No.

REPUBLIC OF INDONESIA

MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FEASIBILITY STUDY ON THE BILA IRRIGATION PROJECT

ANNEX VOLUME– I

I. METEOROLOGY AND HYDROLOGY
II. SOIL AND LAND CLASSIFICATION
III. GEOLOGY
IV. SOIL MECHANICS
V. AGRICULTURE AND AGRICULTURAL ECONOMY

JUNE 1982

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

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ANNEX - I

METEOROLOGY AND HYDROLOGY

ANNEX-I METEOROLOGY AND HYDROLOGY

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ANNEX-I METEOROLOGY AND HYDROLOGY

1. GENERAL

1.1 Objectives

The hydrological investigation and study are conducted to make clear the hydrological properties in and around the area for irrigation and flood control planning with the following specific objectives:

(1) Review and examine the available basic data collected before,

(2) Additional collection of meteorological and hydrological data,

(3) Sampling for water quality analysis,

(4) Studies of flood and drought discharges,

(5) Investigation of sediment load, and

(6) Investigation of flood inundation area.

1.2 River Basin

The major streamflows relevant to the irrigation planning are the Bila, the Kalola and the Gilirang river. The following are the general characteristics of their river basins:

The Bila river originates in Mt. Tallu of the northern mountainous zone and flows into Lake Tempe. The river collects the Boya, the Kalola and the Lancirang rivers in its downstream reaches. The basin stretches over two (2) Kabupaten of Wajo and Sidrap. The river system is shown in Fig. 1.1 and has a catchment area of 1,368 km^2 at the river mouth. River length of the Bila is about 87 km from the river mouth to the headwaters. The elevation of an alluvial plain formed by the main stream of the Bila ranges from about 8 m near Lake Tempe to the maximum about 30 m near the Bila gauging station. The alluvial plain has a flat topography sloping from north to south with gradients ranging from 1/1,000 at the upper to 1/3,500 near Lake Buaya.

A catchment area at the Bila gauging station is 379 km^2. About 95% of the catchment area is the mountainous area covered with thick forest and the remaining is presently used for cultivation of paddy.

The Kalola river, one of tributaries of the Bila, originates from Mt. Bottolingerang with elevation of 262 m and passes through the valley. Catchment area of the proposed dam site is 122 km^2 and total catchment area at the confluence to the Bila river is 167 km^2. In the upstream basin of the proposed dam site, the river basin is classified into three (3) areas. 50% of the basin is the mountainous area with scattered trees, 40% of that is the hilly area with no tree and the remaining is under paddy cultivation.

The Gilirang river basin lies contiguously to the Kalola river basin on the east. The Gilirang river rises from the mountainous zone of east edge of the Bila river basin and flows directly to the Bay of Bone. The catchment areas are 518 km^2 and 300 km^2, 220 km^2 at the river mouth, Tarumpakkae and Gilirang respectively. In the upstream of Gilirang gauging station, the river basin is classified into three kinds by its coverage. About 70% of the basin is the mountainous area with forest, 20% of that is the hilly area with no tree and the remaining is plain area.

On the other hand, the shape of river basin which has influence on flood discharge is estimated by Horton's form factor and Gravelius' compactness.

$$F = A/L^2$$

$$C = 2 \quad A/S$$

where: F; Horton's form factor
C; Gravelius' compactness
A; Catchment area (km^2)
L; River length of mainstream (km)
S; Basin perimeter (km)
: = 3.14

Three (3) river basins are summarized below:

River basin	Bila	Kalola	Gilirang
Point	Bila	Proposed dam site	Gilirang
Catchment area (km^2)	379	122	220
Topography			
Mountain	95%	50%	70%
Hill	-	40%	20%
Plain	5%	10%	10%
Gradient	1/90	1/150	1/430
River length, L	41 km	18 km	43 km
Basin perimeter, S	86 km	48 km	99 km
Form factor (F)	0.23	0.38	0.12
Compactness (C)	0.80	0.82	0.53

2. HYDROLOGICAL DATA

2.1 Meteorological Data

In and around the Bila irrigation project area, there are four (4) meteorological stations as shown below:

(1) Sengkang (Kab. Wajo, Kec. Tempe: P3SA)

- (a) rainfall
- (b) temperature
- (c) relative humidity
- (d) sunshine
- (e) wind velocity
- (f) evaporation

(2) Kanyuara (Kab. Sidrap, Kec. Maritengae: PROSIDA)

- (a) rainfall
- (b) temperature
- (c) relative humidity
- (d) sunshine
- (e) wind velocity
- (f) evaporation

(3) Bontouse (Kab. Wajo, Kec. Tanasitolo: DIPERTA)

- (a) rainfall
- (b) temperature
- (c) relative humidity

(4) Menge (Keb. Wajo, Kec. Belawa: PMA)

- (a) rainfall
- (b) evaporation

The locations of these stations are shown in Fig. 1.1. Meteorological data excluding rainfall data cover for about seven (7) years at Sengkang and Kanyuara, and for three (3) years at Bontouse. These meteorological data provide basic information for the agriculture and irrigation planning.

Rainfall data are described in the Section 2.2 of this ANNEX. General climatic characteristics of the Project area are described hereunder.

(1) Temperature

Mean monthly air temperature is ranging from 26°C to 29°C and annual mean temperature indicates 27.4°C. Higher temperature appears from October to November and lower temperature appears from June to August. Table 2.1 and Fig. 2.1 show the mean air temperature.

(2) Relative humidity

The annual average relative humidity is very high with 80% at Sengkang, 86% at Bontouse and 90% at Kanyuara. Lower relative humidity occurs during September to October. Monthly values are shown in Table 2.2 and Fig. 2.1.

(3) Sunshine

Mean monthly sunshine duration at Sengkang is ranging from 5.0 to 8.0 hours and annual mean sunshine duration is 6.3 hours that is 53% in percentage. Minimum duration occurs from December to January and maximum duration occurs from August to October.

On the other hand, minimum solar radiation at Kanyuara appears from June to August. Maximum solar radiation appears in October. The second maximum appears in March.

Based on the values at two (2) stations, sunshine duration and solar radiation in the Project area will be summarized as follows:

(a) The minimum sunshine value will appear in June.

(b) The maximum sunshine value will occur from September to October.

(c) The second minimum value will occur in the period of December and January, and gradually sunshine value will rise up to the second maximum during March to May.

Table 2.3 and Fig. 2.1 show the monthly sunshine values.

(4) Wind velocity

The wind velocity is generally low. Mean monthly wind velocity is 1.0 to 2.5 m/sec. The lower mean monthly wind velocity occurs during the period of April to June and the higher value appears during August to September. The mean monthly wind velocity is as shown in Table 2.4 and Fig. 2.1.

(5) Evaporation

The annual evaporation from the standard class-A Pan records 2,000 mm (5.5 mm/day) at Sengkang and 2,200 mm (5.9 mm/day) at Kanyuara. The monthly average evaporation reaches its maximum in October at both stations and is approximately 6.6 mm/day at Sengkang and 7.1 mm/day at Kanyuara. The minimum one occurs in June with 3.9 mm/day at Sengkang and 4.7 mm/day at Kanyuara. The mean monthly data are as shown in Table 2.5 and Fig. 2.1.

2.2 Rainfall

Rainfall data of seventeen (17) stations in and around the Project area were collected. The network of the rainfall station in the irrigation project area is well established but that in the river basins is not sufficiently existed. The location of the stations is shown in Fig. 1.1, and the existing conditions of the data are shown in Fig. 2.2. The setting year and operational organization of those stations are given in Table 2.6.

Mean monthly and annual rainfalls at the 17 stations are presented in Table 2.7. Out of those data, 12 stations were selected considering the observation periods, and the monthly rainfalls are illustrated in Fig. 2.3 in terms of average and minimum values.

2.3 Water Level and Discharge Rating Curve

Water level records at 10 stations are made available in the Bila river basin and its surrounding area since 1973 as shown in Table 2.8. The locations of the stations and the periods of available records are shown in Figs. 1.1 and 2.4 respectively.

During the Master Plan Study on the Central South Sulawesi Water Resources Development Project, the discharge rating curves at Bila, Bulu Cenrana and Tanru Tedong stations of the Bila river system were prepared on the basis of the discharge measurement data. In this feasibility study, those rating curves were examined and confirmed based on the supplemental discharge data measured thereafter by PMA during the period of November 1978 through May 1981. However the curves at high water portion could not be checked due to the lack of data on high water.

In the Gilirang river system, there exist two water level gauging stations; Tarumpakkae and Gilirang.

At Gilirang station, a discharge rating curve was prepared in this study based on the discharge data measured by PMA during the period of June through August 1981. On the other hand, the discharge rating curve at Tarumppake station, which was prepared during the Master Plan Study, was not checked because of no supplemental data.

The discharge rating curve at Kalola station was prepared based on the discharge measurement carried out by the Study Team in the month of August 1981 with supplement of calculated discharges from river profiles.

The discharge rating curves at 6 stations thus established are as shown in Fig. 2.5 in which the broken lines on high water portion show the extrapolated curve based on the calculated water level-discharge relation from Manning's formula.

2.4 Water Quality

To make the characteristics of the irrigation water quality more clear, water sampling were carried out in the middle of August 1981 for five (5) wells and the Kalola river to supplement the results made in the Master Plan.

The samples were sent to the Hydrochemical Laboratory, Institute of Hydraulic Engineering, Bandung for analysis. The results of water quality analyses for each sites are shown in Table 2.9. The water quality of the Bila and the Boya rivers analysed in the Master Plan are also shown in Table 2.10.

According to the results, the following matters are clear:

(1) The water in the Project area seems to be harmless for irrigation and domestic purposes.

(2) At the well No.3 in Desa Tancung, sampled water contains a little mineral.

(3) Water quality of the Kalola river (Sample No.6) is almost same as that of the Bila river.

3. WATER RESOURCES

3.1 Rainfall Characteristics

3.1.1 Rainfall in the Bila river basin

The mean annual rainfall in the Bila river basin upstream from Bila water level station varies from 2,000 mm to 2,500 mm. The wet season occurs from April to September and the dry season appears from October to March. Heavy precipitation generally occurs during the period from May to July during the east monsoon season and May is generally the month of heaviest rainfall.

3.1.2 Rainfall in the Project area

For making examination of the tendency on regional distribution of annual rainfall in the Bila Irrigation Project area, mass curves of annual rainfall selected at the stations of Sengkang, Tanru Tedong, Bila and Maroanging were made as shown in Fig. 3.1, using the data during the period from 1931 to 1940. Fig. 3.1 shows that the annual rainfall increases gradually toward the north.

In the Project area, the mean annual rainfall varies from about 2,000 mm in the northern part to about 1,500 mm in the southern part.

About 50 percent of the annual rainfall occurs during the period from April to July. The average monthly rainfalls are about 270 mm during the period from April to July and about 100 mm during the period from August to March.

3.1.3 Seasonal rainfall

For the purpose of examining the soundness of planning years for irrigation study, the rainfalls during the wet and dry seasons at four (4) stations of Rappang, Tanru Tedong, Anabanua and Paria were arranged in the order of magnitude as shown in Table 3.1 and Fig. 3.2. The selection of the above stations was made in view of; (1) availability of long term data, (2) availability of the data in the recent years, (3) the similar pattern of the wet and dry season and (4) close relation to the Project area. Then the period was classified into three (3) periods of dry, average and wet years and the years of 1973/74 - 1980/81 applied for the irrigation study were plotted on the curves in Fig. 3.2.

Fig. 3.2 shows that the dry season rainfalls for the years of 1973/74 - 1980/81 belong to the dry year and the wet season rainfalls of the said years belong to the average year.

Further, the probable rainfalls during the dry season at the said stations were estimated as shown below:

(Unit: mm)

Return period (year)	Rainfall during dry season			
	Rappang	Tanru Tedong	Anabanua	Paria
2	800	660	600	690
5	660	520	435	510
10	600	445	365	430
20	540	365	320	380
50	500	300	275	330

The return periods of the average rainfall of Tanru Tedong during the dry season for the years from 1973/74 to 1980/81 were also estimated as shown below:

Year	Rainfall in dry season (mm)	Return period (year)
1973/74	662	2.0
1974/75	442	10
1975/76	581	2.9
1976/77	515	5.0
1977/78	543	4.0
1978/79	364	20
1979/80	520	5.0
1980/81	559	3.3

3.2 Bila River Discharge

3.2.1 Mean monthly discharge

The daily water levels at Bila, Tanru Tedong and Bulu Cenrana stations were converted into daily discharges using the discharge rating curves at each station. For the purpose of examining the general pattern of the river discharge in the basin, the mean monthly discharges at the said stations are presented in Table 3.2 together with Gilirang river discharge. For the periods lacking in daily water level records the discharge estimate was made by use of a linear regression equation based on the monthly discharge correlation studies between the other gauge stations as shown in Fig. 3.3. The correlation formulae and its correlation coefficients are as follows;

Formula		Correlation coefficient
Q_{Bila}	$= 0.354\ Q_{T.Tedong}$	0.86
$Q_{T.Tedong}$	$= 2.825\ Q_{Bila}$	0.86
$Q_{B.Cenrana}$	$= 0.412\ Q_{T.Tedong}$	0.76

The monthly discharges for May and July 1981 at Tanru Tedong are rather large compared with the discharges for the other months as shown in Table 3.2. For the purpose of the checking the said discharges, the discharge relations between Tanru Tedong and the other two (2) stations were plotted on the graph in Fig. 3.3. The plotted points for Bila are agreed, but the points for Bulu Cenrana are not fitted with the correlation curve. Therefore, the accuracy of the discharges observed at Bulu Cenrana were low for the portion on high water.

Generally, the annual pattern of the river discharge varies widely throughout the year. The wet season flow appears during the months of April through September. But the discharge of September varies widely year by year and is larger than that of August. On the other hand, September occasionally has a small discharge less than 3 m^3/sec at Bila and 10 m^3/sec at Tanru Tedong. From these characteristics, it seems that September is a transitional month to the dry season flow. The drought flow appears during the months of October through March, especially the stream-flow becomes small in November, January and February. The mean monthly discharges are illustrated in Fig. 3.4.

3.2.2 Average 10-day discharge

In order to garp the fluctuation characteristics of discharges in a short period, 10-day average discharges at Bila (downstream) gauging station are examined for the period of April 1973 through July 1981 as shown in Table 3.3. Fig. 3.5 shows the annual pattern of average and minimum 10-day discharge at Bila. It is a large difference in 10-day discharge between mean and minimum values, and the difference between monthly discharge and 10-day discharge is also large, especially during the months of April through September. These fluctuations indicate that the stream-flow of the Bila river changes widely day by day.

3.2.3 Discharge duration

The discharge duration curves at Bila and Tanru Tedon stations are prepared in Fig. 3.6 for the years of 1974 through 1980 at Bila station and 1975 through 1980 at Tanru Tedon station. Table 3.4 shows the discharges which correspond to maximum, 95-day, 185-day, 274-day, 355-day and minimum at the said stations.

3.3 Kalola River Discharge

3.3.1 General

The long-term hydrological data on the Kalola river are not available at present. In order to evaluate the potential water resources of the Kalola river, the estimate of the Kalola river discharge is conducted.

As no water level gauging station had been networked along the Kalola river, a gauging staff was installed near the possible dam site to be studied for the Project by the Study Team. The measurement of the water level was commenced on September 1981 and is going on. The measurements of water levels are carried on in three (3) times a day. Those data provide the effective information for estimate of the Kalola river discharge.

There exist the observed discharge data of the Bila river for 8 years since 1973 and the Gilirang river for six 6 years since 1975, of which watersheds are located contiguously to that of the Kalola river. Although the rainfall station is not networked in the Kalola river watershed, the rainfall data observed around it are available for a long period, emcompassing the watershed of the Kalola river.

First the rainfall characteristics around the watershed are analysed then the runoff characteristics of the observed Kalola river flows and the Bila and the Gilirang river flows are studied.

3.3.2 Analysis of rainfall characteristics around the Kalola river basin

Meteorological or rainfall gauging stations relevant to the watershed of the Kalola river are shown in the Fig. 1.1 and the existing condition of rainfall data is shown in the Fig. 2.2.

Several monthly rainfall patterns for recent years are shown in the Fig. 3.7 which shows considerable monthly fluctuation of rainfalls. In general, rainfall is ample in April, May, June and July, and the occasional increase of rainfall is observed in November and December.

For examining basin rainfall patterns in and around the catchment area, monthly correlation coefficients by using the rainfall records collected in Tanru Tedong and Sengkang were calculated by use of available data from 1931. The results are as shown below:

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Coefficient	0.86	0.38	0.75	0.69	0.59	0.49	0.60	0.80	0.88	0.75	0.63	0.35
Number of months	21	20	21	22	23	21	24	23	22	19	20	19

The above table shows that the rainy months of April, May, June and July are not well agreed with each other, and the dry months of August, September and October well coincide each other.

In the same way, annual correlation coefficients were estimated to reveal the relation between annual rainfalls of Tanru Tedong and those of other places by use of the data available from 1931. The following table indicates the results:

Meteorological stations	Correlation coefficient	Number of years	Location
Bila	0.69	5	Project area
Rappang	0.79	13	West to Project area
Maroanging	0.61	6	North to and elevated from Project area
Bola Malimpong	0.91	7	Project area
Siwa	0.19	5	East Coast

Because of difficulty to know the rainfall patterns in the catchment area of the Kalola river by using single correlation method, double-mass curve method was adopted.

In order to examine the relation between the river runoff depths and rainfall depths of Tanru Tedong, the accumulated monthly rainfall or monthly runoff depths of the Bila and Gilirang rivers for 1976 to 1980 are plotted for the accumulated monthly average rainfall of 7 stations consisting of Rappang, Bulu Cenrana, Tanru Tedong, Belawa, Bontouse, Sakkoli and Paria as shown in Fig. 3.8.

According to the said figure, the rainfall depth of Tanru Tedong is about 1.08 times of the average rainfall of 7 stations, while the runoff of the Bila river is 84% of the average one. Concerning the basin rainfall of the Bila river, it will be somewhat higher than the rainfall of Tanru Tedong since the ratio of the runoff of the Bila river to the Tanru Tedong rainfall, 0.78, is higher than the runoff coefficients generally recognized.

In addition, for estimating the precipitation over mountainous area within which the watershed of the Kalola is included, the rainfall records of 4 stations (Sengkang, Tanru Tedong, Bila and Maroanging) were examined by utilizing the double-mass curve method. Because of extremely poor availability of data observed recently for a continuous period, the precipitation obtained during 1931 and 1940 was used to establish the curves.

The Table 3.5 indicates the average accumulative annual rainfalls of 11 stations and the accumulated precipitations of each station in question. Eleven (11) stations consist of Enrekang, Siwa, Maroanging, Rappan, Bila, Bola Malimpong, Paria, Sengkang, Batu-Batu, Pompanua and Tanru Tedong. The estimated doublemass curves are shown in the Fig. 3.9. Each slope of the curve is as follows:

Station	Correlation curve		Relative depth of rainfall to Tanru Tedong
	Slope	Correlation coefficient	
Sengkang	0.84	0.99	0.79
Tanru Tedong	1.06	0.99	1.00
Bila	1.18	0.99	1.11
Maroanging	1.28	0.99	1.21

In the above four stations, Bila and Maroanging stations are situated in the north of Tanru Tedong and Sengkang meteorological station is located in the south of Tanru Tedong. This states that the northern area has more rain than the southern area.

The rainfall gauging stations which are adjacent to the catchment area of the Kalola river are Tanru Tedong, Bila and Barukku stations. As rainfall data of Bila station in the recent years are extremely few, the preciptation records of this station were excluded from estimating the basin rainfall over the watershed of the Kalola river. The average annual rainfall of Burukku station located in the northern area is more abundant by 25% than that of Tanru Tedong station. The basin rainfall of the Kalola river to expressed by using the precipitation records of Barukku and Tanru Tedong meteorological stations.

3.3.3 Analysis of observed discharge data

The rivers running near the Kalola river are the Bila river and the Gilirang river. The basin characteristics of the above three rivers are as shown in Section 1.2.

The watershed of the Kalola river is more similar to that of the Gilirang river than that of the Bila river from the viewpoint of the coverage of the watershed.

In addition, according to several hydrographs obtained so far, the outflow of the Kalola and the Gilirang rivers increase soon after the rainfalls occurred. After attaining to the peak, the discharges decrease gradually, approaching to the basic flow. On the contrary to the above two rivers, the runoff pattern of the Bila river is characterized by the gentle slope on rising and falling to limbs of hydrographs.

As to the seasonal fluctuation of the river discharge, the discharge of the Gilirang river increases more rapidly than that of the Bila river at the beginning of the wet season and decreases more quickly. During the dry season, the outflow of the Gilirang river is extremely low (See Fig. 3.10). According to the hydrological observation, the Kalola river discharge is very poor during the dry season.

The conclusion is that the runoff pattern of the Kalola river is more similar to that of the Gilirang river than that of the Bila river.

3.3.4 Estimate of the Kalola river discharge

As mentioned in the previous Section, the runoff characteristic of the Gilirang river is similar to that of the Kalola river. It is assumed that the runoff model of the Gilirang river to be analysed can be representive of the Kalola river. In this context, the runoff mathematical model is analysed by use of the Gilirang discharge data and the rainfall depths of the station relevant to the catchment of the river. The station used in this study is selected in view of the similar patterns of runoff and rainfall depths and the overlapping of the data on the same period. Then, the analysis was made for the period of 1980 by use of the rainfall data of Sakkoli rainfall station.

The model established involves several components; precipitation, evaporation, soil moisture, infiltration, storage, and consequent baseflow and direct runoff.

The basic conditions to establish the runoff model of the Gilirang river are as follows:

(1) Monthly rainfall over the basin of the Gilirang river is represented by the monthly precipitation of Sakkoli meteorological station.

(2) Monthly evaporation is estimated by multiplying theoretical evapotranspiration of Sengkang as estimated in ANNEX-VI by the average coefficient depending on the rainfall frequency; the coefficient is referred to the "Crop Water Requirements" published by FAO 1975.

(3) Soil moisture is expressed as the capability which retains the water in the soil. In the model, the upper limit of the capability is set to be 200 mm through out the year. Difference in water depth between precipitation and evaporation is stocked in the soil within a limit of 200 mm. When the soil is saturated, the surplus water contributes to groundwater in part and the remaining induces the surface runoff.

(4) 30% of surplus water is assumed to infiltrate, and 80% of the infiltrated water is supposed to percolate. The percolated water contributes to charge or recharge groundwater.

(5) Groundwater at the initial stage of the dry season is assumed to be slight. The sum of the percolated water and the groundwater in depth was considered as stocked water, 50% of which is lost due to the profound percolation.

(6) The base flow is represented by subtracting the percolated water from the infiltrated water.

(7) The direct runoff is represented by deducting the infiltrated water from the surplus water.

Based on the above basic conditions, runoff simulation of the Gilirang river in 1980 is made. The result of simulation is shown in Table 3.6. The results are as summarized below:

(Unit: mm/month)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Estimated runoff depth	3	1	1	268	446	229	42	136	20	10	5	0
Measured runoff depth	1	1	13	271	443	290	41	167	8	6	2	1

Evaluated runoff depth of each month as well as the monthly runoff pattern well coincides with measured data. Therefore, this mathematical model is able to simulate the runoff of the Gilirang river.

This simulation method is adopted to estimate the runoff of the Kalola river.

The basin rainfall of the Kalola river was evaluated by using the rainfall records of Barukku and Tanru Tedong meteorological stations. The rainfall data which are not available at Barukku station were derived from the precipitation observed at the Tanru Tedong station.

Initial ground water was assumed to be 3 mm in stead of 4 mm for the Gilirang river. Other initial conditions and assumptions are identical with those for the outflow of the Gilirang river.

The calculated runoff discharges were compared with the data recorded for a period from September to November in 1981.

(Unit: m^3/sec)

Month	September	October	November	December
Calculated discharge	7.57	5.54	1.67	
Measured discharge	11.37	5.62	1.38	0.17

The calculated results of October and November coincide with the measured data. Measured discharge of September is greater than the calculated result. Taking into consideration the occurrence of the large runoff observed in September 1981, observation of water level three time a day could not catch the total runoff accurately. It is concluded that this mathematical model is applicable to the estimation of the Kalola discharge.

The calculated monthly runoff discharges of the Kalola for 8 years since 1973 are shown in the Table 3.7 and the data used in the calculation are presented in Table 3.8 and 3.9. The summarized results are as follow:

(Unit: m^3/sec)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Discharge	1.02	2.29	2.21	8.51	7.44	10.7	6.56	5.35	5.32	3.45	2.60	1.46	4.74

The minimum discharge of Kalola river occurs in January and the discharge increases in April. It reaches the maximum of 10.7 m^3/sec in June. After the peak, the discharge of the Kalola decreases with a gentle slope and the average annual discharge is estimated to be 4.74 m^3/sec corresponding to the runoff depth of 1,200 mm.

4. HYDROLOGICAL STUDY FOR WEIR AND RESERVOIR PLAN

4.1 Flood Discharge

4.1.1 Flood discharge of the Bila river

(1) Peak discharge

The records of the observed annual maximum water levels and peak discharges at Bila station are as follows:

Year	Month	Date	Annual maximum value Water level (m)	Peak discharge (m^3/sec)
1974	Sep.	12	3.98	680
1975	July	28	4.07	705
1976	March	13	2.95	430
1977	June	18	3.14	505
1978	May	14	4.10	750
1979	Sep.	11	3.48	590
1980	May	4	2.81	430
1981	May	15	3.38	565

Although the above records are observed at the proposed headworks site of the project, those annual maximum flood data series are too short to derive the probable flood discharges with long term return periods. The probable flood analysis based on the above data series is made for the floods with probabilities less than 5% (20 years flood).

The results are as shown in Fig. 4.1 (1) and summarized below.

Return period (year)	2	5	10	20
Discharge (m^3/sec)	570	730	840	940
Specific discharge (m^3/sec/km^2)	1.50	1.93	2.22	2.48

In order to estimate the probable flood discharges with longer return periods than the above, the regional flood frequency curves in the Central South Sulawesi area are introduced. With reference to the correlation curves between the specific discharge and catchment area for the rivers around Lake Tempe presented in the report of the Master Plan study, the flood frequency curve at the catchment area of the Bila station is prepared as shown in Fig. 4.1 (2).

The regional flood frequency curve as mentioned above is shown in Fig. 4.2. The estimated probable discharges on long-term return period are as follows:

Return period (year)	50	100	200	500	1,000
Discharge (m^3/sec)	1,070	1,180	1,250	1,350	1,500
Specific discharge (m^3/sec/km^2)	2.82	3.11	3.30	3.56	3.96

(2) Flood discharge hydrograph

For the design of spillway of the proposed Bila dam, the probable flood discharge hydrographs at Bila station were prepared for the return periods of 20-year, 100-year, 200-year and 1000-year under the following Condition:

- The estimated probable discharges described above represent the peak discharge of hydrographs.

- A hydrograph is divided into two time components that are rising period up to peak and recession period after peak. The increase and decrease of runoff are expressed by a linear increase during the rising period and a recession curve during the recession period.

- The rising period is assumed at six (6) hours based on the observed discharge hydrographs at Bila station in the past as shown in Fig. 4.3. The runoff discharge during the recession period is expressed by the following formula:

  $Qt = 1.25\ Qp\ \exp - (t-t_p)$

  where, Qt: discharge at time t (m^3/sec)
  Qp: peak discharge (m^3/sec)
  t_p: time at peak discharge (hr)

The calculation results of the probable flood discharge hydrographs at Bila station are shown in Table 4.1 and they are illustrated in Fig. 4.4.

4.1.2 Flood discharge of the Kalola river

(1) Hydrological data

(a) Water level and discharge

In the Kalola river, a staff gauging station was established downstream of the proposed damsite in the beginning of September 1981. Water level observation has been carried out three (3) times per day since the beginning of September 1981. In this study period, two (2) flood records were obtained. They are the floods of September and October 1981 as shown in Fig. 4.5.

(b) Rainfall

At present, there is no rainfall station in the Kalola river basin. Therefore it is unavoidable to apply the data at the rainfall station close to the basin. In this study, the rainfall data at Bila and Tanru Tedong stations were applied for flood analysis of the Kalola river.

(2) Methodology for analysis

The flood analysis of the Kalola river was carried out by means of analysing the rainfall, runoff depth and runoff coefficient observed in the Bila river basin including the Kalola river basin. In this study, the rational formula was adopted in view of the availability of the hydrological data. The runoff coefficient and rainfall intensity of the flood discharge of the Kalola river are estimated as follows:

(a) Runoff coefficient

The runoff coefficient in the rational formula of the Kalola river was estimated be use of the flood date obtained so far.

Rational formula is expressed below:

$$Q = \frac{1}{3.6} A \cdot r \cdot f$$

where: Q : peak discharge (m^3/sec)
A : catchment area (km^2)
r : rainfall intensity (mm/hr)
f : runoff coefficient

In the above formula, the rainfall intensity is defined as average rainfall in mm/hr during the time of concentration which means surface runoff time from remotest point of stream channel in the basin to calculation point. In this study, the time of concentration was assumed at five (5) hours based on the observed data. The rainfall intensities of the past floods were estimated by use of the Mononobe formula as described below:

$$r = (R_{24}/24)(24/T)^{2/3}$$

where, r : rainfall intensity (mm/hr)
R_{24}: daily rainfall (mm/day)
T : time of concentration (hr)

Regarding the constant value of 2/3 in the above formula, it was proved by mass curves of rainfall intensity on the basis of the hourly rainfall record at Bulu Cenrana station as shown in Fig. 4.6. The rainfall intensities of the past floods of the Kalola river were estimated applying the daily rainfall at Bila and Tanru Tedong. Then the runoff coefficients were obtained by the reverse calculation as shown in Table 4.2. Based on the results, the runoff coefficient of the Kalola river was adopted at 0.85.

(b) Rainfall intensity

Due to the lack of rainfall data at the station close to the Kalola river basin, the probable rainfalls of the Kalola river were assumed to be the same as the rainfalls in the Bila river basin which were converted from the probable flood discharge of the Bila river. In making conversion of the flood discharge to the probable rainfall, the time concentration and runoff coefficient of the Bila river basin were assumed at six (6) hours and 0.6 respectively, based on the past flood discharge hydrographs at Bila station as shown in Fig. 4.3 and Table 4.3.

The probable rainfall intensities for the Kalola river basin thus calculated are shown in Table 4.4.

(3) Peak discharge

The peak and specific discharges of the probable floods at the proposed Kalola dam site are as follows:

Return period (year)	5	20	100	200	1000
Peak discharge (m^3/sec)	380	485	610	645	770
Specific discharge (m^3/sec/km^2)	3.11	3.98	5.10	5.29	6.31

(4) Flood discharge hydrograph

For the design of spillway of the proposed Kalola dam, the probable flood discharge hydrographs at the proposed dam site were prepared for the return periods of 5-year, 20-year, 100-year, 200-year and 1000-year under the same condition as to that of the Bila river.

In making the discharge hydrograph, the rising period was assumed at five (5) hours and the following formula was used for the recession period.

$$Qt = 1.25\ Qp\ \exp - (t-t_p)$$

The calculation results of the probable flood discharge hydrographs at the proposed Kalola dam site are shown in Table 4.1 and they are illustrated in Fig. 4.7.

4.2 Sediment Load

In order to determine the capacity of sedimentation of the proposed Kalola reservoir, the sediment yield of the Kalola river basin was estimated on the basis of the data on sediment transport at Tanru Tedong.

For estimation of sediment transport at Tanru Tedong, sediment discharges was divided into two (2) components of bed-load and suspended load including wash load.

(1) Bed-load

Sato-Kikkawa-Ashida formula is adopted to estimate the bed-load. This formula is expressed as follows:

$qB/U^* \, dm = o \, F(o/ c) \, U^{*2}/(s/ w-1)g \, dm$

where; qB; bed-load per unit river width per unit time (m^3/sec/m)
U*; friction velocity (m/sec)
dm; mean diameter (m)
g ; acceleration of gravity (= 9.8 m/sec^2)
o; tractive force of flow (ton/m^2)
c; critical tractive force (ton/m^2)
F ; function of o/ c
s; unit weight of bed material (ton/m^3)
w; unit weight of water (ton/m^3)
o ; = 0.623 (when coefficient of roughness n = 0.025)

Using the cross-section at the point of BI 16.4 just upstream from Tanru Tedong Bridge, the bed-loads for various water discharges were calculated applying dm = 8.0 mm of river bed material obtained from the results of grain size analysis shown in ANNEX IV.

The relation between bed-load and water discharge prepared in the Master Plan Study was reviced as shown in Fig. 4.8. Reviced curve is expressed as the following equation.

Newly obtained curve is expressed as the following equation.

$$QB = 1.511 \times 10^{-6} \, Q^{1.460}$$

(2) Suspended load

Suspended load discharge is estimated by the following equation making reference to the results in the Master Plan.

$$QS = 1.833 \times 10^{-6} \, Q^{1.958}$$

(3) Sediment load at Tanru Tedong

Applying daily discharge during the period from 1975 to 1980, annual total sediment load at Tanru Tedong is calculated using the abovementioned formula. The results are as shown below:

Year	Sediment discharge			
	QB	QS	QB + QS	(QB + QS)/A
	(10^3 m^3/yr)	(10^3 m^3/yr)	(10^3 m^3/yr)	(m^3/yr/km^2)
1975	23.3	347.0	370.3	330
1976	11.6	132.4	144.0	128
1977	13.2	178.3	191.5	171
1978	23.5	365.3	388.8	346
1979	15.0	233.3	248.3	221
1980	17.8	297.0	314.8	280
Average	17.4	258.9	276.3	246

Remarks: QB ; Annual total sediment discharge of bed-load (10^3 m^3/yr)

QS ; Annual total sediment discharge of suspended load (10^3 m^3/yr)

(QB + QS)/A; Specific sediment discharge ($m^3/yr/km^2$)

A ; Catchment area at Tanru Tedong (= 1,123 km^2)

Assuming the void ratio of 30%, specific sediment discharge of the Bila river basin ranges from 240 to 500 $m^3/yr/km^2$ and the average is 351 $m^3/yr/km^2$.

5. FLOOD INUNDATION AREA

5.1 Water Level of Lake Tempe

(1) Review of existing data

Water Level of Lake Tempe was reviewed for the following purposes:

(a) To delineate the irrigation project area near Lake Buaya,

(b) To determine the design water level at the river mouth of the Bila river for the flood control study.

After the completion of the Master Plan Study, the station named "Staff Gauge Danau Tempe" was abolished in November 1978. But water level observation at "AWLR/1 Danau Tempe" was started in March 1978. The location of these stations is shown in Fig. 5.1. The distance between these two (2) stations, Staff Gauge and AWLR, is about five (5) km, so that the relation between water levels at these stations was examined using the recorded data during the same period of March thru October in 1978. This relation is shown in Fig. 5.2. Recorded water levels accord with each other.

(2) Mean monthly water level

Based on the daily water level records, mean monthly water levels were calculated for each year during 1969-1971 and 1975-1981 as shown in Table 5.1. Furthermore, the average water levels for each month are plotted in Fig. 5.3. Fig. 5.3 indicates the following seasonal tendency of water level fluctuation of Lake Tempe.

(a) High water levels occur during a period from May to August.

(b) Low water levels occur during a period from October to December.

(3) Probable annual maximum water level

The available annual maximum water level data of Lake Tempe are shown in Table 5.2. Although the obtained data is not successive, the calculation of probable water levels was made by use of Thomas plot method as shown in Fig. 5.4. The results of calculation are as follows:

/1: Automatic Water Level Recorder

Return period (year)	2	5	10	20	50
Water level (EL. m)	8.0	8.9	9.4	9.9	10.4

Water level (EL. m)	8.0	8.5	9.0	9.5	10.0	10.5
Return period (year)	2.0	3.2	5.7	11.1	25	55

(4) Frequency of low water level

According to the available records in the past, the annual minimum water levels of Lake Tempe are shown in Table 5.3. The lowest annual water level presented in Table 5.3 is EL. 3.2 m in November, 1977. On the other hand, in the Master Plan Study it was clear that a drought occurred in 1972 with a low water level of Lake Tempe lower than that of 1977, by the information collected from local people in Sengkang.

Based on the recorded data and the information, the return period of annual minimum water level was estimated. Fig. 5.5 shows the relation between them. That is,

Return period (year)	2	5	10	20
Water level (EL. m)	3.9	3.4	3.1	2.9

Water level (EL. m)	4.0	3.8	3.6	3.4	3.2	3.0
Return period (year)	1.8	2.3	3.2	5.0	8.3	17.2

The water level of Lake Tempe usually declines from October to November due to the decrease of inflow of rivers draining into Lake Tempe. About 70% of annual minimum water levels occurred during this period of October and November.

(5) High water level duration

To know the duration of inundation caused by high water level of Lake Tempe, the frequency of high water level was studied. For the following three (3) periods; (1) Annual, (2) March to September (flood season of the Bila) and (3) May to August, the duration of high water level was counted.

Table 5.4 shows total days of high water level. Return period of duration were estimated using the data shown in Table 5.4, and the results are shown in Table 5.5 and Fig. 5.6.

(6) Relation between water level of Lake Tempe and flood discharge of the Bila river

The fluctuation of water level of Lake Tempe is caused by the difference between inflow and outflow. The inflow is the runoff from the Bila, Walanae and other small tributaries. The outflow is the discharge through the Cenranae river whith pours into the Bay of Bone. The catchment areas of these river basins are as follows:

Name of basin	Catchment area (km2)	Percentage (%)	Annual rainfall (mm)
Bila	1,368	22.3	1,500 to 2,500
Walanae	3,190	52.0	1,500 to 3,000
Tributaries and Lake Tempe	1,580	25.7	1,500 to 2,000
Total	6,138	100.0	

Since the catchment area of the Bila river basin is about 22 percent of all the river basins, the fluctuation of water level of the lake is mostly affected by the runoff from the Walanae and other tributaries basins.

The monthly mean water level of Lake Tempe and the peak discharge at Tanru Tedong are shown in Fig. 5.7. The fluctuation of water level is summarized below:

(a) The monthly mean water level in a period from May to August is higher than 6 meters

(b) Thd discharges more than 500 m^3/sec occur mainly in a period from April to September

5.2 Existing Condition of Inundation

To estimate inundation area, field investigation was carried out over the areas extending along the Bila, the Boya and the Lancirang rivers.

Number of field investigation is as follows:

Province (Propinsi)	District (Kabupaten)	Subdistrict (Kecamatan)	Village (Desa)	Nos.
Sulawesi-Selatan	Sidrap	Dua Pitue	Tanru Tedong	20
			Bila	10
			Lancirang	10
			Otting	1
	Wajo	Belawa	Belawa	8
			Wele	14
		Tanasitolo	Lowa	2
		Maniang Pajo	Anabanua	2
			Kalola	2
(Total)				69

In each survey point, the following items were investigated by interview:

(1) Maximum flood in the past
(2) Small floods in recent years
(3) Frequency of inundation (depth and duration)
(4) Inundation area (for each flood)
(5) Inundation depth (for each flood)
(6) Inundation duration (for each flood)
(7) Direction of inundated water flow (for each flood)
(8) Form of residence (height of floor, property, etc.)
(9) Resided period of the local people
(10) Others

Based on the results of field investigation, the whole inundation area is characterized in the following each region.

5.2.1 Mainstream of Bila river

Inundated area along the mainstream is located on both sides between the proposed Bila intake site and the river mouth of the Bila. The inundation is caused almost by over-topping of river water due to lack of carrying capacity of the channel, especially in the downstream area from Tanru Tedong. In this area inundated water flows with expansion.

