REPUBLIC OF INDONESIA
Ministry of Public Works
Directorate General of Water Resources Development

PRE-FEASIBILITY STUDY
ON
THE UPPER KOMERING RIVER BASIN
DEVELOPMENT PROJECT

VOLUME II-1

ANNEX

I. METEOROLOGY AND HYDROLOGY
II. SOIL AND LAND SUITABILITY
III. GEOLOGY
IV. SOIL MECHANICS

MARCH 1982

INDIAN OCEAN

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

REPUBLIC OF INDONESIA
Ministry of Public Works
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ABBREVIATION AND LOCAL TERMS

Abbreviations and local terms used in this report are listed below:

A. ABBREVIATIONS

1. Length

mm	millimeter
cm	centimeter
m	meter
km	kilometer

2. Area

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

3. Volume

lit (ℓ)	liter (= 1,000 cm^3)
m^3	cubic meter

4. Weight

mg	milligram
g	gram
kg	kilogram
t	ton (= 1,000 kg)

5. Time

sec	second
min	minute
hr	hour

6. Other measures

%	percent
PS	horse power
kW	kilowatt
kVA	kilovoltampere
kWh	kilowatthour
MW	megawatt
MWh	megawatthour
GW	gigawatt
GWh	gigawatthour
pH	scale for acidity
°C	centigrade
cm/sec	centimeter per second
m/sec	meter per second
m^3/sec	cubic meter per second
lit/sec/ha	liter per second per hectare
m.e/ℓ	milligram equivalent per liter
mgcal/cm^2	milligram calorie per square centimeter
t/ha	ton per hectare
ppm	part per million
EC	electric conductivity
CEC	cation exchange capacity
No. (Nos.)	number(s)

7. Technical term

EL	elevation above mean sea level
H	height
WL	water level
HWL	height water level
LWL	low water level
FWL	flood water level
Q	discharge

8. Currency

US$	US Dollar
Rp.	Indonesian Rupiah

9. Other abbreviations

FAO	Food and Agriculture Organization of United Nations
UNDP	United Nations Development Program
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
WHO	World Health Organization
GDP	Gross Domestic Products
GRP	Gross Regional Products
DPU	Department of Public Works
P_3SA	Sub-directorate of Planning and Programming for Water Resources

B. LOCAL TERMS

Kab.	District (Kabupaten)
Prov.	Province (Provinsi)
OKU	District for Ogan Komering Upper River Basin
OKI	District for Ogan Komering Lower River Basin
BIMAS	Mass Guidance for Self-sufficiency in Food
INMAS	Mass Intensification for Self-sufficiency in Food
BRI	Indonesian People's Bank
CRIA	Central Research Institute for Agriculture, Bogor
PPS	Extension Specialist
PPM	Field Extension Worker
BPP	Rural Extension Center
KUD	Village Unit Cooperative Body
DOLOG	Depot of Logistic
BULOG	Board of Logistic
KIOS	Small Shop
ADC	Agricultural Development Center
UPP	Land Development Unit
KIK	Small Investment Credit
Desa	Village
Kecamatan	Sub-district
Kontak-Tani	Key farmer or leading farmer

Ani-Ani	Small Rice Harvesting Knife
Ulu-Ulu	Water master
WILUD	Wilayah Unit Desa
Pelita (Repelita)	Five-year Development Plan
Dalam Angka	Statistical data
BUUD/KUD	Village farmers' co-operative
BAPPEDA	Regional Planning and Development Agency
BALAI BENIH	Seed Center
PTPT	One of the new organization established under the Ministry of Public Works
Sawah	Paddy field
Polowijo	Second crop, planted after harvest of rainy season paddy
Tegal	Upland field
Ladang	Intermittent cultivation land
Alang-alang	Grass land

ANNEX I

METEOROLOGY AND HYDROLOGY

ANNEX - I

METEOROLOGY AND HYDROLOGY

1.

1.1 METEOROLOGY

The project area is located around 5° South in latitude and belongs to the equator climatic zone. On account of this location, the area is affected by the westerly wind and the trade wind (the SE seasonal wind). The westerly seasonal wind occurs from October to May, and it causes much rainfall in the area.

The meteorological data such as rainfall, sunshine hours, air temperature, relative humidity, solar radiation, wind velocity and evaporation were mainly collected at Sub. P3SA Sumatera Selatan, Sub. P3SA Lampung, Pertanian Office in Baturaja and Palembang. However, the observation was either completely stopped or conducted intermittently. Location of observatories and observation periods of these data are shown in Fig. I-1 to Fig. I-4.

1.2 Rainfall

The rainfall records are available at 35 gauge stations in and around the project area, though the recorded periods vary from station to station, and are often interrupted. The monthly rainfall records at some representative stations are shown in Table I-1 through Table I-6. Further, the annual maximum daily and hourly rainfalls are shown in Table I-7, Table I-8 and Table I-9 respectively. The average yearly rainfall is about 2,630 mm at BK-IX in the project area. It varies widely from year to year ranging from approximately 1,700 mm to approximately 4,600 mm. The maximum daily rainfall was recorded to be 207 mm at Martapura in February 1974, and the maximum hourly rainfall was 80 mm at Raksajiwa in April 30, 1980.

1.3 Sunshine Duration

The sunshine duration records are available at Belitang station and shown in Table I-10. From the figures given in the table, it can be seen that the monthly average sunshine hours vary from 6.2 hours in maximum in May to 4.0 hours in minimum in January.

1.4 Solar Radiation

The monthly solar radiation records at Belitang and Menggala are shown in Table I-11 and Table I-12. Those tables show that mean annual radiation values are 458 mgcal/cm^2 at Menggala and 398 mgcal/cm^2 at Belitang.

1.5 Air Temperature

Table I-13 gives the monthly mean air temperature records at Belitang over a period of 13 years from 1969 to 1981 with some incomplete years. Table I-14 and Table I-15 give the monthly mean air temperature records for Banding Agung and Menggala respectively. The observation periods are 6 years for Banding Agung and 4 years for Menggala. Those tables show that the monthly average air temperature at Belitang and Menggala vary from 26^oC to 28^oC with a little seasonal variations.

1.6 Relative Humidity

The relative humidity records are shown in Table I-16 through Table I-18. Those tables show the monthly relative humidity at Belitang, Banding Agung and Menggala respectively. The monthly average relative humidity reaches its maximum of about 86% and its minimum of about 71%.

1.7 Wind Velocity

The wind velocity records are shown in Table I-19 through Table I-21. Those tables give the monthly mean wind velocity at Belitang, Banding Agung and Menggala respectively. The monthly mean wind velocity is generally low in the flat land. The monthly averages of wind velocity are in the range from 2.3 km/hr to 3.7 km/hr.

1.8 Evaporation

Table I-22 through Table I-24 give the monthly evaporation records at Belitang, Banding Agung and Menggala respectively with some incomplete years. The annual pan evaporation observed at Belitang is about 1,680 mm (4.6 mm/day). The monthly average evaporation reaches its maximum in March; approximately 5.0 mm/day and its minimum in June; approximately 4.2 mm/day respectively.

2. HYDROLOGY

2.1 River and Basin

The Komering river originates from the Lake Ranau of about 127 km^2 in surface area, and flows to the northwest direction down to the confluence with the Baru river. At the confluence, the river changes its course toward northeast, and flows down through the deep and narrow gorge. At Muaradua, it joins with the Saka river; one of its large tributaries, and flows to Martapura through hilly area. The Komering river then runs meandering in the flat plain and reaches Kurungan Nyawa where the intake structure for the Belitang Proper Area is located. Near Cempaka, most of the streamflow flows into the Ogan river through the Randu, the Arisan, the Jambu, the Sigonang and the Anyer rivers.

The catchment area of the Komering river at Martapura is about 4,260 km^2 including the catchment area of about 508 km^2 at the outlet of the Lake Ranau.

2.2 Field Activities

The hydrological data on the Komering river were mainly provided by Sub. P3SA Sumatera Selatan, Sub. P3SA Lampung, PU Belitang, DPMA in Bandung, P3SA Jakarta and Department of Agriculture as shown in Fig. I-5 and I-6.

Discharge measurement was made at Banding Agung, Muaradua, Martapura and Kurungan Nyawa out of the gauging stations shown in Table I-25 to check the existing rating curves. The following table shows the results of measurement made during this survey period.

Results of Streamflow Measurement

Gauging Station	Observed Data	Discharge (m^3/sec)	Gauge Height (m)
Banding Agung	Jul. 29, 1981	20.7	1.15
	Aug. 10, 1981	20.6	1.12
Muaradua	Aug. 08, 1981	95.9	0.42
	Aug. 19, 1981	75.2	0.30
Martapura	Jul. 27, 1981	146.6	0.90
	Aug. 09, 1981	152.5	0.95
Kurungan Nyawa	Jul. 30, 1981	135.4	1.19
	Aug. 11, 1981	129.4	1.12

Note: Discharge measurement at Kurungan Nyawa was carried out immediately downstream of the intake site for Belitang Proper Area and a certain discharge flowed into the proper main canal.

2.3 Discharge of the Komering River

2.3.1 Rating Curve

The existing rating curves at the Banding Agung and Martapura stations are revised using the results of measurement made by the study team this time and by P3SA during the period from February 1972 to June 1981. As for the Muaradua station which was just established in August 1981, the rating curve can not be prepared because of shortage of the measured results; only two-time measurements.

(1) Rating curve at Martapura station

The rating curve (dotted) shown in Fig. I-7 was prepared by P3SA and used for the estimation of river discharge for the period from 1973 to 1978. In this study period, however, this rating curve is modified considering yearly changes of river cross section at the gauging station due to deposition of sediment loads. The modified rating curve also shown in Fig. I-7 is prepared using the discharge data measured 13 times during the period from 1979 to 1980 for the estimation of discharge for the period from 1979 to 1980. The estimated discharge is shown in Table I-26. The rating curve is expressed by the following equation:

$$Q = 37.82\ (H + 1.49)^2$$

where, Q: discharge at the Martapura station (m^3/sec)
H: reading of gauging height (m)

(2) Rating curve at Banding Agung station

Observation of water level at the outlet of the Lake Ranau has been done since 1972, though intermittently. During this period, discharge measurement was carried out 28 times, and the rating curve was prepared by P3SA using these data. According to the data measured during this period, the mean daily water depth at this station was 0.76 m with the standard deviation of 0.12 m. After then, the discharge measurement has been carried out 15 times until now. Since it can be considered that the river bed is very stable and no change has occurred in the river cross section at the gauging station since 1972, the above-mentioned data totaling 43 are used for the modification of the existing rating curve. This can be justified through the fact that the discharge coinciding with the water depth from 0.6 m to 1.1 m shown in Fig. I-8 shows little difference between the discharge obtained by using the existing rating curve and the discharge obtained by using the modified one shown in Fig. I-8. The rating curve thus modified is expressed by the following equation:

$$Q = 11.12\ (H + 0.48)^2$$

2.3.2 Monthly Discharge at Martapura

The above-mentioned rating curves; the existing rating curve for the period from 1972 to 1978 and the modified rating curve for the period from 1979 to 1980, are used for the estimation of discharge whenever the water level records are available. As for the period from 1963 to 1971, the discharge mentioned in the Planning Report/1 is used in this study. For the months in which the water level record is not available, the discharge is calculated by using the Tank Model Method as explained below.

/1: Planning Report on "Belitang Extension Area Agricultural Development Project", ANNEX-IV, FAO.

In general, rainfall-run-off process is nonlinear phenomenon, and run-off consists of surface run-off, subsurface run-off, and groundwater run-off. The nonlinearity of the rainfall-run-off process can be explained by using reservoirs (Tanks) in series and/or in parallel. The Tank Model method consisting essentially of linear reservoirs had been developed as analogous physical models to analyze river run-off. If the Tank Model is established based on the actual discharge for adequate period, the production (estimated run-off) becomes substantially reliable.

The rainfall required in the calculation is obtained by applying the Thiessen Method for which the rainfall data at Martapura, Muaradua and Banding Agung are used. In the simulation between the run-off and the rainfall, the discharge records in 1979 are used, because the daily discharge of this year is well arranged and seems most reliable.

Since no actual evapotranspiration data were available, evapotranspiration to be used for establishment of the Tank Model was estimated from a potential evapotranspiration by the Penman method, taking into account the following albedo values.

Value of Albedo

Open water	5%
Forest	15%

In estimation of evapotranspiration, the vegetation factor of 80% was applied, which was employed from the report on the feasibility study of the Way Seputih and the Way Sekanpung basins/1. Estimated evapotranspiration is shown in Table I-28.

The tank model thus established is as shown in Fig. I-9.

Average annual run-off of the Komering river at Martapura is about 203.1 m^3/sec or 6,484 x $10^6 m^3$ as shown in Table I-26. The average monthly

/1: Feasibility Study on the Way Seputih and the Way Sekanpung Basins, Volume 4, Ministry of Overseas Development, London, 1978.

discharge reaches its maximum in April, and is approximately 292 m^3/sec. The minimum discharge occurs in September, and is approximately 136 m^3/sec. The river discharge varies from year to year and the stream flow pattern is dominated by the seasonal distribution on rainfall.

2.3.3 Monthly Discharge at Banding Agung

The FAO Planning Report also shows the monthly discharge at the Banding Agung station for the period from 1963 to 1971. Since there was no discharge data in that period, the discharge was estimated by taking the correlation between the monthly discharge at Martapura and that from the residual basin extending between Banding Agung and Martapura as shown in Fig. I-10. The monthly discharge at Banding Agung is then simply calculated by deducting the monthly discharge of the residual basin from that of Martapura. As for the period from 1972 to 1980, the discharge is estimated by using the rating curve established in section 2.3.2 hereof.

Table I-27 shows the estimated monthly discharge at the Banding Agung gauging station for the period from 1963 to 1980.

2.3.4 Drought Run-off Analysis

The river discharge of the Komering river varies widely from year to year dominated by the amount of rainfall. The maximum and minimum annual stream flows were estimated at 274.2 m^3/sec in 1976 and 149.0 m^3/sec in 1964 respectively. Drought run-off analysis was made for mean daily discharge from June to October, in which the maximum irrigation requirement occurs every year. The results of probability calculation of drought discharge of the Komering river at Martapura based on the discharge data from 1963 to 1980 are shown in the following table and Fig. I-11.

Drought Discharge at Martapura
(by Gumbel Method)

Return Period (T)	Mean Daily Discharge (m^3/sec)
2	153
5	121
10	104
20	92
50	79

Annual drought discharge at Martapura and each return period are shown in Table I-29.

2.3.5 Flood Analysis on the Komering River

(1) Flood at Martapura

The flood of the Komering river reaches its maximum usually between February and May. The flood at Martapura is estimated by using 11 annual peak discharge data observed during the period from 1971 to 1981 as shown in Table I-30. In the estimation, the Komering river basin was divided into two sub-basins; Ranau basin and the residual basin excluding the Ranau basin, because the flood from the Ranau basin is largely regulated by the Lake Ranau.

The probable peak discharge with a respective return period is calculated for each basin and shown in the following table.

Calculated Peak Discharge
(by Gumbel Method)

(Unit: m^3/sec)

Return Period (T)	Banding Agung A_1 = 508 km^2	Residual River Basin A_2 = 3,752 km^2	Martapura A = 4,260 km^2
2	26.9	889.8	917
3	28.3	1,018.0	1,046
5	29.8	1,160.6	1,190
10	31.8	1,339.9	1,372
15	32.9	1,441.1	1,474
20	33.6	1,511.9	1,546
30	34.7	1,610.9	1,646
50	36.1	1,734.5	1,771
100	37.9	1,901.4	1,939
200	39.7	2,067.6	2,107
1,000	43.9	2,452.6	2,497

(2) Design floods at the respective dam sites

In order to determine the design flood for each dam site; the flood with a 1,000-year return period, the specific discharge of the catchment area of each dam, which excludes the Ranau basin, is calculated using the Rational Formula and the Melchoir's Formula, and the calculated results at Martapura are compared with that estimated using the actually measured data in the preceding sub-section (1) of this section.

The following table shows the comparison of specific discharge estimated by using the above-mentioned formulas.

Comparison between Specific Discharges
Estimated by the Formulas

(Unit: $m^3/sec/km^2$)

Location	Actual Measured Data	Rational Method	Melchoir Method
Komering No.1	-	4.1	2.7
Komering No.2	-	3.6	2.3
Muaradua	-	2.3	1.1
Martapura	0.654	1.3	0.7

The specific discharges calculated in the above are plotted in Fig. I-12. For the reference, the specific discharges obtained for the other dam projects in Indonesia (see Table I-31) are also plotted in Fig. I-12.

From the above calculation, it can generally be said that the specific discharge obtained by using the Rational Formula is bigger than those obtained by using the Melchoir's Formula and the actually observed data. While, the specific discharges obtained by the latter two methods show the similarity at Martapura. Therefore, the design flood for each dam site is determined referring to the results obtained by the Melchoir's Formula. In this determination, the specific discharges obtained for the other dam projects in Indonesia are also referred to.

The following table shows the design flood thus estimated for each dam site.

Design Flood at Each Dam Site

Location	Ranau Basin	Residual River Basin			Design Flood	
	Q	q	CA	Q	CA	Q
	(m^3/sec)	(m^3/sec/km^2)	(km^2)	(m^3/sec)	(km^2)	(m^3/sec)
Ranau	44	-	-	-	508	44
Komering No.1	44	2.5	548	1,370	1,056	1,414
Komering No.2	44	2.2	657	1,445	1,165	1,489
Muaradua	44	0.9	2,358	2,122	2,866	2,166
Martapura	44	0.654	3,752	2,453	4,260	2,497

2.3.6 Study of Water Level at Kurungan Nyawa

The study of the effect on the water level at the Kurungan Nyawa intake due to the intake of water at Perjaya particularly during the dry season is made based on the correlation of water levels of Kurungan Nyawa and Martapura since there are no other data available. The correlation analysis is made by using the water level data during the dry season (from 1975 to 1978).

The following regression line was obtained:

$$Y = 0.970\ X - 16.763$$

where, Y: water level at Kurungan Nyawa (staff gauge 0 m = EL. 66.17 m)

X: water level at Martapura (staff gauge 0 m = EL. 85.67 m)

From the above correlation equation, water level at Kurungan Nyawa for the irrigation water to the downstream area from the Perjaya Headworks is shown in Fig. I-13.

2.4 Run-off the Ogan and Tulangbawang Rivers

2.4.1 Stream Flow of the Ogan at Seri Kumbang

Discharge at Seri Kumbang is roughly estimated by weighed mean of specific discharges at Batu Raja and Tanjung Rambang during the period from 1972 to 1978 as shown in Table I-32.

2.4.2 Stream Flow of the Tulangbawang at Pakuanratu

Discharge at Pakuanratu also has been estimated in the above-mentioned report as shown in the following table:

Discharge at Pakuanratu (m^3/sec)

CA = 3,427 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Discharge	210	260	240	240	190	140	91	81	100	130	180	200	170

3. WATER QUALITY

In order to check the water quality of the Komering and the Ogan rivers, water samplings were carried out at 4 locations shown below in the period from September 30 through December 9, 1979, and the chemical test on the samples were made.

1. Kayu Agung (Komering River)
2. Kangkung (Komering River)
3. Banding Agung (Selabung River)
4. Tanjung Raja (Ogan River)

The results of the chemical analysis are presented in Table I-33. The suitability of water for irrigation and drinking was assessed based on WHO standard for drinking water and Scofield's standard for irrigation as shown in the following table.

<u>Standard for Drinking Water and Irrigation Water</u>

Item		For City Water WHO Standard	For Irrigation
pH		7.0 - 8.5	6.0 - 7.5/1
Electric Conductivity $K \times 10^5$			25
Ca		75	
Mg	ppm	50	
Cl		200 ppm	4 m.e/lit
SO_4		200 ppm	4 m.e/lit
$\frac{Na \times 100}{Na + Ca - Mg + K}$	(m.e/lit)		20%
$KMnO_4$	ppm	10	
B	ppm		0.33 - 1.0

A study of chemical properties of water shows that the water can be used for irrigation. For drinking, the water is proposed to be filtered to remove evaporated residue, and boiled through to destroy all micro-organism which may exist in the water, judging from the amount of $KMnO_4$ demand.

/1: Standard of Japanese Ministry of Agriculture, Forestry and Fishery.

4. ESTABLISHMENT OF METEORO-HYDROLOGICAL NETWORK

4.1 The Existing Meteoro-Hydrological Stations

In the Komering river and the Tulangbawang river basins, the existing meteorological and water level gauging stations are listed in Table I-34. Location of these stations is shown in Fig. I-1.

The observation and recording of instruments in these stations are often interrupted due to inadequate management of the stations. Actually there are some stations in which instruments of recorder are not working in normal conditions, resulting in provision of less reliability of hydrological analysis.

4.2 Immediate Needs on Meteoro-Hydrological Network

In view of vital importance of meteoro-hydrological data on the water resource development, it is urgently needed to establish observation and measurement policies on the operation of meteoro-hydrological stations in both the Komering and the Tulangbavang rivers basin. The immediate need is to guide the operation of and to provide the necessary goods of the existing system to avoid miss operation and interruption of the measurement and recording.

As the results of field investigation in the project area, the present meteorological and hydrological network are still insufficient to provide those data required for the hydrological analysis. The following observatories and gauging stations are further proposed to be established for providing meteorological information to the utmost extent in addition to the existing stations. The location of these stations are shown in Fig. I-1.

i) Meteorological station

1. Belitang
2. Negri Besar

ii) Rain gauge station

1. Martapura
2. Cahaya Bumi

3. Muaradua
4. Kurungan Nyawa
5. Betung

iii) Water level gauge station

1. Muaradua (Komering river)
2. Kurungan Nyawa (Komering river)
3. Rantaukemuning (Saka river)

4.3 Instruments to be Installed

The following instruments for the meteorological and hydrological stations are proposed to be installed. In general, the stations are to be located rather scattered and isolated. The field measurement personnel is normally not so well trained. In view of the above, it is proposed to install automatic recording instruments with clock type driven by wind up spring as much as possible.

i) Meteorological station

1. Automatic rainfall recording gauge
2. Standard rain gauge
3. Maximum-minimum thermometer
4. Dry-wet bulb thermometer
5. Thermo-hydrograph
6. Sunshine recorder
7. Anemometer
8. Class A standard evaporation pan
9. Solarimeter with recorder

ii) Rain gauge station

1. Automatic rain recording gauge
2. Standard rain gauge

iii) Water level gauge station

1. Automatic water level recording gauge
2. Sectional staff gauges

4.4 Observations and Analyses

It is strongly recommended that after installation of the instruments, those observations are to be continuously and properly made with a careful attention. In this connection, the following special notes are drawn:

i) Periodical check of instruments installed and supply of parts, if required, to maintain satisfactory operation of the instruments and to minimize the recording miss,

ii) Appropriate training of instrument measurement personnel,

iii) Establishment of well-communicated system to the meteoro-hydrological office concerned.

(1) Observations

The meteorological and hydrological observations at the proposed stations and the existing stations are made on the following items:

i) Meteorological observation

- rainfall,
- temperature,
- relative humidity,
- sunshine duration,
- wind velocity,
- evaporation, and
- solar radiation.

ii) Hydrological observation

- water level of river,
- periodical discharge measurement; preferably twice a month,
- periodical water sampling; preferably once a month.

(2) Analyses

Based on the meteorological and hydrological data observed and measured at each station, the following basic meteo-hydrological properties to be used for the project formulation are obtained through the statistical and chemical analyses.

i) Meteorological properties

- daily and monthly rainfalls, and annual maximum daily and hourly rainfall,
- monthly average, maximum and minimum temperatures,
- monthly average relative humidity,
- monthly average sunshine duration,
- monthly average wind velocity,
- monthly average evaporation,
- monthly average solar radiation, and
- monthly average evaporation.

ii) Hydrological properties

- monthly average discharge of river,
- drought discharge of river with various return period,
- flood discharge of river with various return period,
- sediment discharge of river, and
- water quality of river.

