REPUBLIC OF INDONESIA

MINISTRY OF PUBLIC WORKS

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

# FEASIBILITY STUDY
# ON
# AIR SELAGAN IRRIGATION PROJECT
# IN BENGKULU PROVINCE

## VOLUME II

## APPENDIX

I METEOROLOGY AND HYDROLOGY
II GEOLOGY AND SOIL MECHANICS
III SOIL AND LAND SUITABILITY
IV AGRICULTURE AND AGRO-ECONOMY
V IRRIGATION AND DRAINAGE
VI IMPLEMENTATION SCHEDULE AND
COST ESTIMATE
VII PROJECT ORGANIZATION AND MANAGEMENT
VIII PROJECT EVALUATION

NOVEMBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

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## SUMMARY

The tentative feature formulated fot the Air Selagan Irrigation Project is summerized below.

| | |
|---|---|
| Survey Area | Both banks of Selagan river about 22,400 ha |
| Project Area | 14,800 ha |
| Gross Farm Area | 8,000 ha |
| Gross Irrigable Area | 4,700 ha |
| Net Irrigable Area | |
| Wet Season | 4,200 ha |
| Dry Season | 4,200 ha |
| Gross Plantation Area | 2,500 ha |
| Net Plantation Area | 2,200 ha |
| Palawija Area | 800 ha |
| Yield and Production | |
| Yield | 5.0 tons (Wet & dry season paddy) |
| Production | 42,000 tons (Paddy) |
| | 46,200 tons (Oil palm) |
| | 5,596 tons (Peanuts,soybean,maize) |
| Benefisheries | |
| Paddy | 2,800 households |
| Oil palm | 1,100 households |
| Transmigrants & Local People | |
| Existing(paddy) | 750 households |
| Planned (Paddy) | 340 households |
| Proposed new(paddy) | 1,010 households |
| Local (paddy) | 700 households |
| Proposed new(oil palm) | 550 households |
| Proposed new(PELAMBAH,oil palm) | 550 households |
| Land Distribution Per Household: | |
| Transmigrants for paddy | |
| Home yard | 0.25 ha |
| Net paddy field(LU.I+LU.II) | 1.50 ha |
| Palawija(LU.II) | 0.25 ha |
| Total | 2.00 ha |
| Transmigrants for plantation | |
| Home yard | 0.25 ha |
| Palawija | 0.25 ha |
| Net Oil palm field | 2.00 ha |
| Total | 2.50 ha |
| Local people for paddy | |
| Net paddy field | 1.50 ha |
| Water Sources | Selagan river |
| Diversion Facility | Selagan weir |
| Location of Weir | 2.3 km upstream of Kp. Lubuk Sahung |
| Catchment Area | 375 km2 |
| River Bed Elevation | EL22.20 m |
| Weir Height | 3.80 m |
| Weir Crest Elevation | EL26.00 m |
| Length of Fixed Weir | 74.00 m |

| | | |
|---|---|---|
| Maximum Diversion Water Requirement : | | |
| Wet season paddy | : | 1.36 l/s/ha |
| Dry season paddy | : | 1.53 l/s/ha |
| Domestic water | : | 100 l/person/day, 3,000 kk |
| Design Intake Discharge | : | 6.45 m3/s |
| Design Intake Water Level | : | WS.25.90 m |
| Intake Method | : | One side intake (right bank) |
| Flood Discharge | : | 1,000 m3/s (1/100 years probability) |
| Flood Water Surface | : | HWL.30.05 (1/100) |
| | | HWL.30.85 (1/1000) |
| Highest Paddy Field | : | |
| Right bank | : | GH23.60 m |
| Left bank | : | GH20.00 m |
| Length of Main Canal | | |
| Link Canal | : | 4.6 km |
| Right bank main canal | : | 10.5 km |
| Left bank main canal | : | 14.0 km |
| Length of Secondary Canal | | |
| Rigth bank | : | 13.0 km |
| Transfer canal | : | 5.1 km (to Mukomuko kiri) |
| Left bank | : | 21.6 km |
| Length of Drainage Canal | | |
| Right bank for paddy | : | 40.1 km |
| for plantation | : | 26.9 km |
| Left bank | : | 32.7 km |
| Related Structure | | |
| Mini Hydro-electric Power Supply | | |
| Maximum generated output | : | 290 KW |
| Effective head | : | 3.50 m |
| Maximu discharge | : | 10.72 m3/s |
| Power supply | : | 100 W/household |
| Maximum benefisheries | : | 8,980 households |

# APPENDIX I

# METEOROLOGY AND HYDROLOGY

# CHAPTER 1 METEOROLOGY

## 1.1 General

The objective area is located around of 2°30' of south latitude and faces the Indian Sea. It belongs to the equator climate zone with much rainfall climatologically and on account of this location, the yearly rainfall of the area is over 3,000 mm on an average. Almost all winds blow from the Sea to the inland, meet the Barisan range, become wet ascending current of air and give much rainfall to the mountaneous area.

There are five (5) rainfall stations and one meteorological station in and around the survey area. The location of the stations are shown in Fig. I-1 and the condition of the data observation in Fig. I-2.

## 1.2 Meteorological Condition

### (1) Rainfall

The average yearly rainfall varies station by station ranging 2,500 mm to 3,800 mm in the area. The maximum daily rainfall was recorded to be 200.7 mm at Pondok Panjang in March 1988.

### (2) Evaporation

The annual evaporation is about 1,830 mm and the daily evaporation on the monthly average ranges 4 mm/day to 6 mm/day.

### (3) Wind velocity

The average annual wind velocity is 29.3 km/day and the daily wind velocity on the monthly average varies from 25.3 km/day to 35.2 km/day.

### (4) Air temperature

The average annual air temperature is 31°C and the average monthly ones range 30°C to 32°C.

### (5) Relative humidity

The average annual relative humidity shows the high value of 93% and the average monthly ones vary from 91% to 95%.

(6) Sunshine ratio

The average annual sunshine ratio is 41% and the average monthly ones range 34% to 53%.

(7) Solar Radiation

The average annual solar radiation is 332 $cal/cm^2/day$ and the average monthly solar radiations are 365 $cal/cm^2/day$ in February at the maximum and 315 $cal/cm^2/day$ in November at the minimum.

## CHAPTER 2 HYDROLOGY

### 2.1 Selagan River

#### 2.1.1 Record of River Water Level

The water levels are recorded at five (5) places shown below. The collected data up to present covers the following periods including a few periods without records.

Table EXISTING WATER LEVEL OBSERVATION STATION

| River | Station | Period |
|---|---|---|
| Air Selagan | Teras Terunjam | 1981-1989 |
| " | Ujung Padang | 1980-1989 |
| Air Manjuto | Lalang Luas | 1980-1987 |
| " | L.B. Pinang | 1981-1986 |
| Air Dikit | Sari Bulan | 1980-1986 |

Ujung Padang on the Air Selagan is located near the estuary and influenced by tidal water level.

#### 2.1.2 Record of Discharge

The discharge observation at four (4) stations except Ujung Padang influenced by tidal water level has been carried out and the rating curve at each station was made using the above discharge observation data.

Teras Terunjam at the Air Selagan

$Q = 40.582 \times (H + 0.139)^2$ 1980 - 1983

$Q = 46.708 \times (H + 0.269)^2$ 1984 - 1986

Note: The data during 1983-1984 show a tendency to increase, thus two rating curves were prepared as shown in the above.

Lalang Luas at the Air Manjuto

$Q = 28.155 \times (H + 0.178)^2$

Lubuk Pinang at the Air Manjuto

$Q = 29.141 \times (H + 0.266)^2$

Sari Bulan at the Air Dikit

$Q = 43.834 \times (H + 0.390)^2$

### 2.1.3 Monthly Discharge

Monthly discharge at the proposed weir site (Catchment area: 375 $km^2$) on the Selagan river were estimated using the discharge data at the Teras Terunjam on the Selagan river as shown in Table I-3.

### 2.1.4 Comparison between The Selagan River and Other Rivers

Catchment area and maximum elevation of the Selagan River at Teras Terunjam and other river's are shown in the following table.

CATCHMENT AREA AND ELEVATION

| Name of River | Place | Catchment Area | Maximum Elevation |
|---|---|---|---|
| Air Selagan | Teras Terunjam | 453.3 $Km^2$ | 1931 m |
| Air Manjuto | Lubuk Pinang | 566.9 | 2543 |
| " | Lalang Luas | 385.0 | 2543 |
| Air Dikit | Sari Bulan | 970.0 | 2935 |

Comparison of monthly mean specific discharge between the Selagan River at Teras Terunjam and the Manjuto River at Lalang Luas is shown in Fig. I-3.

Using the above mentioned specific discharges correlation efficient was calculated by statistical method. (See in Fig. I-4).

Judging from the correlation efficient (= 0.87), that it can be said the relationship of run-off discharge between both river is comparatively similar.

### 2.1.5 Flood

Observed flood discharge of the Selagan river at Teras Terunjam and probable discharge at weir site are as follows:

OBSERVED FLOOD DISCHARGE

| Year | 15 Mar. | Water Level | Discharge | Specific Discharge |
|---|---|---|---|---|
| | | (m) | ($m^3/s$) | ($m^3/s/km^2$) |
| 1984 | 15 Mar. | 2.42 | 338 | 0.75 |
| | 18 Mar. | 3.14 | 543 | 1.20 |
| 1985 | 28 Sep. | 3.04 | 511 | 1.13 |
| | 2 Nov. | 3.19 | 559 | 1.23 |
| 1986 | 1 Jan. | 2.66 | 401 | 0.88 |
| | 14 Mar. | 2.96 | 487 | 1.07 |
| 1987 | 14 Apr. | 3.48 | 656 | 1.45 |
| | 25 May | 3.72 | 743 | 1.64 |

(Catchment area : 453.3 $km^2$)

PROBABLE FLOOD DISCHARGE

| Probable Year | Flood Discharge | Specific Discharge |
|---|---|---|
| 1,000 | 1,316 $m^3/sec$ | 3.52 $m^3/sec$ |
| 100 | 1,000 | 2.67 |
| 50 | 913 | 2.43 |
| 20 | 806 | 2.15 |
| 10 | 731 | 1.95 |
| 5 | 656 | 1.75 |
| 2 | 556 | 1.48 |

(Catchment area : 375 $km^2$)

### 2.1.6 Sedimentation

Amount of sedimentation is estimated 33,000 $m^3$/year at the proposed weir site.

Study material is collected at Teras Terunjam in the Selagan River.

According to the collected data (see in Table I-4), amount of suspended soil is roughly estimated 33 mg/l.

Since the study material is not enough, here shows a method of calculating the amount of sedimentation out of the amount of suspended soil as an example.

| | |
|---|---|
| Average discharge at weir site | 39.57 $m^3/s$ |
| Amount of suspended soil | 33 mg/l |
| Density of sedimentation | 1.5 $ton/m^3$ |

$$q.s = 33 \times 10^{-9} \times 39.57 \times 10^3 \times 86400 \times 365/1.5$$
$$= 27,453 \ m^3/year$$

The amount of sedimentation (Q) with the condition that the amount of run-off of suspended soil is assumed 20% of the total amount;

$$Q = 1.2 \times q.s = 33,000 \ m^3/year$$

But, it may be required to continue the study by the collection of enough study material.

## 2.2 Run-off Analysis

### 2.2.1 Low Water Discharge Analysis

Run-off at the weir site to be proposed for long period is estimated based on the procedure shown in Fig. I-6.

#### (1) Rainfall Data

A rainfall station is situated at Jalinjing in the catchment area located upstream from the weir site to be planned on the Air Selagan. However, the rainfall data are not available because they have not been observed for long time, and are not reliable.

The rainfall data at the following five rainfall stations which are located in and around the study area can be obtained.

1) Pondok Kopi
2) Lalang Luas
3) Ujung Padang
4) Desa Penarik
5) Pondok Panjang

The rainfall station located at Desa Penarik in the Selagan basin is covered with bush. Thus the data may be unreliable. The rainfall data at Ujung Padang may be reliable. They, however, may not be suitable for estimating run-off from the mountainous areas because the station is located near the coast. The rainfall data at the remaining Pondok Kopi, Lalang Luas and Ujung Padang may be reliable. Therefore, they are used for low water discharge analysis after studying the correlation between rainfall and river discharge.

#### (2) Arrangements for Water Level Data

The water level data are obtainable at the following five stations; Teras Terunjam and Ujung Padang in the Air Selagan, Lalang Luas and LB. Pinang in the Air Manjuto, and Sari Bulan in the Air Dikit.

In the above, Ujung Padang station is located at the river mouth of the Air Selagan which is affected by sea level fluctuation, and the remaining four stations are located in the middle reaches of the Air Selagan. From the viewpoints of the basin form, and run-off characteristics, they are comparatively similar each other. However, the water level data at all the stations have been observed insufficiently. Consequently, the water level data at Teras Terunjam where is located 8 km downstream from the weir site to be proposed are employed for low water discharge analysis, and the water level data at other stations are used for comparative study of specific discharge.

(3) Establishment of Rating Curve

Discharge measurement have been carried out four stations excepting Ujung Padang station which is affected by sea level. The rating curves were made by applying the least square method using the above discharge data.

Teras Terunjam at the Air Selagan

$Q = 40.582 \times (H + 0.139)^2$ 1980 - 1983

$Q = 46.708 \times (H + 0.269)^2$ 1984 - 1986

Note: The data during 1983-1984 show a tendency to increase, thus two rating curves were prepared as shown in the above.

Lalang Luas at the Air Manjuto

$Q = 28.155 \times (H + 0.178)^2$

Lubuk Pinang at the Air Manjuto

$Q = 29.141 \times (H + 0.266)^2$

Sari Bulan at the Air Dikit

$Q = 43.834 \times (H + 0.390)^2$

(4) Calculation of River Discharge

The discharge table is made by the use of the water level which were actually observed and the above rating curves.

(5) Low Discharge Analysis

After studying the correlation between rainfall and discharge, the tank model method was applied for low discharge analysis. In the analysis, the following data were used.

Rainfall data - at Pondok Kopi
(In case the data are insufficient because of no observation, the data at Lalang Luas are used.)

Discharge data - at Teras Terunjam
C.A. = 453.3 $km^2$

The discharge was observed during the period from 1981 to 1987. The low discharge was analyzed by using the data of 1981 and 1982 after studying correlation between the discharge and rainfall and no observation of the data.

(6) Determination for Tank Model Factors

For the purpose of long-term low discharge analysis, a four-step tank is applied. Rainfall is put into the first upper tank, and evapotranspiration is deducted from it. In the case when evapotranspiration is short in the first tank, it is deducted from the second, third and fourth tank. Based on the above conditions, the tank model factors are obtained by trial as shown in Fig. I-7.

(7) Review of Tank Model

In order to review whether or not the decided tank model factors are reliable, several trials are made (see Fig. I-8).

The ration of calculated discharge to observed discharge is obtained below.

| Year | Calculated Discharge (Average Discharge) | Observed Discharge (Average Discharge) |
|---|---|---|
| 1981 | 47.6 $m^3$/sec | 46.5 $m^3$/sec * |
| 1982 | 44.4 | 49.1 ** |
| Average | 46.0 | 47.8 |

* Data for December is not included because of no observation.

** Data for August is not included because of no observation.

$$\text{Error} \quad \frac{46.0-47.8}{47.8} = -0.038$$

(The error is about 4%. In the case of low discharge analysis, however, it can be neglected.)

(8) Run-off at Weir Site

River discharge at the proposed weir site with catchment area of 375 $Km^2$ is obtained using the tank model formulated in (6) and daily rainfall data at Pondok Kopi (1981 - 1988).