In the upstream of the confluence of the Boya river, inundated water flows downstream along the river course and on the left side of the Bila river, inundated water scarcely flows over the road which connects Tanru Tedong and Bila villages.

5.2.2 Kalola river

Flood water flows from the hilly area which has a catchment area of 135 km^2. After passing the valley, flood water flows into the left side due to lack of carrying capacity of the channel. Flooded water flows over paddy field along the drainages named S. Padang and S. Belawa and gradually flows into Lake Buaya. The lack of carrying capacity of these streams presently makes inundated water retarded.

On the other hand, flood water which flows through the channel, joints the Bila river just upstream of confluence of the Bila and the Boya. The water surface slope at the downstream of the Kalola is gentle extremely during a flood season, even though the spillway has been constructed at the northern side of provincial road. Gentle water surface slope causes inundation at the downstream of the Kalola. Flooded water at the southern part of this area flows along the S. Wele drainage. When there is no flood on the Kalola river but on the Bila river, flooded water flows into this area along the Kalola river channel reversely and also flows toward south along the S. Wele drainage. The lack of carrying capacity of S. Wele drainage canal causes inundation over paddy field and makes inundated water retarded.

5.2.3 Boya river

In the stretch of 3 to 7 km upstream from the confluence of the Bila river, flood water flows into both sides on occasion. Flooded water into the left side returns to the Boya river channel. Some of flooded water into the right side returns to the Boya and the rest flows toward the provincial road.

Near the confluence of the Bila river, flooded water overflows from the right bank into paddy field when the water level at the confluence is very high. Flooded water is retarded by the provincial road and flows into the low-lying area with the flooded water overflows from the mainstream of the Bila.

5.2.4 Lancirang river

In every flood season, flood water overflows the bank forming submergence, because the channel of the downstream reaches of the Lancirang river is very small.

Near the confluence of the Bila mainstream, flooded water from the Bila, the Boya and the Lancirang rivers flows into the low-lying area. Runoff water from the plain area in Desa Otting also flows into the area mentioned above. Retarded water in depressions flows out gradually to the Bila river according as the water level of the Bila mainstream goes down.

When the Bila river has a longer period of high water level, inundated water flows out into the left side of the downstream of the Bila.

5.2.5 Lake Tempe

In the area near Lake Buaya and Lake Tempe, inundation is caused by the high water level of Lake Tempe. The characteristics of water level of Lake Tempe are described in Section 5.1. The fluctuation of water level at northern part of Lake Buaya is not the same as that of Lake Tempe. The water level and duration of inundation near Lake Buaya are rather higher and longer than that of Lake Tempe.

5.2.6 Other area

In the plain area excluding the area mentioned above, inundation occurs due to lack of the carrying capacity of drainage canals. After the completion of the drainage canal improvement works, inundation will be decreased for a level of improvement scale.

5.3 Inundation Depth and Duration

5.3.1 Inundation area

Inundation area is further divided into several areas in each region as shown in Table 5.6 and Fig. 5.8. Components of inundation area are presented in Table 5.7.

5.3.2 Under present condition

Relation between inundation depth-duration and its return period is estimated in each area under the present condition. Inundation frequency found in the field is adopted to estimate the relation. Furthermore, return period of annual maximum discharges at Bila and Tanru Tedong and the big floods occurred in the past are considered especially in the area along the Bila and Boya rivers. In the Kalola area, the Lancirang area and downstream area of the Bila, inundation frequency in recent years and carrying capacity of existing river channel are taken into consideration.

Estimated inundation depth and duration for each return period are shown in Table 5.8.

5.3.3 After improvement of drainage

Inundation is caused by the ill drainage condition, so that the depth and duration of inundation caused by flooded river water are estimated. On the draiange planning, drainage canal will be designed as to drain the precipitated water, which has a level of 5-year.

Considering the existing condition of the lower reaches of drainage, inundastion depth and duration are estimated as shown in Table 5.9. Based on these relations, mean depth and duration of inundation for each flood are arranged in Table 5.10.

Table 2.1 Mean Monthly Air Temperature

Bengkang

(Unit: °C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	-	-	-	-	26.9	26.3	26.1	25.9	27.1	27.4	28.0	27.8	-
1976	27.9	28.4	28.3	27.8	27.6	25.1	24.8	25.3	26.0	29.2	28.4	28.5	27.3
1977	28.7	29.0	28.0	28.7	29.0	27.0	27.0	27.6	26.9	28.2	28.0	27.0	27.9
1978	27.5	28.0	27.5	27.3	27.6	27.8	26.1	26.3	26.6	28.7	27.1	27.2	27.3
1979	27.4	27.2	27.6	27.2	26.6	26.2	25.7	26.6	27.7	27.7	28.2	27.4	27.1
1980	28.0	27.4	27.3	27.2	26.9	26.4	25.8	26.2	27.1	28.2	7.9	27.4	27.2
1981	27.3	27.5	27.3	27.2	27.2	27.0							
Average	27.8	27.9	27.7	27.6	27.4	26.5	25.9	26.3	26.8	28.2	27.9	27.5	27.3

Kanyuara

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	26.1	27.4	27.8	27.9	27.0	26.3	26.0	26.4	26.9	27.8	27.8	26.9	27.1
1976	26.7	27.0	27.4	27.3	27.0	26.0	25.8	26.4	26.7	27.0	27.5	26.9	26.8
1977	27.3	27.0	27.4	27.4	27.3	26.6	26.7	27.1	27.5	27.3	27.7	26.3	27.1
1978	27.0	27.1	27.0	27.1	26.9	25.8	26.9	25.9	27.1	28.1	27.8	27.5	27.0
1979	26.1	26.2	26.5	27.3	26.8	26.4	26.4	26.9	27.3	27.8	27.6	27.4	26.9
1980	27.2	27.2	27.7	27.7	26.5	27.3	26.8	26.3	28.5	28.3	27.3	28.0	27.4
1981	26.6	26.2	27.1	27.4	26.9	26.7							
Average	26.8	26.9	27.3	27.4	26.9	26.4	26.4	26.5	27.3	27.7	27.7	27.2	27.0

Bontouse

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1979	27.7	27.7	27.5	27.8	28.1	27.8	28.1	28.1	28.0	28.8	28.7	28.2	28.0
1980	28.8	28.5	28.3	-	-	27.3	27.8	27.2	28.0	28.7	28.4	27.8	28.1
1981	27.6	27.8	28.0	28.3	27.5	27.0	26.4						
Average	28.0	28.0	27.9	28.0	27.8	27.4	27.5	27.6	28.0	28.8	28.5	28.0	28.0

Table 2.2 Mean Monthly Relative Humidity

Sengkang

(Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	-	-	-	-	78.3	78.7	75.7	75.2	74.8	75.5	72.2	71.9	-
1976	70.7	66.1	68.0	69.8	73.2	75.5	75.0	68.4	60.7	63.4	68.7	65.2	68.7
1977	66.7	65.0	62.0	68.0	69.0	80.0	72.8	71.3	60.7	74.0	81.0	88.0	73.2
1978	83.7	80.4	86.6	84.9	87.2	87.4	86.8	84.2	85.4	86.4	84.0	90.0	85.6
1979	86.4	90.8	86.8	92.9	85.5	87.3	84.7	76.8	80.2	65.9	77.0	89.1	83.6
1980	86.4	89.6	85.1	89.0	87.5	81.9	85.6	84.0	76.2	84.7	90.8	89.3	85.8
1981	72.1	85.7	88.4	86.8	88.3								
Average	77.7	79.6	79.5	81.9	81.3	81.8	80.1	76.7	76.3	75.0	79.0	82.3	79.2

Kanyuara

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	95.8	95.9	96.5	85.8	87.0	82.9	90.0	95.2	93.6	90.0	87.2	88.0	90.3
1976	90.0	89.0	90.0	91.0	91.0	93.0	95.0	94.0	96.0	97.0	96.0	96.0	93.2
1977	95.0	97.0	97.0	91.5	91.0	93.9	97.0	97.0	96.3	95.8	87.5	91.4	94.2
1978	91.5	98.3	98.8	99.0	98.9	91.9	87.3	84.2	84.3	81.2	84.0	87.5	90.6
1979	87.7	83.7	83.0	83.0	85.0	92.7	69.2	84.5	85.2	80.3	80.8	83.3	84.9
1980	82.6	80.1	81.9	81.2	86.0	83.0	86.0	85.7	76.6	78.3	78.3	87.6	82.3
1981	86.8	87.1	86.4	87.9	90.0	88.4							
Average	89.9	90.2	90.5	88.5	89.1	89.4	90.8	90.1	88.7	87.2	85.6	89.0	89.1

Bontouse

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1979	83.5	83.6	84.0	83.8	82.7	85.4	82.7	79.4	83.7	78.6	84.7	86.0	83.2
1980	85.3	87.7	86.8	87.8	-	90.2	85.3	87.7	83.7	83.9	88.0	90.5	87.0
1981	92.6	90.6	91.8	91.6	93.1	92.7	92.8						
Average	87.1	87.3	87.5	87.7	87.9	89.4	86.9	83.6	83.7	81.2	86.4	88.3	86.4

Table 2.3 Mean Monthly Sunshine Duration

Sengkang

(Unit: hours/month / hours/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	- -	- -	- -	- -	- -	139 (4.6)	179 (5.8)	209 (6.8)	221 (7.4)	215 (6.9)	218 (7.3)	155 (5.0)	- -
1976	194 (6.3)	204 (7.3)	188 (6.1)	210 (7.0)	188 (6.1)	162 (5.4)	200 (6.5)	262 (8.4)	260 (8.7)	213 (6.9)	210 (7.0)	169 (5.5)	2,460 (6.7)
1977	147 (4.7)	117 (4.2)	192 (6.2)	185 (6.2)	201 (6.5)	145 (4.8)	206 (6.6)	292 (7.4)	279 (9.3)	307 (9.9)	231 (7.7)	174 (5.6)	2,413 (6.6)
1978	155 (5.0)	145 (5.2)	162 (5.2)	169 (5.6)	211 (6.8)	178 (5.9)	198 (6.4)	194 (6.3)	183 (6.1)	254 (8.2)	194 (6.5)	161 (5.2)	2,204 (6.0)
1979	155 (5.0)	149 (5.4)	145 (4.7)	183 (6.1)	230 (7.4)	144 (4.8)	216 (7.0)	272 (8.8)	231 (7.7)	244 (7.9)	188 (6.3)	154 (5.0)	2,311 (6.3)
1980	124 (4.0)	132 (4.6)	169 (5.5)	148 (5.0)	177 (5.7)	162 (5.4)	226 (7.0)	206 (6.7)	266 (8.9)	215 (7.0)	177 (5.9)	138 (4.4)	2,140 (5.8)
1981	159 (5.0)	141 (5.0)	195 (6.3)	179 (5.9)	183 (5.9)	204 (6.8)							
Average	156 (5.0)	148 (5.2)	175 (5.7)	179 (6.0)	198 (6.4)	162 (5.4)	204 (6.6)	239 (7.7)	240 (8.0)	241 (7.8)	203 (6.8)	159 (5.1)	2,292 (6.3)

Kanyuara

(Radiation: mℓ/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	18.2	17.2	20.2	17.4	17.3	15.7	15.8	16.7	18.1	21.5	20.5	18.5	18.1
1976	17.1	18.4	18.5	19.9	19.1	18.4	21.5	19.3	18.9	18.9	20.1	17.3	18.9
1977	16.6	17.3	20.5	19.2	18.8	17.5	18.1	19.3	20.7	20.0	18.1	19.3	18.7
1978	18.3	17.9	17.8	18.4	19.9	19.3	19.0	17.8	18.9	20.8	18.9	18.5	18.8
1979	19.9	19.3	17.6	20.0	19.7	15.3	16.2	16.8	17.7	19.8	19.1	19.3	18.4
1980	17.8	20.9	21.9	18.5	17.9	17.3	16.6	16.7	20.5	19.0	20.3	17.0	18.7
1981	18.2	17.3	20.7	21.3	19.6	19.5							
Average	18.0	18.3	19.6	19.2	18.9	17.6	17.9	17.8	19.1	20.0	19.5	18.3	18.7

Table 2.4 Mean Monthly Wind Velocity

Sengkang

(Unit: m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	-	-	-	-	-	-	-	1.0	0.8	0.6	0.7	1.4	-
1976	1.3	1.5	1.5	1.1	1.3	1.2	1.5	1.8	1.6	1.3	0.9	1.5	1.4
1977	1.5	2.0	1.3	1.1	1.0	1.4	1.8	2.0	2.0	2.0	1.4	1.2	1.5
1978	1.2	1.2	1.0	1.1	1.1	1.0	1.1	1.4	1.3	1.3	1.0	1.3	1.1
1979	1.2	1.2	1.1	1.0	1.0	1.3	1.7	1.9	1.8	1.3	1.2	1.3	1.3
1980	1.5	1.3	1.3	0.9	1.7	1.3	1.4	1.5	1.7	1.5	1.4	1.3	1.4
1981	1.8	1.3	1.0	1.0	1.1	0.9							
Average	1.4	1.4	1.2	1.0	1.2	1.2	1.5	1.6	1.5	1.3	1.1	1.3	1.3

Kanyuara

(Unit: m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	2.5	2.2	2.9	2.5	3.7	2.4	2.3	2.0	2.4	1.9	2.6	2.9	2.5
1976	2.6	2.4	2.4	2.3	2.6	2.2	2.2	2.7	3.2	2.6	1.8	2.4	2.5
1977	2.1	3.3	2.3	2.2	1.8	2.0	2.5	2.9	3.2	2.9	1.4	1.6	2.4
1978	1.6	1.7	2.2	2.1	1.7	1.0	1.8	2.3	2.1	2.9	1.7	1.9	1.9
1979	1.9	1.6	2.1	1.9	1.4	1.8	2.0	2.7	2.4	1.8	1.8	1.8	1.9
1980	1.6	1.4	2.0	1.7	2.6	2.1	1.7	2.2	2.3	2.3	1.5	2.1	2.0
1981	2.3	1.4	1.6	1.8	2.7	1.5							
Average	2.1	2.0	2.2	2.1	2.4	1.9	2.1	2.5	2.6	2.4	1.8	2.1	2.2

Table 2.5 Mean Monthly Evaporation

Sengkang

(Unit: m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	-	-	-	-	-	116	128	159	174	135	187	159	-
1976	185	184	185	158	145	113	143	180	206	197	158	168	2,022
1977	168	177	188	131	159	110	134	175	240	303	227	181	2,193
1978	176	176	175	169	140	135	138	160	154	164	148	145	1,880
1979	163	176	153	136	131	119	163	209	186	210	185	122	1,953
1980	169	162	176	142	134	109	145	164	225	222	172	288	2,128
1981	188	134	214	134	126								
Average	178	168	182	145	139	117	141	174	197	205	180	177	2,003

Kanyuara

(Unit: mm/month)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	174	181	189	166	230	202	192	187	140	180	204	165	2,210
1976	174	201	220	180	199	147	198	217	270	228	184	190	2,408
1977	172	132	154	144	160	140	146	143	177	205	208	151	1,932
1978	142	162	150	186	128	98	108	147	163	202	173	157	1,816
1979	176	155	202	184	170	121	158	224	205	275	229	217	2,310
1980	220	221	255	174	167	147	174	193	281	268	219	156	2,474
1981	181	153	188	176	170	146							
Average	177	172	194	173	175	143	163	185	206	226	203	172	2,188

Table 2.6 Rainfall Gauging Stations

No.[1]	Name of Station	Belonging[2], [3]	Setting Year	Kind of data[4]	Data available	River System	Name of River
1.	Enrekang	N. PMG (400)		M	1917 - 1941	Sadang	Sadang
				M	1971 - 1981		
2.	Baraka	N. PMG (400a)		M	1953 - 1955	Bila	Boya
				M	1975 - 1981		
3.	Rappang	N. PMG (402)	1909	M	1917 - 1941	Rappang	Rappang
				M	1952 - 1957		
				M	1962 - 1965		
				M	1971 - 1981		
		N. DIPERTA		D	1972 - 1973		
				D	1975 - 1981		
4.	Maroanging	N. PMG (401b)	1930	A	1931 - 1940	Bila	Lancirang
				M	1954 - 1960		
5.	Bulu Cenrana	A. P3SA	Dec. 1973	D	1974 - 1981	Bila	Boya
6.	Barukku	N. PMG (404a)		M	1921 - 1927	Bila	Bila
				M	1974 - 1981		
		N. P3SA	Sep. 1975	D	1979 - 1981		
7.	Bila	N. PMG (402c)		M	1931 - 1940	Bila	Bila
		A. P3SA	1977	D	1980 - 1981		
8.	Tanru Tedong	N. PMG (403a)	1930	M	1931 - 1941	Bila	Bila
				M	1953 - 1959		
				M	1971 - 1981		
		N. DIPERTA		D	1972 - 1981		
		N. PMA	Nov. 1974	D	1974 - 1981		
9.	Belawa/ Menge	N. PMG (405a)		M	1923 - 1941	Lake Tempe	Belawa
				M	1953 - 1955		
				M	1957 - 1969		
				M	1972		
				M	1977 - 1981		
		N. DIPERTA		D	1977 - 1981		
10.	Anabanua/ Bola Malimpong	N. PMG (403b)	1925	M	1925 - 1941	Lake Buaya	Lanate
				M	1953 - 1967		
				M	1977 - 1981		
		N. DIPERTA		D	1977 - 1981		
11.	Bontouse	N. PMG (405f)	1930	M	1953 - 1966	Lake Tempe	Lake Tempe
				M	1970 - 1972		
				M	1976 - 1981		
		N. DIPERTA		D	1976 - 1981		
16.	Batu-Batu	N. PMG (405c)	1928	A	1930	Lake Tempe	Batu-Batu
				M	1931 - 1941		
				M	1951 - 1955		
				M	1957 - 1967		
				M	1973 - 1977		
		N. DIPERTA		D	1973 - 1977		
17.	Sengkang	N. PMG (405)	1909	M	1917 - 1941	Cenranae	Cenranae
				M	1953 - 1972		
		N. DIPERTA		D	1927 - 1972		
		A. P3SA	May 1974	D	1974 - 1976		
				D	1978 - 1981		
20.	Pampanua	N. PMG (406)	1906	M	1917 - 1941	Cenranae	Cenranae
43.	Sakkoli	N. PMG (403d)	1959	M	1969 - 1977	Gilirang	Gilirang
		N. DIPERTA		D	1977 - 1981		
44.	Paria	N. PMG (404b)	1918	M	1918 - 1941	Gilirang	Gilirang
				M	1953 - 1969		
				M	1971 - 1981		
		N. DIPERTA		D	1976 - 1981		
46.	Siwa	N. PMG (400a)		A	1919 - 1941	Awa	Awa

Remarks : [1] rainfall station number in Fig. 1.1

[2] A ; automatic gauge, N ; normal gauge

[3] PMG ; Meteorology and Geophisics Center
DIPERTA ; Ministry of Agriculture
P3SA ; Sub-directorate of Planning and Programming for Water Resources
PMA ; Institute of Hydraulic Section

[4] A ; annual data
M ; monthly data
D ; daily data

Table 2.7 Mean Monthly Rainfall (1/13)

Enrekang

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1917	184	295	260	263	214	130	230	160	95	293	179	200	2,503
1918	414	298	166	153	242	56	1	0	2	114	231	305	1,982
1919	109	429	172	350	264	138	141	46	37	30	146	265	2,127
1920	258	154	485	371	165	309	171	66	100	100	312	310	2,801
1921	223	398	399	151	116	280	37	45	77	189	206	306	2,427
1922	144	173	208	286	201	213	69	28	58	57	89	314	1,840
1923	150	244	133	397	309	168	195	23	20	83	50	316	2,088
1924	195	342	454	499	274	185	47	95	109	326	305	135	2,867
1925	98	188	126	137	306	252	81	45	26	25	76	235	1,595
1926	337	231	231	122	176	107	87	58	106	93	100	378	2,026
1927	65	137	413	508	130	191	42	4	28	135	198	261	2,132
1928	390	136	465	283	73	197	76	44	53	153	101	175	2,146
1929	170	246	-	183	219	173	103	36	47	3	120	182	-
1930	143	141	360	434	300	101	17	11	1	180	106	211	2,005
1931	46	81	149	354	369	403	141	83	114	115	191	136	2,152
1932	206	116	177	382	392	68	97	107	54	107	174	227	2,017
1933	139	214	160	304	312	129	32	93	43	159	289	80	1,960
1934	179	251	179	181	152	268	417	67	228	106	255	174	2,357
1935	151	394	222	414	197	255	48	18	39	80	214	375	2,407
1936	304	257	301	535	299	193	28	59	90	19	196	129	2,410
1937	258	199	275	287	298	148	95	81	202	79	64	243	2,229
1938	376	167	481	183	303	117	74	104	16	22	221	159	2,223
1939	150	245	315	368	183	326	124	134	10	133	210	128	2,331
1940	222	102	193	162	385	162	7	19	6	63	355	273	1,749
1941	209	235	254	201	369	142	10	4	2	15	160	276	1,877
1971	-	-	-	-	282	161	179	237	429	235	225	188	-
1972	573	81	201	229	171	49	3	90	0	0	206	263	1,866
1973	428	189	229	292	296	233	193	132	337	118	138	409	2,934
1974	136	241	101	276	249	183	183	42	420	319	222	242	2,614
1975	242	177	212	438	170	237	189	159	85	218	60	107	2,334
1976	187	119	245	164	48	38	28	41	1	146	176	273	1,456
1977	184	184	192	401	203	174	7	60	0	0	-	365	-
1978	108	66	343	203	310	36	234	200	129	128	158	118	2,033
1979	310	159	261	216	23	331	79	9	53	3	99	197	1,749
1980	176	183	157	344	241	207	5	18	5	92	183	248	1,854
1981	202	170	567	261	249	137	-	-	-	-	-	-	-
Average	220	204	268	292	233	181	98	70	89	113	171	234	2,172 /1
Max.	428	429	455	535	385	403	417	237	429	326	312	409	2,934 /2
Min.	46	66	101	122	23	38	1	0	0	0	50	80	1,456 /3

Baraka

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1953	-	-	-	127	260	78	59	0	98	144	258	448	-
1954	293	200	211	276	278	561	44	92	164	242	347	519	3,233
1955	76	287	104	265	216	368	529	418	209	171	262	166	3,111
1975	97	160	123	150	204	162	172	183	173	156	52	67	1,699
1976	50	40	47	136	155	250	67	22	44	61	144	68	1,084
1977	84	92	90	175	72	122	27	65	9	0	-	155	-
1978	127	33	145	98	106	47	126	86	108	97	60	107	1,140
1979	46	132	147	138	96	106	46	3	48	11	96	166	1,035
1980	119	62	72	226	144	372	16	114	9	124	75	87	1,420
1981	27	54	181	198	230	57	-	-	-	-	-	-	-
Average	103	118	124	181	176	212	121	109	96	112	162	200	1,714 /1
Max.	293	287	211	265	278	561	529	418	209	242	347	519	3,233 /2
Min.	27	33	47	98	72	47	16	0	9	0	52	68	1,035 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by BMG

Remarks : - no data
/1 total of monthly averages
/2 maximum of annual rainfall
/3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (2/13)

Rappang (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1917	110	396	203	390	353	390	284	177	-	-	-	-	-
1918	216	552	412	254	172	114	0	0	1	108	182	147	2,158
1919	120	281	135	132	292	94	105	15	31	15	150	124	1,500
1920	185	109	162	286	82	431	164	37	-	-	-	127	-
1921	50	181	102	116	170	174	201	54	71	154	132	135	1,540
1922	34	64	32	417	60	210	-	-	-	49	140	-	-
1923	93	128	101	238	240	10	192	0	1	193	32	176	1,406
1924	91	116	419	290	578	226	177	71	251	232	168	165	2,784
1925	25	115	36	237	212	172	39	56	43	6	112	120	1,173
1926	350	122	52	332	295	172	108	136	206	192	74	208	2,247
1927	66	282	243	409	209	160	64	14	53	146	136	256	2,058
1928	-	-	273	198	118	183	31	-	-	-	-	-	-
1929	154	70	157	256	79	112	49	11	235	14	129	215	1,481
1930	53	50	256	277	422	43	15	3	0	168	50	44	1,381
1931	70	240	172	345	565	405	349	78	89	38	246	162	2,758
1932	176	71	142	184	395	124	238	90	5	154	213	122	1,864
1933	94	119	164	374	241	154	79	361	88	361	205	42	2,082
1934	226	144	109	262	184	307	265	109	81	180	76	179	2,122
1935	110	149	227	311	507	217	103	146	3	315	279	139	2,506
1936	124	187	177	222	241	162	79	111	97	67	81	110	1,656
1937	117	138	230	310	163	232	170	-	68	119	168	157	-
1938	416	78	207	77	460	115	92	292	35	110	221	136	2,239
1939	68	230	153	134	424	-	100	56	36	152	64	64	-
1940	139	40	248	111	534	235	89	6	0	4	202	120	1,728
1941	326	114	161	127	491	159	-	-	8	-	-	-	-
1952	-	-	-	-	-	-	127	0	22	154	116	141	-
1953	121	191	167	58	238	-	-	-	-	-	-	51	-
1954	36	74	149	178	206	473	96	201	-	192	155	169	-
1955	76	255	109	136	62	403	297	233	137	102	93	114	2,017
1956	80	72	191	69	358	242	91	256	127	217	101	316	2,120
1957	88	68	234	42	344	90	200	47	0	-	244	-	-
1962	208	71	178	177	184	314	248	198	35	196	163	197	2,169
1963	75	36	137	153	186	157	21	47	0	0	40	65	912
1964	66	291	92	512	356	103	145	-	387	-	-	-	-
1965	32	-	89	35	186	0	0	23	0	132	-	-	-
1971	-	-	-	138	153	139	228	247	238	222	188	89	-
1972	376	152	21	347	160	98	17	26	0	0	148	380	1,725
1973	194	143	142	272	226	292	240	365	393	203	117	150	2,737
1974	24	143	82	172	247	235	176	67	397	216	153	76	1,988
1975	79	54	152	214	285	245	224	254	110	191	83	164	2,055
1976	117	126	202	107	146	198	193	122	1	163	161	56	1,597
1977	133	118	137	294	300	188	78	-	0	6	154	154	-
1978	65	23	-	-	-	164	164	191	325	75	94	168	-
1979	67	44	158	166	118	249	15	10	78	4	76	62	1,047
1980	114	145	114	339	163	160	4	42	35	31	29	164	1,340
1981	31	101	329	179	474	91	478	-	-	-	-	-	-
Average	124	145	169	225	265	196	141	109	95	109	136	144	1,858 /1
Max.	416	552	419	512	578	473	345	365	397	315	279	360	2,784 /2
Min.	24	23	21	35	60	0	0	0	0	0	29	42	912 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by DIPERTA

Remarks : - no data
/1 total of monthly averages
/2 maximum of annual rainfall
/3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (3/13)

Maroangin

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1931	*	*	*	*	*	*	*	*	*	*	*	*	3,475
1932	*	*	*	*	*	*	*	*	*	*	*	*	3,345
1933	*	*	*	*	*	*	*	*	*	*	*	*	3,480
1934	*	*	*	*	*	*	*	*	*	*	*	*	2,763
1935	*	*	*	*	*	*	*	*	*	*	*	*	3,237
1936	*	*	*	*	*	*	*	*	*	*	*	*	2,791
1937	*	*	*	*	*	*	*	*	*	*	*	*	2,683
1938	*	*	*	*	*	*	*	*	*	*	*	*	2,939
1939	*	*	*	*	*	*	*	*	*	*	*	*	2,082
1940	*	*	*	*	*	*	*	*	*	*	*	*	1,724
1954	245	166	131	165	-	863	213	316	188	356	195	270	-
1955	61	145	120	225	303	848	420	315	165	122	94	116	2,934
1956	66	62	75	224	282	510	75	356	217	272	135	279	2,613
1957	184	98	270	92	436	137	341	50	31	68	168	205	2,080
1958	204	397	312	-	301	210	35	366	75	149	-	206	-
1959	141	243	282	157	259	380	87	62	243	-	204	172	-
1960	269	136	316	218	319	358	578	255	377	156	247	-	-
Average	167	178	215	190	317	472	250	246	185	187	174	208	2,789 /1
Max.	269	397	316	284	436	863	578	366	377	356	247	279	3,480 /2
Min.	61	62	75	92	259	137	75	50	31	68	94	116	1,724 /3

Bulu Cenrana

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1974	-	-	-	-	-	147	297	63	595	260	182	169	-
1975	95	64	87	275	260	140	303	269	139	265	51	119	2,067
1976	47	68	69	59	-	-	-	-	-	83	122	50	-
1977	79	-	67	137	16	30	-	-	-	-	-	-	-
1978	102	125	151	108	120	30	0	119	176	127	55	53	1,166
1979	-	-	166	193	119	44	37	45	183	23	15	86	-
1980	-	-	-	127	60	70	0	93	7	80	59	58	-
1981	20	33	48	68	87	47	60	20	-	-	-	-	-
Average	69	73	98	139	110	73	116	103	221	143	81	89	1,314 /1
Max.	102	125	166	275	260	147	303	269	595	260	182	169	2,067 /2
Min.	20	33	48	59	16	30	0	45	7	23	15	50	1,166 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by P3SA

Remarks :
- \- no data
- * uncollected in this study
- /1 total of monthly averages
- /2 maximum of annual rainfall
- /3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (4/13)

Barukku

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1921	47	204	92	133	160	223	198	83	27	139	121	132	1,559
1922	44	46	66	381	84	320	36	50	5	49	14	270	1,165
1923	103	91	101	165	169	9	146	7	0	31	28	127	977
1924	81	32	386	152	438	145	115	27	106	155	206	319	2,162
1925	51	119	54	322	205	118	44	53	26	-	53	88	-
1926	264	167	45	109	214	131	65	106	29	11	32	117	1,290
1927	126	124	245	262	191	242	110	12	34	72	126	188	1,732
1974	32	136	205	360	315	159	117	73	-	118	186	84	-
1975	205	216	172	438	140	184	199	232	182	261	87	137	2,453
1976	45	115	94	89	133	17	57	45	2	-	216	158	-
1977	246	37	105	416	76	16	0	119	0	0	99	250	1,364
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	225	79	337	268	191	599	215	60	192	35	125	255	2,581
1980	75	179	163	592	264	259	177	247	2	36	61	160	2,215
1981	0	23	232	424	418	75	-	-	-	-	-	-	-
Average	110	112	164	279	214	178	114	86	51	83	104	176	1,671 /1
Max.	264	216	386	592	438	599	215	247	192	261	216	319	2,581 /2
Min.	32	32	45	89	76	9	0	7	0	0	14	84	977 /3

Bila

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1931	146	157	138	406	497	565	630	197	177	83	103	76	3,195
1932	116	52	134	350	432	287	477	473	5	307	212	49	2,840
1933	89	135	169	325	487	276	185	369	168	293	191	60	2,747
1934	234	65	64	222	251	422	316	127	144	259	135	30	2,269
1935	53	277	241	471	700	450	235	82	16	384	374	120	3,403
1936	119	77	154	360	512	216	73	29	28	71	72	73	1,784
1937	25	302	568	430	318	597	456	81	139	127	54	74	3,171
1938	268	58	380	95	549	218	314	310	59	204	148	90	2,692
1939	26	291	161	300	514	295	123	-	-	-	-	-	-
1940	-	58	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	297	337	321	148	147	15	42	74	115	-
1981	7	24	173	-	275	233	664	-	217	225	148	-	-
Average	108	136	218	326	443	355	323	196	97	200	151	76	2,634 /1
Max.	268	302	568	430	549	597	664	473	217	384	374	120	3,403 /2
Min.	7	24	64	95	251	216	73	29	5	42	54	30	1,784 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by PJSA

Remarks : - no data
/1 total of monthly averages
/2 maximum of annual rainfall
/3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (5/13)

Tanru Tedong (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1931	34	155	158	189	580	405	529	143	123	67	162	172	2,717
1932	108	35	181	349	215	217	389	163	3	120	155	70	2,005
1933	109	115	92	150	350	202	134	232	135	220	215	18	1,981
1934	130	56	69	203	181	-	-	173	70	166	167	69	-
1935	68	135	195	405	502	388	298	65	8	232	331	49	2,676
1936	60	98	256	242	486	244	91	115	230	6	81	142	2,051
1937	50	242	152	440	289	316	117	68	-	65	50	59	-
1938	254	46	275	117	550	193	183	343	75	101	-	-	-
1939	-	-	175	243	0	218	152	111	78	63	57	-	-
1940	46	63	117	115	643	340	52	41	9	0	67	206	1,699
1941	145	189	119	172	487	191	5	25	0	21	-	-	-
1953	94	144	142	90	260	273	236	0	29	-	175	38	-
1954	81	135	101	90	278	418	177	193	399	126	112	92	2,002
1955	45	126	127	156	109	293	315	376	138	205	-	60	-
1956	-	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	450	47	237	62	18	-	84	77	-
1958	126	166	126	131	-	-	79	380	41	-	65	54	-
1959	57	116	53	118	279	541	310	24	75	-	62	-	-
1971	-	-	-	79	136	208	179	368	236	225	127	27	-
1972	188	84	17	231	188	70	12	70	0	8	64	153	1,085
1973	95	282	100	365	187	389	114	442	277	179	249	101	2,771
1974	37	45	60	249	220	159	196	4	442	200	85	41	1,738
1975	5	66	45	199	360	259	195	230	358	274	36	37	2,064
1976	38	23	173	193	132	341	211	85	106	149	153	31	1,635
1977	76	40	66	223	183	192	0	230	0	15	195	60	1,286
1978	51	64	158	156	448	412	183	133	87	71	44	34	1,841
1979	17	51	147	232	112	474	100	31	437	0	74	11	1,687
1980	95	79	260	445	278	268	14	100	0	18	167	91	1,815
1981	0	13	270	117	484	211	730	-	249	212	98	-	-
Average	80	103	140	176	311	280	194	156	129	114	123	74	1,874 /1
Max.	254	282	275	445	643	541	730	442	437	274	331	206	2,771 /2
Min.	0	13	17	79	0	47	0	0	0	0	36	11	1,085 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by DIPERTA

Remarks : - no data
/1 total of monthly averages
/2 maximum of annual rainfall
/3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (6/13)

Selava (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1923	30	69	11	229	139	24	176	25	0	22	114	129	968
1924	23	63	204	237	399	143	54	79	178	107	61	97	1,725
1925	94	34	13	165	207	110	54	83	119	22	55	112	1,068
1926	262	152	56	140	227	143	69	127	79	44	56	171	1,526
1927	53	61	-	200	190	218	-	-	23	175	57	204	-
1928	106	83	92	130	162	125	8	9	15	0	37	28	795
1929	206	29	94	235	162	120	90	6	131	11	122	124	1,330
1930	44	103	128	346	329	138	26	4	0	-	110	92	-
1931	18	119	273	219	561	344	526	117	70	37	68	-	-
1932	115	55	14	126	302	275	265	44	1	66	173	128	1,584
1933	137	92	59	223	282	134	129	168	129	175	150	13	1,691
1934	281	79	60	153	363	473	132	70	50	250	57	38	2,006
1935	41	125	129	418	342	335	148	50	4	237	237	91	2,157
1936	79	33	178	258	394	267	87	123	52	22	130	37	1,660
1937	113	39	202	214	253	293	147	46	62	95	114	36	1,614
1938	500	57	226	136	364	159	225	249	90	0	198	165	2,369
1939	103	396	96	107	280	245	119	68	39	36	39	45	1,573
1940	-	-	94	90	371	378	11	13	0	0	55	42	-
1941	130	65	73	191	313	131	5	11	13	0	167	328	1,427
1953	45	134	94	17	161	76	199	0	25	41	233	142	1,167
1954	53	29	180	148	195	217	131	101	83	-	-	-	-
1955	-	-	-	-	-	145	39	42	35	78	111	55	-
1956	-	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	133	47	0	4	108	82	-
1958	129	68	23	112	267	269	43	182	53	124	112	118	1,500
1959	68	49	100	124	193	431	92	11	119	11	110	109	1,426
1960	61	68	32	100	221	129	330	241	68	79	151	39	1,539
1961	174	145	69	321	152	210	17	15	-	6	130	102	-
1962	185	62	206	110	126	351	78	292	39	87	-	76	-
1963	76	52	85	37	206	56	82	50	3	0	4	52	703
1964	46	252	54	298	152	116	242	122	213	161	26	111	1,793
1965	39	-	66	189	239	87	7	63	0	23	73	55	-
1966	125	71	163	259	181	107	38	45	45	104	45	72	1,257
1967	138	81	89	155	103	146	162	97	15	191	110	65	1,352
1968	59	81	193	97	51	240	67	233	66	29	120	390	1,626
1969	68	49	89	451	526	310	126	139	-	-	-	-	-
1972	-	-	-	143	10	21	5	15	0	0	28	107	-
1977	-	-	132	-	-	-	-	29	0	-	-	41	-
1978	-	43	273	282	345	73	227	88	128	100	66	113	-
1979	67	76	127	113	97	251	20	0	440	0	16	42	-
1980	-	-	-	-	-	87	7	173	5	75	45	170	-
1981	41	67	286	181	255	177	-	-	-	-	-	-	-
Average	108	88	118	189	244	190	112	84	63	66	99	103	1,466 /1
Max.	500	396	286	451	561	473	526	292	440	250	237	390	2,369 /2
Min.	18	29	11	17	10	21	5	0	0	0	4	13	703 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by DIPERTA

Remarks : - no data
/1 total of monthly averages
/2 maximum of annual rainfall
/3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (7/13)

Anabanua/Bola Malimpong

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1925	-	33	95	150	277	219	83	107	50	31	42	133	-
1926	167	65	162	217	266	343	124	117	185	9	143	82	1,880
1927	25	152	108	310	185	447	125	25	42	142	71	74	1,706
1928	77	10	80	92	155	460	105	134	17	-	156	39	-
1929	229	-	197	124	452	218	171	12	92	2	193	203	-
1930	10	108	129	355	472	203	47	17	0	96	150	89	1,676
1931	84	176	167	187	782	269	402	91	66	19	115	50	2,408
1932	67	19	56	418	250	409	349	114	23	136	195	82	2,118
1933	210	46	93	211	489	165	187	240	106	190	120	7	2,070
1934	190	60	59	209	368	393	260	99	62	186	86	72	2,046
1935	28	121	83	331	478	317	253	90	13	255	248	61	2,278
1936	52	97	253	496	420	280	78	124	176	0	10	48	2,034
1937	44	156	198	302	234	285	141	11	106	102	87	127	1,843
1938	250	51	272	150	528	245	199	-	-	-	-	-	-
1939	-	-	-	-	411	219	73	81	51	56	49	27	-
1940	20	40	106	124	556	444	29	42	0	0	139	101	1,601
1941	131	53	67	164	345	305	18	26	0	51	197	238	1,595
1953	97	60	70	112	392	238	-	5	80	92	258	156	-
1954	66	84	53	25	342	236	-	-	149	149	80	89	-
1955	6	206	77	174	156	233	296	321	175	110	36	44	1,784
1956	29	40	192	275	198	257	100	222	43	118	84	63	1,621
1957	0	32	-	83	436	31	141	76	33	3	76	163	-
1958	71	299	192	203	212	279	113	259	77	154	33	24	1,916
1959	41	177	297	157	298	658	192	24	124	40	64	74	2,116
1960	72	64	68	151	259	213	460	235	206	105	111	72	2,016
1961	117	157	100	661	291	-	61	38	-	7	252	209	-
1962	145	47	186	-	-	252	139	540	80	-	-	148	-
1963	131	92	69	73	519	165	161	60	1	0	86	89	1,466
1964	46	200	103	511	150	57	529	122	297	245	54	62	2,376
1965	61	-	34	357	406	91	36	63	0	11	141	184	-
1966	79	41	329	320	307	150	115	56	25	52	77	137	1,688
1967	35	26	141	180	160	313	430	173	10	0	193	123	1,864
1977	-	-	-	-	138	258	102	112	0	51	-	-	-
1978	-	-	-	172	256	-	204	42	247	123	98	147	-
1979	39	102	186	220	215	402	41	0	392	0	33	42	1,672
1980	98	71	93	433	397	207	11	142	4	51	56	99	1,662
1981	0	23	232	424	418	75	-	-	-	-	-	-	-
Average	82	89	138	246	342	267	172	112	85	78	114	99	1,824 /1
Max.	250	299	329	661	782	658	529	540	392	255	258	238	2,408 /2
Min.	0	10	34	25	138	31	11	0	0	0	10	7	1,446 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by DIPERTA