Table I-1 MONTHLY RAINFALL AT BK IX

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1956	310.0	282.0	305.0	200.0	156.0	95.0	216.0	262.0	223.0	421.0	556.0	274.0	3,300.0
57	681.0	231.0	405.0	368.0	164.0	358.0	181.0	153.0	108.0	87.0	463.0	437.0	3,638.0
58	347.0	299.0	578.0	260.0	76.0	53.0	110.0	150.0	10.0	241.0	565.0	286.0	2,975.0
59	383.0	-	308.0	400.0	454.0	104.0	34.0	3.0	67.0	-	-	-	-
1960	400.0	286.0	264.0	155.0	117.0	40.0	63.0	49.0	34.0	78.0	183.0	351.0	2,020.0
61	336.0	202.0	337.0	340.0	124.0	132.0	10.0	1.0	7.0	0	156.0	378.0	2,023.0
62	258.0	284.0	454.0	181.0	341.0	55.0	83.0	173.0	125.0	249.0	189.0	386.0	2,778.0
63	562.0	342.0	275.0	256.0	110.0	14.0	52.0	7.0	-	72.0	190.0	170.0	-
64	-	-	-	-	-	-	-	63.0	84.0	-	-	-	-
65	160.0	158.0	320.0	141.0	33.0	156.0	41.0	-	-	252.0	184.0	243.0	-
66	358.0	274.0	341.0	209.0	186.0	57.0	30.0	12.0	-	-	-	430.0	-
67	371.0	335.0	156.0	186.0	176.0	30.0	85.0	0	12.0	145.0	265.0	236.0	1,997.0
68	247.0	146.0	424.0	350.0	158.0	208.0	165.0	198.0	70.0	205.0	729.0	421.0	3,321.0
69	546.0	265.0	283.0	254.0	301.0	109.0	48.0	35.0	255.0	72.0	318.0	419.0	2,905.0
1970	274.0	157.0	260.0	562.0	201.0	15.0	47.0	45.0	17.0	-	50.0	243.0	-
71	361.0	293.0	195.0	256.0	80.0	23.0	48.0	41.0	23.0	143.0	188.0	195.0	1,851.0
72	353.0	106.0	308.0	249.0	164.0	68.0	0	4.0	26.0	26.0	153.0	236.0	1,685.0
73	74.0	187.0	196.0	258.0	383.0	113.0	82.0	381.0	264.0	335.0	256.0	-	-
74	-	179.0	349.0	205.0	183.0	40.0	190.0	104.0	178.0	217.0	254.0	470.0	-
75	-	-	-	-	-	-	-	-	-	-	-	-	-
76	-	-	-	-	-	-	-	-	-	-	-	-	-
77	-	-	-	-	-	-	-	-	-	-	-	-	-
78	379.0	496.0	155.0	384.0	245.0	156.0	77.0	165.0	366.0	459.0	309.0	478.0	4,184.0
79	303.0	222.0	384.0	246.0	280.0	114.0	69.0	61.0	165.0	270.0	150.0	438.0	2,702.0
1980	214.0	106.0	284.0	338.0	275.0	75.0	245.0	100.0	280.0	290.0	432.0	-	-
Average	345.9	242.5	313.4	276.1	200.3	96.0	93.8	95.5	121.8	209.8	294.2	338.4	2,627.7

Table I-2 MONTHLY RAINFALL AT KURUNGAN NYAWA (BK.O)

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1955	406.0	209.0	631.0	425.0	40.0	113.0	280.0	40.0	120.0	336.0	185.0	377.0	3,162.0
56	419.0	215.0	333.0	295.0	269.0	140.0	215.0	141.0	141.0	295.0	322.0	308.0	3,093.0
57	485.0	253.0	317.0	391.0	252.0	106.0	255.0	172.0	23.0	199.0	232.0	648.0	3,333.0
58	357.0	447.0	451.0	242.0	272.0	182.0	89.0	268.0	27.0	176.0	419.0	423.0	3,353.0
59	328.0	-	-	225.0	351.0	51.0	55.0	8.0	23.0	-	-	-	-
1960	570.0	223.0	389.0	533.0	132.0	56.0	133.0	126.0	154.0	101.0	302.0	715.0	3,434.0
61	273.0	309.0	336.0	452.0	453.0	236.0	5.0	41.0	31.0	23.0	230.0	493.0	2,882.0
62	494.0	253.0	514.0	287.0	311.0	151.0	290.0	131.0	277.0	286.0	184.0	-	-
63	289.0	346.0	308.0	114.0	131.0	67.0	6.0	19.0	0	261.0	93.0	335.0	1,969.0
64	-	-	-	-	-	-	-	68.0	81.0	-	-	-	-
65	219.0	291.0	397.0	378.0	181.0	-	-	-	-	122.0	163.0	222.0	-
66	-	326.0	360.0	176.0	208.0	-	106.0	-	-	392.0	393.0	-	-
67	271.0	387.0	298.0	259.0	257.0	42.0	59.0	0	8.0	163.0	178.0	372.0	2,294.0
68	225.0	134.0	369.0	277.0	205.0	233.0	65.0	197.0	141.0	214.0	412.0	412.0	2,884.0
69	372.0	309.0	518.0	193.0	217.0	92.0	124.0	40.0	281.0	148.0	571.0	372.0	3,237.0
1970	321.0	139.0	447.0	538.0	351.0	137.0	83.0	59.0	92.0	140.0	212.0	580.0	3,099.0
71	232.0	250.0	408.0	305.0	164.0	110.0	91.0	84.0	27.0	393.0	233.0	334.0	2,631.0
72	386.0	228.0	505.0	313.0	140.0	76.0	0	72.0	21.0	38.0	164.0	366.0	2,309.0
73	239.0	373.0	285.0	228.0	563.0	165.0	9.0	213.0	307.0	127.0	222.0	273.0	3,004.0
74	202.0	285.0	275.0	281.0	405.0	70.0	103.0	149.0	173.0	195.0	252.0	361.0	2,751.0
78	388.0	351.0	388.0	209.0	229.0	264.0	98.0	147.0	198.0	432.0	293.0	333.0	3,330.0
79	329.0	224.0	433.0	206.0	150.0	120.0	97.0	64.0	211.0	296.0	141.0	365.0	2,636.0
1980	211.0	229.0	426.0	219.0	154.0	264.0	97.0	177.0	103.0	318.0	212.0	350.0	2,760.0
Average	334.1	275.3	399.4	297.5	247.0	140.8	113.0	110.8	122.0	221.7	257.8	402.1	2,921.5

Table I-3 MONTHLY RAINFALL AT MARTAPURA

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1951	592.0	362.0	242.0	328.0	166.0	171.0	126.0	70.0	112.0	128.0	94.0	570.0	2,961.0
52	568.0	408.0	735.0	399.0	393.0	189.0	235.0	259.0	271.0	108.0	435.0	682.0	4,682.0
53	786.0	628.0	636.0	408.0	364.0	96.0	139.0	17.0	21.0	189.0	622.0	297.0	4,203.0
54	367.0	419.0	318.0	168.0	214.0	97.0	79.0	121.0	35.0	97.0	71.0	229.0	2,215.0
55	196.0	188.0	370.0	233.0	90.0	114.0	87.0	154.0	292.0	231.0	159.0	504.0	2,618.0
56	392.0	233.0	369.0	363.0	163.0	140.0	334.0	108.0	202.0	255.0	351.0	173.0	3,083.0
58	468.0	328.0	491.0	644.0	98.0	189.0	-	220.0	12.0	162.0	336.0	443.0	-
1960	420.0	301.0	308.0	-	-	44.0	-	194.0	42.0	76.0	361.0	527.0	-
66	270.0	160.0	132.0	218.0	321.0	285.0	40.0	280.0	30.0	340.0	180.0	500.0	2,756.0
1971	286.0	281.0	457.0	271.0	257.0	188.0	7.0	52.0	38.0	242.0	201.0	151.0	2,431.0
72	318.0	259.0	560.0	410.0	192.0	55.0	3.0	76.0	54.0	9.0	145.0	346.0	2,427.0
73	275.0	217.0	134.0	241.0	428.0	259.0	30.0	453.0	321.0	199.0	93.0	234.0	2,884.0
74	102.0	417.0	160.0	209.0	235.0	52.0	201.0	89.0	189.0	183.0	227.0	356.0	2,420.0
75	305.0	319.0	225.0	181.0	174.0	50.0	150.0	630.0	192.0	277.0	391.0	182.0	2,209.0
76	215.0	-	270.0	214.0	30.0	54.0	99.0	210.0	65.0	305.0	417.0	556.0	-
77	289.0	199.0	121.0	642.0	129.0	77.0	96.0	119.0	132.0	126.0	189.0	416.0	2,535.0
78	-	-	-	-	-	-	-	-	-	-	-	-	-
79	-	-	-	112.0	152.0	55.0	99.0	0	93.0	353.0	261.0	212.0	-
1980	180.0	122.0	206.0	147.0	227.0	129.0	3.0	213.0	163.0	361.0	135.0	393.0	2,279.0
81	331.0	99.0	263.0	69.0	226.0	113.0	-	-	-	-	-	-	-
Average	353.3	2906.	333.2	292.1	214.4	124.1	108.0	149.9	125.8	202.3	259.3	376.2	2,829.0

Table I-4 MONTHLY RAINFALL AT MUARADUA

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1952	383.0	319.0	394.0	282.0	-	40.0	41.0	111.0	167.0	-	270.0	482.0	-
53	416.0	303.0	204.0	228.0	326.0	49.0	82.0	34.0	13.0	287.0	264.0	220.0	2,426.0
1966	270.0	100.0	400.0	102.0	340.0	219.0	111.0	124.0	60.0	167.0	270.0	380.0	2,543.0
67	185.0	265.0	460.0	155.0	330.0	100.0	125.0	-	-	75.0	380.0	245.0	-
68	145.0	65.0	370.0	275.0	215.0	250.0	222.0	210.0	125.0	250.0	365.0	340.0	2,832.0
69	398.0	210.0	174.0	524.0	277.0	200.0	290.0	140.0	152.0	200.0	314.0	465.0	2,344.0
1970	307.0	190.0	340.0	243.0	495.0	50.0	141.0	304.0	192.0	103.0	299.0	175.0	2,839.0
71	140.0	189.0	285.0	345.0	162.0	115.0	260.0	160.0	80.0	241.0	215.0	340.0	2,532.0
72	298.0	219.0	443.0	358.0	304.0	-	-	-	-	-	-	-	-
73	86.0	255.0	159.0	230.0	242.0	95.0	39.0	153.0	138.0	132.0	-	-	-
74	129.0	182.0	111.0	380.0	219.0	68.0	299.0	38.0	327.0	227.0	115.0	173.0	2,268.0
75	267.0	210.0	159.0	196.0	82.0	60.0	30.0	163.0	153.0	202.0	206.0	76.0	1,804.0
76	136.0	148.0	261.0	197.0	89.0	9.0	76.0	67.0	24.0	309.0	352.0	331.0	1,999.0
77	253.0	319.0	134.0	402.0	153.0	214.0	55.0	15.0	109.0	17.0	182.0	387.0	2,240.0
78	191.0	287.0	259.0	156.0	304.0	190.0	217.0	70.0	190.0	341.0	166.0	287.0	2,558.0
79	193.0	281.0	259.0	426.0	268.0	129.0	157.0	165.0	85.0	127.0	55.0	31.0	2,176.0
1980	28.0	23.0	178.0	180.0	17.0	33.0	210.0	478.0	87.0	411.0	488.0	645.0	2,778.0
Average	225.0	203.8	270.0	275.2	238.9	113.8	147.2	148.8	126.8	205.9	262.7	305.1	2,523.2

Table I-5 MONTHLY RAINFALL AT BANDING AGUNG

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1973	-	343.0	251.0	285.0	113.0	131.0	96.0	147.0	267.0	186.0	113.0	251.0	-
74	128.0	190.0	157.0	233.0	283.0	123.0	96.0	121.0	228.0	100.0	244.0	141.0	2,044
75	278.0	285.0	144.0	321.0	166.0	26.0	179.0	151.0	113.0	217.0	206.0	176.0	2,262
76	413.0	148.0	152.0	49.0	-	0	272.0	51.0	-	274.0	318.0	136.0	-
77	189.0	263.0	-	-	144.0	214.0	21.0	91.0	58.0	56.0	153.0	239.0	-
78	133.0	102.0	439.0	150.0	271.0	55.0	-	-	-	224.0	290.0	464.0	-
79	92.0	115.0	158.0	210.0	115.0	78.0	92.0	71.0	184.0	203.0	243.0	215.0	1,776
1980	415.0	254.0	177.0	412.0	-	-	177.0	145.0	204.0	-	-	302.0	-
Average	235.4	212.5	211.1	237.1	182.0	104.5	133.3	111.0	175.7	180.0	223.9	240.5	2,247

Table I-6 MONTHLY RAINFALL AT MENGGALA

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1972	320.0	434.0	535.0	121.0	188.0	6.0	10.0	1.0	0	0	188.0	395.0	2,198
73	280.0	451.0	364.0	125.0	395.0	212.0	17.0	-	-	-	-	-	-
74	211.0	314.0	438.0	228.0	28.0	92.0	133.0	116.0	209.0	289.0	301.0	387.0	2,746
75	444.0	290.0	229.0	261.0	153.0	47.0	196.0	152.0	170.0	385.0	193.0	149.0	2,669
76	198.0	176.0	499.0	222.0	85.0	50.0	37.0	81.0	22.0	79.0	152.0	202.0	1,803
77	266.0	213.0	329.0	125.0	115.0	141.0	131.0	4.0	78.0	14.0	226.0	591.0	2,233
78	286.0	423.0	421.0	75.0	125.0	228.0	226.0	30.0	233.0	255.0	264.0	260.0	2,826
79	326.0	272.0	171.0	415.0	189.0	129.0	105.0	96.0	187.0	219.0	118.0	403.0	2,630
1980	259.0	199.0	207.0	165.0	43.0	144.0	103.0	78.0	121.0	188.0	314.0	431.0	2,252
Average	287.8	308.0	354.8	193.0	146.8	116.6	106.4	69.8	127.5	178.6	219.5	352.3	2,461

Table I-7 ANNUAL MAXIMUM DAILY RAINFALL

(Unit : mm)

Year	Martapura	Banding Agung	Muaradua	Kurungan Nyawa	Belitang BK-IX	Menggala
1971	-	-	-	83.0	60.0	-
72	115.0	-	-	84.0	65.0	87.0
73	128.0	73.0	73.0	122.0	75.0	87.0
74	207.0	65.0	93.0	123.0	147.0	100.0
75	119.0	78.0	67.0	-	-	111.0
76	103.0	134.0	109.0	-	-	96.0
77	174.0	56.0	109.0	-	-	140.0
78	-	86.0	93.0	120.0	92.0	175.0
79	88.0	54.0	116.0	120.0	96.0	107.0
80	95.0	60.0	110.0	120.0	160.0	90.0

Table I-8 HOURLY RAINFALL AT RAKSAJIWA

Date	RAINFALL DURATION						
	20 min	40 min	1 hour	2 hour	3 hour	4 hour	5 hour
	mm	mm	mm	mm	mm	mm	mm
Feb. 2, 1976	28.0	45.4	51.6	59.0	62.4	63.0	-
Mar.12,	10.8	19.2	27.2	33.6	38.4	45.0	47.8
Mar.18,	20.0	40.0	46.8	52.6	56.6	58.8	61.1
Mar.27,	12.0	22.0	27.0	32.2	37.2	39.6	-
Apr.25,	8.0	15.0	20.0	31.4	32.8	38.2	40.2
Aug.28,	13.0	25.0	25.3	33.9	-	-	-
Nov. 2,	32.6	40.2	46.2	-	-	-	-
Jan.18, 1977	20.0	33.4	46.6	57.6	66.6	68.8	-
Apr. 6,	20.0	30.8	34.8	38.8	53.6	60.2	64.4
Apr.13,	27.0	37.8	39.2	55.4	59.2	62.4	63.8
Apr.25,	14.6	27.6	31.8	-	-	-	-
Jun. 7,	13.4	21.8	22.6	-	-	-	-
Apr. 3, 1978	20.8	36.0	47.0	87.5	-	-	-
May 13,	26.2	28.3	29.8	34.0	-	-	-
Feb. 6, 1979	19.5	29.8	31.5	42.0	48.5	52.5	59.2
Feb. 7,	30.3	36.8	37.3	39.9	-	-	-
Feb.23,	21.0	37.5	42.0	46.4	53.7	55.3	55.9
Feb.25,	37.5	49.2	58.9	76.9	78.6	82.7	85.7
Apr. 5,	19.0	21.5	24.4	-	-	-	-
May 23	17.4	20.5	23.2	-	-	-	-
Aug. 8,	10.1	20.2	27.3	30.6	32.6	36.9	-
Sep. 1,	17.3	28.8	30.6	33.9	-	-	-
Sep.27,	20.0	29.6	31.9	34.6	-	-	-
Oct.30,	10.5	20.2	22,2	31.5	36.6	37.8	-
Oct.27, 1980	31.5	60.8	64.3	67.1	69.4	70.1	70.7
Mar. 6, 1981	30.0	57.0	64.0	108.0	112.7	117.0	121.5
Mar.20,	30.0	50.0	63.2	79.8	84.4		
Apr.30,	47.0	75.0	80.0	80.9	81.3		

Table I-9 ANNUAL MAXIMUM HOURLY RAINFALL

Station : Raksajiwa

Year	Rainfall (mm) ∿ Duration						
	min 20	min 40	hour 1	2	3	4	5
1976	32.6	45.4	51.6	59.0	62.4	63.0	63.0
1977	27.0	37.8	46.6	57.6	66.6	68.8	68.8
1978	26.2	36.0	47.0	87.5	87.5	87.5	87.5
1979	37.5	49.2	58.9	76.9	78.6	82.7	85.7
1980	31.5	60.8	64.3	67.1	69.4	70.1	70.7
1981	47.0	75.0	80.0	108.0	112.7	117.0	121.5
Maximum	47.0	75.0	80.0	108.0	112.7	117.0	121.5

Data 1976 January ∿ 1981 May

Year	Rainfall Intensity (mm/hr) ∿ duration						
	min 20	min 40	hour 1	2	3	4	5
1976	97.8	68.1	51.6	29.5	20.8	15.8	12.6
1977	81.0	56.7	46.6	28.8	22.2	17.2	13.8
1978	78.6	54.0	47.0	43.8	29.2	21.9	17.5
1979	112.5	73.8	58.9	38.5	26.2	20.7	17.1
1980	94.5	91.2	64.3	33.6	23.1	17.5	14.1
1981	141.0	112.5	80.0	54.0	37.6	29.3	24.3
Maximum	141.0	112.5	80.0	54.0	37.6	29.3	24.3

Table I-10 MONTHLY SUNSHINE DURATION AT BELITANG

(Unit : Hr)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1969	4.94	-	-	5.85	-	-	-	-	-	-	5.78	4.35	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	4.48	4.69	-	-	-	-	-	-	-	-	-
1972	4.00	-	5.10	6.60	6.30	7.20	-	6.80	5.30	4.50	4.80	4.30	-
1973	5.60	5.60	4.30	5.10	5.50	5.40	-	6.80	4.80	6.30	5.70	3.40	-
1974	2.50	4.00	5.70	7.40	6.10	6.00	5.80	5.50	5.30	4.80	4.70	4.00	5.15
1975	4.10	4.00	-	5.00	-	5.00	5.10	5.80	5.70	5.60	5.40	3.20	-
1976	2.90	5.60	4.70	-	7.40	6.60	5.70	6.30	5.90	4.50	4.40	5.00	-
1977	3.50	3.60	4.20	6.70	7.20	6.60	6.70	6.60	6.50	5.60	4.90	5.10	5.60
1978	5.40	-	-	5.30	5.90	4.90	4.10	5.90	4.30	3.40	4.20	3.40	-
1979	4.20	3.40	-	4.80	6.10	5.10	4.50	4.50	4.00	5.80	5.00	4.80	-
1980	4.00	4.60	5.60	3.60	6.00	5.80	6.50	5.50	5.00	4.20	3.70	2.90	4.80
1981	2.40	5.60	5.70	6.30	5.50	5.60	-	-	-	-	-	-	-
Average	4.00	4.00	5.00	5.60	6.20	5.80	5.50	5.90	5.20	5.00	4.90	4.10	5.20

Table I-11 MONTHLY SOLAR RADIATION AT BELITANG

(Unit : mmH_2O)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1971	-	-	-	-	-	-	-	-	-	-	-	14.0	-
1972	13.4	-	-	-	-	12.6	13.7	12.4	12.2	12.1	13.3	13.6	-
1973	13.5	14.0	11.9	13.9	12.7	12.0	13.4	13.9	11.4	13.7	13.7	11.2	12.9
1974	10.3	11.6	12.9	14.5	12.5	-	11.4	12.3	12.7	14.1	13.9	13.5	-
1975	12.2	11.8	-	13.1	12.3	11.0	10.7	12.3	12.9	13.8	13.6	11.2	-
1976	9.2	12.9	13.1	14.0	13.4	12.4	12.2	13.5	14.3	14.5	13.8	13.3	13.1
1977	11.2	11.8	12.8	14.2	13.2	12.1	12.3	13.5	14.1	13.9	13.1	12.2	12.9
1978	-	12.6	-	14.8	13.8	12.0	8.9	14.1	-	12.1	8.4	16.0	-
1979	17.4	13.1	15.4	14.5	-	12.8	10.0	13.0	14.3	14.1	14.0	11.7	-
1980	10.0	12.0	16.6	12.8	13.7	14.0	13.1	13.4	10.7	12.3	13.8	10.9	12.8
1981	7.5	11.7	14.8	14.5	12.9	11.6	-	-	-	-	-	-	-
Average ($mm\ H_2O$)	11.6	12.4	13.9	14.0	13.1	12.3	11.7	13.2	12.8	13.4	13.1	12.8	12.9
Average (Cal/cm^2)	363.5	385.2	425.7	428.4	404.1	382.5	366.3	406.8	396.0	412.2	404.1	396.0	397.6

Table I-12 MONTHLY SOLAR RADIATION AT MENGGALA

(Unit : $gm\ Cal/cm^2$)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	480.3	473.0	462.0	458.0	454.7	416.7	381.3	412.7	467.7	474.0	493.7	439.3	451.1
1976	-	465.0	492.0	483.7	479.0	454.0	421.7	466.7	464.3	427.0	442.3	481.3	-
1977	417.3	435.3	466.7	494.7	472.0	444.3	438.7	470.3	456.0	486.7	480.3	492.0	462.9
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	479.8	452.7	512.2	501.4	477.1	452.7	423.0	433.8	447.3	-	404.1	444.6	-
Average	459.1	456.5	483.2	484.5	470.7	441.9	416.2	445.9	458.8	462.6	455.1	464.3	458.2

Table I-13 MONTHLY AIR TEMPERATURE AT BELITANG

(Unit : C^{O})

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1969	27.4	27.0	28.0	27.8	28.3	27.4	27.5	27.1	27.9	28.0	28.0	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	26.1	28.1	26.7	27.8	27.8	27.2	27.5	27.8	-	26.5	-
1972	25.8	26.7	26.7	26.9	27.4	28.0	27.9	28.1	28.4	28.8	28.3	27.6	27.6
1973	27.6	27.4	27.6	28.1	27.5	27.5	28.2	27.3	26.7	27.3	27.8	26.4	27.5
1974	26.1	26.0	26.9	28.0	27.7	27.3	26.8	27.3	26.7	27.7	27.0	26.5	27.0
1975	26.6	26.5	-	27.8	28.1	27.7	26.8	27.4	27.1	27.3	27.0	27.8	-
1976	21.3	26.7	27.0	27.5	-	27.8	27.4	27.8	28.2	27.6	27.4	27.4	-
1977	26.7	26.5	27.0	27.8	28.1	27.5	27.6	28.1	28.4	29.2	28.3	27.4	27.7
1978	27.1	27.6	27.7	27.9	27.1	27.7	27.2	28.0	-	27.5	27.4	26.8	-
1979	27.0	27.1	27.9	28.1	28.3	28.1	27.3	27.6	27.7	28.0	27.5	26.9	27.6
1980	27.1	27.1	27.4	27.7	28.8	27.9	28.0	27.6	26.8	26.7	27.2	26.8	27.4
1981	26.2	27.3	28.4	28.2	27.6	28.0	-	-	-	-	-	-	-
Average	26.3	26.9	27.3	27.8	27.8	27.7	27.5	27.6	27.5	27.8	27.6	26.9	27.4

Table I-14 MONTHLY AIR TEMPERATURE AT BANDING AGUNG

(Unit : C°)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	23.3	23.9	24.0	24.2	24.5	23.2	24.3	22.8	23.4	23.8	24.3	23.7	23.8
1976	22.4	22.7	23.9	23.9	24.2	24.0	23.7	24.0	23.2	23.6	23.5	23.3	23.5
1977	22.9	23.2	23.7	25.0	24.0	23.9	23.2	23.2	24.2	24.5	24.0	24.3	23.8
1978	23.6	24.3	24.6	24.4	24.3	24.9	24.4	22.9	24.0	24.1	24.0	23.6	24.1
1979	-	-	-	-	-	-	-	-	23.8	24.8	24.5	25.0	-
1980	23.7	23.9	24.3	24.5	22.8	24.9	23.7	22.1	24.9	24.1	23.6	24.5	23.9
Average	23.2	23.6	24.1	24.4	24.0	24.2	23.9	23.0	23.9	24.2	24.0	24.1	23.9

Table I-15 MONTHLY AIR TEMPERATURE AT MENGGALA

(Unit : C°)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	27.0	27.2	26.6	27.8	27.6	26.1	24.9	25.5	25.7	26.0	26.3	25.3	26.3
1976	-	27.5	27.6	27.7	27.7	26.9	26.9	27.9	28.0	27.7	27.7	28.0	27.6
1977	27.5	27.1	27.7	28.0	28.9	27.8	27.2	27.8	28.0	28.4	28.3	29.0	28.0
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	26.8	27.1	27.6	27.6	27.8	27.3	26.5	26.4	27.7	-	28.2	28.4	-
Average	27.1	27.2	27.4	27.8	28.0	27.0	26.4	26.9	27.4	27.4	27.6	27.7	27.3

Table I-16 MONTHLY RELATIVE HUMIDITY AT BELITANG

(Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1969	82	84	82	82	82	83	77	75	77	75	78	81	80
1970	82	80	82	83	82	82	80	76	77	81	82	82	81
1971	85	84	85	81	80	80	74	72	77	78	-	85	-
1972	86	84	85	85	84	81	73	75	70	68	75	81	79
1973	81	83	83	82	84	82	74	79	83	81	79	83	81
1974	82	82	82	81	80	80	80	80	82	79	82	78	81
1975	82	81	83	82	80	79	79	80	80	80	81	81	81
1976	83	80	82	82	-	76	76	76	70	80	81	81	-
1977	84	83	83	84	84	81	77	73	72	67	75	83	79
1978	82	84	83	84	83	81	77	73	72	67	75	83	82
1979	84	84	81	84	80	80	81	77	79	79	81	83	81
1980	82	81	79	84	82	-	80	78	79	82	83	81	-
1981	83	81	82	83	84	79	-	-	-	-	-	-	-
Average	83	82	82	83	82	80	78	78	77	78	80	83	81

Table I-17 MONTHLY RELATIVE HUMIDITY AT BANDING AGUNG

(Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	82	78	82	79	75	81	72	85	81	83	80	87	80
1976	82	86	88	81	85	84	86	81	83	81	82	83	84
1977	82	87	80	82	-	88	89	88	82	85	80	77	-
1978	88	78	78	77	84	82	82	83	91	80	81	83	82
1979	-	-	-	-	-	-	-	-	82	79	82	83	-
1980	86	86	87	88	82	82	80	80	80	79	82	83	83
Average	83	83	83	81	82	83	82	83	83	81	81	83	82

Table I-18 MONTHLY RELATIVE HUMIDITY AT MENGGALA

(Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	89	88	88	88	88	93	93	92	91	91	90	90	90
1976	-	-	63	71	-	-	-	65	63	70	71	71	-
1977	62	59	59	76	84	64	58	53	53	51	51	57	57
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	83	84	79	83	85	83	87	86	81	-	84	79	-
Average	79	77	72	80	86	80	79	74	72	71	74	74	76

Table I-19 MONTHLY MEAN WIND VELOCITY AT BELITANG

(Unit : km/hr)

Year	Nan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1971	-	-	-	-	-	-	-	-	-	-	-	3.2	-
1972	4.6	3.6	3.6	2.6	2.8	3.1	3.9	4.8	4.7	4.3	3.4	3.5	3.7
1973	4.5	4.3	3.7	2.6	2.4	2.3	2.7	3.0	3.2	3.0	2.9	3.8	3.2
1974	-	4.4	3.6	2.8	2.8	2.6	2.9	3.2	3.2	2.6	3.1	3.3	-
1975	3.4	3.7	-	2.6	2.5	2.9	3.3	3.4	2.7	2.7	2.9	3.0	-
1976	3.9	3.1	3.0	2.5	2.4	2.3	3.1	3.1	3.1	2.5	2.2	2.6	3.0
1977	3.1	3.3	2.9	2.2	2.1	2.3	3.1	3.5	3.2	3.6	2.4	3.0	2.9
1978	-	3.0	-	2.6	2.7	1.8	3.2	2.4	-	2.4	2.5	3.3	-
1979	3.4	3.1	3.0	2.5	2.2	2.2	2.3	2.8	2.7	2.5	2.3	3.2	2.7
1980	3.7	3.6	2.8	2.3	1.9	2.0	2.2	2.4	2.4	1.9	1.9	2.6	2.5
1981	3.3	3.1	2.8	2.5	2.1	1.8	-	-	-	-	-	-	-
Average	3.7	3.5	3.2	2.5	2.4	2.3	3.0	3.2	3.2	2.8	2.6	3.2	3.0

Table I-20 MONTHLY MEAN WIND VELOCITY AT BANDING AGUNG

(Unit : km/hr)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	3.8	-	4.4	4.6	4.5	4.2	5.6	4.5	4.8	5.1	5.5	4.2	-
1976	2.4	2.6	-	-	-	-	-	-	-	-	-	-	-
Average	3.1	2.6	4.4	4.6	4.5	4.2	5.6	4.5	4.8	5.1	5.5	4.2	4.4

Table I-21 MONTHLY MEAN WIND VELOCITY AT MENGGALA

(Unit : km/hr)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	2.2	2.4	2.0	2.0	2.2	2.4	2.6	2.7	2.5	2.6	2.5	2.7	2.4
1976	-	2.4	2.7	2.6	3.0	2.9	3.4	3.1	3.6	2.3	2.3	2.4	-
1977	2.6	3.0	2.7	2.1	2.4	2.5	3.2	3.3	4.1	3.0	2.5	2.8	2.9
Average	2.4	2.6	2.5	2.2	2.5	2.6	3.1	3.0	3.4	2.6	2.4	2.6	2.7

Table I-22 MONTHLY EVAPORATION AT BELITANG

(BY CLASS-A PAN)

(Unit : mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1971	-	-	6.3*	6.4*	6.2*	4.3*	-	-	-	-	-	-	-
1972	-	-	-	-	4.7	4.7	5.5	5.9	5.9	-	5.3	5.1	-
1973	5.1	-	-	-	4.7	4.2	4.9	-	4.2	-	4.9	4.5	-
1974	4.3	4.3	-	5.5	-	-	-	5.1	-	-	-	4.6	-
1975	4.0	4.3	-	4.9	-	4.1	-	4.7	4.8	4.9	5.0	4.2	-
1976	3.8	4.3	4.6	4.9	4.4	4.4	4.3	4.9	4.9	4.4	4.4	4.4	4.5
1977	3.8	3.8	4.1	4.4	4.3	4.0	4.1	4.5	5.0	5.3	3.6	4.8	4.3
1978	-	4.3	-	4.5	4.3	3.9	3.7	4.4	5.1	-	4.5	4.3	-
1979	5.2	5.0	5.2	4.5	4.5	4.0	3.6	4.7	4.5	5.1	4.7	4.2	4.6
1980	5.0	4.4	5.3	4.1	4.4	4.2	4.3	4.1	4.1	4.3	4.0	4.2	4.4
1981	3.0	4.7	4.7	4.6	4.1	3.8	-	-	-	-	-	-	-
Average	4.3	4.4	5.0	4.9	4.6	4.2	4.3	4.8	4.8	4.8	4.6	4.5	4.6

Note : * The value measured by Piche evaporation.

