204.8	157.2	160.5	160.9	169.9	134.2	123.4	155.2	140.7	134.4	1922.0
1983	180.5	181.3	212.5	190.3	165.4	146.6	163.7	157.6	132.1	145.0	138.5	142.4	1955.9
1984	160.7	158.1	177.2	161.4	161.1	136.4	142.0	157.9	155.6	140.0	160.3	145.4	1856.1
1985	185.5	150.8	169.5	154.7	158.7	150.7	163.1	153.3	137.6	142.5	117.9	128.7	1813.0
1986	171.4	206.1	210.1	168.3	143.1	162.2	165.6	171.1	151.8	136.9	118.4	162.0	1997.0
1987	168.9	241.1	232.4	217.5	164.2	156.2	173.0	149.2	143.7	161.1	129.2	143.8	2100.3
1988	202.9	187.2	209.0	178.8	150.0	148.4	150.2	147.9	137.2	132.6	150.7	185.0	1979.9
1989	197.0	209.5	200.2	171.5	164.9	148.1	150.6	147.3	164.4	122.7	137.3	194.0	2007.5
1990	190.0	194.0	227.9	172.0	155.5	152.5	159.0	164.4	133.4	142.2	130.8	143.5	1965.2
Ave.	184.5	187.7	202.6	175.1	158.5	150.4	157.2	153.2	141.4	142.5	135.7	153.5	1942.2
(Daily)	6.0	6.7	6.5	5.8	5.1	5.0	5.1	4.9	4.7	4.6	4.5	5.0	5.3

Source) "Hydrological Data, Rainfall and Evaporation Records for Malaysia 1981-1985 and 1986-1990", Drainage Irrigation Division, Ministry of Agriculture Malaysia.

STATION NO. 6108301 STATION NAME: KOMPLEK RUMAH MUDA, KEDAH

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	166.1	158.1	207.1	129.3	112.5	120.1	120.9	136.7	108.2	117.0	87.0	135.2	1598.2
1982	176.7	165.7	176.1	144.6	131.0	117.4	119.3	122.8	126.2	115.5	109.8	99.0	1604.1
1983	159.9	171.3	190.7	157.2	142.3	129.8	124.7	131.6	127.9	126.9	123.6	132.8	1718.7
1984	138.7	118.1	170.1	155.1	143.1	143.0	138.4	146.7	136.6	134.9	134.3	114.8	1673.8
1985	191.5	155.8	158.3	169.3	155.1	144.6	161.6	151.4	130.9	135.5	131.4	142.6	1828.0
1986	145.8	197.1	205.8	180.9	157.2	148.9	153.0	142.4	124.6	133.8	124.2	154.8	1868.5
1987	180.0	213.1	184.9	194.0	171.2	145.2	165.4	150.3	141.5	155.1	125.9	134.5	1961.1
1988	176.3	184.4	212.9	186.0	146.1	126.2	133.3	148.1	122.9	119.6	128.0	163.0	1846.8
1989	166.9	194.6	200.5	160.3	145.5	135.3	137.8	138.7	161.7	117.2	140.4	173.7	1872.6
1990	188.7	193.4	220.9	174.8	143.2	131.8	141.8	153.8	134.4	151.4	127.3	139.4	1900.9
Ave.	169.1	175.2	192.7	165.2	144.7	134.2	139.6	142.3	131.5	130.7	123.2	133.0	1787.3
(Daily)	5.5	6.2	6.2	5.5	4.7	4.5	4.5	4.6	4.4	4.2	4.1	4.5	4.9

Source) "Hydrological Data, Rainfall and Evaporation Records for Malaysia 1981-1985 and 1986-1990", Drainage Irrigation Division, Ministry of Agriculture Malaysia.

STATION NO. 5303351 STATION NAME: PINTU KAWALAN P/S KUALA SALA, KEDAH

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	196.9	161.7	221.6	165.3	163.5	147.9	150.5	161.9	153.2	159.7	137.7	166.1	1986.0
1982	211.9	178.4	205.8	197.7	157.0	155.7	167.9	165.3	169.6	168.6	144.3	161.3	2083.5
1983	171.7	170.3	191.0	177.3	163.8	147.3	150.6	149.5	155.8	149.8	132.8	146.2	1906.1
1984	152.9	143.1	166.1	157.6	151.4	139.3	145.5	155.0	139.0	139.8	159.3	157.6	1806.6
1985	185.5	161.6	169.0	155.4	159.9	160.9	168.2	160.3	148.6	150.6	136.5	155.7	1912.2
1986	157.4	184.2	189.0	162.4	163.2	166.6	156.7	156.8	148.4	143.2	144.3	179.9	1952.1
1987	202.8	213.9	192.5	199.6	169.6	155.4	172.8	156.1	154.0	154.3	128.4	148.3	2047.7
1988	180.7	171.4	184.5	169.6	150.9	141.0	146.4	163.1	152.0	146.4	140.8	156.7	1903.8
1989	180.9	181.2	192.2	163.2	170.5	155.3	153.5	151.3	148.8	151.8	139.4	165.1	1953.2
1990	153.9	170.6	194.3	162.6	153.6	153.0	154.6	156.7	137.9	142.6	137.7	141.9	1859.4
Ave.	179.5	173.6	190.6	171.1	160.3	152.2	156.7	157.6	150.7	150.7	140.1	157.9	1941.1
(Daily)	5.8	6.2	6.1	5.7	5.2	5.1	5.1	5.1	5.0	4.9	4.7	5.1	5.3

Source) "Hydrological Data, Rainfall and Evaporation Records for Malaysia 1981-1985 and 1986-1990", Drainage Irrigation Division, Ministry of Agriculture Malaysia.

STATION NO. 48603 STATION NAME: ALOR SETAR, KEDAH

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1981	158.1	154.0	182.9	129.0	108.5	105.0	111.6	114.7	102.0	117.8	93.0	136.4	1513.0
1982	179.8	176.4	189.1	150.0	139.5	126.0	124.0	120.9	117.0	130.2	111.0	130.2	1694.1
1983	189.1	154.0	189.1	165.0	127.1	111.0	117.8	114.7	111.0	105.4	117.0	130.2	1631.4
1984	155.0	142.1	161.2	138.0	117.8	96.0	99.2	117.8	114.0	120.9	117.0	117.8	1496.8
1985	170.5	126.0	139.5	144.0	127.1	114.0	120.9	130.2	120.0	114.7	105.0	114.7	1526.6
1986	148.8	190.4	201.5	159.0	136.4	123.0	127.1	127.1	105.0	114.7	90.0	155.0	1678.0
1987	189.1	212.8	186.0	183.0	130.2	117.0	130.2	114.7	108.0	124.0	87.0	117.8	1699.8
1988	186.0	162.4	170.5	153.0	114.7	114.0	114.7	130.2	114.0	108.5	108.0	170.5	1646.5
1989	189.1	196.0	164.3	135.0	127.1	114.0	114.7	111.6	126.0	114.7	141.0	173.6	1707.1
1990	186.0	204.4	226.3	165.0	120.9	108.0	111.6	133.3	99.0	133.3	120.0	151.9	1759.7
Ave.	175.2	171.9	181.0	152.1	124.9	112.8	117.2	121.5	111.6	118.4	108.9	139.8	1635.3
(Daily)	5.7	6.1	5.8	5.1	4.0	3.8	3.8	3.9	3.7	3.8	3.6	4.5	4.5

Source) Malaysian Meteorological Service.

TABLE I. 5.2.1 COEFFICIENTS OF THIESSEN'S POLYGON FOR LOW FLOW ANALYSIS

Rainfall Station	River Discharge Station Nami	Jeniang	L.Victoria	K.Pegang	Lengkuas
5406083			0.026		
5407080			0.079	0.015	
5505084			0.003		
5506082			0.028		
5507076			0.076		
5606077			0.048		
5608074			0.074	0.380	
5609072			0.022	0.124	
5708071			0.049	0.249	
5806065		0.163	0.071		
5806066		0.014	0.044		
5807067		0.019	0.076	0.002	
5808001	0.262	0.222	0.151	0.230	
6106034	0.007	0.045	0.020		0.138
6108001	0.715	0.526	0.228		0.020
6204028					0.023
6205036					0.080
6206035					0.113
6207032	0.016	0.011	0.005		0.204
6305029					0.136
6306031					0.286
Total	1.000	1.000	1.000	1.000	1.000

Note : Above coefficients are computed in the condition of inclusion of dam basins.

TABLE I. 5.2.2 MONTHLY BASIN AVERAGE RAINFALL (1/5)

Basin Name: Nami Gauging Station

Hydrological	Monthly Total (mm/month)												
Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
1959	163.4	430.7	265.3	148.0	274.8	152.8	357.2	264.6	83.1	51.2	41.6	72.8	2305.5
1960	387.0	216.1	194.5	243.1	215.4	434.8	234.9	323.5	58.2	82.3	137.6	173.1	2700.5
1961	259.0	153.0	228.8	124.6	119.2	144.3	297.1	197.1	158.6	73.8	52.6	149.0	1957.1
1962	198.9	188.3	204.1	235.0	227.2	193.6	383.3	127.8	91.2	78.1	41.2	123.7	2092.4
1963	89.0	280.4	179.0	197.9	123.0	286.7	295.2	319.7	101.7	43.9	50.1	139.6	2112.2
1964	72.6	351.5	165.5	204.2	172.9	310.6	236.7	262.8	84.9	0.0	72.7	195.4	2129.8
1965	184.4	156.5	164.3	190.3	173.0	245.8	450.4	187.3	333.8	73.6	83.6	94.1	2323.1
1966	195.1	230.3	182.8	112.2	153.1	235.0	225.2	272.1	184.0	166.7	56.4	44.6	2057.5
1967	270.2	394.5	202.2	174.3	140.5	133.3	356.1	306.7	44.1	0.8	94.0	83.2	2199.9
1968	157.8	166.1	172.3	260.8	159.8	178.1	291.0	137.4	111.7	143.1	97.0	186.4	2061.5
1969	123.4	243.6	192.5	124.1	359.6	144.5	304.3	232.1	62.0	58.1	0.0	112.7	1956.9
1970	192.4	251.3	124.2	206.0	153.1	309.0	224.5	261.6	189.0	48.5	244.5	194.1	2398.2
1971	93.3	223.7	259.8	151.9	164.8	241.4	244.5	113.5	130.0	0.0	185.4	67.1	1875.4
1972	265.1	171.8	247.2	75.6	160.7	455.0	239.9	311.5	164.5	71.1	79.9	148.4	2420.7
1973	428.5	249.8	160.8	241.2	384.6	151.1	277.2	272.4	216.7	57.1	85.7	99.6	2624.7
1974	184.1	179.9	124.2	167.8	144.7	355.6	73.5	44.3	71.7	95.6	100.8	173.7	1715.7
1975	191.6	273.9	67.6	270.3	102.1	240.8	242.6	258.1	277.5	0.0	23.7	94.9	2043.1
1976	244.0	252.2	201.4	269.1	102.2	231.6	233.1	254.2	100.2	69.5	7.0	5.7	1970.2
1977	139.9	185.4	294.6	56.8	235.4	242.6	465.8	190.9	27.2	58.2	0.1	81.2	2038.1
1978	134.2	193.2	108.7	259.7	123.9	184.5	158.2	98.1	67.0	8.8	29.7	26.9	1392.9
1979	281.6	146.9	173.4	31.4	164.5	348.8	182.7	344.5	1.4	0.0	66.2	177.7	1917.1
1980	164.3	228.2	161.6	179.0	268.1	226.8	362.3	184.3	82.9	5.4	91.6	52.0	2026.5
1981	93.8	463.5	135.6	134.7	101.7	299.7	127.0	237.8	100.5	0.0	25.8	212.1	1932.2
1982	179.4	290.4	42.3	186.4	162.8	350.9	177.1	314.9	118.3	0.6	20.9	146.1	1990.1
1983	83.6	215.1	162.6	172.6	302.0	417.7	163.6	193.3	183.3	49.8	2.2	208.2	2178.8
1984	184.7	115.7	118.9	348.8	102.1	173.9	307.8	165.7	148.3	4.2	266.4	139.9	2076.4
1985	118.7	363.8	149.1	258.4	218.8	244.8	264.8	393.7	22.0	12.7	0.4	143.6	2188.8
1986	207.8	176.6	82.2	91.2	145.7	291.9	495.4	299.4	81.2	0.0	0.0	147.0	2018.4
1987	138.9	259.4	188.7	125.9	361.1	441.6	431.8	216.5	164.9	2.2	57.5	55.9	2444.4
1988	297.7	291.7	140.7	239.7	524.0	282.0	183.6	401.5	56.9	19.0	0.0	150.9	2587.7
1989	253.2	252.8	178.1	170.0	145.4	412.7	339.0	137.4	4.6	26.0	53.0	219.5	2191.7
1990	186.7	285.3	84.0	65.6	114.4	268.9	397.1	242.3	85.6	14.0	28.6	114.2	1906.7
1991	254.4	433.5	228.3	302.1	211.7	169.4	304.3	194.0	64.2	12.3	123.4	66.8	2384.4
Ave.	194.5	252.0	169.3	182.9	199.8	267.5	282.6	234.6	111.4	40.4	68.0	124.9	2127.8

TABLE I. 5.2.2 MONTHLY BASIN AVERAGE RAINFALL (2/5)