Remarks : - no data
/1 total of monthly averages
/2 maximum of annual rainfall
/3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (8/13)

Bontouse

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1953	6	-	-	53	186	99	156	0	44	73	297	140	-
1954	52	66	98	86	254	214	148	3	184	225	178	203	1,611
1955	57	206	239	329	292	333	576	620	221	216	65	88	3,242
1956	126	0	175	166	215	269	44	231	174	310	60	112	1,882
1957	100	75	91	28	257	88	70	82	0	25	27	99	942
1958	111	91	184	229	277	185	88	119	61	195	78	66	1,684
1959	133	107	113	82	314	409	47	47	56	12	241	61	1,620
1960	120	76	3	-	-	-	343	141	134	18	121	51	-
1961	204	134	156	385	179	431	-	9	-	1	109	-	-
1962	418	51	302	-	196	309	-	-	72	-	249	173	-
1963	191	120	66	57	306	123	36	26	0	0	14	26	967
1964	44	183	94	402	124	227	477	53	204	197	27	74	2,106
1965	36	50	38	237	202	17	17	32	0	10	12	59	710
1966	97	57	117	384	200	80	10	33	39	110	139	176	1,438
1970	18	10	128	167	322	338	296	187	105	245	177	10	2,003
1971	23	18	28	107	68	72	100	288	43	42	23	46	863
1972	164	77	56	62	76	41	4	31	0	0	29	134	674
1976	34	0	14	120	257	-	222	14	0	60	126	-	-
1977	-	35	24	41	17	56	7	2	0	0	108	87	-
1978	69	16	247	237	283	122	211	67	142	176	140	260	1,970
1979	40	37	233	365	180	208	60	0	226	25	39	75	1,288
1980	49	158	57	257	260	180	11	70	0	5	73	146	1,266
1981	29	21	248	91	375	95	-	-	-	-	-	-	-
Average	98	72	123	176	220	191	146	93	86	87	106	104	1,506 /1
Max.	418	206	302	402	322	431	576	620	226	310	297	260	3,242 /2
Min.	6	0	3	28	17	17	4	0	0	0	12	10	674 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by DIPERTA

Remarks : - no data
/1 total of monthly averages
/2 maximum of annual rainfall
/3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (9/13)

Batu-Batu

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1930	*	*	*	*	*	*	*	*	*	*	*	*	1,290
1931	150	75	250	145	582	217	113	117	36	0	82	56	1,823
1932	117	22	157	315	169	257	244	40	0	45	77	183	1,626
1933	0	352	75	112	421	130	101	242	71	192	137	35	1,868
1934	218	130	72	84	357	275	91	105	42	179	66	61	1,650
1935	115	113	262	278	502	246	79	6	0	235	212	125	2,173
1936	86	46	219	239	195	183	136	96	33	0	149	57	1,439
1937	132	205	204	343	239	324	198	24	61	21	79	77	1,507
1938	522	64	304	135	439	243	176	186	73	38	259	190	2,679
1939	94	244	125	233	255	292	163	68	10	53	65	64	1,576
1940	197	134	40	175	487	277	10	14	0	0	89	79	1,502
1941	75	82	70	150	292	136	0	7	0	0	189	226	1,227
1951	15	50	55	125	60	295	-	-	-	-	-	-	-
1952	85	55	219	105	129	175	82	0	5	0	30	37	922
1953	35	143	105	15	205	55	160	0	17	-	410	-	-
1954	0	-	-	-	-	240	45	119	65	110	67	-	-
1955	111	219	172	148	298	239	175	320	115	25	-	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	500	75	113	138	0	59	47	100	-
1958	120	161	74	188	231	104	65	111	42	125	56	195	1,472
1959	54	101	119	224	270	327	64	11	103	-	101	171	-
1960	47	193	90	220	251	156	222	177	43	22	-	37	-
1961	171	157	131	333	154	93	16	17	0	2	105	-	-
1962	186	90	259	166	116	192	69	112	62	-	25	194	-
1963	143	58	93	58	151	103	-	35	0	0	10	-	-
1964	92	170	108	-	226	107	183	131	160	215	129	68	-
1965	46	197	170	222	-	-	-	-	0	0	113	65	-
1966	346	114	194	400	125	107	38	50	15	64	170	95	1,718
1967	244	177	61	121	125	-	-	40	-	-	-	-	-
1973	68	174	55	67	89	250	188	130	455	54	131	208	1,669
1974	59	127	81	192	77	83	104	10	173	161	73	32	1,172
1975	-	10	127	108	246	168	144	127	110	366	52	123	-
1976	63	25	155	43	92	119	119	24	0	-	262	31	-
1977	167	142	117	318	152	243	142	53	0	0	26	52	-
Average	125	128	139	181	248	191	154	84	56	76	115	102	1,593 /1
Max.	522	352	304	400	582	327	244	320	455	366	410	226	2,679 /2
Min.	0	10	40	15	60	55	0	0	0	0	0	31	922 /3

Data Source: before 1977 Master Plan Study Report

Remarks :
- \- no data
- * uncollected in this study
- /1 total of monthly averages
- /2 maximum of annual rainfall
- /3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (10/13)

Sengkang (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1917	33	179	54	134	171	326	124	203	81	154	201	43	1,703
1918	36	146	116	70	163	57	0	0	0	37	114	97	836
1919	73	227	165	133	216	67	105	3	30	0	96	76	1,191
1920	83	39	212	226	263	221	98	95	56	98	202	63	1,656
1921	8	260	85	134	248	330	315	147	63	154	84	89	1,937
1922	18	19	32	243	291	180	46	81	17	127	111	128	1,293
1923	56	151	54	304	221	0	322	21	0	25	46	189	1,389
1924	58	74	252	219	417	211	81	170	72	122	293	165	2,132
1925	50	86	31	136	332	245	69	53	19	0	61	73	1,155
1926	147	121	85	122	228	171	70	100	55	13	118	163	1,393
1927	115	143	171	287	162	337	213	16	49	103	76	85	1,758
1928	134	22	57	106	299	150	45	35	7	11	92	60	1,018
1929	219	12	51	278	181	211	99	20	24	11	288	94	1,486
1930	23	76	81	437	321	188	20	10	0	135	89	54	1,434
1931	17	178	197	155	493	294	162	52	57	40	120	43	1,808
1932	72	10	179	243	256	219	219	33	18	67	101	92	1,509
1933	116	90	67	201	455	131	205	166	132	152	129	46	1,870
1934	150	67	63	178	212	395	240	89	83	164	123	132	1,902
1935	109	141	163	321	526	234	76	60	0	222	189	79	2,120
1936	78	3	205	367	293	174	111	114	54	28	135	121	1,683
1937	53	122	130	235	272	217	272	76	83	43	70	87	1,660
1938	388	72	300	124	506	298	135	280	63	42	245	144	2,597
1939	59	211	58	145	332	292	102	161	35	20	41	37	1,493
1940	90	47	85	146	515	293	35	46	0	0	150	140	1,527
1941	65	33	77	134	243	227	2	10	6	24	266	232	1,319
1953	52	79	147	146	181	51	157	4	36	32	178	67	1,330
1954	47	84	79	93	292	243	125	95	184	203	142	150	1,737
1955	37	27	137	164	194	277	397	316	84	211	57	68	2,159
1956	180	45	75	181	148	333	46	135	198	199	40	90	1,676
1957	86	43	130	43	295	131	149	63	10	9	28	120	1,108
1958	129	170	120	239	304	121	55	116	21	181	81	137	1,674
1959	44	76	178	179	366	293	129	26	54	19	132	97	1,593
1960	220	52	45	151	221	260	309	89	101	29	125	42	1,644
1961	146	98	61	361	172	243	24	-	-	13	75	120	-
1962	147	52	243	178	146	204	87	161	38	58	-	36	-
1963	70	65	103	44	197	98	67	66	0	0	0	49	759
1964	87	208	60	291	100	123	210	84	207	161	25	113	1,689
1965	68	50	-	169	262	178	3	10	0	0	22	32	-
1966	47	94	109	354	128	199	21	30	31	69	128	94	1,304
1967	76	42	115	304	67	247	222	80	16	13	44	2	1,028
1968	50	39	288	231	64	221	243	303	21	114	102	150	1,626
1969	56	17	139	137	231	92	95	140	6	27	55	139	1,134
1970	26	26	109	88	256	245	300	171	306	160	288	23	1,936
1971	-	-	-	105	108	198	95	178	144	144	114	72	-
1972	213	-	-	-	-	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	130	235	49	165	150	106	22	-
1975	13	57	9	124	88	152	42	110	192	160	61	53	1,056
1976	29	21	65	111	154	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	166	180	273	130	143	220	104	64	-
1979	40	138	184	181	166	332	37	0	223	16	106	101	1,520
1980	50	136	165	325	334	232	35	109	1	14	315	217	1,733
1981	45	81	283	175	291	103	394	-	98	120	126	-	-
Average	86	88	125	189	251	207	138	90	67	82	116	94	1,533 /1
Max.	388	227	300	437	526	395	397	316	306	222	291	232	2,597 /2
Min.	13	3	9	44	64	0	0	0	0	0	0	2	759 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by P3SA

Remarks : - no data
/1 total of monthly averages
/2 maximum of annual rainfall
/3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (11/13)

Pampanua

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1917	67	255	117	236	257	368	179	202	155	333	133	42	2,344
1918	166	176	63	124	180	77	10	0	0	14	-	151	-
1919	95	398	137	107	285	92	162	0	39	0	48	61	1,424
1920	79	27	139	317	154	105	192	66	30	134	301	40	1,584
1921	25	134	88	149	120	262	289	195	75	219	173	-	-
1922	75	19	96	502	182	219	85	51	11	34	56	103	1,433
1923	70	89	77	243	221	54	129	100	12	25	43	147	1,210
1924	145	490	509	349	450	276	132	138	117	175	256	55	3,100
1925	53	47	34	173	245	261	95	70	45	0	98	83	1,204
1926	133	240	216	146	265	250	56	89	35	2	73	223	1,728
1927	96	73	272	243	155	211	119	23	76	150	79	27	1,524
1928	124	30	159	198	334	222	60	76	29	27	151	37	1,447
1929	116	40	184	190	132	277	242	23	12	9	106	284	1,615
1930	64	60	136	327	436	183	39	9	0	149	60	59	1,522
1931	119	200	192	163	434	370	198	78	35	29	115	199	2,132
1932	100	64	139	270	341	238	158	41	9	113	196	63	1,732
1933	86	85	55	310	271	142	239	141	113	164	111	105	1,822
1934	203	102	39	290	282	280	230	163	57	89	192	147	2,674
1935	49	85	201	327	550	332	133	49	0	262	199	47	2,214
1936	116	99	191	429	331	213	66	102	37	48	79	149	1,840
1937	16	200	141	264	167	210	308	107	134	79	58	193	1,877
1938	215	136	311	92	413	274	200	158	52	22	172	105	2,150
1939	30	251	42	126	318	295	92	199	22	56	70	87	1,588
1940	45	123	120	230	455	246	19	66	0	0	75	157	1,536
1941	41	249	99	353	340	98	10	19	2	36	191	304	1,742
Average	93	147	150	246	293	222	137	87	43	87	127	119	1,751 /1
Max.	215	498	509	502	550	370	308	202	155	333	301	304	3,100 /2
Min.	16	19	34	92	120	54	10	0	0	0	43	27	1,204 /3

Sakkoli

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1969	0	-	-	-	242	107	196	179	38	47	65	109	-
1970	3	12	191	122	0	385	433	157	190	69	146	34	1,742
1971	36	36	17	86	130	61	281	361	329	168	0	0	1,505
1972	130	0	0	246	208	142	0	0	0	27	123	280	1,156
1973	179	99	213	0	0	0	486	0	670	117	0	0	1,764
1974	0	0	46	183	452	60	-	3	70	337	0	0	-
1975	45	63	46	265	437	372	253	162	501	308	126	29	2,607
1976	4	2	149	396	371	584	360	45	0	186	172	0	2,269
1977	105	81	111	29	231	405	253	44	0	40	215	311	1,625
1978	-	-	213	445	330	-	-	-	247	-	-	-	-
1979	39	-	136	-	-	-	-	-	-	-	33	-	-
1980	21	83	156	481	619	320	131	259	3	59	70	162	2,144
1981	0	13	245	300	640	263	-	-	-	-	-	-	-
Average	47	39	127	232	305	245	264	121	186	136	68	92	1,882 /1
Max.	179	99	245	481	640	584	486	361	670	337	215	311	2,607 /2
Min.	0	0	0	0	0	0	0	0	0	40	0	0	1,156 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by DIPERTA

Remarks : - no data
/1 total of monthly averages
/2 maximum of annual rainfall
/3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (12/13)

Paria

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1918	-	-	-	-	-	-	-	-	-	6	270	132	-
1919	121	136	45	385	340	94	134	36	178	0	99	113	1,681
1920	18	32	395	395	146	107	107	97	87	235	84	53	1,556
1921	9	149	69	101	184	403	249	225	38	108	92	67	1,784
1922	22	1	166	394	473	8	73	38	15	392	160	11	1,782
1923	34	141	54	436	335	14	207	43	5	49	114	259	1,691
1924	106	134	340	222	587	260	181	93	229	178	383	38	2,751
1925	29	27	44	97	228	238	111	122	50	0	117	104	1,167
1926	129	235	80	81	396	230	113	73	91	8	79	35	1,550
1927	65	162	225	356	271	440	166	40	47	171	318	90	2,351
1928	66	11	8	-	292	292	53	107	27	43	65	28	-
1929	136	62	38	232	241	234	115	7	81	0	66	237	1,469
1930	1	83	245	700	456	282	38	1	20	166	149	43	2,184
1931	66	157	168	193	616	456	421	114	40	160	140	183	2,714
1932	22	62	259	488	404	318	307	60	63	-	-	40	-
1933	67	103	192	235	650	168	81	376	154	199	107	82	2,417
1934	257	133	52	171	381	393	252	109	68	191	82	218	2,307
1935	23	184	65	355	589	468	218	57	0	205	174	144	2,482
1936	59	100	361	345	438	141	75	167	93	25	95	140	2,039
1937	46	50	242	197	331	314	160	52	140	170	94	105	1,921
1938	253	36	259	220	525	271	243	238	103	79	187	140	2,554
1939	22	202	39	420	497	400	157	189	97	116	75	2	2,216
1940	1	55	121	136	725	443	0	12	0	0	-	-	-
1941	62	148	65	212	454	198	34	34	13	21	262	306	1,811
1953	97	75	101	64	317	242	306	0	90	29	201	244	1,766
1954	21	99	120	136	373	449	194	124	193	316	189	87	2,301
1955	144	188	136	329	364	451	369	643	292	291	176	106	3,489
1956	58	35	198	415	440	321	175	627	156	179	285	193	3,082
1957	90	42	50	120	676	143	214	264	0	68	370	504	2,561
1958	182	259	328	541	756	362	94	279	0	142	-	42	-
1959	0	99	39	370	763	780	133	58	103	18	69	127	2,559
1960	51	135	10	158	325	402	593	178	298	54	240	120	2,564
1961	123	356	182	559	406	423	57	-	-	5	-	-	-
1962	109	17	441	202	385	-	202	223	56	-	-	-	-
1963	-	68	32	110	365	254	131	15	0	-	18	90	-
1964	99	297	145	828	507	211	786	231	366	393	-	83	-
1965	0	-	5	761	623	147	94	97	0	15	-	153	-
1966	452	623	232	644	594	445	367	158	120	-	-	682	-
1967	31	127	71	446	465	663	212	80	5	0	334	27	2,461
1968	12	25	230	456	466	790	258	514	222	355	7	62	3,397
1969	106	67	305	-	862	416	200	135	65	290	265	513	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	23	167	172	194	442	148	-	-	-	-
1972	176	-	-	184	405	53	5	18	0	0	160	444	-
1973	311	101	220	209	368	343	-	244	493	326	82	90	-
1974	32	38	63	256	241	240	616	29	-	259	86	19	-
1975	80	186	63	342	516	503	258	254	623	344	177	20	3,366
1976	13	7	74	161	360	-	325	-	0	176	434	-	-
1977	171	101	103	145	135	429	40	122	0	0	147	263	1,656
1978	107	25	233	134	372	245	279	102	120	197	138	97	2,049
1979	15	14	55	274	210	590	68	0	209	-	101	52	-
1980	5	6	50	460	446	471	63	74	0	30	86	85	1,796
1981	0	23	232	424	418	131	-	-	-	-	-	-	-
Average	84	113	144	309	429	323	200	150	108	130	162	145	2,297 /1
Max.	452	623	441	828	862	790	786	643	623	393	434	682	3,489 /2
Min.	0	1	5	23	135	8	0	0	0	0	7	2	1,167 /3

Data Source: before 1977 Master Plan Study Report
after 1978 Monthly Data by DIPEMTA

Remarks : - no data
/1 total of monthly averages
/2 maximum of annual rainfall
/3 minimum of annual rainfall

Table 2.7 Mean Monthly Rainfall (13/13)

Siva

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1919	*	*	*	*	*	*	*	*	*	*	*	*	2,049
1920	*	*	*	*	*	*	*	*	*	*	*	*	2,718
1921	*	*	*	*	*	*	*	*	*	*	*	*	3,146
1922	*	*	*	*	*	*	*	*	*	*	*	*	-
1923	*	*	*	*	*	*	*	*	*	*	*	*	2,728
1924	*	*	*	*	*	*	*	*	*	*	*	*	2,987
1925	*	*	*	*	*	*	*	*	*	*	*	*	2,897
1926	*	*	*	*	*	*	*	*	*	*	*	*	3,419
1927	*	*	*	*	*	*	*	*	*	*	*	*	2,360
1928	*	*	*	*	*	*	*	*	*	*	*	*	-
1929	*	*	*	*	*	*	*	*	*	*	*	*	3,128
1930	*	*	*	*	*	*	*	*	*	*	*	*	2,930
1931	*	*	*	*	*	*	*	*	*	*	*	*	3,430
1932	*	*	*	*	*	*	*	*	*	*	*	*	3,574
1933	*	*	*	*	*	*	*	*	*	*	*	*	2,173
1934	*	*	*	*	*	*	*	*	*	*	*	*	1,842
1935	*	*	*	*	*	*	*	*	*	*	*	*	2,302
1936	*	*	*	*	*	*	*	*	*	*	*	*	-
1937	*	*	*	*	*	*	*	*	*	*	*	*	2,296
1938	*	*	*	*	*	*	*	*	*	*	*	*	2,778
1939	*	*	*	*	*	*	*	*	*	*	*	*	-
1940	*	*	*	*	*	*	*	*	*	*	*	*	2,439
1941	*	*	*	*	*	*	*	*	*	*	*	*	2,255
Average	*	*	*	*	*	*	*	*	*	*	*	*	2,711 /1
Max.	*	*	*	*	*	*	*	*	*	*	*	*	3,574 /2
Min.	*	*	*	*	*	*	*	*	*	*	*	*	1,842 /3

Data Source: annual data by PMG

Remarks :
- \- no data
- * uncollected in this study
- /1 average of annual rainfall
- /2 maximum of annual rainfall
- /3 minimum of annual rainfall

Table 2.8 Water Level Gauging Stations

No.	Name of Station	Belonging	Setting Year	River System	Name of River
1.	Bulu Cenrana (1)	N. P3SA	Oct. 1975	Bila	Boya
2.	Bulu Cenrana (2)	N. P3SA A. P3SA	Oct. 1975 Mar. 1977	Bila	Boya
3.	Bila (Downstream)	A. PMA	Apr. 1973	Bila	Bila
4.	Tanru Tedong	A. PMA	Mar. 1974	Bila	Bila
24.	L. Tempe	A. P3SA	Mar. 1978	L. Tempe	L. Tempe
25.	L. Tempe	N. P3SA	Oct. 1975	L. Tempe	L. Tempe
26.	Laringgi	N. DIPERTA	Feb. 1968	L. Tempe	L. Tempe
28.	Gilirang	N. P3SA A. P3SA	Sep. 1975 Oct. 1978	Gilirang	Gilirang
29.	Tarumpakkae	N. P3SA	Sep. 1975	Gilirang	Gilirang
30.	Bila (Upstream)	A. PMA	Jul. 1978	Bila	Bila
31.	Kalola	N. P3SA	Sep. 1981	Bila	Kalola

Remark: 1. No. of station is shown in Fig. 1.1 in accordance with Master Plan Study.

2. Classification of automatic gauge : A
Classification of ordinary gauge : N

Table 2.9 Result of Water Quality Analysis
(Sampled 21 Aug. 1981)

Parameter		Unit	(1) Well No.-1	(2) Well No.-2	(3) Well No.-3	(4) Well No.-4	(5) Well No.-5	(6) Kalola River
Chemical & Physical Properties								
Colour		Unit PtCo	5.0	5.0	5.0	5.0	5.0	5.0
Conductivity		mg/l SiO_2	1.8	1.8	1.8	1.8	1.8	1.8
Total Solid		mg/l	388	406	1,200	640	630	96
pH		-	8.4	8.5	9.0	8.7	8.8	8.8
S.A.R.			0.4	0.6	7.5	1.6	2.7	0.12
% Natrium			11	16	71	31	48	7.3
R.S.C.			-	0.3	11	0.01	5.8	0.5
D.H.L.		umho/cm	550	580	1,580	990	820	120
+ Ion (K)								
Potassium	(K)	mg/l	0.52	0.82	11.3	2.1	2.11	1.8
Sodium	(Na)	mg/l	13.7	21.2	251	65	90	2.1
Calcium	(Ca)	mg/l	41	43	8.7	33	6.9	13
Magnesium	(Mg)	mg/l	34	31	46	57	47	5.7
Iron	(Fe)	mg/l	0.02	*	0.01	*	*	0.05
Manganese	(Mn)	mg/l	*	*	*	*	*	*
Ammonium	(NH_4)	mg/l	0.54	0.48	0.05	0.25	0.04	*
- Ion (A)								
Chloride	(Cl)	mg/l	53	43	37	87	9.7	4.9
Sulphate	(SO_4)	mg/l	2.8	4.8	75	63	11.6	1.0
Nitrate	(NO_3)	mg/l	4.4	1.4	0.04	2.9	0.67	*
Nitrite	(NO_2)	mg/l	*	*	*	0.01	0.02	0.02
Bicarbonate	(HCO_3)	mg/l	238	260	783	330	468	67
Carbonate	(CO_3)	mg/l	14	21	63	28	70	14
Phosphor	(P)	mg/l	*	*	*	*	*	*
Boron	(B)	mg/l	*	*	0.02	0.01	0.002	0.004
Copper	(Cu)	mg/l	*	*	*	*	*	*
Cadmium	(Cd)	mg/l	*	*	*	*	*	*
Lead	(Pb)	mg/l	*	*	*	*	*	*
Zinc	(Zn)	mg/l	*	*	*	*	*	*
Nickel	(Ni)	mg/l	*	*	*	*	*	*
Chromium	(Cr)	mg/l	*	*	*	*	*	*

Remark: - no analysis
* negligibly small

(1): Kab. Sidrap, Kec. Dua Pitue, Desa Bila, Kampung Pallae
(2): Kab. Sidrap, Kec. Dua Pitue, Desa Tanru Tedong, Kampung Awakaluku
(3): Kab. Wajo, Kec. Tanasitolo, Desa Tancung, Kampung Labuangpatu
(4): Kab. Wajo, Kec. Maniangpajo, Desa Anabanua, Kampung Bola Malirpong
(5): Kab. Wajo, Kec. Maniangpajo, Desa Kalola, Kampung Awatarae
(6): Kab. Sidrap, Kec. Dua Pitue, Desa Tanru Tedong, Kampung Kalosi

Table 2.10 Water Quality Analysis Made in Master Plan

Parameter		Unit	Bila		Bulu Cenrana	
			Oct.1978	Mar.1979	Oct.1978	Mar.1979
Chemical & Physical Properties						
Colour		Unit PtCo	13 K	2.5	2.5	7.5
Disolved Solid		mg/ℓ	100	-	932	-
Suspended Solid		mg/ℓ	332	-	88	-
Total Solid		mg/ℓ	432	-	1,020	-
Conductivity		mg/ℓ	174	34	1,210	185.0
p.H.		-	8.4	7.6	8.5	7.6
Organic Solid		mg/ℓ $KMnO_4$	12	-	8.2	-
CO_2		mg/ℓ	-	16	-	8.8
Hardness		d	4.4	-	18.5	-
+ Ion (K)						
Potassium	(K)	mg/ℓ	1.1	2.4	20	1.4
Sodium	(Na)	mg/ℓ	4.2	2.1	230	3.9
Calcium	(Ca)	mg/ℓ	18	1.5	50	21
Magnesium	(Mg)	mg/ℓ	8.0	1.5	50	4.4
Iron	(Fe)	mg/ℓ	0.42	*	*	*
Manganese	(Mn)	mg/ℓ	*	*	*	*
Ammonium	(NH_4)	mg/ℓ	0.04	0.13	0.24	0.10
Nitrogen Total		mg/ℓ	-	0.45	0.63	0.59
- Ion (A)						
Fluorine	(F)	mg/ℓ	1.2	*	0.24	0.10
Chloride	(Cl)	mg/ℓ	4.2	3.3	23	6.0
Sulphate	(SO_4)	mg/ℓ	5.1	6.3	449	4.6
Nitrate	(NO_3)	mg/ℓ	7.7	0.21	2.9	0.28
Nitrite	(NO_2)	mg/ℓ	0.03	*	0.02	*
Phosphate	(PO_4)	mg/ℓ	*	0.26	0.08	0.24
Silicate	(SiO_2)	mg/ℓ	42	24	51	32
Bicarbonate	(HCO_3)	mg/ℓ	87	10	346	78
Carbonate	(CO_3)	mg/ℓ	10	-	32	-
Phosphor	(P)	mg/ℓ	-	-	0.03	-
Silicon	(Si)	mg/ℓ	20	-	24	-
Boron	(B)	mg/ℓ	*	0.02	*	0.10
Copper	(Cu)	mg/ℓ	*	*	*	*
Cadmium	(Cd)	mg/ℓ	*	*	*	*
Lead	(Pb)	mg/ℓ	*	*	*	*
Zinc	(Zn)	mg/ℓ	0.12	*	0.87	*

Remark: - no analysis

* negligibly small

Table 3.1 Seasonal Rainfall

(Unit : mm/6 months)

Year	Rappang		Tanru Tedong		Acabanuo		Paria	
	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
1918	541	979						
19	669	745					1,167	457
1920	-	-					939	599
21	786	551					1,200	476
22	-	-					1,001	1,001
23	683	1,027					1,040	1,002
24	1,593	741					1,572	699
25	759	762			886	600	846	665
26	1,249	1,065			1,252	519	984	574
27	929	-			1,134	454	1,320	664
28	-	-			953	-	-	392
29	742	714			1,069	651	910	632
1930	760	744			1,094	762	1,497	749
31	1,830	785	1,969	725	1,797	326	1,850	1,237
32	1,036	866	1,336	661	1,563	768	1,640	-
33	1,297	887	1,203	708	1,398	626	1,667	830
34	1,208	921	-	800	1,391	576	1,374	763
35	1,287	1,221	1,666	1,026	1,482	966	1,687	1,043
36	912	743	1,498	673	1,574	456	1,259	598
37	-	1,145	-	749	1,139	889	1,214	917
38	1,071	918	1,461	-	-	-	1,600	669
39	-	707	802	-	-	298	1,760	370
1940	975	927	1,200	726	1,195	491	1,316	-
41	-	-	-	-	858	-	945	-
42	-	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-
46	-	-	-	-	-	-	-	-
47	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-
49	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-
51	-	-	-	-	-	-	-	-
52	-	890	-	-	-	-	-	-
53	-	-	868	-	-	709	1,019	714
54	-	956	1,355	628	-	607	1,469	1,060
55	1,268	652	1,453	-	1,305	451	2,448	864
56	1,143	1,024	-	-	1,095	-	2,134	833
57	718	-	-	-	800	804	1,417	1,731
58	-	-	-	-	1,143	676	2,032	-
59	-	-	1,347	-	1,453	402	2,207	410
1960	-	-	-	-	1,524	662	1,954	1,075
61	-	-	-	-	-	845	-	-
62	1,156	804	-	-	-	-	-	-
63	559	560	-	-	979	524	875	-
64	-	-	-	-	1,666	-	2,929	-
65	-	-	-	-	953	785	1,722	-
66	-	-	-	-	973	468	2,328	-
67	-	-	-	-	1,345	-	1,871	628
68	-	-	-	-	-	-	2,706	902
69	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-
71	1,143	1,048	1,206	668	-	-	1,146	-
72	648	1,007	571	702	-	-	665	-
73	1,788	719	1,774	662	-	-	-	431
74	1,294	730	1,270	442	-	-	-	693
75	1,332	883	1,601	581	-	-	2,496	635
76	772	768	1,068	515	-	-	-	-
77	-	-	834	543	-	-	871	775
78	-	606	1,419	364	-	695	1,252	516
79	636	515	1,386	520	1,270	337	1,371	-
1980	743	685	1,105	559	1,194	451	1,534	456

Remarks : Wet Season ; April - September
Dry Season ; October - March

Table 3.2 Mean Monthly Discharge (1/2)

Gilirang (Catchment area: 220 km^2)

(Unit: m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1978	-	-	-	-	-	-	-	-	-	9.6	5.9	15.8	-
1979	6.5	1.3	0.4	6.5	-	-	10.8	4.3	4.0	0.4	1.4	1.1	-
1980	(0.1)	(0.1)	1.1	23.0	36.4	24.6	3.4	13.7	0.7	0.5	0.2	0.1	8.7
1981	0.0	0.1	3.2										
Average	2.2	0.5	1.5	14.8	36.4	24.6	7.1	9.0	2.4	5.3	2.5	5.7	9.3

Tarumpakkae (Catchment area: 300 km^2)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1975	-	-	-	-	-	-	-	-	59.7	22.2	3.8	2.0	-
1976	1.1	0.4	1.5	3.3	27.0	38.8	62.3	11.1	0.8	16.1	2.3	1.0	13.9
1977	24.5	33.0	37.5	35.2	30.3	56.1	60.0	23.1	15.0	11.9	2.0	3.8	27.6
1978	14.9	2.3	9.4	19.6	68.3	7.5	23.3	-	15.2	9.7	2.3	20.9	17.6
1979	3.1	3.3	-	-	-	-	-	-	-	-	-	-	-
Average	10.9	9.8	16.1	19.4	41.9	34.1	48.5	17.1	22.7	15.0	2.6	6.9	20.4

Table 3.2 Mean Monthly Discharge (2/2)

Bila (Catchment area: 379 km^2)

(Unit: m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1973	-	-	-	-	45.2	26.6	50.7	28.2	36.1	19.5	14.6	28.1	-
1974	7.7	8.8	3.7	15.1	18.5	16.8	31.9	12.2	54.2	28.2	18.3	13.1	19.6
1975	9.8	28.7	23.3	10.1	(21.8)	-	36.1	33.3	47.2	28.9	14.8	11.0	-
1976	5.6	3.5	10.0	7.8	21.6	14.5	10.9	-	2.9	4.9	11.5	9.5	-
1977	9.2	-	7.7	29.5	17.2	25.8	10.6	17.2	2.5	2.4	2.5	31.0	-
1978	18.3	11.7	27.2	31.5	47.3	32.3	33.3	17.8	19.2	11.0	7.9	23.0	23.5
1979	8.7	13.7	12.8	24.6	18.4	28.2	12.1	3.8	14.4	3.3	5.5	12.2	13.1
1980	13.1	6.6	5.9	24.7	32.1	31.8	9.4	8.9	4.9	3.4	3.6	6.4	12.6
1981	2.7	3.0	14.3	23.5	49.0	16.4	50.7						
Average	9.4	10.9	13.1	20.9	30.1	24.1	27.3	17.3	22.7	12.7	9.8	16.8	18.0

Remarks, ( ): Estimated discharge from Tanru Tedong by use of correlation formula;
$Q_{Bila} = 0.354\ Q_{T.Tedong}$

Tanru Tedong (Catchment area: 1,123 km^2)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1974	-	-	-	38.0	50.0	43.2	57.9	31.0	(153.1)	96.9	50.8	40.3	-
1975	22.0	-	26.4	34.2	61.6	-	97.5	50.9	104.4	65.3	36.1	31.7	-
1976	23.1	14.4	37.1	41.2	25.6	63.4	54.2	-	8.0	10.7	39.0	40.0	-
1977	30.4	-	41.2	81.8	31.5	70.5	17.2	31.8	8.0	4.7	4.3	53.1	-
1978	50.8	21.7	37.6	52.3	103.8	73.3	32.9	61.9	69.3	21.5	18.5	39.7	53.0
1979	24.5	(38.7)	(36.2)	52.9	40.1	(79.7)	17.1	15.2	48.5	9.9	11.8	21.1	32.3
1980	26.1	17.7	20.0	(69.8)	(90.7)	120.6	34.6	22.8	10.5	(9.6)	9.0	14.5	37.1
1981	8.5	7.6	48.7	58.5	150.5	21.7	180.3	17.3					
Average	26.5	20.0	35.3	53.6	69.2	67.5	67.7	33.0	57.4	31.2	24.2	34.3	43.4

Remarks, ( ): Estimated discharge from Bila by use of correlation formula;
$Q_{T.Tedong} = 2.825\ Q_{Bila}$

Balu Centana (Catchment area: 514 km^2)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1975	(9.1)	-	(10.9)	(14.1)	(25.4)	-	(40.2)	(21.0)	(43.0)	17.8	9.4	16.8	-
1976	13.1	12.6	31.7	27.3	30.9	27.8	30.3	9.0	3.9	4.6	11.5	10.5	17.8
1977	10.7	-	24.8	39.1	14.3	21.4	4.0	-	1.1	0.5	6.2	19.4	-
1978	25.2	11.8	28.5	(21.5)	(42.8)	(30.2)	(34.2)	24.8	(28.6)	(8.9)	13.7	26.2	24.8
1979	19.0	26.9	-	19.5	16.5	-	15.8	5.2	11.8	3.4	4.4	17.3	-
1980	16.4	9.3	10.8	-	-	(49.7)	(14.3)	(9.4)	1.8	4.4	6.2	9.8	-
1981	5.8	2.6	(20.1)	(24.1)	36.3*	2.5	33.4*	(7.1)					
Average	14.2	12.6	21.1	24.3	27.7	26.3	24.6	12.8	15.0	6.5	8.6	16.7	17.6

Remarks, ( ): Estimated discharge from Tanru Tedong by use of correlation formula;
$Q_{B.Centana} = 0.412\ Q_{T.Tedong}$
* : Values do not fit the correlation curve.

Table 3.3 10-day Average Discharge of the Bila River
(at Bila)

(Unit : m^3/s)

Year / Month	1973	1974	1975	1976	1977	1978	1979	1980	1981	Ave.
		11.3	9.5	8.1	19.5	13.4	11.3	16.0	3.0	11.5
Jan.		7.3	7.3	5.2	4.7	21.1	6.5	14.8	2.6	8.7
		7.0	15.9	3.9	3.4	20.1	8.5	8.9	2.7	8.8
		6.1	48.6 /1	3.1	3.9	8.8	9.4	8.4	2.7	11.4
Feb.		12.2	28.9	3.2	5.4	10.4	22.4	3.8	2.8	11.1
		8.5	20.1	4.3	6.7	17.0	8.4	8.0	3.5	9.6
		3.9	27.7	8.2	5.4	32.8	9.0	9.1	6.2	12.8
Mar.		3.0	21.2	13.3	4.8	27.0	6.7	4.3	3.6	11.0
		4.5	17.0	8.7	12.6	22.3	21.4	4.3	30.6	15.2
	51.7	12.8	14.2	6.9	39.5	30.4	32.9	20.9	24.7	26.0
Apr.	29.2 /1	25.5	7.5	11.2	33.2	15.0	14.3	28.5	16.3	20.1
	26.9	7.0	8.7	5.3	16.0	49.2	29.2	24.9	29.5	21.9
	33.1	16.9	27.0	48.7	25.1	65.6	35.2	43.9	47.0	38.1
May	52.7	15.3	51.6 /2	7.4	13.1	63.9	12.8	17.0	79.0	34.8
	49.5	22.9	41.2 /2	9.9	13.7	15.7	8.3	35.3	23.7	24.5
	24.4	9.2	36.6 /2	7.2	18.3	35.9	35.8	22.9	9.3	22.2
Jun.	14.7	22.6	31.7	20.5	49.1	30.4	32.2	57.5	24.6	31.5
	40.8	20.6	18.0	15.8	10.0	30.8	16.7	15.2	15.4	20.4
	86.5	34.1	17.8	19.0	13.1	24.8	12.5	11.3	36.6	28.4
Jul.	41.4	38.1	39.3	5.5	9.1	32.4	18.5	12.8	57.6	28.3
	26.5	24.4	49.0	8.5	9.7	41.8	5.8	4.7	57.3	25.3
	50.5	14.8	19.3	17.5 /1	9.4	27.7	3.0	8.5		18.8
Aug.	16.4	9.9	33.9	12.0 /1	25.3	16.8	2.9	6.4		15.5
	18.6	12.0	35.6	6.3 /1	5.9	9.5	5.3	11.5		13.1
	24.1	35.7	75.8	3.2 /1	2.6	20.6	22.4	6.3		23.8
Sep.	47.8	97.1	34.9	2.8	2.5	15.0	17.9	4.6		27.8
	36.2	29.6	31.1	2.7	2.5	22.0	3.0	3.0		16.3
	14.7	25.2	47.9	4.3	2.6	9.2	2.7	2.8		13.7
Oct.	8.4	44.0	18.1	3.8	2.4	6.8	3.5	4.1		11.4
	34.0	17.8	21.6	6.3	2.3	15.6	3.6	3.3		13.1
	19.1	21.1 /1	20.7	5.7	2.2	6.6	5.1	3.0		10.4
Nov.	12.9	22.1	12.5	18.0	2.3	8.6	5.8	3.0		10.7
	11.8	10.8	11.3	10.9	2.7	7.6	6.3	5.0		8.3
	30.0	14.3	17.8	7.1	12.4	12.3	6.8	5.7		13.3
Dec.	30.1	8.9	9.7	6.6	57.1	37.8	13.9	5.2		22.2
	18.1	15.7	6.1	14.2	23.3	24.0	15.6	8.3		15.7

Remarks, /1 : Estimated discharge by use of interpolation curve.
/2 : Estimated discharge from Tanru Tedong by use of correlation curve.