Table I-23 MONTHLY EVAPORATION AT BANDING AGUNG

(BY CLASS-A PAN)

(Unit : mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	5.8	4.9	5.5	5.0	4.7	5.1	6.7	5.4	5.8	-	-	5.0	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	4.9	5.3	3.3	3.5	5.1	5.4	4.9	5.4	5.1	5.6	5.2	4.6	4.9
1979	-	-	-	-	-	-	-	-	3.5	3.6	-	-	-
1980	3.7	3.7	4.4	3.5	-	5.1	-	-	-	3.6	4.4	-	-
Average	4.8	4.6	4.4	4.0	4.9	5.2	5.8	5.4	4.8	4.9	4.8	4.8	4.9

Table I-24 MONTHLY EVAPORATION AT MENGGALA

(BY CLASS-A PAN)

(Unit : mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Average
1975	6.1	3.7	5.5	4.7	4.2	3.0	4.3	5.0	-	8.6	5.7	4.6	-
1976	-	6.2	8.7	6.1	5.3	3.5	3.6	4.1	4.1	4.4	5.0	5.1	-
1977	5.4	7.0	7.6	5.2	3.7	5.6	3.8	3.8	4.6	4.2	5.0	7.2	5.3
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	4.7	5.8	5.1	6.5	5.1	3.9	3.9	3.5	-	-	-	-
Average	5.8	5.4	6.7	5.3	4.9	4.3	3.9	4.2	4.1	5.7	5.2	5.6	5.1

Table I-25 EXISTING HYDROLOGICAL AND CLIMATOLOGICAL STATIONS

A. Gauging Station

Name of Station	Place	Gauge	Remarks
Ogan	Baturaja Kota	S.G.	
Ogan	Baturaja Terusan	A.W.L.R.	
Selabung	Banding Agung	A.W.L.R.	
Komering	Martapura	A.W.L.R.	
Komering	Kurungan Nyawa	S.G.	
Pisang	Sri Numpi 1	A.W.L.R.	
Lempuing	Cahaya Bumi	S.G.	
Belitang	Raman Condong	S.G.	
Belitang	Cahaya Bumi	A.W.L.R.	
Komering	Menanga	A.W.L.R.	under repairing
Komering	Cempaka	A.W.L.R.	
Randu	Suka Bumi	S.G.	
Arisan	Gunung Batu	S.G.	
Jambu	Tg. Lubuk	S.G.	
Sigonan	Suka Raja	S.G.	
Anyar	Lubuk Rukam	S.G.	
Komering	Kayu Agung	A.W.L.R.	
Komering	Kayu Agung	S.G.	
Macak	Cahaya Bumi	A.W.L.R.	

B. Climatological Station

Raksajiwa	Pertanian Office		
Baturaja			
Banding Agung	Mess PEMDA		Standard rainfall gauge only
Belitang			
Martapura			
Kurungan Nyawa			standard rainfall gauge only

Table I-26 MONTHLY DISCHARGE AT MARTAPURA

(Unit : m^3/sec) C.A = 4,260 Km^2

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1963	193.8	274.2	252.4	201.6	252.1	186.3	115.0	88.0	78.3	76.1	69.4	64.8	149.7
1964	141.6	166.2	204.4	266.2	138.1	118.4	118.3	100.2	99.6	116.3	115.0	203.8	149.0
1965	243.5	347.1	255.5	391.8	306.7	299.6	132.9	146.7	108.8	86.6	125.6	120.2	213.7
1966	155.2	133.6	241.7	132.3	233.0	217.5	129.8	119.4	101.8	99.3	122.7	237.9	160.3
1967	182.6	241.9	360.3	214.9	269.8	146.6	127.2	76.9	77.1	71.4	106.2	118.1	167.7
1968	113.9	103.7	150.6	204.2	177.7	212.4	194.0	173.9	126.2	143.6	275.1	307.9	181.9
1969	369.3	292.4	175.5	407.9	316.9	246.2	264.4	160.5	140.2	137.0	228.3	383.0	260.1
1970	341.9	267.9	290.5	255.3	412.3	181.0	143.4	217.4	179.7	132.9	189.7	157.7	230.8
1971	293.2	163.4	200.9	299.7	227.3	141.1	99.9	96.7	98.3	178.4	260.5	287.7	203.9
1972	336.9	321.9	309.5	416.3	471.5	200.9	91.9	71.2	59.3	45.1	71.2	189.5	215.4
1973	244.4	292.4	241.6	316.7	292.7	219.2	111.2	128.9	272.3	224.1	221.9	222.4	232.3
1974	113.6	230.9	119.6	261.6	278.0	113.3	96.5	98.6	206.7	218.6	190.6	236.0	180.3
1975	260.0	380.3	188.3	306.9	136.8	172.5	189.0	230.9	231.7	228.0	307.4	206.5	236.5
1976	306.0	294.9	372.0	447.9	130.6	190.1	152.6	167.8	150.6	270.8	321.7	385.7	274.2
1977	371.3	465.7	257.8	427.0	256.7	238.9	131.0	105.6	102.9	78.5	98.8	249.5	231.9
1978	258.8	273.7	297.9	224.7	288.6	234.7	215.8	129.4	136.6	190.2	187.3	308.0	228.8
1979	160.2	199.3	202.2	275.4	228.1	176.1	154.7	131.5	122.1	120.9	166.6	148.2	173.8
1980	155.3	120.1	165.6	202.1	124.6	103.2	168.8	198.4	135.1	118.9	248.3	411.1	179.3
Mean	235.6	253.9	238.1	291.8	252.3	188.8	146.5	135.7	134.9	140.9	183.7	235.4	203.1

Table I-27 MONTHLY DISCHARGE AT BANDING AGUNG

(Unit ; m^3/sec) C.A = 508 km^2

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1963	16.5	17.7	18.6	16.8	18.6	16.2	16.9	13.9	12.1	10.7	10.4	9.5	14.8
1964	17.2	15.3	16.9	18.9	17.2	17.0	17.0	16.4	16.4	17.0	16.9	16.9	16.9
1965	18.3	20.6	18.6	21.1	19.9	19.7	17.2	17.2	16.8	13.7	17.1	17.1	18.1
1966	17.1	17.2	18.2	17.2	18.0	17.4	17.2	17.0	16.5	16.4	17.1	18.1	17.3
1967	16.0	18.2	20.7	17.3	19.0	17.2	17.2	16.3	11.8	10.8	16.7	17.0	16.5
1968	16.9	16.6	17.1	16.9	15.8	17.2	16.5	15.6	17.1	17.2	19.2	19.9	17.2
1969	20.8	19.6	15.7	21.2	20.1	18.4	18.9	17.0	17.2	17.2	17.8	21.0	18.7
1970	20.5	19.0	19.5	18.6	21.2	16.0	17.2	17.4	15.9	17.2	16.3	17.0	18.0
1971	19.7	17.0	16.6	21.1	17.6	17.2	14.1	13.8	16.0	16.3	18.9	19.5	17.3
1972	20.4	29.4	28.8	27.8	28.8	20.9	14.6	11.4	8.8	6.4	7.7	10.1	17.9
1973	13.8	17.0	19.1	20.9	18.2	17.8	15.8	15.4	18.2	20.4	20.4	18.2	17.9
1974	16.2	16.2	17.0	17.4	15.4	13.8	18.0	14.6	22.3	21.4	17.1	16.3	17.1
1975	20.4	21.8	18.2	20.4	20.4	17.8	12.8	13.1	13.5	12.8	14.2	13.1	16.5
1976	18.8	22.7	22.4	22.9	22.5	16.8	13.7	15.4	11.8	13.5	18.0	17.2	18.0
1977	20.0	24.9	21.3	27.9	25.7	24.4	22.3	17.9	16.0	14.9	14.3	18.5	20.7
1978	17.8	18.4	20.9	19.8	20.4	17.5	17.4	18.2	16.2	16.5	23.0	19.9	18.8
1979	27.2	28.5	25.0	28.5	26.2	24.8	22.6	19.7	19.8	19.0	23.0	23.1	24.0
1980	18.7	26.1	26.6	27.6	28.2	24.5	22.0	22.2	22.4	22.5	29.7	30.8	25.1
Average	18.7	20.3	20.1	21.2	20.7	18.6	17.3	16.3	16.0	15.8	17.7	18.0	18.4

Table I-28 ACTUAL EVAPOTRANSPIRATION IN THE DRAINAGE AREA

Month	Eo mm/day	Mean Albedo	E_T mm/day	Vegetation Factor %	E_{Ta} mm/month	Remarks
Jan	4.56	0.19	3.63	85	96	
Feb	4.71	"	3.74	"	89	
Mar	4.91	"	3.91	"	103	
Apr	4.98	"	3.97	"	101	
May	4.76	"	3.78	"	100	
Jun	4.43	"	3.51	"	89	
Jul	4.42	"	3.50	"	92	
Aug	4.66	"	3.70	"	98	
Sep	4.93	"	3.92	"	100	
Oct	5.20	"	4.16	"	110	Annual E_{Ta}
Nov	4.88	"	3.88	"	99	1,175 mm
Dec	4.66	"	3.73	"	98	

Note :

Eo : Evaporation from open water surface calculated by Penman Method

Et : Potential evapotranxpiration

ETa : Evapotranspiration

Table I-29 ANNUAL DROUGHT DISCHARGE AT MARTAPURA

Year	5 Months Discharge (Jan.-Oct.)	Mean Daily Discharge (m^3/sec)	Return Period
1963	543.7	108.7	1/9
1964	552.8	110.6	1/8
1965	774.6	154.9	1/2
1966	667.8	133.6	1/4
1967	499.2	99.8	1/12
1968	850.1	170.0	1/1.6
1969	948.3	189.7	1/1.3
1970	854.4	170.9	1/1.6
1971	614.4	122.9	1/5
1972	468.4	93.7	1/18
1973	955.7	191.1	1/1.3
1974	733.7	146.7	1/3
1975	1,052.1	210.4	1/1.2
1976	931.9	186.4	1/1.4
1977	656.9	131.4	1/4
1978	906.7	181.3	1/1.2
1979	705.3	141.1	1/3
1980	1,081.8	216.4	1/1.2

Table I-30 ANNUAL PEAK DISCHARGE

(Unit: m^3/sec)

Year	Date	Banding Agung $A_1 = 508\ km^2$	Residual River Basin $A_2 = 3,752\ km^2$	Martapura $A = 4,260\ km^2$
1971	19 NOV.	18.9	755	774
1972	27 APR.	28.4	845	873
1973	6 NOV.	24.5	737	762
1974	13 APR.	24.9	638	663
1975	8 FEB.	25.2	827	852
1976	20 OCT.	26.4	689	715
1977	3 APR.	27.6	1,052	1,080
1978	14 MAR.	25.6	861	887
1979	15 JUL.	29.9	1,208	1,238
1980	22 JUN.	32.1	1,406	1,438
1981	22 MAY	–	1,120	1,146

Table I-31 CATCHMENT AREA AND FLOOD SPECIFIC DISCHARGE

No.	River or Dam	Location	Catchment Area (km^2)	Flood Discharge (m^3/sec)	Specific Discharge ($m^3/sec/km^2$)
1	Bendo	E. Java	138	850	6.2
2	Lahor	E. Java	160	690	4.1
3	Selorejo	E. Java	236	920	3.9
4	Way Rarem	Pekurun	328	1,300	4.0
5	K. Pemali	Notok	790	2,100	2.7
6	Riamkanan	Kalimantan	1,043	1,950	1.9
7	Tjiudjung	Pamarajan	1,418	2,900	2.0
8	K. Brantas	Karangkates	2,050	4,200	2.1
9	K. Brantas	Wlingi	2,890	3,440	1.2
10	Jatiluhur	W. Java	4,500	8,000	1.8
11	Jipang	E. Java	10,810	8,660	0.8
	(Komering)	(Martapura)	4,260	2,497	0.6

Return Period: 1/1,000

Table I-32 DISCHARGE OF OGAN RIVER AT SERI KUMBANG

$CA = 2,802\ km^2$

	Specific discharge at Batu Raja	Specific discharge at Tg. Rambang	Weighted mean specific discharge	Q m^3/sec	Remarks
Jan.	0.064	0.040	0.055	154	Baturaja CA
Feb.	0.067	0.043	0.058	163	$= 2,096\ km^2$
Mar.	0.063	0.042	0.055	154	Tg. Rambang
Apr.	0.111	0.041	0.084	235	$CA = 1,318\ km^2$
May	0.068	0.017	0.048	134	
Jun.	0.035	0.009	0.025	70	
Jul.	0.027	0.004	0.018	50	
Aug.	0.025	0.003	0.016	45	
Sep.	0.043	0.011	0.031	87	
Oct.	0.042	0.009	0.029	81	
Nov.	0.055	0.025	0.043	120	
Dec.	0.068	0.037	0.056	157	

Table I-33 WATER QUALITY ANALYSIS

RIVER		KOMERING		KOMERING		SELABUNG		OGAN
LOCATION		Kayu Agung		Kangkung		Banding Agung		Tj. Raja
SAMPLE NO.		1-1	1-2	2-1	2-2	3-1	3-2	T.R.
DATE OF COLLECTION		Sep.30,1979	Oct.30,1979	Oct. 9,1979	Oct.30,1979	Oct. 8,1979	Oct.23,1979	Dec. 9,1979
PH		6.90	6.60	6.80	7.10	7.52	7.71	7.35
Electric Conductivity	μv/cm	7.565x10	3.490x10	7.240x10	6.785x10	2.470×10^2	2.420×10^2	6.060x10
Na	meq/ℓ	0.02	0.01	0.02	0.02	0.09	0.09	0.02
	mg/ℓ	0.52	0.27	0.47	0.41	2.03	1.97	0.41
K	meq/ℓ	0.03	0.02	0.03	0.03	0.05	0.04	0.02
	mg/ℓ	1.07	0.93	1.07	1.07	1.87	1.73	0.80
Ca	meq/ℓ	0.25	0.08	0.30	0.27	0.84	0.82	0.23
	mg/ℓ	5.07	1.54	5.95	5.51	16.75	16.53	4.63
Mg	meq/ℓ	0.13	0.04	0.13	0.13	1.01	0.41	0.10
	mg/ℓ	1.58	0.51	1.64	1.54	12.33	4.99	1.22
Alkalinity	meq/ℓ	0.48	0.08	0.50	0.46	1.58	1.58	0.36
C	meq/ℓ	0.12	0.16	0.18	0.11	0.45	0.40	0.19
	mg/ℓ	4.15	5.70	6.22	3.97	15.89	14.33	6.91
SO_4	meq/ℓ	0.12	0.08	0.10	0.09	0.37	0.35	0.09
	mg/ℓ	5.53	3.62	4.91	4.51	17.95	16.93	4.16
SiO_2	mg/ℓ	38.52	20.69	35.36	35.46	18.79	19.74	30.50
ΣCation	meq/ℓ	0.43	0.15	0.48	0.45	1.99	1.37	0.37
ΣAnion	meq/ℓ	0.71	0.32	0.78	0.67	2.40	2.34	0.64
ΣIon	meq/ℓ	1.15	0.47	1.26	1.11	4.39	3.70	1.01
Evaporated Residue	ppm	85.8	85.7	153.9	144.6	123.8	163.9	145.4
Surface Substance	ppm	15.0	41.9	70.4	81.2	14.0	30.5	87.1
NO_3-N	ppm	0.10	0.25	0.10	0.09	0.02	0.04	0.12
$KMnO_4$ demand	ppm	21.5	39.5	20.1	21.8	6.4	3.1	21.0
B	ppm	0.03	0.02	0.03	0.03	0.14	0.14	0.03

Table I-34 EXISTING METEOROLOGICAL AND WATER LEVEL GAUGING STATIONS

Discription	Nos. of Station	Location
Climatological station	6	Palembang, Banding Agung, Raksajiwa, BX X, Menggala, Kasui
Rain gauging station	48	Talang Betutu, Kentan, Sukarami, Unsri, Kamboja, Sukamaju, Pampangan, Indralaya, Sp. Padang, Tg. Raja, Tg. Batu, Kayuagung, Prabumulih (2), Suka Raja, Pedamaran, Tg. Lubuk, Muara Kuang, Cempaka, BKXVII, BKIX, Lahat, Pemulutan, Pengandonan, Baturaja, Buay Madang, Kurungan Nyawa, Martapura, Mesir Hilir, Muaraduakisam, Simpangan, Muaradua, Puluaberingin, Gelumbang, Sekojo, Simpang Sender, Gunung Raya, Way Giham, Blambangan Umpu, Tj. Agung, Tahmi, Tahmi Lumut, Rantau Temiany, Bt. Kemuning, Kota Bumi, Sinar Ogan, Pendopo, Purajaya
Water Level gauging station		
Automatic gauge	18	Sp. Padang, Tg. Raja, Tg. Rambang, Cempaka, Cahaya Bumi (2), Baturaja, Sri Numpi, Pakuan Ratu, Kayuagung, Martapura, Rantaujanku, Tg. Agung, Negri Batin, Banjarmasin, Rantau Temiang, Banaing Agung, Besay
Staff gauge	12	Kayuagung, Sri Nanti, Suka Raja, S. Jambu, S. Randu, Cahaya Bumi (2), Baturaja, Muncak Kabau, Kurungan, Sri Numpi Martapura