(a) Yearly discharge

Yearly discharges are obtained as follows;

| | |
|---|---|
| 1981 | 1,248 x $10^6$ |
| 1982 | 1,079 x $10^6$ |
| 1983 | 1,494 x $10^6$ |
| 1984 | 1,082 x $10^6$ |
| 1985 | 995 x $10^6$ |
| 1986 | 1,092 x $10^6$ |
| 1987 | 1,363 x $10^6$ |
| 1988 | 1,639 x $10^6$ |
| Average | 1,249 x $10^6$ $m^3$ |

Yearly total volume of run-off fluctuates from 995 x $10^6$ to 1,639 x $10^6 m^3$ and the average is estimated at 1,249 x $106 m^3$.

(b) Monthly Discharge

Monthly average discharge at the proposed weir site are obtained as in Table I-3 and drought discharges occur in May to August.

(c) Ten Days Discharge

Ten days discharges are obtained as in Table I-5.

2.2.2 Flood Run-off Analysis

The following methods are named to estimate flood discharge:

i) Rational Methods

- Melchior (catchment are > 100 $km^2$)
- Rational formula
- Haspers

ii) Unit Hydrograph

iii) Storage Function Method

The daily rainfall data are available at five stations in and around the study area.
The detailed analysis by the foregoing methods are discussed below.

(a) Probable Rainfall

The maximum daily rainfall at the stations are shown in Table I-6.

Iwai's method and Gumbel-Chow's method are applied to obtain the probable rainfall. The calculation results are shown in the following tables.

The probable rainfall varies widely due to the rainfall data having short period observation. To be on the safe side, however, the probable rainfall at Pondok Panjang indicating large values which are obtained by the application of Iwai's method are adopted.

Probable Daily Rainfall

Iwai's Method

| Return Period | Pondok Kopi | Jalinjing | Lg.Luas | Ujung Padang | Penarik | Pondok Panjang |
|---|---|---|---|---|---|---|
| 1/1,000 | 309.7 | 187.4 | 222.0 | 282.9 | 253.8 | 349.9 |
| 1/200 | 267.3 | 165.9 | 193.3 | 251.0 | 224.3 | 289.6 |
| 1/100 | 248.9 | 156.0 | 181.4 | 236.7 | 210.9 | 265.8 |
| 1/50 | 230.2 | 145.5 | 169.6 | 221.8 | 196.9 | 243.1 |
| 1/20 | 204.8 | 130.5 | 154.1 | 200.9 | 177.3 | 214.8 |
| 1/10 | 184.6 | 117.8 | 142.4 | 183.8 | 161.0 | 194.4 |
| 1/5 | 162.8 | 103.1 | 130.2 | 164.6 | 142.6 | 174.4 |
| 1/2 | 128.0 | 77.3 | 112.2 | 132.4 | 111.3 | 147.1 |

Gumbel Chow Method

| Return Period | Pondok Kopi | Jalinjing | Lg.Luas | Ujung Padang | Penarik | Pondok Panjang |
|---|---|---|---|---|---|---|
| 1/1,000 | 268.2 | 212.4 | 205.4 | 297.2 | 275.6 | 288.4 |
| 1/200 | 233.5 | 178.4 | 182.5 | 256.0 | 234.5 | 254.0 |
| 1/100 | 218.5 | 163.7 | 172.6 | 238.2 | 216.7 | 239.2 |
| 1/50 | 203.5 | 149.0 | 162.7 | 220.4 | 198.9 | 224.3 |
| 1/20 | 183.4 | 129.4 | 149.5 | 196.5 | 175.1 | 204.4 |
| 1/10 | 167.9 | 114.1 | 139.2 | 178.2 | 156.7 | 189.1 |
| 1/5 | 151.8 | 98.3 | 128.5 | 159.0 | 137.6 | 173.1 |
| 1/2 | 127.4 | 74.4 | 112.4 | 130.0 | 108.6 | 148.9 |

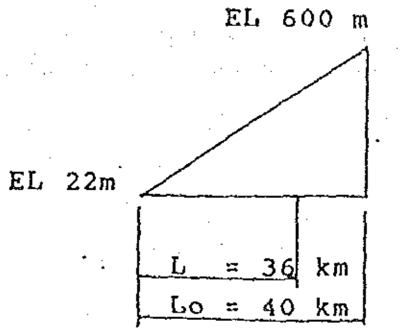
(b) Flood Discharge calculated by Melchior Method

The peak discharge which is calculated with every return period by applying Melchior method is as follows:

$A = 375\ km^2$, $L = 36\ km$, $H = 578\ m$, $I = 0.016$

$\alpha = 0.60$

$F = (\pi / 4) \times L_1 \times L_2$




where,

| | | |
|---|---|---|
| A | : | catchment area |
| L | : | watercourse length ($L_0 \times 0.90$) |
| H | : | Difference between the highest elevation of the basin and the elevation of the proposed weir site |
| I | : | river bed gradient |
| | : | run-off coefficient |
| F | : | area of ellipse = / 4 x 36 x 18 = 509 $km^2$ |
| $L_1$ | : | large axis length 36 km |
| $L_2$ | : | small axis length 18 km |

| Return Period | Rainfall | Tc | Peak Discharge |
|---|---|---|---|
| 1,000 | 349.9 mm | 8.4 hour | 1,300 $m^3/s$ |
| 100 | 265.8 | 8.9 | 957 |
| 50 | 243.1 | 9.0 | 848 |
| 20 | 214.8 | 9.3 | 749 |
| 10 | 194.4 | 9.6 | 656 |
| 5 | 174.4 | 9.8 | 589 |
| 2 | 147.1 | 10.0 | 496 |

Tc : Time of concentration

(c) Flood Discharge calculated by Rational Formula

The peak discharge is calculated by the use of the following formula:

$$q = 0.2778 * f * rt$$
$$Q = q * A$$

where, Q : peak flood discharge ($m^3/sec$)
q : Specific peak flood discharge ($m^3/sic/km^2$)
A : Catchment area ($km^2$)

f : Run-off coefficient 0.6
rt : Mean rainfall intensity within the arrival time of flood (mm/hr)

The mean rainfall intensity within the arrival time of flood is obtained by the following equation :

$$rt = \frac{r24}{24} \left[ \frac{24}{T} \right]^n$$

where, r24 : Maximum daily rainfall (mm)
n : 1/3 - 2/3 usually n = 2/3

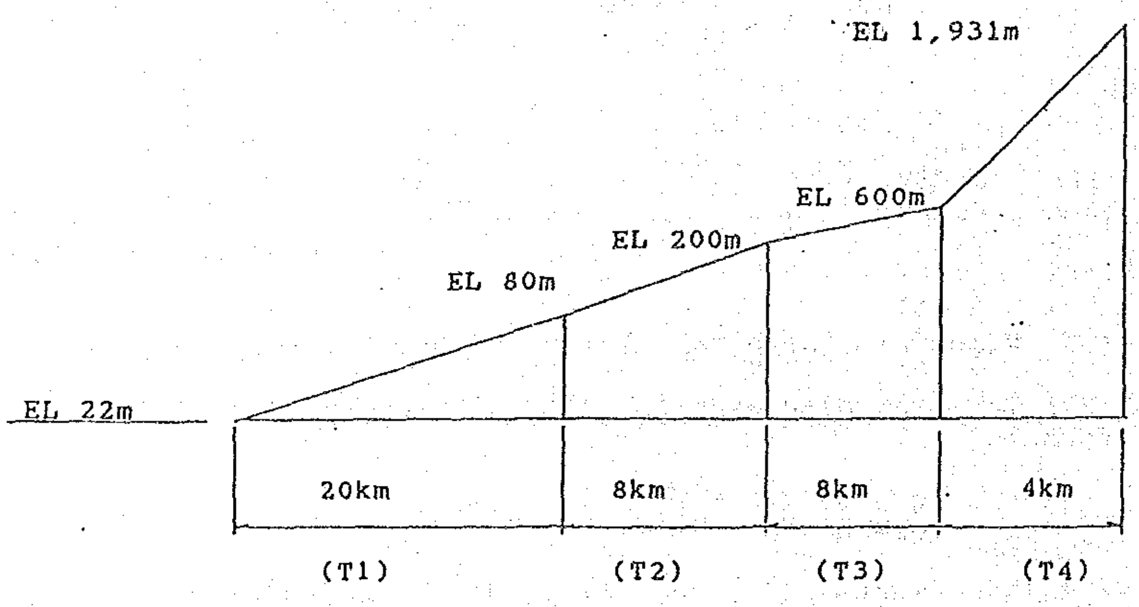
Velocity of flood (W) and the arrival time of flood (T) are calculated by Rziha's formula expressed as follows :

$$W = 72 \times \frac{H}{L}^{0.6}$$

$$T = \frac{L}{W}$$

where, H : Altitude difference (m)
L : River length (km)

The schematic diagram of longitudinal section in the basin is expressed as in the following :



$$W_1 = 72\left(\frac{0.058}{20}\right)^{0.6} = 2.16 \quad T_1 = \frac{L}{W} = \frac{20.0}{2.16} = 9.3 \text{ hr}$$

$$W_2 = 72\left(\frac{0.12}{8}\right)^{0.6} = 5.79 \quad T_2 = \frac{L}{W} = \frac{8}{5.79} = 1.4 \text{ hr}$$

$$W_3 = 72\left(\frac{0.48}{8}\right)^{0.6} = 11.93 \quad T_3 = \frac{L}{W} = \frac{8}{11.93} = 0.7 \text{ hr}$$

$$W_4 = 72\left(\frac{1.33}{4}\right)^{0.6} = 37.19 \quad T_1 = \frac{L}{W} = \frac{4}{37.19} = 0.1 \text{ hr}$$

$$T = T_1 + T_2 + T_3 + T_4 = 11.5 \text{ hr}$$

The peak discharge which is calculated with every return period by applying the formal is as follows :

| Return Period | Rainfall | rt | Peak Discharge |
|---|---|---|---|
| 1,000 | 349.9 | 21.1 mm/hour | 1,319 $m^3/s$ |
| 100 | 265.8 | 16.0 | 1,000 |
| 50 | 243.1 | 14.6 | 913 |
| 20 | 214.8 | 12.9 | 806 |
| 10 | 194.4 | 11.7 | 731 |
| 5 | 174.4 | 10.5 | 656 |
| 2 | 147.1 | 8.9 | 556 |

(d) Flood Discharge calculated by Hasper's Method

The peak discharge is calculated by using the following formula :

$$Q = \alpha * \beta * q * f$$

where, Q : Peak flood discharge ($m^3$/sec)
$\alpha$ : Run-off coefficient
$\beta$ : Reduction coefficient
q : Specific discharge ($m^3/sec/km^2$)
f : Catchment area ($km^2$)

Run-off coefficient ($\alpha$), time of concentration ($t$), and reduction coefficient ($\beta$) are obtained by the following equations :

$$\alpha = \frac{1 + 0.012f^{0.7}}{1 + 0.075f^{0.7}} = \frac{1 + 0.012 \times 375^{0.7}}{1 + 0.075 \times 375^{0.7}} = 0.31$$

$$t = 0.1\ L^{0.8} \times i^{-0.3} = 0.1 \times 36^{0.8} \times 0.016^{-0.3} = 6.1\ \text{hr}$$

$$\frac{1}{\beta} = 1 + \frac{t + 3.7 \times 1.0^{-0.4t}}{t^2 + 15} \times \frac{f^{3/4}}{12}$$

$$= 1 + \frac{6.1 \times 3.7 \times 1.0^{-0.4x6.1}}{6.1^2 + 15} \times \frac{375^{3/4}}{12} = 1.832$$

$$\beta = 0.55$$

$$q = \frac{r}{3.6t}$$

$$r = \frac{tR}{t + 1}$$

$$R = R + SNUt$$

$$S = \frac{Rn - R}{U}$$

where, r : rainfall intensity within the arrival time of flood

R : Daily rainfall with return period T

R : Mean maximum daily rainfall

S : Standard deviation

Ut : Standard variable for return period

Rn : Maximum daily rainfall in the past n years during which the data have been observed

U : Standard variable with return period for Rn

$$S = \frac{200.7 - 153.4}{185}$$

The peak discharge is calculated with every return period by applying the formula as follows :

| Return Period | U | R | r | q | Peak Discharge |
|---|---|---|---|---|---|
| | | mm | mm | $m^3/sec/km^2$ | $m^3/sec$ |
| 1,000 | 5.92 | 305 | 262 | 11.93 | 763 |
| 100 | 3.43 | 241 | 107 | 9.43 | 603 |
| 50 | 2.75 | 224 | 192 | 8.74 | 559 |
| 20 | 1.89 | 202 | 174 | 7.92 | 506 |
| 10 | 1.27 | 186 | 160 | 7.29 | 466 |
| 5 | 0.64 | 170 | 146 | 6.65 | 425 |
| 2 | -0.22 | 148 | 127 | 5.78 | 370 |

(e) Unit Hydrograph Method

The unit hydrograph is presented by the following equation :

$Q_{max} = 1/36 * A * R_0 / ( 0.3 T_1 + T_{0.3} )$

Ascending curve : $Q_a / Q_{max} = ( t / T_1 )^{2.4}$

Recession curve :

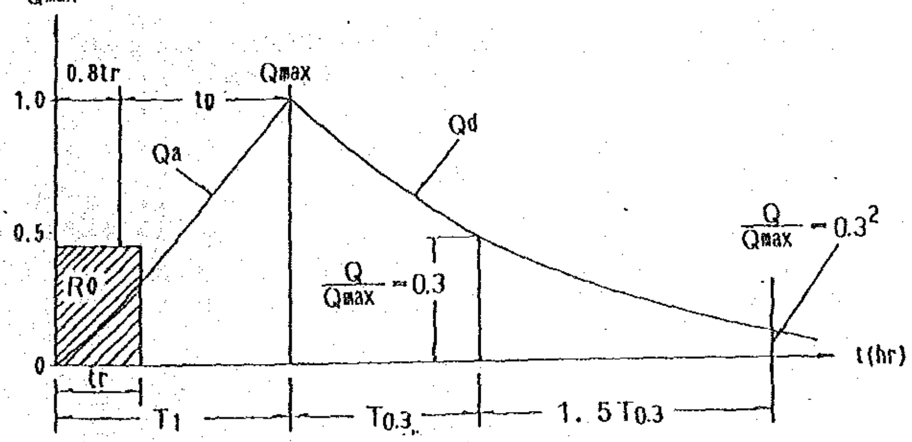
in case of $Q_d / Q_{max} \geqq 0.3$ : $Q_d / Q_{max} = 0.3^{\{(t-T_1)/T_{0.3}\}}$

in case of $0.3 \geqq Q_d / Q_{max} \geqq 0.3^2$ :

$Q_d / 0.3Q_{max} = 0.3^{\{[t-(T_1+T_{0.3})] / 1.5 T_{0.3}\}}$

in case of $0.3^2 \geqq Q_d / Q_{max}$

$Q_d / 0.3^2 Q_{max} = 0.3^{\{[t-(T_1+T_{0.3}+1.5T_{0.3})] / 3T_{0.3}\}}$




Explanation on Unit Hydrograph

where,

$Q_{max}$ : Maximum discharge in the unit hydrograph ($m^3/s$)
$Q_a$, $Q_d$ : Discharge on ascending curve ( $Q_a$ ) or recession curve ( $Q_d$ ) ($m^3/s$)
A : Catchment area ($km^2$)
$R_0$ : Effective rainfall
$T_1$ : Time from starting of run off to the maximum discharge (hour)
$T_{0.3}$ : Time from the maximum discharge to the discharge of 0.3 times the maximum discharge (hour)
$t_r$ : Unit time (hour)

Nakayasu assumed the unit hydrograph as mentioned above and $T_1$ and $T_{0.3}$ can be presented by specificity of catchment area. He also assumed a time lag ($t_g$) (taken 0.8 $t_r$) from a peak rainfall in a unit time ($t_r$) to the maximum discharge can be presented using the maximum flow length (L km) as mentioned below.

in case of $L \leq 15$ km : $t_g = 0.21 * L^{0.7}$
in case of $L < 15$ km : $t_g = 0.4 + 0.058 * L$

$T_1$ and $T_{0.3}$ can be expressed applying the time lag ($t_g$) mentioned above as follows :

a) in case of river with earlier run off after rain and quick withdraw : $T_{0.3} = 1.5\ t_g$

b) in case of river with later run off after rain and slow withdraw : $T_{0.3} = 3.0\ t_g$

c) in case of river with condition between a) and b) above : $T_{0.3} = 2.0\ t_g$ or $T_{0.3} = t_g + 0.8\ t_r$

Then, the unit hydrograph can be drawn applying $t_r = (\ 0.5 - 1.0\ )\ t_g$.