Table 3.4 Discharge Duration

Bila

Discharge (m^3/sec)

Year	Maximum	95-day	185-day	275-day	355-day	Minimum
1974	204.0	20.7	12.8	8.3	3.0	2.9
1975	305.0	30.4	19.1	12.8	4.7	1.7
1976	245.0	10.4	6.0	3.0	2.6	2.5
1977	189.0	14.1	6.8	2.8	2.2	2.2
1978	355.0	24.0	15.5	9.9	5.1	3.7
1979	159.3	13.5	7.3	6.0	2.7	2.7
1980	129.7	14.1	6.8	5.1	2.7	2.6
Average	226.7	18.2	10.6	6.8	3.3	2.6
Maximum	355.0	30.4	19.1	12.8	5.1	3.7
Minimum	129.7	13.5	6.0	2.8	2.2	1.7

Tanru Tedong

Year	Maximum	95-day	185-day	275-day	355-day	Minimum
1975	505.5	64.1	35.2	20.7	9.4	3.1
1976	303.4	44.9	26.9	15.0	5.3	3.7
1977	481.2	42.1	30.9	10.8	2.7	2.5
1978	630.0	59.5	41.6	19.6	16.0	14.4
1979	537.2	39.2	19.0	12.0	7.8	2.1
1980	603.7	39.6	19.0	11.6	6.5	5.8
Average	510.2	48.2	28.8	15.0	8.0	5.3
Maximum	630.0	64.1	41.6	20.7	16.0	14.4
Minimum	303.4	39.2	19.0	11.6	2.7	2.1

Table 3.5 Accumulated Rainfalls of 11 Stations

(Unit: mm)

Year	Enrekang	Siva	Moroangin	Rappang	Bila	Malimpong	Paria	Senkang	Batu-Batu	Pompanua	Tanru Tedong	Average
1931	2,152	3,430	3,475	2,758	3,195	2,408	2,734	1,808	1,823	2,132	2,717	2,603
1932	2,017	3,574	3,345	1,864	2,840	2,118		1,509	1,626	1,732	2,005	2,263
1933	1,960	2,143	3,480	2,082	2,747	2,070	2,417	1,870	1,868	1,822	1,981	2,222
1934	2,357	1,842	2,763	2,122	2,269	2,044	2,307	1,902	1,680	2,674		2,196
1935	2,407	2,302	3,237	2,506	3,403	2,278	2,482	2,120	2,173	2,214	2,676	2,527
1936	2,410		2,791	1,658	1,784	2,034	2,039	1,683	1,439	1,840	2,051	1,973
1937	2,229	2,296	2,683		3,171	1,843	1,921	1,660	1,907	1,677		2,176
1938	2,223	2,778	2,939	2,239	2,692		2,554	2,597	2,629	2,150		2,533
1939	2,334		2,082				2,216	1,493	1,576	1,588		1,882
1940	1,749	2,489	1,724	1,728		1,601		1,527	1,502	1,536	1,699	2,210
Total	21,843	20,854	28,519	16,957	22,101	16,396	18,670	18,169	18,223	19,565	13,129	214,421
Mean	2,184	2,054	2,852	2,120	2,763	2,050	2,334	1,817	1,822	1,957	2,188	2,210

Year	Accumulation			
	Moroangin	Bila	Senkang	Tanru Tedong
1931	3,475	3,195	1,808	2,717
1932	6,820	6,035	3,317	4,722
1933	10,300	8,782	5,187	6,703
1934	13,063	11,051	7,089	6,703
1935	16,300	14,454	9,209	9,379
1936	19,091	16,238	10,892	11,430
1937	21,774	19,409	12,552	11,430
1938	24,713	22,101	15,149	11,430
1939	26,795	22,101	16,642	11,430
1940	28,517	22,101	18,169	13,129

Remarks: This table is formulated by using correlation method between Tanru Tedong and Pompanua.
Correlation equation is Y = 799.22 + 1.5896 x X (X: Pompanua, Y: Tanru Tedong).

Table 3.6 Gilirang Water Balance (1980)

(Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. Precipitation	21	83	156	481	619	320	111	259	3	59	70	162
2. Evaporation	97	92	126	108	122	108	109	123	36	107	94	103
3. 1 - 2	-76	-9	27	373	437	212	2	136	-33	-48	-24	59
4. Soil Moisture	124	115	142	200	200	200	200	200	167	119	95	154
5. Surplus	0	0	0	315	437	212	2	136	0	0	0	0
6. Infiltration	0	0	0	95	149	64	1	41	0	0	0	0
7. Infiltration x 0.8	0	0	0	76	119	51	0	33	0	0	0	0
8. K x V(N-1)	4	2	1	1	38	79	65	33	33	16	8	4
9. Storage	4	2	1	76	157	130	65	65	33	16	8	4
10. V(N) = V(N) - V(N-1)	-3	-1	-1	47	51	-17	-40	0	-20	-10	-5	0
11. Baseflow	3	1	1	48	98	81	41	41	20	10	5	0
12. Direct Runoff	0	0	0	221	348	149	1	95	0	0	0	0
Estimated Q	3	1	1	268	446	229	42	136	20	10	5	0
Observed Q	1	1	13	271	443	290	41	167	8	6	2	1

Remarks: 1) Infiltration/Surplus = 0.30
2) Initial K x V(N-1) = 4.0
3) V(N) = (V(N) - V(N-1))/0.80

Table 3.7 Kalola Water Balance (1/4)

Summary (Unit: m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1973	1.01	11.45	1.08	13.90	5.92	16.67	3.05	18.89	9.97	5.70	9.49	2.90	8.34
1974	0.09	0.05	0.02	2.41	6.35	4.74	5.84	0.79	12.93	6.26	1.55	0.98	3.50
1975	2.41	4.09	1.09	10.44	3.98	4.99	4.03	5.97	3.75	6.15	0.84	0.64	4.03
1976	0.09	0.05	0.33	4.60	2.50	13.64	8.45	2.72	4.44	3.79	3.40	0.92	3.74
1977	0.09	0.05	0.02	4.25	5.69	8.17	0.97	9.16	1.04	0.50	4.34	1.01	2.94
1978	1.21	2.04	4.13	5.48	17.93	18.95	7.03	3.85	1.71	2.11	1.47	0.42	5.53
1979	3.07	0.51	7.52	7.20	3.32	19.66	4.82	1.23	5.92	0.76	0.47	4.78	4.94
1980	1.08	2.33	3.07	18.43	7.73	7.72	2.12	3.21	0.59	0.28	0.15	0	3.69
1981	0.09	0.05	2.65	9.89	13.57	1.80	22.76	2.34	7.57	5.54	1.67		6.18
Average	1.02	2.29	2.21	8.51	7.44	10.70	6.56	5.35	5.32	3.45	2.60	1.46	4.74
Maximum	3.07	11.45	7.52	18.43	17.93	19.66	22.76	18.89	12.93	6.26	9.49	4.78	
Minimum	0.09	0.05	0.02	2.41	2.50	1.80	0.97	0.79	0.59	0.28	0.15	0	

1973 (Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1. Precipitation	119	354	126	459	235	486	143	556	348	225	302	127	3,481
2. Evaporation	95	90	123	124	118	98	113	95	153	122	96	117	1,344
3. 1 - 2	24	264	3	335	117	388	30	461	195	103	206	10	
4. Soil Moisture	200	200	200	200	200	200	200	200	200	200	200	200	
5. Surplus	24	264	3	335	117	388	30	461	195	103	206	10	
6. Infiltration	7	79	1	100	35	117	9	138	59	31	62	3	
7. Infiltration x 0.8	6	63	1	80	28	93	7	111	47	25	49	2	
8. K x V(N-1)	3	4	34	17	49	38	66	37	74	60	42	46	
9. Storage	9	68	35	98	77	132	73	147	120	85	92	48	
10. V(N) = V(N) - V(N-1)	2	37	-21	39	-13	34	-37	46	-17	-22	4	-54	
11. Baseflow	5	42	22	61	48	82	46	92	75	53	57	57	
12. Direct Runoff	17	185	2	234	82	272	21	323	137	72	144	7	
Estimated Q	22	227	24	295	130	354	67	415	212	125	202	64	2,137
Observed Q (m^3/sec)	1.01	11.45	1.08	13.90	5.92	16.67	3.05	18.89	9.97	5.70	9.49	2.90	

1974 (Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1. Precipitation	37	45	60	249	220	159	196	4	442	200	85	41	1,738
Precipitation x 1.25	47	57	75	313	277	200	246	5	556	251	107	52	2,165
2. Evaporation	95	90	123	124	118	98	113	95	153	122	96	117	1,344
3. 1 - 2	-48	-33	-48	189	159	102	133	-90	403	129	11	-65	
4. Soil Moisture	152	119	71	200	200	200	200	110	200	200	200	135	
5. Surplus	0	0	0	60	159	102	133	0	313	129	11	0	
6. Infiltration	0	0	0	18	48	31	40	0	94	39	3	0	
7. Infiltration x 0.8	0	0	0	14	38	24	32	0	75	31	3	0	
8. K x V(N-1)	3	2	1	0	7	23	24	28	14	45	38	20	
9. Storage	3	2	1	15	45	47	56	28	89	75	40	20	
10. V(N) = V(N) - V(N-1)	-2	-1	0	9	19	1	5	-17	38	-8	-22	-21	
11. Baseflow	2	1	0	9	28	29	35	17	56	47	25	21	
12. Direct Runoff	0	0	0	42	111	71	93	0	219	90	8	0	
Estimated Q	2	1	0	51	139	101	128	17	275	137	33	21	937
Observed Q (m^3/sec)	0.09	0.05	0.02	2.41	6.35	4.74	5.84	0.79	12.93	6.26	1.55	0.98	

Table 3.7 Kalola Water Balance (2/4)

1975 (Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1. Precipitation	155	179	140	378	195	203	198	232	226	264	74	112	2,356
2. Evaporation	95	90	123	124	118	98	113	95	153	122	96	117	1,344
3. 1 - 2	60	89	17	254	77	105	85	137	73	142	-22	-5	
4. Soil Moisture	200	200	200	200	200	200	200	200	200	200	178	172	
5. Surplus	60	89	17	254	77	105	85	137	73	142	0	0	
6. Infiltration	18	27	5	76	23	32	26	41	22	43	0	0	
7. Infiltration x 0.8	14	21	4	61	18	25	20	33	18	34	0	0	
8. K x V(N-1)	3	9	15	10	35	27	26	23	28	23	28	14	
9. Storage	17	30	19	71	54	52	46	56	46	57	28	14	
10. V(N) = V(N) - V(N-1)	7	8	-7	32	-10	-1	-4	6	7	7	-18	-14	
11. Baseflow	11	19	12	44	34	33	29	35	28	36	18	14	
12. Direct Runoff	42	62	12	178	54	74	60	96	51	99	0	0	
Estimated Q	53	81	24	222	87	106	89	131	80	135	18	14	1,039
Observed Q (m^3/sec)	2.41	4.09	1.09	10.44	3.98	4.93	4.03	5.97	3.75	6.15	0.84	0.64	

1976 (Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1. Precipitation	48	29	217	243	166	429	265	107	133	187	192	39	2,055
2. Evaporation	71	100	115	129	112	98	81	70	42	107	123	49	1,097
3. 1 - 2	-23	-71	102	114	54	331	184	37	91	80	69	-10	
4. Soil Moisture	177	106	200	200	200	200	200	200	200	200	200	190	
5. Surplus	0	0	8	114	54	331	184	37	91	80	69	0	
6. Infiltration	0	0	2	34	16	99	55	11	27	24	21	0	
7. Infiltration x 0.8	0	0	2	27	13	79	44	9	22	19	17	0	
8. K x V(K-1)	3	2	1	1	14	14	47	45	27	24	22	19	
9. Storage	3	2	3	29	27	93	91	54	49	44	38	19	
10. V(N) = V(N) - V(N-1)	-2	-1	1	16	-1	41	-1	-23	-3	-3	-3	-20	
11. Baseflow	2	1	2	18	17	58	57	34	31	27	24	20	
12. Direct Runoff	0	0	6	80	38	232	129	26	64	56	48	0	
Estimated Q	2	1	7	98	55	290	165	60	94	83	72	20	968
Observed Q (m^3/sec)	0.09	0.05	0.33	4.60	2.50	13.64	8.45	2.72	4.44	3.79	3.40	0.92	

1977 (Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1. Precipitation	96	50	83	280	238	241	0	289	0	19	245	75	1,617
2. Evaporation	108	86	71	138	100	54	15	50	20	22	120	70	854
3. 1 - 2	-12	-36	12	142	138	187	-15	239	-20	-3	125	5	
4. Soil Moisture	188	152	164	200	200	200	185	200	180	177	200	200	
5. Surplus	0	0	0	106	138	187	0	224	0	0	102	5	
6. Infiltration	0	0	0	32	41	56	0	67	0	0	31	2	
7. Infiltration x 0.8	0	0	0	25	33	45	0	54	0	0	24	1	
8. K x V(N-1)	3	2	1	0	13	23	34	17	35	18	9	17	
9. Storage	3	2	1	26	46	68	34	71	35	18	33	18	
10. V(N) = V(N) - V(N-1)	-2	-1	0	16	13	14	-21	23	-22	-11	10	-17	
11. Baseflow	2	1	0	16	29	42	21	44	22	11	21	19	
12. Direct Runoff	0	0	0	74	96	131	0	157	0	0	71	4	
Estimated Q	2	1	0	90	125	174	21	201	22	11	92	22	762
Observed Q (m^3/sec)	0.09	0.05	0.02	4.25	5.69	8.17	0.97	9.16	1.04	0.50	4.34	1.01	

Table 3.7 Kalola Water Balance (3/4)

1978

(Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1. Precipitation	64	80	199	196	563	518	230	167	106	89	55	43	2,310
2. Evaporation	35	36	98	71	117	92	110	109	89	49	29	69	904
3. 1 - 2	29	44	101	125	446	426	120	58	17	40	26	-26	
4. Soil Moisture	200	200	200	200	200	200	200	200	200	200	200	174	
5. Surplus	29	44	101	125	446	426	120	58	17	40	26	0	
6. Infiltration	9	13	30	38	134	128	36	17	5	12	8	0	
7. Infiltration x 0.8	7	11	24	30	107	102	29	14	4	10	6	0	
8. K x V(N-1)	3	5	8	16	23	65	84	56	35	20	15	10	
9. Storage	10	16	32	46	130	167	112	70	39	29	21	10	
10. V(N) = V(N) - V(N-1)	2	3	10	9	53	23	-34	-26	-19	-6	-5	-9	
11. Baseflow	6	10	20	29	81	105	70	44	24	18	13	9	
12. Direct Runoff	20	31	71	88	312	298	84	41	12	28	18	0	
Estimated Q	27	41	91	116	394	403	154	84	36	46	31	9	1,432
Observed Q (m^3/sec)	1.71	2.04	4.13	5.48	17.93	18.95	7.03	3.85	1.71	2.11	1.47	0.42	

1979

(Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1. Precipitation	173	72	290	259	171	568	186	53	253	26	113	194	2,358
2. Evaporation	96	68	100	98	109	94	112	70	104	39	98	94	1,082
3. 1 - 2	77	4	190	161	62	474	74	-17	149	-13	15	100	
4. Soil Moisture	200	200	200	200	200	200	200	183	200	187	200	200	
5. Surplus	77	4	190	161	62	474	74	0	132	0	2	100	
6. Infiltration	23	1	57	48	19	142	22	0	40	0	1	30	
7. Infiltration x 0.8	18	1	46	39	15	114	18	0	32	0	0	24	
8. K x V(N-1)	3	11	6	26	32	24	69	43	22	27	13	7	
9. Storage	21	12	51	64	47	137	86	43	53	27	14	31	
10. V(N) = V(N) - V(N-1)	10	-6	25	8	-11	56	-32	-27	6	-17	-8	-5	
11. Baseflow	13	7	32	40	29	85	54	27	33	17	9	35	
12. Direct Runoff	54	3	133	113	43	332	52	0	92	0	1	70	
Estimated Q	67	10	165	153	73	418	106	27	126	17	10	105	1,276
Observed Q (m^3/sec)	3.07	0.51	7.52	7.20	3.32	19.66	4.82	1.23	5.92	0.76	0.47	4.78	

1980

(Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1. Precipitation	80	154	187	555	268	261	136	210	2	32	88	143	2,116
2. Evaporation	54	101	114	104	113	104	113	145	41	64	69	103	1,125
3. 1 - 2	26	53	73	451	155	157	23	65	-39	-32	19	40	
4. Soil Moisture	200	200	200	200	200	200	200	200	161	129	148	188	
5. Surplus	26	53	73	451	155	157	23	65	0	0	0	0	
6. Infiltration	8	16	22	135	47	47	7	20	0	0	0	0	
7. Infiltration x 0.8	6	13	18	108	37	38	6	16	0	0	0	0	
8. K x V(N-1)	3	4	9	13	61	49	43	24	20	10	5	3	
9. Storage	9	17	26	121	98	87	49	40	20	10	5	3	
10. V(N) = V(N) - V(N-1)	2	5	6	60	-15	-7	-24	-6	-13	-6	-3	0	
11. Baseflow	5	11	16	76	61	54	31	25	13	6	3	0	
12. Direct Runoff	18	37	51	316	109	110	16	46	0	0	0	0	
Estimated Q	24	48	67	391	170	164	47	71	13	6	3	0	1,003
Observed Q (m^3/sec)	1.08	2.33	3.07	18.43	7.71	7.72	2.12	3.21	0.59	0.28	0.15	0.00	

Table 3.7 Kalola Water Balance (4/4)

1981

(Unit: mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1. Precipitation	0	21	242	347	435	109	703	20	249	212	98	102	2,548
2. Evaporation	32	59	104	106	109	105	136	23	87	98	81	123	1,094
3. 1 - 2	-32	-38	138	241	326	4	567	-3	162	114	17	-21	
4. Soil Moisture	168	130	200	200	200	200	200	197	200	200	200	179	
5. Surplus	0	0	68	241	326	4	567	0	159	114	17	0	
6. Infiltration	0	0	20	72	98	1	170	0	48	34	5	0	
7. Infiltration x 0.8	0	0	16	58	78	1	136	0	38	27	4	0	
8. K x V(N-1)	3	2	1	9	33	56	28	82	41	40	35	16	
9. Storage	3	2	17	66	111	57	164	82	79	67	38	18	
10. V(N) = V(N) - V(N-1)	-2	-1	10	31	28	-34	67	-51	-2	-8	-18	-14	
11. Baseflow	2	1	11	41	70	35	103	51	50	42	23	14	
12. Direct Runoff	0	0	48	169	228	3	397	0	111	80	12	0	
Estimated Q	2	1	58	210	298	38	500	51	161	122	35	14	1,470
Observed Q (m^3/sec)	0.09	0.05	2.65	9.89	13.57	1.80	22.76	11.37	5.32	1.38	0.20	0.62	

Remarks: For August 1975 - June 1981, the evaporation was estimated based on the potential evapotranspiration of Sengkang; for January - July 1975 and July - December 1981, the average monthly potential evapotranspiration on two stations (Sengkang and Kanyuara) was adopted for estimation.

Table 3.8 Rainfall in the Kalola River Water Balance

Month	1973		1974		1975			1976		1977	
	Rainfall of Tanru Tedong	Estimated Rainfall	Rainfall of Tanru Tedong	Estimated Rainfall	Rainfall of Tanru Tedong	Rainfall of Barukku	Estimated Rainfall	Rainfall of Tanru Tedong	Estimated Rainfall	Rainfall of Tanru Tedong	Estimated Rainfall
1	95	119	37	47	5	205	155	38	48	76	96
2	282	354	45	57	66	216	179	23	29	40	50
3	100	126	60	75	45	172	140	173	217	66	83
4	365	459	249	313	199	438	378	193	243	223	280
5	187	235	220	277	360	140	195	132	166	189	238
6	389	486	159	200	259	184	203	341	429	192	241
7	114	143	196	246	195	199	198	211	265	0	0
8	442	556	4	5	230	232	232	85	107	230	289
9	277	348	442	556	358	182	226	106	133	0	0
10	179	225	200	251	274	261	264	149	187	15	19
11	240	302	85	107	6	87	74	153	192	195	245
12	101	127	41	52	37	137	112	31	39	60	75

Month	1978		1979			1980			1981		
	Rainfall of Tanru Tedong	Estimated Rainfall	Rainfall of Tanru Tedong	Rainfall of Barukku	Estimated Rainfall	Rainfall of Tanru Tedong	Rainfall of Barukku	Estimated Rainfall	Rainfall of Tanru Tedong	Rainfall of Barukku	Estimated Rainfall
1	51	64	17	225	173	95	75	80	0	0	0
2	64	80	51	79	72	79	179	154	13	23	21
3	158	199	147	337	290	260	163	187	270	232	242
4	156	196	232	268	259	445	592	555	117	424	347
5	448	563	112	191	171	278	24	268	484	418	435
6	412	518	474	599	568	268	259	261	211	75	109
									Rainfall of Tanru Tedong	Rainfall of Bila	Estimated Rainfall
7	183	230	100	215	166	14	177	136	730	664	697
8	133	167	31	60	53	100	247	210	-	-	20
9	87	106	437	192	253	0	2	2	249	217	233
10	71	89	0	35	26	18	36	32	212	225	219
11	44	55	75	125	113	167	61	88	98	148	123
12	34	43	11	255	194	91	160	143	90	113	102

Remarks: For '73, '74, '76, '77 and '78, estimated rainfall = rainfall of Tanru Tedong x 1.25; refer to Fig. 3.10.
For '75, '79 and '80, estimated rainfall = rainfall of Tanru Tedong x 0.25 + rainfall of Barukku x 0.75.
For the period from January and July in 1981, estimated rainfall = (rainfall of Tanru Tedong + rainfall of Bila) x 1/2.
The precipitation of August 1981 is rainfall recorded at Bulu Cenrana because of no other available data.

Table 3.9 Evaporation in the Kalola River Water Balance

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1973	95	90	123	124	118	98	113	95	153	122	96	117	1,344
1974	95	90	123	124	118	98	113	95	153	122	96	117	1,344
1975	95	90	123	124	118	98	113	95	153	122	96	117	1,344
1976	71	100	115	129	112	98	81	70	42	107	123	49	1,097
1977	108	86	71	138	100	54	15	50	20	22	120	70	854
1978	35	36	98	71	117	92	110	109	89	49	29	69	904
1979	96	68	100	98	109	94	112	70	104	39	98	94	1,082
1980	54	101	114	104	113	104	113	145	41	64	69	103	1,125
1981	32	59	104	106	109	105	136	23	87	98	81	123	1,094
Average	76	80	108	113	113	93	101	84	94	83	90	95	1,130

Table 4.1 Probable Flood Hydrograph

Bila

Time (hr)	Discharge (m^3/sec) 5-yr.	20-yr.	100-yr.	200-yr.	1000-yr.
0	0	0	0	0	0
1	122	157	197	208	250
2	243	313	393	417	500
3	365	470	590	625	750
4	487	627	787	833	1,000
5	608	783	983	1,042	1,250
6	730	940	1,180	1,250	1,500
7	584	752	944	1,000	1,200
8	467	602	755	800	960
9	374	481	604	640	768
10	299	385	483	512	614
11	239	308	387	410	492
12	191	246	309	328	393
13	153	197	247	262	315
14	122	158	198	210	252
15	98	126	158	168	201
16	78	101	126	134	161
17	63	81	101	107	129
18	50	65	81	86	103
19	40	52	65	69	82
20	32	41	52	55	66
21	26	33	42	44	53

Kalola

Time (hr)	Discharge (m^3/sec) 5-yr.	20-yr.	100-yr.	200-yr.	1000-yr.
0	0	0	0	0	0
1	76	97	122	129	154
2	152	194	244	258	308
3	228	291	366	387	462
4	304	388	488	516	616
5	380	485	610	645	770
6	304	388	488	516	616
7	243	310	390	413	493
8	195	248	312	330	394
9	156	199	250	264	315
10	125	159	200	211	252
11	100	127	160	169	202
12	80	102	128	135	161
13	64	81	102	108	129
14	51	65	82	87	103
15	41	52	65	69	83
16	33	42	52	55	66
17	26	33	42	44	53
18	21	27	34	35	42
19	17	21	27	28	34
20	13	17	21	22	27
21	11	14	17	18	22

Table 4.2 Runoff Coefficient of the Kalola River Basin (at Kalola W.L Station)

Flood			Peak Discharge Q_p /1 (m^3/s)	Time Concentration T (hr)	Rainfall		Runoff Coefficient f
Year	Month	Date			Daily R_{24} /2 (mm/day)	Intensity r (mm/hr)	
1981	Sep.	6	110	7	50	4.74	0.70
1981	Sep.	9	200	7	76	7.20	0.82
1981	Oct.	8	110	6	35	3.67	0.87

Remarks, /1: observed discharge at Kalola W.L. station

/2: basin average daily rainfall estimated from rainfalls at Bila and Tanru Tedong

Catchment area: 122 km^2

Table 4.3 Runoff Coefficient of the Bila River Basin (at Bila W.L Station)

Flood			Peak Discharge Q_p /1 (m^3/s)	Time Concentration T (hr)	Rainfall		Runoff Coefficient f
Year	Month	Date			Daily R_{24} /2 (mm/day)	Intensity r (mm/hr)	
1974	Sep.	11	505	3	91	15.17	0.32
1974	Sep.	12	680	8	94	8.15	0.79
1978	Apr.	28	660	6	75	7.87	0.80
1979	June	9	555	6	85	8.92	0.59
1979	Sep.	11	590	6	90	9.45	0.59
1981	May	14	565	6	89	9.34	0.57
						Average =	0.6

Remarks, /1: observed discharge at Bila W.L. station

/2: basin average daily rainfall estimated from rainfalls at Bulu Cenrana, Tanru Tedong and Barukku

Catchment area: 379 km^2

Table 4.4 Probable Flood Discharge at Kalola Dam Site

Return period (year)	Daily rainfall on the Kalola river (mm/day)	Rainfall intensity r (mm/hr)	Runoff coefficient f	Flood Discharge Q (m^3/sec)
1,000	226	26.8	0.85	772
200	189	22.4	0.85	645
100	178	21.1	0.85	608
20	142	16.8	0.85	484
5	110	13.0	0.85	374

Remark: $Q = \frac{1}{3.6} f.r.A$ $A = 122\ km^2$

Table 5.1 Monthly and Yearly Average Water Level of Lake Tempe

(Unit: EL.m)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1968	-	6.215	5.865	6.795	5.815	6.445	7.115	7.855	6.595	4.715	4.775	5.155	6.105
1969	5.975	5.945	5.805	6.485	7.145	8.025	6.975	6.095	5.525	4.615	4.465	-	6.095
1970	5.539	5.485	6.515	5.715	6.635	8.675	7.785	7.305	6.165	5.605	5.055	5.445	6.325
1971	5.725	5.595	5.995	5.115	4.285	5.545	6.135	6.275	6.675	6.725	6.365	6.355	5.895
1972	8.035	7.985	6.975	5.615	4.615	-	-	-	-	-	-	-	-
1975	(5.156)	(5.579)	(5.336)	(5.341)	(6.918)	(7.775)	(7.027)	(7.318)	(6.775)	(6.710)	6.100	5.652	6.307
1976	5.624	5.071	4.922	4.862	5.014	5.688	6.207	5.002	4.057	4.100	4.035	4.482	4.922
1977	5.953	6.473	6.713	6.473	5.827	7.111	6.785	5.008	3.938	(3.462)	(3.256)	(4.199)	5.441
1978	5.310	4.843	5.246	5.244	6.767	6.710	6.582	6.412	5.301	4.909	4.551	4.859	5.561
1979	5.883	5.281	5.162	5.439	6.015	4.898	4.290	5.225	4.896	4.370	3.857	3.922	4.937
1980	4.694	5.164	5.491	6.644	7.533	7.356	6.177	4.764	4.043	3.632	3.592	4.465	5.296
1981	5.628	5.203	5.278	6.460	7.327	6.870	7.126	6.813	5.319	-	-	-	-
Average	5.775	5.737	5.775	5.849	6.158	6.827	6.564	6.188	5.390	4.884	4.605	4.948	5.725

Note: (   ) shows estimated values from the water level at Sengkang (Cenranae River), using the correlation between the water levels at Sengkang and Lake Tempe

Table 5.2 Annual Maximum Water Levels of Lake Tempe

Year	Month	W.L (m)	Zero Point of Gage (m)	Water Level (EL.m)	Remarks
1939	Feb.	9.43	0.0	9.49	DPU
1940	Jun.	9.33	0.0	9.33	"
1941	Jun.	8.00	0.0	8.00	"
1948	Jun.	9.33	0.0	8.33	"
1952	Jun.	6.93	0.0	6.93	"
1953	Feb.	7.86	0.0	7.86	"
1954	Jun.	9.38	0.0	9.38	"
1968	Aug.	3.95	3.3	7.34	Dinas Perikanan
1969	Jun.	4.32	3.3	7.62	" "
1970	Jun.	6.28	3.3	9.58	" "
1971	Oct.	3.90	3.3	7.20	" "
1975	Jun.	-	-	8.10	Estimated
1976	Jul.	2.91	3.875	6.785	P3SA (Staff Gage)
1977	Jun.	5.05	3.875	8.925	" (")
1978	May	3.63	3.875	7.505	" (")
1979	May	3.14	3.285	6.425	" (AWLR)
1980	May	(4.69)	3.285	8.00	Estimated
1981	Jul.	5.00	3.285	8.258	P3SA (AWLR, before Oct.)

Table 5.3 Annual Minimum Water Level of Lake Tempe

Year	Month	L.W.L (EL.m)	Rank	Remarks
1968	Oct.	3.9	5	
1969	Nov.	4.3	8	
1970	Nov.	4.3	9	
1971	May	4.2	7	
1972	-	(3.0)	1	Assumed
1975	Apr.	4.9	11	Estimated
1976	Nov.	3.9	6	
1977	Nov.	3.2	2	Estimated
1978	Nov.	4.5	10	
1979	Nov.	3.7	4	
1980	Nov.	3.5	3	

Table 5.4 High Water Level Days of Lake Tempe

(Unit: days)

Year	Water Level (El. m)																				
	6.5			7.0			7.5			8.0			8.5			9.0			9.5		
	W.S.	D.S.	Anu.	W.S.	D.S.	Anu.	W.S.	D.S.	Anu.	W.S.	D.S.	Anu.	W.S.	D.S.	Anu.	W.S.	D.S.	Anu.	W.S.	D.S.	Anu.
1939	54	91	118	24	46	72		14	39		3	27			16			7			
1940	64	64	64	55	55	55	40	40	40	24	24	24	10	10	10	10	4	4			
1941	65	65	65	36	36	36	18	18	18	1	1	1									
1948	109	115	175	89	89	113	35	35	35	19	19	19									
1952	51	66	66																		
1953	85	119	147	33	50	75	11	21	36												
1954	115	-	-	100		-	81		-	77		-	50		-	17		-			
1968	50	53	53	23	23	23															
1969	59	59	59	34	34	34	17	17	17												
1970	91	91	91	68	68	68	40	40	40	15	15	15	5	5	5	4	4	4	1	1	1
1971	0	0	8			3															
1975	113	140	173	86	89	93	50	50	50	4	4	4									
1976	7	7	7																		
1977	35	68	88	30	38	49	20	20	20	12	12	12	7	7	7						
1978	80	80	80	11	11	11	1	1	1												
1979	0	0	0																		
1980	71	90	99	64	81	87	24	24	24	1	1	1									
1981	88	105		55	55		39	39		19	19										

Remark: W.S.; Wet seasin (May - August)

D.S.; Dry season (September - March)

Table 5.5 Return Period of Water Level Duration of Lake Tempe

Return Period (year)		2	3	5	10	20
Duration	(days)					
(Annual)	9.5 m	0	0	0	0	1
	9.0 m	0	0	4	11	17
	8.5 m	0	0	11	26	37
	8.0 m	3	14	25	37	47
	7.5 m	20	33	45	59	70
(Mar. - Sep.)	9.5 m	0	0	0	0	1
	9.0 m	0	0	1	8	15
	8.5 m	0	0	6	18	28
	8.0 m	0	10	23	36	47
	7.5 m	18	30	42	54	70
(May - Aug.)	9.5 m	0	0	0	0	1
	9.0 m	0	0	1	8	15
	8.5 m	0	0	5	18	28
	8.0 m	0	8	21	35	47
	7.5 m	18	28	41	54	70

Duration (days)		1	7	15	20	30
Return Period	(year)					
(Annual)	9.5 m	12	-	-	-	-
	9.0 m	5.4	6.8	15.4	30	-
	8.5 m	2.9	4.1	5.8	7.3	12.5
	8.0 m	2.0	2.2	3.0	3.7	6.3
	7.5 m	1.4	1.5	1.8	2.0	2.7
(Mar. - Sep.)	9.5 m	12	-	-	-	-
	9.0 m	5.4	8.6	20	35	-
	8.5 m	3.9	5.4	8.3	13.0	23
	8.0 m	2.3	2.7	3.6	4.4	7.0
	7.5 m	1.4	1.5	1.9	2.1	3.0
(May - Aug.)	9.5 m	12	-	-	-	-
	9.0 m	5.4	8.6	20	35	-
	8.5 m	3.9	5.4	8.3	13.0	24
	8.0 m	2.5	2.9	3.8	4.7	7.4
	7.5 m	1.4	1.7	2.1	2.4	3.3

Table 5.6 Inundation Area

Code No.	Kabupaten (District)	Kecamatan (Subdistrict)	Desa (Village)	Location
BI - 1	Sidrap	Dua Pitue	Bila	Bila AWLR station - confluence of the Boya
BI - 2	Sidrap	Dua Pitue	Tanru Tedong	Left bank, Tanru Tedong - confluence of Lancirang
BI - 3	Wajo	Belawa	Wele	Along S. Ate drainage
KA - 1	Wajo	Maniang Pajo	Kalola	Left bank of the Kalola river
KA - 2	Sidrap	Dua Pitue	Tanru Tedong	Left bank of the Kalola river
KA - 3	Sidrap	Dua Pitue	Tanru Tedong	Southern area of the Provincial road
KA - 4	Wajo	Belawa	Wele	Along S. Padang drainage
BK - 1	Sidrap	Dua Pitue	Tanru Tedong	Right bank in downstream of the Kalola
BK - 2	Sidrap	Dua Pitue	Tanru Tedong	West side area of S. Wele drainage
BK - 3	Wajo	Belawa	Wele	West side area of S. Wele drainage
BO - 1	Sidrap	Dua Pitue	Bila	Left bank of the Boya river
BO - 2	Sidrap	Dua Pitue	Otting	Right bank of the Boya river
BO - 3	Sidrap	Dua Pitue	Lancirang	West side area of S. Jampu drainage
BO - 4	Sidrap	Dua Pitue	Lancirang	Southern area of the Provincial road
BB - 1	Sidrap	Dua Pitue	Tanru Tedong	Right bank of the Bila, northern area of the road
BB - 2	Sidrap	Dua Pitue	Tanru Tedong	Right bank of the Bila, southern area of the road
LA - 1	Sidrap	Dua Pitue	Lancirang	West side area of Kampung Ajubissue
LA - 2	Sidrap	Dua Pitue	Otting	East side area of Kampung Ajibissue
LA - 3	Sidrap	Dua Pitue	Lancirang	Along the Lancirang, northern area of Provincial road
LA - 4	Sidrap	Dua Pitue	Lancirang	West side area of Kampung Samallangi
LA - 5	Sidrap	Dua Pitue	Lancirang	Southern area of the Provincial road
BL - 1	Wajo	Belawa	Wele	Right bank in downstream of the Bila river

Table 5.7 Estimated Inundation Area

Code No.	Paddy Area (km^2) /1	Others (km^2)	Total (km^2)	Estimated Paddy Field (ha) /2	Remarks
BI - 1	2.43	5.80	8.23	220	X /3
BI - 2	4.67	1.43	6.10	420	X
BI - 3	7.00	2.33	9.33	630	X
KA - 1	1.16	0.30	1.46	100	X
KA - 2	0.15	0.70	0.85	10	X
KA - 3	8.72	0.50	9.22	780	X
KA - 4	3.21	1.01	4.22	290	X
BK - 1	4.00	0.25	4.25	360	X
BK - 2	2.74	0.63	3.37	250	X
BK - 3	3.08	1.02	4.10	280	X
BO - 1	1.03	0.35	1.38	90	X
Sub-total	38.19	14.32	52.51	3,430	X
BO - 2	3.15	0.12	3.27	280	- /4
BO - 3	5.80	0.82	6.62	520	-
BO - 4	2.23	1.71	3.94	200	-
BB - 1	8.50	0.97	9.47	770	-
BB - 2	2.12	3.51	5.63	190	-
LA - 1	8.06	2.45	10.51	730	-
LA - 2	7.53	0.45	7.98	680	-
LA - 3	1.51	3.00	4.51	140	-
LA - 4	5.05	0.50	5.55	450	-
LA - 5	3.08	2.57	5.65	280	-
BL - 1	9.53	4.89	14.42	860	-
Sub-total	56.56	20.99	77.55	5,100	-
Total	94.75	35.31	130.06	8,530	

Note: /1 measured on the map of 1/25,000 prepared by JICA in 1978.

/2 adopted values for estimation of flood damage.

/3 X; in the Bila irrigation project area.

/4 -; out of the Bila irrigation project area.