Basin Name: Jeniang Gauging Station

Hydrological	Monthly Total (mm/month)												
Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
1959	168.8	434.8	265.3	160.4	290.9	161.9	367.7	277.9	80.1	47.3	34.6	77.6	2367.3
1960	358.6	230.3	206.1	252.4	229.5	419.4	263.6	324.9	70.9	73.3	140.6	179.0	2748.6
1961	259.6	144.5	217.6	126.5	113.7	168.3	298.9	201.8	159.7	68.8	41.2	160.0	1960.6
1962	199.1	212.6	207.3	239.7	232.8	194.9	411.4	113.5	90.1	74.2	34.9	114.8	2125.3
1963	83.6	328.3	182.2	186.1	124.8	265.0	316.5	348.5	100.8	44.9	49.4	115.3	2163.4
1964	106.4	341.2	155.0	234.8	160.6	327.6	259.3	260.7	81.0	0.0	62.2	187.2	2196.0
1965	209.4	181.0	152.1	193.2	210.8	259.4	450.2	194.4	320.6	75.2	99.2	95.1	2440.6
1966	195.7	245.3	194.0	125.9	155.8	265.3	229.3	280.0	185.3	168.0	54.5	40.5	2139.6
1967	270.3	382.4	223.4	170.7	153.5	148.8	364.6	300.1	39.0	1.2	90.9	68.8	2213.7
1968	184.6	161.8	187.9	271.3	189.3	179.3	321.5	129.6	113.0	150.2	91.9	201.3	2181.7
1969	128.9	245.0	192.0	128.7	368.7	150.0	350.1	264.3	66.5	57.6	0.1	129.4	2081.3
1970	194.4	277.5	115.7	221.9	168.0	314.2	239.2	267.5	178.8	43.1	215.8	187.4	2423.5
1971	83.7	215.2	264.4	148.0	189.3	260.7	264.5	126.0	143.7	0.3	169.7	65.5	1929.0
1972	263.5	161.8	251.4	69.3	150.5	468.7	272.0	351.5	152.1	67.5	66.8	145.2	2418.3
1973	398.0	236.5	167.7	247.3	374.7	148.2	301.9	256.8	219.8	58.6	85.2	94.9	2587.4
1974	175.8	193.4	120.3	165.8	159.8	374.0	94.6	90.9	64.5	113.4	115.4	162.1	1830.0
1975	206.2	255.3	72.0	281.2	110.2	265.9	255.5	246.9	289.3	0.0	28.7	100.5	2111.7
1976	248.5	285.5	192.6	270.7	120.7	247.4	282.5	286.8	89.6	73.0	19.4	7.8	2124.5
1977	127.6	211.9	280.3	57.5	293.5	260.5	486.4	174.4	34.1	64.3	0.4	113.7	2104.6
1978	148.3	217.7	142.3	251.9	145.5	190.5	213.2	124.2	58.3	8.8	27.8	32.0	1560.5
1979	307.2	145.7	175.6	83.5	164.5	348.0	195.3	333.3	1.1	0.0	60.4	181.4	1994.0
1980	181.4	245.5	152.7	186.3	289.5	252.9	438.5	249.2	90.8	16.6	98.7	56.4	2258.5
1981	151.3	465.8	144.6	129.4	108.7	307.0	125.8	213.8	85.0	0.1	24.9	181.6	1938.0
1982	231.1	327.2	49.1	181.7	163.0	348.7	221.7	334.6	120.0	3.6	22.9	134.5	2138.1
1983	97.0	235.1	152.7	165.4	291.9	427.6	192.7	161.2	191.4	57.4	28.7	189.1	2210.2
1984	229.2	133.2	117.2	354.8	94.2	172.4	284.6	156.2	145.6	35.7	219.2	169.8	2112.1
1985	146.9	325.9	158.3	233.1	216.1	252.8	300.6	417.3	24.6	10.8	4.3	153.5	2245.2
1986	226.4	192.0	84.3	112.1	145.9	322.3	482.4	342.3	96.5	2.7	0.9	165.3	2173.1
1987	148.2	265.3	187.8	131.0	368.5	482.4	439.3	259.6	152.8	5.9	93.0	71.8	2603.6
1988	342.7	261.1	162.8	248.8	500.3	288.3	196.6	377.9	47.0	20.4	2.2	151.5	2597.6
1989	239.1	244.9	161.5	194.7	159.1	408.5	364.6	139.3	14.4	26.0	53.5	178.6	2184.2
1990	177.8	291.1	105.6	98.4	114.3	283.2	419.9	229.6	80.7	13.0	39.0	114.0	1966.6
1991	243.7	438.6	198.2	317.5	230.6	182.0	309.1	175.6	61.2	31.6	113.7	79.8	2379.6
Ave.	204.0	258.5	170.8	189.0	206.6	277.6	300.5	243.9	110.6	42.8	66.4	124.4	2197.2

TABLE I. 5.2.2 MONTHLY BASIN AVERAGE RAINFALL (3/5)

Basin Name: Ldg. Victoria Gauging Station

Hydrological Year	Monthly Total (mm/month)												
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
1959	224.1	362.0	273.0	167.7	257.8	202.7	391.9	268.1	115.9	50.1	41.8	118.8	2473.9
1960	305.9	203.4	206.8	257.9	208.7	351.8	213.1	304.0	113.8	88.0	147.0	199.9	2600.3
1961	258.5	189.1	201.3	154.5	116.6	220.7	315.8	259.4	202.6	86.1	44.5	194.2	2241.3
1962	229.3	261.0	199.1	228.8	215.0	174.1	464.9	148.4	123.4	104.8	32.5	132.8	2314.1
1963	106.3	318.2	167.6	172.9	142.1	286.2	354.5	386.3	112.8	61.5	57.4	83.9	2249.7
1964	186.8	321.5	150.1	306.9	154.0	365.9	295.8	287.7	87.5	1.2	67.0	193.8	2418.2
1965	255.3	207.9	130.2	200.5	274.4	280.5	506.3	236.1	297.7	79.1	126.3	156.7	2751.0
1966	226.3	243.7	196.9	190.7	170.4	257.9	311.0	284.1	231.3	219.6	45.4	51.4	2428.7
1967	298.8	328.9	201.0	149.2	169.8	207.0	374.0	335.2	46.9	13.8	60.1	96.6	2279.1
1968	194.6	188.2	179.2	255.9	237.5	152.6	359.8	122.8	152.3	146.4	81.3	215.3	2285.9
1969	165.7	301.0	227.8	124.0	368.8	149.3	470.6	338.7	99.5	103.7	4.9	152.3	2506.3
1970	215.0	343.1	137.4	222.0	195.9	321.6	364.2	355.5	200.1	52.4	199.5	177.2	2783.9
1971	93.4	204.5	258.2	139.0	251.4	310.3	313.5	165.7	221.5	15.5	164.1	71.9	2209.0
1972	313.5	128.3	232.6	77.4	147.7	414.7	346.7	425.9	151.5	52.7	55.6	139.6	2456.2
1973	422.0	273.4	166.4	223.8	294.6	168.2	363.1	259.2	259.1	60.6	91.1	98.9	2680.4
1974	204.7	233.4	120.2	180.1	138.3	356.1	130.9	156.3	56.0	180.1	168.3	194.5	2118.9
1975	233.6	263.9	74.9	284.0	115.1	288.4	273.2	235.1	320.9	1.6	61.7	130.9	2283.3
1976	253.8	264.6	177.6	255.6	150.8	280.6	387.5	322.6	93.4	72.7	28.6	21.5	2309.3
1977	124.6	219.8	229.6	74.6	294.0	272.6	531.1	154.0	75.0	75.3	21.5	137.3	2209.4
1978	198.1	223.3	152.8	168.4	159.2	164.5	257.2	142.6	44.6	15.1	49.6	60.6	1656.0
1979	329.5	143.5	181.8	155.9	165.0	299.0	206.7	353.8	11.8	11.0	62.2	194.1	2114.3
1980	206.2	211.2	179.9	173.8	293.1	313.8	447.2	336.1	123.6	24.3	124.1	79.4	2512.7
1981	235.5	422.4	147.5	143.0	123.0	327.1	191.4	176.7	72.0	7.5	41.2	147.8	2035.1
1982	266.3	324.1	50.1	153.0	160.8	317.4	295.2	353.1	112.5	15.6	71.2	146.3	2285.8
1983	115.6	305.2	158.6	166.5	270.7	414.2	216.0	150.4	176.9	77.0	49.8	191.6	2290.3
1984	264.4	170.0	105.2	336.5	100.3	193.6	290.9	204.3	180.7	40.7	226.2	218.7	2331.5
1985	147.1	324.6	129.7	204.3	205.7	258.4	354.8	410.1	43.8	20.3	27.9	152.1	2278.6
1986	237.2	217.0	122.8	118.6	159.8	346.9	436.5	317.3	115.8	4.7	4.4	175.7	2256.7
1987	164.2	254.6	196.4	148.2	333.9	443.1	490.0	342.1	152.9	19.9	136.7	135.1	2822.1
1988	358.0	243.0	171.0	228.6	431.9	281.7	219.6	310.1	53.8	40.7	39.4	194.1	2571.9
1989	302.5	238.9	162.1	211.0	164.3	392.5	385.3	147.8	59.0	40.0	84.9	158.0	2344.3
1990	198.6	300.9	114.8	131.4	99.5	283.9	472.7	246.9	75.6	32.0	51.8	189.7	2197.8
1991	237.1	475.6	145.9	276.8	232.6	204.1	303.1	179.3	74.5	44.1	127.3	78.3	2378.7
Ave.	229.9	263.9	168.1	191.0	206.1	282.0	343.5	264.1	129.1	56.3	78.6	142.0	2354.7

TABLE I. 5.2.2 MONTHLY BASIN AVERAGE RAINFALL (4/5)

Basin Name: Kuala Pegang Gauging Station

Hydrological Year	Monthly Total (mm/month)												
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
1959	164.7	324.0	239.9	174.9	182.2	223.0	332.6	220.4	137.9	37.5	26.6	111.5	2175.2
1960	236.7	218.7	258.5	252.5	182.0	276.4	121.5	280.4	93.2	102.7	140.6	161.5	2322.7
1961	223.9	295.1	236.1	123.6	149.5	234.9	305.8	258.1	189.1	67.4	46.9	192.2	2322.6
1962	218.9	268.5	123.6	272.1	174.2	162.9	446.7	165.8	133.3	73.2	14.4	125.9	2179.5
1963	161.4	300.9	127.8	149.6	167.6	249.3	283.6	364.2	70.7	45.0	29.7	47.2	1997.0
1964	195.9	257.0	121.1	255.5	83.6	281.1	271.0	243.9	72.2	0.0	47.9	164.1	1998.3
1965	297.4	195.3	203.5	224.1	275.9	229.6	423.9	173.8	214.9	70.1	114.8	110.0	2533.3
1966	252.4	230.8	191.4	232.1	156.8	207.0	556.9	276.8	237.4	311.6	22.4	41.5	2517.1
1967	241.5	290.6	181.9	118.6	161.0	240.6	351.4	368.7	49.0	6.3	32.8	56.0	2098.4
1968	217.1	214.9	141.2	221.6	287.1	126.6	259.8	104.4	161.4	104.7	61.6	258.6	2157.0
1969	208.6	294.6	240.3	148.2	392.4	116.5	552.3	375.6	80.7	109.2	5.9	91.7	2616.0
1970	203.8	324.4	182.9	187.4	255.1	315.6	323.2	378.0	235.4	81.8	165.2	179.9	2832.7
1971	79.4	231.9	235.6	192.3	193.8	308.5	279.5	232.1	242.0	38.7	148.8	64.7	2245.3
1972	393.9	94.7	230.2	100.7	161.1	358.3	396.1	464.7	150.3	32.2	46.1	98.5	2524.8
1973	509.6	355.4	171.3	222.5	248.8	174.4	396.4	269.8	359.4	106.8	87.2	64.0	2965.6
1974	188.8	290.3	118.2	124.9	104.0	352.0	125.8	150.1	66.5	247.4	201.5	239.9	2207.4
1975	289.0	384.5	70.4	300.1	81.5	241.9	291.1	206.3	385.1	0.4	97.5	101.3	2449.1
1976	270.9	252.0	162.5	200.2	135.3	224.4	495.8	212.2	79.5	29.2	7.3	24.0	2093.1
1977	111.7	203.6	204.3	90.6	245.1	221.1	479.0	114.8	56.8	97.5	34.9	144.6	2004.0
1978	167.0	263.8	178.3	154.1	148.2	147.1	241.8	132.2	39.6	8.2	64.3	56.3	1600.9
1979	301.9	168.3	139.4	181.8	155.1	297.5	173.9	337.8	2.0	1.6	45.6	198.4	2001.3
1980	252.0	168.7	220.5	134.2	287.5	257.1	448.6	375.8	100.7	38.4	155.3	55.1	2493.9
1981	261.3	375.6	118.7	110.6	93.9	293.8	189.1	126.2	68.0	5.6	55.2	129.7	1827.7
1982	300.8	318.2	67.2	134.6	137.2	282.2	231.1	237.1	85.1	7.4	99.3	172.4	2070.6
1983	100.9	318.2	156.2	185.8	319.0	397.3	253.2	159.0	167.4	61.3	45.3	170.4	2334.0
1984	187.4	194.9	95.0	232.0	108.3	231.3	354.5	172.6	143.6	23.6	183.4	191.1	2122.7
1985	128.6	318.8	103.1	147.9	208.5	243.2	337.4	462.8	32.5	27.1	45.7	119.6	2175.0
1986	218.9	215.1	161.8	113.1	173.9	370.3	362.6	277.7	91.1	2.1	0.4	205.4	2192.4
1987	175.9	246.8	223.4	124.9	289.3	439.6	519.3	349.4	119.4	10.0	130.2	120.7	2748.9
1988	376.3	288.0	204.4	238.1	368.5	224.6	233.3	345.3	68.7	29.3	10.0	252.1	2638.6
1989	245.7	214.7	168.5	222.2	128.4	331.2	333.4	135.5	72.6	41.5	68.2	107.8	2069.7
1990	224.0	265.0	127.2	128.2	71.9	251.7	499.3	240.4	69.9	45.4	46.8	161.9	2129.7
1991	208.7	475.1	64.4	220.2	201.4	164.5	311.2	158.3	55.8	40.5	138.4	64.8	2101.1
Ave.	230.8	268.3	165.6	179.3	191.9	258.7	332.8	253.6	125.2	57.7	74.1	129.7	2265.6

TABLE I. 5.2.2 MONTHLY BASIN AVERAGE RAINFALL (5/5)