The unit hydrograph using the catchment area of $A = 375\ km^2$ at the proposed weir site becomes as follows.

*** Basic paratmeters for unit hydrograph ***

```
** Catchment area          A=   375.0 (KM2 )
** Maximum flow length     L=    40.0 (KM)
** Time lag               TG=    2.70 (HR)
** Unit time              TO=    1.35 (HR)
** TK =  3.0 * TG           =    8.10 (HR)
** TP =  TG + 0.8 * TO      =    3.78 (HR)
** TO3 =  TP + TK           =   11.88 (HR)
** T32 =  TP+TK+1.5*TK      =   24.03 (HR)
** QP =  1.0/(0.3*TP+TK)    =   0.108 (MM/HR)
```

***** Results of calculation *****

| Time (HR) | Unit -Q (MM/HR) | Time (HR) | Unit -Q (MM/HR) |
|---|---|---|---|
| 1.0 | 0.004 | 28.0 | 0.007 |
| 2.0 | 0.024 | 29.0 | 0.007 |
| 3.0 | 0.063 | 30.0 | 0.006 |
| 4.0 | 0.110 | 31.0 | 0.006 |
| 5.0 | 0.092 | 32.0 | 0.005 |
| 6.0 | 0.079 | 33.0 | 0.005 |
| 7.0 | 0.068 | 34.0 | 0.005 |
| 8.0 | 0.059 | 35.0 | 0.004 |
| 9.0 | 0.051 | 36.0 | 0.004 |
| 10.0 | 0.044 | 37.0 | 0.004 |
| 11.0 | 0.038 | 38.0 | 0.003 |
| 12.0 | 0.033 | 39.0 | 0.003 |
| 13.0 | 0.030 | 40.0 | 0.003 |
| 14.0 | 0.026 | 41.0 | 0.003 |
| 15.0 | 0.024 | 42.0 | 0.003 |
| 16.0 | 0.022 | 43.0 | 0.002 |
| 17.0 | 0.020 | 44.0 | 0.002 |
| 18.0 | 0.018 | 45.0 | 0.002 |
| 19.0 | 0.016 | 46.0 | 0.002 |
| 20.0 | 0.015 | 47.0 | 0.002 |
| 21.0 | 0.013 | 48.0 | 0.002 |
| 22.0 | 0.012 | 49.0 | 0.002 |
| 23.0 | 0.011 | 50.0 | 0.001 |
| 24.0 | 0.010 | 51.0 | 0.001 |
| 25.0 | 0.009 | 52.0 | 0.001 |
| 26.0 | 0.008 | 53.0 | 0.001 |
| 27.0 | 0.008 | 54.0 | 0.001 |
| | | 55.0 | 0.001 |

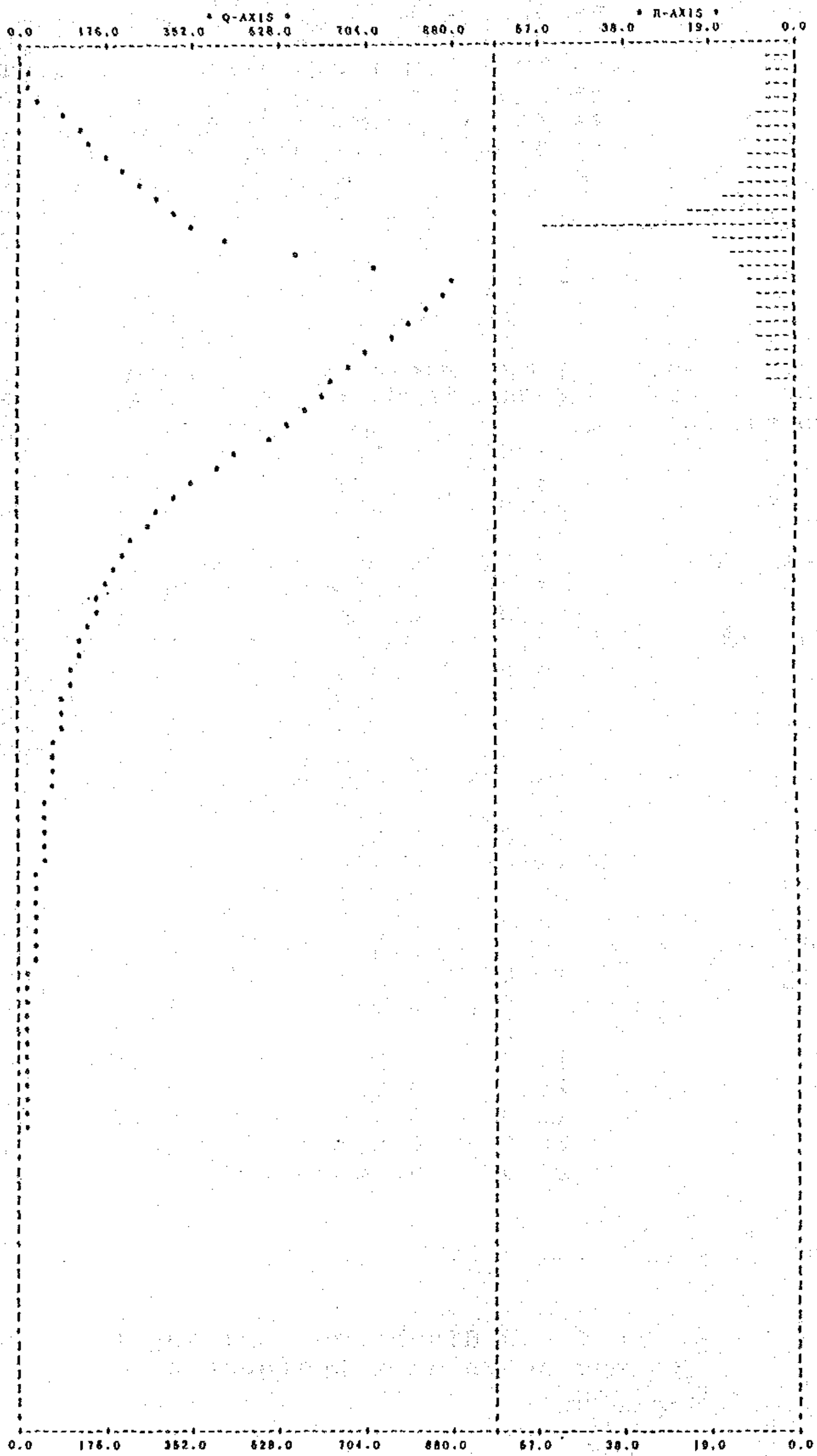
The flood discharge applying the probable rainfall to the above unit hydrograph are calculated as follows.

# EXSAMPLE OF CALCULATION FOR FLOOD DISCHARGE
## (In case of probable rainfall of 1/10)

* AREA=375 km$^2$ *

*** Type of Rainfall...W=1/10 R=266.0 MM/3DAYS ***

| TIME | RAIN | EFFECTIVE RAINFALL | DIS |
|---|---|---|---|
| 0 | 5.6 | 3.36 | 7.500 |
| 1 | 5.8 | 3.48 | 8.900 |
| 2 | 6.1 | 3.66 | 17.350 |
| 3 | 6.5 | 3.90 | 39.775 |
| 4 | 6.9 | 4.14 | 79.613 |
| 5 | 7.4 | 4.44 | 115.069 |
| 6 | 8.0 | 4.80 | 148.231 |
| 7 | 8.8 | 5.28 | 179.969 |
| 8 | 9.9 | 5.94 | 211.069 |
| 9 | 11.6 | 6.96 | 242.481 |
| 10 | 14.5 | 8.70 | 275.525 |
| 11 | 22.5 | 13.50 | 312.531 |
| 12 | 54.2 | 32.52 | 368.425 |
| 13 | 17.3 | 10.38 | 430.175 |
| 14 | 12.8 | 7.68 | 654.444 |
| 15 | 10.7 | 6.42 | 724.831 |
| 16 | 9.3 | 5.58 | 877.250 |
| 17 | 8.4 | 5.04 | 860.000 |
| 18 | 7.7 | 4.62 | 828.238 |
| 19 | 7.1 | 4.26 | 790.388 |
| 20 | 6.7 | 4.02 | 751.538 |
| 21 | 6.3 | 3.78 | 712.456 |
| 22 | 6.0 | 3.60 | 674.631 |
| 23 | 5.7 | 3.42 | 639.344 |
| 24 | | | 607.788 |
| 25 | | | 579.969 |
| 26 | | | 544.900 |
| 27 | | | 502.413 |
| 28 | | | 445.581 |
| 29 | | | 397.056 |
| 30 | | | 354.315 |
| 31 | | | 317.256 |
| 32 | | | 286.094 |
| 33 | | | 256.844 |
| 34 | | | 233.356 |
| 35 | | | 212.431 |
| 36 | | | 193.925 |
| 37 | | | 177.125 |
| 38 | | | 162.319 |
| 39 | | | 150.694 |
| 40 | | | 138.325 |
| 41 | | | 128.813 |
| 42 | | | 118.413 |
| 43 | | | 110.456 |
| 44 | | | 101.275 |
| 45 | | | 95.175 |
| 46 | | | 89.338 |
| 47 | | | 82.031 |
| 48 | | | 77.369 |
| 49 | | | 72.944 |
| 50 | | | 66.713 |
| 51 | | | 62.875 |
| 52 | | | 59.650 |
| 53 | | | 56.438 |
| 54 | | | 53.200 |
| 55 | | | 48.050 |
| 56 | | | 45.244 |
| 57 | | | 42.713 |
| 58 | | | 40.269 |
| 59 | | | 38.163 |
| 60 | | | 35.925 |
| 61 | | | 33.219 |
| 62 | | | 28.888 |
| 63 | | | 26.838 |
| 64 | | | 25.025 |
| 65 | | | 23.256 |
| 66 | | | 21.313 |
| 67 | | | 19.481 |
| 68 | | | 16.613 |
| 69 | | | 14.088 |
| 70 | | | 12.869 |
| 71 | | | 11.806 |
| 72 | | | 10.850 |
| 73 | | | 9.969 |
| 74 | | | 9.488 |
| 75 | | | 9.044 |
| 76 | | | 8.625 |
| 77 | | | 8.231 |
| 78 | | | 7.856 |
| 79 | | | 7.500 |
| 80 | | | 7.500 |
| 81 | | | 7.500 |
| 82 | | | 7.500 |
| 83 | | | 7.500 |
| 84 | | | 7.500 |
| 85 | | | 7.500 |
| 86 | | | 7.500 |
| 87 | | | 7.500 |
| 88 | | | 7.500 |
| 89 | | | 7.500 |
| 90 | | | 7.500 |
| 91 | | | 7.500 |
| 92 | | | 7.500 |
| 93 | | | 7.500 |
| 94 | | | 7.500 |
| 95 | | | 7.500 |



| Return Period | Rainfall | Peak Discharge |
|---|---|---|
| 1,000 | 349.9 mm | 1,152 $m^3$ |
| 100 | 265.8 | 860 |
| 50 | 243.1 | 803 |
| 20 | 214.8 | 710 |
| 10 | 194.4 | 644 |
| 5 | 174.4 | 578 |
| 2 | 147.1 | 488 |

(f) Peaks Over Threshold (POT) Method

When flood records are of shorter periods or do not cover a long period, POT method can be used if at least records of two (2) continuous years are available. From the records the peak flows exceeding an arbitrarily set threshold value $q_0$ are identified.
The threshold is set in such a way that on average between two (2) and five (5) peaks exceed the threshold value $q_0$.
This results in M peak values with an average value $q_p$ over a total recording period of N years.
The mean annual flood is computed as published by DPMA, 1983 :

$$MAF = q_0 + ( q_p - q_0 )( 0.58 + I_n )$$

where, MAF : Mean annual flood in $m^3/s$
$q_0$ : Threshold discharge in $m^3/s$
$q_p$ : Average peak discharge in $m^3/s$
: M / N
M : Number of peak values
N : Number of years

The mean annual flood of the Air Selagan River at Teras Terunjam of which catchment area is 453.3 $km^2$ is computed.

The computation is made with the following conditions :

- The continuous water level records from 1983 to 1986 are used.
- The river discharge observations were carried out when the river discharges were less than 100 $m^3/s$.
  Therefore, the river discharge more than 100 $m^3/s$ are obtained from the rating curve drawn by relations between river discharges and water levels during the river discharges were less than 100 $m^3/s$.

From an initial scan of the record the threshold of 260 $m^3/s$ seemed likely to give a suitable number of floods for the POT series. Nine independent floods were abstracted as listed below :

| YEAR | FLOOD ($m^3/s$) |
|---|---|
| 1983 | 271 |
| 1984 | 338 |
| | 311 |
| | 271 |
| 1985 | 559 |
| | 551 |
| | 327 |
| 1986 | 487 |
| | 401 |
| | 338 |
| | 266 |

Floods in the incomplete year at the end of the record were ignored.

In the notation given above ;

Threshold, $q_0$ = 260 $m^3/s$
Number of years of data, N = 4
Number of floods over the threshold, M = 11

Therefore, $q_p$ = 375 $m^3/s$
= 2.75 floods/year,
and MAF = 443 $m^3/s$

Thus, using the POT method the mean annual flood for Air Selagan at Teras Terunjam is estimated to be 443 $m^3/s$.