Table 5.8 Probable Inundation Depth and Duration
(Under present condition with ill drainage)

Code No.	Item	Probability					
		2/1	1/1	1/2	1/5	1/10	1/20
BI - 1	Depth (m)	0.20	0.30	0.60	0.80	0.95	1.05
	Duration (days)	1	1	1	1	1	1
BI - 2	Depth (m)	-	0.30	0.50	0.65	0.75	0.80
	Duration (days)	-	1	4	4	4	4
BI - 3	Depth (m)	0.30	0.40	0.80	1.15	1.40	1.50
	Duration (days)	2	4	4	4	4	4
KA - 1	Depth (m)	0.10	0.40	0.10	0.40	0.50	0.55
	Duration (days)	1	1	1	1	1	1
KA - 2	Depth (m)	0.05	0.10	0.40	0.70	0.80	0.90
	Duration (days)	1	1	1	1	1	1
KA - 3	Depth (m)	0.30	0.40	1.00	1.20	1.35	1.45
	Duration (days)	2	3	3	4	4	4
KA - 4	Depth (m)	0.30	0.40	0.90	1.00	1.05	1.10
	Duration (days)	2	3	5	6	7	8
BK - 1	Depth (m)	0.20	0.30	0.80	1.05	1.20	1.30
	Duration (days)	1	3	5	6	6	7
BK - 2	Depth (m)	0.30	0.40	0.90	1.10	1.20	1.30
	Duration (days)	2	2	3	5	5	5
BK - 3	Depth (m)	0.30	0.40	0.90	1.15	1.30	1.45
	Duration (days)	2	3	4	4	4	4
BO - 1	Depth (m)	-	0.05	0.10	0.35	0.55	1.05
	Duration (days)	-	1	1	1	1	1
BO - 2	Depth (m)	-	0.05	0.10	0.35	0.55	1.05
	Duration (days)	-	1	1	1	1	1
BO - 3	Depth (m)	0.20	0.25	0.30	1.10	1.30	1.50
	Duration (days)	1	1	1	1	1	1
BO - 4	Depth (m)	0.30	0-50	0.70	0.90	1.00	1.15
	Duration (days)	2	3	8	10	10	10
BB - 1	Depth (m)	0.30	0.40	0.80	1.10	1.30	1.50
	Duration (days)	1	1	1	1	1	1
BB - 2	Depth (m)	0.30	0.50	0.70	0.90	1.00	1.15
	Duration (days)	2	3	8	10	10	10
LA - 1	Depth (m)	0.30	0.40	0.80	1.00	1.10	1.25
	Duration (days)	2	3	5	7	7	7
LA - 2	Depth (m)	0.20	0.25	0.30	0.70	1.00	1.15
	Duration (days)	1	2	2	4	7	7
LA - 3	Depth (m)	0.30	0.40	0.80	1.00	1.10	1.25
	Duration (days)	3	4	6	8	8	8
LA - 4	Depth (m)	0.20	0.30	0.60	0.90	1.05	1.20
	Duration (days)	3	4	6	8	8	8
LA - 5	Depth (m)	0.30	0.50	0.80	1.10	1.20	1.30
	Duration (days)	3	4	5	8	8	8
BL - 1	Depth (m)	0.30	0.40	0.70	0.90	1.05	1.15
	Duration (days)	4	6	7	8	8	8

Table 5.9 Probable Inundation Depth and Duration
(After improvement of drainage)

Code No.	Item	Probability 2/1	1/1	1/2	1/5	1/10	1/20
BI - 1	Depth (m)	0.20	0.30	0.60	0.80	0.95	1.05
	Duration (days)	1	1	1	1	1	1
BI - 2	Depth (m)	-	0.30	0.50	0.65	0.75	0.80
	Duration (days)	-	1	3	3	3	3
BI - 3	Depth (m)	0.20	0.30	0.70	1.05	1.30	1.40
	Duration (days)	1	3	3	3	3	3
KA - 1	Depth (m)	-	0.30	1.00	1.30	1.40	1.45
	Duration (days)	-	1	1	2	2	2
KA - 2	Depth (m)	-	-	0.30	0.60	0.70	0.80
	Duration (days)	-	-	1	1	1	1
KA - 3	Depth (m)	0.20	0.30	0.90	1.10	1.25	1.35
	Duration (days)	1	2	2	3	3	3
KA - 4	Depth (m)	0.20	0.30	0.80	0.90	0.95	1.00
	Duration (days)	1	2	4	5	6	7
BK - 1	Depth (m)	0.20	0.30	0.80	1.05	1.20	1.30
	Duration (days)	1	2	4	5	5	6
BK - 2	Depth (m)	0.20	0.30	0.80	1.00	1.10	1.20
	Duration (days)	1	1	2	4	4	4
BK - 3	Depth (m)	0.20	0.30	0.80	1.05	1.20	1.35
	Duration (days)	1	2	3	3	3	3
BO - 1	Depth (m)	-	-	0.10	0.35	0.55	1.05
	Duration (days)	-	-	1	1	1	1
BO - 2	Depth (m)	-	-	0.10	0.35	0.55	1.05
	Duration (days)	-	-	1	1	1	1
BO - 3	Depth (m)	0.10	0.15	0.20	1.00	1.20	1.40
	Duration (days)	1	1	1	1	1	1
BO - 4	Depth (m)	0.30	0.50	0.70	0.90	1.00	1.15
	Duration (days)	1	2	7	9	9	9
BB - 1	Depth (m)	0.20	0.30	0.70	1.00	1.20	1.40
	Duration (days)	1	1	1	1	1	1
BB - 2	Detph (m)	0.30	0.50	0.70	0.90	1.00	1.15
	Duration (days)	1	2	7	9	9	9
LA - 1	Depth (m)	0.20	0.30	0.70	0.90	1.00	1.15
	Duration (days)	1	2	4	6	6	6
LA - 2	Depth (m)	0.10	0.15	0.20	0.60	0.90	1.05
	Duration (days)	1	1	1	3	6	6
LA - 3	Depth (m)	0.20	0.30	0.70	0.90	1.00	1.15
	Duration (days)	2	3	5	7	7	7
LA - 4	Depth (m)	0.10	0.20	0.50	0.80	0.95	1.10
	Duration (days)	2	3	5	7	7	7
LA - 5	Depth (m)	0.30	0.50	0.80	1.10	1.20	1.30
	Duration (days)	2	3	4	7	7	7
BL - 1	Depth (m)	0.20	0.30	0.60	0.80	0.95	1.05
	Duration (days)	3	5	6	7	7	7

Table 5.10 Estimated Flood Inundation Depth and Duration

H: mean depth (m)
T: duration (days)

Year	1974								1975								1976				1977			
Month	Jul. 15		Sep. 12-17		Oct. 16-17		Dec. 25		Jun. 19		Jul. 28-30		Aug. 12-14		Aug. 31		Mar. 4-5		May 4-6		Apr. 17		Jun. 14-20	
Q(m³/sec)	629		924		710		659		678		831		804		732		767		878		647		672	
Code	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T
BI - 1	-		0.55	6	0.20	2	0.10	1	0.15	1	0.30	3	0.25	3	0.20	1	0.25	2	0.40	3	0.05	1	0.05	5
BI - 2	-	-	0.45	6	0.05	2	-	-	-	-	0.30	3	0.20	3	0.10	1	0.15	2	0.35	3	-	-	-	-
BI - 3	0.15	1	0.70	6	0.20	2	0.15	1	0.20	1	0.30	3	0.25	3	0.20	2	0.25	2	0.45	3	0.15	1	0.15	5
MA - 1	-	-	0.80	6	0.05	2	-	-	-	-	0.40	3	0.20	3	0.10	1	0.15	2	0.60	3	-	-	-	-
MA - 2	-	-	0.45	6	-	-	-	-	-	-	0.10	3	-	-	-	-	-	-	0.25	3	-	-	-	-
MA - 3	0.15	1	0.70	6	0.20	2	0.15	1	0.20	1	0.35	3	0.25	3	0.20	1	0.25	2	0.55	3	0.15	1	0.15	5
MA - 4	0.15	1	0.60	6	0.20	2	0.15	1	0.20	1	0.35	3	0.25	3	0.20	1	0.25	2	0.50	4	0.15	1	0.15	5
EK - 1	-	-	0.70	6	0.20	2	-	-	0.10	1	0.35	3	0.25	3	0.20	1	0.25	2	0.50	4	-	-	0.05	5
EK - 2	-	-	0.65	6	0.20	2	-	-	0.10	1	0.35	3	0.25	3	0.20	1	0.25	2	0.50	3	-	-	0.05	5
EK - 3	0.15	1	0.70	6	0.20	2	0.15	1	0.20	1	0.35	3	0.25	3	0.20	1	0.25	2	0.50	3	0.15	1	0.15	5
BO - 1	-	-	0.35	6	-	-	-	-	-	-	0.05	3	-	-	-	-	-	-	0.10	3	-	-	-	-
BO - 2	-	-	0.35	6	-	-	-	-	-	-	0.05	3	-	-	-	-	-	-	0.10	3	-	-	-	-
BO - 3	0.10	1	0.70	6	0.10	2	0.10	1	0.10	1	0.15	3	0.15	3	0.10	1	0.15	2	0.20	3	0.10	1	0.10	5
BO - 4	0.15	1	0.60	9	0.25	2	0.20	1	0.20	1	0.40	4	0.35	3	0.30	1	0.30	2	0.45	7	0.20	1	0.20	5
EB - 1	-	-	0.70	6	0.20	2	-	-	0.10	1	0.30	3	0.25	3	0.20	1	0.25	2	0.43	3	-	-	0.05	5
EB - 2	0.15	1	0.60	9	0.25	2	0.20	1	0.20	1	0.40	4	0.35	3	0.30	1	0.30	2	0.45	7	0.20	1	0.20	5
LA - 1	0.15	1	0.60	6	0.20	2	0.15	1	0.20	1	0.30	3	0.25	3	0.20	1	0.25	2	0.45	4	0.15	1	0.15	5
LA - 2	-	-	0.55	6	0.10	2	-	-	-	-	0.35	3	0.15	3	0.10	1	0.15	2	0.20	3	-	-	-	-
LA - 3	0.15	2	0.60	7	0.20	2	0.15	2	0.20	2	0.30	4	0.25	3	0.20	2	0.25	2	0.45	5	0.15	2	0.15	5
LA - 4	0.05	2	0.50	7	0.10	2	0.10	2	0.10	2	0.25	4	0.20	3	0.10	2	0.15	3	0.35	5	0.10	2	0.10	5
LA - 5	0.15	2	0.70	7	0.25	2	0.20	2	0.25	2	0.40	3	0.35	3	0.25	2	0.30	3	0.50	4	0.20	2	0.25	5
EL - 1	0.15	2	0.60	7	0.20	3	0.15	2	0.20	3	0.30	5	0.25	5	0.20	3	0.25	4	0.40	6	0.15	2	0.15	5

	1978						1979				1980		1981					
Month	May 1-2		Jun. 26-27		Jul. 23-24		Jun. 9-11		Sep. 11		May 4-6		Mar. 27-29		May 14-18		Jul. 22-25	
Q(m³/s)	814		772		810		873		891		700		705		898		748	
Code	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T
BI - 1	0.25	3	0.25	2	0.25	3	0.40	3	0.45	1	0.20	3	0.20	3	0.50	1	0.20	5
BI - 2	0.25	3	0.20	2	0.25	3	0.35	3	0.40	3	-	-	-	-	0.45	3	0.15	5
BI - 3	0.25	3	0.25	3	0.25	3	0.40	3	0.50	3	0.20	3	0.20	3	0.60	3	0.20	5
MA - 1	0.25	3	0.20	2	0.25	3	0.55	3	0.65	1	-	-	-	-	0.70	1	0.15	5
MA - 2	-	-	-	-	-	-	0.20	2	0.30	1	-	-	-	-	0.35	1	-	-
MA - 3	0.25	3	0.25	2	0.25	3	0.50	3	0.60	3	0.20	3	0.20	3	0.65	3	0.20	5
MA - 4	0.25	3	0.25	2	0.25	3	0.45	4	0.55	5	0.20	3	0.20	3	0.55	3	0.20	5
EK - 1	0.25	3	0.25	2	0.25	3	0.45	4	0.60	5	0.15	3	0.20	3	0.65	3	0.20	5
EK - 2	0.25	3	0.25	2	0.25	3	0.45	3	0.55	3	0.15	3	0.20	3	0.60	3	0.20	5
EK - 3	0.25	3	0.25	2	0.25	3	0.45	3	0.60	3	0.20	3	0.20	3	0.65	3	0.20	5
BO - 1	-	-	-	-	-	-	0.10	2	0.20	1	-	-	-	-	0.25	1	-	-
BO - 2	-	-	-	-	-	-	0.10	2	0.20	1	-	-	-	-	0.25	1	-	-
BO - 3	0.15	3	0.15	2	0.15	3	0.20	3	0.40	1	0.10	3	0.10	3	0.55	1	0.10	5
BO - 4	0.35	3	0.30	2	0.35	3	0.45	7	0.50	9	0.25	3	0.25	3	0.55	9	0.30	5
EB - 1	0.25	3	0.25	2	0.25	3	0.40	3	0.55	1	0.15	3	0.20	3	0.60	1	0.20	5
EB - 2	0.35	3	0.30	2	0.35	3	0.45	7	0.50	9	0.25	3	0.25	3	0.55	9	0.30	5
LA - 1	0.25	3	0.25	2	0.25	3	0.40	4	0.50	5	0.20	3	0.20	3	0.55	6	0.20	5
LA - 2	0.15	3	0.15	2	0.15	3	0.20	3	0.35	3	0.05	3	0.10	3	0.40	3	0.10	5
LA - 3	0.25	3	0.25	3	0.25	3	0.40	5	0.50	6	0.20	3	0.20	3	0.55	7	0.20	5
LA - 4	0.20	3	0.20	3	0.20	3	0.35	5	0.40	6	0.10	3	0.10	3	0.45	7	0.15	5
LA - 5	0.35	3	0.35	3	0.35	3	0.50	4	0.60	6	0.25	3	0.25	3	0.65	7	0.30	5
EL - 1	0.25	5	0.25	5	0.25	5	0.40	6	0.45	7	0.20	3	0.20	3	0.50	7	0.20	5

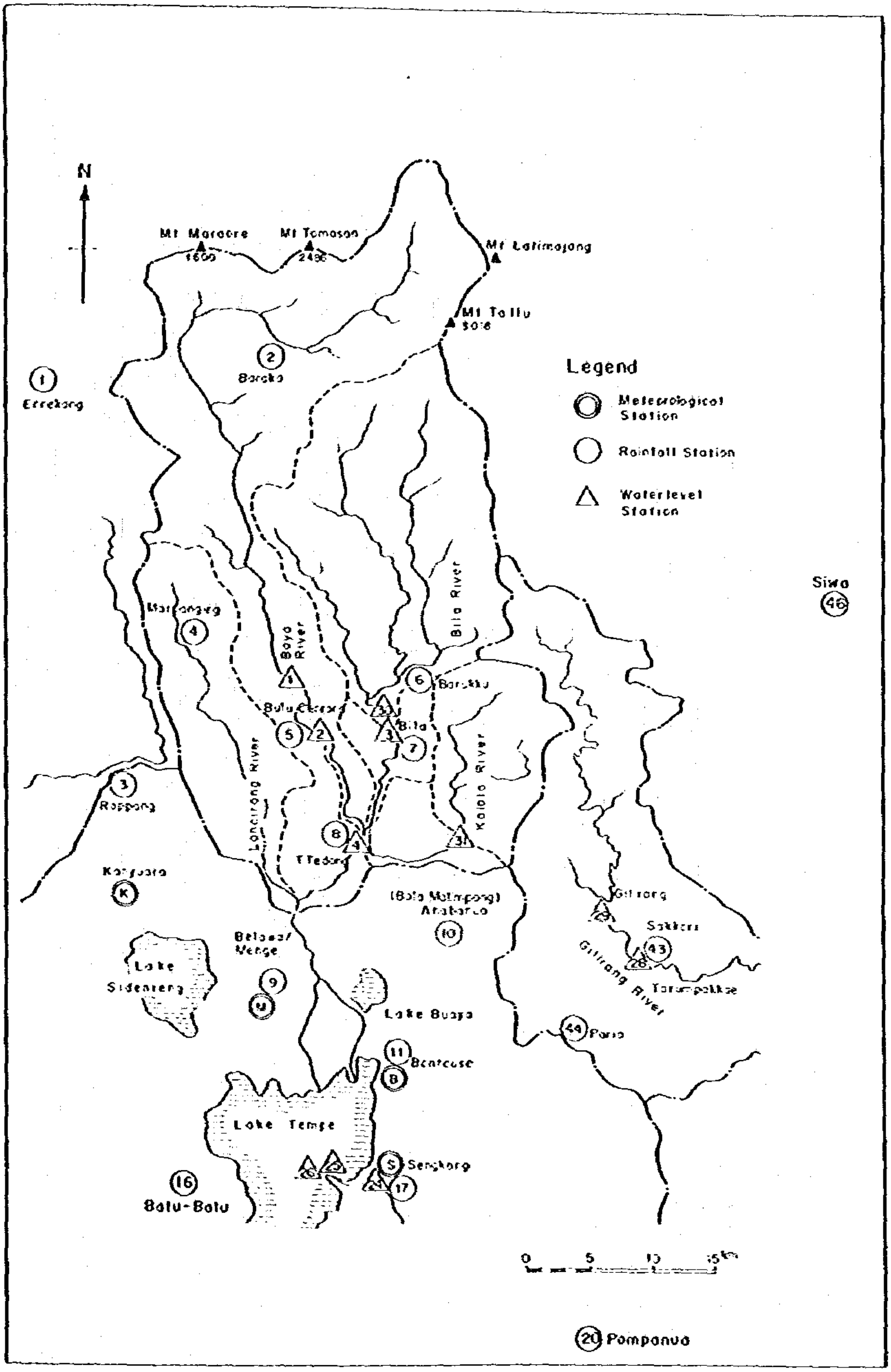


Fig. 1.1 BILA RIVER BASIN

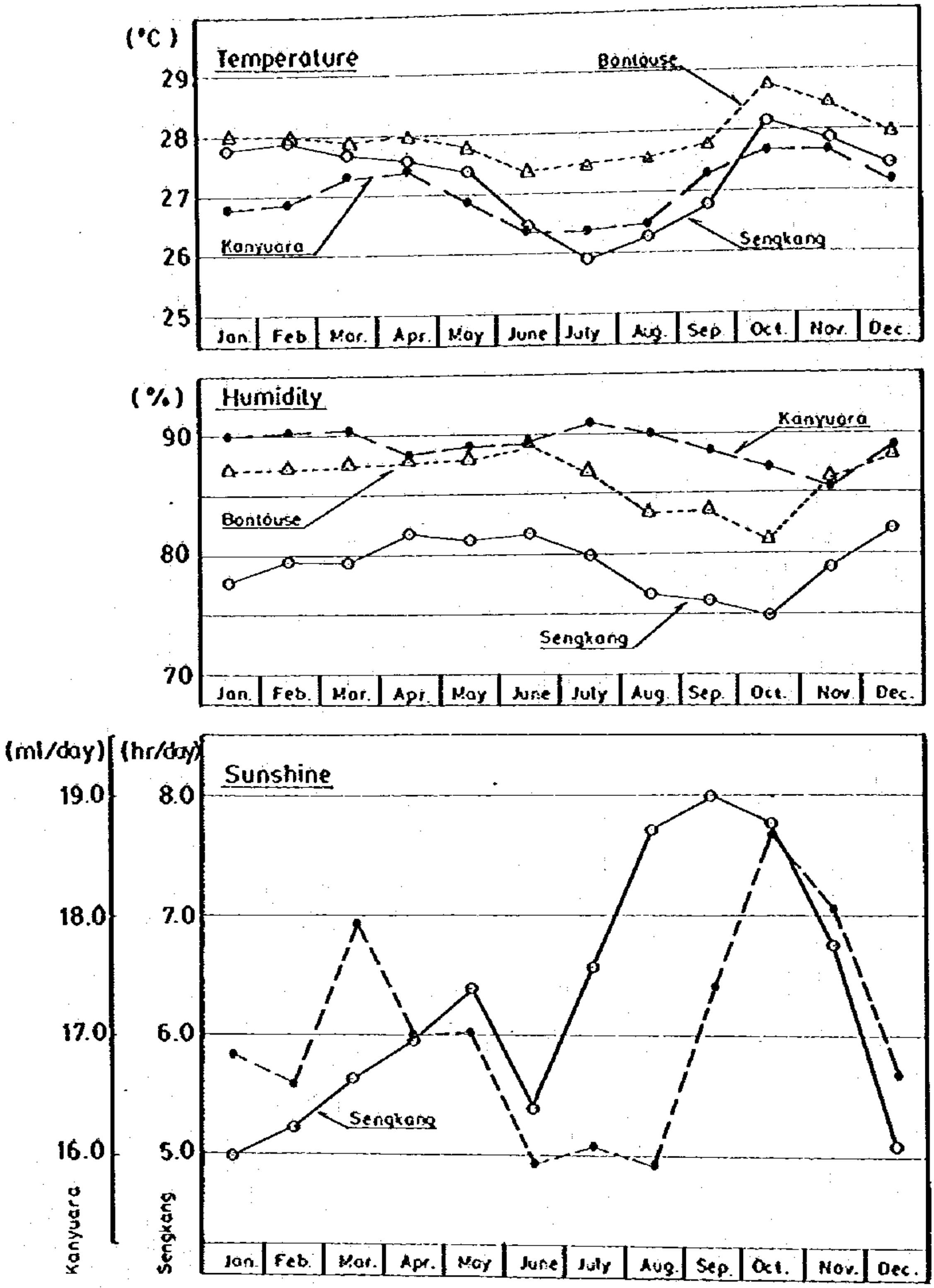
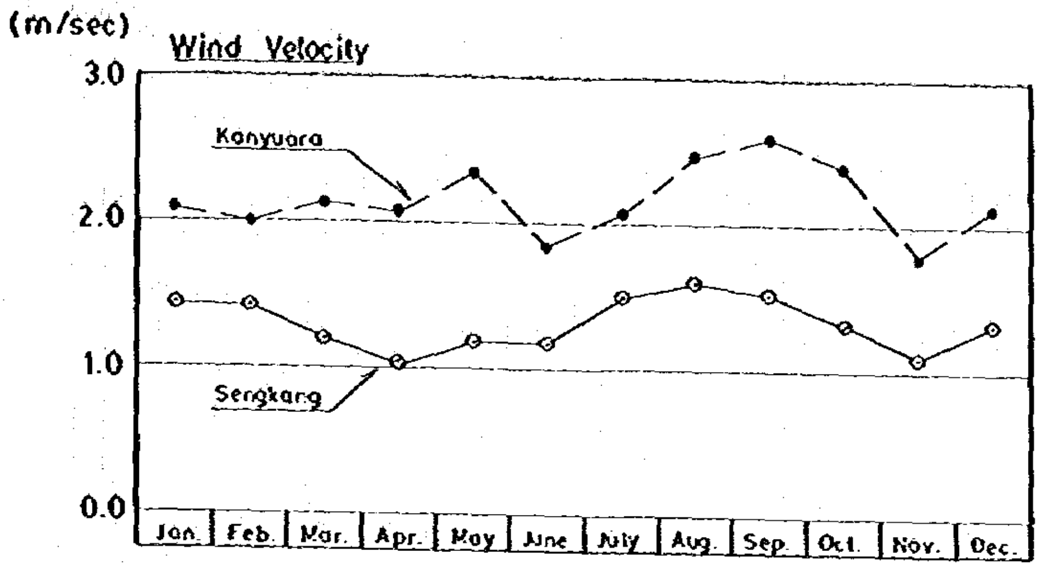


Fig. 2.1 MEAN MONTHLY DATA ON METEOROLOGY (1/2)
(TEMPERATURE, HUMIDITY, SUNSHINE, DISTILLATION)



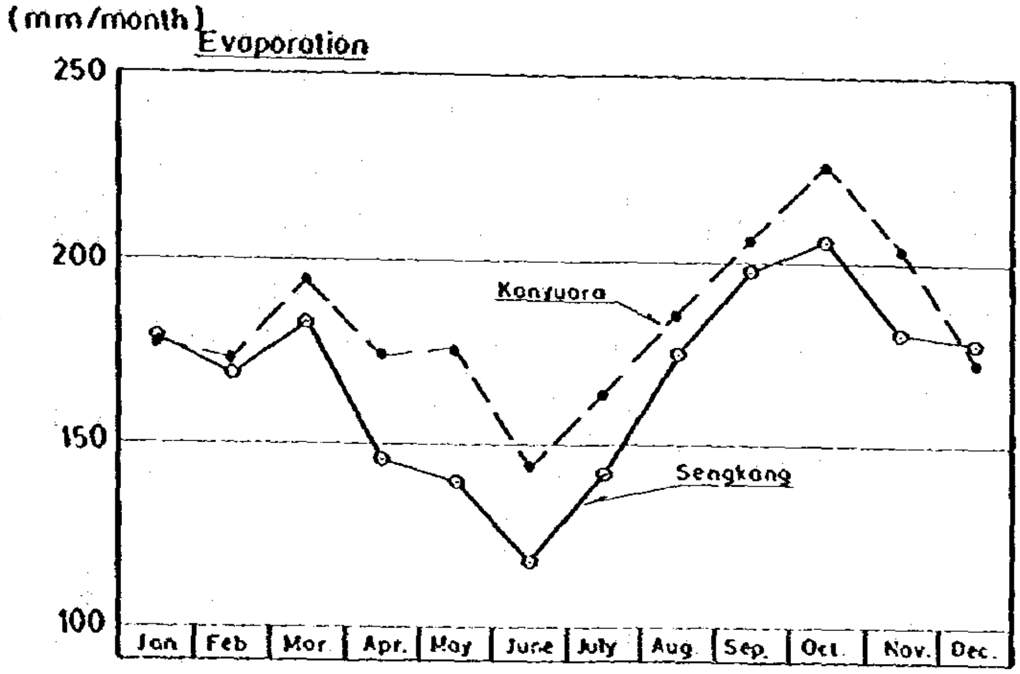


Fig. 2.1 MEAN MONTHLY DATA ON METEOROLOGY (2/2)
(WIND VELOCITY, EVAPORATION)

No.	Station / Year (19-)	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	No.
1	Enrekang				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○							1
2	Baraka																																			2
3	Rappang				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○							3
4	Maroanging																		△	△	△	△	△	△	△	△	△	△								4
5	Bulu Cenrana																																			5
6	Barukku								○	○	○	○	○	○	○																					6
7	Bila																		○	○	○	○	○	○	○	○	○	○								7
8	Tanru Tedong																		○	○	○	○	○	○	○	○	○	○	○							8
9	Belawa / Menge										○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○							9
10	Anabanua/Bola Malimpong												○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○							10
11	Bontouse																																			11
16	Batu Batu																	△	○	○	○	○	○	○	○	○	○	○	○							16
17	Sengkang				○	○	○	○	○	○	○	○	○	○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎							17
20	Pompanua				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○							20
43	Sakkori																																			43
44	Pario					○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○							44
46	Siwa						△	△	△		△	△	△	△	△		△	△	△	△	△	△	△		△	△		△	△							46

No.	Station / Year (19-)	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	No.
1	Enrekang																								○	○	○	○	○	◎	◎	○	○	○	○	1
2	Baraka						○	○	○																				○	◎	◎	◎	○	○	○	2
3	Rappang					○	○	○	○	○	○					○	○	○	○						○	◎	◎	○	◎	◎	◎	◎	◎	◎	◎	3
4	Maroanging							○	○	○	○	○	○	○																						4
5	Bulu Cenrana																											◎	◎	◎	◎	◎	◎	◎	◎	5
6	Barukku																											○	○	○	○	○	◎	◎	◎	6
7	Bila																																	◎	◎	7
8	Tanru Tedong						○	○	○		○	○	○												○	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	8
9	Belawa / Menge						○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○			○					◎	◎	◎	◎	◎	9
10	Anabanua/Bola Malimpong						○	○	○	○	○	○	○	○	○	○	○	○	○	○	○										◎	◎	◎	◎	◎	10
11	Bontouse						○	○	○	○	○	○	○	○	○	○	○	○	○	○				○	○	○				◎	◎	◎	◎	◎	◎	11
16	Batu Batu				○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○						◎	◎	◎	◎	◎					16
17	Sengkang						◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎		◎	◎	◎		◎	◎	◎	◎	17
20	Pompanua																																			20
43	Sakkori																						○	○	○	○	○	○	○	◎	◎	◎	◎	◎	◎	43
44	Pario						○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	◎	◎	◎	◎	◎	◎	44
46	Siwa																																			46

LEGEND : △ Annual data
○ Monthly data
• Daily data

Fig. 2.2 COLLECTED RAINFALL DATA

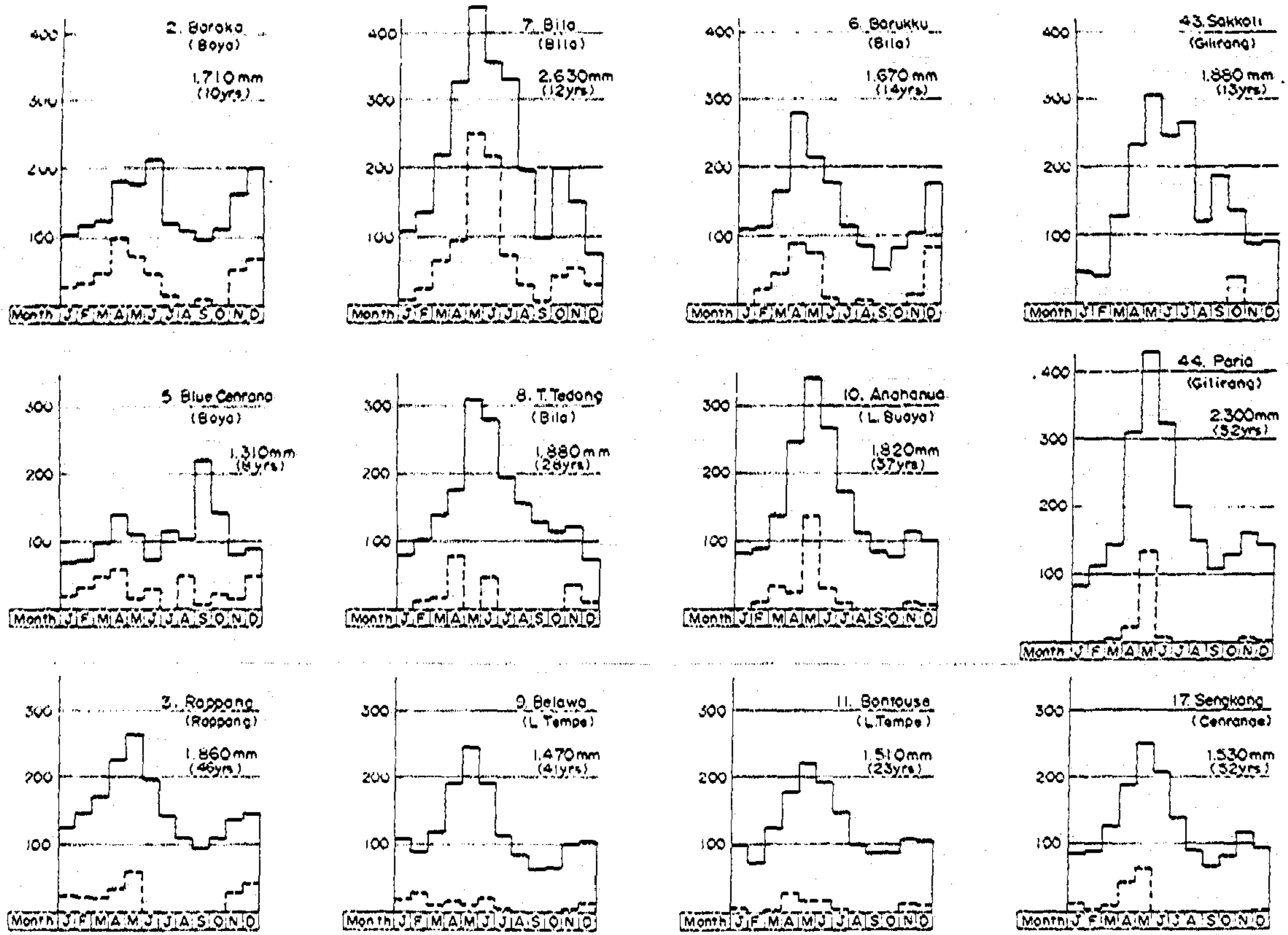


Fig. 2.3 ANNUAL PATTERN OF MEAN MONTHLY RAINFALL

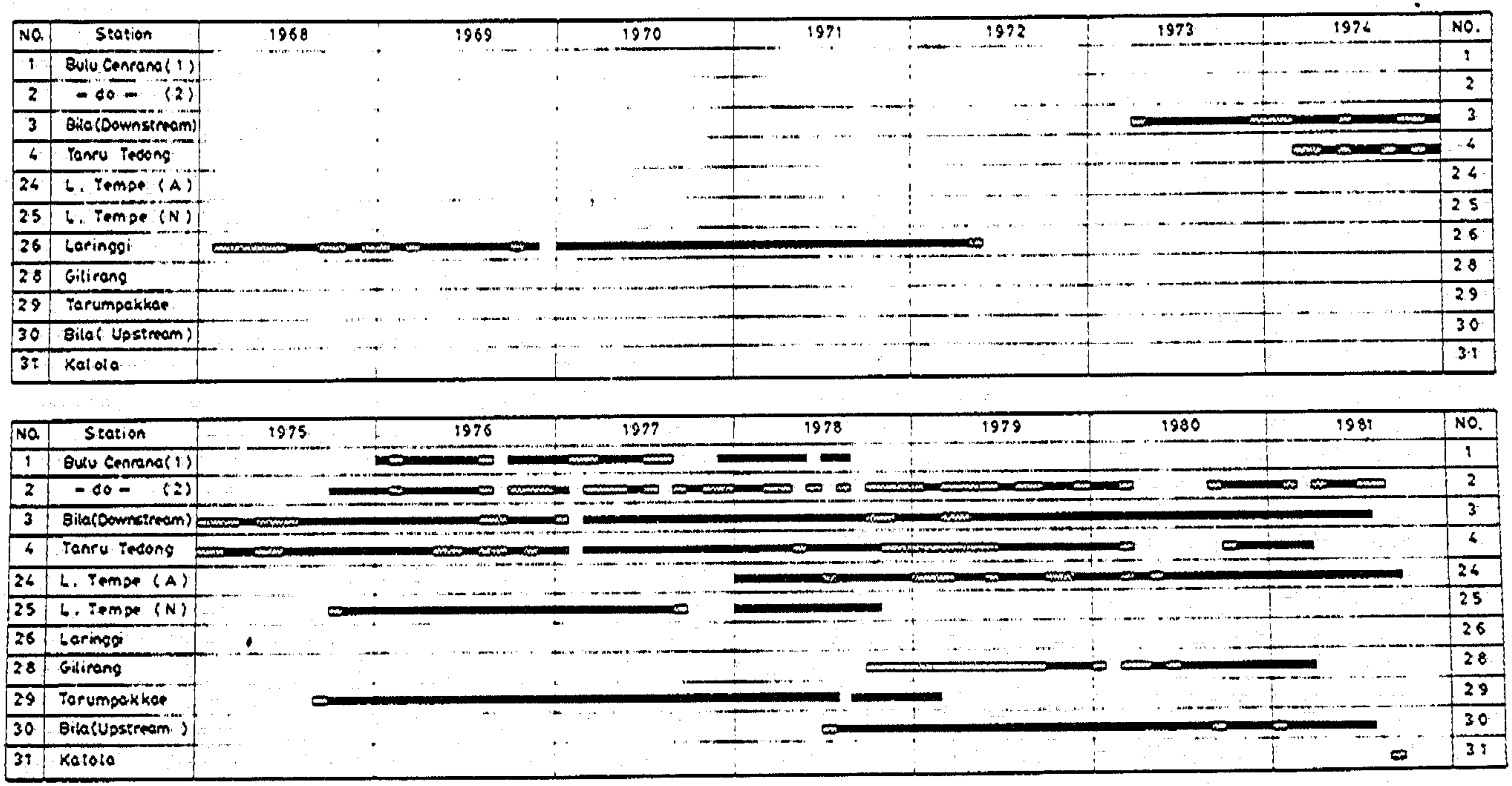
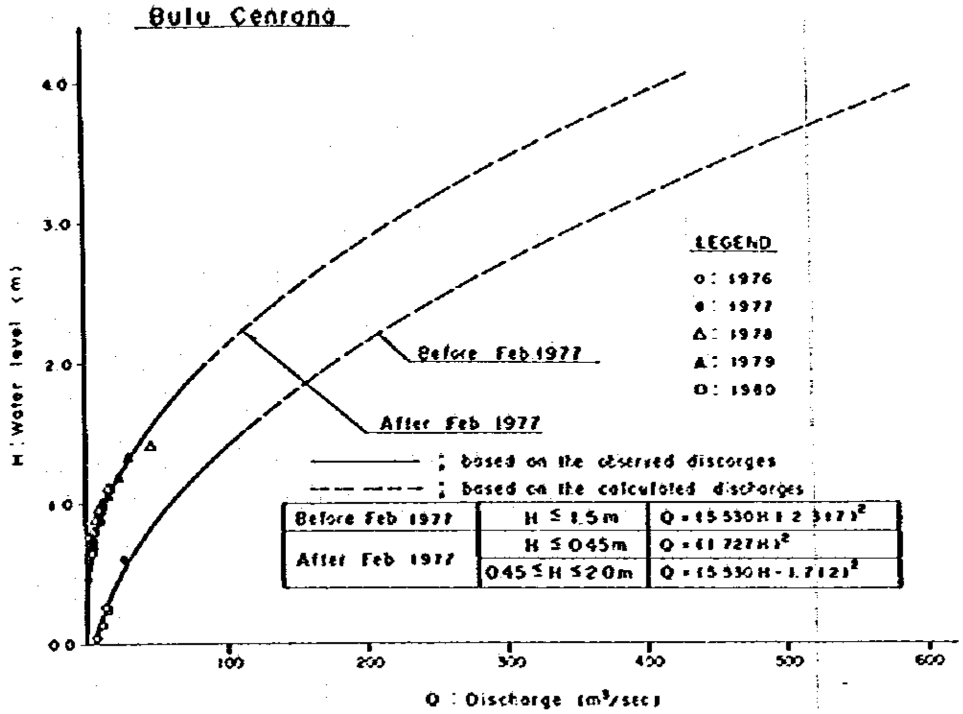


Fig. 2.4 EXISTING CONDITION OF WATER LEVEL DATA

Legend: Data available / Data partialy available



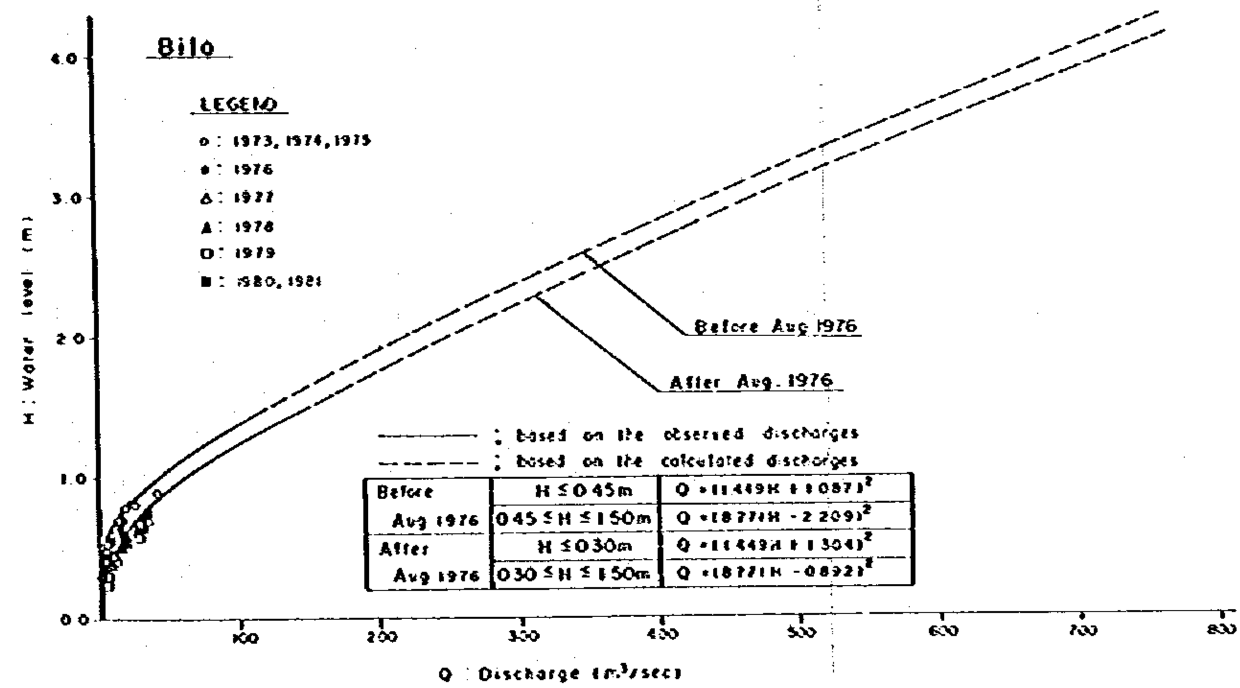
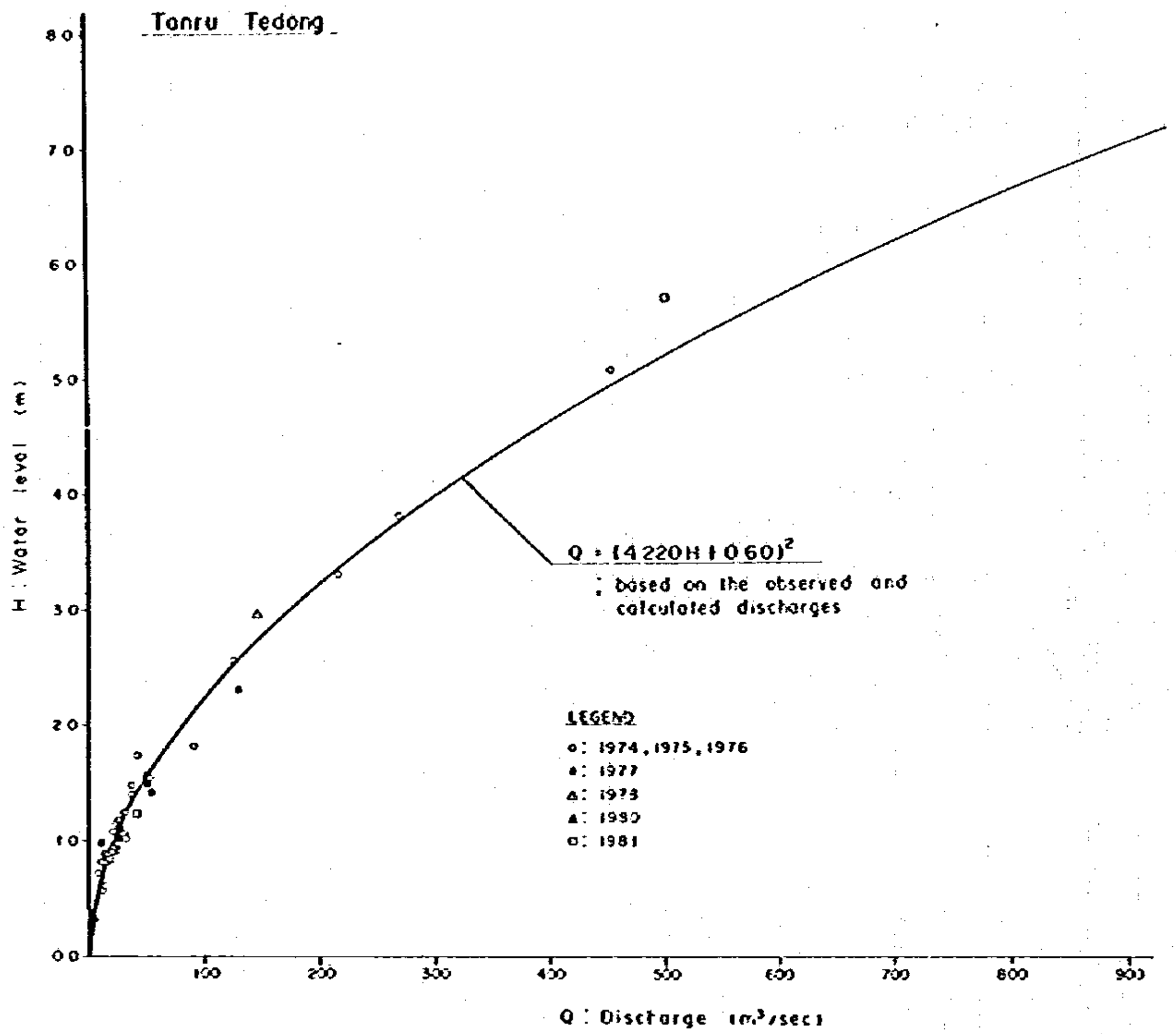