Basin Name: Lengkuas Gauging Station

Hydrological Year	Monthly Total (mm/month)												
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
1959	115.4	371.6	203.9	138.2	181.4	165.9	272.8	396.0	74.9	41.8	23.9	74.2	2060.0
1960	238.4	184.6	121.5	164.1	174.0	248.4	128.8	223.2	37.3	54.0	80.6	98.8	1753.7
1961	135.4	119.4	138.9	78.0	79.0	168.5	272.7	148.5	149.0	38.0	28.6	132.8	1484.8
1962	162.9	165.9	134.7	172.8	214.0	218.6	350.4	83.3	62.5	49.9	1.2	145.0	1761.2
1963	75.3	226.1	99.8	127.0	121.3	203.7	259.6	269.5	64.9	36.6	32.5	61.4	1577.7
1964	144.6	229.3	86.8	165.8	129.9	268.7	271.7	246.7	39.3	0.0	48.5	121.3	1752.6
1965	165.2	177.5	79.2	135.5	246.6	198.1	390.9	236.9	304.8	70.8	60.6	89.9	2156.0
1966	165.8	202.7	153.4	118.1	116.9	243.8	290.8	220.8	140.2	132.5	30.5	21.3	1836.8
1967	197.3	289.0	221.4	152.6	135.1	228.0	316.2	242.8	30.6	9.7	50.7	160.0	2033.4
1968	226.1	136.2	138.5	243.9	212.1	217.1	349.1	111.6	144.5	94.7	32.7	156.7	2061.2
1969	158.1	191.3	199.8	129.1	325.6	161.7	323.6	265.2	37.8	44.5	0.0	101.7	1938.4
1970	159.1	275.7	119.3	210.7	204.6	291.7	281.7	218.4	236.5	17.0	183.5	156.1	2354.3
1971	39.3	172.0	193.9	111.2	235.8	216.2	328.6	145.5	100.2	0.0	92.5	59.9	1695.1
1972	242.4	91.5	154.5	57.8	119.1	490.8	259.5	357.6	149.9	78.5	28.5	64.7	2094.8
1973	325.8	287.4	160.7	189.1	262.8	166.1	284.3	232.3	186.1	40.9	87.8	42.6	2265.9
1974	90.0	215.5	148.8	124.7	116.6	343.9	160.0	199.1	64.3	117.3	81.6	127.2	1789.0
1975	161.7	177.8	128.4	249.8	117.7	267.0	263.3	247.4	262.7	0.1	26.8	75.7	1978.4
1976	233.5	295.0	142.4	232.5	107.1	236.5	292.3	257.2	52.0	12.4	7.5	1.7	1870.1
1977	56.1	259.4	191.6	54.6	203.4	188.9	434.8	81.2	16.5	44.3	0.0	143.6	1674.4
1978	117.3	240.9	137.2	217.8	113.5	249.1	253.5	154.1	69.1	7.9	42.5	73.2	1676.1
1979	352.4	165.7	192.6	154.6	219.1	259.8	155.0	274.3	1.9	0.6	34.6	99.8	1930.4
1980	261.3	211.4	115.5	129.0	227.1	183.8	337.3	259.9	103.0	11.2	30.1	46.9	1916.5
1981	176.3	280.5	79.6	60.4	45.6	211.8	145.5	177.2	64.3	0.0	21.9	111.9	1375.0
1982	333.0	313.0	70.0	202.1	115.9	219.5	279.2	272.2	138.5	1.6	12.8	77.4	2035.2
1983	74.9	286.0	120.8	88.5	230.4	339.3	314.2	206.5	141.9	31.7	15	138.2	1987.4
1984	156.1	116.6	133.3	198.7	71.7	167.5	205.5	134.6	180.2	1.1	147.4	127.2	1639.9
1985	135.9	223.5	162.9	76.7	178.8	210.4	250.6	331.1	24.3	1.9	1.9	98.3	1696.3
1986	264.5	141.3	98.1	69.7	144.6	268.7	384.2	296.7	70.9	0.7	0.1	149.6	1889.1
1987	90.5	208.6	114.1	70.5	334.5	388.1	365.2	320.3	230.6	2.5	76.3	72.6	2273.8
1988	270.6	188.1	84.4	327.9	326.9	350.1	159.7	350.5	56.6	15.4	1.2	134.0	2265.4
1989	230.1	207.9	177.4	191.5	96.4	330.4	330.6	70.3	3.8	23.3	76.7	125.6	1864.0
1990	159.8	269.3	56.9	114.7	60.8	145.4	359.8	190.5	89.2	11.2	21.5	164.3	1643.4
1991	253.1	445.3	147.6	358.3	194.7	166.2	268.7	129.8	70.6	0.3	100.5	145.1	2300.2
Ave.	180.9	223.8	136.5	155.0	171.6	242.8	283.6	222.7	103.0	30.1	44.9	103.0	1897.9

TABLE I. 5.2.3 ANNUAL RUNOFF AND LOSS OF OBSERVED NATURAL FLOW

Station : Nami (6007415)

Unit : mm

Hydrological Year	Basin Rainfall	Observed Runoff	Loss	Analysed Year
1961	1957.1	878.9	1078.2	
1962	2092.4	501.4	1591.0	O
1963	2112.2	646.0	1466.2	O
1964	2129.8	559.2	1570.6	O
1965	2323.1	1000.4	1322.7	O
: 1966	2057.5	1307.3	750.2	
Average of Analysed Year	2164.4	676.8	1487.6	

Station : Jeniang (5806414)

Unit : mm

Hydrological Year	Basin Rainfall	Observed Runoff	Loss	Analysed Year
1961	1960.6	592.4	1368.2	O
1962	2125.3	700.7	1424.6	O
1963	2163.4	923.7	1239.7	O
1964	2196.0	717.0	1479.0	O
1965	2440.6	227.5	2213.1	
1966	2139.6	115.9	2023.7	
Average of Analysed Year	2111.3	733.5	1377.9	

Station : Ldg. Victoria (5505412)

Unit : mm

Hydrological Year	Basin Rainfall	Observed Runoff	Loss	Analysed Year
1961	2241.3	760.2	1481.1	O
1962	2314.1	769.9	1544.2	O
1963	2249.7	768.7	1481.0	O
1964	2418.2	821.2	1597.0	O
1965	2751.0	1036.2	1714.8	O
1966	2428.7	1068.9	1359.8	O
Average of Analysed Year	2400.5	870.9	1529.7	

Station : Lengkuas (5204421)

Unit : mm

Hydrological Year	Basin Rainfall	Observed Runoff	Loss	Analysed Year
1961	1484.8	302.3	1182.5	O
1962	1761.2	475.5	1285.7	O
1963	1577.7	258.3	1319.4	O
1964	1752.6	305.6	1447.0	O
1965	2156.0	717.0	1439.0	O
1966	1836.8	630.9	1205.9	O
Average of Analysed Year	1761.5	448.3	1313.3	

Station : Kuala Pegang (5608418)

Unit : mm

Hydrological Year	Basin Rainfall	Observed Runoff	Loss	Analysed Year
1977	2004.0	1003.3	1000.7	O
1979	2001.3	633.3	1368.0	O
Average of Analysed Year	2002.7	818.3	1184.4	

TABLE I. 5.2.4 BASIN EVAPOTRANSPIRATION FOR TANK MODEL

(Unit : mm)

Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
[Evaporation at Key Station]													
Alor Setar #	5.07	4.03	3.76	3.78	3.92	3.72	3.82	3.63	4.51	5.65	6.10	5.84	1636
Komplek Rumah Muda #	5.51	4.67	4.47	4.50	4.59	4.38	4.22	4.11	4.48	5.45	6.21	6.22	1787
Base Value ##	5.3	4.4	4.1	4.1	4.3	4.1	4.0	3.9	4.5	5.6	6.2	6.0	1717
[Basin Evapotranspiration]													
Nami	4.592	3.812	3.552	3.552	3.725	3.552	3.465	3.379	3.899	4.852	5.371	5.198	1488
Jeniang	4.253	3.531	3.290	3.290	3.451	3.290	3.210	3.130	3.611	4.494	4.975	4.815	1378
Ldg. Victoria	4.722	3.920	3.653	3.653	3.831	3.653	3.563	3.474	4.009	4.989	5.523	5.345	1530
K Pegang	3.656	3.035	2.828	2.828	2.966	2.828	2.759	2.690	3.104	3.863	4.277	4.139	1184
Lengkuas	4.054	3.365	3.136	3.136	3.289	3.136	3.060	2.983	3.442	4.283	4.742	4.590	1313

Note : Above figures show the mean daily values within each month.

: Average evaporation of ten years, 1981 - 1990.

: Average of two key stations, Alor Setar and Komplek Rumah Muda.

TABLE I. 5.3.1 ESTIMATED PARAMETERS OF TANK MODEL

Tank Paremeter	Analysed Station				
	Nami	Jeniang	L.Victoria	K.Pegang	Lengkuas
[1st Tank]					
a1	0.38000	0.45540	0.67300	0.69160	0.20000
a2	0.02200	0.04265	0.03000	0.04576	0.02300
a0	0.37000	0.21100	0.29600	0.22942	0.05000
A1	94	94	94	50	60
A2	10	39	39	15	25
[2nd Tank]					
b1	0.03000	0.03410	0.06340	0.11287	0.04500
b0	0.16000	0.07960	0.13400	0.22969	0.08750
B	2	2	2	10	15
[3rd Tank]					
c1	0.00850	0.00871	0.00873	0.01921	0.01600
c0	0.00940	0.00902	0.01090	0.01849	0.08750
C	1	1	1	1	10
[4th Tank]					
d1	0.00045	0.00090	0.00100	0.00177	0.00020
D	0	0	0	0	0

Note : As for the Tank Parameters, refer to Fig. I. 5.1.1.

TABLE I. 5.3.2 ANNUAL RUNOFF AND LOSS OF GENERATED NATURAL FLOW (1/2)

Station: Nami (6007415)

Unit:mm

Hydrological Year	Basin Rainfall	Generated Runoff	Loss
1959	2305.5	772.7	1532.8
1960	2700.5	927.8	1772.7
1961	1957.1	564.9	1392.2
1962	2092.4	700.2	1392.2
1963	2112.2	649.3	1462.9
1964	2129.8	659.5	1470.3
1965	2323.1	759.0	1564.1
1966	2057.5	604.5	1453.0
1967	2199.9	735.8	1464.1
1968	2061.5	536.7	1524.8
1969	1956.9	635.7	1321.2
1970	2398.2	726.0	1672.2
1971	1875.4	552.5	1322.9
1972	2420.7	754.3	1666.4
1973	2624.7	946.9	1677.8
1974	1715.7	465.0	1250.7
1975	2043.1	638.0	1405.1
1976	1970.2	644.4	1325.8
1977	2038.1	627.1	1411.0
1978	1392.9	315.6	1077.3
1979	1917.1	454.0	1463.1
1980	2026.5	529.2	1497.3
1981	1932.2	466.9	1465.3
1982	1990.1	483.1	1507.0
1983	2178.8	556.8	1622.0
1984	2076.4	494.0	1582.4
1985	2188.8	668.1	1520.7
1986	2018.4	566.9	1451.5
1987	2444.4	804.8	1639.6
1988	2587.7	896.8	1690.9
1989	2191.7	662.0	1529.7
1990	1906.7	577.8	1328.9
1991	2384.4	795.1	1589.3
Average	2127.8	641.6	1486.3

Station: Jeniang (5806414)

Unit: mm

Hydrological Year	Basin Rainfall	Generated Runoff	Loss
1959	2367.3	975.9	1391.4
1960	2748.6	1125.9	1622.7
1961	1960.6	693.0	1267.6
1962	2125.3	849.5	1275.8
1963	2163.4	809.0	1354.4
1964	2196.0	803.8	1392.2
1965	2440.6	960.8	1479.8
1966	2139.6	792.7	1346.9
1967	2213.7	910.5	1303.2
1968	2181.7	682.3	1499.4
1969	2081.3	837.2	1244.1
1970	2423.5	899.9	1523.6
1971	1929.0	691.5	1237.5
1972	2418.3	908.7	1509.6
1973	2587.4	1116.1	1471.3
1974	1830.0	584.6	1245.4
1975	2111.7	802.4	1309.3
1976	2124.5	862.9	1261.6
1977	2104.6	779.3	1325.3
1978	1560.5	463.5	1097.0
1979	1994.0	583.6	1410.4
1980	2258.5	766.4	1492.1
1981	1936.0	592.4	1343.6
1982	2138.1	709.7	1428.4
1983	2210.2	727.6	1482.6
1984	2112.1	651.0	1461.1
1985	2245.2	874.1	1371.1
1986	2173.1	813.4	1359.7
1987	2603.6	1092.9	1510.7
1988	2597.6	1154.3	1443.3
1989	2184.2	846.6	1337.6
1990	1966.6	736.1	1230.5
1991	2379.6	954.6	1425.0
Average	2197.2	819.8	1377.4

Station: Ldg. Victoria (5505412)

Unit: mm

Hydrological Year	Basin Rainfall	Generated Runoff	Loss
1959	2473.9	908.6	1565.3
1960	2600.3	901.6	1698.7
1961	2241.3	759.0	1482.3
1962	2314.1	863.5	1450.6
1963	2249.7	797.4	1452.3
1964	2418.2	841.5	1576.7
1965	2751.0	1027.2	1723.8
1966	2428.7	922.7	1506.0
1967	2279.1	888.9	1390.2
1968	2285.9	676.5	1609.4
1969	2506.3	985.0	1521.3
1970	2783.9	1066.9	1717.0
1971	2209.0	817.6	1391.4
1972	2486.2	936.3	1549.9
1973	2680.4	1087.2	1593.2
1974	2118.9	637.3	1481.6
1975	2283.3	829.4	1453.9
1976	2309.3	909.5	1399.8
1977	2209.4	752.5	1456.9
1978	1656.0	448.5	1207.5
1979	2114.3	569.9	1544.4
1980	2512.7	800.2	1712.5
1981	2035.1	610.6	1424.5
1982	2285.6	682.9	1602.7
1983	2290.3	691.4	1598.9
1984	2331.5	659.2	1672.3
1985	2278.6	808.0	1470.6
1986	2256.7	768.4	1488.3
1987	2822.1	1059.4	1762.7
1988	2571.9	1004.9	1567.0
1989	2344.3	874.4	1469.9
1990	2197.8	759.1	1438.7
1991	2378.7	888.1	1490.6
Average	2354.7	825.3	1529.4

TABLE I. 5.3.2 ANNUAL RUNOFF AND LOSS OF GENERATED NATURAL FLOW (2/2)

Station: Kuala Pegang (5608418)

Unit: mm

Hydrological Year	Basin Rainfall	Generated Runoff	Loss
1959	2175.2	966.3	1208.9
1960	2322.7	1005.4	1317.3
1961	2322.6	1089.0	1233.6
1962	2179.5	1096.3	1083.2
1963	1997.0	925.9	1071.1
1964	1998.3	812.7	1185.6
1965	2533.3	1180.2	1353.1
1966	2517.1	1311.9	1205.2
1967	2098.4	1068.3	1030.1
1968	2157.0	828.9	1328.1
1969	2616.0	1429.6	1186.4
1970	2832.7	1453.3	1379.4
1971	2245.3	1136.2	1109.1
1972	2524.8	1391.8	1133.0
1973	2965.6	1703.1	1262.5
1974	2207.4	957.1	1250.3
1975	2449.1	1381.6	1067.5
1976	2093.1	1143.1	950.0
1977	2004.0	835.5	1168.5
1978	1600.9	604.1	996.8
1979	2001.3	776.4	1224.9
1980	2493.9	1124.9	1369.0
1981	1827.7	750.0	1077.7
1982	2070.6	805.2	1265.4
1983	2334.0	1074.4	1259.6
1984	2122.7	868.0	1254.7
1985	2175.0	1097.3	1077.7
1986	2192.4	1018.8	1173.7
1987	2748.9	1433.4	1315.5
1988	2638.6	1406.9	1231.7
1989	2089.7	1011.9	1077.8
1990	2129.7	1002.2	1127.5
1991	2101.1	972.9	1128.2
Average	2265.6	1080.7	1184.9

Station: Lengkuas (6204421)

Unit: mm

Hydrological Year	Basin Rainfall	Gnerated Runoff	Loss
1959	2060.0	699.7	1360.3
1960	1753.7	380.1	1373.6
1961	1484.8	264.4	1220.4
1962	1761.2	509.0	1252.2
1963	1577.7	383.9	1193.8
1964	1752.6	478.9	1273.7
1965	2156.0	687.7	1468.3
1966	1836.8	496.2	1340.6
1967	2033.4	654.2	1379.2
1968	2061.2	552.8	1508.4
1969	1938.4	636.9	1301.5
1970	2354.3	800.1	1554.2
1971	1695.1	473.4	1221.7
1972	2094.8	764.5	1330.3
1973	2265.9	800.6	1465.3
1974	1789.0	405.7	1383.3
1975	1978.4	645.6	1332.8
1976	1870.1	709.3	1160.8
1977	1674.4	568.5	1105.9
1978	1676.1	449.7	1226.4
1979	1930.4	631.0	1299.4
1980	1916.5	603.0	1313.5
1981	1375.0	280.0	1095.0
1982	2035.2	676.9	1358.3
1983	1987.4	664.1	1323.3
1984	1639.9	272.5	1367.4
1985	1696.3	502.3	1194.0
1986	1889.1	606.3	1282.8
1987	2273.8	951.5	1322.3
1988	2265.4	898.2	1367.2
1989	1864.0	560.8	1303.2
1990	1643.4	446.0	1197.4
1991	2300.2	838.8	1461.4
Average	1897.9	584.6	1313.3