Fig. 1-1 LOCATION MAP OF HYDRO METEOROLOGICAL STATION

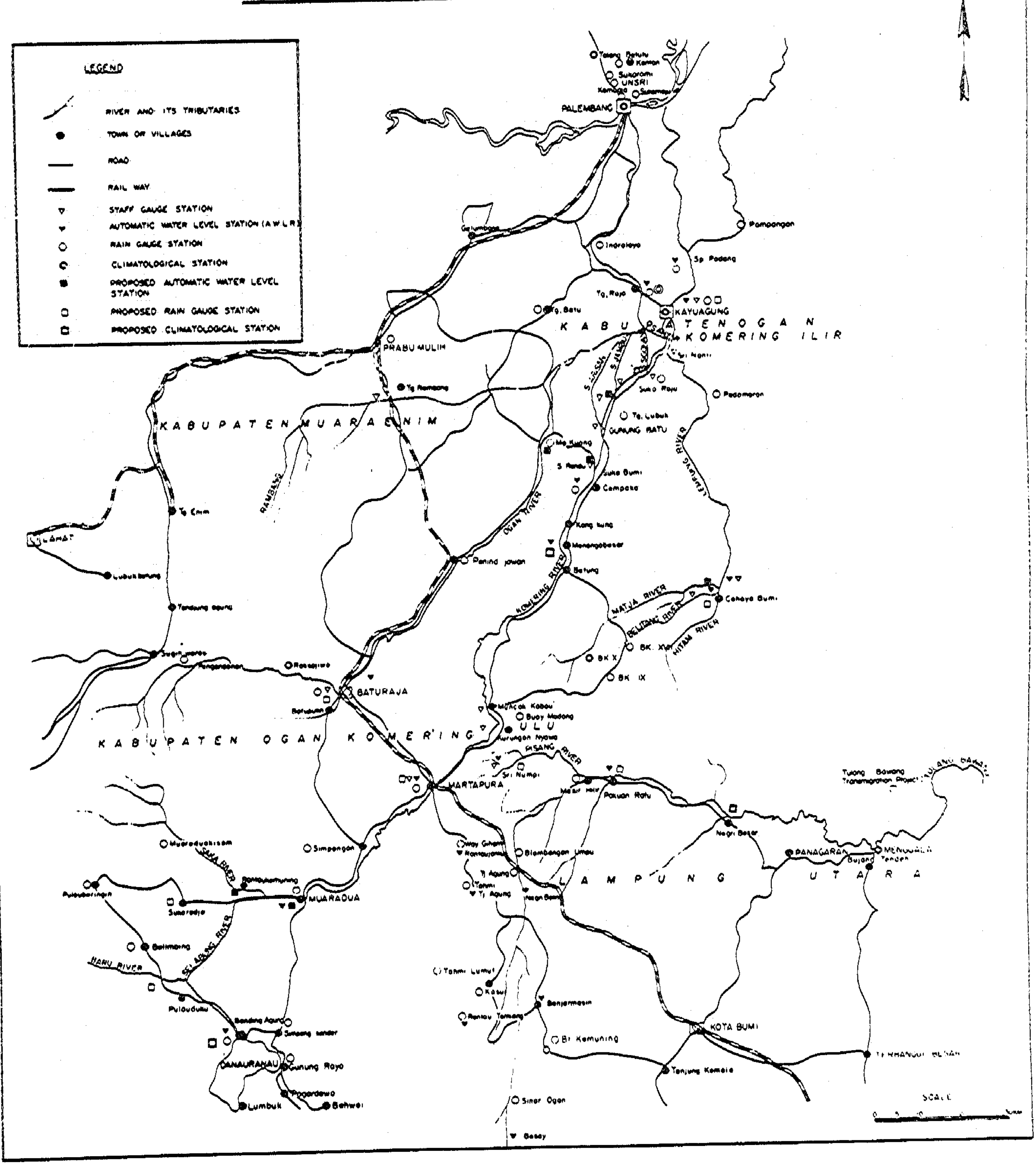


Fig. I-2 DAILY RAINFALL DATA

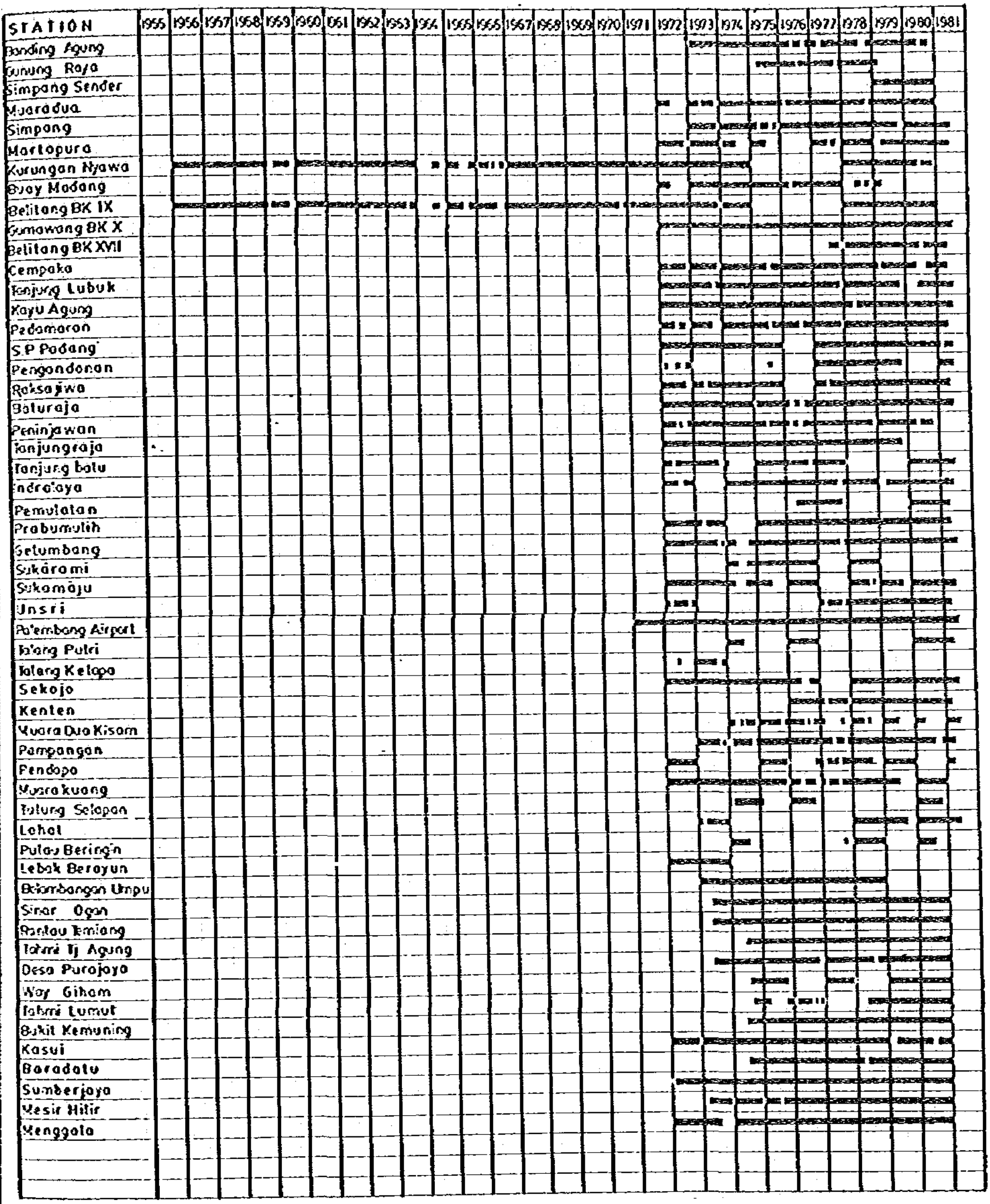


Fig. I-3 MONTHLY RAINFALL DATA

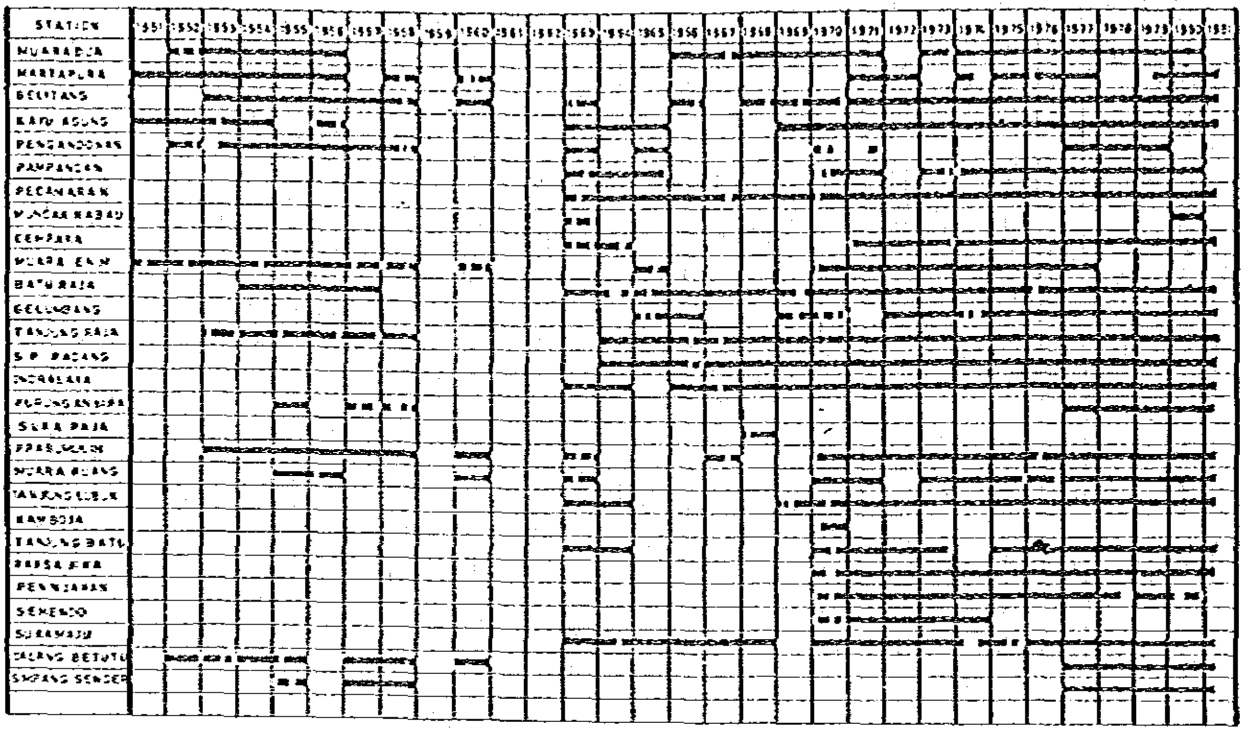


Fig. I-4 AVAILABLE CLIMATOLOGICAL DATA

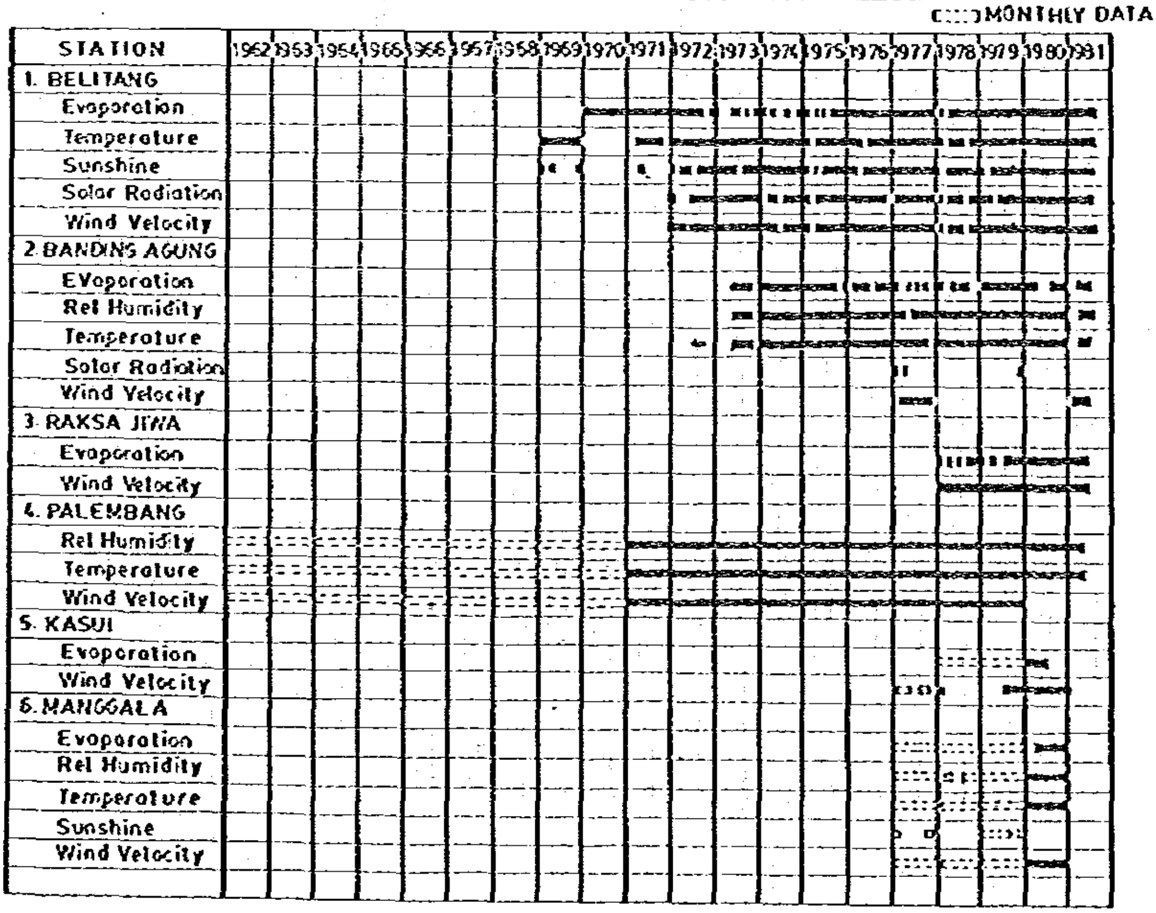


Fig. I-5 AVAILABLE HYDROLOGICAL DATA

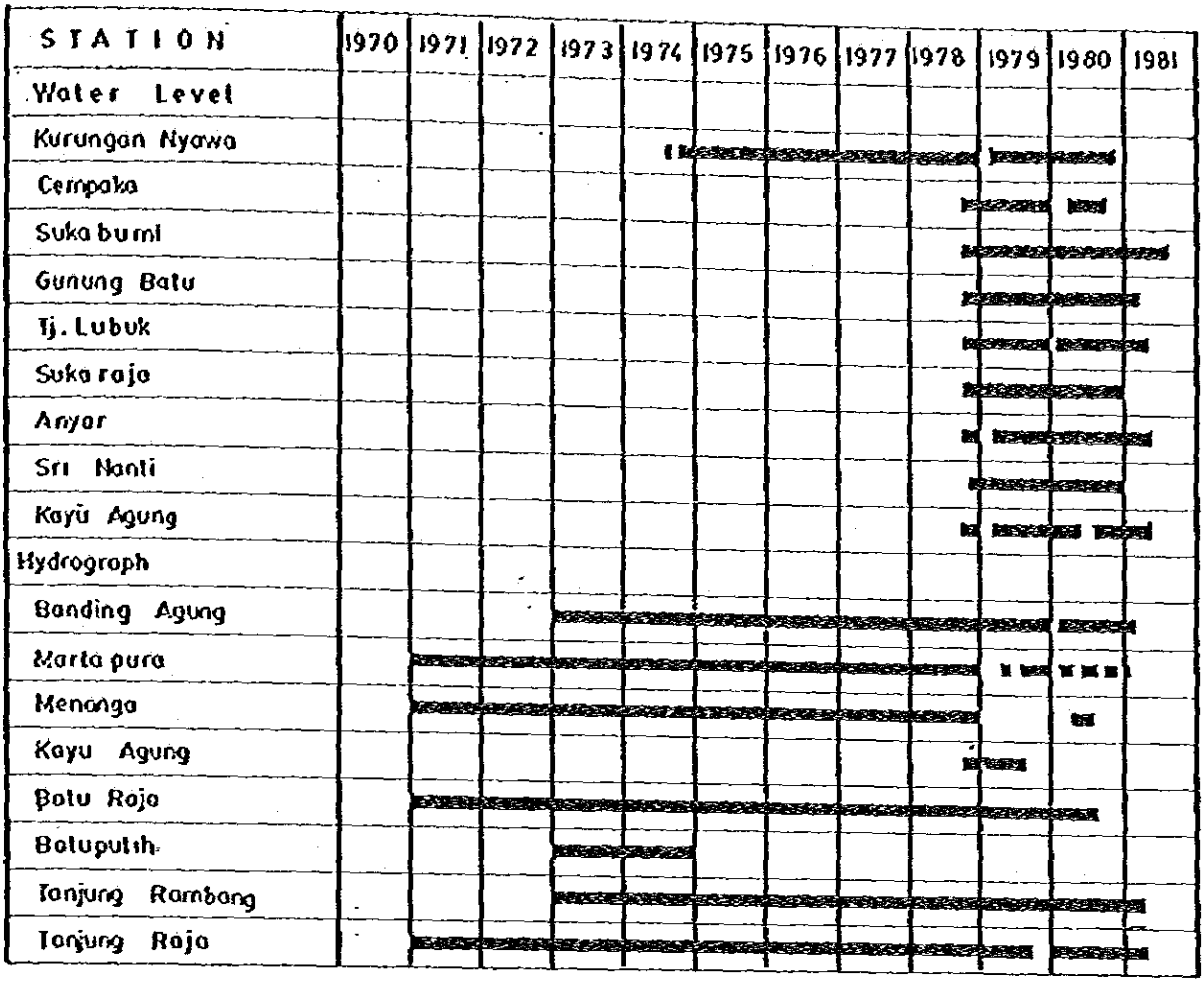


Fig. I-6 AVAILABLE DISCHARGE DATA

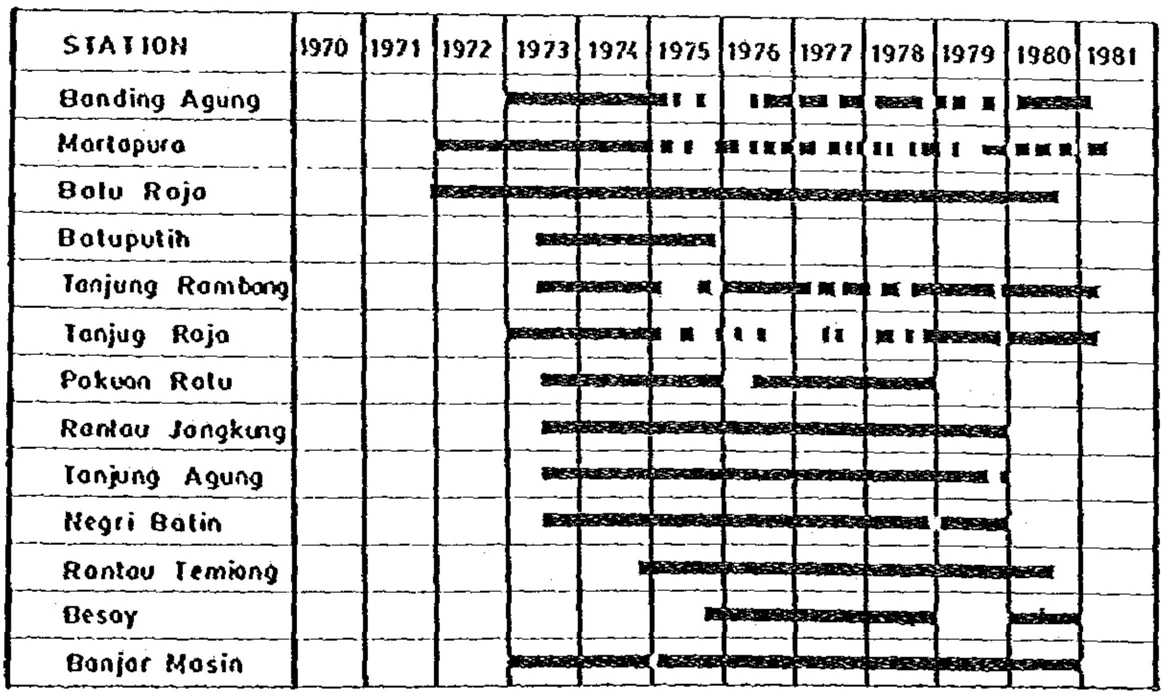


Fig. I-7 RATING CURVE AT MARTAPURA (KOMERING RIVER)

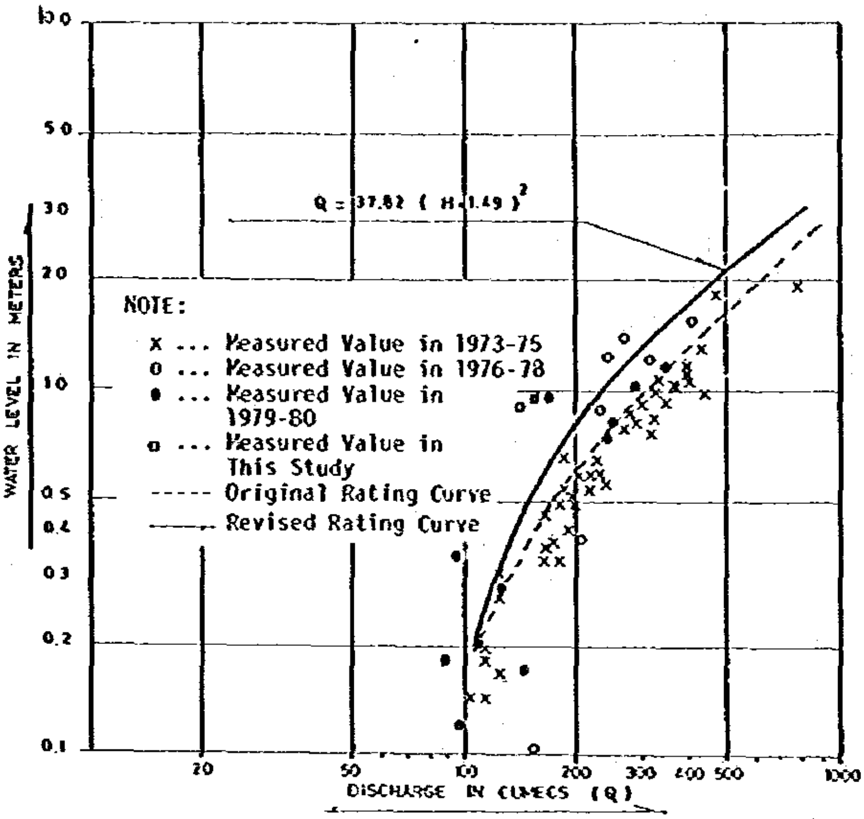


Fig. I-8 RATING CURVE AT BANDING AGUNG (SELABUNG RIVER)