Fig. 2.5 DISCHARGE RATING CURVES (1/3)



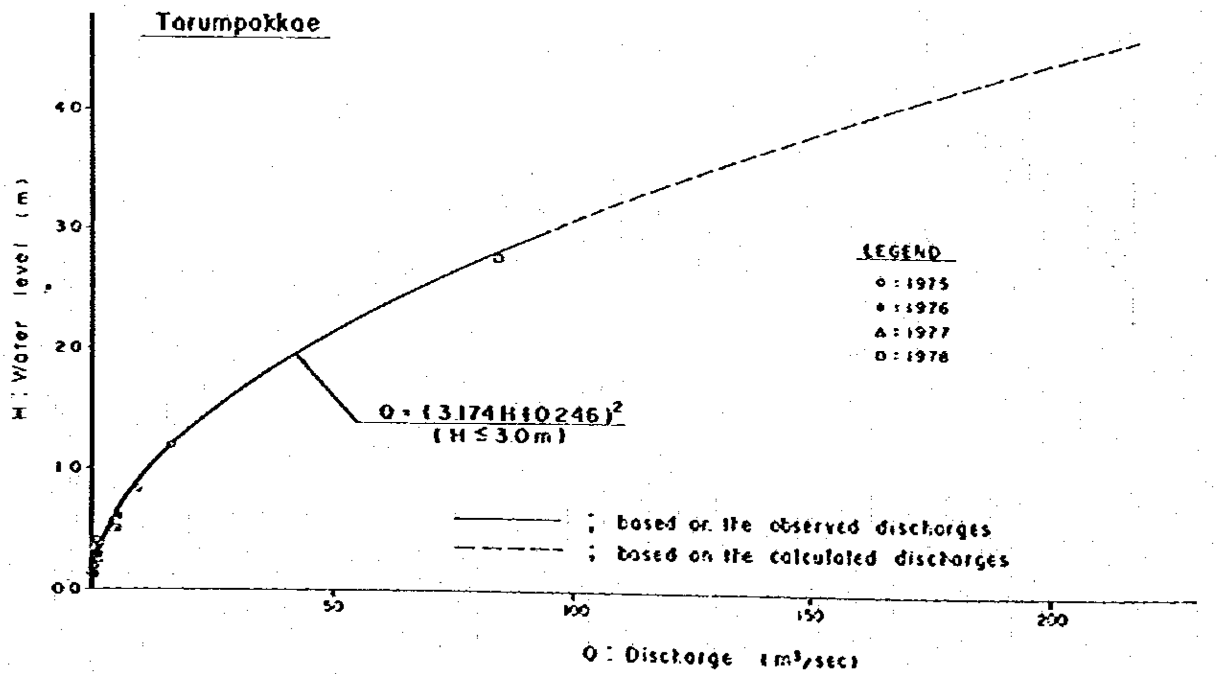
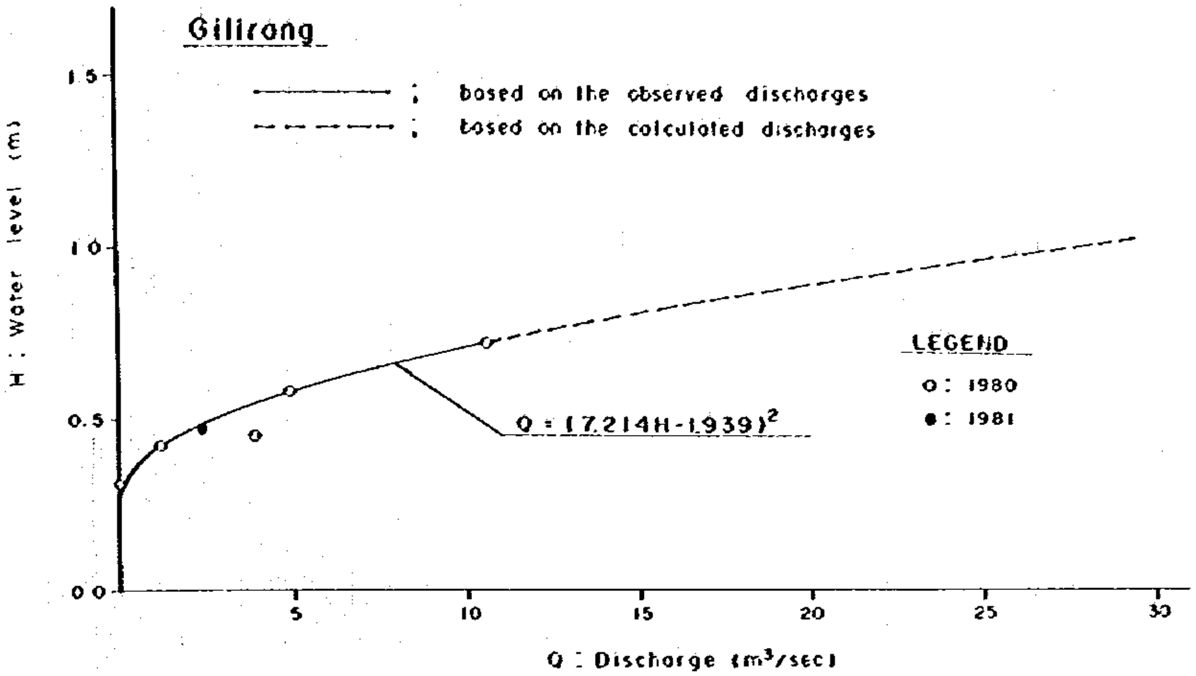


Fig. 2.5 DISCHARGE RATING CURVES (2/3)



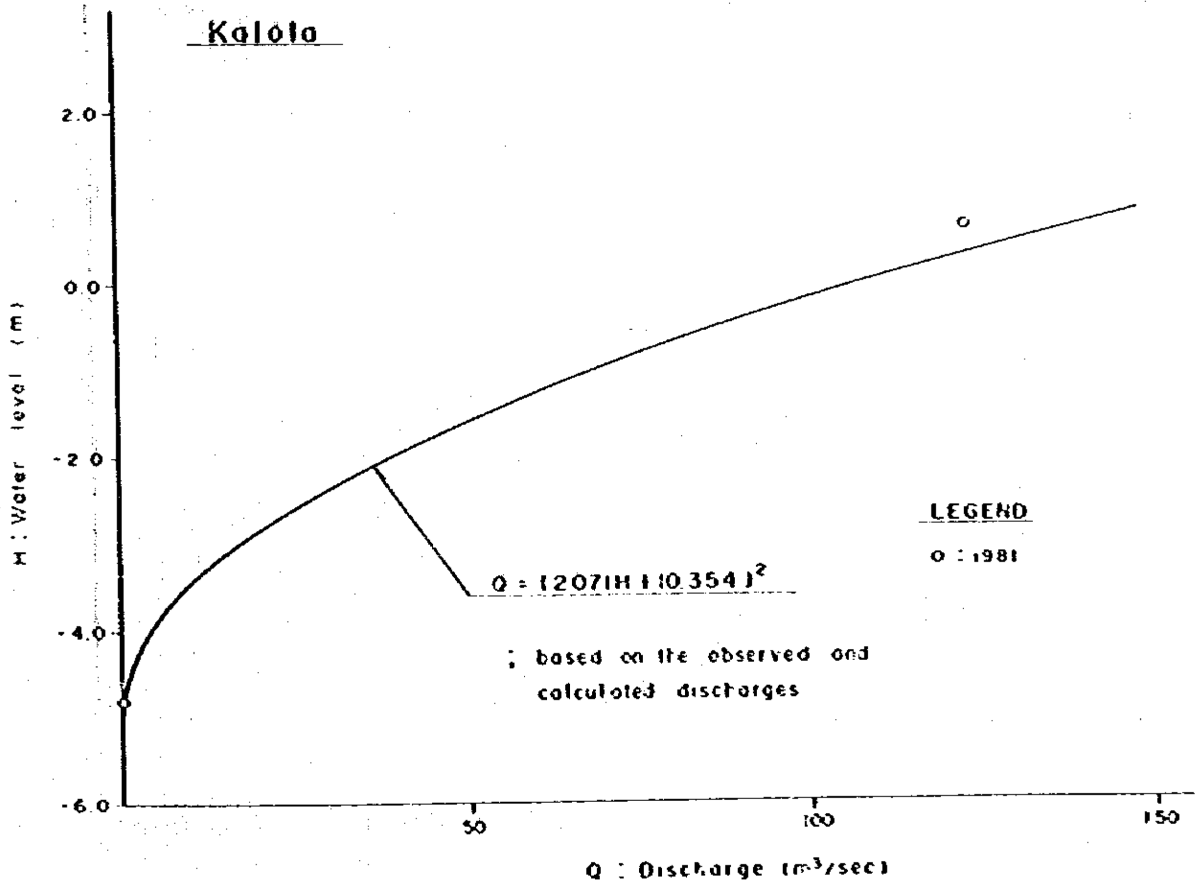


Fig. 2.5 DISCHARGE RATING CURVES (3/3)

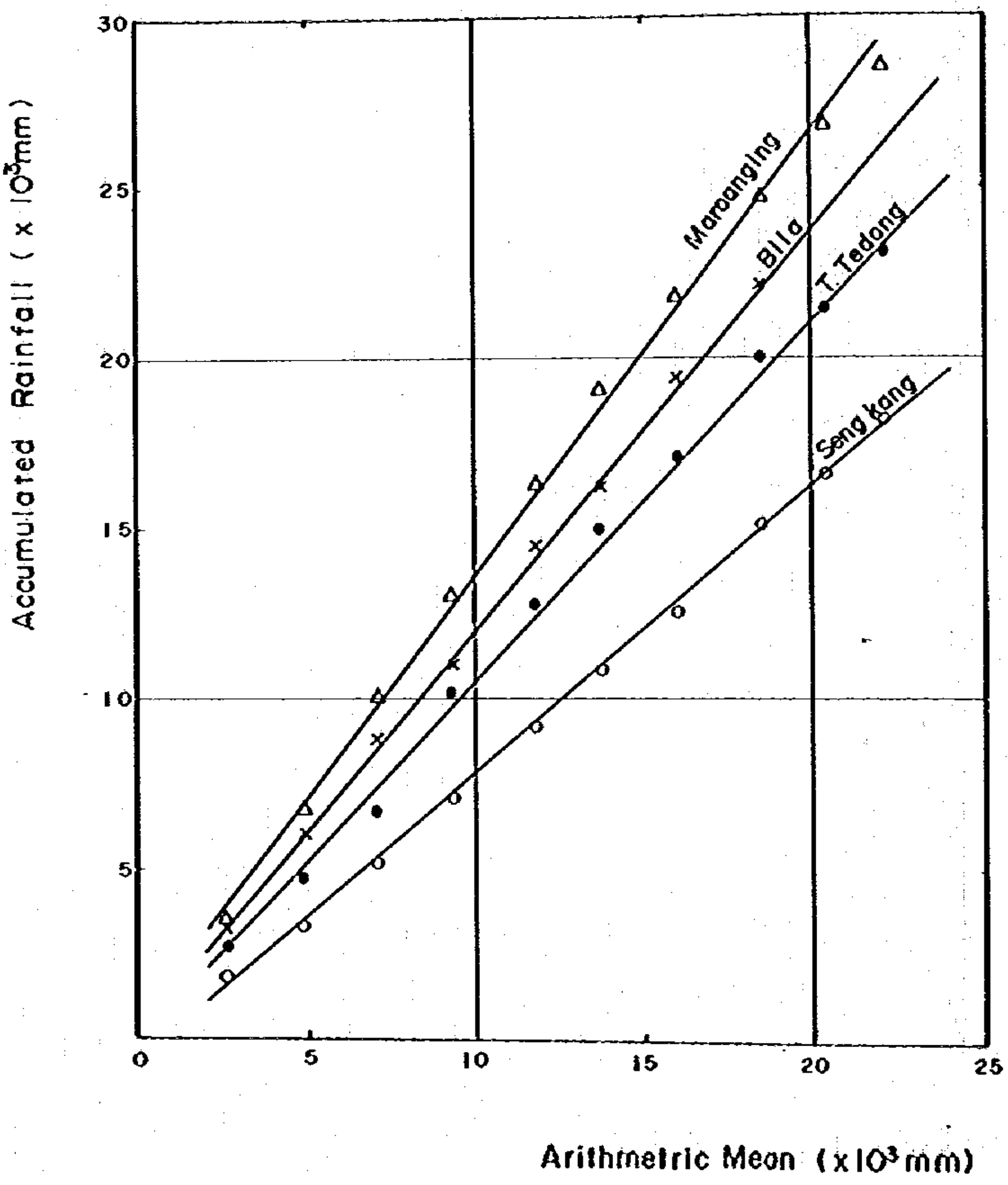


Fig. 3.1 MASS-CURVE OF ANNUAL RAINFALL

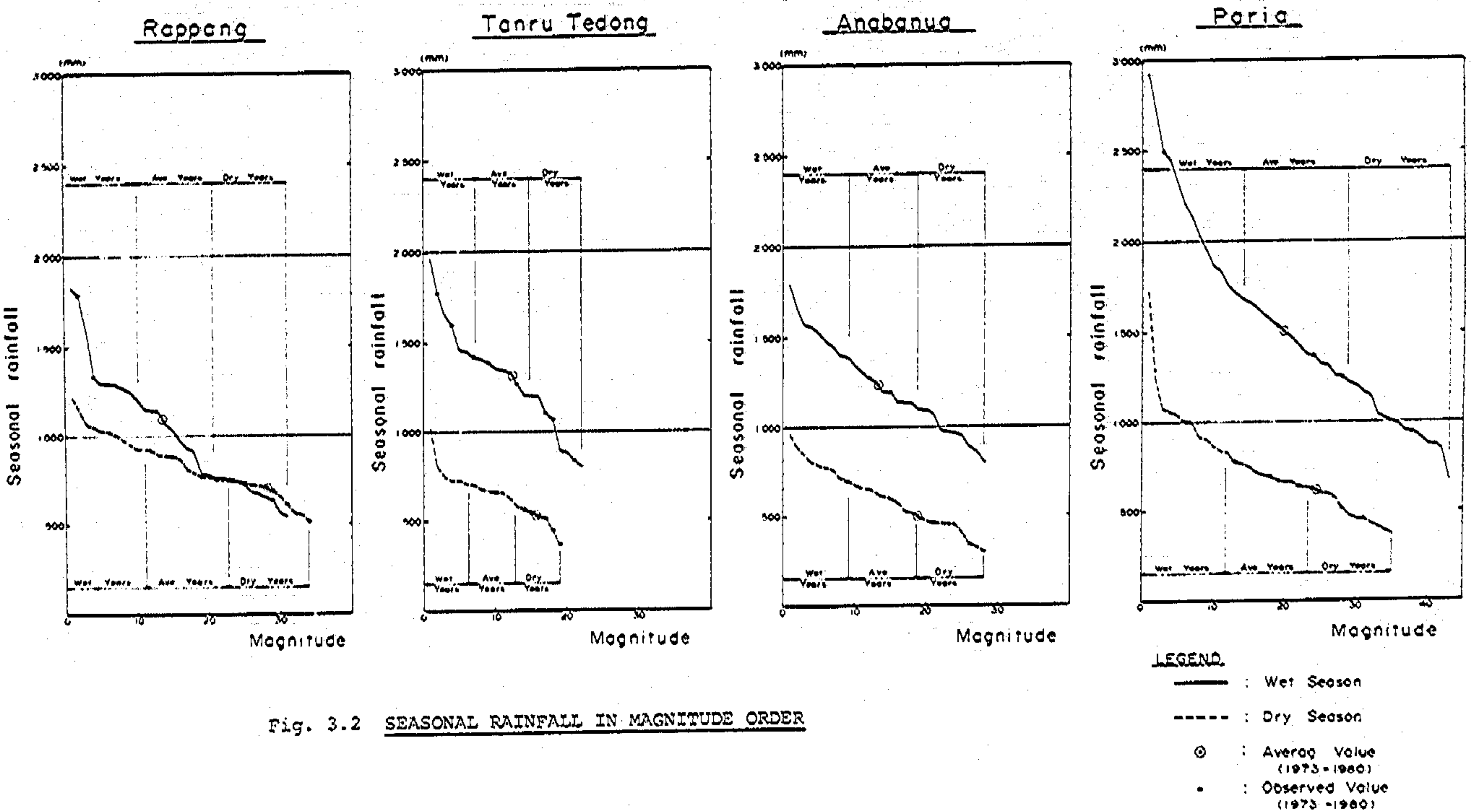
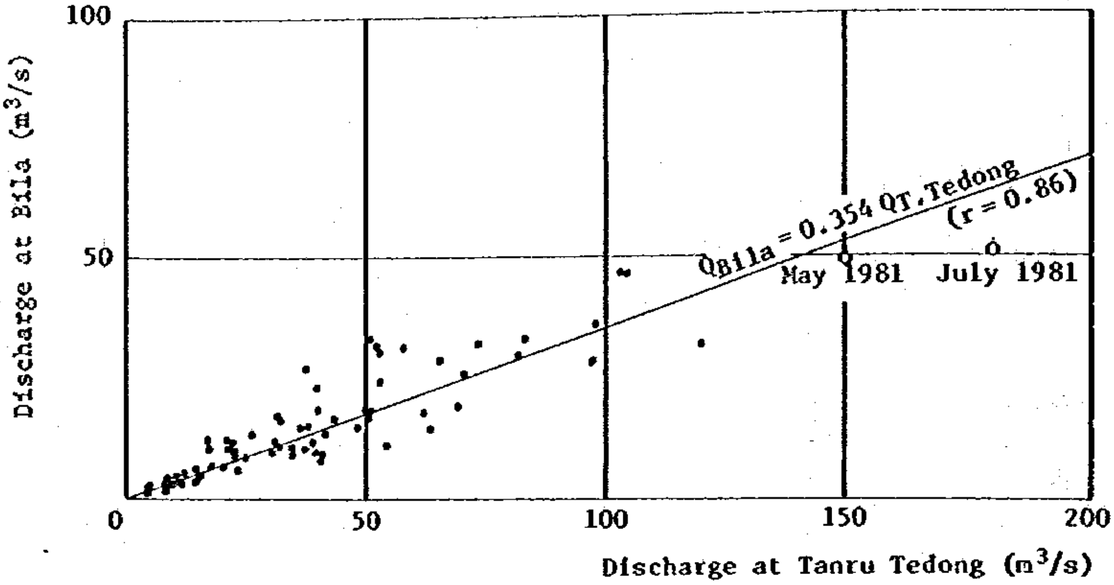


Fig. 3.2 SEASONAL RAINFALL IN MAGNITUDE ORDER



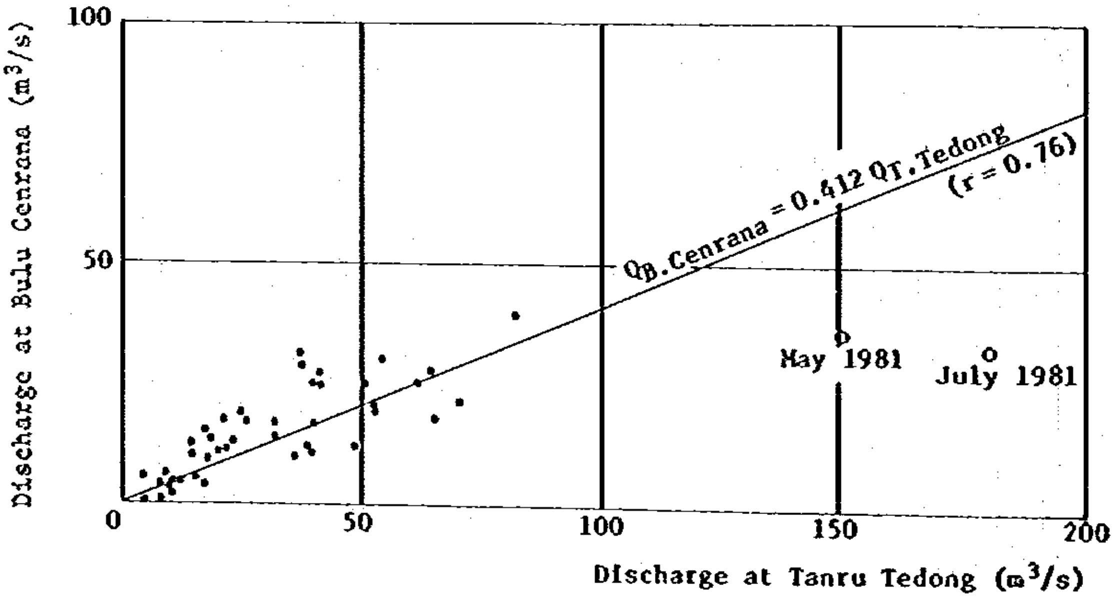


Fig. 3.3 MONTHLY DISCHARGE RELATION

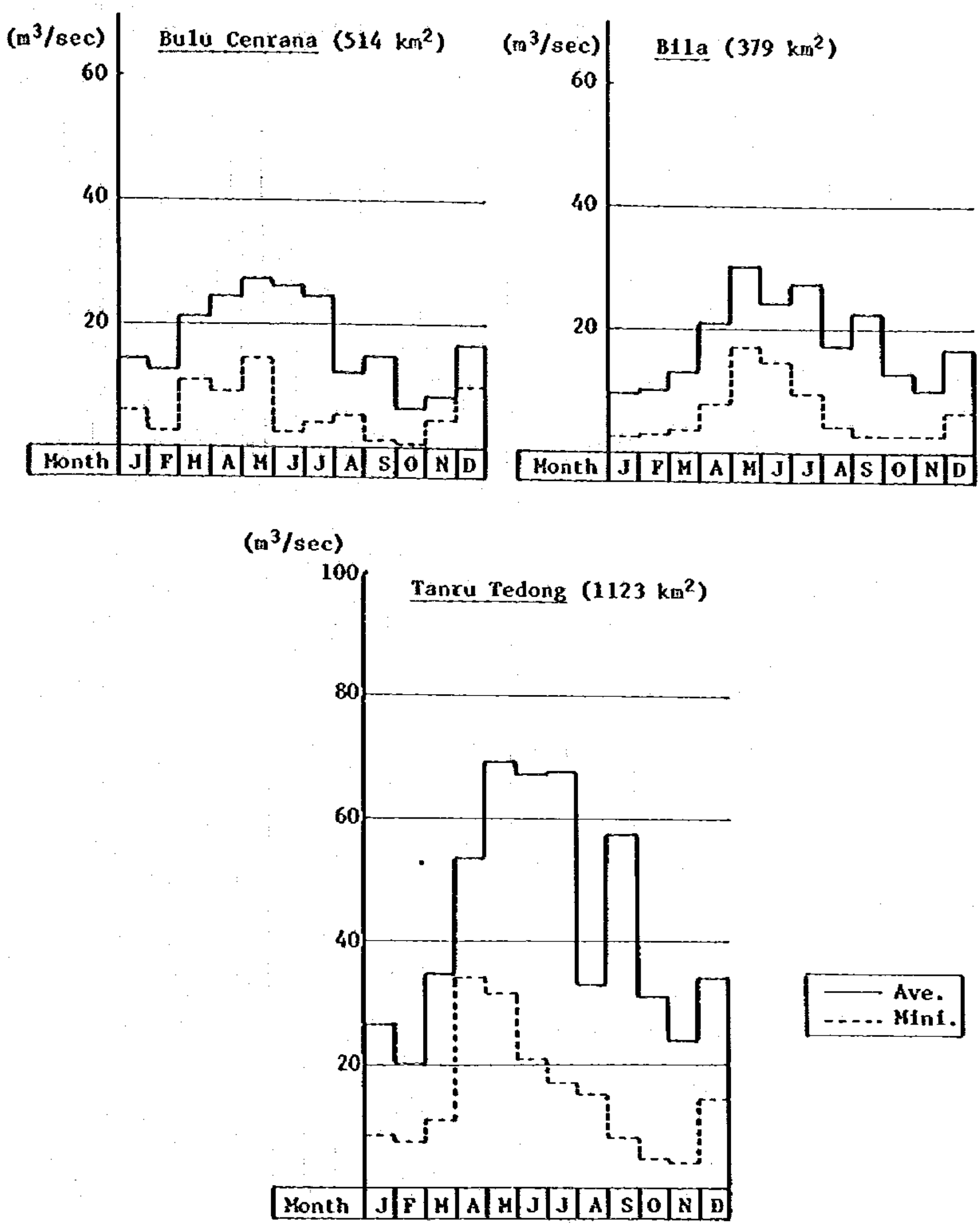


Fig. 3.4 ANNUAL PATTERN OF MEAN MONTHLY DISCHARGE

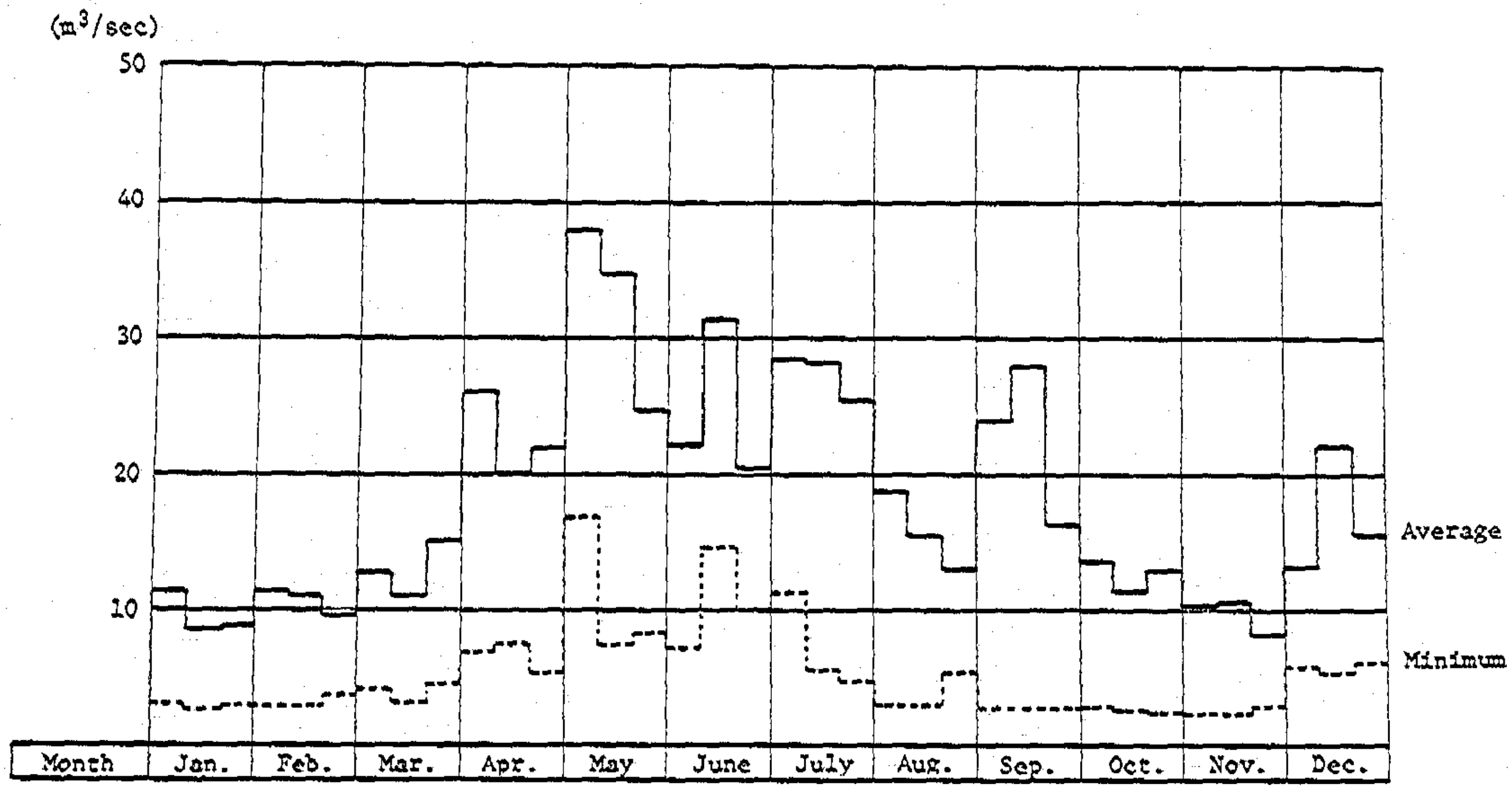
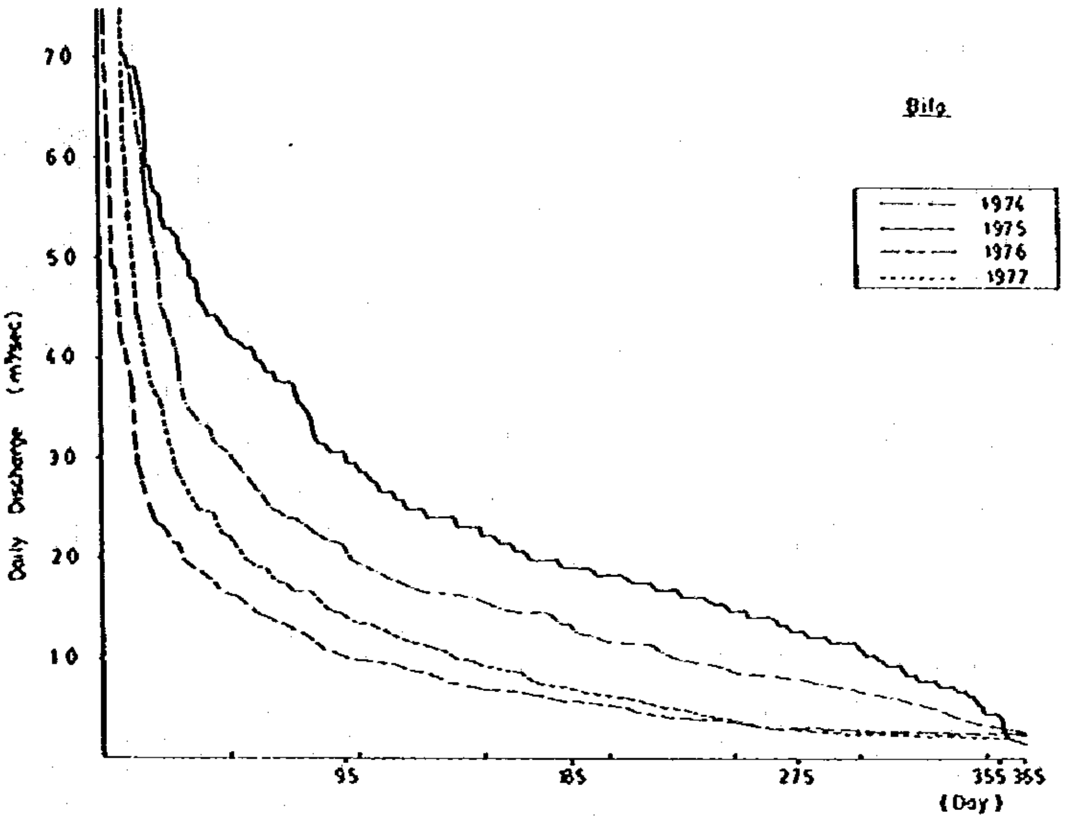


Fig. 3.5 ANNUAL PATTERN OF MEAN 10-DAYS DISCHARGE AT BILA



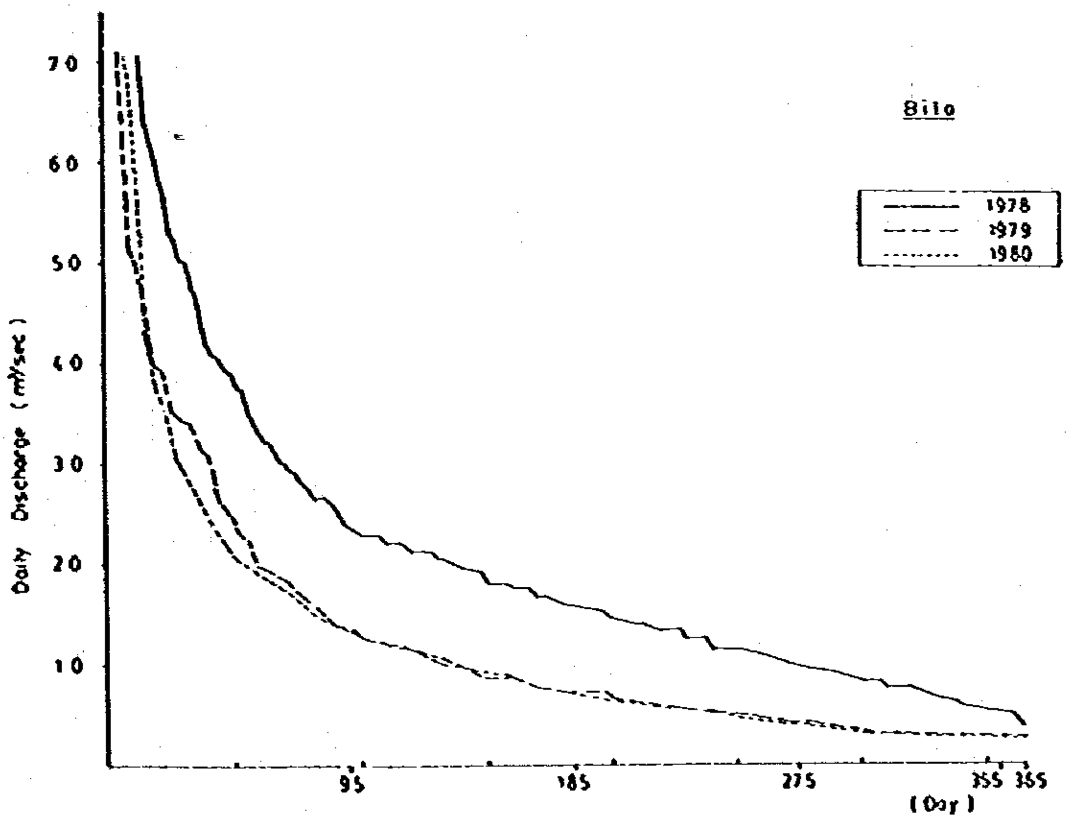
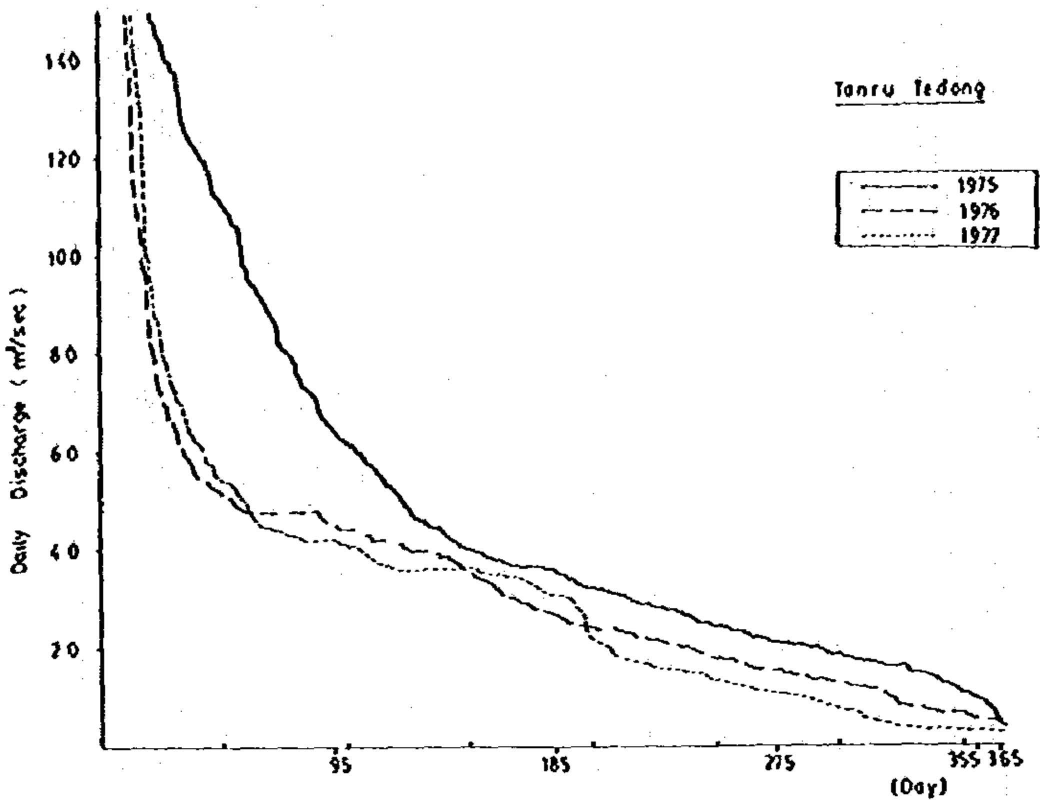