TABLE I. 5.3.3 MONTHLY AVERAGE OF GENERATED DISCHARGE (1/5)

Station Name: Nami Gauging Station (Unit: m³/s)

Hydrological Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual Average
1959	9.301	43.757	48.768	29.963	42.210	32.286	29.277	57.315	36.207	14.114	6.931	6.650	29.810
1960	34.431	41.452	29.099	32.044	33.472	73.022	51.485	51.431	35.769	18.342	14.287	14.729	35.833
1961	21.320	29.295	25.472	19.559	18.797	15.185	30.033	35.465	24.411	13.640	9.072	13.103	21.855
1962	11.704	31.961	28.962	32.565	36.538	36.966	47.311	38.268	24.389	15.413	7.911	11.473	27.089
1963	7.636	21.927	27.449	24.129	20.466	30.970	46.422	50.574	40.617	14.957	6.773	8.051	25.052
1964	13.239	34.072	26.495	23.597	22.178	51.772	32.956	47.816	29.915	10.029	7.376	6.146	25.512
1965	33.331	18.070	21.462	21.459	20.630	31.637	49.458	47.131	56.642	28.162	13.560	9.384	29.361
1966	12.112	25.269	26.628	17.996	16.305	23.098	33.931	37.910	34.513	33.738	8.977	8.946	23.385
1967	15.559	57.591	35.358	35.243	24.730	20.917	39.205	47.863	35.445	10.317	10.300	7.165	28.389
1968	12.094	17.294	16.059	33.518	22.012	27.024	37.870	30.095	16.668	14.771	10.394	10.430	20.763
1969	17.107	26.109	22.247	23.453	33.484	34.092	40.993	40.685	29.646	11.106	5.893	8.984	24.591
1970	8.683	30.646	22.823	24.179	23.773	37.736	35.177	38.124	35.569	21.194	16.661	41.207	28.087
1971	13.428	13.251	28.675	24.093	26.542	32.745	32.224	27.369	21.002	7.717	14.571	8.271	21.315
1972	19.986	24.962	28.777	19.453	18.586	44.927	47.990	54.368	46.680	22.843	9.482	10.808	29.180
1973	35.014	45.625	39.293	36.030	58.903	40.006	46.155	47.085	48.014	20.226	10.411	9.780	36.633
1974	21.778	23.202	18.329	16.908	17.190	35.185	32.872	13.037	8.521	9.420	7.857	13.063	17.990
1975	17.676	28.801	20.246	23.979	20.434	29.232	30.135	41.614	48.173	20.246	6.351	7.594	24.615
1976	16.729	37.386	31.924	35.609	23.714	26.760	34.281	37.892	25.714	16.974	5.892	4.857	24.928
1977	9.124	14.030	32.793	15.637	24.058	34.435	63.912	54.014	24.664	8.460	4.935	4.279	24.261
1978	6.394	15.809	7.760	24.177	15.836	21.480	22.700	15.118	8.787	3.305	2.527	1.636	12.208
1979	18.295	18.202	19.403	4.694	5.800	35.000	23.585	47.348	21.541	3.385	2.900	10.635	17.517
1980	5.062	20.923	18.863	15.007	29.472	27.833	51.479	38.068	25.460	5.466	2.719	3.777	20.471
1981	4.557	32.996	29.936	20.186	11.490	30.871	19.279	29.233	23.031	3.318	1.387	10.546	18.060
1982	9.762	22.236	12.744	15.533	9.565	31.281	34.164	43.522	29.878	7.840	1.708	5.118	18.689
1983	4.012	10.632	17.666	13.906	29.279	53.702	34.788	39.240	37.538	8.902	2.183	5.609	21.482
1984	16.904	11.521	10.586	34.841	17.583	14.245	38.581	29.563	19.187	6.416	9.814	19.007	19.110
1985	5.472	27.872	34.124	28.490	32.290	28.601	39.638	54.297	35.367	9.793	3.538	9.142	25.847
1986	14.076	13.362	11.886	7.341	6.746	23.921	65.460	58.893	38.440	10.432	3.283	8.221	21.933
1987	8.667	16.189	28.206	11.899	47.434	55.450	68.867	62.536	48.403	15.433	4.764	3.917	31.049
1988	23.669	32.279	23.062	33.537	48.789	66.386	53.775	65.692	41.529	13.240	5.501	7.322	34.693
1989	21.128	25.172	25.838	26.918	19.035	40.298	54.431	50.274	19.303	6.374	5.464	12.266	25.610
1990	19.952	35.269	18.963	10.359	8.338	21.513	44.023	56.466	29.309	9.293	5.273	8.693	22.352
1991	13.047	44.002	62.391	44.869	37.150	33.242	38.819	47.041	22.445	8.034	10.175	6.622	30.675
Ave.	15.139	27.216	25.766	23.684	24.950	34.603	40.949	43.477	30.993	13.017	7.241	9.613	24.800

TABLE I. 5.3.3 MONTHLY AVERAGE OF GENERATED DISCHARGE (2/5)

Station Name: Jeriang Gauging Station (Unit: m3/s)

Hydrological Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual Average
1959	13.201	88.372	83.878	48.149	77.028	58.831	55.131	114.263	60.262	23.534	10.988	9.786	53.699
1960	54.014	72.127	43.986	59.513	60.290	129.360	88.560	89.660	65.019	31.918	23.175	26.290	62.122
1961	35.999	52.970	40.536	33.063	32.718	30.565	53.438	67.237	41.240	35.112	13.619	20.671	38.238
1962	15.208	59.134	46.713	62.210	53.625	68.773	89.562	68.560	37.856	24.918	11.426	15.435	46.873
1963	9.635	46.608	53.085	39.559	33.597	52.618	82.593	96.009	73.325	25.509	10.903	9.630	44.514
1964	19.494	55.352	43.658	40.530	39.796	94.328	57.943	94.536	49.569	17.843	9.774	8.458	44.352
1965	54.476	35.771	37.138	37.393	39.922	65.371	89.994	92.428	96.302	46.120	23.190	16.355	53.012
1966	19.529	50.072	48.175	33.140	32.676	42.812	71.721	70.416	63.769	60.441	17.068	12.649	43.738
1967	22.188	114.379	54.720	63.229	39.182	42.548	73.478	86.411	59.608	17.897	15.805	9.685	50.097
1968	16.308	29.784	27.941	63.988	45.880	48.248	72.881	57.254	28.553	26.928	16.875	15.050	37.644
1969	31.520	45.052	41.660	41.625	63.872	61.197	78.018	83.473	59.439	22.901	10.404	12.764	46.193
1970	14.661	52.868	42.053	43.841	44.897	68.143	67.330	71.237	58.862	36.292	20.707	72.047	49.652
1971	17.572	31.117	45.945	43.264	48.479	68.455	61.185	54.137	39.579	16.357	17.877	12.424	38.050
1972	30.407	41.258	45.983	32.998	29.987	75.973	87.746	106.620	83.314	36.441	15.062	14.337	50.139
1973	56.889	74.996	64.322	53.524	107.068	67.097	79.272	80.704	86.150	32.480	18.568	14.490	61.583
1974	28.519	41.942	26.080	28.540	34.730	63.771	65.683	30.279	17.319	16.774	12.059	20.051	32.256
1975	32.867	42.237	36.790	39.281	41.790	55.073	57.992	74.890	89.316	35.720	11.325	11.164	44.152
1976	26.118	77.485	56.669	58.264	42.244	51.965	74.428	79.192	49.674	33.611	10.911	8.002	47.613
1977	10.461	29.920	56.016	26.430	38.007	65.829	129.016	91.279	37.573	15.068	7.831	6.721	42.993
1978	10.566	32.107	19.182	45.534	32.571	42.964	51.169	39.326	20.181	6.179	3.718	1.539	25.574
1979	28.691	39.912	33.042	11.950	14.085	67.299	42.867	84.694	36.784	6.161	3.080	17.647	32.111
1980	6.214	37.290	36.567	24.933	55.131	51.775	117.929	87.086	58.173	17.672	5.406	6.063	42.284
1981	13.926	55.033	60.517	34.577	21.593	60.523	37.072	47.539	37.541	7.397	3.477	11.861	32.684
1982	20.231	54.704	35.455	31.185	19.003	60.384	70.898	84.585	60.073	18.471	5.101	7.950	39.160
1983	6.509	26.913	35.863	23.561	51.395	99.099	67.871	69.450	65.828	17.697	6.316	9.377	40.035
1984	35.840	29.535	23.385	74.090	33.559	25.183	63.478	50.020	30.538	16.200	12.702	33.971	35.921
1985	15.006	47.293	62.730	44.190	56.328	50.033	79.125	103.015	72.524	21.642	8.513	15.710	48.223
1986	29.386	32.219	28.565	19.544	15.297	47.982	127.131	114.762	72.716	23.162	8.063	17.477	44.878
1987	15.553	29.726	55.358	23.188	95.346	115.749	131.162	116.932	34.770	30.126	13.021	9.666	60.133
1988	56.316	59.213	42.511	68.833	93.445	119.958	94.140	114.616	66.698	22.128	11.736	12.123	63.689
1989	38.142	44.619	42.659	49.745	37.504	72.826	106.687	92.965	34.220	14.077	10.415	15.082	46.711
1990	29.740	60.125	35.031	21.233	17.563	45.859	83.152	110.130	45.026	16.865	9.159	12.238	40.612
1991	19.393	74.674	108.681	78.738	61.603	61.595	68.341	83.876	34.335	14.983	14.076	9.619	52.528
Ave.	25.290	50.450	45.906	42.425	45.946	64.611	78.091	82.060	55.034	23.897	11.891	15.040	45.196

TABLE I. 5.3.3 MONTHLY AVERAGE OF GENERATED DISCHARGE (3/5)

Station Name: Ldg. Victoria Gauging Station (Unit: m3/s)

Hydrological Year	Monthly Average												Annual Average
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
1959	43.797	180.801	169.667	102.284	142.868	119.815	143.012	246.833	130.910	45.338	25.539	26.842	115.223
1960	90.686	133.910	93.679	129.332	108.102	204.873	138.651	178.706	112.938	63.876	57.494	61.501	114.646
1961	81.006	135.615	92.552	66.635	72.171	84.634	153.158	175.822	118.148	89.779	30.759	54.092	96.516
1962	45.217	165.603	98.000	125.442	121.137	128.252	234.325	156.939	95.698	72.601	25.050	38.092	109.806
1963	28.063	127.774	90.904	73.567	62.376	125.532	198.091	245.625	156.926	55.409	26.887	20.240	101.118
1964	41.334	136.707	82.214	121.780	98.954	219.635	160.538	235.607	98.680	36.437	22.923	25.834	106.938
1965	128.597	106.776	67.632	81.649	122.936	150.952	245.764	244.641	212.348	93.265	60.584	47.658	130.613
1966	72.753	122.246	104.064	103.268	83.089	113.472	200.711	185.842	166.398	164.430	46.880	33.135	117.329
1967	73.078	220.897	113.691	107.462	80.398	107.066	190.816	213.217	139.304	42.139	33.989	27.328	112.721
1968	46.985	77.059	69.394	117.683	121.777	92.094	169.990	129.137	68.449	68.744	30.045	35.324	86.026
1969	80.814	135.256	122.273	93.645	147.522	119.235	259.418	237.834	161.199	71.500	31.880	35.285	125.253
1970	56.355	147.603	116.498	109.908	115.944	174.409	221.081	247.177	153.469	99.510	59.000	121.219	135.659
1971	45.345	73.259	111.330	89.086	128.918	191.838	182.530	140.839	140.423	57.003	50.880	31.649	103.675
1972	99.687	91.754	104.457	61.439	62.606	165.368	199.431	311.627	180.121	76.851	35.215	38.523	119.051
1973	146.772	177.623	147.420	114.789	194.309	124.035	188.322	138.002	202.099	75.645	46.152	36.912	138.246
1974	76.311	111.366	63.298	70.308	72.943	146.744	124.044	90.012	46.959	65.550	39.633	63.008	81.042
1975	86.796	114.088	73.734	109.582	77.928	145.381	138.843	176.288	191.453	76.612	30.026	35.557	106.171
1976	63.863	160.780	106.439	122.269	86.727	147.871	222.370	219.700	127.920	71.078	30.020	22.874	115.847
1977	22.032	80.226	107.582	43.202	88.888	145.462	312.690	180.396	80.519	37.956	21.306	23.051	93.680
1978	47.722	90.731	48.207	84.002	55.893	79.683	110.269	99.994	38.017	14.574	8.567	3.610	57.036
1979	80.765	85.739	76.214	45.707	38.536	148.257	83.746	192.313	68.833	10.796	5.984	32.707	72.267
1980	30.863	65.666	76.726	57.907	110.341	131.624	287.825	224.847	151.987	43.214	18.918	14.869	101.747
1981	70.974	144.694	122.248	71.622	48.739	165.999	94.261	111.640	60.512	15.967	9.231	14.350	77.640
1982	58.172	143.579	63.434	52.455	31.905	113.981	166.725	215.465	120.210	33.614	13.074	25.564	86.831
1983	10.273	123.053	90.981	61.257	102.541	230.678	139.845	124.417	100.867	25.909	14.157	23.759	87.680
1984	90.391	85.344	47.412	149.918	56.613	58.337	147.507	132.279	88.246	31.832	36.768	76.447	83.822
1985	36.648	129.833	102.822	82.562	90.694	96.785	196.055	251.064	144.673	41.617	20.431	34.318	102.739
1986	65.419	84.754	66.161	42.588	47.744	137.043	243.297	241.221	142.418	40.015	18.249	39.656	97.701
1987	35.250	84.515	107.730	47.871	185.774	223.703	303.576	291.850	198.081	61.143	39.205	31.157	134.341
1988	145.426	136.834	93.599	140.225	154.486	246.458	194.537	191.859	118.850	40.765	28.577	37.369	127.776
1989	132.415	124.355	88.266	118.468	73.880	170.402	246.455	201.970	72.899	38.448	31.264	32.453	111.186
1990	60.052	156.172	63.425	53.284	34.021	108.914	218.615	243.487	96.364	35.633	23.545	48.953	96.520
1991	65.249	194.551	200.077	149.789	120.719	133.885	155.348	172.850	62.636	33.194	37.821	24.437	112.621
Ave.	68.458	125.732	96.604	90.940	95.348	144.105	190.060	197.442	122.685	55.623	30.702	36.903	104.858

TABLE I. 5.3.3 MONTHLY AVERAGE OF GENERATED DISCHARGE (4/5)