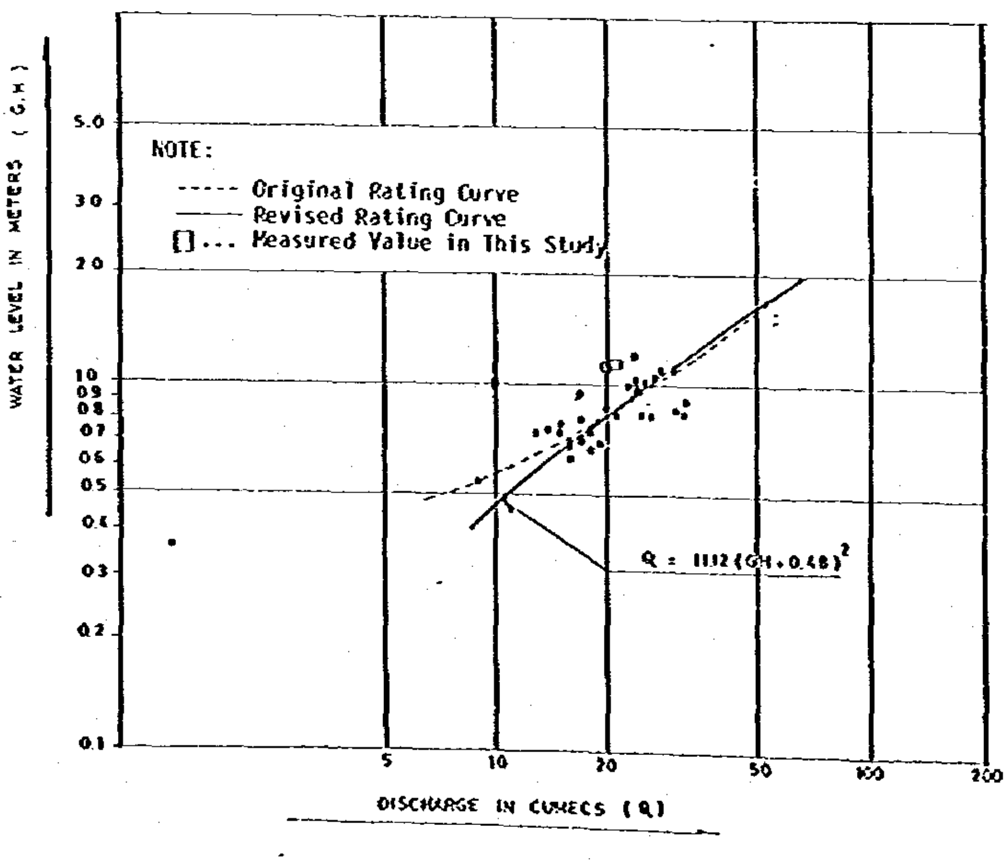


Fig. I-9 ASSUMED TANK MODEL

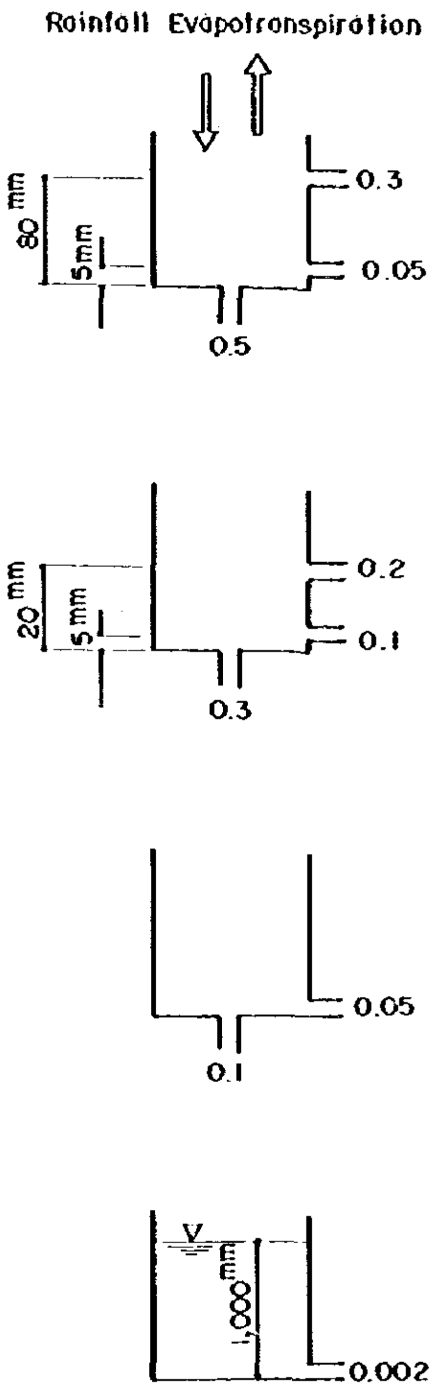


Fig. I-10 CORRELATION OF STREAMFLOW BETWEEN WHOLE BASIN AND RESIDUAL BASIN

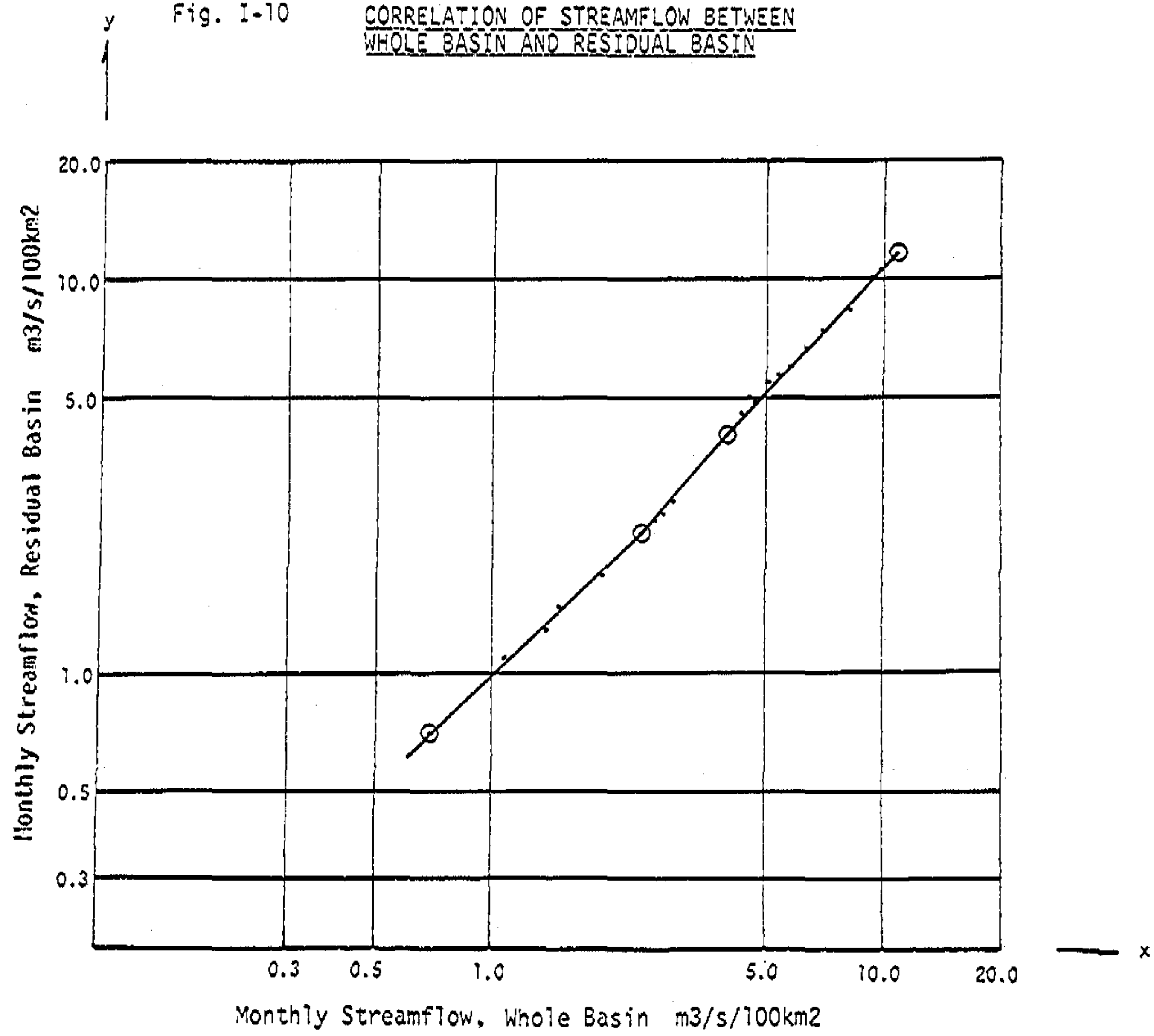


Fig. I-11 DROUGHT DISCHARGE AT MARTAPURA

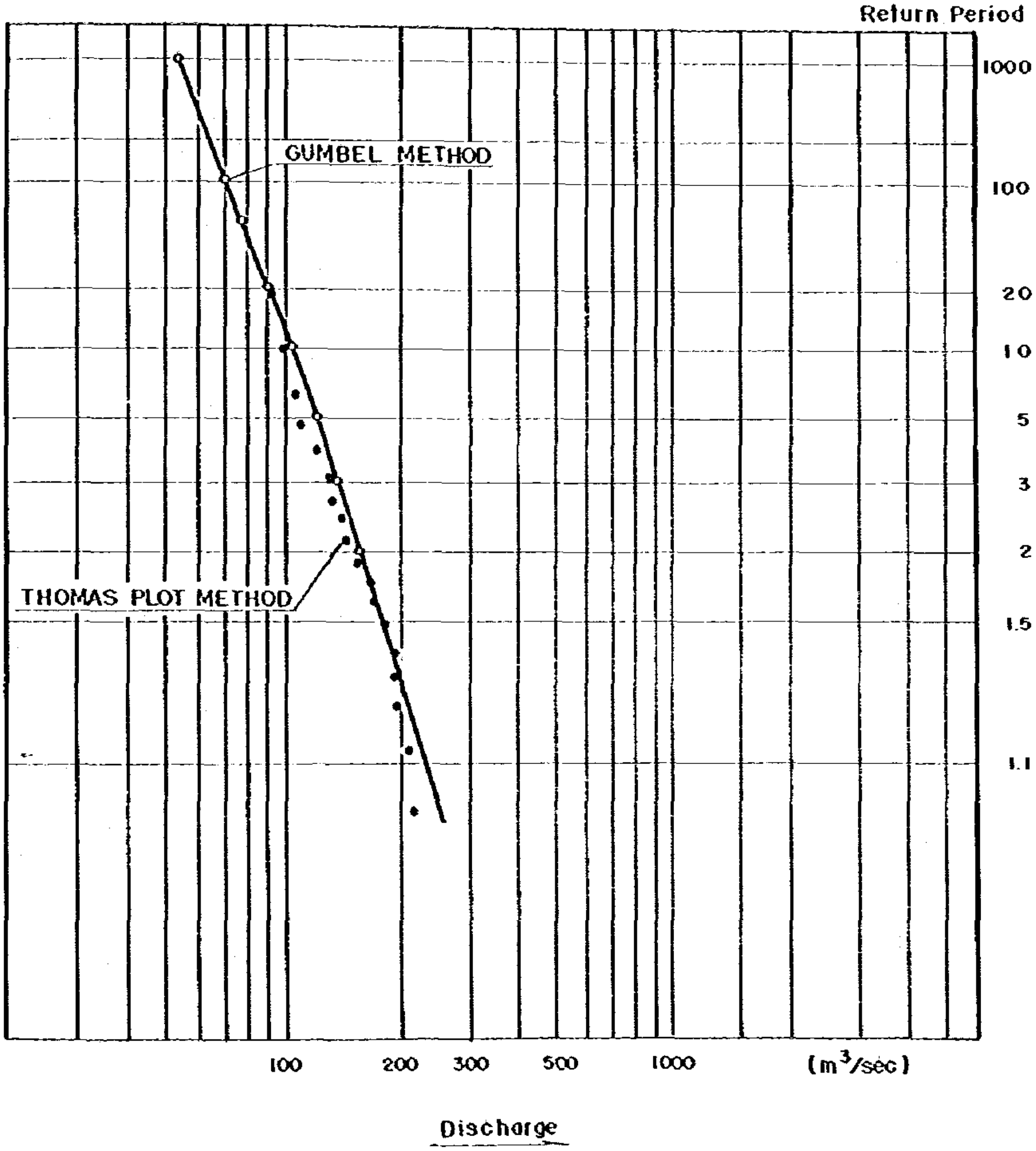


Fig. I-12 RELATION BETWEEN RESIDUAL RIVER BASIN AREA AND SPECIFIC DISCHARGE

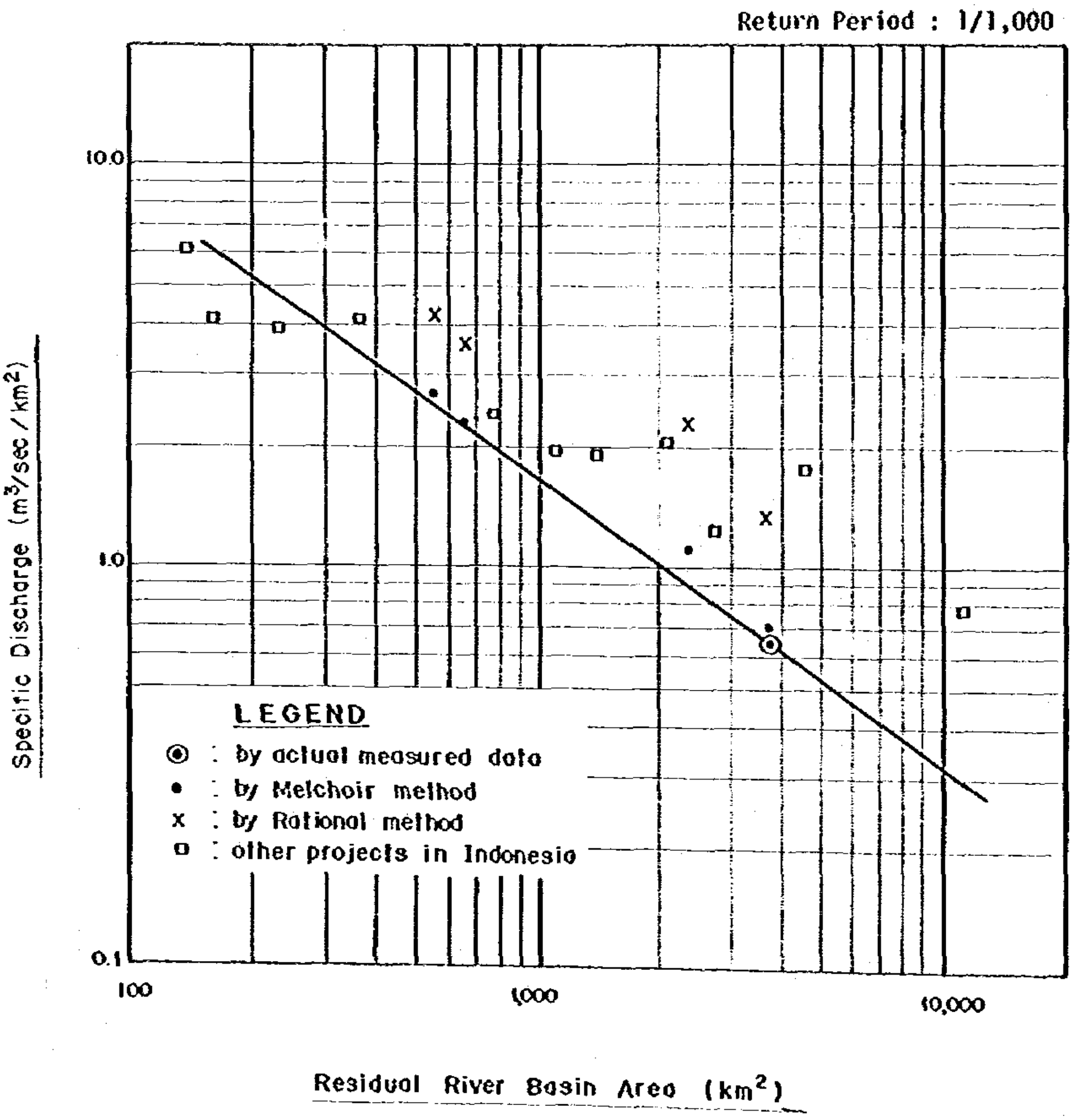
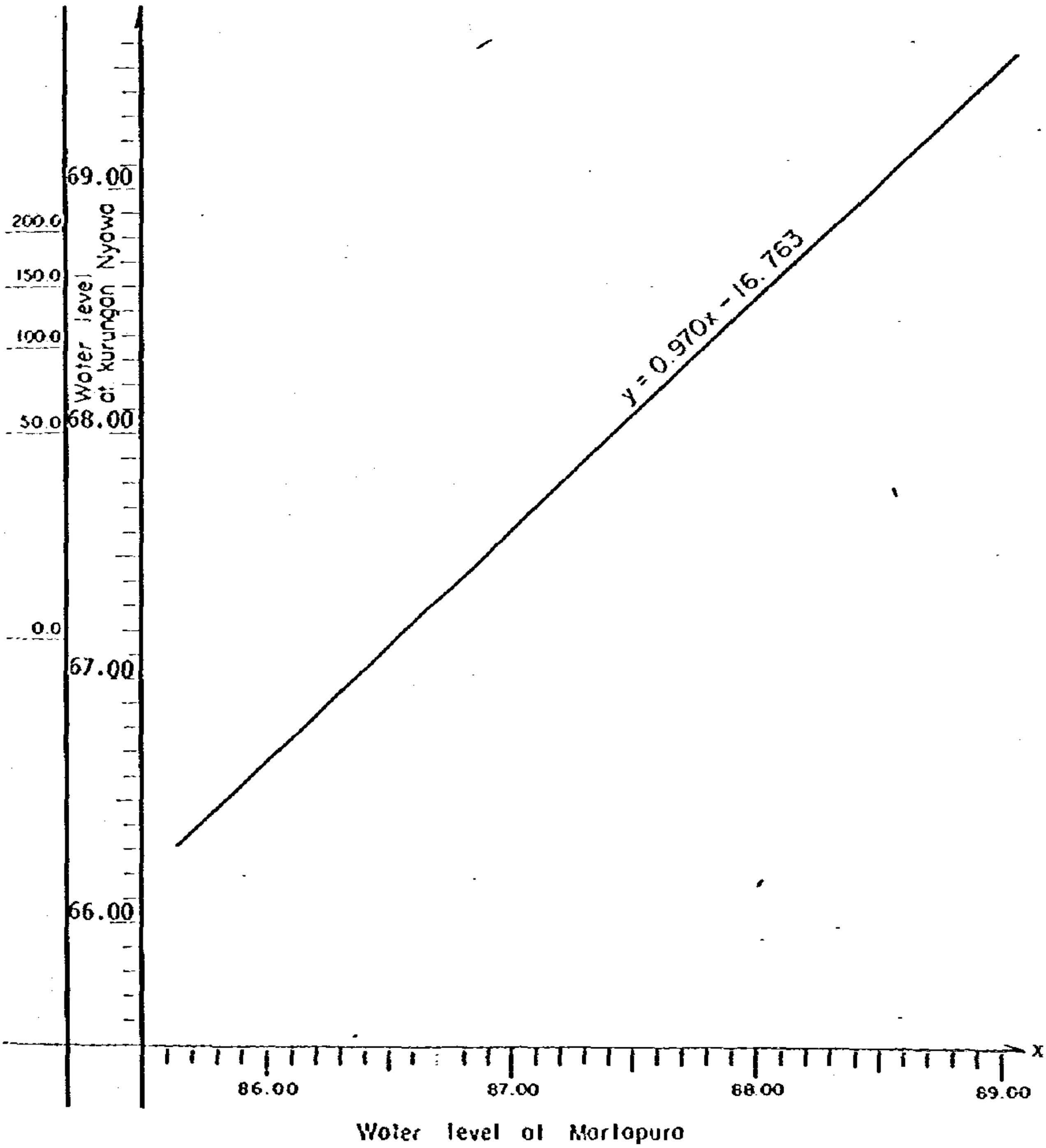


Fig. I-13 CORRELATION OF WATER LEVEL BETWEEN MARTAPURA AND KURUNGAN NYAWA



ANNEX II

SOIL AND LAND SUITABILITY

ANNEX - II

SOIL AND LAND SUITABILITY

1. GENERAL

The present soil survey is carried out in order to identify the major soil groups, to reveal their distributions and to evaluate their adaptabilities to profitable irrigation farming.

This report presents the procedure of the survey, the description of the soils and the land suitability classification.

1.1 History of Soil Survey

In the past, the soil surveys in Southern Sumatra have been carried out by several experts as summarized below.

(1) First study was done by Dr. Van der Voort /1 on morphology and distribution of soils in the Belitang Proper Area in 1936 and detailed soil map on a scale of 1 : 10,000 was prepared for the area of about 12,000 ha in the alluvial plain lying among the hills. The result was applied to the rural development projects containing the transmigration program of those days.

(2) Dr. M. Soepraptoharjo conducted the reconnaissance soil survey for about 200,000 ha in the southern part of South Sumatra Province in 1957.

(3) In 1971, the exploratory Soil Map of Southern Sumatra /2 on a scale of 1 : 1,000,000 as an attachment of Indonesia Text, was published by the Soil Research Institute in Bogor in order to provide the basic data for the rural development plans proposed in Repelita I.

/1 : Van der Voort, M.(1936) : Versalang Van De Bodenkundige Kaerterring Van Het Belitang Gebied.

/2 : Soil Research Institute, Bogor (1971) : An explanatory text to the exploratory soil map of South Sumatra.

(4) FAO/UNDP started the reconnaissance survy for the land and water resources development in Southeastern Sumatra from 1970 and completed the survey in 1976. Based on the survey results with the interpretation of aerial photographs, FAO prepared the reconnaissance soil map and land capability map covering about 43,000 km2/1.

(5) Besides, for the detailed planning of agricultural development in both the Belitang Proper and Extension Areas, FAO/UNDP carried out the soil survey in 190,000 ha of the said areas in 1972, and prepared the soil map on a scale of 1 : 50,000/2.

(6) Thence, for the comprehensive study on the Upper Komering River Basin Development Project, JICA carried out the reconnaissance soil survey over the total area of about 500,000 ha and prepared the soil map and land capability map on a scale of 1 : 100,000 in 1980/3.

(7) Following the above survey and study, JICA carried out the semi detailed soil survey in 90,000 ha for the feasilibity study of the Komering-1 Irrigation Development Project in 1981, and prepared the soil map and the land suitability classification map on a scale of 1 : 50,000/4.

/1 : FAO/UNDP (1976): Land and Water Resources Development in south-east Sumatra, INDONESIA, FAO/UNDP, AG; DP/INS/09/518.

/2 : FAO/UNDP (1973) : Belitang Extension Area Agricultural Development Project, FAO/UNDP, AGL ; SF/INS/18 - 1. Annex E.

/3 : JICA (1980) : Comprehensive Study on the Upper Komering River Basin Development

/4 : JICA (1981), Feasibility Study on the Komering-1 Irrigation Development Project in the Upper Komering River Basin.

1.2 Survey Area

The present soil survey is carried out over the total area of 225,800 ha. The survey area is divided into three sub-areas in accordance with the development units ; the Muncak Kabau area (39,600 ha) and the Lempuing area (29,600 ha) in South Sumatra province and the Tulangbawang area (156,600 ha) in Lampung province. The followings are the explanation of the location and the physiographic condition of each development area.

The Muncak Kabau area lies between the right bank of the Komering river and the north western peneplain of Komering-I Project Area, and extends from Muncak Kabau to Betung. The land form of this area is mostly classified into the alluvial plain. This alluvial plain includes the narrow strips of natural levees along the Komering river. The low and small relict hills are scattered in this alluvial plain. The depressions occur extensively in the northern part of this area. Furthermore, almost flat peneplain/1 occupies the eastern area adjacent to the extension of the northwest peneplain of Komering-I Project Area.

The Lempuing area is located on the left bank of two rivers ; the Lempuing and the Macak. These rivers respectively run in the north and northeast directions along the foot of northwestern and southeastern peneplains extending over the Komering-I Project Area. This area is geomorphologically classfied into peneplain, river terrace, alluvial plain, natural levee and depression. The alluvial plain, as well as the alluvial plain in the Belitang Proper Area, had been formed by the old Komering river or its branches. The peneplains extend over both the western and eastern parts of this area sandwiching the said alluvial plain. The river terrace occupies the narrow and low-lying terrain between the alluvial plain and the eastern peneplain. The depression extends over the northern part of the area.

/1 : Peneplain is physiographically defined as the land which had been eroded up to the base level of erosion and has generally flat or almost flat topography.

The Tulangbawang area extends on the left bank of the Tulangbawang river from Musi Ilir to Menggala. Geomorphologically, this area can broadly be subdivided into two terrains, i.e. the gently undulating peneplain and the depression. The peneplain occupies a low hill area extending from west to east in the area. The depression occurs in the eastern part of the area, mainly, along the Tulangbawang river.

1.3 Survey Method

1.3.1 Procedure of Soil Survey

The past surveys show the close correlation between the distribution of soils and their physiographical feature. This information is fully taken into consideration when the pre-study is carried out. Prior to the present field survey, the provisional soil map is prepared applying the remote sensing techniques, i.e. satellite image analysis/1 and aerial photo-interpretation.

The natural conditions of land surface such as vegetation, geomorphology, lithology and limnology are examined using the satellite image. Furthermore the survey area is divided into several physiographical units on the 1 : 50,000 map using two series of aerial photographs on scales of 1 : 20,000 prepared by JICA in 1979 and 1 : 50,000 prepared by FAO in 1971.

Based on the selection of test pit sites using the provisional map, 54 pits, one meter deep for each, are dug at a density of one pit per 1,500 ha in the Muncak Kabau area, 1,200 ha in the Lempuing area and 12,000 ha in the Tulangbawang area respectively.

Soils are described according to the standards of "Guideline for Soil Profile Description" produced by the Food and Agriculture Organization of the United Nations (FAO) in 1977. The items of description

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/1 : Space photograph, which was taken by NASA - USA on June 22, 1978, consists of three spectral bands (4,5 and 7) and covers the 185 km x 185 km area having the center in S 04° 19' / E 104° 11' (Martapura).

are of (1) thickness of horizon and horizon boundary, (2) color of matrix, (3) mottling (color, abundance, size and contrast), (4) texture (5) structure (grade, type and size), (6) consistence, (7) compactness and (8) others (cutan, porosity, clay coating, rooting, etc.)

In order to confirm the boundary of soil group, boring exploration with hand auger is supplementally carried out. In addition, the basic intake rates are measured at 6 representative sites. The soil description and the measurement results of intake rates are given in detail in the Data Book.

1.3.2 Laboratory Test

In order to clarify chemical and physical properties of soils, 99 soil samples are collected at 29 representative profiles. These soil samples are analyzed at the Soil Laboratory of Srivijaya University.

The items of analyses are (1) particle size distribution, (2) total carbon, (3) total nitrogen, (4) pH (H_2O), (5) electric conductivity (EC_5), (6) cation exchange capacity (CEC), (7) exchangeable cations (Ca, Mg, Na and K) and (8) available phosphate. The detailed results are presented in the Data Book.

2. Soil

2.1 Soil Classification

The soil classification is made according to the national soil classification system of Indonesia/1. This system is correlated with the modified D/S System in 1978, FAO/UNESCO System and Soil Taxonomy System of U.S. Department of Agriculture as shown in Table II-1. The soils in the survey area are classified into five Great

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/1 : Sistem Klasifikas : tanah di Balai Penyelidikan Tanah, M. Soepraphohardjo, Bogor, 1961. (commonly called "D/S System").

Groups, namely, Podzolic Soils, Alluvial Soils, Hydromorphic Soils, Gley Soils and Organic Soils. The location, land use, land form and soil name of each test pit are given in Table II-2. These five Great Groups are further classified into 11 Sub-groups mainly based on the color of subsoil as shown in Table LL-3.

The characteristics of Great Groups and Sub-groups are explained as in the followings. The physical and chemical status is rated applying the criteria shown in Table II-4.

2.1.1 Podzolic Soils

The soils of this Great Group originate from the residuals of sandstone, claystone and tuff, and extend widely on the peneplain. The topography is flat to gently undulating with steep slope or escarpment at its edge. The total area is 184,400 ha or 81.6% of the total survey area.

All the soils of this Great Group have a horizon sequence of A-B-C in common. The soils are deep to moderately deep, well to moderately well drained having slow to medium drainability and moderate permeability. Groundwater table is generally deep and the land is free from flooding. There are plinthite formation in the upper or lower parts of B horizon within 125 cm of the surface, and coarse sands of quartz are included in A and B horizons.

Podzolic Soils are, in general, deficient in the essential plant nutrients and strongly acid. Soil nutrient status, however, could be supplemented by the application of manures and chemical fertilizers. As for the cultivation of paddy rice, it is considered that the strongly acid conditions could be improved to some extent by the supply of irrigation water.

The remarkable constraint among the limiting factors for agricultural development is the erosion hazard due to the excessive run-off resulting from the heavy tropical showers. At present, the lands are truncated by erosion in consequence of deforestation. The conservation treatments such as contour farming, bench terracing, mulching, etc. are required for controlling or preventing sheet erosion on the sloping land.

This Great Group is subdivided into four Sub-groups, namely, Yellowish Brown Podzolic Soils, Reddish Brown Podzolic Soils, Brown Podzolic Soils and Orange Podzolic Soils.

Sub-group 1 Yellowish Brown Podzolic Soils

The soils of this Sub-group extend over the gently undulating land on the upper peneplain in the Muncak Kabau area and on the eastern peneplain in the Lempuing area. The total area covered with these soils is estimated at around 32,200 ha. At present, alang alang grasses predominantly cover the fallow area after rough reclamation. Cassava is a main crop in these areas. Other upland crops such as maize, peanut and sweet potato are planted in very limited scale. The upland paddy is also cultivated within very limited extent in the wet season.

Yellowish Brown Podzolic Soils are characterized by argillic B horizon and yellowish brown color in subsoils. The topsoils are dark brown in color, medium in texture, weak subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. The subsoils are predominantly yellowish brown in color, fine in texture, structureless massive and slightly sticky and slightly plastic in consistence when wet.

According to the soil chemical analyses, the soil reaction expressed in pH value ranges from 4.1 to 4.7 (very strongly acid) in both topsoils and subsoils. The organic matter content is moderately high to high in topsoils, while low in subsoils. Cation exchange capacity (CEC) ranges from 31 to 44 m.eq. throughout the profile. Base saturation degree is very low in common. Total nitrogen is 0.22% on an average in topsoils, while it abruptly decreases to 0.06% in subsoils.

In the light of the soil profile features as well as soil chemical and physical properties, the soils of Yellowish Brown Podzolic Soils can be utilized for the cultivation of crops, though the application of manures and chemical fertilizers is required so as to obtain good yields. As for the cultivation of diversified crops, it is required to improve the soil conditions particularly the soil acidity by means of liming practice. The conditions will be improved slightly under irrigation farming for paddy rice. The undulating topography restricts the profitable cultivation for paddy rice due to the limitation of field plot to a small size.

Sub-group 2 Reddish Brown Podzolic Soils

The soils of this Sub-group extend over the western undulating peneplain in the Lempuing area. The total area covered with these soils is 10,400 ha. At present, the land is mostly grown with along along and with sparse secondary forest. Extremely small area is used for the cultivation of cassava ard cther diversified crops.

Reddish Brown Podzolic Soils are characterized by argillic B horizon having reddish brown color in subsoils. The topsoils are brown in color, medium in texture, structureless massive, slightly sticky and plastic in consistence when wet. The subsoils are predominantly reddish brown in color, fine in texture, structureless massive and sticky and plastic in consistence when wet. Many ironstone nodules are found throughout the profile.

Regarding the chemical properties, the soils are very strongly acid with pH value ranging from 4.1 to 4.5. The contents of organic matter are high in topsoils, while low in subsoils. In spite of the high value over 40 m.eq. of CEC, the base saturation degree is low throughout the profile.

The chemical and physical properties are very similar to Yellowish Brown Podzolic Soils. The main constraints for the profitable farming are the deficit of essential plant nutrition, very strongly acid condition, lack of water in the dry season and undulating topography. In order to attain the high production of rice and polowijo, relatively high capital investment and recurrent cost will be required for land melioration and reclamation.

Sub-group 3 Brown Podzolic Soils

The soils of this Sub-group extend over the gently sloping land on the lower peneplain adjacent to the upper peneplain and the relict hills in the alluvial plane in the Muncak Kabau area. Besides, the soils occur locally in the Tulangbawang area in limited scale associated with other Podzolic Sub-groups. The total area of these soils is estimated at around 1,300 ha. At present, most of the area is covered with dense forest and alang alang.

Brown Podzolic Soils have remarkably brown color in subsoils. The topsoils are mostly dark brown in color, medium to fine in texture, weak subangular blocky in structure and have slightly sticky and slightly plastic to plastic consistence when wet. The subsoils are predominantly brown in color, fine to coarse in texture, structureless massive and slightly sticky and slightly plastic in consistence when wet.

According to the soil chemical analyses, the soils are extremely acid to strongly acid with pH value ranging from 4.0 to 5.1. The content of organic carbon is estimated at 1.9% on an average in topsoils and 0.6% in subsoils. CEC ranges from 32 to 47 m.eq. in both topsoils and subsoils. The base saturation degrees are low throughout the profile.

In view of the soil profile features and chemical properties, it is considered that the soils of this group would be arable for the diversified crops, though proper improvement of soil nutrient status and reaction are required so as to attain the further production increase. Regarding the land suitability for paddy rice cultivation under irrigated condition, the grade is estimated at rather low, because the lands in the alluvial plain are isolated and small in extension, and the lands adjacent to the upper peneplain are sloping.

Sub-group 4 Orange Podzolic Soils

The soils of this Sub-group extend widely over the undulating peneplain in the Tulangbawang area. The acreage of this soil group is estimated at 140,500 ha. At present, most of the area is covered with dense forest and alang alang.

The soils have plinthite within 100 cm from the surface caused by the seasonal fluctuation of groundwater. The topsoils are dark yellowish brown in color, medium in texture, weak subangular blocky in structure, slightly sticky and slightly plastic in consistence when wet. The conditions of soil chemical properties are almost similar to those of Podzolic Sub-groups explained hereinabove.

In the light of the soil and land conditions, the Orange Podzolic Soils can be defined as suitable for the agricultural use. Major constraints for the intensive farming are undulating topography, unfavorable soil reaction and poor nutrient status. These require rather high capital investment so as to attain the profitable production.

2.1.2 Alluvial Soils

The soils of this Great Group extend over the well to poorly drained lands of the river terrace and the natural levees. They originate from the alluvial deposits and their topography is flat to nearly flat. The lands are about 50 cm higher than alluvial plain. The groundwater table stays 50 cm below the land surface. The land is free from flooding. In many cases, they occur associated with Hydromorphic Soils. The total area is 1,700 ha or 0.8% of the total survey area.

In general, Alluvial Soils have A-(B)-C horizon sequence with gray to brown color and fine texture. They are shallow to moderately deep. They are suitable for irrigation farming, because their topography allows the excess water to be drained easily. However the heavy textured soils which occur partly on the river terrace restrict the workability and tillability. The content of essential plant nutrients in the soil is poor in common.

This Great Group consists of two Sub-groups, i.e. Grayish Yellow Brown Alluvial Soils and Brown Alluvial Soils.

Sub-group 5 Grayish Yellow Brown Alluvial Soils

The soils of this Sub-group occupy the river terraces and natural levees in the Lempuing area. The total area covered with these soils is 1,700 ha. At present, most lands of these soils are used for farmyard or the plantation of perennial crops such as coconut, banana and clove along with various crops such as cassava, tomato, sweet potato and eggplant etc.

The topsoils are brown in color, fine in texture, medium sub-angular blocky in structure, slightly sticky and slightly plastic in consistence when wet. The subsoils are predominantly grayish yellow brown in color, fine in texture, structureless massive, slightly sticky and slightly plastic in consistence when wet.

According to the chemical analyses, the pH value ranges from 4.9 (very strongly acid) to 5.2 (strongly acid) throughout the profile. The content of organic matter is moderately high in topsoils, while low in subsoils. CEC is estimated at more than 30 m.eq. in both topsoils and subsoils. Base saturation degree of these soils is estimated at less than 10% of CEC. The essential plant nutrients such as nitrogen, phosphate and potassium are moderately high to high.

The land of these soils are free from seasonal flooding. External drainage condition is generally good, but internal condition is slightly poor. The groundwater table remains at around 100 cm below the surface in the dry season.