Fig. 3.6 DISCHARGE DURATION CURVE (1/2)



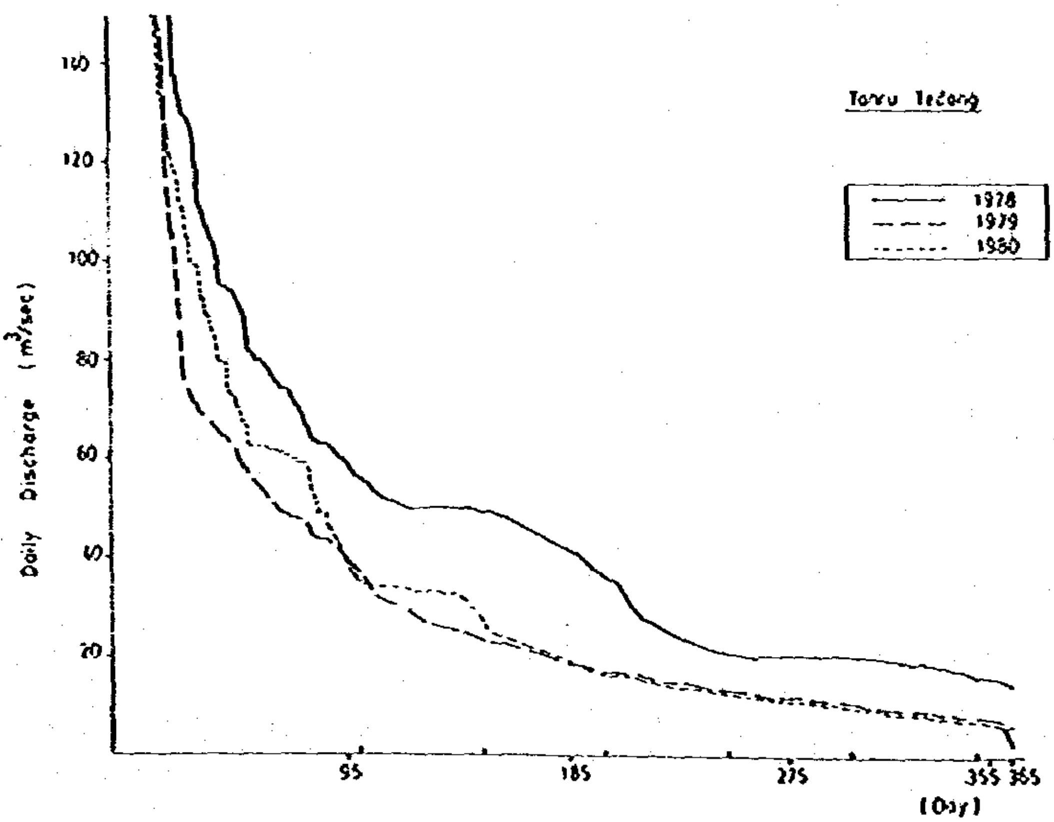
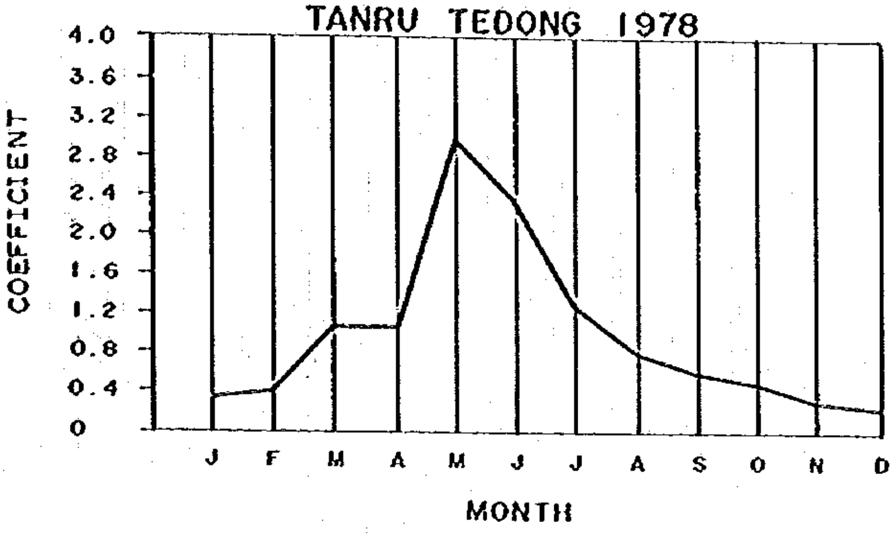
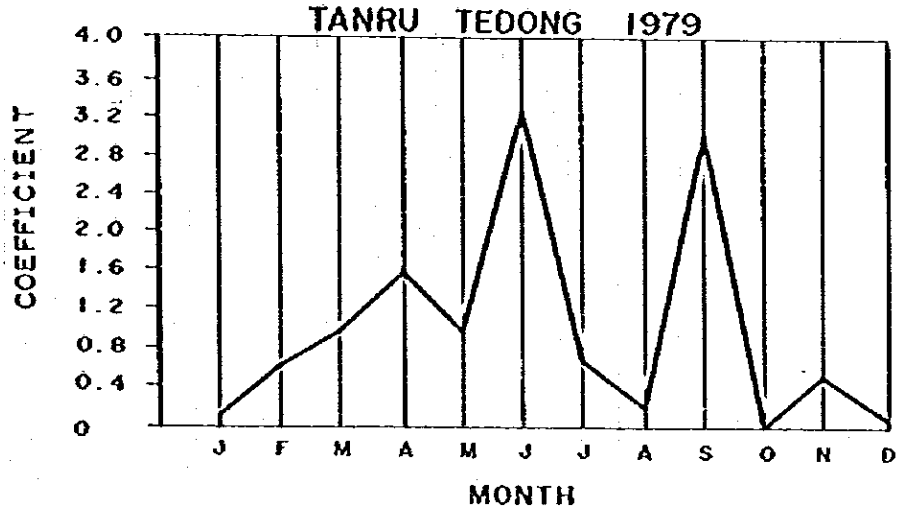


Fig. 3.6 DISCHARGE DURATION CURVE (2/2)





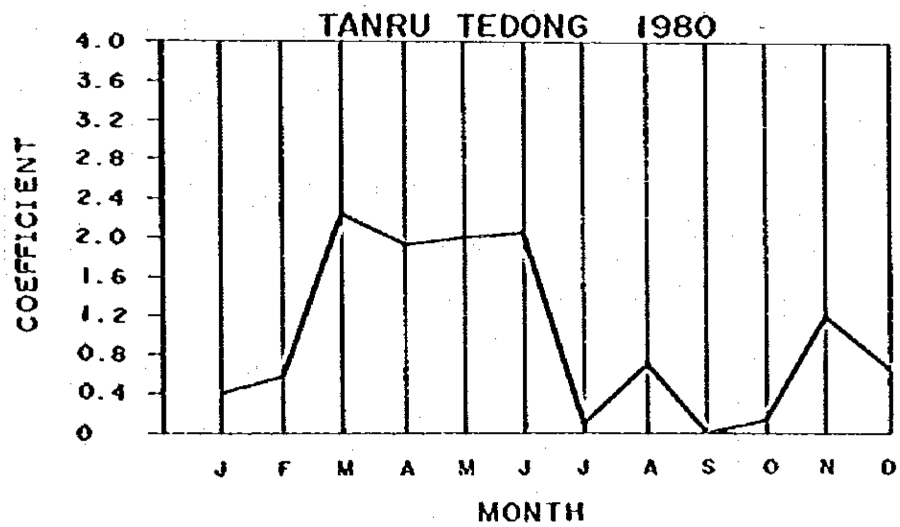
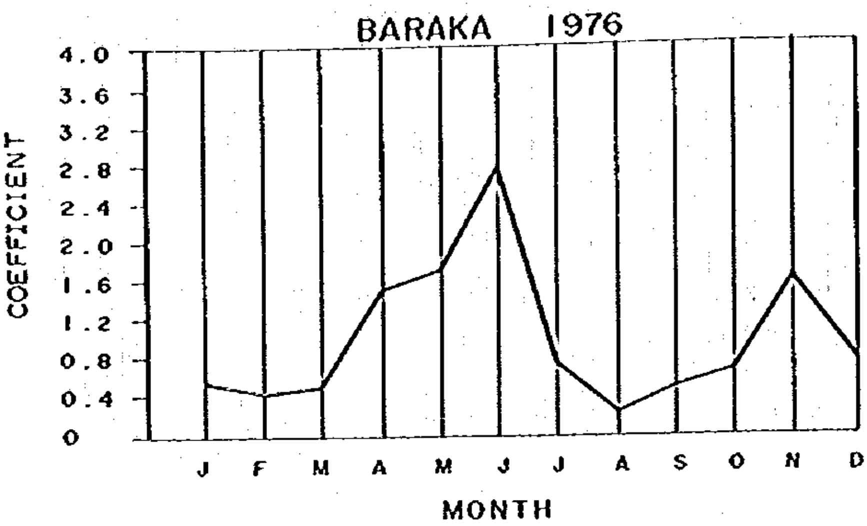
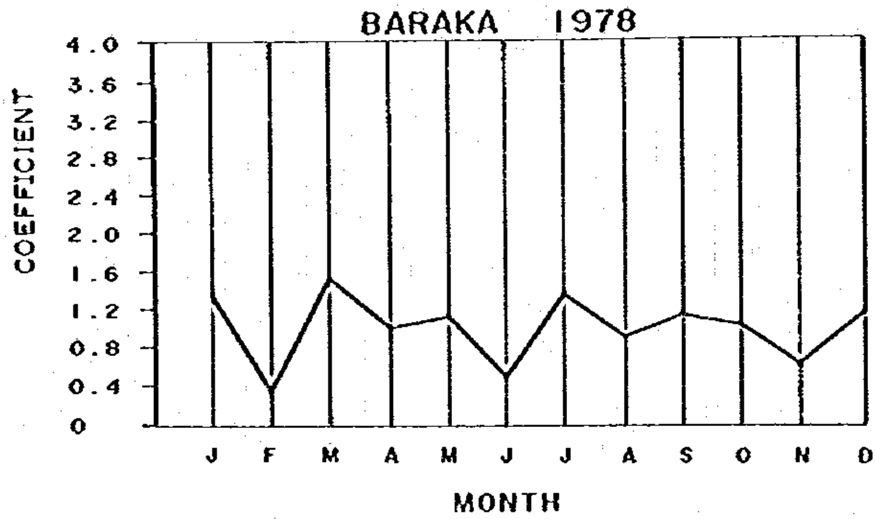


Fig. 3.7 MONTHLY RAINFALL DISTRIBUTION PATTERN (1/3)





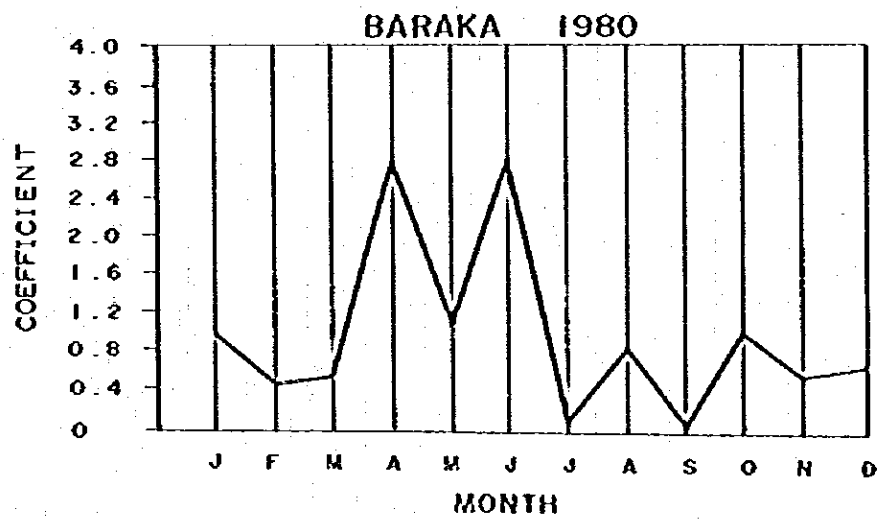
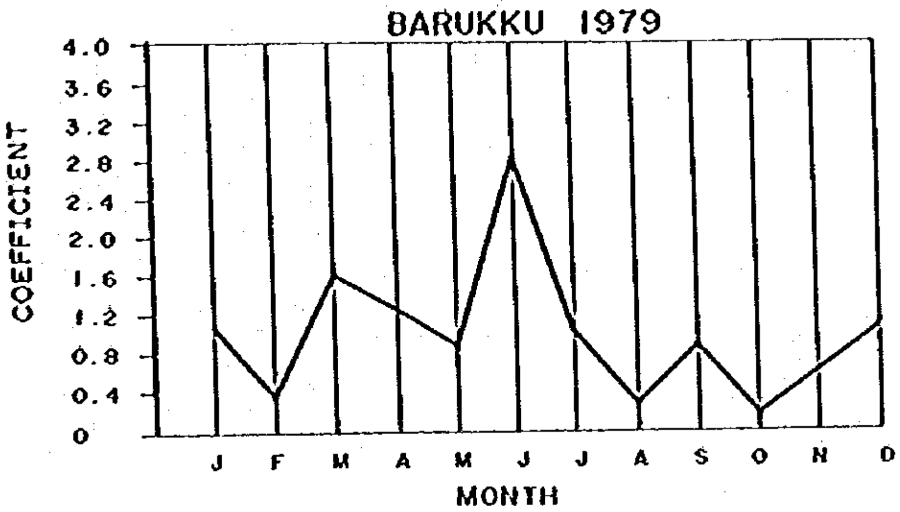


Fig. 3.7 MONTHLY RAINFALL DISTRIBUTION PATTERN (2/3)



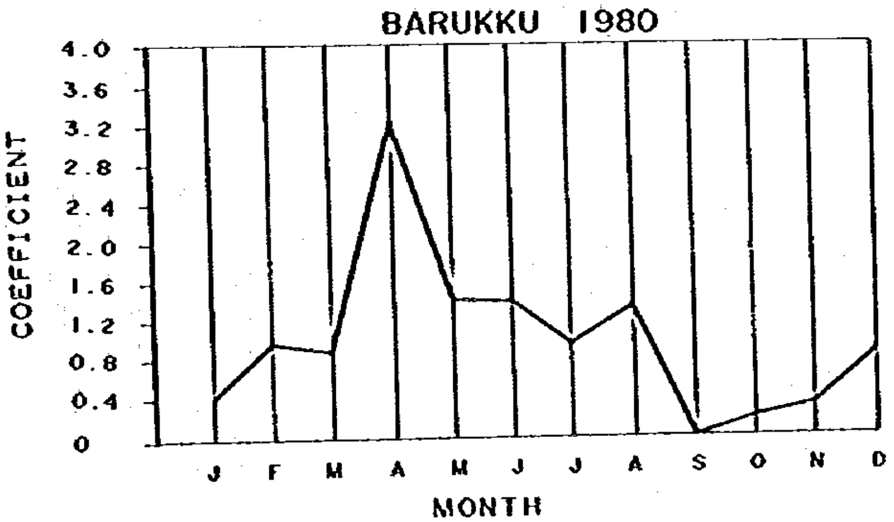


Fig. 3.7 MONTHLY RAINFALL DISTRIBUTION PATTERN (3/3)

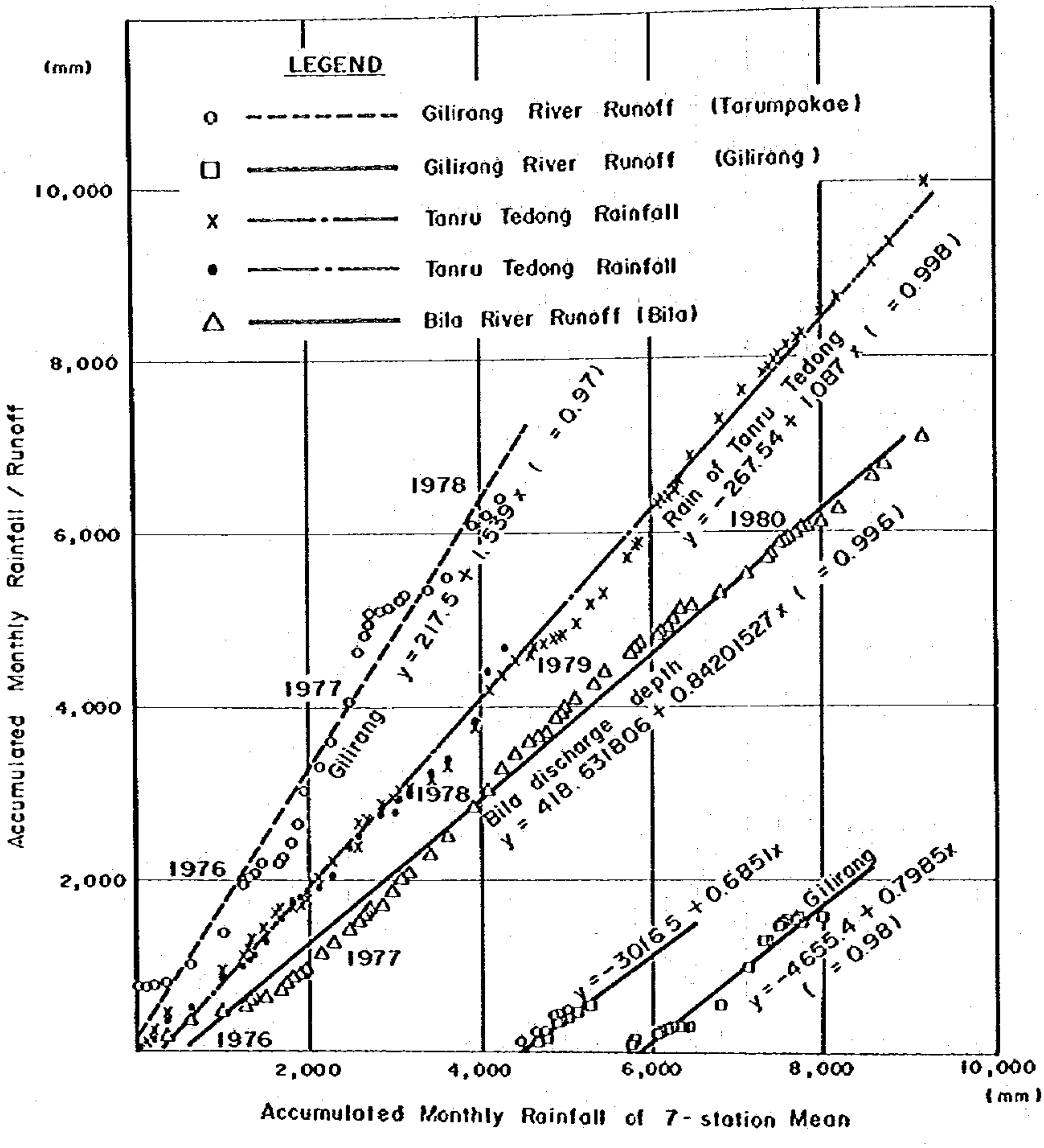


Fig. 3.8 DOUBLE MASS-CURVE ANALYSIS OF RUNOFF

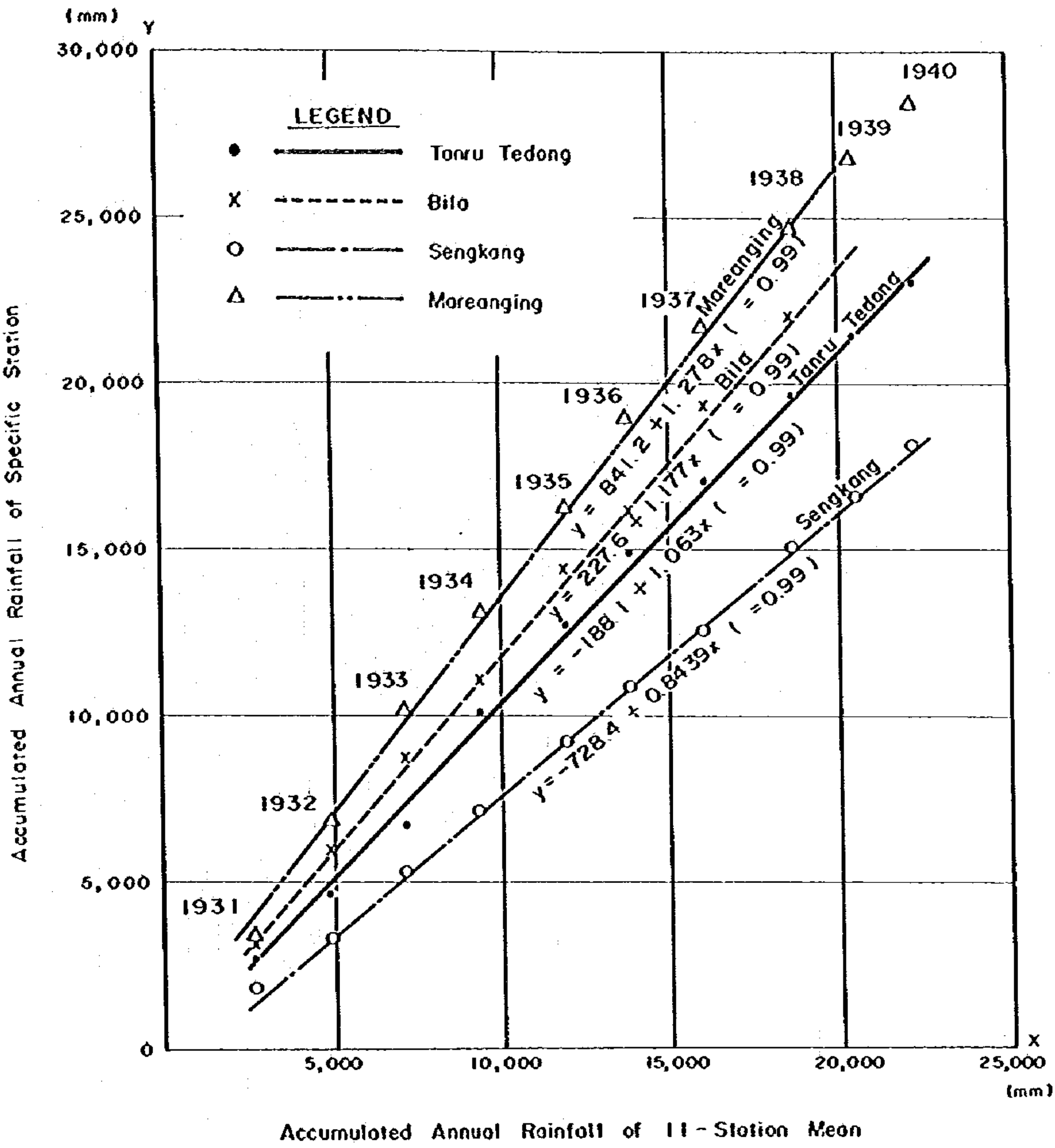


Fig. 3.9 DOUBLE MASS-CURVE ANALYSIS OF RAINFALL

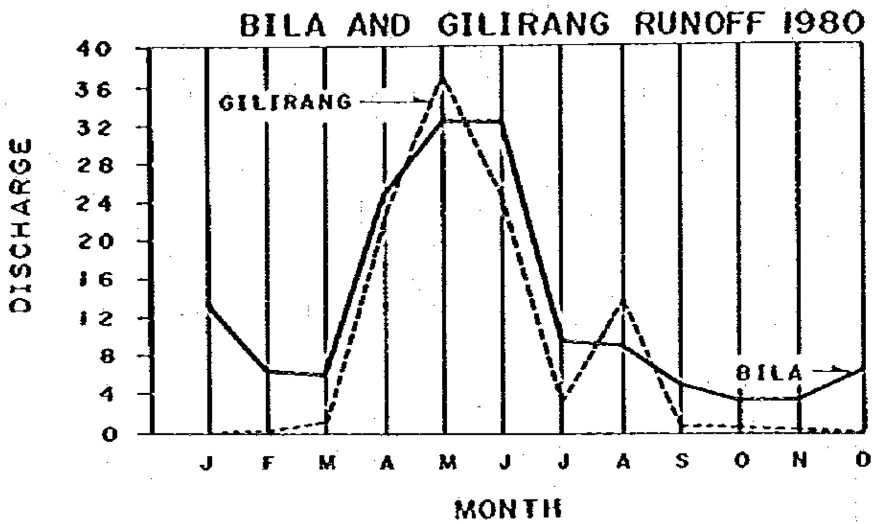


Fig. 3.10 RUNOFF PATTERN OF BILA AND GILIRANG RIVERS

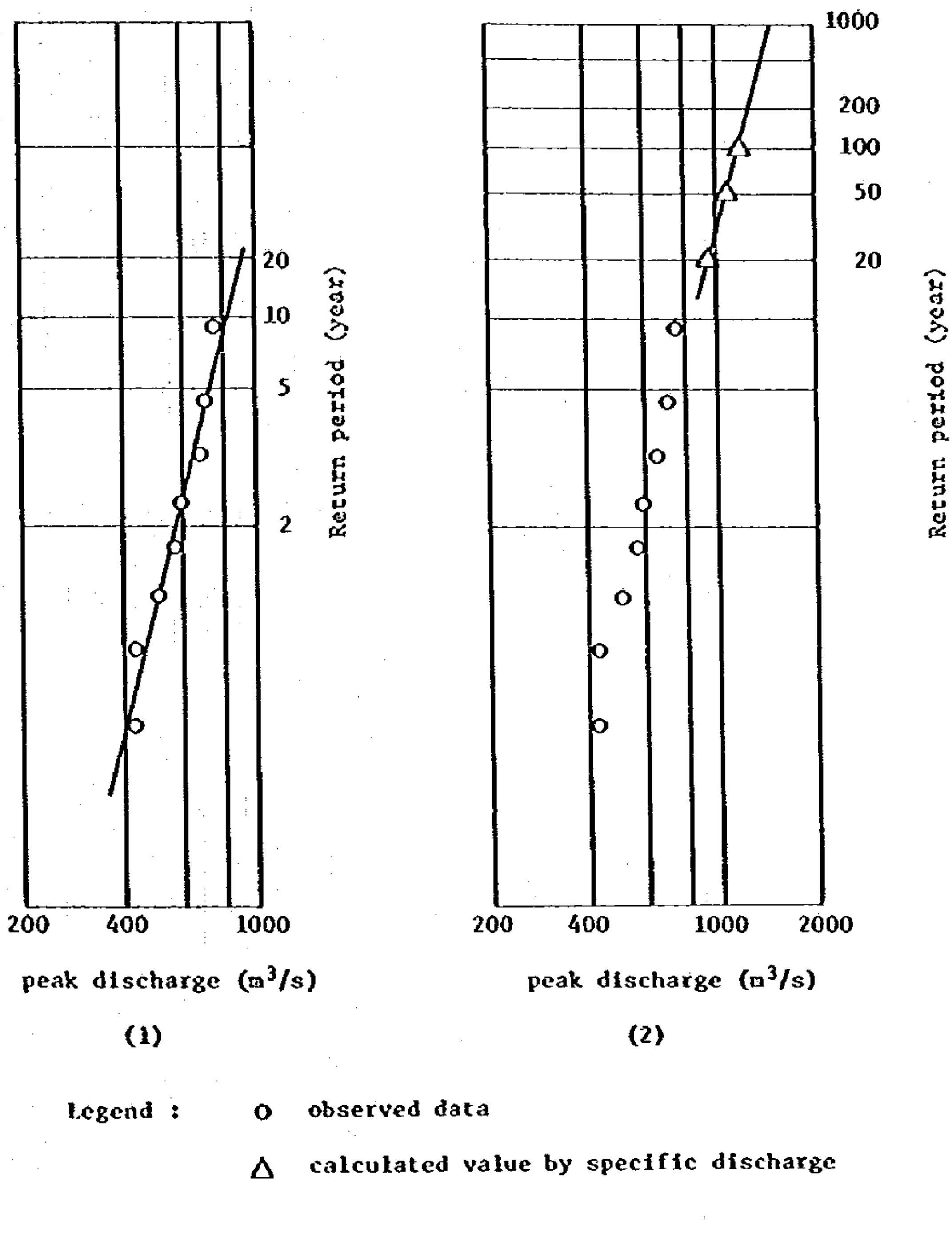


Fig. 4.1 PROBABLE FLOOD DISCHARGE AT BILA

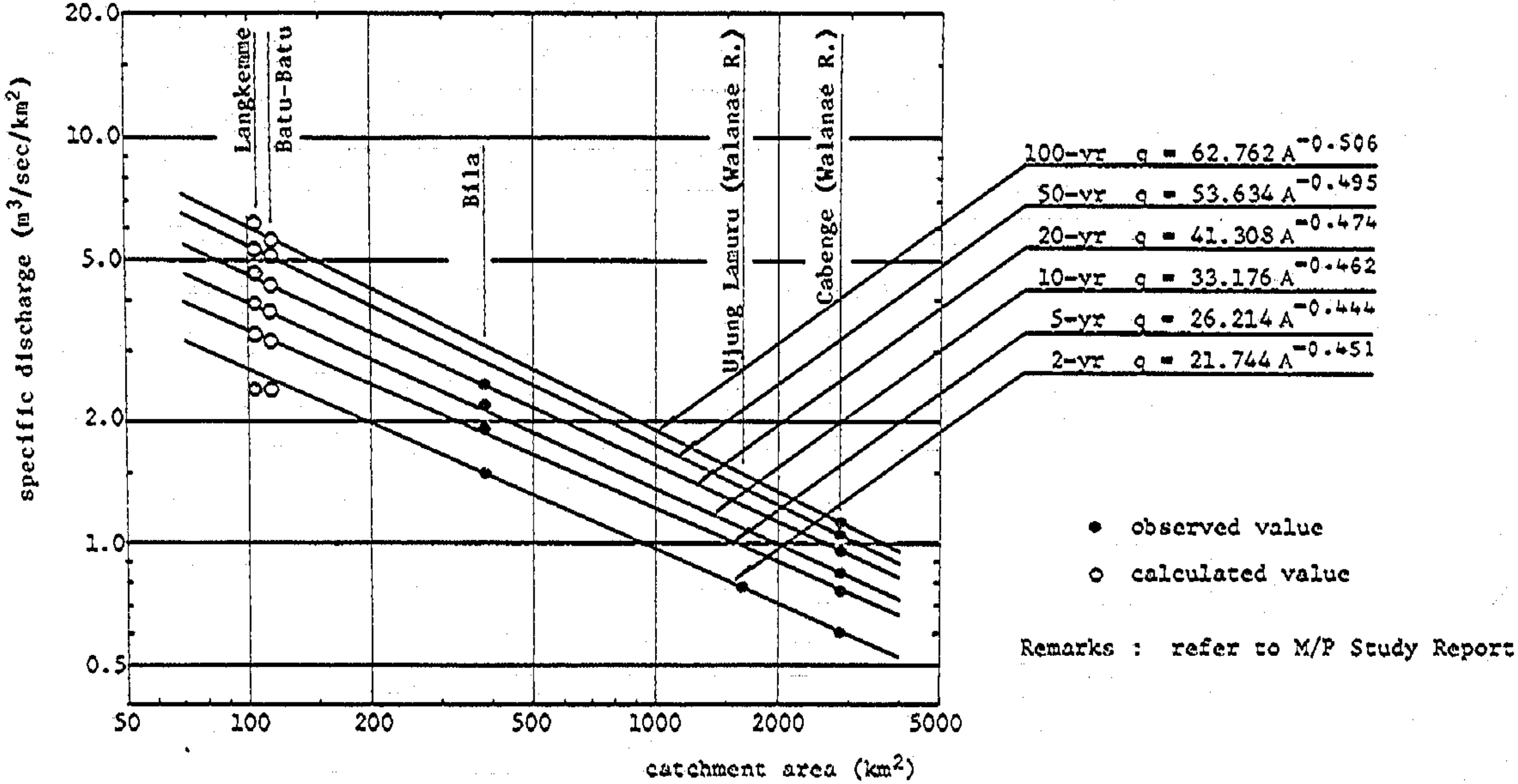
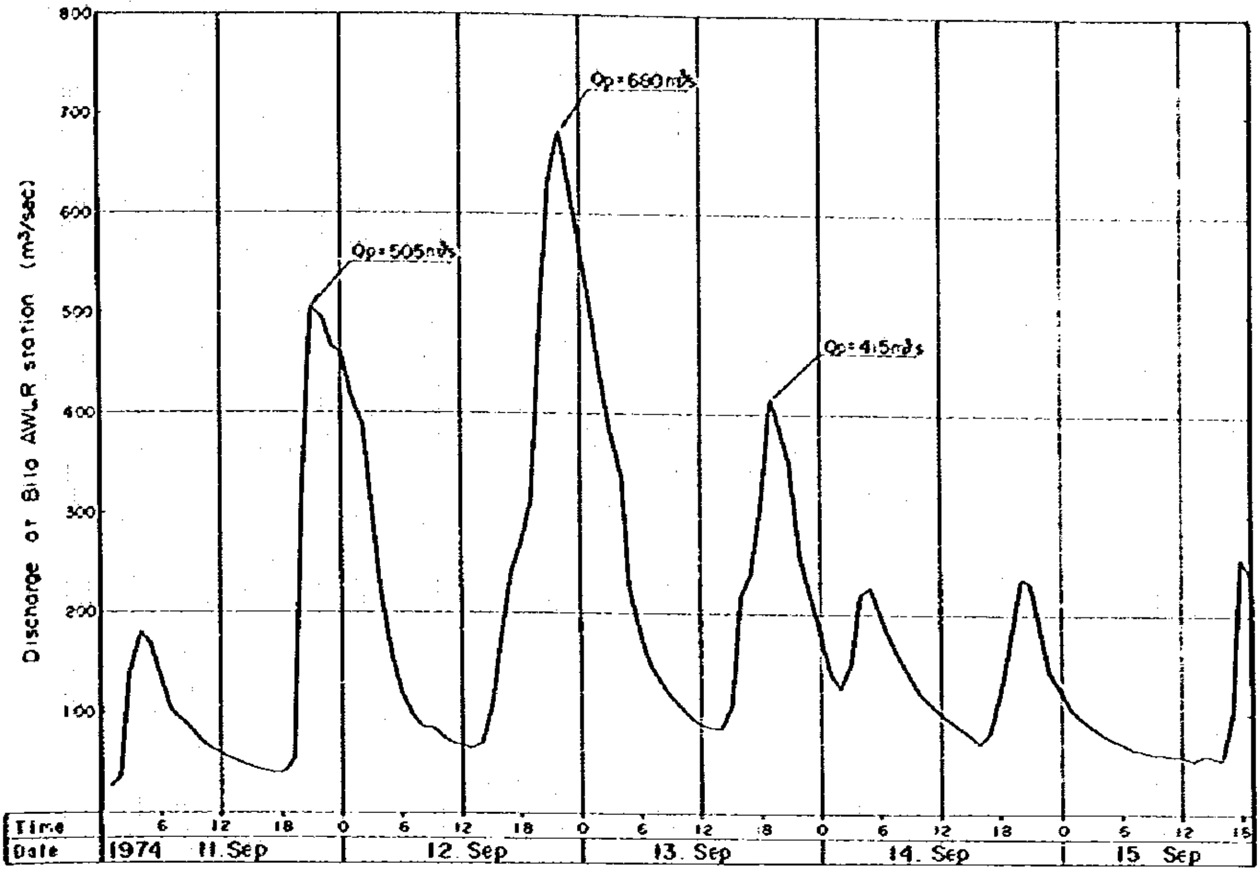


Fig. 4.2 RELATION BETWEEN SPECIFIC DISCHARGE AND CATCHMENT AREA



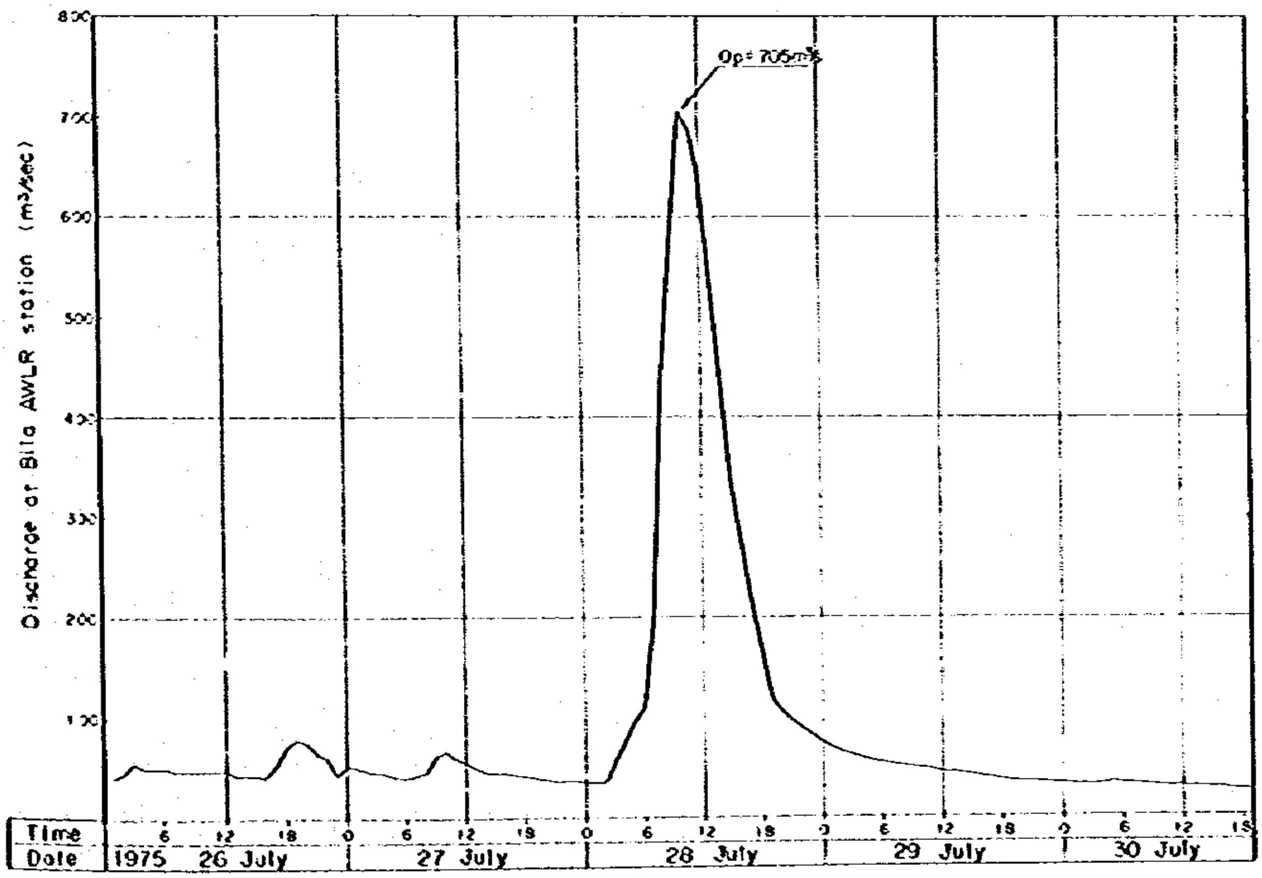
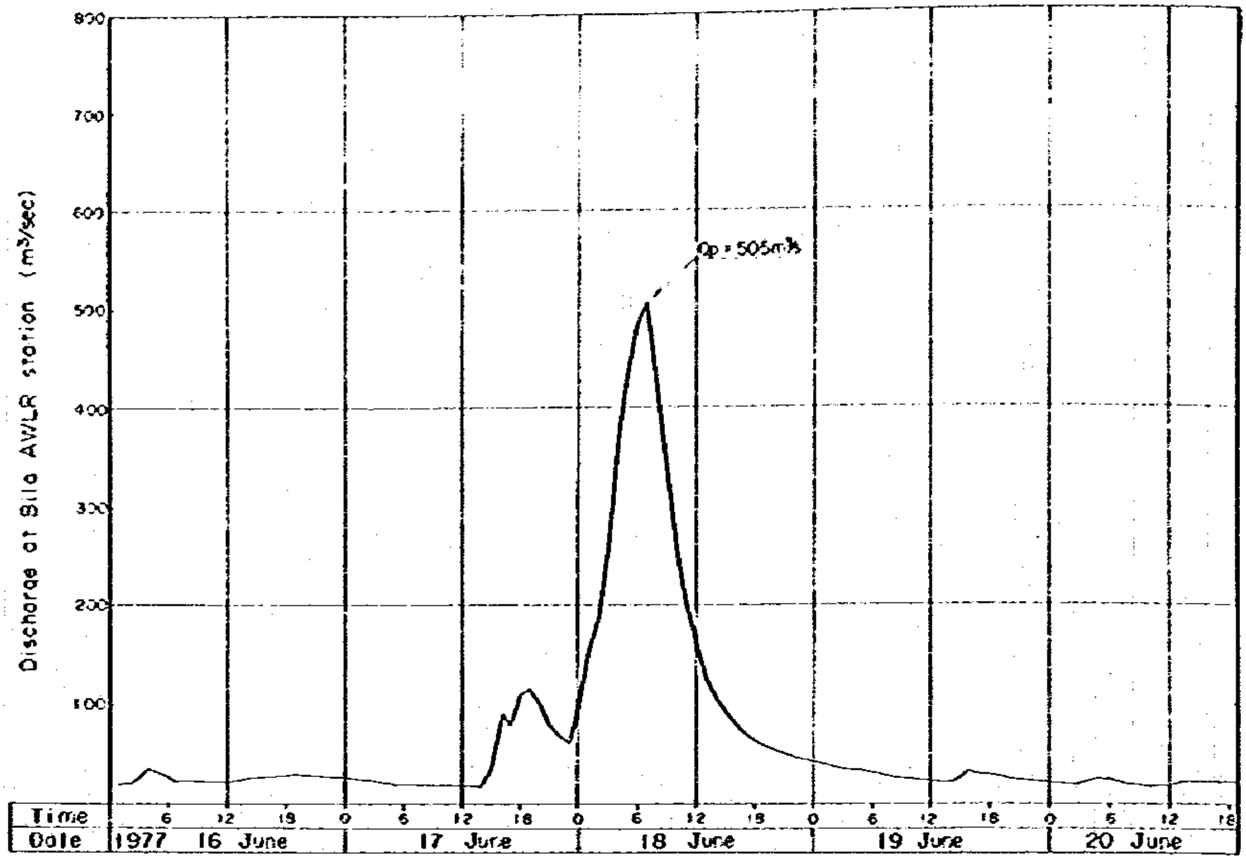