Station Name: Kuala Pegang Gauging Station (Unit: m3/s)

Hydrological Year	Monthly Average												Annual Average
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
1959	6.151	36.826	30.391	20.492	21.436	23.015	34.265	40.118	26.335	8.142	4.772	5.533	21.512
1960	11.958	36.661	28.464	31.902	20.403	35.698	19.245	31.736	17.862	10.317	10.550	13.972	22.445
1961	14.344	52.106	32.069	13.286	16.225	21.665	39.302	33.372	24.001	19.227	6.490	12.247	24.310
1962	12.877	42.037	17.000	25.237	28.481	26.077	58.604	35.900	19.921	12.016	6.020	7.736	24.474
1963	11.146	31.437	16.568	13.676	15.504	26.725	37.013	56.428	22.708	7.336	5.168	3.557	20.614
1964	10.003	25.257	13.506	23.567	14.316	32.215	30.109	41.418	14.966	5.065	3.323	3.311	18.141
1965	31.825	23.683	24.482	23.356	33.061	28.506	49.578	37.435	32.272	12.112	12.592	6.478	26.346
1966	18.502	29.675	26.272	25.081	19.341	19.159	54.871	38.792	39.523	62.085	8.968	6.745	29.287
1967	13.616	43.161	22.198	17.591	13.943	23.931	48.358	57.435	27.073	7.747	5.766	4.079	23.784
1968	11.781	22.317	14.161	20.318	30.485	21.067	30.802	18.950	12.525	11.266	5.376	21.483	18.505
1969	17.959	36.632	31.074	24.646	47.766	23.309	82.414	58.413	31.936	13.224	7.455	5.875	31.914
1970	13.167	29.177	32.956	25.999	33.288	42.428	46.949	62.990	34.835	25.146	17.232	24.377	32.443
1971	11.668	19.941	28.183	26.091	25.636	47.266	36.927	36.284	35.551	15.307	12.120	8.419	25.294
1972	40.428	25.087	25.277	16.076	15.259	39.995	57.834	84.751	37.523	12.762	8.072	9.691	31.071
1973	61.827	54.011	33.536	27.708	38.791	25.525	49.204	49.462	63.293	23.940	12.664	8.412	38.020
1974	13.946	37.249	17.532	13.218	13.531	37.382	25.761	18.380	11.194	28.668	17.913	21.278	21.366
1975	34.986	52.477	25.449	36.478	17.776	27.574	34.497	39.324	50.532	16.779	7.836	14.997	30.758
1976	23.494	38.251	25.348	18.653	17.335	28.906	72.968	39.157	19.931	10.042	6.279	4.413	25.518
1977	4.376	20.184	22.876	10.907	17.008	23.688	70.536	26.057	11.248	5.898	4.310	5.428	18.652
1978	8.760	32.413	14.985	17.019	11.457	15.582	25.647	19.852	8.126	3.535	2.291	1.251	13.486
1979	18.407	19.207	14.583	11.981	8.946	44.474	16.753	42.390	13.524	3.039	1.318	13.408	17.255
1980	15.005	14.627	24.297	13.328	25.238	28.423	74.780	57.893	25.673	8.365	7.914	4.952	25.113
1981	24.413	41.757	20.786	10.309	7.666	33.782	20.655	18.670	12.240	4.495	3.131	2.687	16.743
1982	24.844	31.358	19.494	11.738	7.043	20.692	35.060	29.376	18.103	5.331	4.118	7.853	17.974
1983	4.434	41.289	22.964	16.212	27.137	69.036	34.188	30.837	21.882	7.398	4.995	6.462	23.920
1984	15.031	20.817	12.730	23.457	11.428	18.941	49.612	30.196	17.677	7.330	8.087	16.043	19.377
1985	10.078	34.526	21.825	11.553	22.427	19.264	51.908	78.793	24.733	7.108	5.233	5.678	24.497
1986	15.462	20.382	20.758	10.436	15.355	40.419	53.209	46.072	25.454	7.041	4.465	13.111	22.742
1987	11.553	23.602	35.541	13.318	33.020	55.883	87.349	60.168	38.262	8.518	9.291	6.101	31.912
1988	43.217	38.908	28.645	38.211	40.223	41.902	37.028	56.495	22.759	8.466	6.303	13.752	31.408
1989	25.276	28.001	20.675	31.357	14.621	32.849	50.817	35.693	11.729	7.930	5.939	5.256	22.589
1990	19.758	35.064	15.642	11.239	7.758	18.807	64.560	58.346	16.225	6.162	4.704	9.243	22.373
1991	13.659	59.464	26.651	22.340	19.663	19.218	29.110	37.314	10.358	5.821	11.285	4.695	21.660
Ave.	18.593	33.260	23.242	19.904	20.958	30.712	43.755	42.866	24.696	12.051	7.335	9.048	24.107

TABLE I. 5.3.3 MONTHLY AVERAGE OF GENERATED DISCHARGE (5/5)

Station Name: Lengkuas Gauging Station (Unit: m3/s)

Hydrological Year	Monthly Average												Annual Average
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
1959	3 864	81.175	32 128	12 749	14.867	18 342	33 274	83.157	43.403	4 830	4.467	4.177	28 101
1960	7 330	43 643	5.437	8 015	16 071	35.407	15 070	29 048	9 222	4.771	4 835	4 345	15 308
1961	4.221	9 521	6 036	4 445	4.212	5 975	41.169	22 635	11.160	7.448	4 196	6 027	10 643
1962	4.461	22 739	6 810	22 220	18.450	56 601	66 261	20 882	4.711	4 503	4.100	12 834	20 437
1963	3 975	12 137	9.761	4 868	4 280	18 917	40 869	61.109	17.732	4.203	3 881	3 555	15 416
1964	3 645	38 970	5 984	4.531	6 806	38.400	49.751	64.241	7.914	3 907	3 545	3 301	19 287
1965	12 056	17.973	5 989	4 255	28 658	36 060	72.715	63 139	73 828	7.484	4 226	3 642	27.696
1966	4 847	23 672	17.899	5 519	4.578	22 524	72.464	30.131	33 210	14.817	4 393	4 061	19 931
1967	5 655	67.654	33 267	18 050	8 320	21.072	80 054	44 274	14.196	4 583	4 620	12.117	26 274
1968	25 811	17.415	5 797	28 571	25.466	36 979	81.236	17.519	6 959	8 665	4.807	6.129	22 263
1969	11.827	21.635	13 983	24 944	46 643	33 216	57.537	68 654	13.166	5 345	4 975	4 609	25 643
1970	7.766	43.204	19 867	20 375	26 211	58 085	56 416	47.732	31 848	10 860	18 547	44.585	32 223
1971	5.196	7.352	14 280	10.169	37.457	39 919	56 852	28 528	11 373	5.721	5 639	5.180	13 012
1972	15.179	13 360	6 571	5 499	5 701	109 295	51.811	116 030	29.136	7.752	5 510	5.179	30 789
1973	30 803	71.364	43.483	8 914	53 813	20 205	49 560	47.941	40 361	6 416	6 205	5 699	32 241
1974	5.460	15 330	12 693	7 652	6 822	53 348	38 916	26 251	9 219	7.483	6 067	6 883	16 339
1975	6 872	8.432	15 583	35 917	12.466	43 163	46 604	63 044	57.973	8.551	6 185	5 830	25 929
1976	20.168	81 862	10.920	30.130	10 916	36 425	62 617	58 088	11.820	6 419	6 009	5 587	28 565
1977	5 226	32 645	37.714	6.174	12 625	19 865	104.792	32 954	5.700	5 329	4.990	5 097	22 833
1978	4.951	28 321	12 980	19 511	9 346	45 567	42 208	32 332	6 909	5.225	4.906	4 551	18.111
1979	33 545	60 863	27.138	8 871	15 658	67.501	12 673	54 343	10 313	5.147	4.736	4 585	25 340
1980	24.677	27.946	18 617	5 380	14.233	22 358	84.856	61 053	16 568	5 300	4 904	4 536	24.284
1981	6 709	26 904	15.435	4 685	4.538	17.752	8.144	27.474	11.142	4.491	4 093	3 966	11.277
1982	34 636	73.941	17.227	20 630	5 105	18.417	51 590	61.879	28.709	4.953	4 346	4 228	27.262
1983	3 808	25.482	25.413	4.824	19 574	68 231	75 606	63 344	21.183	4 528	4 201	4.148	26 671
1984	5 533	4.322	3 992	23.766	6 062	6 678	27.630	17.700	19 616	5 257	4.262	5 901	10 974
1985	4.882	25.181	25 258	4.747	12 105	18 362	50 965	73 730	14 676	4.558	4.142	3 925	20 230
1986	29 675	11.408	6 680	4 009	5 245	24.437	112 533	63 378	20 319	4.336	3 922	5 926	24.416
1987	3 696	10 060	20 685	3.734	61.704	90 923	98 964	76 603	79 038	4 352	4 063	3 806	38 214
1988	22.476	29 902	5 572	70 215	38 714	107 686	41 060	79 558	25.496	4 527	4.130	3 894	36 171
1989	6 535	35.185	13 664	36 550	5.970	47.426	86.133	20.477	4 641	4 301	4.290	4 016	22 586
1990	4 934	49.441	6.222	3 959	3 891	4 291	56 836	60 258	8 283	4 038	3 667	8 423	17 959
1991	10 863	101 670	66 268	70 585	17.855	22 376	51.423	33 388	5.167	4.360	4 242	14 080	33 686
Ave.	11 556	34.567	17 253	16 499	17.105	38 358	56 927	50 028	21.364	5 896	5 064	6 823	23 524

TABLE I. 5.3.4 FLOW-DURATION TABLE (1/5)

Station Name: Nami (C.A.=1,220 km2)

Hydrological	Annual Basin	Discharge# (m3/s)						
Year	Rainfall(mm)	Min.	Q355	Q275	Q185	Q95	Max.	Mean
1959	2305.5	4.9	5.4	11.0	27.6	39.3	161.4	29.8
1960	2700.5	5.2	7.2	22.0	33.1	43.2	464.6	35.9
1961	1957.1	6.4	6.7	13.9	19.2	28.1	60.3	21.9
1962	2092.4	5.8	6.1	13.0	24.3	35.3	227.4	27.1
1963	2112.2	5.4	5.5	10.6	21.3	36.2	127.7	25.1
1964	2129.8	4.8	5.1	9.2	23.4	34.0	197.8	25.5
1965	2323.1	6.2	6.5	15.9	23.9	39.1	141.6	29.4
1966	2057.5	6.0	6.1	13.0	20.7	31.2	71.2	23.4
1967	2199.9	5.7	5.9	11.5	25.3	38.2	142.6	28.4
1968	2061.5	5.3	5.4	11.1	19.6	26.4	85.6	20.8
1969	1956.9	4.9	5.2	12.5	23.1	33.9	81.0	24.6
1970	2398.2	4.4	4.7	17.3	26.6	36.4	149.4	28.1
1971	1875.4	5.0	5.3	12.8	21.0	27.4	70.7	21.3
1972	2430.7	4.8	5.8	15.4	24.5	40.3	89.2	29.2
1973	2624.7	7.2	7.5	23.4	36.8	46.7	100.1	35.6
1974	1715.7	5.6	5.9	8.4	14.5	21.2	174.3	18.0
1975	2043.1	5.3	5.6	11.8	20.4	33.4	142.6	24.6
1976	1970.2	4.4	4.7	12.1	24.0	34.4	103.4	24.9
1977	2033.1	3.9	4.1	6.5	17.4	35.3	103.8	24.3
1978	1392.9	1.2	1.5	3.7	11.4	17.4	40.7	12.2
1979	1917.1	0.9	1.2	3.8	13.7	25.4	61.2	17.5
1980	2026.5	0.8	1.2	5.6	17.1	31.4	77.6	20.5
1981	1332.2	0.7	0.9	5.7	16.7	24.8	70.2	18.1
1982	1990.1	0.8	1.1	6.3	14.3	26.0	75.3	18.7
1983	2178.8	0.7	1.4	6.0	16.1	31.7	166.1	21.5
1984	2076.4	2.1	2.4	10.2	14.9	24.6	77.1	19.1
1985	2188.8	2.2	2.8	8.3	25.0	37.0	76.8	25.8
1986	2018.4	2.6	2.7	5.3	12.6	23.1	285.3	21.9
1987	2444.4	2.3	2.5	5.7	24.8	48.4	150.5	31.0
1988	2587.7	3.5	4.9	16.1	28.2	46.2	428.0	34.7
1989	2191.7	4.4	4.7	14.1	21.7	31.9	83.9	25.6
1990	1906.7	4.0	4.3	8.4	17.5	31.3	95.2	22.4
1991	2384.4	4.3	4.9	11.9	30.9	41.0	392.8	30.7
Average	2127.8	4.0	4.4	11.0	21.6	33.5	144.7	24.8
Max.	2700.5	7.2	7.5	23.4	36.8	43.4	464.6	36.6
Min.	1392.9	0.7	0.9	3.7	11.4	17.4	40.7	12.2

TABLE I. 5.3.4 FLOW-DURATION TABLE (2/5)

Station Name: Jeniang (C.A.=1,740 km2)

Hydrological	Annual Basin	Discharge# (m3/s)						
Year	Rainfall(mm)	Min.	Q355	Q275	Q185	Q95	Max.	Mean
1959	2367.3	7.7	8.5	18.6	47.6	72.8	418.8	53.7
1960	2748.6	7.9	12.3	37.6	57.2	76.6	667.8	62.1
1961	1960.6	10.4	10.9	24.0	33.5	52.7	104.5	39.2
1962	2125.3	8.5	9.3	21.7	41.9	63.0	313.2	46.9
1963	2163.4	7.4	7.8	14.9	37.2	63.3	137.2	44.5
1964	2196.0	6.4	7.2	13.9	40.3	58.5	400.0	44.4
1965	2440.6	10.5	11.9	30.7	45.3	70.9	174.3	53.0
1966	2139.6	10.0	10.7	24.4	37.1	62.0	122.8	43.7
1967	2213.7	8.4	9.2	17.7	42.5	72.2	378.2	50.1
1968	2181.7	7.9	8.7	20.3	32.8	49.7	120.8	37.6
1969	2081.3	7.7	8.6	23.4	40.9	61.0	357.7	46.2
1970	2423.5	7.3	9.2	30.8	49.4	65.4	320.6	49.7
1971	1929.0	8.0	8.8	19.7	36.3	49.3	309.2	38.0
1972	2418.3	7.8	9.7	24.7	38.6	74.3	249.2	50.1
1973	2587.4	11.8	12.8	37.8	64.1	79.1	206.8	61.6
1974	1830.0	9.3	10.1	19.1	29.1	37.0	122.8	32.3
1975	2111.7	8.5	9.2	22.5	39.0	64.2	319.3	44.2
1976	2124.5	6.7	7.5	20.8	46.7	71.1	159.3	47.6
1977	2104.6	5.6	6.1	11.1	28.8	62.2	584.0	43.0
1978	1560.5	0.5	1.1	6.7	24.1	41.9	61.9	25.6
1979	1994.0	0.3	1.0	10.2	25.8	46.1	111.7	32.1
1980	2258.5	0.8	1.9	11.9	36.3	57.4	268.0	42.3
1981	1936.0	2.0	2.6	12.7	28.0	45.1	121.5	32.7
1982	2138.1	2.7	3.4	16.8	29.9	55.7	132.3	39.2
1983	2210.2	2.4	4.0	13.7	32.7	57.3	338.8	40.0
1984	2112.1	5.7	6.3	19.5	29.7	46.2	279.3	35.9
1985	2245.2	6.0	6.6	19.1	45.6	69.5	156.8	43.2
1986	2173.1	6.3	7.0	15.1	28.8	59.1	466.2	44.9
1987	2603.6	5.8	8.8	16.5	45.1	92.8	451.5	60.1
1988	2597.6	8.7	10.1	30.6	54.0	83.5	682.4	63.7
1989	2184.2	8.0	8.7	25.3	33.7	54.2	167.8	46.7
1990	1966.6	6.4	7.2	18.3	30.4	50.9	248.1	40.6
1991	2379.6	6.9	7.9	20.0	51.1	67.0	750.9	52.5
Average	2197.2	6.7	7.7	20.3	39.1	61.6	294.1	45.2
Max.	2748.6	11.8	12.8	37.8	64.1	92.8	750.9	63.7
Min.	1560.5	0.3	1.0	6.7	24.1	37.0	61.9	25.6

Note) #. Generated Natural Flow.
Min.: Minimum discharge in a year.
Qn: Discharge of n-day exceedance in a year.
Max.: Maximum discharge in a year.
Mean: Mean discharge in a year.