The flood discharges of the Selagan River at Teras Terunjam and the proposed weir site are calculated by the following formula using MAF and GF (Growth Factor).

$$Q = GF \times MAF$$

where, Q : Flood discharge
MAF : Mean Annual Flood
GF : Growth factors derived from the study on flood data in Java and Sumatra by IOH/DPMA shown in the following table :

Table of Growth Factors GF (T, AREA)

| Return Period | Reduced Variation | Catchment area ($km^2$) | | | | | |
|---|---|---|---|---|---|---|---|
| T | y | 180 or less | 300 | 600 | 900 | 1,200 | 1,500 or more |
| 5 | 1.50 | 1.28 | 1.27 | 1.24 | 1.22 | 1.19 | 1.17 |
| 10 | 2.25 | 1.56 | 1.54 | 1.48 | 1.44 | 1.41 | 1.37 |
| 20 | 2.97 | 1.88 | 1.84 | 1.75 | 1.70 | 1.64 | 1.59 |
| 50 | 3.90 | 2.35 | 2.30 | 2.18 | 2.10 | 2.03 | 1.95 |
| 100 | 4.60 | 2.78 | 2.72 | 2.57 | 2.47 | 2.37 | 2.27 |
| 200 | 5.30 | 3.27 | 3.20 | 3.01 | 2.89 | 2.78 | 2.66 |
| 500 | 6.21 | 4.01 | 3.92 | 3.70 | 3.56 | 3.41 | 3.27 |
| 1,000 | 6.91 | 4.68 | 4.58 | 4.32 | 4.16 | 4.01 | 3.85 |

The flood discharges are as follows :

| Return Period | GF | MAF ($m^3/s$) | Flood Discharge ($m^3/s$) | |
|---|---|---|---|---|
| | | | Teras Terunjam (A=453.3 $km^2$) | Weir Site (A=375 $km^2$) |
| 1,000 | 3.11 | 443 | 1,378 | 1,140 |
| 100 | 2.65 | 443 | 1,174 | 971 |
| 50 | 2.24 | 443 | 992 | 821 |
| 20 | 1.80 | 443 | 797 | 659 |
| 10 | 1.51 | 443 | 669 | 553 |
| 5 | 1.26 | 443 | 558 | 462 |

(g) Design Flood Discharge

The peak discharge with every return period which are calculated by the method mentioned above are summarized in the following table :

## ESTIMATED FLOOD DISCHARGE

| Return Period | Melchior's Method | | Rational Formula | | Hasper's Method | | Unit Hydrograph Method | | POT Method | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Peak Dis. | Spec. Dis. | Peak Dis. | Spec. Dis. | Peak Dis. | Spec. Dis. | Peak Dis. | Spec. Dis. | Peak Dis. | Spec. Dis. |
| | $m^3/sec$ | $m^3/s/km^2$ | $m^3/sec$ | $m^3/s/km^2$ | $m^3/sec$ | $m^3/sec$ | $m^3/s/km^2$ $m^3/sec$ | $m^3/s/km^2$ | $m^3/sec$ | $m^3/s/km^2$ |
| 1,000 | 1,300 | 3.47 | 1,319 | 3.52 | 763 | 2.03 | 1,152 | 3.07 | 1,140 | 3.04 |
| 100 | 957 | 2.55 | 1,000 | 2.67 | 603 | 1.61 | 860 | 2.29 | 971 | 2.59 |
| 50 | 848 | 2.26 | 913 | 2.43 | 559 | 1.49 | 803 | 2.14 | 821 | 2.19 |
| 20 | 749 | 2.00 | 806 | 2.15 | 506 | 1.35 | 710 | 1.89 | 659 | 1.76 |
| 10 | 656 | 1.75 | 731 | 1.95 | 466 | 1.24 | 644 | 1.72 | 553 | 1.47 |
| 5 | 589 | 1.57 | 656 | 1.75 | 425 | 1.13 | 578 | 1.54 | 462 | 1.23 |
| 2 | 496 | 1.32 | 556 | 1.48 | 370 | 0.99 | 488 | 1.30 | - | - |

For safety's sake, the flood discharge at the proposed weir site on the Air Selagan which is calculated by Rational formula is adopted because of insufficient rainfall data.

## 2.3 Water Quality

In order to check the water quality of the Selagan River, water samplings were carried out and the laboratory test on the samples were made (See Table I-7, I-8, I-9).

The suitability 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.

STANDARD FOR DRINKING WATER AND IRRIGATION WATER

| 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 | ppm | 75 | |
| Mg | ppm | 50 | |
| Cl | ppm | 200 | 4 m.e/l |
| $SO_4$ | ppm | 200 | 4 m.e/l |
| $\frac{Na \times 100}{Na + Ca + Mg + K}$ | (m.e/l) | | 20 % |
| $KMnO_4$ | ppm | 10 | |
| B | ppm | | 0.33 - 1 |

(1): Standard of Ministry of Agriculture, Forestry and Fisheries of Japan

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 thoroughly to destroy all micro-organism which may exist in the water, judging from the amount of $KMnO_4$ demand.

## 2.4 Tidal Movement

### 2.4.1 Record of Water Level

Ujung Padang on the Selagan River is located near the estuary and influenced by tidal water level. Daily maximum water level and minimum water level at Ujung Padang are shown in Fig. I-9.

The average water level is (-) 3.57m. The maximum water level is (-) 2.45m and minimum is (-) 4.48m.

2.4.2 Back Water by the Tide

The Selagan River is influenced by the tide of the Sea in the upstream of about 13Km.

The shematic diagram of longitudinal section in the Selagan River is expressed as in the following:

Longitudinal Section in The Selagan River

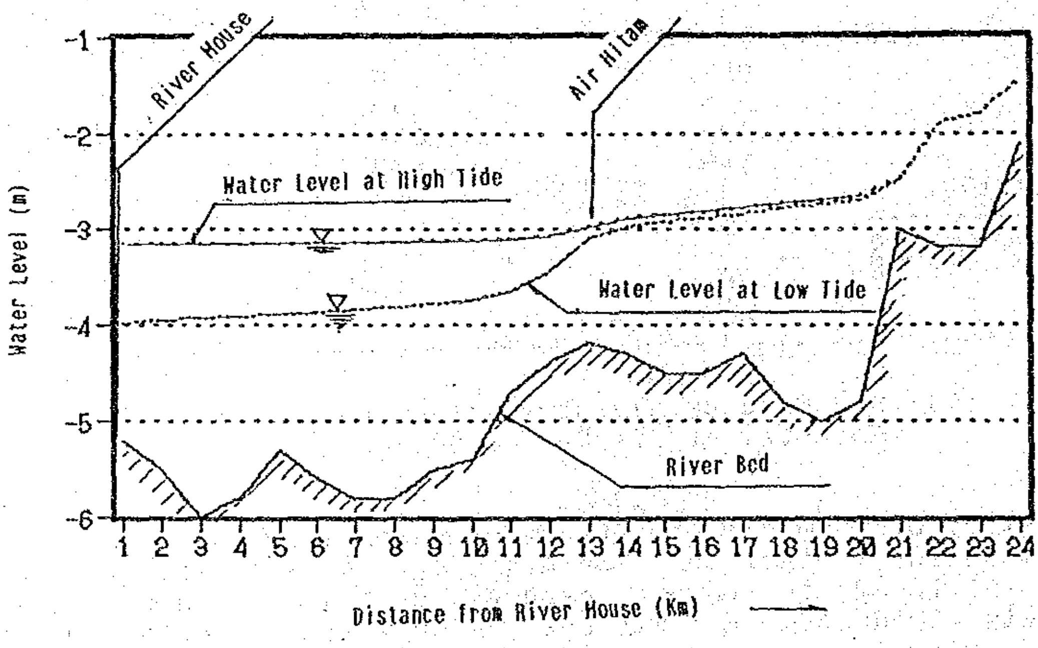


Table I-1 MONTHLY MEAN RAINFALL RECORDS

Unit : mm

| Station | JAN. | FEB. | MAR. | APR. | MAY. | JUN. | JUL. | AUG. | SEP. | OCT. | NOV. | DEC. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jalining | 304.2 | 269.3 | 240.1 | 166.3 | 194.6 | 175.2 | 196.9 | 159.4 | 350.6 | 382.0 | 432.1 | 276.7 | 3,097.4 |
| Pondok Panjang | 412.1 | 218.1 | 401.1 | 291.9 | 185.6 | 163.7 | 209.7 | 265.1 | 388.0 | 368.1 | 390.7 | 380.5 | 3,674.6 |
| Lalang Luas | 384.1 | 224.3 | 370.2 | 290.6 | 232.6 | 198.2 | 196.2 | 221.0 | 364.5 | 395.9 | 372.0 | 236.5 | 3,486.1 |
| Pondok Kopi | 373.5 | 267.7 | 439.0 | 297.5 | 254.8 | 185.1 | 225.4 | 185.7 | 354.1 | 397.7 | 401.3 | 360.9 | 3,742.7 |
| Ds Penarik | 178.2 | 157.8 | 221.4 | 146.1 | 124.0 | 127.2 | 174.4 | 72.1 | 314.3 | 329.5 | 378.3 | 227.9 | 2,451.2 |
| Ujung Padang | 296.4 | 199.7 | 270.9 | 191.9 | 163.7 | 126.4 | 197.6 | 153.7 | 303.0 | 337.6 | 340.8 | 253.9 | 2,839.9 |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

Table I-2 MONTHLY CLIMATOLOGICAL RECORDS AT PONDOK PANJANG

(1) Monthly Average of Evaporation at Pondok Panjang

Unit mm

| | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Evaporation | 5.6 | 4.8 | 5.5 | 4.9 | 4.9 | 4.3 | 4.2 | 4.0 | 5.5 | 5.2 | 5.4 | 6.0 |

(2) Monthly Average of Wind Velocity at Pondok Panjang

Unit km/day

| | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wind Velocity | 27.9 | 28.8 | 30.2 | 27.9 | 25.3 | 25.4 | 25.6 | 30.9 | 35.2 | 32.3 | 30.5 | 31.1 |

(3) Monthly Average of Temperature at Pondok Panjang

Unit ℃

| | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | 31.2 | 31.6 | 31.6 | 31.8 | 32.0 | 31.9 | 31.8 | 31.8 | 31.1 | 30.9 | 31.0 | 31.2 |

(4) Monthly Average of Relative Humidity at Pondok Panjang

Unit %

| | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Relative Humidity | 92.0 | 91.0 | 92.0 | 91.0 | 91.0 | 93.0 | 95.0 | 93.0 | 93.0 | 94.0 | 94.0 | 93.0 |

(5) Monthly Average of Sunshine Duration at Pondok Panjang

Unit %

| | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sunshine Duration | 40.0 | 42.0 | 36.0 | 41.0 | 45.0 | 48.0 | 53.0 | 44.0 | 35.0 | 34.0 | 37.0 | 42.0 |

(6) Monthly Average of Solar Radiation at Pondok Panjang

Unit Cal/cm²/day

| | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Solar Radiation | 336 | 368 | 329 | 345 | 333 | 329 | 320 | 326 | 330 | 333 | 315 | 325 |

Table I-3 MONTHLY DISCHARGES AT PROPOSED WEIR SITE

C.A.= 375 km2 Unit : m3/s

| YEAR | JAN. | FEB. | MAR. | APR. | MAY. | JUN. | JUL. | AUG. | SEP. | OCT. | NOV. | DEC. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 30.21 | 36.26 | 56.58 | 40.14 | 43.85 | 21.91 | 25.34 | 12.51 | 62.12 | 60.66 | 38.95 | 46.01 | 39.56 |
| 82 | 57.11 | 60.55 | 31.00 | 34.09 | 19.18 | 24.25 | 12.58 | 19.84 | 16.59 | 19.27 | 60.86 | 57.65 | 34.20 |
| 83 | 53.17 | 56.63 | 49.01 | 47.02 | 26.92 | 38.85 | 27.78 | 55.61 | 46.73 | 62.14 | 44.09 | 61.04 | 47.38 |
| 84 | 48.34 | 23.59 | 42.43 | 36.70 | 27.82 | 12.86 | 19.28 | 19.74 | 45.12 | 26.40 | 49.07 | 58.82 | 34.22 |
| 85 | 48.42 | 49.05 | 45.41 | 20.37 | 21.83 | 22.42 | 19.41 | 8.57 | 38.14 | 40.85 | 43.49 | 22.30 | 31.55 |
| 86 | 37.55 | 22.87 | 59.82 | 37.23 | 32.47 | 22.72 | 21.71 | 24.96 | 32.23 | 58.10 | 21.94 | 41.92 | 34.62 |
| 87 | 62.36 | 30.10 | 71.03 | 75.33 | 23.11 | 23.12 | 28.71 | 20.50 | 41.29 | 43.91 | 37.58 | 60.47 | 43.22 |
| 88 | 73.23 | 41.81 | 69.28 | 52.60 | 35.97 | 10.40 | 30.35 | 32.43 | 51.96 | 46.83 | 119.56 | 57.92 | 51.84 |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Mean | 51.30 | 40.11 | 53.07 | 42.94 | 28.89 | 22.07 | 23.15 | 24.27 | 41.77 | 44.77 | 51.94 | 50.77 | 39.57 |

Table I-4 SUSPENDED SOIL IN THE SELAGAN RIVER AT TERAS TERUNJAM

| Year | Date | Water Level | Suspended Soil | Run-off Discharge | Total Sedimentation |
|---|---|---|---|---|---|
| 1983 | 24-Feb. | 0.75m | 70 mg/l | 30.65 $m^3/s$ | 185 ton/day |
| " | 9-Dec. | 1.25 | 41 | 35.90 | 127 |
| " | " | 1.21 | 40 | 34.50 | 119 |
| 1984 | 22-Mar. | 1.33 | 37 | 49.15 | 157 |
| " | " | 1.34 | 36 | 50.96 | 159 |
| " | " | 1.33 | 29 | 49.15 | 123 |
| " | 23-Sep. | 0.65 | 22 | 26.46 | 50 |
| " | 9-Nov. | 1.32 | 29 | 48.64 | 122 |
| " | 10-Nov. | 1.28 | 21 | 43.86 | 80 |
| " | " | 1.24 | 17 | 42.79 | 63 |
| Average | | 1.18 | 33 | 41.71 | 115 |