In the light of soil conditions mentioned above, the soils have no severe constraints for agricultural use. However, there is no room for new development, because the land has been occupied by the farm-yard and plantation of perennial crops.

Sub-group 6 Brown Alluvial Soils

The soils of this Sub-group develop locally on the natural levee along the Komering river in the Muncak Kabau area. On the soil map, the development of these soils is explained as the soils associated with Brown Hydromorphic because of their small and intricate extent. The lands are mainly used for the plantation of coconut and banana.

Brown Alluvial Soils have, in general, a weak profile development of A-(B)-C horizon or layer. The matrix color is dark brown in topsoils and brown in subsoils. Texture quality is predominantly silt loam. The structure is weak subangular blocky in topsoils, while structureless massive in subsoils. Throughout the profile, the soils are slightly sticky, slightly plastic in consistence when wet and hard when dry.

With respect to the chemical properties, pH value varies from 4.8 (very strongly acid) to 5.3 (strongly acid) throughout the profile. Total organic carbon is moderately high in topsoils, while low in subsoils. Total nitrogen in topsoils is very high, but the contents abruptly decrease in subsoils. CEC is estimated at about 34 m.eq. on an average and saturated by the bases of 4% throughout the profile.

As for the hydrodynamics, external drainage is good, but internal condition is slightly poor. The lands are free from seasonal flooding.

In view of the soil conditions, Brown Alluvial Soils on the natural levee are suitable for the cultivation of diversified crops or plantation of perennial crops such as coconut and banana. However, the physical nature of lands, though small in extension, is unfavorable for the profitable farming.

2.1.3 Hydromorphic Soils

The soils of this Great Group occur on the natural levees in the Muncak Kabau area and on the alluvial plain in the Lempuing area, and extend over the low-lying grassland in the Tulangbawang area. Their parent materials are recent alluvial deposits. Total area is 16,700 ha or 7.4% of the total survey area.

They have specific horizon sequence of A-(B)-C characterized by hydromorphic properties within 50 cm below the land surface, and have higher chroma in soil color than the soils of Gley Great Group. These soils are rather deep and poorly to moderately drained with low external drainability and low permeability. The land is free from flooding in general.

There is the limited area to be developed newly for agriculture on the natural levee, because most parts of this area are used for the farmyard or the plantation of perennial crops such as banana, coconut, clove, etc. Furthermore the size of land is too small to be developed economically.

This Great Group consists of two Sub-groups, i.e. Brown Hydromorphic Soils and Gray Hydromorphic Soils.

Sub-group 7 Brown Hydromorphic Soils

The soils of this Sub-group occupy the natural levees along the Komering river in the Muncak Kabau area. The total area is 600 ha. At present, most lands of these soils are used for farmyard, upland fields and the plantation of perennial crops.

Brown Hydromorphic Soils are characterized by the hydromorphic properties within 50 cm below the surface. The topsoils are medium subangular blocky in structure. The subsoils are weak massive and moderately blocky in structure. Throughout the profile, the soils are predominantly brown in color, fine in texture and slightly sticky and slightly plastic in consistence when wet.

According to the soil chemical analyses, the soil reaction expressed in pH value ranges from 4.0 (extremely acid) to 6.5 (slightly acid) in both topsoils and subsoils. Total organic carbon is estimated at 2.5% in topsoils and 0.8% in subsoils on an average. CEC ranges from 32 to 66 m.eq. throughout the profile and base saturation degree is estimated at around 4% of CEC on an average. Total nitrogen is 0.22% on an average in topsoils, while it abruptly decreases to 0.05% in subsoils. Available phosphate is 1.12 mg (low) and 0.59 mg (very low) on an average in topsoils and subsoils respectively.

As for the hydrodynamics, external drainage condition is good, while internal condition is poor. Groundwater table lies at around 50 to 100 cm below the surface in the dry season. In the rainy season, groundwater rises up to near the ground surface.

In the light of soil and land conditions, Brown Hydromorphic Soils can be defined as suitable for the cultivation of diversified crops. However, there is no land to be developed newly due to extensive use for farmyard and coconut plantation.

Sub-group 8 Gray Hydromorphic Soils

The soils of this Sub-group develop on the moderately drained lands in the depression in the Tulangbawang area. The total area of these soils is 16,100 ha. At present, the lands are covered with sparse shrub and grasses.

Generally, Gray Hydromorphic Soils have A-Bg-Cg in horizon sequence and hydromorphic properties within 50 cm below the surface. The topsoils are dark brown in color, fine in texture, weak sub-angular blocky in structure, slightly sticky and slightly plastic in consistence when wet. The subsoils are predominantly gray in color, fine in texture, structureless massive, slightly sticky and slightly plastic in consistence when wet.

Regarding the chemical properties, the soils are extremely acid with pH value ranging from 3.8 to 4.0. The contents of organic carbon are moderately high in both topsoils and subsoils. CEC is estimated at around 52 m.eq. (extremely high) on an average, and the capacity is saturated by the bases at less than 4% on an average.

The drainage conditions are externally and internally poor due to flat or depressed topography. The lands are generally free from seasonal flooding, but suffer from seasonal inundation.

In the light of the soil and land conditions, Gray Hydromorphic Soils will be suitable for the cultivation of both upland crops and paddy, though proper drainage improvement, fertilization and supplemental irrigation in the dry season are required so as to attain the stable and good yield.

2.1.4 Grey Soils

The soils of this Great Group develop extensively on the alluvial plain, narrow inland valleyes and depression. The parent materials are recent alluvial deposits and the run-off deposits derived from the adjacent hills. The topography is flat to nearly flat. The total area is 23,000 ha or 10.2% of the total survey area.

The soils have a horizon sequence of A-Ag-Cg having hydromorphic properties within 50 cm below the surface. Most of these soils have gray-colored surface horizon with low chroma less than 2. External and internal drainage are very poor. Groundwater table is high in wet season or throughout the year. Water-logging caused by over-irrigation should therefore be eliminated by proper drainage system. The contents of essential plant nutrients in the soils are poor in common. The lands covered with this Great Group are broadly used for paddy field at present. For introduction of upland crops, high capital investment will be required for the improvement of drainage condition.

The Great Group is subdivided into two Sub-groups, i.e. Low Humic Gley Soils and Humic Gley Soils.

Sub-group 9 Low Humic Gley Soils

The soils of this Sub-group widely extend over recent alluvial plain and flat inland valleys. The total area covered with these soils are 3,800 ha in the Muncak Kabau area and 8,700 ha in the Lempuing area. At present, these soils are used for paddy cultivation in the wet season, but in the dry season they are left fallow due to the deficit of water supply.

These soils have lower organic matter contents as compared with Humic Gley Soils. Throughout the profile, the soils are predominantly gray in color, very fine in texture, structureless massive and very sticky and very plastic in consistence when wet.

With respect to the soil chemical properties, Low Humic Gley Soils are extremely acid to strongly acid with pH value ranging from 4.2 to 5.5. Total organic carbon is estimated at 1.9% on an average in topsoils and 0.7% in subsoils. CEC is 48 m.eq. on an average throughout the profile, and bases saturate 4% of the capacity. Total nitrogen is 0.16% on an average in topsoils and it decreases to 0.06% in subsoils. Available phosphate is extremely low in both topsoils and subsoils. Patassium is moderately high in both soils.

As to hydrodynamic characteristics, the soils have low permeability coefficient and poor or imperfect drainabilities. They suffer from seasonal flooding. The groundwater table lies within 100 cm below the surface in the dry season and comes up to near the ground surface in the wet season.

According to the soil properties mentioned above, the soils of this group would be suitable for paddy rice cultivation, although proper improvement of drainage, supplemental irrigation in the dry season and fertilization are required so as to expect the further production increase. As for the cultivation of diversified crops, it is considered that the lands of these soils will be marginally suitable or unsuitable mainly because of their poor drainability.

Sub-group 10 Humic Gley Soils

The soils of this Sub-group develop extensively in the alluvial depression. They represent about 4,100 ha in the Muncak Kabau area and 6,400 ha in the Lempuing area. At present, some small parts of the area are used for paddy cultivation in the wet season. A major parts of the soils are left fallow and covered with swampy grasses and shrub due to deep inundation condition in the rainy season and mushy condition in the dry season.

The topsoils are predominantly dark gray in color, fine in texture, structureless massive and sticky and slightly sticky in consistence when wet. The subsoils are gray in color, coarse in texture, structureless and slightly sticky and slightly plestic in consistence when wet.

According to the chemical analyses, the soils are extremely acid. Total organic carbon is estimated at about 3.6% in topsoils and about 0.7% in subsoils. Total nitrogen content is high throughout the profile. Available phosphate is moderately high (0.54 to 0.64 mg). CEC ranges from 32 to 40 m.eq. throughout the profile, and its capacity is saturated at about 5% by bases.

The groundwater table lies at the surface or within around 50 cm below the surface in the dry season. The lands are submerged rather deeply in the wet season. The drainage conditions are externally and internally poor due to their depressed topography.

In the light of conditions mentioned above, the lands of this soil group are suitable for paddy rice cultivation. However, for introduction of diversified crops, high capital investment will be required for the improvement of drainage and chemical conditions.

2.1.5 Organic Soils

The soils of this Great Group occur locally on swamp land among depressions in limited scale. They are classified into the associated soil with Gley Soils and Hydromorphic Soils.

They have a special horizon sequence of O-Cg in general. The O horizon is of accumulated layer of plant remnants decomposed to some extents. The land of these soils is submerged throughout the year. In order to use these soils for farming, proper drainage control would be required. They may be rapidly altered in thickness due to the decomposition and compression of organic matter when dried. In the light of the abovementioned conditions, these lands are unsuitable for irrigation farming.

This Great Group consists of one Sub-group, i.e. Organic Sub-group.

Sub-group 11 Organic Soils

The soils of this Sub-group occupy deep depression. The uppermost part is composed of accumulated remains of plants. They have horizon sequence of O-Og-Cg. The topsoils are very dark brown in color, fine in texture, structureless, non-sticky and non-plastic in consistence when wet. The subsoils are brownish brown in color, fine in texture, structureless, non-sticky and non-plastic in consistence when wet.

They have extremely strong acid soil reaction in both topsoil and subsoil. The contents of organic matter are very high in both soils. Cation exchange capacities are very high in both soils, while base saturation degrees are very low in both soils.

The lands of these soils are not suitable for the agricultural use due to their submerged condition throughout the year. For the profitable farming, extremely high capital investment will be required for the improvement of drainage condition.

3. LAND SUITABILITY

3.1 Category of Land Suitability Classification

The land suitability in the Project Area is classified into three categories, i.e. Order, Class and Sub-class by the application of the Framework for Land Evaluation, FAO in 1976. The categories are defined as in the followings.

3.1.1 Order

The highest category is Order and the land in the project area is divided into two Orders as follows;

(1) Suitable --- S

Land on which the sustained use of paddy and polowijo are expected to yield benefits to justify the required recurrent inputs without unacceptable risk to land resources on the site or in adjacent area.

(2) Non-suitable --- N

Land on which the sustained use of paddy and polowijo can not be expected to result sufficient benefits to justify the required recurrent inputs.

In addition to the above two Orders, the system sets forth Conditionally suitable (Cs) phase which is originally categorized in Suitable order and indicates the land to be required the specific management for profitable farming. For the present study, however, Cs phase is not applied according to the methodology prevailing in Indonesia.

3.1.2 Class

Suitable order and Non-suitable order are subdivided into three and two classes respectively as follows;

(1) Highly suitable --- S1

Land having no significant or only minor limitations to the sustained cultivation of paddy and polowijo that will significantly reduce production levels.

(2) Moderately suitable --- S2

Land having limitations which in the aggregate are moderately severe for the sustained cultivation of paddy and polowijo and will so reduce production levels.

(3) Marginally suitable --- S3

Land having limitations which in the aggregate are severe for the sustained cultivation of paddy and polowijo and will so reduce production levels that such expenditure will only be marginally justified.

(4) Currently non-suitable --- N1

Land having limitations which appear so severe as to preclude any possibility of successful sustained paddy and polowijo cultivation, or having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at presently acceptable cost.

(5) Permanently non-suitable --- N2

Land having limitations which appear so severe as to preclude any possibility of successful sustained paddy and cultivation.

3.1.3 Sub-Class

Each class is divided into sub-classes according to the kind of limiting factors. The following conditions are considered as the notable limiting factors or constraints for the cultivation of paddy and polowijo in this survey area.

Topography (t) : limitation due to unfavorable relief, e.g. macro or micro relief, and/or relative elevation limiting to its use (unsuitable elevation for economical gravity irrigation, and relief conditions unsuitable for economical drainage improvement and economical field arrangement).

Erosion (e) : limitation caused by erosion hazards or past erosion damages.

Drainability (w) : limitation caused by waterlogging due to high groundwater table, long consecutive seasonal floodings, low permeability or slow surface drainage and/or the combination of these regimes.

Inundation (i) : limitation due to frequent floodings.

Acidity (O) : limitation due to strong acid soil reaction (pH), and/or high degree of 1N-KCl extractable aluminium (so-called active or free aluminon) and or low degree of base saturation to cation exchange capacity (CEC).

Fertility (f)	:	limitation due to low contents of chemical nutrients in the soils particularly of nitrogen, phosphate, potassium, effective bases. Generally, organic carbon is not essential factor of this evaluation.
Physical soil deficiency (p)	:	limitation due to unfavorable physical soil properties, e.g. very hard consistence, firmly consolidated soils, massive structure, very plastic and sticky consistence when wet, etc.
Depth (d)	:	limitation due to shallowness of soils, restricting root development and/or effective irrigation and drainage operation.

Each of above limitations is expressed by abbreviated symbol and is used as the suffix of Sub-class nomination of land suitability.

3.2 Grading of Features by Land Suitability

The gradings of essential land features by land suitability are summarized as shown in Table II-6.

3.3 Evaluation of Land Suitability by Soil Group

Based upon the gradient of limiting factor to land suitability, the grade of land suitability is evaluated by Sub-group as listed in Table II-7. The acreage and proportional extent to each land suitability unit are tabulated in Table II-8. These suitability units show the significant limitations, which are selected from all the limiting factors given in Table II-7. The distribution of each unit is illustrated on the land suitability map (Fig. II-1 to II-3).

Table II-1 GREAT GROUP OF D/S SYSTEM CORRELATED WITH FAO/UNESCO SYSTEM AND SOIL TAXONOMY

Dudal/Soepraptohardjo system (1957, 1961)	D/S system (modified in 1978)	FAO/UNESCO /1 (1974)	SOIL TAXONOMY /2 (1975)
1. Alluvial Soils	Alluvial Soils	Fluvisols	Entisols
			Inceptisols
2. Andosols	Andosols	Andosols	Inceptisols
			Ultisols
3. Brown Forest Soils	Brunizem	Cambisols	Inceptisols
4. Grumusols	Grumusols	Vertisols	Vertisols
5. Latosols	Cambisols	Cambisols	Inceptisols
	Latosols	Nitosols	Ultisols
			Inceptisols
			Alfisols
6. Lithosols	Lithosols	Lithosols	(Lithic sub-groups)
7. Mediterranean	Mediterranean	Luvisols	Alfisols
8. Organic Soils	Organosols	Histosols	Histosols
9. Podzolic	Podzolic	Podzolic	Spodosols
10. Reddish Yellow Podzolic	Podzolic	Acrisols	Ultisols
			Alfisols
11. Regosols	Regosols	Regosols	Entisols
			Inceptisols
12. Renzinas	Renzinas	Renzinas	Mollisols
13. Gley Soils	Gleysols	Gleysols	Entisols
Humic Gley Soils			Inceptisols
Low Humic Gley Soils			
Gray Hydromorphic Soils			
Hydromorphic Alluvial Soils			

/1 : FAO/UNESCO (United Nations Educational, Scientific and Cultural Organization). 1974. FAO-Unesco soil map of the world, 1:500,000 Vo. 1, Legend. Paris.

/2 : USDA (United States Department of Agriculture), Soil Conservation Service, Soil Survey Staff. 1975. Soil taxonomy: a basic system of soil classification for making and interpreting soil surveys. USDA Agric. Handbook. 436. US Government Printing Office, Washington, D.C.

Table II-2 PIT NUMBERS AND SOME DESCRIPTIONS OF THE SAMPLES

Pit No.	Location	Land Use or Vegetation	Physiography	Great Group (D/S system, 1961)
Lempuing Area				
1	Bumi Agung	Alang alang	Natural levee	Hydromorphic
2	Cahaya Maju	Alang alang	Natural levee	Alluvial
3	Cahaya Maju	Paddy	Alluvial plain	Gley
4	Bumi Agung	Paddy	Alluvial plain	Gley
5	Tebing Suluh	Forest	Peneplain	Podzolic
6	Tebing Suluh	Alang alang	River terrace	Alluvial
7	Tebing Suluh	Alang alang	Natural levee	Alluvial
8	Tebing Suluh	Paddy	Alluvial plain	Gley
9	Cahaya Maju	Alang alang	Natural levee	Alluvial
10	Cahaya Maju	Alang alang	Peneplain	Podzolic
11	Tulung Harapan	Upland field	Peneplain	Podzolic
12	Tugu Mulyo	Paddy	Alluvial plain	Gley
13	Cahaya Maju	Alang alang	Natural levee	Gley
14	Lebuk Kunir	Alang alang	Natural levee	Alluvial
15	Tugu Mulyo	Upland field	Natural levee	Alluvial
16	Bumi Agung	Paddy	Alluvial plain	Hydromorphic
17	Karang Anyar	Alang alang	Peneplain	Podzolic
18	Karang Anyar	Paddy	Alluvial plain	Gley
19	Karang Anyar	Paddy	Alluvial plain	Gley
20	Marga Dadi	Alang alang	Peneplain	Podzolic
21	Cahaya Negeri	Paddy	Inland valley	Gley
22	Karang Melati	Alang alang	Peneplain	Podzolic
23	Lubuk Seberuk	Paddy	Alluvial plain	Hydromorphic
24	Marga Dadi	Alang alang	Peneplain	Podzolic
Muncak Kabau Area				
25	Rasuan	Perennial crops	Natural levee	Hydromorphic
26	Gunung Terang	Shrub	Peneplain	Podzolic
27	Rasuan	Paddy	Depression	Gley
28	Rasuan	Perennial crops	Natural levee	Hydromorphic
29	Gunung Terang	Paddy	Inland valley	Gley

(to be continued)

Pit No.	Location	Land Use or Vegetation	Physiography	Great Group (D/S system, 1961)
30	Mendayun	Paddy	Alluvial plain	Gley
31	Kotanegara	Alang alang	Peneplain	Podzolic
32	Pendanagung	Paddy	Alluvial plain	Gley
33	Mendayun	Alang alang	Peneplain	Podzolic
34	Kotanegara	Paddy	Inland valley	Gley
35	Cinta Negara	Perennial crops	Natural levee	Hydromorphic
36	Cinta Negara	Forest	Peneplain	Podzolic
37	Riang Bandung	Perennial crops	Natural levee	Alluvial
38	Riang Bandung	Perennial crops	Natural levee	Hydromorphic
39	Muncak Kabau	Paddy	Inland valley	Hydromorphic
40	Sribunga	Paddy	Alluvial plain	Gley
41	Rasuan	Swamp	Depression	Organic
Tulangbawang Area				
42	Mesir Ilir	Forest	Peneplain	Hydromorphic
43	Mesir Ilir	Alang alang	Peneplain	Podzolic
44	Negara Batin	Alang alang	Peneplain	Podzolic
45	Negara Batin	Shrub	Peneplain	Podzolic
46	Negara Batin	Alang alang	Peneplain	Podzolic
47	Negara Batin	Alang alang	Peneplain	Podzolic
48	Cakat Nyenyek	Swamp	Depression	Hydromorphic
49	Cakat Nyenyek	Forest	Peneplain	Podzolic
50	Pancakarsa Purnajaya	Forest	Peneplain	Podzolic
51	Pancakarsa Purnajaya	Upland field	Peneplain	Podzolic
52	Pancakarsa Purnajaya	Swamp	Depression	Organic
53	Banjaragung	Forest	Peneplain	Podzolic
54	Banjaragung	Forest	Peneplain	Podzolic

Table II-3 SOIL CLASSIFICATION

Great Group	Sub-group	Test Pit No.
1. Podzolic Soils	1. Yellowish Brown Podzolic Soils	5,10,24,26,31, 43,44
	2. Reddish Brown Podzolic Soils	11,17,20,22
	3. Brown Podzolic Soils	33,36,45,46,47, 49
	4. Orange Podzolic Soils	50,51,53,54
2. Alluvial Soils	5. Grayish Yellow Brown Alluvial Soils	2,6,7,9,14,15
	6. Brown Alluvial Soils	37
3. Hydromorphic Soils	7. Brown Hydromorphic Soils	1,16,23,25,28, 35,38,39,42
	8. Gray Hydromorphic Soils	48
4. Gley Soils	9. Low Humic Gley Soils	3,4,12,13,18,21, 29,30,32,34,40
	10. Humic Gley Soils	8,19,27
5. Organic Soils	11. Organic Soils	41,52

Table II-4 RATING OF SOIL CONDITION

1. Textural classes (FAO Standard)/1

Coarse textured	:	sands, loamy sands and sandy loams with less than 15 percent clay, and more than 5 percent sand.
Medium textured	:	loams, silty loams, sandy clay loams, clay loams and silty clay loams with less than 25 percent clay.
Fine textured	:	sandy clays, light clays, silty clays and heavy clays with more than 25 percent clay.

2. Soil acidity

	pH/2 (Soil-water ratio 1:2.5)	Exchange aciding/3 (y1)
Slightly acid to neutral	: 6.1 to 7.3	less than 3
Medium acid	: 5.6 to 6.0	3 to 6
Strongly acid	: 5.1 to 5.5	
Very strongly acid	: 4.6 to 5.0	6 to 15
Extremely acid	: below 4.5	more than 15

3. Soil fertilities/3

	High	Moderately high	Low
Organic carbon (%)	more than 2.0	2.0 to 1.0	less than 1.0
Total nitrogen (%)	more than 0.05	0.05 to 0.01	less than 0.01
Available P_2O_5 (mg/100g)	more than 10	10 to 2	less than 2
CEC (me/100g)	more than 20	20 to 10	less than 10
Ex-potassium(me/100g)	more than 0.2	0.2 to 0.0	less than 0.1
Base saturation (%)	more than 50	50 to 20	less than 20

4. Others

	High	Moderately high	Low
Salinity/2 (EC , mmho/cm)	more than 8	8 to 4	less than 4

Source: /1 Guidelines for Soil Profile Description, FAO (1977)

/2 Soil Survey Manual, USDA (1951)

/3 Procedure of Productive Capability Classification of Land, Ministry of Agriculture and Forestry, Japan (1965)

Table II-5 ACREAGE AND PROPORTIONAL EXTENT OF EACH SOIL MAPPING UNIT

A. THE MINCAK KABAU AREA

Mapping Symbol	Soil Mapping Unit	Associated Soil	Land Form	Soil Survey Area		Gross Irrigable Area	
				ha	%	ha	%
I	Yellowish Brown Podzolic Soils	-	Peneplain	29,800	75.2	10,300	60.9
III	Brown Podzolic Soils	-	Peneplain	1,300	3.3	400	2.4
VI	Brown Hydromorphic Soils	Brown Alluvial Soils	Natural levee	600	1.5	600	3.6
VIII	Low Humic Gley Soils	Brown Hydromorphic Soils	Inland valley · Alluvial plain	3,800	9.6	3,100	18.3
IX	Humic Gley Soils	Organic Soils	Depression	4,100	10.4	2,500	14.8
	Total			39,600	100.0	16,900	100.0

B. THE LEMPUING AREA

Mapping Symbol	Soil Mapping Unit	Associated Soil	Land Form	Soil Survey Area		Gross Irrigable Area	
				ha	%	ha	%
I	Yellowish Brown Podzolic Soils	-	Peneplain	2,400	8.1	2,400	12.4
II	Reddish Brown Podzolic Soils	-	Peneplain	10,400	35.1	5,800	29.9
V	Grayish Yellow Brown Alluvial Soils	Brown Hydromorphic Soils	Natural levee · River terrace	1,700	5.8	1,700	8.8
VIII	Low Humic Gley Soils	Brown Hydromorphic Soils Humic Gley Soils	Alluvial plain · Inland valley	8,700	29.4	8,700	44.8
IX	Humic Gley Soils	Organic Soils	Depression	6,400	21.6	800	4.1
	Total			29,600	100.0	19,400	100.0

C. THE TULANGBAWANG AREA

Mapping Symbol	Soil Mapping Unit	Associated Soil	Land Form	Soil Survey Area		Gross Irrigable Area	
				ha	%	ha	%
IV	Orange Podzolic Soils	Yellowish Brown Podzolic Soils Brown Podzolic Soils Brown Hydromorphic Soils	Peneplain	140,500	89.7	79,700	99.3
VII	Grey Hydromorphic Soils	Organic Soils Humic Gley Soils	Depression	16,100	10.3	600	0.7
	Total			156,600	100.0	80,300	100.0

Table II-6 CRITERIA FOR RATING OF LIMITING FACTOR

Limiting Factor	Proposed Land Use	Highly Suitable 1	Moderately Suitable 2	Marginally Suitable 3	Currently Non-suitable 4
1. Topography (t)					
- slope	paddy	0	0 to 3°	3° to 8°	more than 8°
	polovijo	less than 3°	3° to 8°	8° to 15°	more than 15°
2. Erosion (e)					
- evidence of the sheet erosion	-	non to slight	moderate	severe	-
- susceptibility to the soil erosion	-	insignificant	slight	moderate	severe
3. Drainability (w)					
- drainability	paddy & polovijo	well	moderately	poorly	very poorly
4. Inundation (i)					
- seasonal flooding	Paddy & polovijo	non seasonal flooding	seasonal flooding shallowing	seasonal flooding deeply	flooding throughout the year
- inundation	- do -	non inundated	sometime inundated	frequently inundated	inundated all the time
5. Acidity (o)					
- pH (soil-water 1:2.5)	paddy	8.0 to 5.1	5.0 to 4.6	less than 4.5	-
	polovijo	8.0 to 6.1	6.0 to 5.1	5.0 to 4.6	less than 4.5
6. Fertility (f)					
- organic carbon (%)	paddy & polovijo	more than 2.0	2.0 to 1.0	less than 1.0	-
- total nitrogen (%)	- do -	more than 0.05	0.05 to 0.01	less than 0.01	-
- available P_2O_5 (mg/100g)	- do -	more than 10	10 to 2	less than 2	-
- CEC (me/100g)	- do -	more than 20	20 to 10	less than 10	-
- exchangeable K (me/100g)	- do -	more than 0.2	0.2 to 0.1	less than 0.1	-
- base saturation (%)	- do -	more than 50	50 to 20	less than 20	-
7. Physical Soil Deficiency (p)					
- consistence when wet	paddy & polovijo	non to slightly sticky and non to slightly plastic	sticky and plastic	very sticky and very plastic	-
- consistence when dry	- do -	loose to rather hard	hard to very hard	extremely hard	extremely hard
8. Depth (d)					
- effective soil depth (cm)	paddy	more than 50	50 to 25	25 to 15	less than 15
	polovijo	more than 100	100 to 50	50 to 15	less than 15

Source: Land suitability classification for irrigated paddy and diversified crops defined by U.S. Bureau of Reclamation, 1967.