Fig. 4.3 FLOOD HYDROGRAPH AT BILA (1/2)
(1974, 1975)



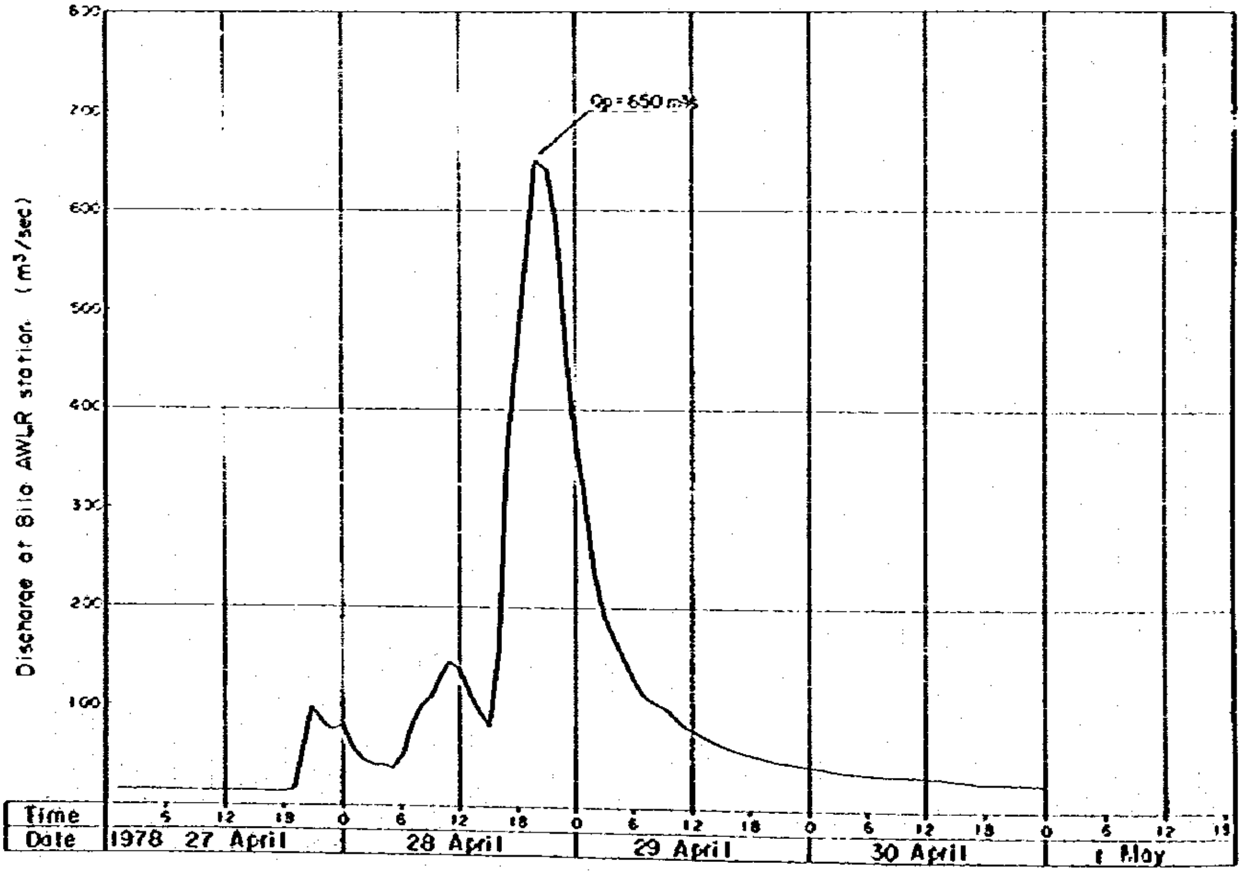


Fig. 4.3 FLOOD HYDROGRAPH AT BILA (2/2)
(1977, 1978)

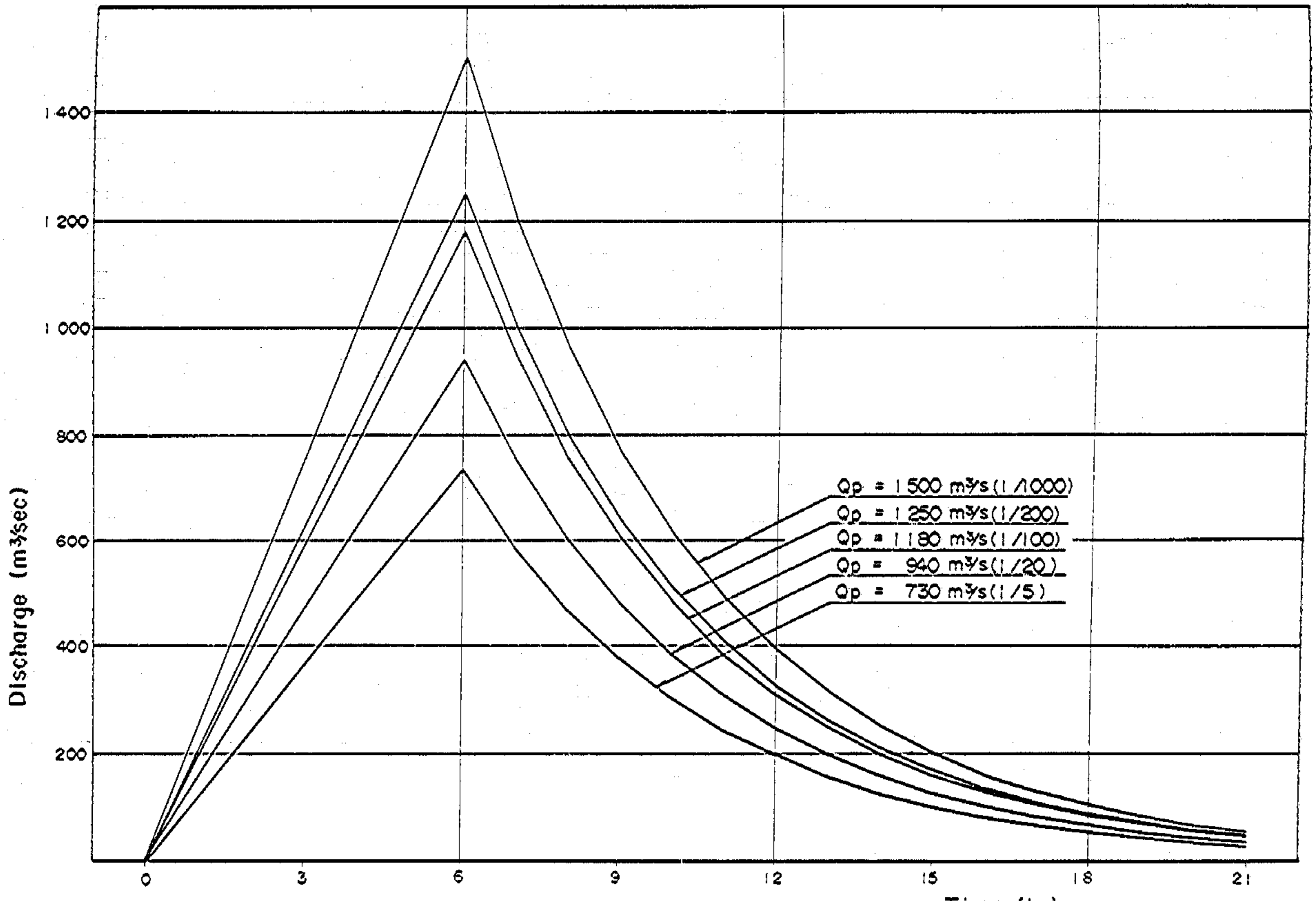


Fig. 4.4 PROBABLE FLOOD HYDROGRAPH AT BILA

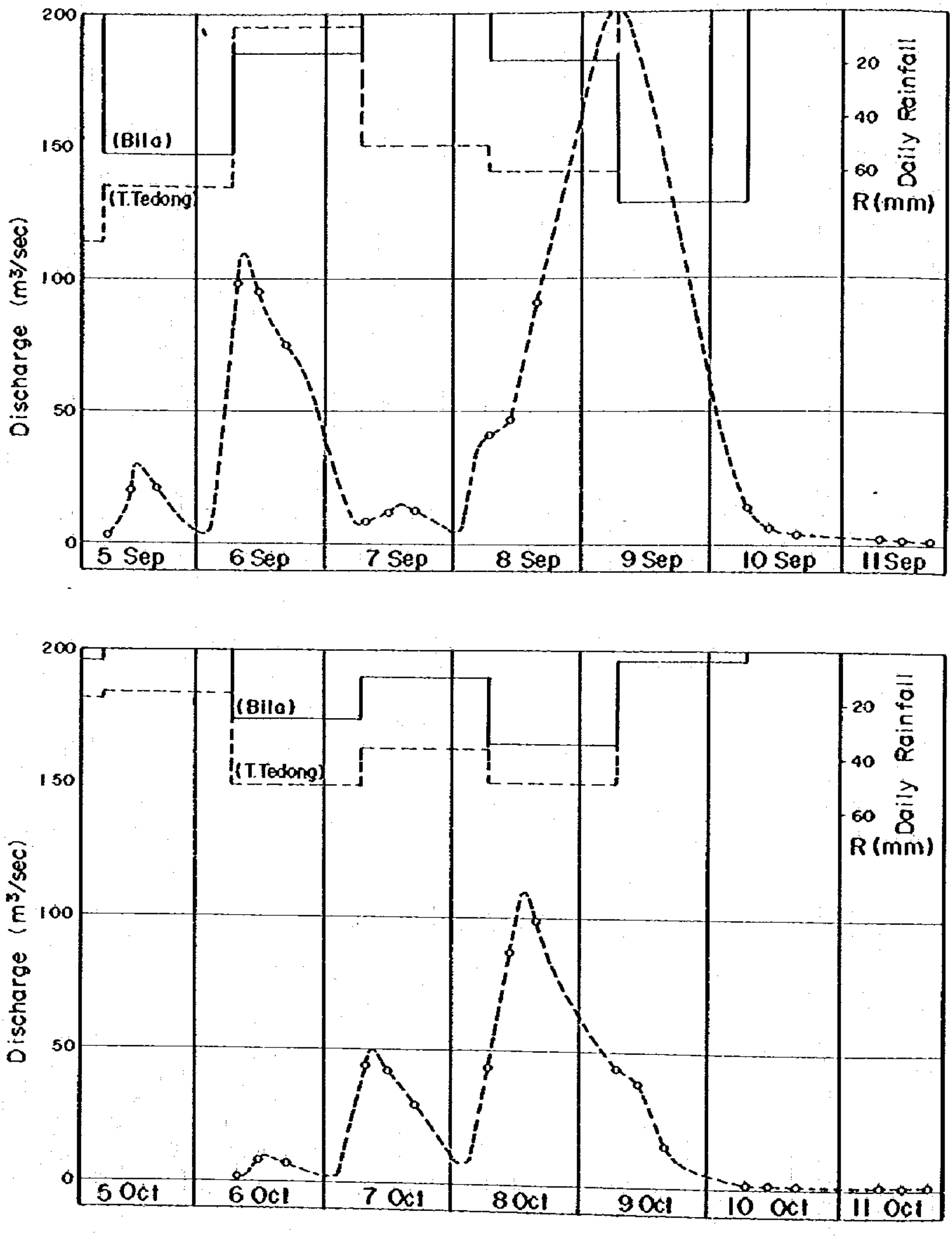
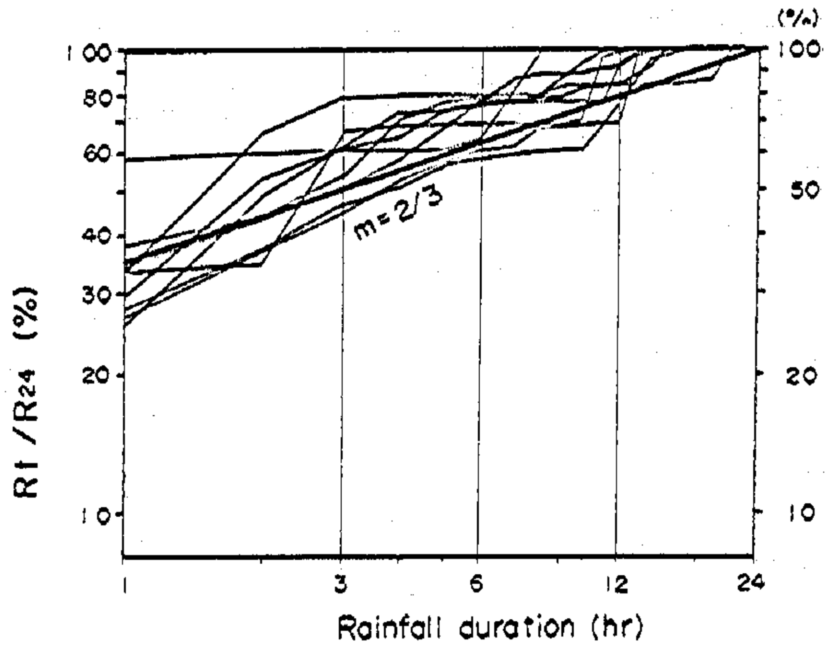


Fig. 4.5 HYDROGRAPH OF KALOLA RIVER (1981)



$$r = \left(\frac{R_{24}}{24}\right)\left(\frac{24}{T}\right)^{m}$$

$$r = Rt / T$$

Fig. 4.6 DAILY RAINFALL AND HOURLY RAINFALL

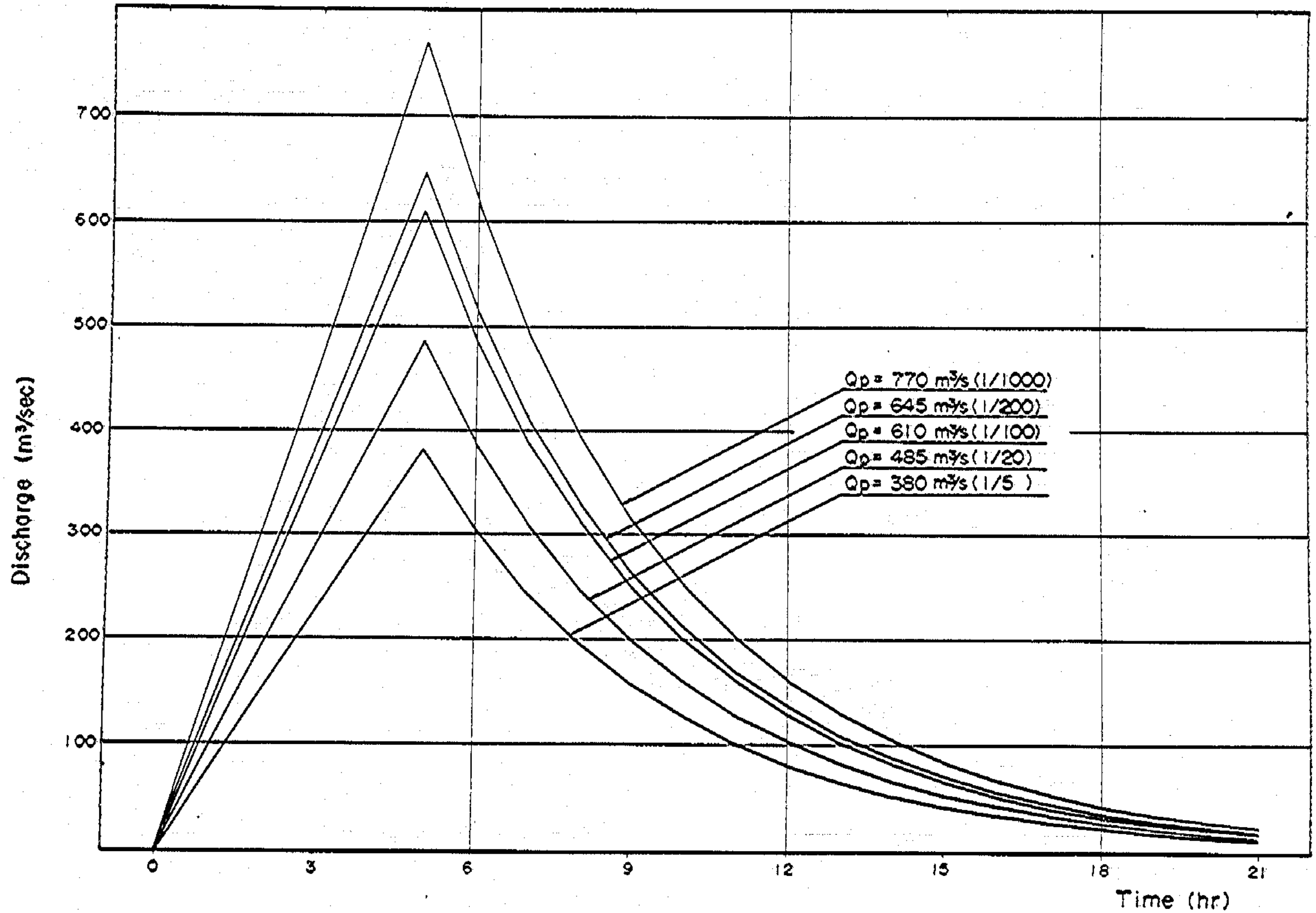


Fig. 4.7 PROBABLE FLOOD HYDROGRAPH OF KALOLA DAM

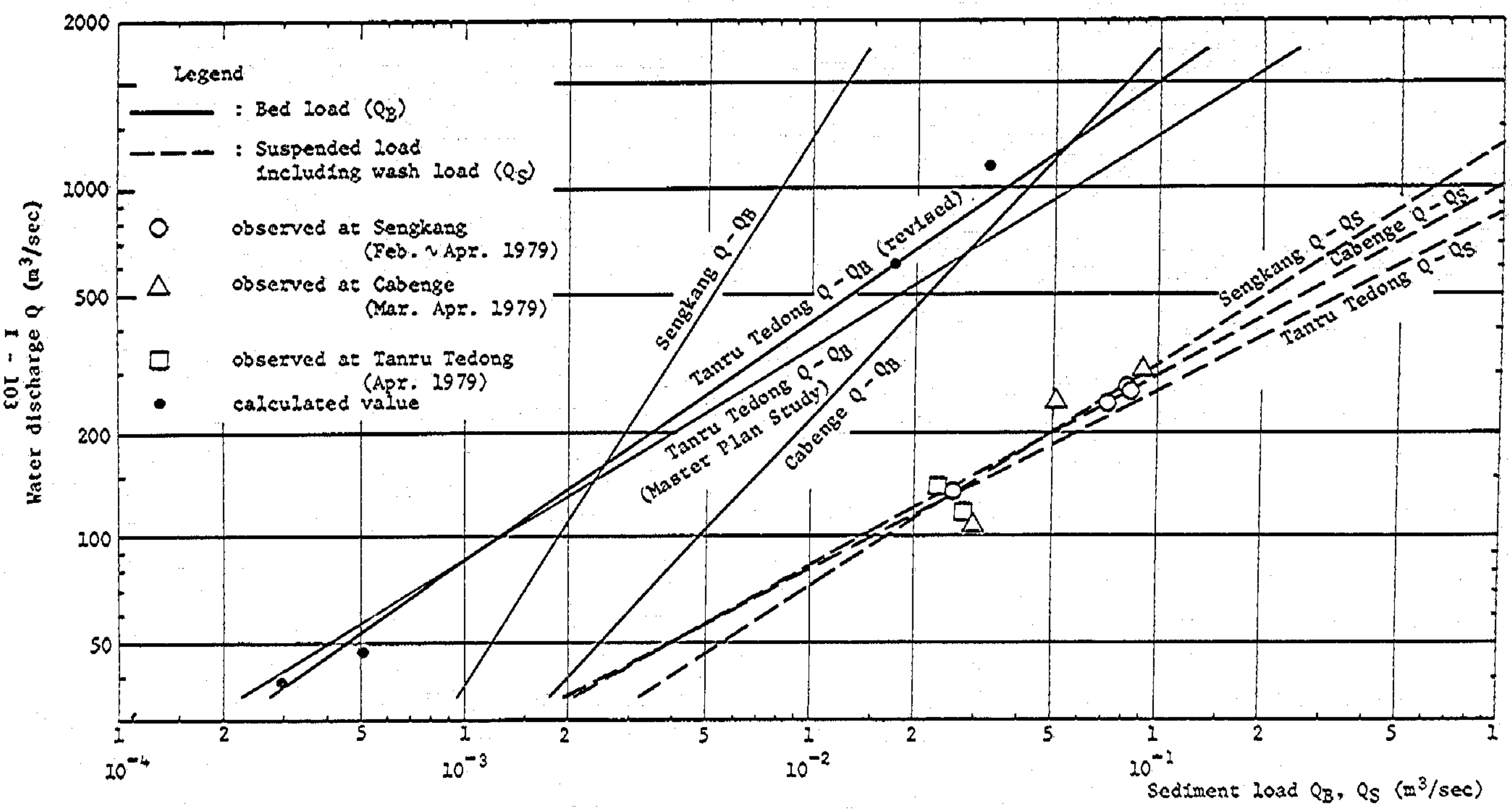


Fig. 4.8 RELATION BETWEEN SEDIMENT LOAD AND DISCHARGE

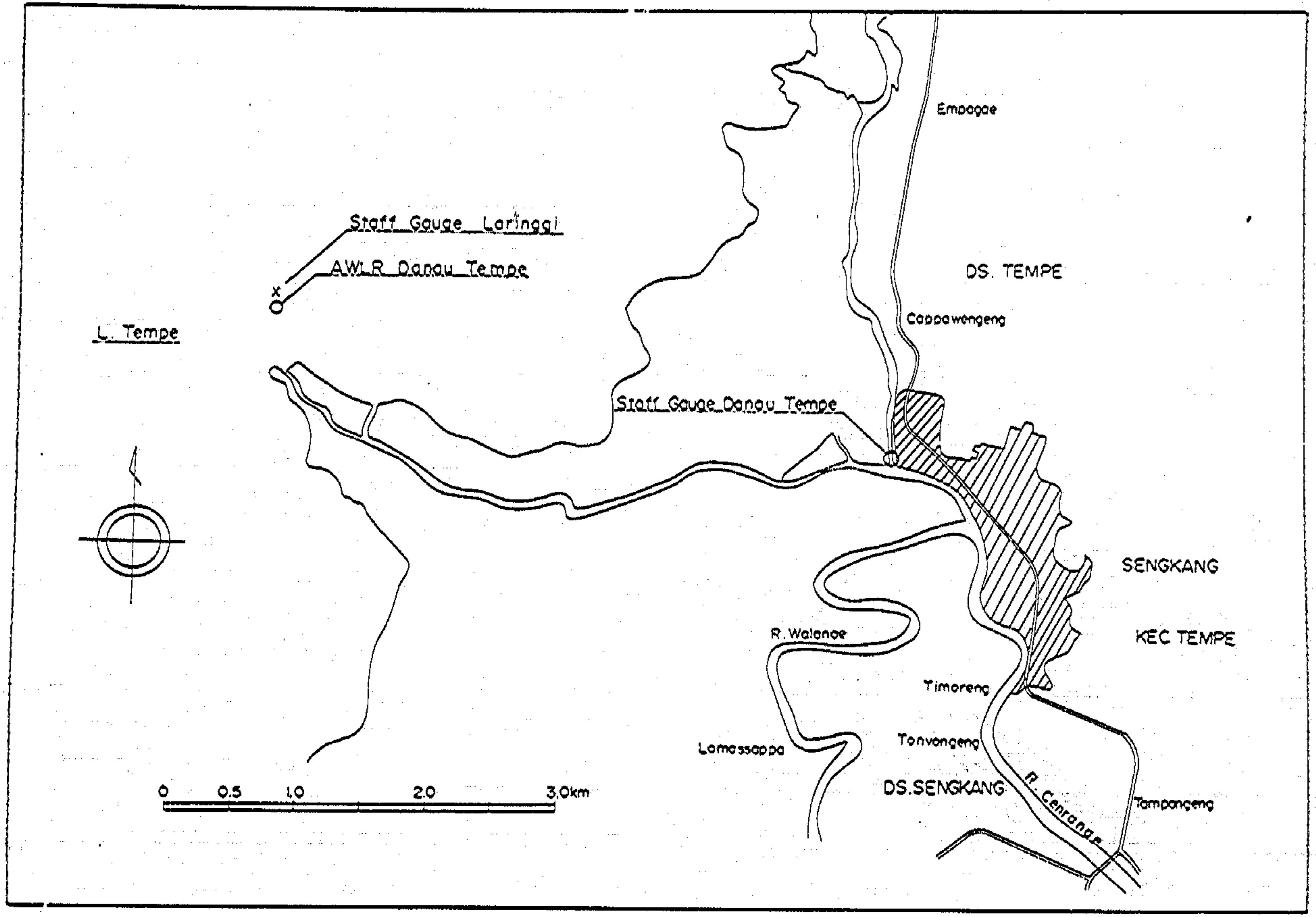


Fig. 5.1 LOCATION OF WATER LEVEL STATION

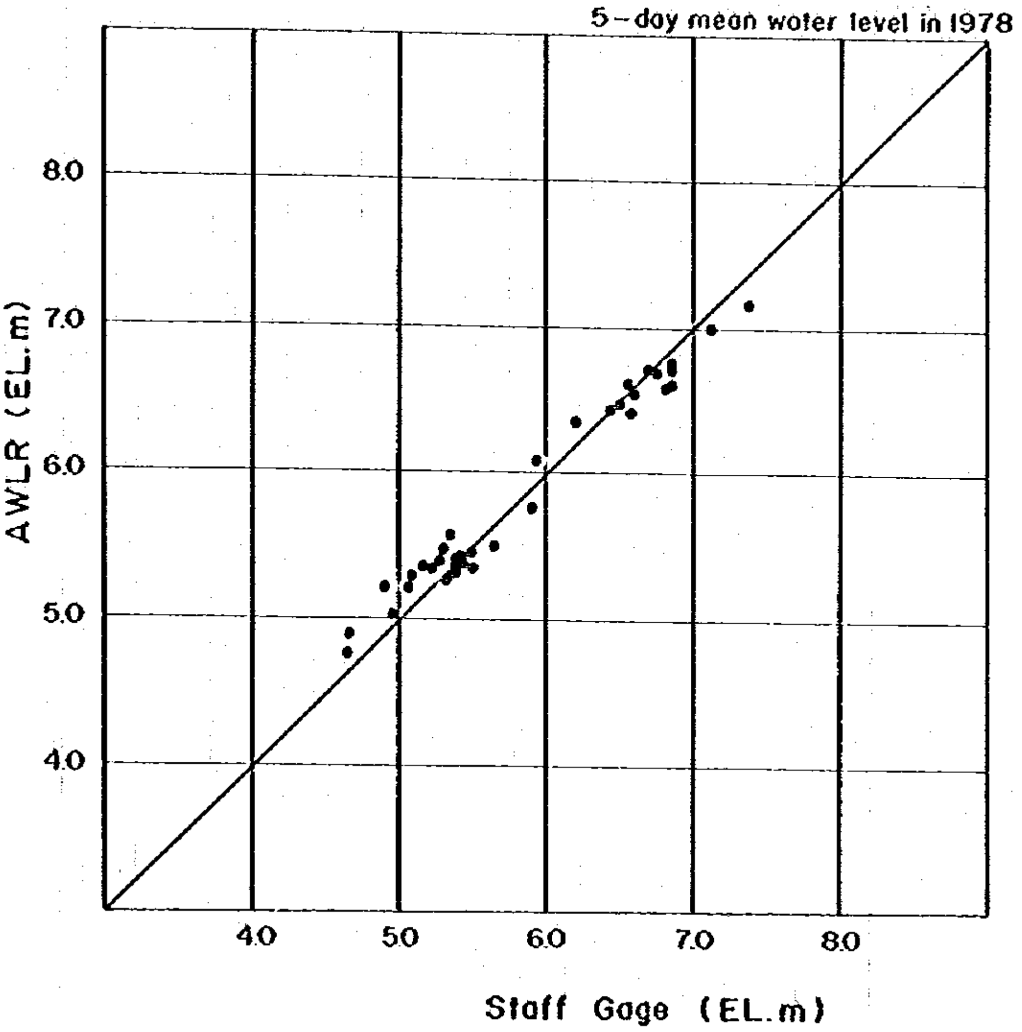


Fig. 5.2 RELATION OF WATER LEVEL
(AWLR LAKE TEMPE STAFF GAUGE - LAKE TEMPE)

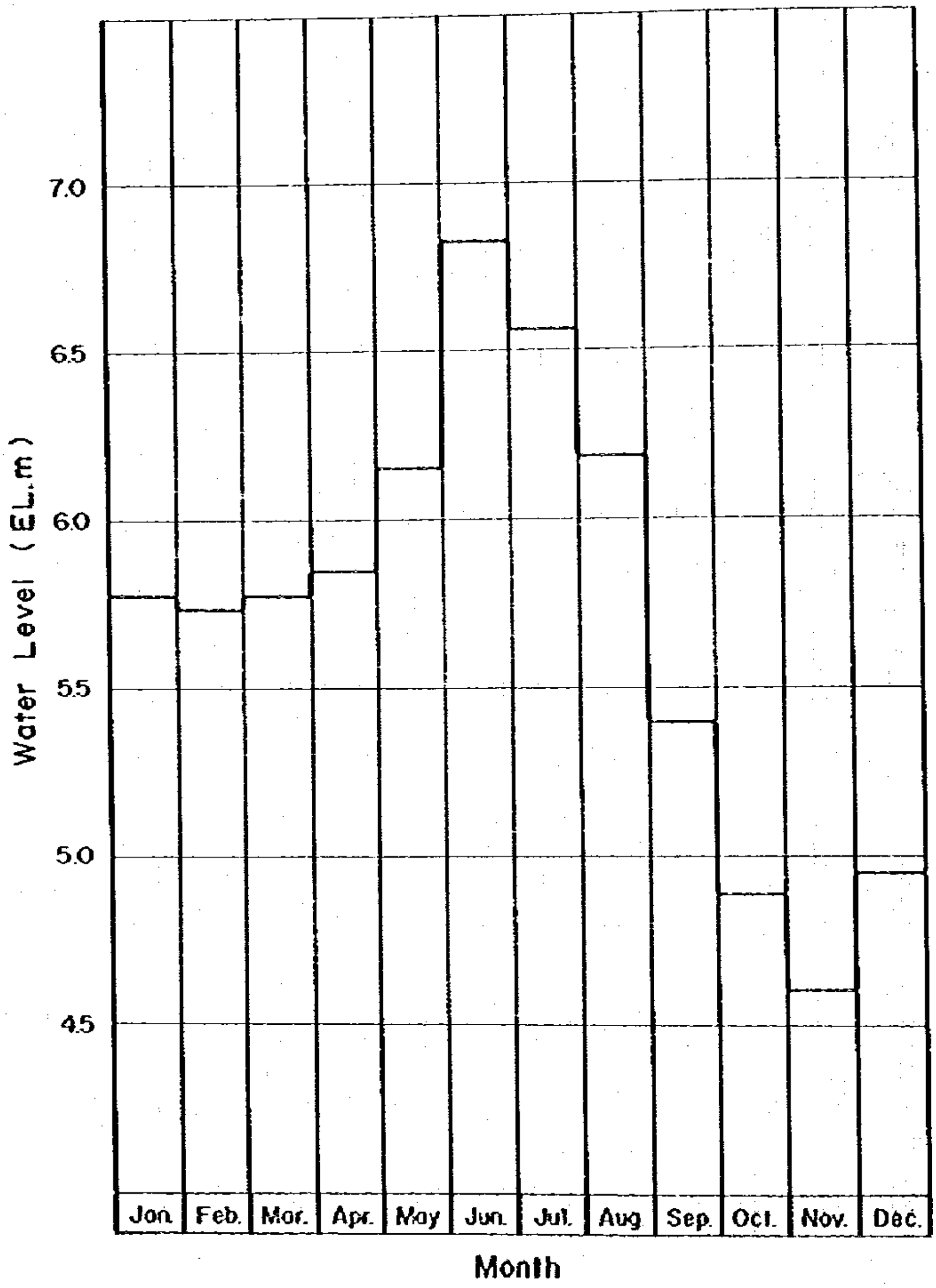


Fig. 5.3 MONTHLY WATER LEVEL HYDROGRAPH (LAKE TEMPE)

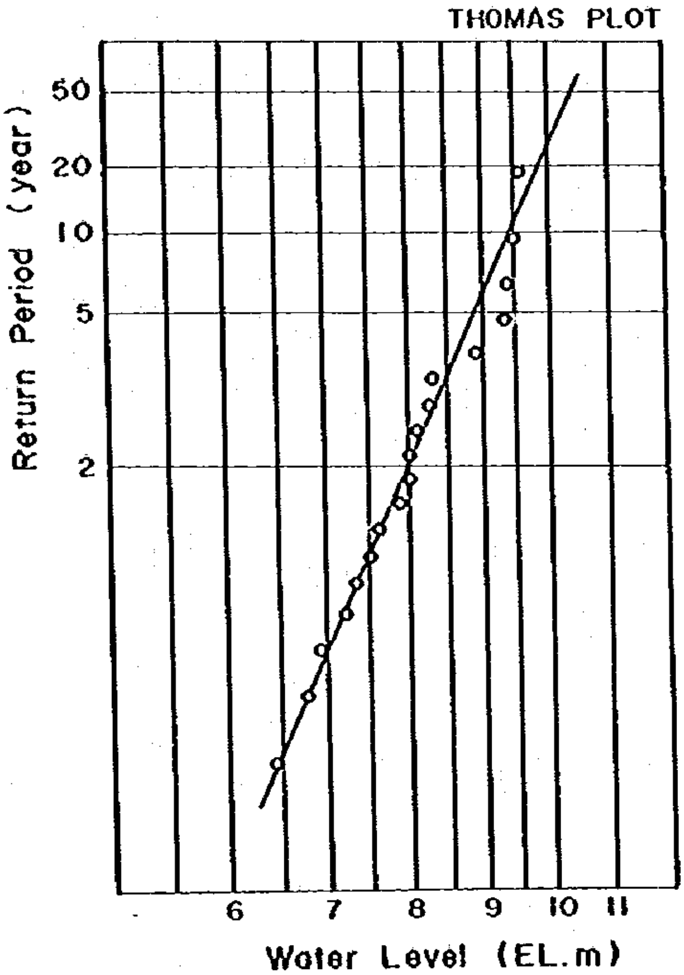


Fig. 5.4 RETURN PERIOD OF ANNUAL MAXIMUM WATER LEVEL (AT LAKE TEMPE)

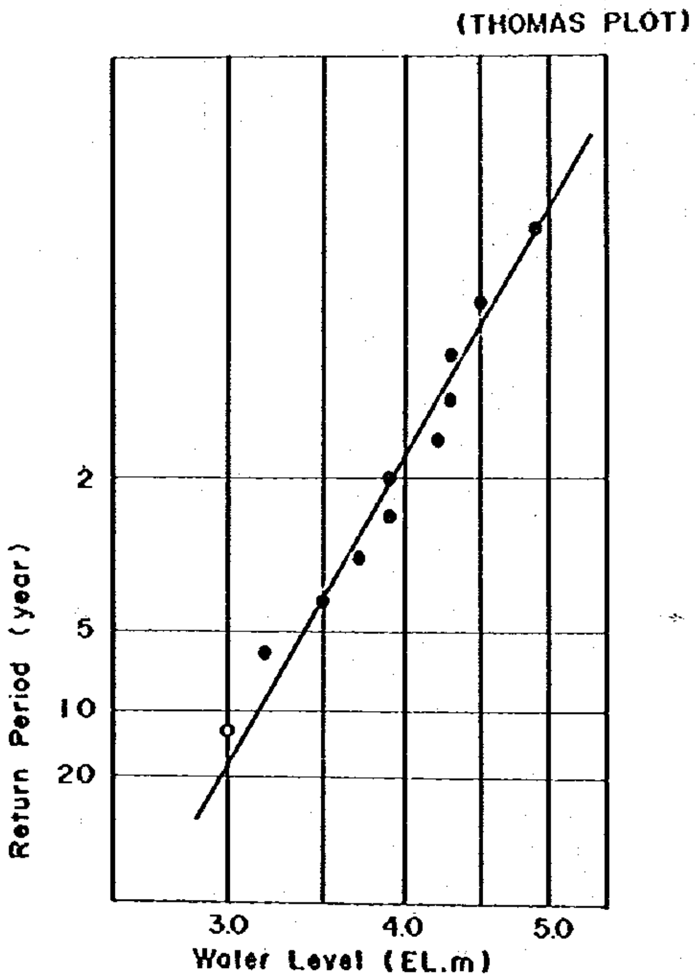


Fig. 5.5 RETURN PERIOD OF WATER LEVEL OF LAKE TEMPE
(ANNUAL MINIMUM WATER LEVEL)