Table I-5 10-DAYS DISCHARGE AT PROPOSED WEIR SITE

C.A.= 375 km2 Unit:m3/s

| | | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 1-10 | 61.21 | 104.77 | 32.46 | 51.33 | 67.30 | 72.22 | 84.46 | 56.20 | 66.24 |
| | 11-20 | 19.85 | 40.74 | 51.24 | 55.87 | 39.94 | 27.05 | 48.79 | 68.48 | 43.99 |
| | 21-31 | 11.46 | 28.66 | 73.76 | 38.77 | 38.95 | 15.58 | 54.60 | 93.02 | 44.35 |
| Feb. | 1-10 | 35.60 | 72.49 | 81.12 | 25.87 | 77.58 | 23.64 | 33.57 | 55.71 | 50.70 |
| | 11-20 | 28.10 | 47.18 | 38.96 | 11.89 | 49.05 | 16.66 | 25.53 | 40.39 | 32.22 |
| | 21-28 | 47.27 | 62.34 | 48.13 | 34.07 | 13.38 | 29.66 | 31.47 | 27.96 | 36.78 |
| Mar | 1-10 | 60.20 | 28.86 | 38.46 | 57.37 | 38.21 | 39.46 | 105.21 | 37.81 | 50.70 |
| | 11-20 | 62.27 | 38.68 | 62.86 | 31.94 | 49.44 | 79.64 | 79.49 | 47.58 | 56.49 |
| | 21-31 | 48.12 | 25.95 | 46.00 | 38.39 | 48.28 | 60.30 | 32.25 | 117.61 | 52.11 |
| Apr. | 1-10 | 58.26 | 30.37 | 44.91 | 38.02 | 14.71 | 22.33 | 69.61 | 47.85 | 40.76 |
| | 11-20 | 34.02 | 15.28 | 34.06 | 22.30 | 21.41 | 26.51 | 77.18 | 42.03 | 34.10 |
| | 21-30 | 28.13 | 56.62 | 62.09 | 49.79 | 24.99 | 62.86 | 79.21 | 67.91 | 53.95 |
| May. | 1-10 | 29.67 | 13.76 | 25.86 | 48.06 | 7.91 | 62.89 | 29.34 | 52.28 | 33.72 |
| | 11-20 | 66.46 | 13.38 | 29.07 | 17.59 | 30.52 | 12.95 | 10.54 | 47.22 | 28.47 |
| | 21-31 | 36.20 | 29.37 | 25.91 | 18.72 | 26.59 | 22.56 | 28.87 | 10.91 | 24.89 |
| Jun. | 1-10 | 45.70 | 35.13 | 23.29 | 12.20 | 7.59 | 28.28 | 20.34 | 13.18 | 23.21 |
| | 11-20 | 13.64 | 23.71 | 50.76 | 18.20 | 44.27 | 21.99 | 28.32 | 5.76 | 25.83 |
| | 21-30 | 6.38 | 13.89 | 42.51 | 8.19 | 15.41 | 17.89 | 20.70 | 12.25 | 17.15 |
| Jul. | 1-10 | 24.31 | 15.13 | 24.75 | 5.74 | 27.83 | 7.58 | 38.44 | 31.12 | 21.86 |
| | 11-20 | 19.78 | 14.90 | 21.81 | 25.97 | 20.64 | 18.96 | 28.08 | 23.26 | 21.67 |
| | 21-31 | 31.33 | 8.14 | 35.95 | 25.51 | 10.63 | 37.05 | 20.44 | 36.08 | 25.64 |
| Aug. | 1-10 | 10.23 | 29.09 | 91.30 | 37.00 | 5.22 | 24.11 | 19.83 | 33.91 | 31.34 |
| | 11-20 | 7.54 | 22.21 | 26.09 | 9.19 | 7.19 | 9.10 | 18.24 | 39.07 | 17.33 |
| | 21-31 | 19.09 | 9.27 | 49.98 | 13.65 | 12.86 | 40.17 | 23.16 | 25.04 | 24.15 |
| Sep. | 1-10 | 104.01 | 5.02 | 65.23 | 25.76 | 38.24 | 40.03 | 6.74 | 20.06 | 38.14 |
| | 11-20 | 46.96 | 19.69 | 52.73 | 61.51 | 22.74 | 14.55 | 35.23 | 38.41 | 36.48 |
| | 21-30 | 35.41 | 25.08 | 22.24 | 48.09 | 53.45 | 42.11 | 81.91 | 97.40 | 50.71 |
| Oct. | 1-10 | 33.94 | 34.89 | 61.60 | 18.16 | 53.64 | 57.52 | 39.72 | 32.50 | 41.50 |
| | 11-20 | 74.86 | 15.93 | 76.22 | 12.95 | 24.40 | 79.72 | 40.25 | 44.00 | 46.04 |
| | 21-31 | 72.04 | 8.12 | 49.82 | 46.11 | 44.17 | 38.98 | 51.04 | 62.42 | 46.59 |
| Nov. | 1-10 | 35.45 | 100.13 | 52.61 | 38.88 | 48.65 | 28.39 | 63.60 | 67.67 | 54.42 |
| | 11-20 | 35.97 | 37.29 | 26.47 | 55.51 | 24.05 | 16.63 | 19.54 | 110.59 | 40.76 |
| | 21-30 | 45.42 | 45.14 | 53.20 | 52.80 | 57.77 | 20.80 | 29.60 | 180.43 | 60.65 |
| Dec. | 1-10 | 33.52 | 30.88 | 46.87 | 36.43 | 24.54 | 23.63 | 84.83 | 64.46 | 43.15 |
| | 11-20 | 33.52 | 70.60 | 38.22 | 54.12 | 12.90 | 55.73 | 71.34 | 86.52 | 52.87 |
| | 21-31 | 68.71 | 70.23 | 94.67 | 83.44 | 28.81 | 45.98 | 28.44 | 25.97 | 55.78 |

## Table I-6 DAILY MAXIMUM RAINFALL RECORDS

| | Pondok Kopi | | Jalinjing | | Lg.Luas | | Ujung Padang | | Penarik | | Pondok Panjang | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | HB | HO | HB | HO | HB | HO | HB | HO | HB | HO | HB | HO |
| 1980 | | | | | | *94.7 | *159.2 | *161.1 | *121.1 | *78.5 | | |
| 1981 | 40.6 | *65.1 | | | *83.4 | 96.6 | 125.0 | 125.1 | 160.6 | *128.4 | | |
| 1982 | *151.1 | *155.1 | *76.2 | | *125.2 | 146.6 | *95.3 | *127.1 | 102.4 | | *125.6 | *125.7 |
| 1983 | 104.4 | *124.3 | *44.6 | *67.3 | *123.0 | *123.3 | *164.3 | *102.6 | 60.9 | *69.1 | 129.3 | 128.8 |
| 1984 | 150.9 | *150.9 | *74.8 | | 109.4 | *104.0 | - | | 80.9 | 90.0 | 128.9 | *129.2 |
| 1985 | *156.4 | *142.8 | 120.5 | | 99.1 | *74.6 | *93.5 | | 94.3 | *55.2 | 157.6 | *85.0 |
| 1986 | 130.2 | | 35.2 | | 138.7 | *58.2 | 135.2 | | 160.6 | | 146.0 | *146.3 |
| 1987 | 132.8 | | *112.7 | | *114.9 | | 87.8 | | | | *185.0 | |
| 1988 | 140.5 | | *65.3 | | | | *189.3 | | | | 200.7 | |

H.B Rainfall Gauge

H.O Automatic Rainfall Gauge

* The data with no observation period are found.

Table I-7 WATER QUALITY TEST FOR DRINKING

| ITEM | UNIT | TEST POINT | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Electric Conductivity | Umho/cm | 370.0 | 55.0 | 35.0 | 75.0 | 55.0 | 50.0 | 55.0 | 45.0 |
| PH | | 7.9 | 7.7 | 7.0 | 7.2 | 7.1 | 7.1 | 6.7 | 7.0 |
| Ca | mg/l | 36.0 | 4.2 | 2.4 | 5.6 | 5.0 | 4.0 | 4.0 | 3.6 |
| Mg | " | 7.7 | 1.8 | 1.2 | 2.2 | 1.7 | 1.3 | 1.5 | 1.2 |
| Na | " | 1.6 | 0.89 | 0.66 | 0.97 | 0.53 | 1.5 | 1.1 | 0.85 |
| K | " | 1.3 | 0.57 | 0.53 | 0.38 | 0.74 | 0.78 | 0.54 | 0.52 |
| Fe | " | 0.06 | 0.06 | 0.02 | 0.03 | 0.23 | 0.04 | 0.19 | 0.12 |
| Mn | " | 0.05 | 0.07 | 0.03 | 0.08 | 0.06 | 0.07 | 0.05 | 0.09 |
| Zn | " | 0.01 | 0.01 | 0.02 | 0.48 | 0.02 | 0.02 | 0.35 | 0.02 |
| F | " | 0.05 | 0.10 | 0.05 | 0.10 | 0.10 | 0.05 | 0.05 | 0.05 |
| Cl | " | 28.0 | 2.4 | 1.7 | 2.8 | 2.4 | 2.0 | 2.4 | 1.7 |
| SO4 | " | 3.5 | 1.0 | 0.6 | 1.2 | 10.0 | 0.9 | 1.1 | 0.8 |
| NH4 | " | 0.05 | 0.07 | 0.04 | 0.03 | 0.09 | 0.15 | 0.07 | 0.08 |
| NO3 | " | 0.12 | 0.15 | 0.10 | 0.08 | 0.22 | 0.34 | 0.20 | 0.25 |
| HCO3 | " | 100.0 | 20.0 | 12.0 | 25.0 | 20.0 | 20.0 | 18.0 | 15.0 |
| KMnO4 | " | 5.0 | 8.2 | 8.7 | 6.0 | 20.0 | 17.0 | 9.0 | 12.0 |

Test Point 1 Air Selagan : Muko-Muko
2 " : Pondok-Kopi
3 " : Teras Terunjam
4 " : Lubuk Sahung
5 " : SP III
6 " : SP IV
7 Air Ledeng : Muko-Muko
8 Air Selagan : Pondok Batu

Observed Period : Oct. - 1989

Table I-8 WATER QUALITY TEST FOR IRRIGATION

| ITEM | UNIT | TEST POINT | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Electric Conductivity | Umho/cm | 45.0 | 45.0 | 45.0 | 280.0 | 34.0 | 52.0 | 43.0 | 38.0 |
| PH | | 7.1 | 7.1 | 7.0 | 6.9 | 7.2 | 7.0 | 7.0 | 7.1 |
| Ca | mg/l | 4.2 | 3.4 | 4.4 | 7.8 | 4.2 | 6.4 | 4.2 | 3.8 |
| B | " | 0.02 | 0.02 | 0.02 | 0.04 | 0.03 | 0.02 | 0.04 | 0.03 |
| Mg | " | 1.5 | 1.5 | 0.97 | 3.5 | 0.97 | 1.3 | 1.3 | 0.85 |
| Na | " | 0.90 | 0.77 | 0.76 | 30.00 | 0.51 | 0.43 | 0.84 | 0.71 |
| K | " | 0.44 | 0.41 | 0.41 | 2.40 | 0.49 | 0.68 | 0.71 | 0.73 |
| Mn | " | 0.08 | 0.04 | 0.02 | 0.05 | 0.03 | 0.07 | 0.05 | 0.08 |
| Cl | " | 2.5 | 2.2 | 2.2 | 50.0 | 1.8 | 2.8 | 2.5 | 1.8 |
| SO4 | " | 0.7 | 0.8 | 0.7 | 8.2 | 0.5 | 0.9 | 0.8 | 0.7 |
| HCO | " | 18.0 | 15.0 | 16.0 | 30.0 | 16.0 | 23.0 | 19.0 | 15.0 |

Test Point 1 Air Selagan : Surian Bungkal
2 " : Teras Terunjam
3 " : Lubuk Sahung
4 " : River Mouse
5 " : Pondok Kopi
6 " : SP III
7 " : SP IV
8 Air Betung : Teras Terunjam

Observed Period
Oct. 1989 - Nov. 1989

Table I-9 WATER QUALITY TEST AND SALINITY TEST

| NO | ITEM | UNIT | SAMPLE No | | |
|---|---|---|---|---|---|
| | | | 1 | 2 | 3 |
| 1 | SALINITY | 0/00 | 0 | 0 | 0 |
| 2 | ELECTRICAL CONDUCTIVITY | mhO/cm | 53 | 32 | 35 |
| 3 | CHLORIDE | mg/l | 4.6 | 2.8 | 2.8 |

Note :
- -Sample No.1 Confluence of Air Hitam and Air Selagan at High Tide
- -Sample No.2 Confluence of Air Hitam and Air Selagan at Low Tide
- -Sample No.3 Air Selagan around SP.III

| NO | ITEM | UNIT | SAMPLE No | | |
|---|---|---|---|---|---|
| | | | 1 | 2 | 3 |
| 1 | COD(Chemical Oxygen Demand) | mg/l | 5.18 | 2.3 | 0 |
| 2 | S,S(Suspended Solid 0.45 m) | mg/l | 4 | 3 | 3 |
| 3 | ZN (Zine) | mg/l | N.I | 0.01 | 0.01 |
| 4 | CU (Copper) | mg/l | N.I | N.I | N.I |
| 5 | A.S (Arsentic) | mg/l | N.I | N.I | N.I |

Note :
- -N.I no identified when laboratory test is done due to a content of Cu and As too small to identify
- -Sample No.1 Upstream of the Weir
- -Sample No.2,3 Downstream of the Weir

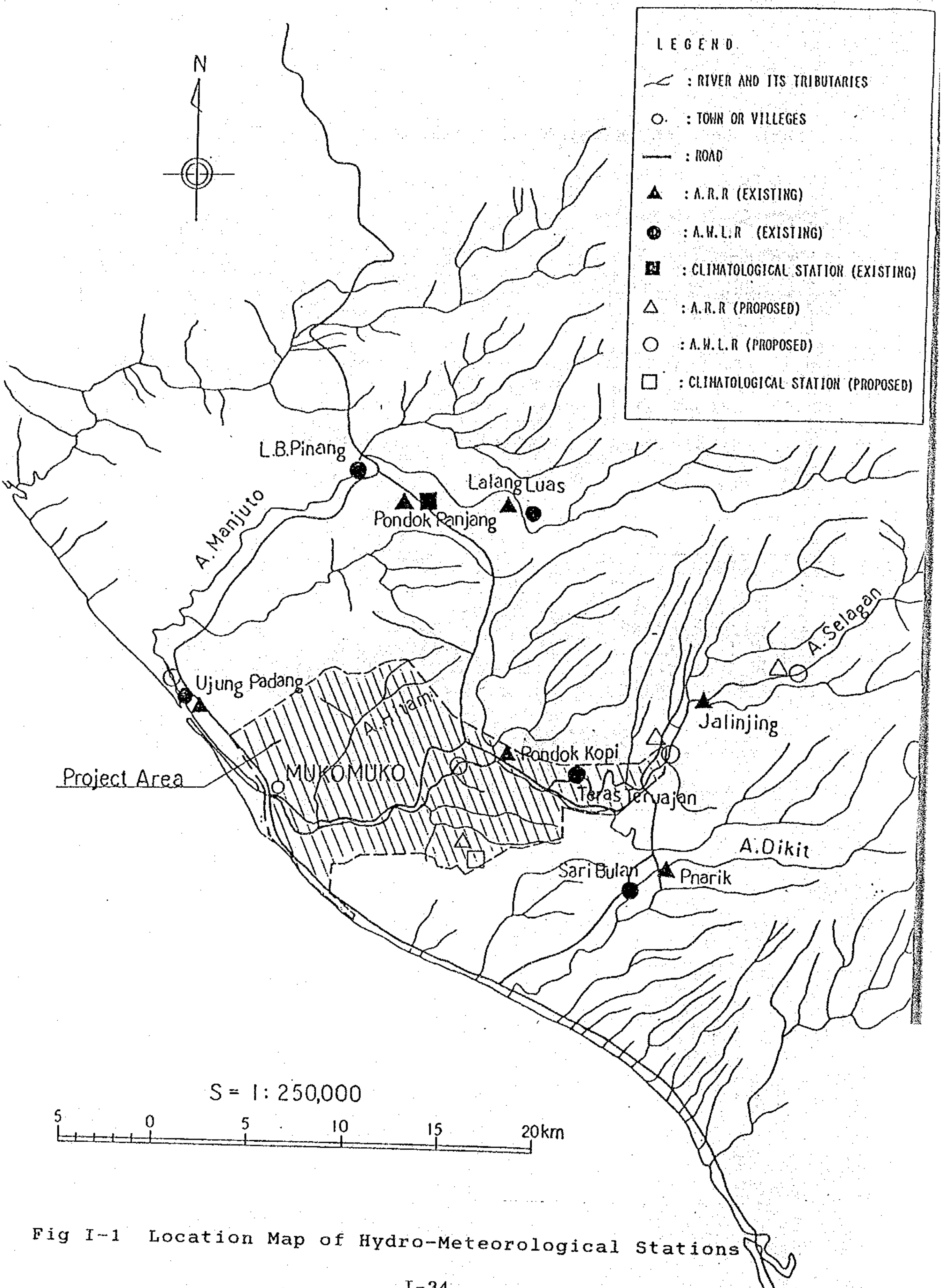
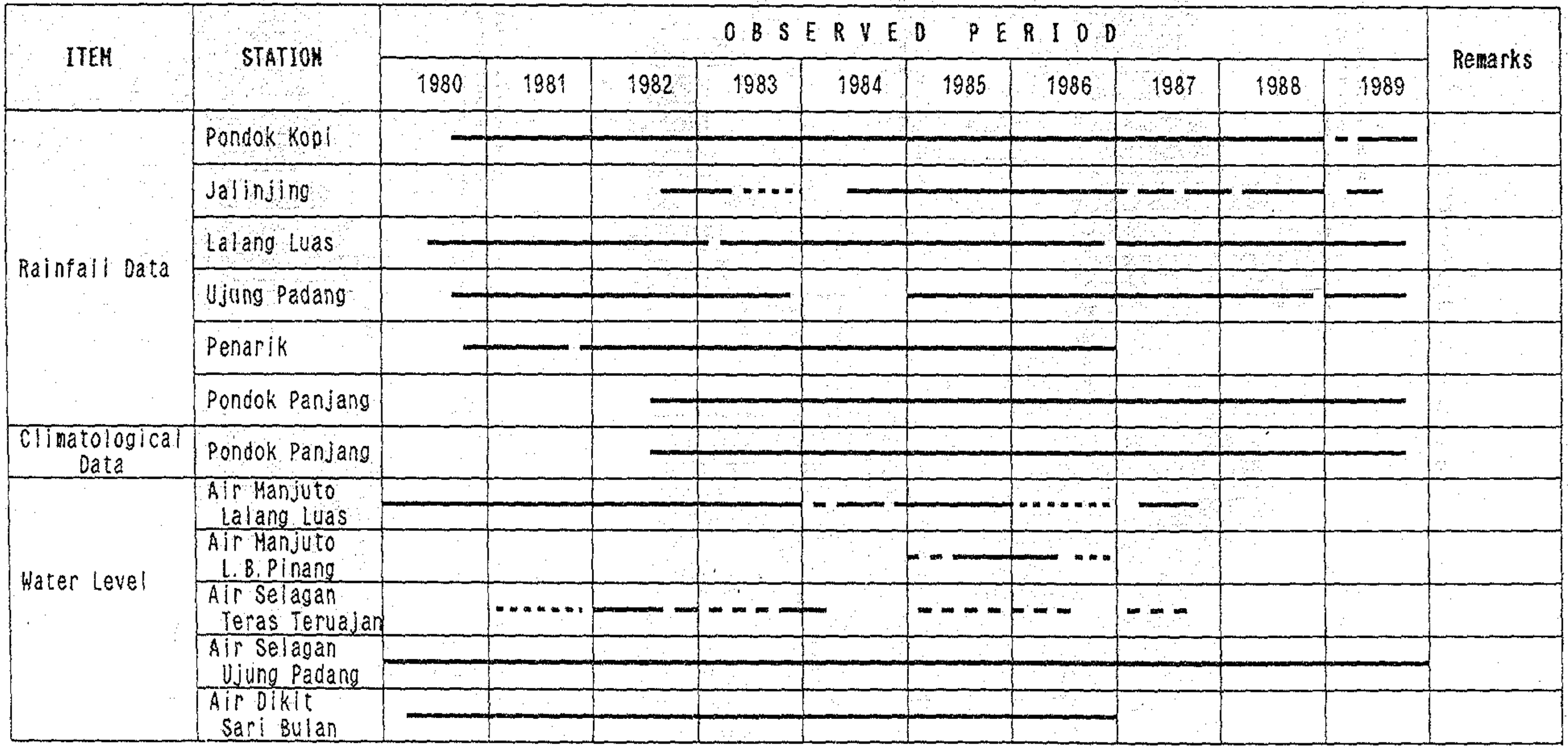
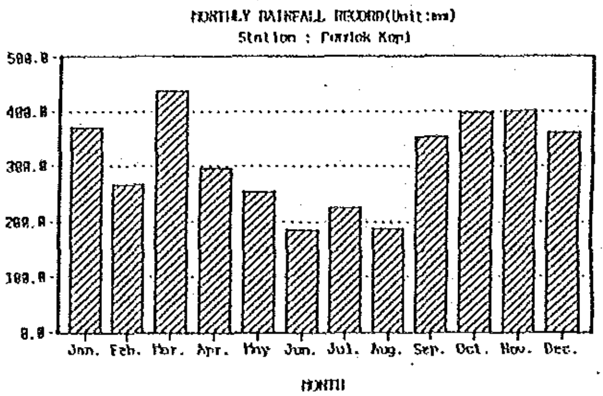