TABLE I. 5.3.4 FLOW-DURATION TABLE (3/5)

Station Name: Ldg. Victoria (C.A.=4,010 km2)

Hydrological Year	Annual Basin Rainfall(mm)	Discharge# (m3/s) Min.	Q355	Q275	Q185	Q95	Max.	Mean
1959	2473.9	18.2	21.2	51.0	106.9	155.0	461.9	115.2
1960	2600.3	20.9	27.2	72.1	107.7	146.1	330.8	114.6
1961	2241.3	24.8	26.3	50.2	85.0	132.3	230.9	96.5
1962	2314.1	21.9	23.9	54.3	86.1	151.5	386.6	109.8
1963	2249.7	17.8	19.0	39.8	79.3	143.7	299.2	101.1
1964	2418.2	16.0	18.0	38.4	73.4	145.0	383.5	107.0
1965	2751.0	25.9	30.3	69.4	116.4	168.3	398.8	130.6
1966	2428.7	25.6	30.5	65.9	101.9	157.0	338.4	117.3
1967	2279.1	21.2	23.2	53.7	91.0	170.9	323.0	112.7
1968	2255.9	20.8	21.6	46.9	79.6	108.2	255.1	86.0
1969	2506.3	23.4	24.7	57.6	104.9	167.9	354.2	125.3
1970	2783.9	25.9	31.7	75.7	124.1	183.2	346.8	135.7
1971	2209.0	26.5	28.0	49.2	83.4	136.9	542.0	103.7
1972	2486.2	26.1	27.4	43.6	86.4	175.8	394.2	119.1
1973	2630.4	30.0	32.6	85.7	131.1	187.6	330.2	138.2
1974	2115.9	27.2	29.0	50.3	74.2	94.3	263.5	81.0
1975	2293.3	25.4	26.3	55.0	88.5	156.1	290.6	105.2
1976	2309.3	13.4	21.7	51.1	95.3	178.4	315.7	115.6
1977	2209.4	15.8	16.9	26.7	53.4	133.7	508.1	95.7
1978	1656.0	0.2	2.1	17.2	51.8	83.0	181.4	57.0
1979	2114.3	0.7	2.8	23.9	58.4	98.4	233.2	72.3
1980	2512.7	0.6	10.0	30.7	75.1	135.7	410.3	101.7
1981	2035.1	5.0	6.0	26.1	66.7	119.2	246.8	77.6
1982	2285.6	4.9	8.2	29.6	64.4	131.0	274.2	86.8
1983	2290.3	5.0	6.6	25.8	76.8	127.0	347.8	87.7
1984	2331.5	15.4	16.9	43.8	68.8	111.5	341.9	83.8
1985	2278.6	14.7	15.9	38.3	78.2	156.0	346.6	102.7
1986	2256.7	13.8	14.9	29.5	72.5	123.6	354.5	97.7
1987	2822.1	12.0	21.1	39.2	97.8	238.1	405.3	134.3
1988	2571.9	24.2	25.4	64.9	111.5	176.4	543.9	127.8
1989	2344.3	21.7	23.2	56.0	96.3	137.0	371.1	111.2
1990	2197.8	16.9	18.9	36.9	68.7	124.7	465.2	96.5
1991	2378.7	17.3	19.0	46.8	95.9	143.5	815.1	112.6
Average	2354.7	18.0	20.3	46.9	87.0	145.4	366.7	104.8
Max.	2822.1	30.0	32.6	85.7	131.1	238.1	815.1	138.2
Min.	1656.0	0.2	2.1	17.2	51.8	83.0	181.4	57.0

TABLE I. 5.3.4 FLOW-DURATION TABLE (4/5)

Station Name: Kuala Pegang (C.A.=704 km2)

Hydrological Year	Annual Basin Rainfall(mm)	Discharge# (m3/s) Min.	Q355	Q275	Q185	Q95	Max.	Mean
1959	2175.2	3.0	3.2	7.6	18.6	29.2	252.3	21.5
1960	2322.7	5.1	5.4	12.0	17.5	25.5	253.9	22.4
1961	2322.6	5.6	6.0	11.9	18.0	26.5	416.0	24.3
1962	2179.5	4.5	4.9	11.2	15.8	23.1	202.0	24.5
1963	1997.0	3.0	3.3	7.1	15.9	28.9	139.6	20.6
1964	1998.3	1.8	2.3	5.8	13.2	22.2	147.9	18.1
1965	2533.3	5.3	5.7	15.0	23.6	31.6	154.3	26.3
1966	2517.1	5.4	6.4	15.9	21.6	33.8	586.7	29.3
1967	2098.4	3.6	3.9	7.9	17.2	30.2	276.9	23.8
1968	2157.0	3.5	4.7	9.7	15.5	22.5	174.2	19.5
1969	2616.0	5.1	5.7	13.7	24.3	39.4	273.9	31.9
1970	2832.7	6.9	8.0	16.9	29.4	40.2	163.0	32.4
1971	2245.3	7.1	7.3	13.0	22.4	32.1	209.4	25.3
1972	2524.8	6.1	6.7	11.8	18.1	41.1	265.7	31.1
1973	2965.6	7.4	8.0	20.0	29.2	46.7	397.4	38.0
1974	2207.4	7.8	9.1	12.4	16.1	23.9	123.6	21.4
1975	2449.1	7.0	7.6	14.8	25.0	38.0	221.2	30.8
1976	2093.1	3.6	4.1	10.2	18.0	30.0	266.2	25.5
1977	2004.0	2.6	3.0	5.3	12.7	23.1	267.8	18.7
1978	1600.9	0.6	0.7	4.6	11.6	16.5	291.5	13.5
1979	2001.3	0.6	1.1	5.6	12.8	20.2	132.6	17.3
1980	2493.9	0.9	2.7	10.4	17.1	30.5	336.1	25.1
1981	1827.7	1.8	2.2	5.3	13.0	21.2	248.9	16.7
1982	2070.6	2.8	3.0	6.8	15.0	25.1	140.6	18.0
1983	2334.0	2.3	2.7	6.8	16.9	30.8	358.9	23.9
1984	2122.7	4.9	5.3	9.6	14.2	22.2	197.4	19.4
1985	2175.0	3.7	4.2	7.4	12.4	29.3	482.4	24.5
1986	2192.4	3.4	3.8	8.5	16.4	32.4	149.8	22.7
1987	2748.9	3.3	5.6	8.0	19.3	40.6	317.2	31.9
1988	2638.6	5.2	5.5	14.2	24.2	34.5	417.1	31.4
1989	2089.7	4.4	4.8	8.7	18.5	29.1	190.9	22.6
1990	2129.7	3.5	3.9	7.5	13.9	26.3	300.9	22.4
1991	2101.1	3.2	3.8	7.7	15.9	23.9	209.3	21.7
Average	2265.6	4.1	4.7	10.1	18.1	29.6	253.7	24.1
Max.	2965.6	7.8	9.1	20.0	29.4	46.7	586.7	38.0
Min.	1600.9	0.6	0.7	4.6	11.6	16.5	123.6	13.5

Note) # : Generated Natural Flow.
Min.: Minimum discharge in a year.
Qn: Discharge of n-day exceedance in a year.
Max.: Maximum discharge in a year.
Mean: Mean discharge in a year.

TABLE I. 5.3.4 FLOW-DURATION TABLE (5/5)

Station Name: Lengkuas (C.A.=1,270 km2)

Hydrological Year	Annual Basin Rainfall(mm)	Discharge# (m3/s)						
		Min.	Q355	Q275	Q185	Q95	Max.	Mean
1959	2060.0	3.8	3.8	4.7	12.2	23.6	379.9	29.1
1960	1753.7	4.1	4.1	4.5	7.1	17.5	130.3	15.3
1961	1484.8	4.0	4.0	4.2	4.5	10.1	99.7	10.6
1962	1761.2	3.7	3.8	4.4	6.4	17.7	281.3	20.5
1963	1577.7	3.5	3.5	3.9	4.5	16.6	187.7	15.4
1964	1752.6	3.1	3.2	3.6	5.0	21.7	132.4	19.3
1965	2156.0	3.4	3.4	4.2	10.2	27.5	252.3	27.7
1966	1836.8	3.8	3.8	4.2	6.6	19.7	248.5	20.0
1967	2033.4	3.8	3.8	4.5	8.9	25.9	294.6	26.3
1968	2061.2	4.4	4.5	5.2	11.1	25.5	179.7	22.3
1969	1938.4	4.5	4.6	5.4	13.8	24.6	209.9	25.6
1970	2354.3	4.5	4.5	8.8	20.8	39.5	238.6	32.2
1971	1695.1	5.0	5.0	5.4	7.8	17.3	205.9	19.0
1972	2094.8	5.0	5.0	5.3	6.6	25.8	258.8	30.8
1973	2265.9	5.0	5.6	6.3	19.6	30.4	236.3	32.2
1974	1789.0	5.4	5.4	6.0	7.3	15.7	208.2	16.3
1975	1978.4	5.7	5.7	6.4	11.3	26.5	309.3	25.9
1976	1870.1	5.4	5.5	6.2	9.7	31.5	232.7	28.6
1977	1674.4	4.6	4.7	5.3	5.8	20.8	270.3	22.9
1978	1676.1	4.4	4.5	5.0	7.6	19.6	228.1	18.1
1979	1300.4	4.4	4.5	5.3	11.0	24.2	243.0	25.3
1980	1916.5	4.4	4.4	5.0	11.1	26.0	206.1	24.3
1981	1375.0	3.8	3.9	4.5	5.0	12.7	141.6	11.3
1982	2035.2	3.8	3.9	4.6	10.4	28.6	246.6	27.3
1983	1987.4	3.7	3.8	4.2	10.6	25.4	168.4	26.7
1984	1639.9	3.9	3.9	4.1	4.6	9.8	176.9	11.0
1985	1696.3	3.7	3.7	4.2	7.0	20.0	192.8	20.2
1986	1889.1	3.6	3.7	4.0	6.3	18.3	358.5	24.4
1987	2273.8	3.5	3.6	3.8	6.7	43.0	402.6	38.2
1988	2265.4	3.7	3.9	4.5	10.5	30.4	546.5	36.2
1989	1864.0	3.7	3.8	4.3	6.1	20.1	201.7	22.6
1990	1643.4	3.4	3.5	3.9	4.2	13.9	235.1	18.0
1991	2300.2	3.4	3.9	4.6	12.1	32.1	430.7	33.7
Average	1897.9	4.1	4.2	4.9	8.9	23.3	246.6	23.5
Max.	2354.3	5.7	5.7	8.8	20.8	43.0	546.5	38.2
Min.	1375.0	3.1	3.2	3.6	4.2	9.8	99.7	10.6

Note) #: Generated Natural Flow.
Min.: Minimum discharge in a year.
Qn: Discharge of n-day exceedance in a year.
Max.: Maximum discharge in a year.
Mean: Mean discharge in a year.

TABLE I. 6.1.1 COEFFICIENTS OF THIESSEN'S POLYGON FOR FLOOD RUNOFF ANALYSIS

	TYPE-I*					TYPE-II**			
BASIN	6108001	5808001	5806066	5507076	5504035	6108001	5808001	5806066	5507076
I. SUB-BASIN									
DB1	0.209	0.791				0.209	0.791		
DB2	1.000					1.000			
DB3	1.000					1.000			
DB4	1.000					1.000			
MB1-1	1.000					1.000			
MB1-2	0.728	0.272				0.728	0.272		
MB2	1.000					1.000			
MB3	0.092	0.020	0.888			0.092	0.020	0.888	
MB4			1.000					1.000	
MB5			1.000					1.000	
MB6			0.457	0.543				0.457	0.543
MB7			0.391	0.609				0.391	0.609
MB8				1.000					1.000
MB9				0.968	0.032				1.000
MB10			0.020	0.390	0.590			0.020	0.980
MB11					1.000				1.000
MB12					1.000				1.000
BB1	0.167	0.827	0.006			0.167	0.827	0.006	
CB1		1.000					1.000		
CB2		0.176	0.824				0.176	0.824	
CB3		0.312	0.688				0.312	0.688	
CB4			1.000					1.000	
CB5		0.149	0.851				0.149	0.851	
CB6			1.000					1.000	
KB1		1.000					1.000		
KB2		1.000					1.000		
KB3		0.716		0.284			0.716		0.284
KB4		0.275		0.725			0.275		0.725
KB5				1.000					1.000
KB6		0.314		0.686			0.314		0.686
KB7				1.000					1.000
KB8				1.000					1.000
SB1				1.000					1.000
SB2				1.000					1.000
RB1				1.000					1.000
II.REF.POINT#									
JENIANG	0.597	0.243	0.160			0.597	0.243	0.160	
J.S.OMAR	0.312	0.302	0.196	0.190		0.312	0.302	0.196	0.190
LDG.VICTORIA	0.259	0.251	0.163	0.327		0.259	0.251	0.163	0.327
K.PEGANG		0.590		0.410			0.590		0.410
SIK		0.902	0.098				0.902	0.098	

Note) *: Type-I using 5 rainfall stations, **: Type-II using 4 rainfall stations.
#: Including Muda dam basin.