Land classification system prepared by the Ministry of Agriculture, Forestry and Fisheries of Japan.

Table II-7 LAND SUITABILITY GRADING FOR PADDY AND POLOWIJO BY SOIL SUB-GROUP

Soil in Great Group	Podzolic Soils								Alluvial Soils				Hydromorphic Soils				Gley Soils				Organic Soils	
Soil in Sub-group	1		2		3		4		5		6		7		8		9		10		11	
Land Form	Peneplain								River Terrace Natural Levee		Natural Levee		Natural Levee Inland Valley Alluvial Plain		Depression		Inland Valley Alluvial Plain		Inland Valley Alluvial Plain Depression		Depression	
Present Land Use	Alang alang Upland Field		Alang alang				Forest		Alang alang Upland Field		House Yard Perennial Crops		Perennial Crops Paddy		Shrub		Paddy		Paddy Aquatic Plant		Shrub of Aquatic Plant	
Proposed Land Use /1	pd	pl	pd	pl	pd	pl	pd	pl	pd	pl	pd	pl	pd	pl	pd	pl	pd	pl	pd	pl	pd	pl
Land Feature /2																						
- topography (t)	1-3	1-2	2-3	1-2	1-3	1-2	2-3	1-3	2	1	2	1	1-2	1	1	1-2	1	1	1-2	1	1	1
- erosion (e)	1	2	1	2	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
- drainability (w)	1	1	1	1	1	1	1	1	1	1	1-2	1	2-4	2-4	1	2-4	2-4	3-4	2	3-4	4	4
- inundation (i)	1	1	1	1	1	1	1	1	1	1	1	1	2-4	2-4	1-2	2-3	2-4	3-4	3	3	4	4
- acidity /4 (o)	3	3-4	3	4	3	4	3	4	2	3	1	2	2-3	3-4	3	4	2	3	3	4	3	4
- fertility /4 (f)	3	3	3	3	3	3	3	3	3	3	3	3	2	2	3	3	2	2	2-3	2-3	3	3
- physical soil deficiency (p)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
- depth (d)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3
Suitability Class	S3	S2	S3	S2	S3	S2	S3	S2,S3	S2	S1	S2	S1	S2,N1	S3,N1	S1,S2	S3,N1	S3,N1	S3,N1	S1-3	N1	N1	N1
Limiting Factors /3 in Sub-class	t,o f	t,e o,f	t,o f	t,e o,f	t,o f	t,o o,f	t,o f	t,e o,f	t,o f		t,f		i,w	w i,o	i	i,w f	f w,i	w,o i	w,i o,f	w,i o,f	w,i o,f,p	w,i o,f,p

Note: /1: Column pd and pl indicate the land use for paddy and polowijo respectively.

/2: Figures show the rating of limiting factor shown in Table II-6.

/3: See the subsection 3.1.3 hereof.

/4: These limitations can be improved by proper limiting and fertilization with Project.

Table II-8 ACREAGE AND PROPORTIONAL EXTENT OF EACH LAND SUITABILITY UNIT

A. THE MUNCAK KABAU AREA

Grade	Suitability Class	Suitability Sub-class		Survey Area		Gross Irrigable Area	
		Paddy	Polovijo	ha	%	ha	%
I.	Highly suitable	S1	S2v	3,400	8.6	3,100	18.3
II.	Moderately suitable	S2t	S1	600	1.5	600	3.6
		S2i	S3vi	1,200	3.0	1,200	7.1
III.	Marginally suitable	S3tf	S2tef	31,100	78.6	10,700	63.3
		S3vif	N1vif	1,700	4.3	1,300	7.7
IV.	Currently non-suitable	N1vi	N1vio	1,600	4.0	0	0.0
	Total			39,600	100.0	16,900	100.0

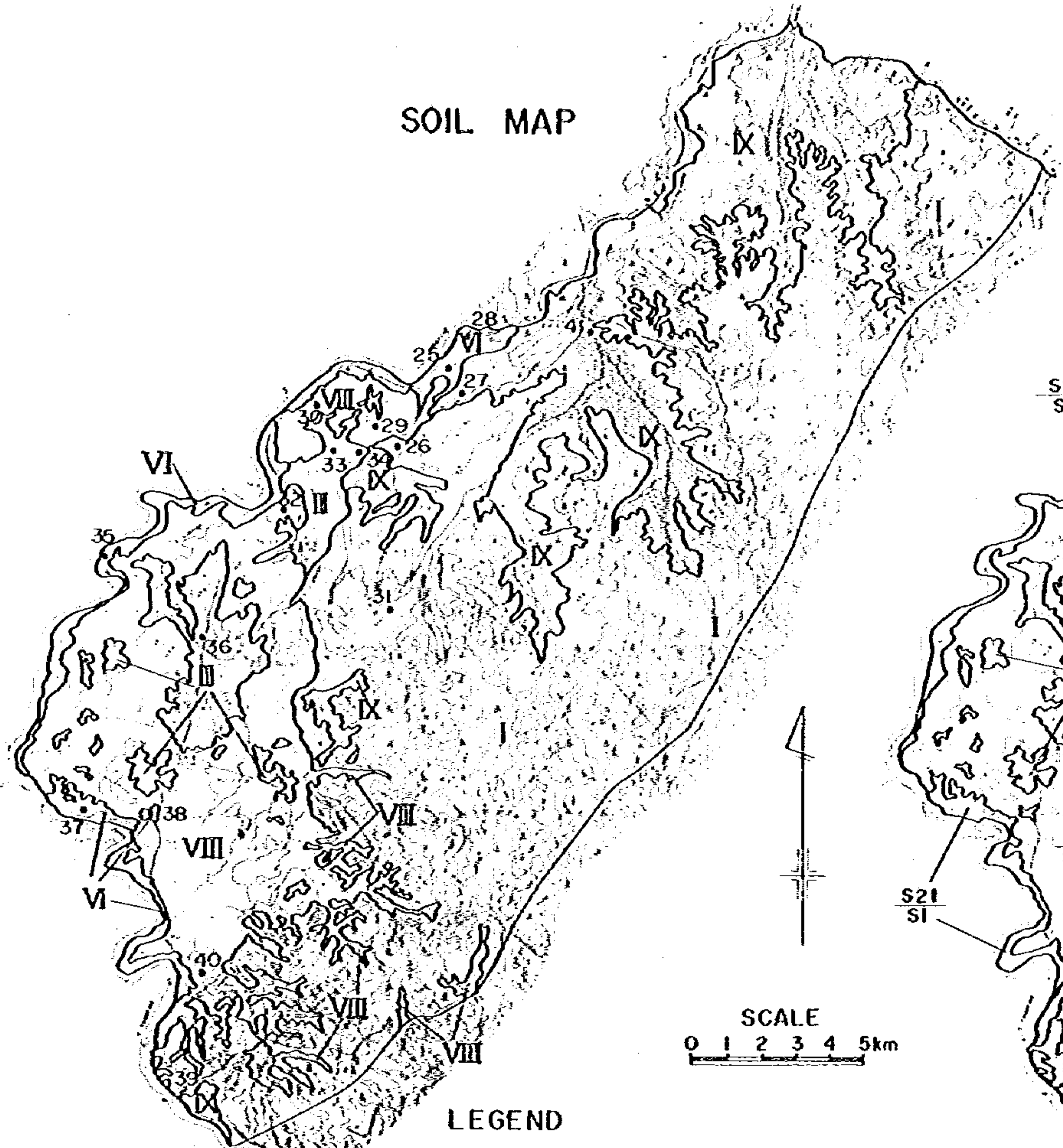
B. THE LEMPUING AREA

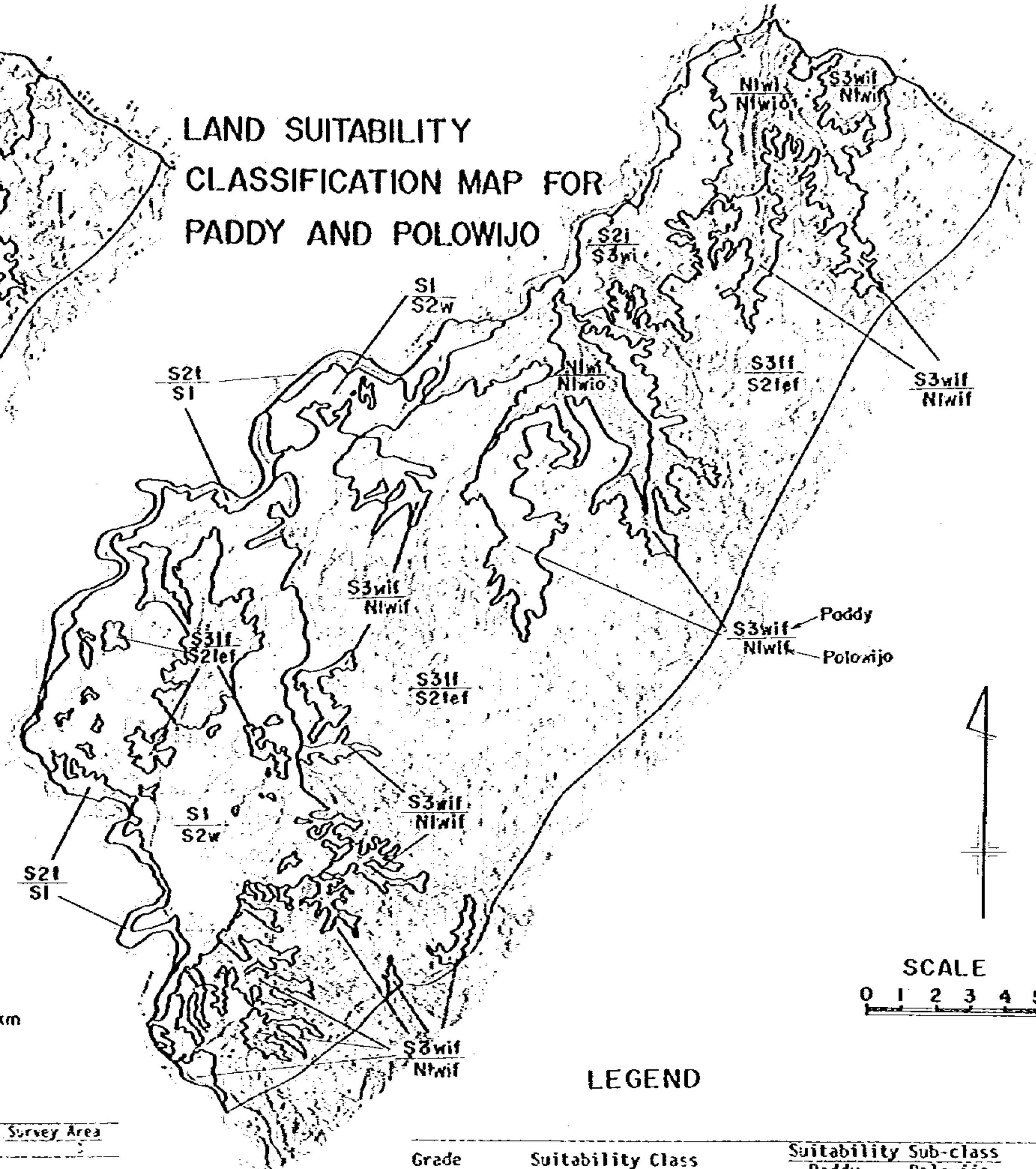
Grade	Suitability Class	Suitability Sub-class		Survey Area		Gross Irrigable Area	
		Paddy	Polovijo	ha	%	ha	%
I.	Highly suitable	S1	S2v	7,900	26.8	7,900	40.7
II.	Moderately suitable	S2t	S1	1,700	5.7	1,700	8.8
		S2i	S3vi	800	2.7	800	4.1
III.	Marginally suitable	S3tf	S2tef	12,800	43.2	8,200	42.3
		S3vif	N1io	800	2.7	800	4.1
IV.	Currently non-suitable	N1vi	N1vio	5,600	18.9	0	0.0
	Total			29,600	100.0	19,400	100.0

C. THE TULANGBAWANG AREA

Grade	Suitability Class	Suitability Sub-class		Survey Area		Gross Irrigable Area	
		Paddy	Polovijo	ha	%	ha	%
II.	Moderately suitable	S2i	S3vi	900	0.6	600	0.7
III.	Marginally suitable	S3tf	S2tef	130,600	83.4	70,800	88.2
		S3tf	S3tef	9,900	6.3	8,900	11.1
IV.	Currently non-suitable	N1v	N1vio	15,200	9.7	0	0.0
	Total			156,000	100.0	80,300	100.0

Fig.II - I SOIL AND LAND SUITABILITY CLASSIFICATION MAPS IN THE MUNCAK KABAU AREA





LEGEND

Mapping Symbol	Soil Mapping Unit	Associated Soil	Land Form	Soil Survey Area ha	%
I	Yellowish Brown Podzolic Soils	-	Peneplain	29,800	75.2
III	Brown Podzolic Soils	-	Peneplain	1,300	3.3
VI	Brown Hydromorphic Soils	Brown Alluvial Soils	Natural levee	600	1.5
VIII	Low Humic Gley Soils	Brown Hydromorphic Soils	Inland valley Alluvial plain	3,800	9.6
IX	Humic Gley Soils	Organic Soils	Depression	4,100	10.4
	Total			39,600	100.0

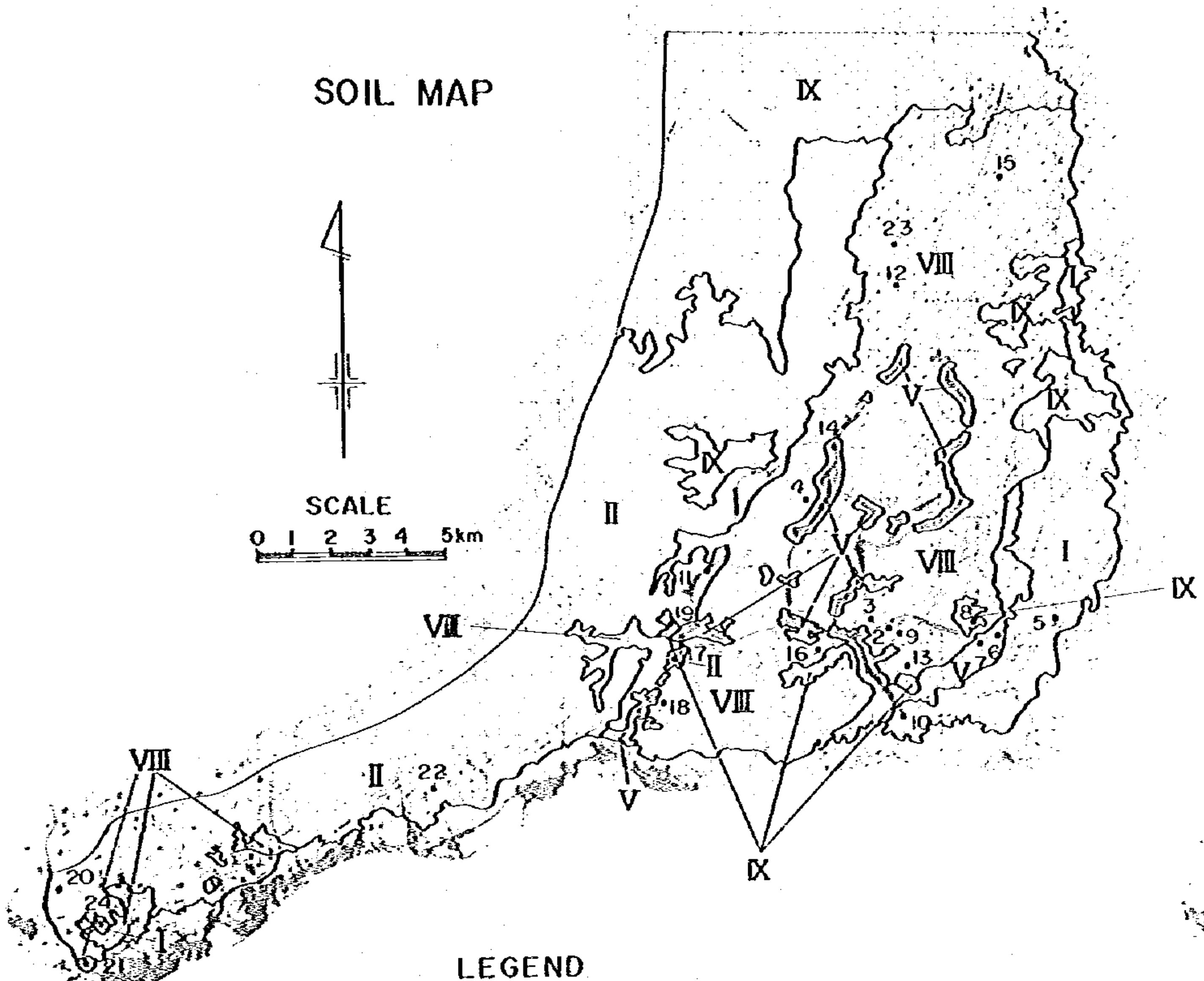
LEGEND

Grade	Suitability Class	Suitability Sub-class Paddy	Polowijo	Survey Area ha	%
I.	Highly suitable	S1	S2w	3,400	8.6
II.	Moderately suitable	S2t	S1	600	1.5
		S2i	S3wi	1,200	3.0
III.	Marginally suitable	S3tf	S2tef	31,100	78.6
		S3wif	N1wif	1,700	4.3
IV.	Currently non-suitable	N1wi	N1wio	1,600	4.0
	Total			39,600	100.0

Following abbreviated symbol letters indicate the limiting factor.

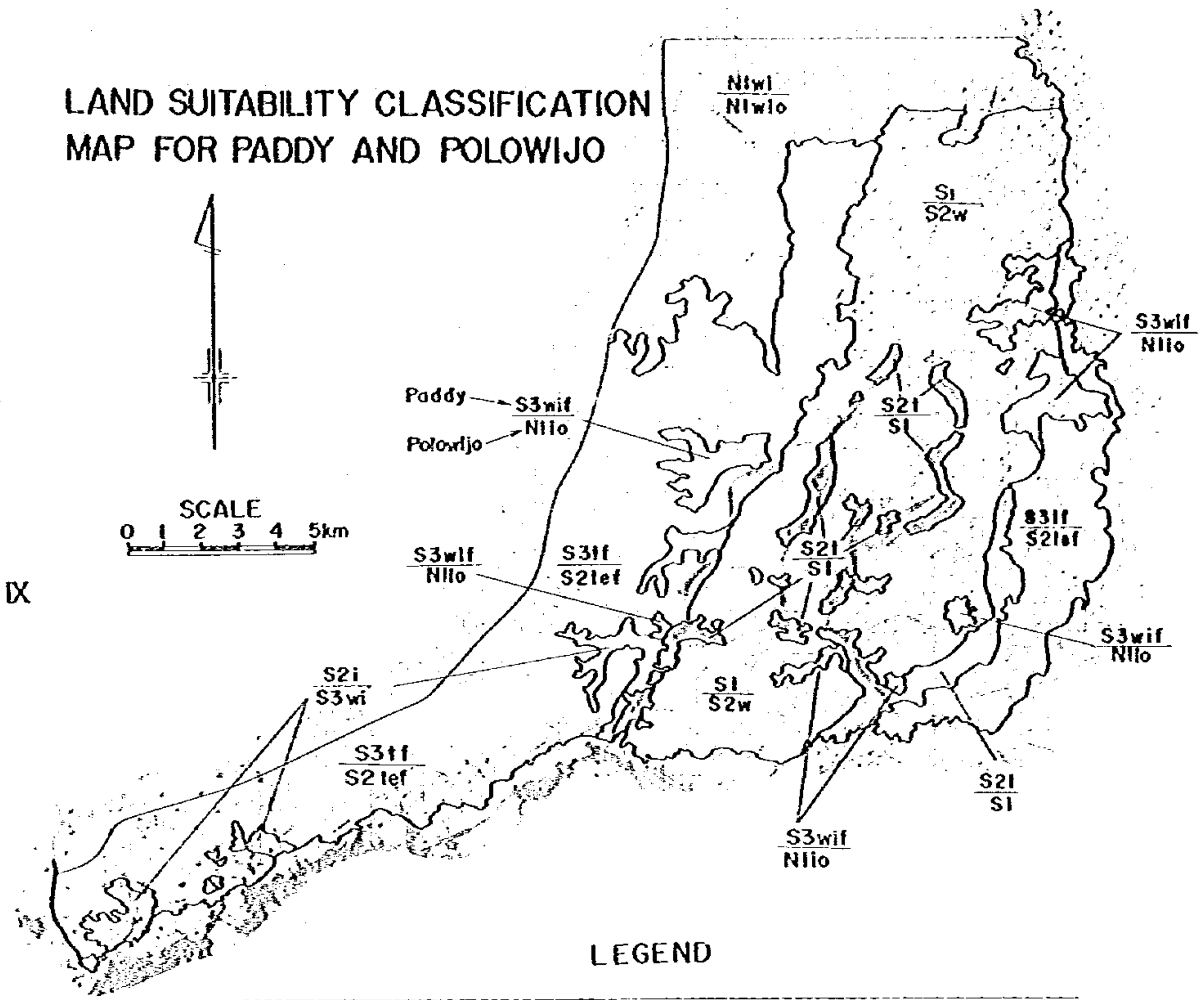
t: topography
w: drainability
o: acidity
e: erosion
i: inundation
f: fertility

Fig.II-2 SOIL AND LAND SUITABILITY CLASSIFICATION MAPS IN THE LEMPUING AREA



LEGEND

Mapping Symbol	Soil Mapping Unit	Associated Soil	Land Form	Soil Survey Area ha	Soil Survey Area %
I	Yellowish Brown Podzolic Soils	-	Peneplain	2,400	8.1
II	Reddish Brown Podzolic Soils	-	Peneplain	10,400	35.1
V	Grayish Yellow Brown Alluvial Soils	Brown Hydromorphic Soils	Natural levee River terrace	1,700	5.3
VIII	Low Humic Gley Soils	Brown Hydromorphic Soils Humic Gley Soils	Alluvial Plain Inland valley	3,700	29.4
IX	Humic Gley Soils	Organic Soils	Depression	6,400	21.5
	Total			29,600	100.0



LEGEND

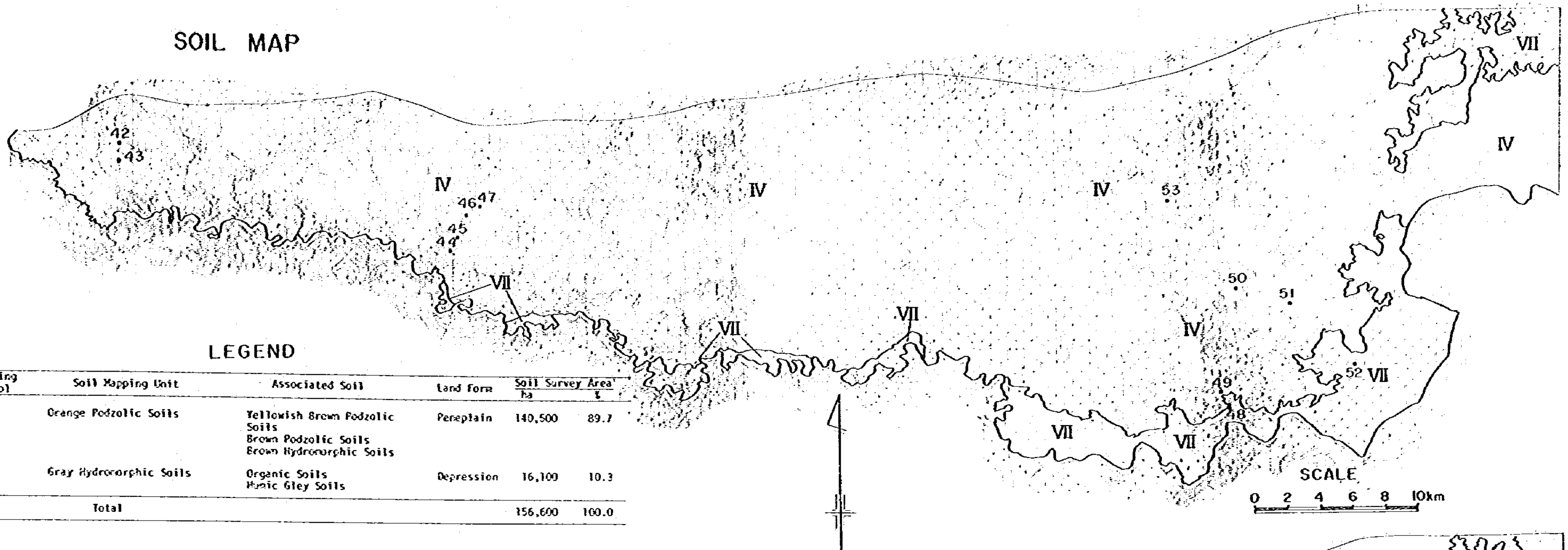
Grade	Suitability Class	Suitability Sub-class Paddy	Suitability Sub-class Polowijo	Survey Area ha	Survey Area %
I.	Highly suitable	S1	S2w	7,900	26.8
II.	Moderately suitable	S2t	S1	1,700	5.7
		S2i	S3wi	800	2.7
III.	Marginally suitable	S3tf	S2tef	12,800	43.2
		S3wif	N1io	800	2.7
IV.	Currently non-suitable	N1wi	N1wio	5,600	18.9
	Total			29,600	100.0

Following abbreviated symbol letters indicate the limiting factor.

t: topography
w: drainability
o: acidity
e: erosion
i: inundation
f: fertility

Fig. II-3 SOIL AND LAND SUITABILITY CLASSIFICATION MAPS IN THE TULANGBAWANG AREA

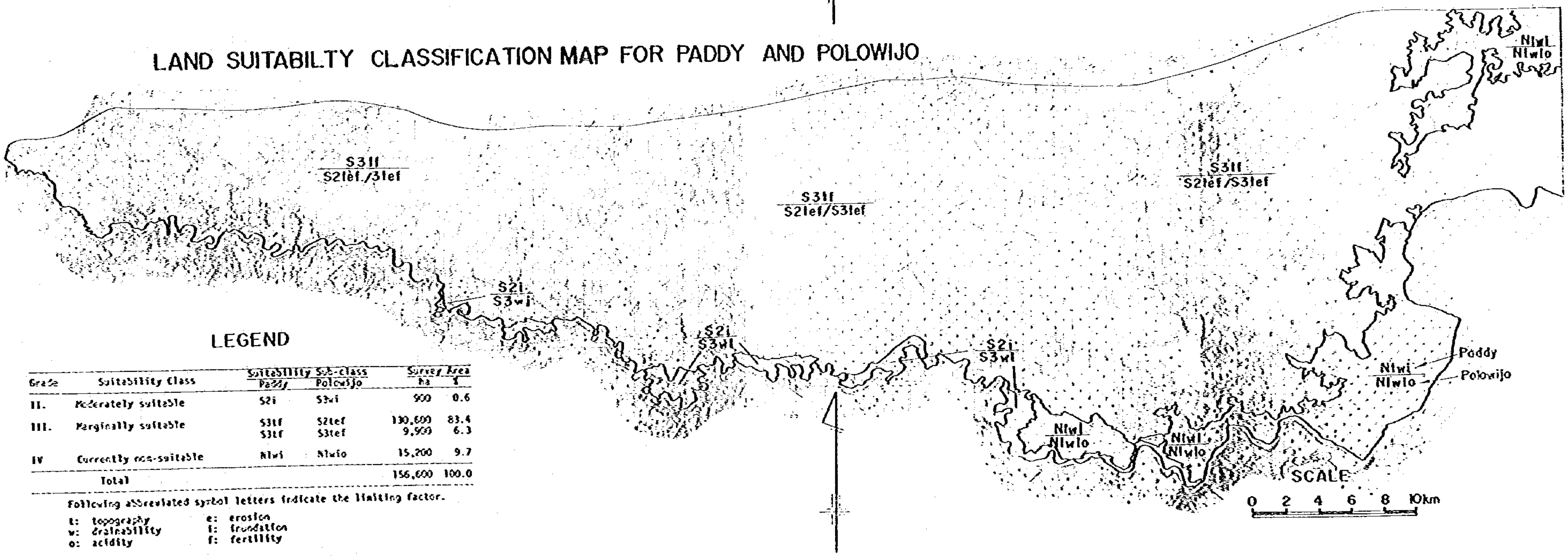
SOIL MAP



LEGEND

Mapping Symbol	Soil Mapping Unit	Associated Soil	Land Form	Soil Survey Area ha	Soil Survey Area %
IV	Orange Podzolic Soils	Yellowish Brown Podzolic Soils Brown Podzolic Soils Brown Hydromorphic Soils	Peneplain	140,500	89.7
VII	Gray Hydromorphic Soils	Organic Soils Humic Gley Soils	Depression	16,100	10.3
	Total			156,600	100.0

LAND SUITABILTY CLASSIFICATION MAP FOR PADDY AND POLOWIJO



LEGEND

Grade	Suitability Class	Suitability Sub-class Paddy	Suitability Sub-class Polowijo	Survey Area ha	Survey Area %
II.	Moderately suitable	S2i	S3wi	900	0.6
III.	Marginally suitable	S3tf S3tf	S2tef S3tef	130,600 9,900	83.4 6.3
IV	Currently non-suitable	N1wi	N1wio	15,200	9.7
	Total			156,600	100.0

Following abbreviated symbol letters indicate the limiting factor.

t: topography
w: drainability
o: acidity
e: erosion
i: inundation
f: fertility

ANNEX III

GEOLOGY

ANNEX - III

GEOLOGY

1. GENERAL GEOLOGY OF THE UPPER KOMERING BASIN

1.1 Summary

The upper Komering river basin is situated in the northeastern wing of the Barisan mountain range which forms the backborn of Sumatra Island and extends some 1,650 km from the northern Aceh in the north to Semangko bay in the south. The basin is divided topographically and geologically into the following six belts running in parallel to the Barisan, forming a wide zonal structure from southwest to northeast.