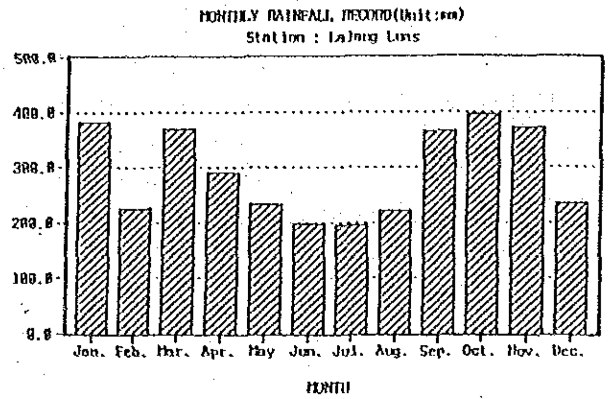

Fig I-1 Location Map of Hydro-Meteorological Stations

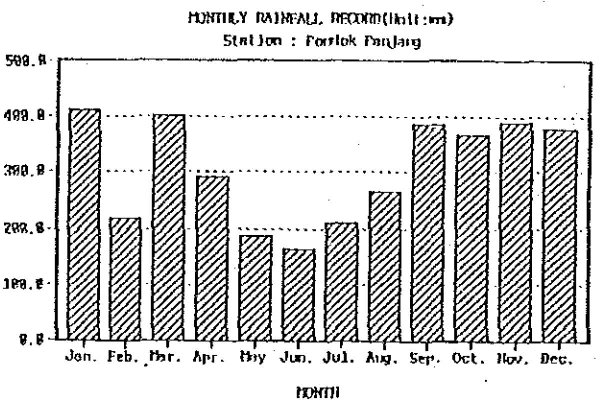
Fig I-2  Available Climatological and Hydrological Data

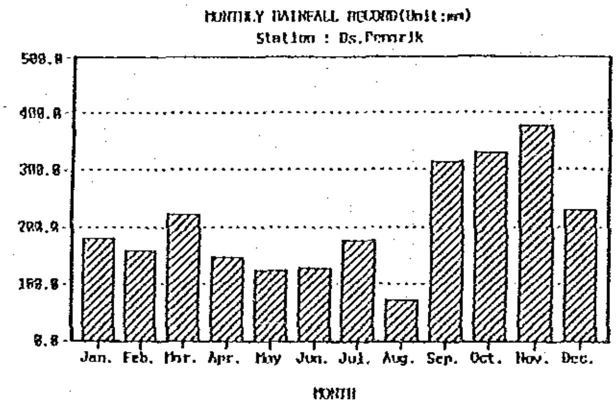


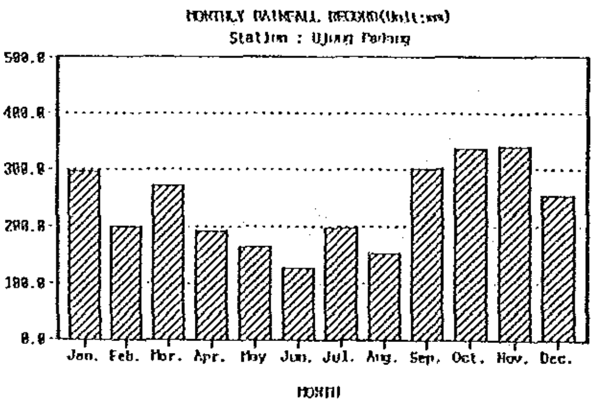
## Fig I-3 Monthly Mean Rainfall Records



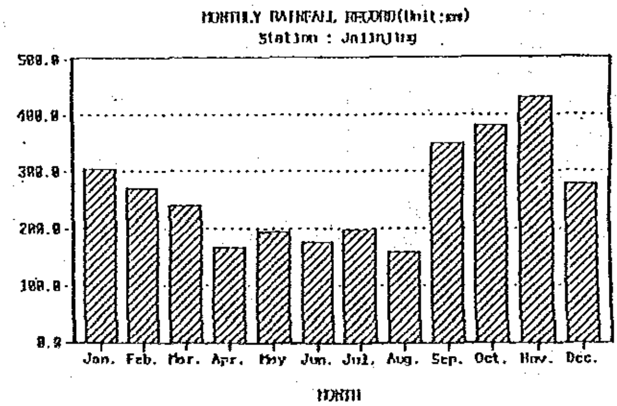



Fig I-4 Comparison of Monthly Mean River Discharge

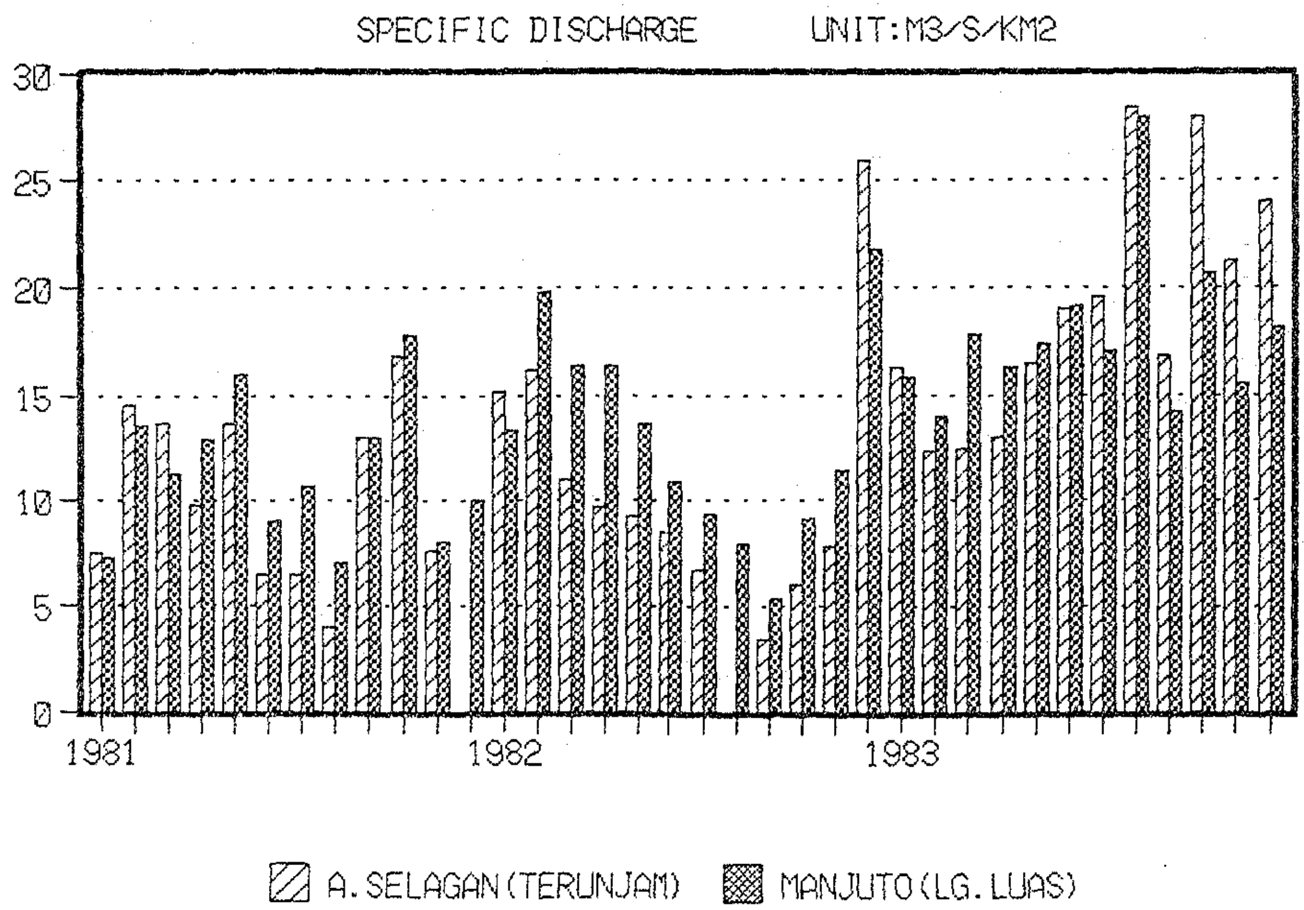


Fig I-5 Correlation between Monthly Mean Discharge at Air Selagan and Air Manjuto

* A.SELAGAN - A.MANJUTO MONTHLY DISCHARGE(M3/S/KM2)

X ..... MONTHLY MEAN DISCHARGE AT T.TERUNJAM
Y ..... MONTHLY MEAN DISCHARGE AT LG.LUAS

| | | | | | |
|---|---|---|---|---|---|
| | | A = | .650 | A = | 1.155 |
| NOS OF DATA... | 34 | B = | 5.486 | B = | -2.963 |
| CORR COEF .... | .866 | SQRT(Y)= | 2.457 | SQRT(Y)= | 3.275 |