TABLE I. 6.1.2 ANNUAL MAXIMUM RAINFALL

(Unit:mm)

No.	Calender Year	Jeniang G.S. 3-Day	J.S. Omar G.S. 3-Day	Ldg.Victoria G.S. 3-Day	K.Pegang G.S. 1-Day	Sik 1-Day
1	1959	163.4	132.6	133.0	53.7	63.7
2	1960	182.4	127.7	108.5	53.6	91.5
3	1961	86.5	80.0	71.6	75.7	60.1
4	1962	127.4	100.3	101.0	60.4	75.6
5	1963	107.8	89.9	79.8	46.9	75.3
6	1964	110.7	91.6	100.4	52.7	53.9
7	1965	110.1	90.2	97.5	55.1	67.4
8	1966	98.7	92.1	84.4	67.7	64.3
9	1967	153.1	145.0	139.8	103.2	80.2
10	1968	113.8	82.6	79.2	33.9	47.0
11	1969	129.4	126.6	116.3	68.0	63.3
12	1970	122.4	93.2	87.6	42.7	57.5
13	1971	143.8	139.8	141.9	67.1	86.1
14	1972	107.6	93.2	88.6	48.3	84.2
15	1973	135.0	120.5	110.8	92.3	89.8
16	1974	98.4	75.1	72.0	61.4	48.6
17	1975	147.8	126.4	119.2	67.3	65.5
18	1976	118.2	104.7	112.8	63.0	56.9
19	1977	133.2	106.3	103.3	58.6	85.8
20	1978	62.7	74.8	71.6	55.3	63.2
21	1979	101.8	78.5	73.0	41.5	62.0
22	1980	98.6	89.2	91.0	67.9	53.0
23	1981	100.5	88.2	78.8	56.3	51.0
24	1982	113.8	87.5	91.3	47.6	52.5
25	1983	151.2	118.0	108.4	65.7	61.8
26	1984	100.2	92.4	100.8	54.0	65.9
27	1985	112.6	111.4	106.2	98.5	83.5
28	1986	128.2	103.8	97.3	45.5	76.5
29	1987	127.6	104.4	108.2	61.2	60.5
30	1988	182.1	157.3	145.3	80.5	82.0
31	1989	115.4	98.6	97.0	52.4	62.9
32	1990	98.3	106.1	107.3	52.5	92.3
33	1991	161.4	121.2	122.8	44.0	78.4
34	1992	120.7	142.2	135.3	68.7	100.8

TABLE I. 6.1.3 PROBABLE BASIN RAINFALL

(Unit:mm)

Return Period (Year)	Jeniang G.S. 3-Day	J.S.Omar G.S. 3-Day	Ldg.Victoria G.S. 3-Day	K.Pegang G.S. 1-Day	Sik 1-Day
2	119.7	103.6	100.4	58.9	68.6
5	144.0	122.6	119.1	72.4	81.8
10	158.6	133.8	130.3	80.6	89.6
20	171.7	143.9	140.3	88.1	96.6
30	179.0	149.5	145.8	92.3	100.5
50	187.9	156.2	152.5	97.3	105.2
100	199.4	165.0	161.2	104.1	111.3
200	210.7	173.4	169.6	110.6	117.2

Note) Method: Logarithmic Normal Distribution.

TABLE I. 6.3.1 ESTIMATED PARAMETERS OF STORAGE FUNCTION MODEL

I. RIVER BASIN MODEL

River Basin	Area (km2)	K	P	Tl	f_1	f_2	Rsa (mm)
DB1	365.1	66.9	0.333	0.9	0.4	0.9	150
DB2	275.5	67.7	0.333	0.5	0.4	0.9	150
DB3	269.8	108.2	0.333	1.6	0.4	0.9	150
DB4	73.6	53.4	0.333	0.0	0.4	0.9	150
MB1-1	129.0	62.2	0.333	0.0	0.4	0.9	150
MB1-2	107.0	76.2	0.333	0.5	0.4	0.9	150
MB2	96.7	81.9	0.333	0.0	0.4	0.9	150
MB3	211.8	60.5	0.333	0.2	0.4	0.9	150
MB4	89.0	90.7	0.333	0.1	0.4	0.9	150
MB5	63.8	31.3	0.333	0.0	0.8	1.0	50
MB6	262.6	48.2	0.333	0.6	0.8	1.0	50
MB7	60.3	82.2	0.333	0.4	0.8	1.0	50
MB8	25.8	30.6	0.333	0.0	0.8	1.0	50
MB9	28.4	105.4	0.333	0.0	0.8	1.0	50
BS1	122.5	56.5	0.333	0.6	0.4	0.9	150
CB1	135.2	46.7	0.333	0.2	0.4	0.9	80
CB2	18.2	33.6	0.333	0.0	0.4	0.9	80
CB3	57.3	75.6	0.333	0.2	0.4	0.9	80
CB4	22.0	22.4	0.333	0.0	0.4	0.9	80
CB5	68.4	78.2	0.333	0.2	0.4	0.9	80
CB6	33.8	47.6	0.333	0.0	0.4	0.9	80
KB1	147.6	58.5	0.333	0.7	0.4	0.9	80
KB2	162.0	45.6	0.333	0.2	0.4	0.9	80
KB3	79.1	45.4	0.333	0.2	0.4	0.9	80
KB4	86.7	32.8	0.333	0.0	0.4	0.9	80
KB5	146.8	45.1	0.333	0.6	0.4	0.9	80
KB6	81.8	46.4	0.333	0.2	0.4	0.9	80
KB7	121.0	42.8	0.333	0.3	0.4	0.9	80
KB8	43.4	117.1	0.333	0.0	0.4	0.9	80
SB1	264.6	75.2	0.333	0.4	0.8	1.0	50
SB2	246.9	92.2	0.333	1.1	0.8	1.0	50
RB1	114.3	123.6	0.333	0.8	0.8	1.0	50

Note) K,p : Constant parameters,
Tl : Lag time,
f_1 : Primary run-off ratio,
f_2 : Saturation run-off ratio,
Rsa : Saturation rainfall.

II. RIVER CHANNEL MODEL

River Channel	Channel Length (km)	Channel Slope	Channel Width (m)	K	P	Tl	Tlz
OC1	23.0	1/600	25	27.5	0.6	0.4	6.5
DC2 #	12.0	1/700	25	15.0	0.6	0.2	3.4
MC1-1	18.6	1/900	25	25.1	0.6	0.4	5.2
MC1-2	5.2	1/1700	25	8.5	0.6	0.2	1.4
MC2	18.9	1/1700	30	33.1	0.6	0.6	5.1
MC3	21.0	1/1300	50	41.6	0.6	0.6	5.7
MC4	11.8	1/12300	70	52.6	0.6	1.0	2.5
MC5	11.3	1/2700	80	16.1	0.7	0.4	3.0
MC6	26.7	1/3100	80	55.4	0.7	1.1	6.9
MC7	6.1	1/1600	90	13.6	0.8	0.2	1.6
MC8	11.0	1/40700	90	42.1	0.8	1.6	1.7
MC9	6.5	1/2500	100	11.3	0.8	0.2	1.8
CC1	7.0	1/1000	25	12.2	0.6	0.2	1.9
CC2	7.5	1/3800	30	28.0	0.7	0.3	2.0
CC3	8.0	1/3800	30	29.8	0.7	0.4	2.0
KC1	16.0	1/500	25	22.7	0.6	0.3	1.2
KC2	12.3	1/700	30	20.7	0.6	0.2	0.9
KC3	4.6	1/1500	40	11.0	0.6	0.1	0.4
KC4	16.1	1/1400	50	40.8	0.7	0.4	1.1
KC5	12.7	1/1400	50	32.3	0.8	0.3	0.9
SC1	24.4	1/1300	30	65.8	0.7	0.6	6.7

Note) #. This channel is applied instead of Muda dam reservoir in the runoff calculation.

TABLE I. 6.4.1 RAINFALL ADJUSTMENT RATE (1/5)

Basin : Sik

Flood Pattern	Actual Rainfall (mm)	R^5 81.8	R^{10} 89.6	R^{20} 96.6	R^{50} 105.2	R^{100} 111.3
1979	73.06	1.12	1.23	1.32	1.44	1.52
1980	100.68	0.81	0.89	0.96	1.04	1.11
1982	75.54	1.08	1.19	1.28	1.39	1.47
1983	52.32	1.56	1.71	1.85	2.01	2.13
1984	76.61	1.07	1.17	1.26	1.37	1.45
1985	117.89	0.69	0.76	0.82	0.89	0.94
1986	96.42	0.85	0.93	1.00	1.09	1.15
1987	82.11	1.00	1.09	1.18	1.28	1.36
1988	72.23	1.13	1.24	1.34	1.46	1.54
1989	58.65	1.39	1.53	1.65	1.79	1.90
1990	95.66	0.86	0.94	1.01	1.10	1.16

Note) R^N : Probable rainfall of N-year return period.

TABLE I. 6.4.1 RAINFALL ADJUSTMENT RATE (2/5)

Basin : Kuala Pegang Gauging Station

Flood Pattern	Actual Rainfall (mm)	R^5 72.4	R^{10} 80.6	R^{20} 88.1	R^{50} 97.3	R^{100} 104.1
1979	22.06	3.28	3.65	3.99	4.41	4.72
1980	71.40	1.01	1.13	1.23	1.36	1.46
1982	60.74	1.19	1.33	1.45	1.60	1.71
1983	58.00	1.25	1.39	1.52	1.68	1.79
1984	54.92	1.32	1.47	1.60	1.77	1.90
1985	41.61	1.74	1.94	2.12	2.34	2.50
1986	65.08	1.11	1.24	1.35	1.50	1.60
1987	34.55	2.10	2.33	2.55	2.82	3.01
1988	71.84	1.01	1.12	1.23	1.35	1.45
1989	68.38	1.06	1.18	1.29	1.42	1.52
1990	58.12	1.25	1.39	1.52	1.67	1.79

TABLE I. 6.4.1 RAINFALL ADJUSTMENT RATE (3/5)

Basin : Jeniang Gauging Station

Flood Pattern	Actual Rainfall (mm)	R^5 144.0	R^{10} 158.6	R^{20} 171.7	R^{50} 187.9	R^{100} 199.4
1979	65.84	2.19	2.41	2.61	2.85	3.03
1980	103.87	1.39	1.53	1.65	1.81	1.92
1982	110.79	1.30	1.43	1.55	1.70	1.80
1983	150.54	0.96	1.05	1.14	1.25	1.32
1984	53.01	2.72	2.99	3.24	3.54	3.76
1985	124.04	1.16	1.28	1.38	1.51	1.61
1986	112.18	1.28	1.41	1.53	1.67	1.78
1987	144.33	1.00	1.10	1.19	1.30	1.38
1988	177.66	0.81	0.89	0.97	1.06	1.12
1989	100.63	1.43	1.58	1.71	1.87	1.98
1990	105.79	1.36	1.50	1.62	1.78	1.88

TABLE I. 6.4.1 RAINFALL ADJUSTMENT RATE (4/5)

Basin : Jam. Syed Omar Gauging Station

Flood Pattern	Actual Rainfall (mm)	R^5	R^{10}	R^{20}	R^{50}	R^{100}
		Probable Rainfall (mm)				
		122.6	133.8	143.9	156.2	165.0
1979	79.93	1.53	1.67	1.80	1.95	2.06
1980	83.45	1.47	1.60	1.72	1.87	1.98
1982	83.81	1.46	1.60	1.72	1.86	1.97
1983	102.07	1.20	1.31	1.41	1.53	1.62
1984	91.08	1.35	1.47	1.58	1.71	1.81
1985	148.52	0.83	0.90	0.97	1.05	1.11
1986	89.61	1.37	1.49	1.61	1.74	1.84
1987	126.88	0.97	1.05	1.13	1.23	1.30
1988	147.00	0.83	0.91	0.98	1.06	1.12
1989	97.06	1.26	1.38	1.48	1.61	1.70
1990	73.98	1.66	1.81	1.95	2.11	2.23

TABLE I. 6.4.1 RAINFALL ADJUSTMENT RATE (5/5)

Basin : Ldg. Victoria Gauging Station

Flood Pattern	Actual Rainfall (mm)	R^5	R^{10}	R^{20}	R^{50}	R^{100}
		Probable Rainfall (mm)				
		119.1	130.3	140.3	152.5	161.2
1979	55.22	2.16	2.36	2.54	2.76	2.92
1980	101.68	1.17	1.28	1.38	1.50	1.59
1982	79.35	1.50	1.64	1.77	1.92	2.03
1983	81.05	1.47	1.61	1.73	1.88	1.99
1984	104.41	1.14	1.25	1.34	1.46	1.54
1985	137.43	0.87	0.95	1.02	1.11	1.17
1986	83.82	1.42	1.55	1.67	1.82	1.92
1987	119.12	1.00	1.09	1.18	1.28	1.35
1988	137.39	0.87	0.95	1.02	1.11	1.17
1989	100.28	1.19	1.30	1.40	1.52	1.61
1990	98.08	1.21	1.33	1.43	1.55	1.64

TABLE I. 6.4.2 RESULTS OF PROBABLE FLOOD RUNOFF CALCULATION (1/5)

Probability : 5-Year Return Period (Unit : m3/s)

Flood Pattern	Sik	K.Pegang G.S.	Jeniang G.S.	Jam.Syed Omar G.S.	L.Victoria G.S.
1979	52	570	665	764	916
1980	73	***254***	335	591	1136
1982	69	205	577	***816***	852
1983	54	164	***560***	1000	879
1984	***70***	232	1057	1521	1467
1985	73	205	487	862	***882***
1986	67	255	497	757	869
1987	54	201	436	633	731
1988	73	186	450	679	777
1989	60	200	471	697	815
1990	61	270	412	793	775

Note) Above figures in ***bold italic style*** mean the values of the coverage rate of 70%.