Zone	Name	Width (km)	Altitude (m)	Geology	Proposed Facilities
(1)	Barisan mountain range	-	>1,000	N-Gr, Ya	-
(2)	Ranau depression	5	400-600	Rt	Ranau P/S
(3)	Hilly mountain land	10	400-800	Tl, Rt	K-1,K-2 dam & P/S
(4)	Undulating hilly land	25	150-300	Tl,Bl,Rt,Tr	Muaradua dam
(5)	Garba mountain range	15	300-800	P-Gr,Mes,Oa	-
(6)	Lower undulating hilly land	25	150 >	Plm	Intake weirs & Canal

Note; P/S - (power station), K-1 (Komering No.1), K-2 (Komering No.2).

The Selabung river originates from the Lake Ranau situated in zone-(2), Ranau depression, and flows down for about 20 km northwestward along the depression forming a narrow and deep gorge in the welded tuff which fills up the depression. The Selabung river joins the Baru river and makes a right angle turn to northwestward at about 1-km upstream of the Komering No.1 damsite. The Komering No.2 damsite is located in the northeastern margin of zone-(3), Hilly mountain land, in which the Selabung river forms a strip of terrace-like bench and a narrow ravine dissecting the welded tuff. Then, the Selabung river flows down northeastward through zone-(4), Undulating hilly land, which is mainly underlaid by the Tertiary sedimentary rocks, as a consequent valley until the Muaradua damsite. The Muaradua damsite is located at just downstream of the confluence with the Saka river, from which confluence the Komering river begins. (As shown in Fig. III-1 and Fig. III-2)

1.2 Stratigraphy

The geological strata distributing in the basin are stratigraphically classified into the following succession;

Quarternary	Holocene	River-bed Deposit	
		Young Volcanic Products(Ya)	andestic lava
	Pleistocene	Terrace Deposit(Tr)	
		Ranau Tuff(Rt)	acid volcanic ash; welded tuff
Tertiary	Pleiocene	Palembang Formation(Plm)	sandstone, mudstone
	Miocene	Telisa Formation(Tl)	sandstone, marl, shale
		Baturaja Limestone(Bl)	
		Old Andesite(Oa)	
		Granite(N-Gr)	
Mesozoic	Cretaceous	Granite(P-Gr)	
		Garba Series(Mes)	slate

1.3 Geological Structure

The eastern wing of the Barisan mountains range in this area consists of topographically, several zones running from NW to SE, being closely correlated with geological structure as shown in Fig. III-1 and III-2. They are, from west to east, explained briefly as follows:

(1) Barisan mountains range shows a flat skyline in altitude ranging from 1,000 m to 1,500 m consisting of Neogene granite and igneous rocks with several higher summits of young volcanic cones in altitude from 1,700 m to 1,900 m. In the eastern side of the range, namely the watershed of the Komering river, the mountains are bordered by steep slopes formed by a block faulting which has been developed since the late Pleiocene, and also formed the following zone adjoining at the east.

(2) Ranau depression (Semangko graten) is in altitude ranging from 400 m to 600 m, running in parallel to the general structure in this area, i.e. NW-SE direction, width of 5 km. The Ranau depression is the northern stretch of the Semangko graben which is a typical rift-structure connected with tensional movements. The lake Ranau occupies the south-eastern part of the depression, and is a volcano-tectonic basin which was formed couldron shaped subsidence. The south-eastern side of couldron was filled with lava produced during subsequent eruption of the conical volcano of Genung Seminoeng (EL. 1,881 m), and the south western side is bordered by steep fault escarpment. Eruptions in the past at the Ranau couldron filled the Ranau depression northwestward as pyroclastic flows partially welded, and spread in the north-east direction covering the hilly mountain land as a aelian tuffs.

The Kuala river, i.e. the uppermost reach of the Komering, is the only outlet of the lake Ranau, and flows for about 20 km northwestward dissecting deeply the Ranau depression to form a narrow gorge, changing the name of river to the Selabung, until it joins with the Baru river which comes from the opposite direction in the depression. The Selabung river makes a right angle turn northeastward across the following hilly mountain land.

(3) Hilly mountain land is in altitude ranging from 400 m to 800 m forming a 10 km-wide belt consisting of sedimentary rocks of Telisa formation of the Tertiary, partially being covered by young andestic volcanic products. The Selabung river penetrates the hilly mountain land straightly northeastward forming a deep and narrow ravine joining numerous small streams. Interesting facts are that the terrace-like

bench at height of 60 m to 100 m from the river bed is developed along the Selabung river in width of about 200 m in both of the bank, and the side wall of ravine consists of welded tuff obviously being the same rock with it in the Ranau depression, though the hilly mountain adjoining the terrace-like bench consists of the Tertiary sedimentary rocks. These facts suggest that the present valley of the Selabung has been already a valley or depression which dissected the Tertiary prior to the Ranau eruption.

The pyroclastic flow from the Ranau volcano has come down through the Ranau depression and the old Selabung valley, covering the old topography developed in the Tertiary sedimentary rocks, and filling up the valley forming a terrace-like bench along the Selabung.

The proposed Komering No.1 and No.2 dams and power stations are located in the ravine of Selabung in this zone. The site geology, especially the boundary condition between the welded tuff and the Tertiary sedimentary rocks should be clarified to estimate bearing capacity and water seepage in the dam foundation.

(4) Undulated hilly land has a width of 20 km to 25 km in altitude ranging from 150 m to 300 m, descending gradually northeastward to Muaradua where the Selabung joins with the Saka river and is called as the Komering river in the down stream. This area is underlaid by the Tertiary sedimentary rocks of the Telisa formation, covered by acid volcanic ash of the Ranau tuff at the hilly area and also by the terrace and fluvial deposits along the rivers.

The Telisa formation is broadly folded with low to moderate dip into a northwest-trending syncline, therefore the bed dips south in the Muaradua damsite which is located slightly downstream of the confluence of the Selabung and the Saka river, and dips north near the Komering No.2 damsite.

(5) Garba mountains range has a width of 15 km in altitude ranging from 300 m to 800 m, showing a gentle skyline being similar to a peneplain. The Komering river flows down through the range forming a comparatively wide valley with a width of river channel of 100 m to 150 m. The Garba mountain range consists of the Pre-Tertiary basement complex such as Cretaceous slate and intruded granite covered by the Tertiary andesite.

(6) Lower undulating hilly land extends over the area from the foothill of Garba mountains to 25 km northeastward in altitude less than 150 m. The area is underlaid by Pleistocene formation of soft tuffaceous sandstone and mudstone, and partially covered by recent fluvial deposits of the Komering river.

1.4 Location of Proposed Facilities

The proposed Ranau Power scheme is located in zone (2), Ranau depression, and the Komering No.1 and No.2 power schemes are located in zone (3), hilly mountain land.

The Muaradua damsite is planned at the northeastern boarder of zone (4), undulated hilly land. Some of construction materials, for instance, impervious core material of fill-type dam will be obtained from zone (5), Garba mountain range.

Lower part of zone (6) will be irrigated with the proposed irrigation networks.

2. GEOLOGICAL INVESTIGATION CARRIED OUT

2.1 General

The geological investigation was carried out in the following items and quantities in accordance with the Inception Report dated on July 1981;

Geological Investigation

Item	Quantity and Description		
Field Reconnaissance	Komering No.1, No.2, Muaradua damsite, Ranau Power Station. Preliminary reconnaissance covering whole area of the Upper Komering basin.		
Electric Sounding with vertical resistivity method	Muaradua damsite	7 points	
	Komering No.1 damsite	5 points	
	Komering No.2 damsite	5 points	
	Ranau power station	2 points	
	Total	19 points	
Boring Investigation with coring in 66 mm, water pressure test, and standard penetration test.	Muaradua damsite	5 holes	250 m
	Komering No.1 damsite	2 holes	200 m
	Komering No.2 damsite	2 holes	230 m
	Ranau power station	1 hole	100 m
	Total	10 holes	780 m

Among the above items, the field reconnaissance, electric sounding and geological mapping were performed by the Expert with a close co-operation made by his Indonesian counterparts.

The boring investigation is still being carried out by the local contractor of DPU and 60% of total quantity have been completed as of December 20, 1981.

As for the technical details of boring investigation, the technical specifications describing the methods of field work and data interpretation were proposed in the Inception Report.

2.2 Vertical Electric Sounding

2.2.1 Method of Sounding

Vertical electric sounding was carried out to outline the geological conditions, especially the thickness of overburden in the proposed damsites and Ranau power station site.

Generally, vertical electric sounding is effective for investigation of soft and loose deposits forming a flat ground surface, but not so effective for investigation of rock foundation. However, in the Komering basin, topography in damsites are characterized by the existance of wide terrace or terrace-like bench as follows:

Damsite	Elevation of terrace	Proposed crest of dam
Komering No.1	EL. 430 - 450 m	EL. 423 m
Komering No.2	EL. 280 - 300 m	EL. 255 m
Muaradua	EL. 140 - 150 m	EL. 143 m

Thickness of terrace deposits may restrict the heighest water level of the reservoir. Therefore, for a quick determination of overburden, vertical electric sounding was applied for the investigation.

As for the theory and method of vertical electric sounding applied in this study, a detailed instruction note was submitted to the Provincial P3SA as "Technical Note on Engineering Geology", so that the description is not made in this report.

2.2.2 Results of Sounding

The result of VES (vertical electric sounding) are shown in Fig. III-3 (ρ - a curve) plotting the relationship between the specific resistivity (ρ_a) and electrode spacing (a) on a log-log coordinate.

The analysis of VES data shown in the (ρ- a) curve as the resistivity log reveals the following geological conditions in each site;

a) Muaradua damsite

Layer	Resistivity	Depth until
Top-soil	58 - 230/m	0.4 - 1.5 m
Terrace deposit	53 - 240/m	1.4 - 9.6 m
Sandstone	13 - 47/m	-
Mudstone	less than 12/m	

Overburden including top-soil and terrace deposit covers thinly over the site in thickness ranging from 0.4 m to 4.2 m in general. But at MD-1 point, a high resistivity layer with a thickness of 9.6 m was found. This condition was also confirmed by the boring investigation in BH.M-2, where a coarse sand layer with thickness of 9.5 m covers the bedrock. These facts induce an assumption that an old river channel deeply dissected in the bedrock has been filled with the terrace deposits consisting of coarse sand.

b) Komering No.1 damsite

Layer	Resistivity	Depth until
Top-soil	60 - 130/m	0.2 - 0.9 m
Volcanic ash	52 - 300/m	1.5 - 5.5 m
Welded tuff	520 - 1,500/m	-

In this site, as clarified by soil mechanical survey and boring investigation, the terrace-like benches in the right bank are covered with volcanic ash and underlaid by welded tuff without any intercalation of terrace deposit. Poundation of dam may be entirely composed of welded tuff.

c) Komering No.2 damsite

Layer	Resistivity	Depth until
Top-soil	160 - 460/m	0.5 - 0.7 m
Terrace deposit	60 - 253/m	2.0 - 14.5 m
Welded tuff	480 - 1,013/m	-

Terrace deposit distributes widely along the flat benches in both banks. The thickness of the deposit ranges from 5.6 m 14.5 m in the right bank and from 2 m to 2.2 m in the left bank. This condition should be taken into consideration for decision of the full water level of reservoir.

d) Ranau power station site

Layer	Resistivity	Depth until
Top-soil	165 - 230/m	0.4 - 0.7 m
Terrace deposit	1,650 - 1,840/m	10 - 14 m
Welded tuff	413 - 460/m	34 - 36 m
Volcanic rocks	690 - 825/m	-

Remarkable fact is that the terrace deposit in this area has a very high resistivity of 1,650 - 1,840/m, and thickly distributes over the area. The composition of terrace deposit in this area is likely to be of a unsaturated sand and gravel.

A boundary between the welded tuff and volcanic rocks is assumed in the deep subsurface. These conditions may affect to the selection of location and design of power station.

2.3 Boring Investigation

2.3.1 Muaradua Damsite

The following items were investigated with 5 bore holes of 250 m in total length.

- Thickness of the overburden and weathered zone of the bedrock
- Hardness of compactness of sandstone in the bedrock
- Permeability of the bedrock under high water pressure
- Bearing capacity of the overburden

Results of boring investigation are shown in Fig. III-8 "Summary of Drill Log", and reveal the following matters;

(a) Overburden consists of acid volcanic ash and terrace deposit. Acid volcanic ash distributes over the hill which forms the left abutment, with thickness of 5 m at B.M-1. Terrace deposit is composed of coarse sand and covers the peninsular-like flat terrace in the left bank, with thickness of 9.6 m at B.M-2 and B.M-3. Results of standard penetration tests indicate that acid volcanic ash has a relatively low bearing capacity as N-value being less than $N = 8$, namely, the ultimate bearing capacity less than 5 tons/m^2. Meanwhile, the bearing capacity of terrace deposit is estimated to be $q_u = 31$ tons/m^2 from $N \geqq 25$.

(b) The bedrock is composed of sedimentary rock of Telisa formation, chiefly grained sandstone intercalated with conglomerate and mudstone layers. Coarse grained sandstone layer is an alternation of well compacted arkosic sandstone and loosely compacted fine to medium grained tuffaceous sandstone, with a thickness of unit layer of 0.3 m to 0.7 m.

(c) Permeability of the bedrock is rather low as $Lu = 1$ to 5 according to the water pressure test so far conducted.

2.3.2 Komering No.1 Damsite

The following items were investigated with 2 bore holes of 200 m in total length.

- Thickness of acid volcanic ash covering welded tuff, and weathered zone of welded tuff
- Compactness of welded tuff and interbedding volcanic ash and/or sedimentary materials.
- Permeability of welded tuff under high water pressure

Results of boring investigation are shown in Fig. III-8 "Summary of Drill Log", and reveal the following matters:

(a) Acid volcanic ash distributes widely over the terrace-like flat benches which form both abutments, with thickness ranging from 2 m to 6.6 m, in very soft condition.

(b) A deep weathered zone was determined to be welded tuff as investigated at B.K1-1 to the depth of 18.8 m and at B.K1-2 to the depth of 28.4 m. In this weathered zone, boring cores were hardly recovered and cuttings of coarse quartz and feldspar particles were obtained.

(c) In B.K1-1, the base of welded tuff was found at depth of 89.3 m. Mudstone likely of the Telisa formation, underlie the welded tuff with the interbedded "old talus deposit" with a thickness of 8.7 m.

(d) Permeability of welded tuff underlying "old terrace deposit" and mudstone is slightly high; Lu = 6 to 24 according to the water pressure tests so far carried out.

2.3.3 Komering No.2 Damsite and Ranau Power Station Site

Boring investigation is still going on as of December 20, 1981, so that the results will be described in the Final Report.

3. SITE GEOLOGY

3.1 General

Site geology in each proposed facility is summarized as follows, but this study is only tentative and subject to revision based on the final results of boring investigation which is still going on at the Komering No.2 dam site and Ranau Power station site.

3.2 Muaradua Damsite

3.2.1 Topography

The site is located at about 1.5-km west of Muaradua; just downstream of the confluence of the Selabung river and the Saka river. Topography in the surroundings of damsite consists of three units, namely, the hills with flat skyline at altitude of 160 - 170 m, the terrace at altitude of 125 - 135 m and the present river-bed at altitude of 115 - 120 m.

At the damsite, hills in the left bank and right bank are about 500 m apart each other across a wide terrace. The present river-bed has been formed by re-dissecting of the terrace, forming a shallow valley with a width of about 100 m and meandering in a wide range.

The axis of dam runs through a peninsular-like terrace formed by meadering of the Komering river in the left bank, and abuts to gentle hill-slopes in both of the banks.

3.2.2 Geology

The bedrock in damsite consists of sedimentary rocks, chiefly grained sandstone with intercalations of conglomerate and mudstone layers. These sedimentary rocks are assumed to be a part of the Telisa formation of Tertiary in age. Telisa formation in the damsite dips 15^o - 20^o southwestward, namely, dipping from the downstream to the upstream, from the left to the right bank.

Coarse grained sandstone layer is composed of alternation of well compacted arkosic sandstone and loosely compacted fine to medium grained tuffaceous sandstone, with thickness of an unit layer of 0.3 m to 0.7 m. Conglomerate crops out in the point of peninsular-like terrace in the left bank, and is composed of fine grained gravels scattering in arkosic matrix well compacted.

In the bore-hole B.M-4, a mudstone layer with thickness of about 5 m was found at the depth from 38 m to 43 m, and the same mudstone layer crops out in the river-bed at the point of about 200 m downstream of the damsite. Computed degree of the dip of mudstone connecting the bore-hole and the outcrop results in 15° which is almost same with the general dip of the Telisa formation measured in the damsite, so that any tectonical disturbance in the Telisa formation will not be assumed in the damsite.

Terrace deposit consisting of medium to coarse grained sand with rounded cobble sized gravels covers the Telisa formation over the peninsular-like terrace. The thickness of the terrace deposit ranges within 3 m according to the result of Vertical Electric Sounding and boring investigation. However, the maximum thickness of the terrace deposit was determined to be 9.6 m at the bore-hole B.M-2 where an old river channel deeply dissected in the bedrock is assumed.

Acid volcanic ash of a part of the Ranau Tuff distributes only on the flat top of hills in both banks, with thickness less than 5 m. Volcanic ash is of white-colored loose layer affected by a slight argillization, and contains many cobble sized pumice.

River-bed deposit distributes over the upstream area of the confluence, forming a wide flood channel, and is composed of sand and cobble sized gravel. At the damsite, river-bed deposit was not seen due to cover of flowing water.

The geological map and profile of the damsite are shown in Fig. III-6 and Fig. III-7.

3.2.3 Dam Foundation

(1) Bearing capacity of bedrock might be insufficient as a foundation of high concrete gravity dam due to existence of loosely compacted tuffaceous sandstone in the bedrock. Fill type dam will be preferable.

(2) Permeability of bedrock is rather low as measured in the bore-holes, and show the Lu value of 1 to 5 in general. Watertightness of the bedrock might be obtainable with an ordinal grout curtain.

(3) Bearing capacity of terrace deposit is expressed as the angle of internal friction corresponding to the compactness and density of the deposit. At the damsite, the angle of internal friction of the terrace deposit ranges from $\phi = 35^\circ$ to 40° according to the result of standard penetration test as follows;

$$\phi = \sqrt{12 \times N} + 20^\circ$$

where, ϕ ; angle of internal friction,

N ; N-value by standard penetration test,

$N \geqq 25$ at the damsite.

Meanwhile, the angle of internal friction of the proposed banking materials of dam is assumed to be $\phi = 35^\circ$ in the maximum, so that the terrace deposit might be sufficient in bearing capacity as the base of dam body.

(4) Height of bedrock surface in the abutment was determined as to be higher than EL. 150 m by geological mapping at the damsite and to be high enough against the proposed crest of dam; EL. 143 m.

3.3 Komering No.1 Damsite

3.3.1 Topography

The site is located at about 35 km southwestward of Muaradua town; about 18 km northwestward of the Lake Ranau. In the surroundings and upstream area of the site, a wide terrace in a width of 200 m to 300 m is developed in both banks at the altitude of EL. 430 - 440 m with gentle undulations.

The Selabung river deeply dissects the terrace; until EL. 350 m, forming a steep and narrow gorge with a width of 100 - 130 m and a depth of 80 - 90 m.

3.3.2 Geology

Geology of the site consists mainly of welded tuff covered with acid volcanic ash and underlain by the Tertiary sedimentary rocks. Welded tuff and acid volcanic ash are assumed as the pyrocalstic flow facis and the aeolian tuff facis of the Ranau tuff respectively.

The Tertiary sedimentary rocks consisting of very weathered mudstone were found in the bore-hole B.K-1 at the depth of 98 m together with the old talus deposit which is composed of well consolidated sandy clay and angular to semi-rounded shaped gravels with a thickness of 8.7 m. In this hole, the total thickness of welded tuff was determined to be 84.3 m. The base of welded tuff (EL. 331 m in B.K-1) is situated at 19 m below the river-bed of the Selabung (EL. 350 m). Shape of old topography presently covered by the Ranau tuff might be irregular and should be clarified in the future study. However, according to the results so far inspected in the field reconnaissance, the Tertiary sedimentary rocks does not crop out nearby the damsite.

Welded tuff crops out in the slope of valley below EL. 410 m, forming steep or vertical cliffs. Vertical block joints are developed over the welded tuff at interval of 2 m - 3 m, and horizontal joints gently inclined towards upstream are seen. Welded tuff is greyish white colored and massive rock being moderately so hard as to hammer rebounding with dull sounds making slight dent, and composed of scattering phenocryst of quarz, mica and feldspars in the maximum size of 1.5 mm and glassy coarse goundmass. Pumices in diameter of 5 to 8 cm are also contained in ratio of 4 - 6 pieces per 20 x 20 cm surface area of welded tuff.

Volcanic ash is white colored soft layer covering welded tuff over the terrace with thickness of 3 m to 5.5 m, and is composed of glassy ash and small fragments of pumice. Near the ground surface, volcanic ash has been altered and argillized by superficial weathering.

In the riverbed, bedrock is covered by sand and gravel with a large amount of boulders consisting chiefly of hard volcanic rocks such as andesite and tuff breccia in the maximum diameter of 80 cm, and with small amount but in big diameter of more than 150 cm of welded tuff boulders shaped in semi-rounded. The geological profile is shown in Fig. III-4.

3.3.3 Dam Foundation

(1) Bearing capacity of welded tuff should be the basic data to select the suitable type of dam. However, it is very difficult to estimate the value without a result of in-place rock shearing test at present. Generally speaking, bearing capacity, namely, shearing strength of welded tuff, varies in a wide range corresponding to the degree of welding. In this damsite, welded tuff seems relatively so soft as to allow breaking by hand-hammer, and to have rather low shearing strength less than 10 kg/cm^2. Therefore, a fill-type dam might be suitable for this site.

(2) Old talus deposit and mudstone were found in B.K1-1, and the base of welded tuff is situated at EL. 331 m; about 19 m below the present river-bed. As for the permeability of old talus deposit and mudstone, water pressure test in the bore-hole showed rather low Lugeon value, namely Lu = 7 to 9, likely due to clayey matrix and very consolidated condition of the deposit as seen in the boring core-sample. In view of the load acting since welded tuff filled up the old topography, the old talus deposit has already been consolidated by the weight of total thickness of welded tuff, and the weight was removed by erosion afterward. In case of a fill type dam constructed, the load of dam acting to old talus deposit might be less than the weight of welded tuff already eroded, since the height of dam will be 85 m, and the depth of eroded valley is assumed to be more than 90 m.

Therefore, subsidence of the foundation by weight of dam body might be considerably small, and existence of the old talus deposit would not be the essential defect as a foundation of fill type dam, though a dense and thick grout curtain should be required to cut-off the seepage of the storaged water through the old talus deposit.