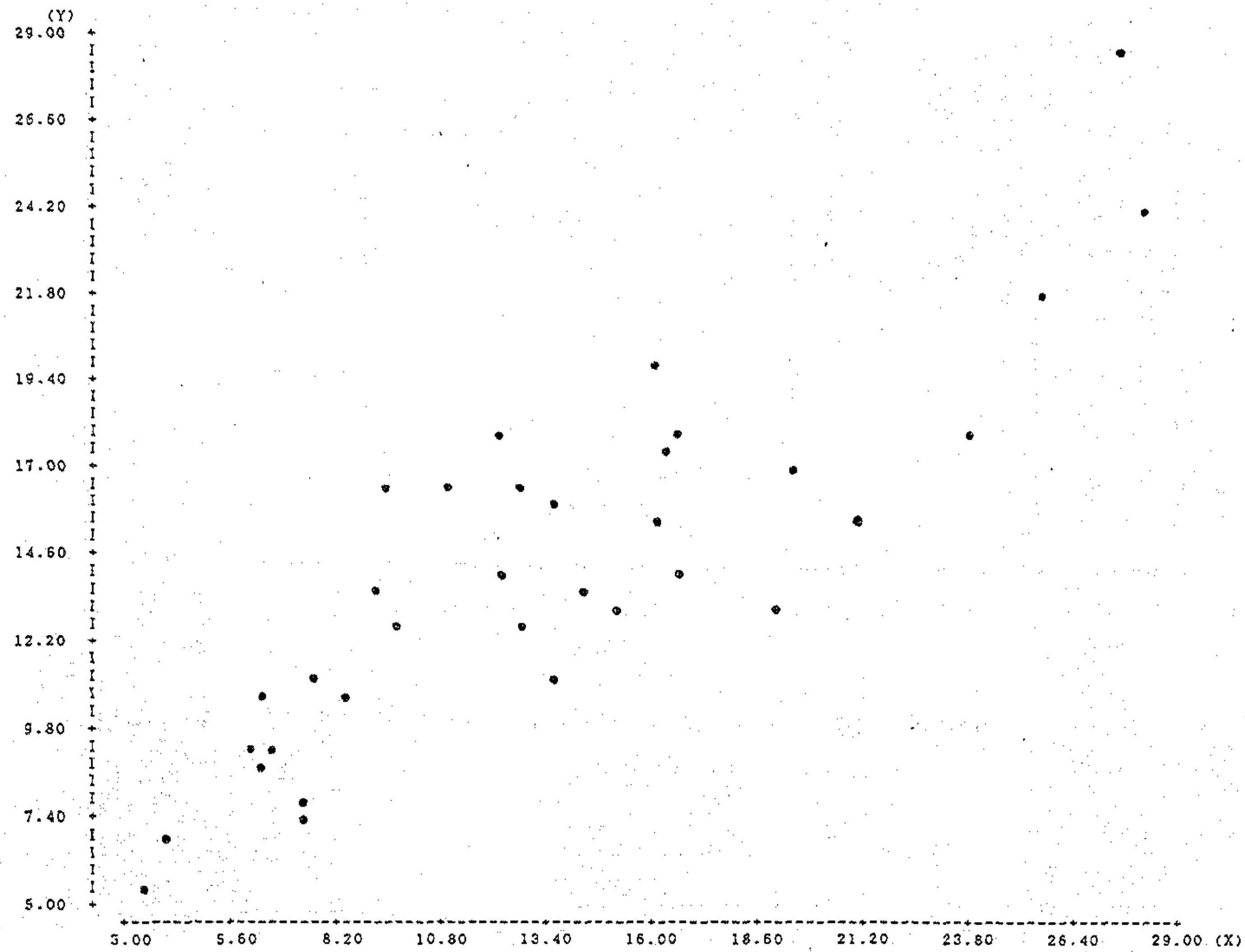


Fig I-6 Procedure of Hydrological Analysis

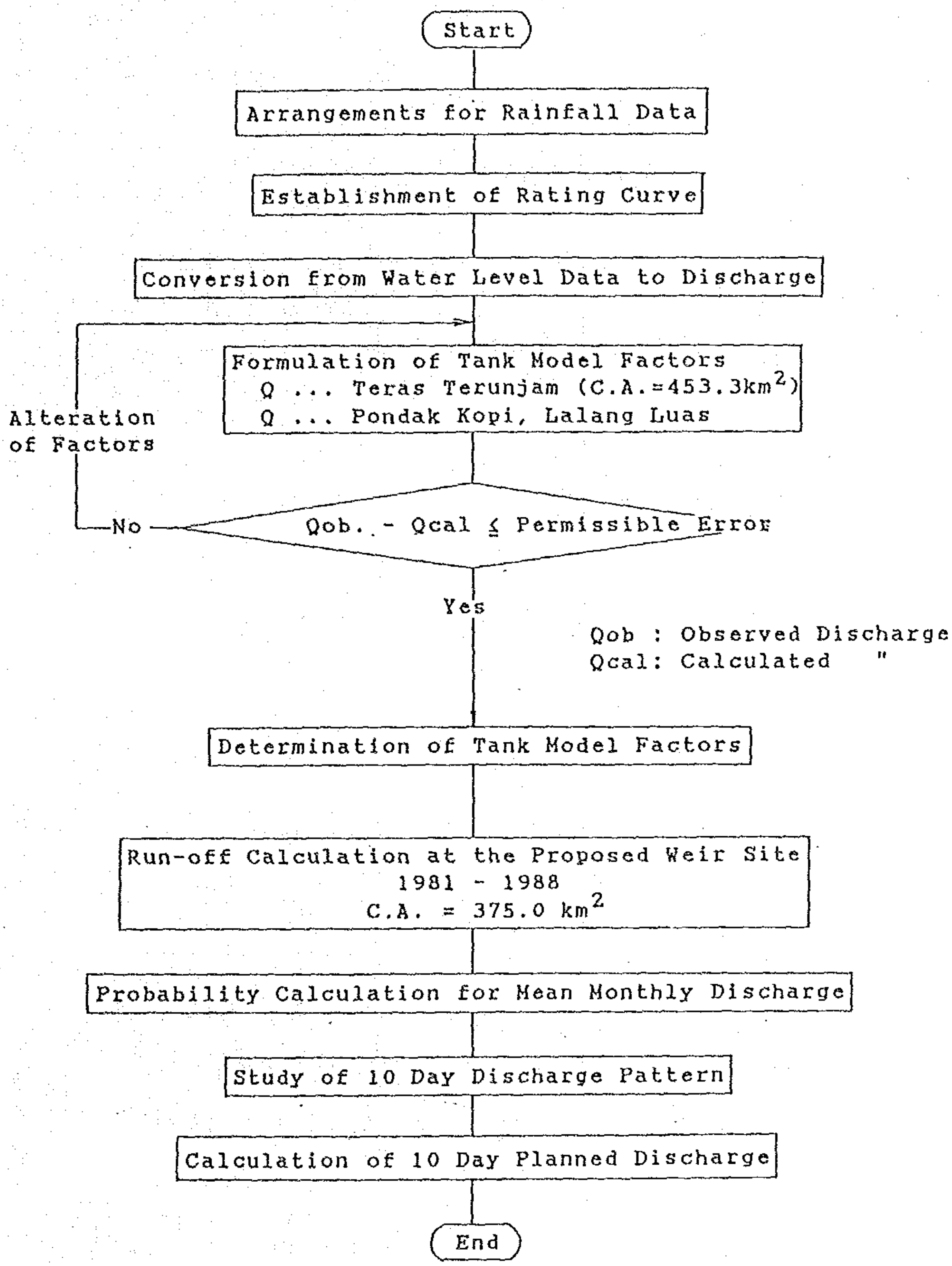


Fig I-7 Schematic Diagram of Tank Model

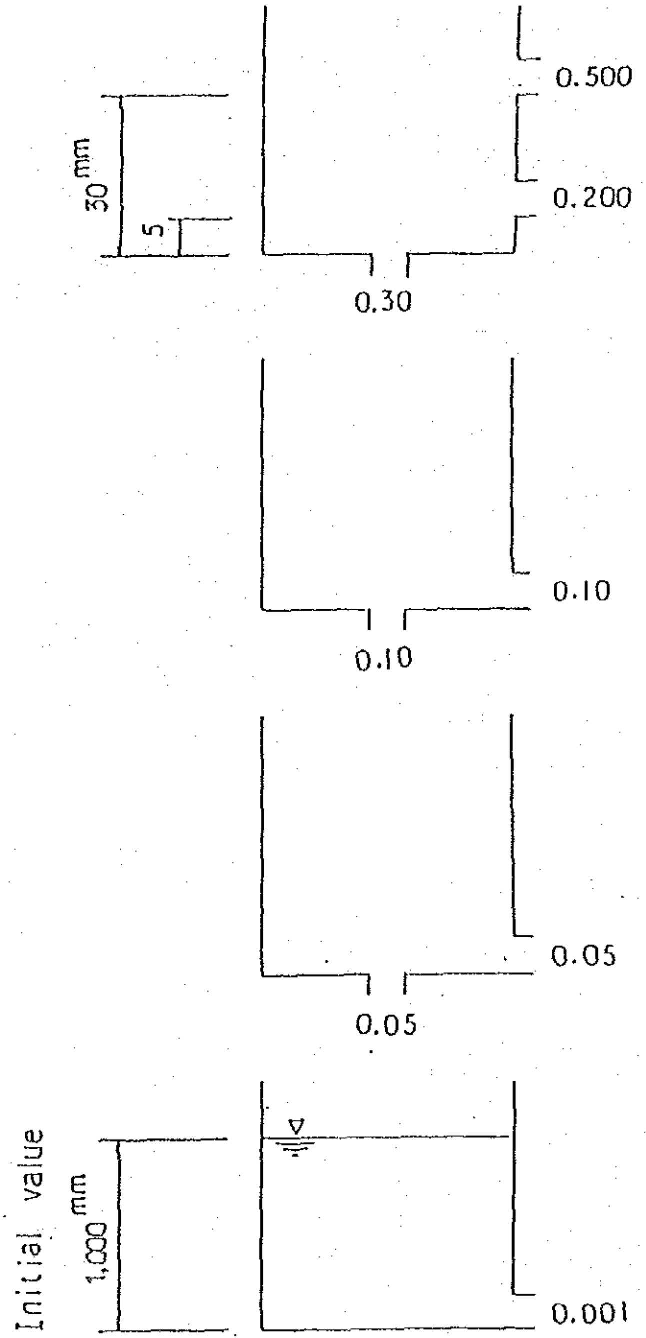
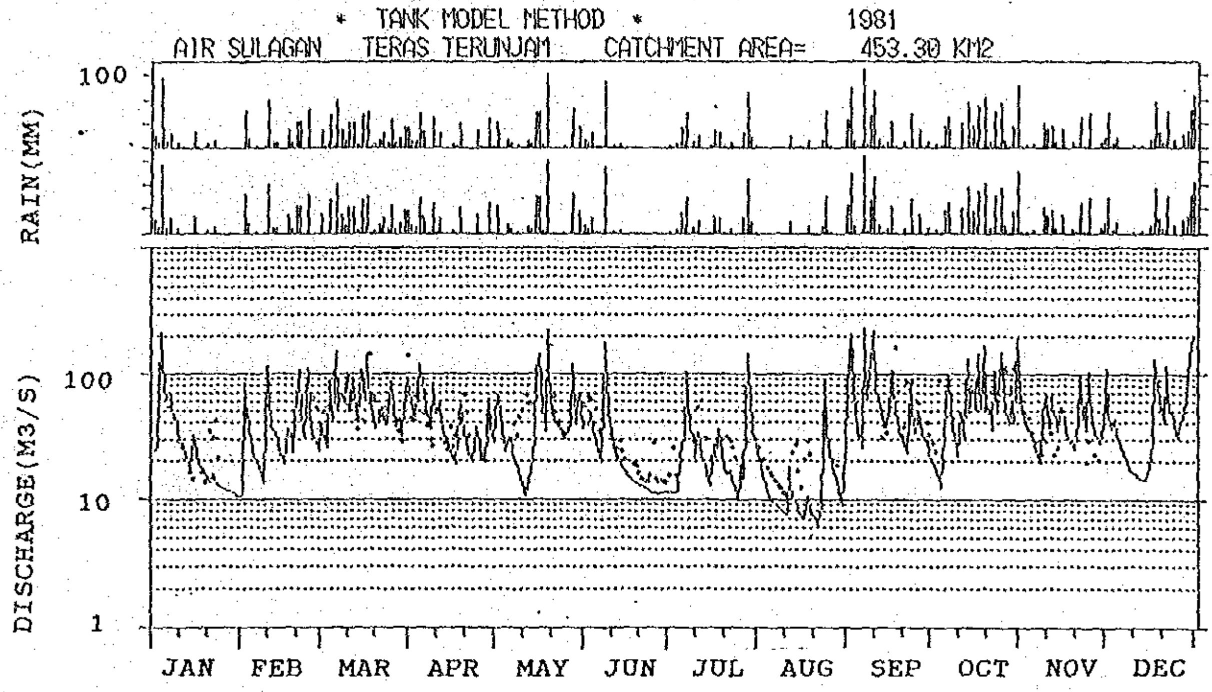
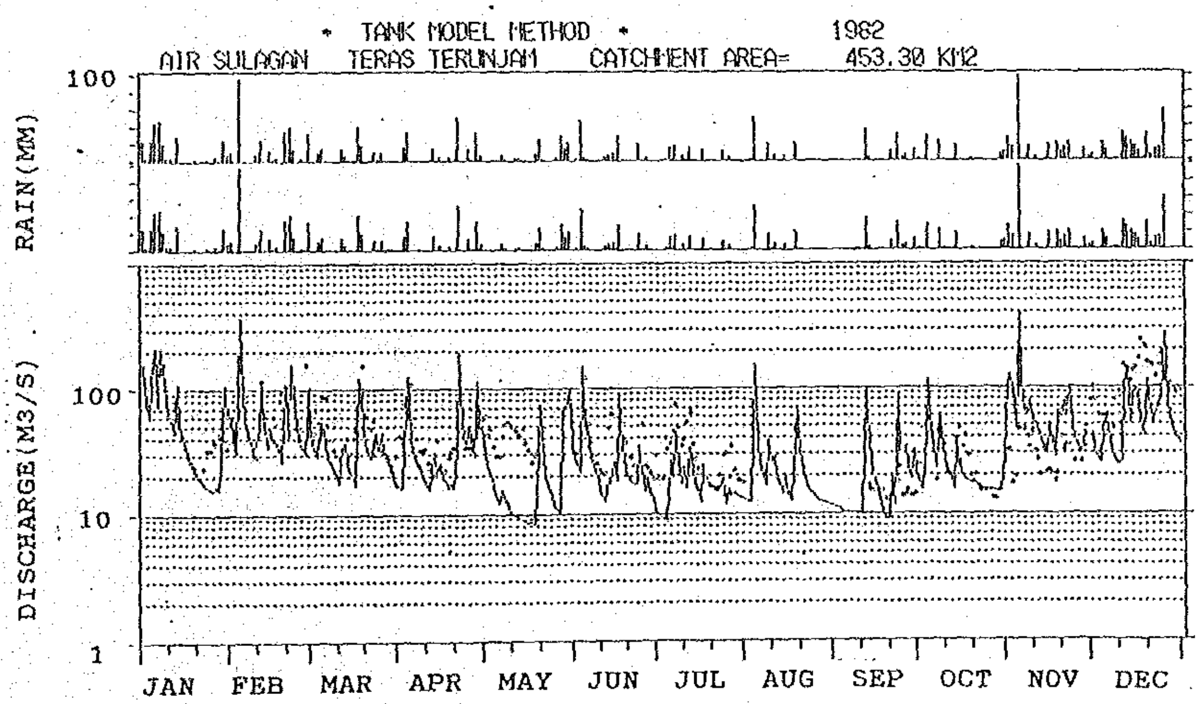


Fig I-8 Result of Calculation by Tank Model Method




NOTE: - CALCULATED DISCHARGE(M3/S)
* OBSERVED DISCHARGE(M3/S)



# APPENDIX II

# GEOLOGY AND SOIL MECHANICS

# CHAPTER 1 GENERAL

The site investigation on geology and soil mechanics was carried out in the Project area for the study.

The purposes of the investigation are to investigate the proposed weir site foundation, soil properties along the main canal and embankment material and to estimate to the design.

The past investigation on the Project was carried out by Indonesian consultant.

In this report, their results are referred to.

Furthermore, with respect to geology of wide area, the data issued by Indonesian Geological Research and Development Center were referred to.

The summary of the results is as follows:

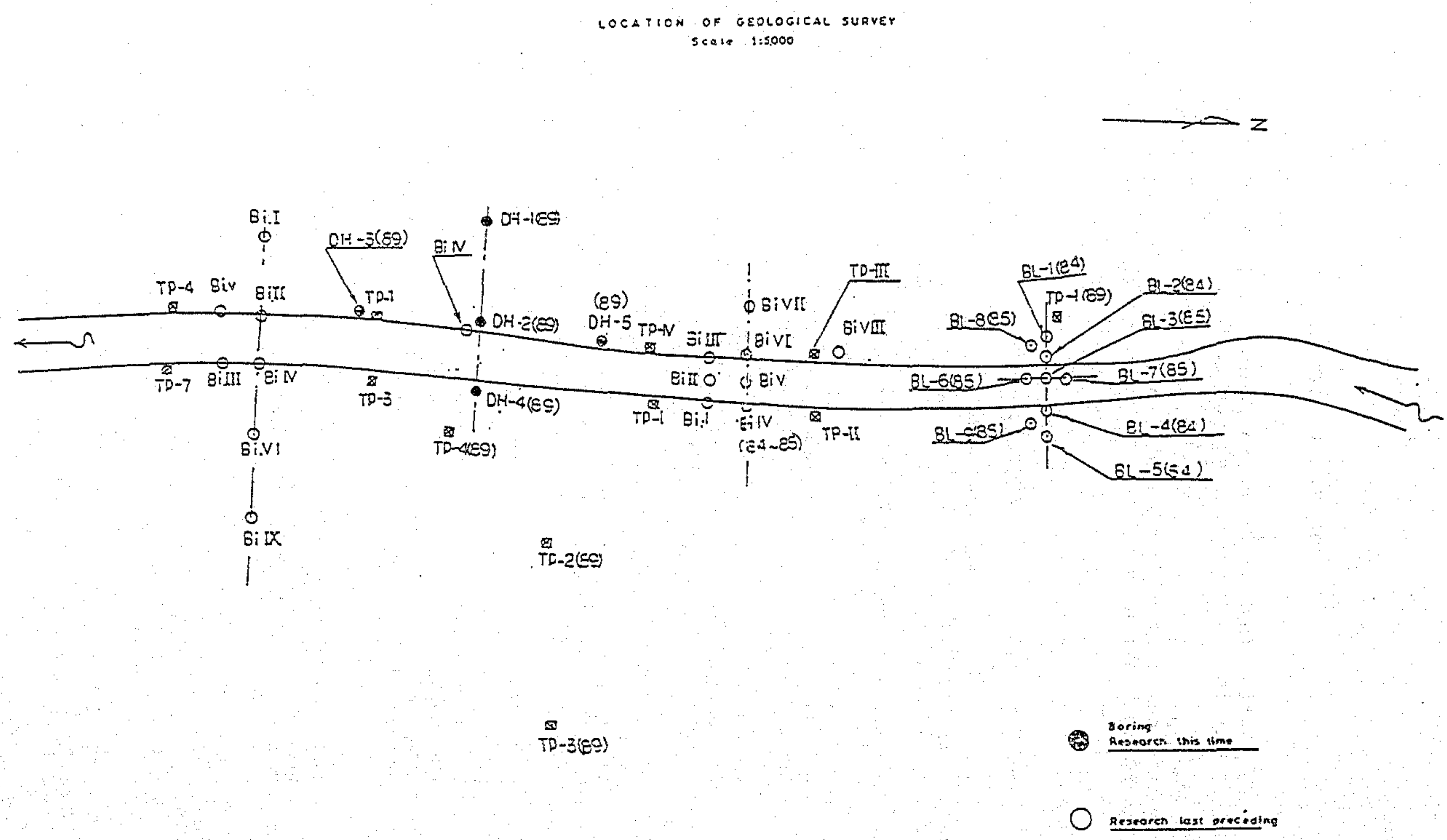
(1) At the proposed weir site, weathered pumice-tuff crops out on either bank and tuffaceous sandstone exists at EL.20m on the river bed. This was caused by the fact that weathered tuff on the river bed was scored and was replaced by deposited gravel. Therefore, outcrop on either bank is weathered 0.50 - 1.00m deep. The terraces on both banks are covered with 2m of tuffaceous clay containing Quaternary Pleistocene andesite gravel, and Pleistocene reddish clay cover the surface.