TABLE I. 6.4.2 RESULTS OF PROBABLE FLOOD RUNOFF CALCULATION (2/5)

Probability : 10-Year Return Period (Unit : m3/s)

Flood Pattern	Sik	K.Pegang G.S.	Jeniang G.S.	Jam.Syed Omar G.S.	L.Victoria G.S.
1979	62	729	817	877	1049
1980	93	335	384	660	1316
1982	***87***	259	700	***972***	996
1983	63	193	***672***	1184	***1024***
1984	86	298	1391	1749	1715
1985	93	255	596	983	1008
1986	82	***331***	591	857	992
1987	63	248	500	707	825
1988	90	225	520	773	879
1989	72	245	551	813	935
1990	73	347	475	909	873

TABLE I. 6.4.2 RESULTS OF PROBABLE FLOOD RUNOFF CALCULATION (3/5)

Probability : 20-Year Return Period (Unit : m3/s)

Flood Pattern	Sik	K.Pegang G.S.	Jeniang G.S.	Jam.Syed Omar G.S.	L.Victoria G.S.
1979	71	894	978	988	1177
1980	113	418	431	727	1490
1982	***103***	314	835	1123	1147
1983	73	222	***804***	1366	***1158***
1984	102	365	1733	1965	1929
1985	113	307	693	***1114***	1126
1986	96	***408***	696	977	1119
1987	72	302	565	790	928
1988	108	269	599	866	978
1989	84	291	634	919	1054
1990	83	430	537	1035	958

TABLE I. 6.4.2 RESULTS OF PROBABLE FLOOD RUNOFF CALCULATION (4/5)

Probability : 50-Year Return Period (Unit : m3/s)

Flood Pattern	Sik	K.Pegang G.S.	Jeniang G.S.	Jam.Syed Omar G.S.	L.Victoria G.S.
1979	84	1106	1203	1123	1343
1980	140	549	500	817	1712
1982	*127*	399	1028	1319	*1338*
1983	86	263	*986*	1599	1337
1984	124	479	2135	2223	2227
1985	140	387	817	*1275*	1287
1986	117	*539*	840	1123	1298
1987	83	379	658	903	1053
1988	137	325	703	984	1120
1989	99	352	757	1068	1209
1990	99	543	633	1201	1062

TABLE I. 6.4.2 RESULTS OF PROBABLE FLOOD RUNOFF CALCULATION (5/5)

Probability : 100-Year Return Period (Unit : m3/s)

Flood Pattern	Sik	K.Pegang G.S.	Jeniang G.S.	Jam.Syed Omar G.S.	L.Victoria G.S.
1979	94	1278	1386	1223	1470
1980	168	679	552	887	1886
1982	*149*	476	1174	1483	1486
1983	98	296	*1118*	1778	*1477*
1984	146	579	2586	2416	2932
1985	162	453	909	*1403*	1402
1986	133	*633*	965	1245	1427
1987	93	449	738	988	1147
1988	160	382	784	1082	1224
1989	113	409	858	1178	1331
1990	112	649	706	1338	1142

TABLE I. 7.2.1 FLOOD MITIGATION EFFECT OF MUDA DAM

(Unit : m3/s)

Flood	Dam Site			Jeniang G.S.			Jam. Syed Omar G.S.			Ldg. Victoria G.S.		
Pattern	W/O	W	Effect	W/O	W	Effect	W/O	W	Effect	W/O	W	Effect
1979	1147	497	650	1203	***680***	523	1123	***1053***	70	1343	1262	81
1980	341	194	147	500	397	103	817	784	33	1712	1629	***83***
1982	923	476	***447***	1028	635	393	1319	946	373	***1338***	1048	290
1983	***837***	498	339	***986***	680	***306***	1599	1194	405	1337	***1257***	80
1984	856	329	527	2135	2076	59	2223	2171	52	2227	2161	66
1985	761	268	493	817	750	67	***1275***	1194	81	1287	1205	82
1986	620	322	298	840	508	332	1123	985	138	1298	1137	161
1997	483	311	172	658	452	206	903	855	48	1053	1003	50
1988	539	308	231	703	476	227	984	753	***231***	1120	913	207
1989	676	***367***	309	757	510	247	1068	1004	64	1209	1139	70
1990	531	327	204	633	446	187	1201	940	261	1062	1008	54

Note) W/O: Without condition of the dam in question,
W : With condition of the dam in question,
Above figures in ***bold italic style*** mean the values of the coverage rate of 70%.

TABLE I. 7.2.2 FLOOD MITIGATION EFFECT OF BERIS DAM

(Unit : m3/s)

Flood	Dam Site			Jeniang Gauging Station		
Pattern	W/O	W	Effect	W/O	W	Effect
1979	13	6	7	1203	1196	7
1980	38	10	28	500	486	14
1982	75	12	63	1028	1023	5
1983	30	9	21	***986***	***976***	10
1984	698	59	639	2135	1631	504
1985	666	46	620	817	833	-16
1986	28	7	21	840	829	***11***
1987	96	14	82	658	653	5
1988	84	13	71	703	692	11
1989	***107***	***15***	92	757	758	-1
1990	176	31	145	633	636	-3

Note) W/O: Without condition of the dam in question,
W : With condition of the dam in question,
Above figures in ***bold italic style*** mean the values of the coverage rate of 70%.

TABLE I. 7.2.3 RESULTS OF REGULATED DISCHARGE CALCULATION (1/5)

Probability: 5-Year Return Period (Unit : m3/s)

Flood Pattern	Muda Dam Site	Jeniang G.S.	Before Confluence	Kuala Ketil (Muda Main)	Jam.Syed Omar G.S.	L.Victoria G.S.
1979	264	391	331	***697***	***696***	842
1980	133	229	507	562	539	1064
1982	262	370	***512***	602	605	686
1983	272	***390***	670	764	764	805
1984	187	990	727	1504	1467	1406
1985	155	403	448	777	784	***807***
1986	187	304	577	676	677	763
1987	203	306	393	581	589	697
1988	197	306	407	523	530	640
1989	***225***	329	348	636	636	751
1990	203	295	499	627	634	724

Note) Above figures in ***bold italic style*** mean the values of the coverage rate of 70%.

TABLE I. 7.2.3 RESULTS OF REGULATED DISCHARGE CALCULATION (2/5)

Probability: 10-Year Return Period (Unit : m3/s)

Flood Pattern	Muda Dam Site	Jeniang G.S.	Before Confluence	Kuala Ketil (Muda Main)	Jam.Syed Omar G.S.	L.Victoria G.S.
1979	325	470	374	***810***	***808***	973
1980	146	256	587	642	613	1239
1982	316	439	***612***	711	712	795
1983	328	***465***	799	899	898	***948***
1984	229	1306	823	1744	1698	1652
1985	190	514	512	897	904	931
1986	225	359	664	771	771	872
1987	234	347	435	654	663	778
1988	227	351	464	592	599	721
1989	***265***	380	384	754	751	870
1990	239	340	570	715	722	821

TABLE I. 7.2.3 RESULTS OF REGULATED DISCHARGE CALCULATION (3/5)

Probability: 20-Year Return Period (Unit : m3/s)

Flood Pattern	Muda Dam Site	Jeniang G.S.	Before Confluence	Kuala Ketil (Muda Main)	Jam.Syed Omar G.S.	L.Victoria G.S.
1979	399	559	421	***923***	***919***	1098
1980	166	319	668	724	686	1411
1982	382	519	***707***	816	816	908
1983	400	***556***	925	1031	1029	***1080***
1984	272	1658	915	1969	1911	1865
1985	222	615	578	1030	1034	1046
1986	266	422	756	873	871	983
1987	266	389	480	735	744	880
1988	262	405	520	660	666	801
1989	***305***	432	417	862	856	987
1990	274	382	646	810	817	905

TABLE I. 7.2.3 RESULTS OF REGULATED DISCHARGE CALCULATION (4/5)

Probability: 50-Year Return Period (Unit : m3/s)

Flood Pattern	Muda Dam Site	Jeniang G.S.	Before Confluence	Kuala Ketil (Muda Main)	Jam.Syed Omar G.S.	L.Victoria G.S.
1979	497	680	480	1058	1053	1262
1980	194	397	776	833	784	1629
1982	476	635	827	947	946	1048
1983	498	680	1083	1198	1194	1257
1984	329	2076	1027	2245	2171	2161
1985	268	750	658	1195	1194	1205
1986	322	508	860	989	985	1137
1987	311	452	543	845	855	1003
1988	308	476	595	745	753	913
1989	367	510	466	1015	1004	1139
1990	327	446	744	934	940	1008

TABLE I. 7.2.3 RESULTS OF REGULATED DISCHARGE CALCULATION (5/5)

Probability: 100-Year Return Period (Unit : m3/s)

Flood Pattern	Muda Dam Site	Jeniang G.S.	Before Confluence	Kuala Ketil (Muda Main)	Jam.Syed Omar G.S.	L.Victoria G.S.
1979	577	779	525	1159	1153	1387
1980	215	460	863	920	864	1802
1982	544	718	928	1057	1055	1156
1983	564	764	1206	1328	1324	1395
1984	383	2483	1113	245	2365	2367
1985	306	853	720	1327	1322	1317
1986	377	584	943	1084	1078	1247
1987	351	506	589	929	939	1095
1988	343	530	653	815	824	994
1989	418	576	503	1130	1114	1261
1990	370	496	825	1035	1041	1087

TABLE I. 8.2.1 FLOOD MITIGATION CALCULATION OF TAWAR MUDA DAM

(Unit : m3/s)

Flood Pattern	Dam Site Jeniang G.S.=1/50 #) W/O	W	Effect	V (MCM)	Jeniang G.S. Jeniang G.S.=1/50 W/O	W	Effect	Jam. Syed Omar G.S. Ldg.Victoria G.S.=1/50 W/O	W	Effect	Ldg. Victoria G.S. Ldg.Victoria G.S.=1/50 W/O	W	Effect
1979	563	192	371	45	***680***	***452***	228	1056	1056	0	1262	1262	0
1980	219	90	129	45	397	397	0	1211	1211	0	1629	1629	0
1982	534	188	346	45	635	411	224	1006	698	308	1048	***747***	301
1983	569	215	354	45	680	430	250	1052	1052	0	***1257***	***1257***	0
1984	314	92	252	45	2076	2076	0	1679	1679	0	2161	2161	0
1985	286	91	195	45	750	643	107	1190	1190	0	1205	1205	0
1986	368	118	250	45	508	461	47	***1060***	***1060***	***0***	1137	1129	8
1987	348	110	238	45	452	343	109	915	915	0	1003	1002	***1***
1988	358	126	232	45	476	320	***156***	813	759	54	913	847	66
1989	***411***	***131***	***280***	***45***	510	363	147	901	901	0	1139	1139	0
1990	353	111	242	45	446	316	130	948	948	0	1008	1008	0

Note) This calculation is executed under the condition of the existence of Muda dam.

W/O: Without condition of the dam in question,

W : With condition of the dam in question,

V : Calculated volume for flood mitigation in million cubic meters,

Above figures in ***bold italic style*** mean the values of the coverage rate of 70%.

#) Basin Name=1/50: Using the model hyetograph of 50-year return period on the named basin.

TABLE I. 8.2.2 FLOOD MITIGATION CALCULATION OF CHAROK TEBAR DAM

(Unit : m3/s)

Flood Pattern	Dam Site Sik =1/50 #) W/O	W	Effect	V (MCM)	Sik Sik =1/50 W/O	W	Effect
1979	22	9	13	0.38	84	73	11
1980	47	9	38	0.69	140	107	33
1982	***43***	***9***	***34***	***0.63***	***126***	98	***28***
1983	26	9	17	0.57	86	71	15
1984	40	9	31	0.57	124	***99***	25
1985	46	9	37	0.70	140	107	33
1986	34	9	25	0.62	117	93	24
1987	23	9	14	0.41	83	70	13
1988	47	9	38	0.70	137	103	34
1989	30	9	21	0.62	99	80	19
1990	27	9	18	0.46	99	82	17

Note) W/O: Without condition of the dam in question,

W : With condition of the dam in question,

V : Calculated volume for flood mitigation in million cubic meters,

Above figures in ***bold italic style*** mean the values of the coverage rate of 70%.

#) Basin Name=1/50: Using the model hyetograph of 50-year return period on the named basin.

TABLE I. 8.2.3 FLOOD MITIGATION CALCULATION OF LEGONG DAM

(Unit : m3/s)

Flood Pattern	Dam Site Kuala Pegang=1/50 #)				Pulai Kuala Pegang=1/50			Kuala Ketil (Ketil River) Jam.Syed Omar=1/50		
	W/O	W	Effect	V (MCM)	W/O	W	Effect	W/O	W	Effect
1979	3	3	0	0.00	43	43	0	755	681	74
1980	126	17	109	1.56	579	487	92	143	143	0
1982	76	17	59	0.86	372	326	46	209	207	2
1983	22	17	5	0.04	143	141	2	174	174	0
1984	97	17	80	***1.22***	***479***	***415***	***64***	1218	1211	7
1985	53	17	36	0.91	332	295	37	***660***	***596***	64
1986	97	17	80	1.66	535	466	69	154	154	0
1987	62	17	45	0.60	299	269	30	332	318	14
1988	45	17	28	0.47	264	242	22	258	250	8
1989	22	17	5	0.06	149	146	3	674	657	***17***
1990	***87***	***17***	***70***	1.80	537	473	64	198	162	36

Note) W/O: Without condition of the dam in question,
W : With condition of the dam in question,
V : Calculated volume for flood mitigation in million cubic meters,
Above figures in ***bold italic style*** mean the values of the coverage rate of 70%.
#) Basin Name=1/50: Using the model hyetograph of 50-year return period on the named basin.

TABLE I. 8.2.4 FLOOD MITIGATION CALCULATION OF WENG DAM

(Unit : m3/s)

Flood Pattern	Dam Site Kuala Pegang=1/50 #)				Pulai Kuala Pegang=1/50			Kuala Ketil (Ketil River) Jam.Syed Omar=1/50		
	W/O	W	Effect	V (MCM)	W/O	W	Effect	W/O	W	Effect
1979	2	2	0	0.00	43	43	0	755	704	51
1980	67	10	57	1.10	579	536	43	143	143	0
1982	39	10	29	0.60	372	349	23	209	207	2
1983	14	10	4	0.04	143	141	2	174	174	0
1984	52	10	42	***0.89***	***479***	***446***	***33***	1218	1208	***10***
1985	31	10	21	0.70	332	313	19	***660***	***615***	45
1986	***51***	***10***	***41***	1.22	535	497	38	154	154	0
1987	32	10	22	0.40	299	284	15	332	322	10
1988	26	10	16	0.36	264	251	13	258	252	6
1989	13	10	3	0.03	149	148	1	674	663	11
1990	53	10	43	1.39	537	497	40	198	196	2

Note) W/O: Without condition of the dam in question,
W : With condition of the dam in question,
V : Calculated volume for flood mitigation in million cubic meters,
Above figures in ***bold italic style*** mean the values of the coverage rate of 70%.
#) Basin Name=1/50: Using the model hyetograph of 50-year return period on the named basin.

TABLE I. 9.1.1 TIDAL LEVEL RECORD AT PULAU PINANG STATION

YEAR	ELW	MLWS	MLWN	MHWN	MHWS	EHW
[Observation Record]						
1985	0.98	1.61	2.44	2.93	3.64	4.08
1986	1.05	1.61	2.40	2.96	3.65	4.06
1987	0.98	1.58	2.38	2.90	3.63	4.15
1988	1.06	1.63	2.44	3.00	3.67	4.08
1989	0.99	1.66	2.42	2.97	3.63	4.17
1990	1.02	1.58	2.46	2.86	3.50	4.06
1991	1.10	1.57	2.38	2.90	3.64	4.09
1992	0.89	1.61	2.46	2.95	3.67	4.06
1993	0.98	1.61	2.45	2.93	3.69	4.17
[Average]						
Record(m)	1.01	1.61	2.43	2.93	3.64	4.10
m. LSD	-1.53	-0.93	-0.11	0.40	1.10	1.57

Note)

ELW: Extreme Low Water, EHW: Extreme High Water,
MLWS: Mean Low Water Springs, MHWS: Mean High Water Springs,
MLWN: Mean Low Water Neaps, MHWN: Mean High Water Neaps,
LSD: Land Survey Datum = (Tide Gauge Readings) - 2.535 (m).

(Source: Department of Survey and Mapping)