(2) Foundation ground for either main canal is stable for constructing canals and related structures because deposit mainly consists of tuffaceous clay.

(3) The River deposit covers to the extent of 200 - 300m on either bank from the present channel, and is suitable for the foundation of the secondary canals. In the middle of the swamp area, however, these exist thick weak foundation. Especially in the low lying and flat area located between the Air Hitam and the Air Manjuto, the weak foundation is thick.

The embankment materials can not be found in the area passing through the secondary canals. Consequently, the materials will be conveyed from the terrace area.

# Fig.II-1 LOCATION OF GEOLOGICAL SURVEY



# CHAPTER 2 SOIL AND GEOLOGICAL INVESTIGATION

## 2.1 Location and Quantity of Investigation

The content of the investigation for this study is shown in Table II-1, the location in Fig. II-2.

The investigation listed on the Table II-2 except cone penetration test was carried out by Indonesian CV. SECOM, Survey-Civil Engineering-Consultants under the Contract of the JICA Feasibility Study Team.

## 2.2 Methods of Investigation

1) Test pitting and sampling

In the principle of depth 3 meters, four spots at weir site, and three spots along main canal routes were excavated.

Disturbed and undisturbed samples were taken out for laboratory tests.

2) In-site permeability test

Coefficient of permeability of Quaternary fine sand or silt are tested by Charging method and Recovery method in the test pits.

3) Dutch cone penetration test

Utilizing the capacity of 5 ton class machine, tests were carried out at 26 points of the downstream of weir site and link canal route.

Tests were stopped at the depth of qc (cone bearing capacity) = $150kg.f/cm^2$, because of the capacity limit of machine.

4) Soil test

Soil test to the sample from test pits was carried out in CV. SECOM laboratory in Bandung.

## 2.3 Test Results

The test results are shown in Fig. II-2 to Fig. II-8 and Table II-2 and Table II-3.

Table II-1 NUMBER OF SOIL & GEOLOGICAL INVESTIGATION IN 1989

| | Hole No. | Depth | GH | S.P.T | P.T | S.T | Remarks |
|---|---|---|---|---|---|---|---|
| | | (m) | EL(m) | (nos) | (nos) | (Sample) | |
| Boring | DH-1 | 20.00 | 29.216 | 19 | 20 | 1 | Weir Site Right |
| | DH-2 | 20.00 | 27.176 | 19 | 19 | 1 | " |
| | DH-3 | 20.00 | 26.70 | 19 | 19 | 1 | " |
| | DH-4 | 20.00 | 28.126 | 19 | 19 | 1 | Weir Site Left |
| | DH-5 | 20.00 | 27.436 | 19 | 19 | 1 | Weir Site Right |
| | Points 5 | 100 | | 95 | 96 | 5 | |
| Test Pit | TP-1 | 3.00 | - | - | - | 1 | Weir Site |
| | TP-2 | 3.00 | - | - | - | 1 | " |
| | TP-3 | 3.00 | - | - | - | 1 | " |
| | TP-4 | 3.00 | - | - | - | 1 | " |
| | TP-1' | 3.00 | - | - | - | 1 | Canal |
| | TP-2' | 3.00 | - | - | - | 1 | " |
| | TP-3' | 3.00 | - | - | - | 1 | " |
| | 7 Pits | 21.0 | | | | 7 | |
| Cone Penetration test | | | | | | 48 Points | |

Remarks: S.P.T : Standard Penatration Test

P.T : Permeability Test

S.T : Soil Test Sample

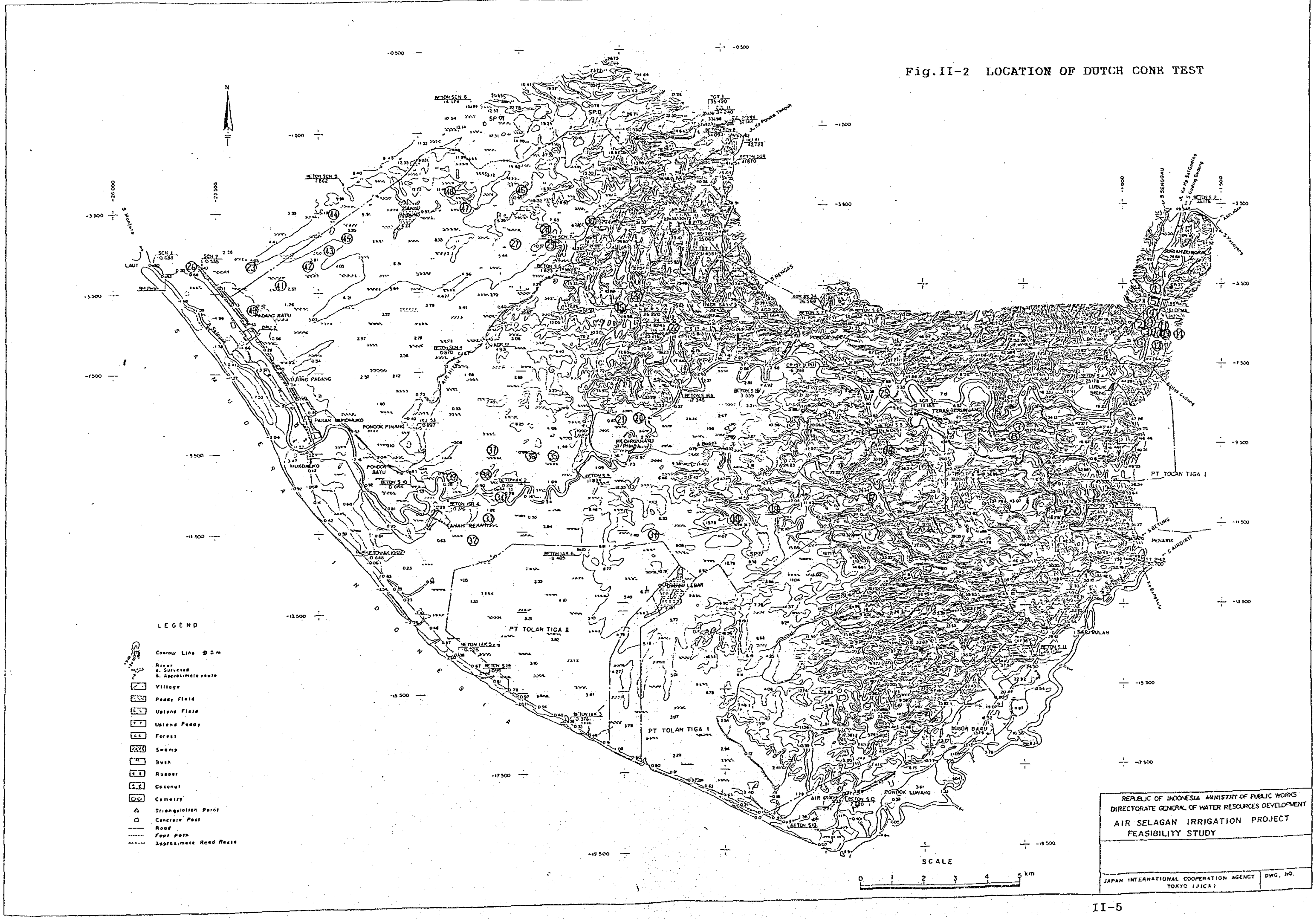



Fig.II-2 LOCATION OF DUTCH CONE TEST

# Fig.II-3 SIMPLIFIED GEOLOGIC COLUMN (1/2)

LOCATION: Proposed weir site at Air Selagan Ds.Lubuk Sahung
NO. : TP.1
DATE: 30-9/1-10-'89
TESTED BY: Sukino

| PROFILE | DESCRIPTION | REMARK |
|---|---|---|
| 0.00 – 0.75 | Top Soil: Clay, sandy silt blackish brown, mixed plant roots, soft. | |
| 0.75 – 3.00 | Breccious tuff Completely weathered (CW) to highly weathered (HW) Yellowish brown, Clay, silt, Sondi, sticky, rather compact. | Undisturbed Sample. 2.60–3.00 m |

LOCATION: Proposed weir site at Air Selagan Ds.Surian Bungkol
NO. : TP.3
DATE: 6-10/7-10-'89
TESTED BY: Sukino

| PROFILE | DESCRIPTION | REMARK |
|---|---|---|
| 0.00 – 0.70 | Top Soil: clay, sandy silt blackish brown, mixed plant roots, soft. | |
| 0.70 – 3.00 | Breccious tuff, Completely weathered (CW) to highly weathered (HW), Yellowish brown – whitish brown, clay, sandy silt, sticky, rather compact. | Undisturbed Sample. 2.60–3.00 m |

LOCATION: Proposed weir site at Air Selagan Ds.Lubuk Sahung
NO. : TP.2
DATE: 2-10/3-10-'89
TESTED BY: Sukino

| PROFILE | DESCRIPTION | REMARK |
|---|---|---|
| 0.00 – 0.75 | Top Soil: clay, sandy silt blackish brown, mixed plant roots | |
| 0.75 – 3.0 | Breccious tuff, Completely weathered (CW) to highly weathered (HW), yellowish brown, clay, sandy silt, sticky, rather compact. | Undisturbed Sample. 2.60–3.00 m |

LOCATION: Proposed weir site at Air Selagan Ds.Surian Bungkol
NO. : TP.4
DATE: 4-10/5-10-'89
TESTED BY: Sukino

| PROFILE | DESCRIPTION | REMARK |
|---|---|---|
| 0.00 – 0.75 | Top Soil: Clay, sandy silt, blackish brown mixed plant roots, soft. | |
| 0.75 – 3.00 | Breccious tuff Completely weathered (CW) to higly weathered (HW), yellowish brown to whittish brown sticky, rather compact. | Undisturbed Sample. 2.60–3.00 m |

# Fig.II-3 SIMPLIFIED GEOLOGIC COLUMN (2/2)

LOCATION: Proposed canal site along Air Selagan at Teras Terunjam
NO. : TP.1
DATE: 7-10-'89
TESTED BY: Sukino

| Propil | Diskripsi | Keterangan |
|---|---|---|
| 0.00 – 0.75 | Tanah penutup, lempung lanau pasiran coklat kehitaman, campur akar tumbuh-tumbuhan, lunak. | |
| 0.75 – 3.00 | Tufa breksi lapuk sempurna hingga lapuk kuat (CW-HW), lempung lanau pasiran, sedikit fragmen batuan, dipijit membekas, padat. | undistubed sample 2.60-3.00 m |

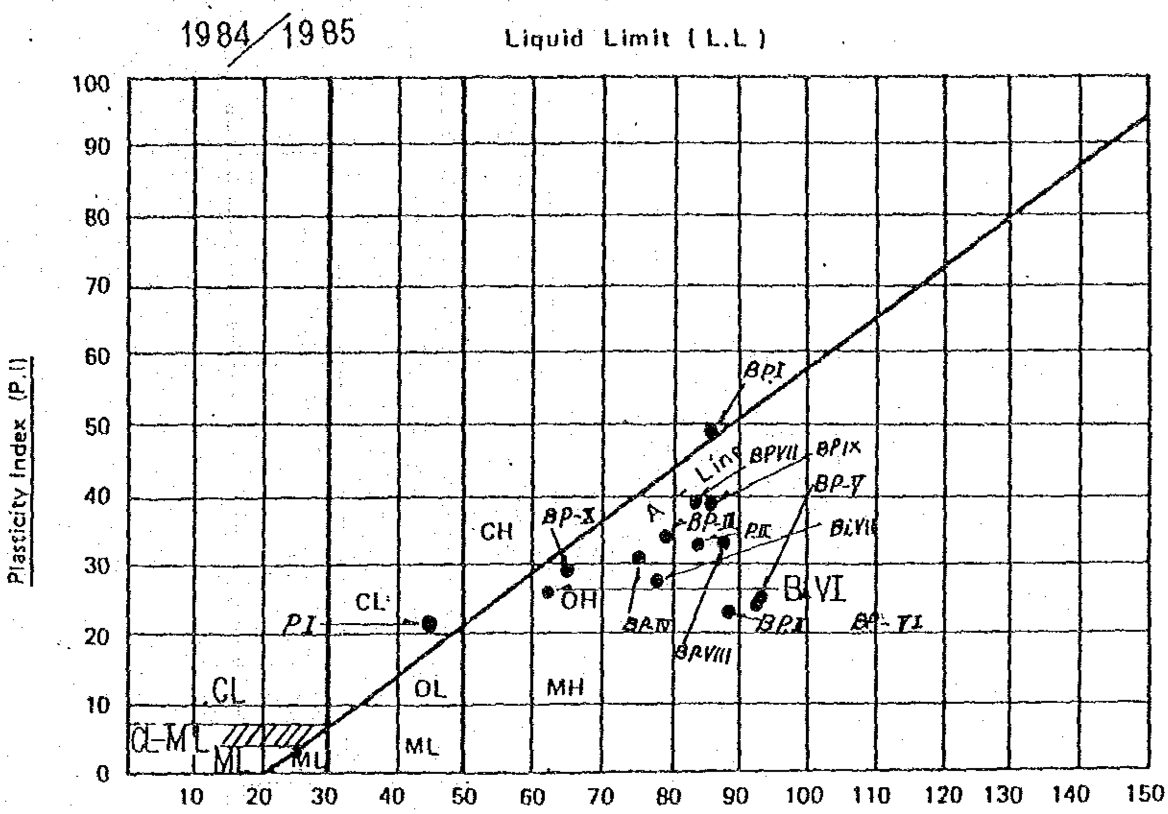
LOCATION: Proposed canal site along Air Selagan at SP IV
NO. : TP.2
DATE: 10-10-'89
TESTED BY: Sukino

| Propil | Diskripsi | Keterangan |
|---|---|---|
| 0.00 – 0.60 | Tanah penutup, lempung lanau pasiran coklat kehitaman campur, akar tumbuhan, lunak. | |
| 0.60 – 3.00 | Tufa breksi lapuk sempurna hingga lapuk kuat (CW-HW). Lempung lanau pasiran sedikit fragmen batuan, dipijit membekas, padat. | undistubed sample 2.60-3.00 m. |

LOCATION: Proposed canal site along Air Selagan at SP II
NO. : TP.3
DATE: 8-10-'89
TESTED BY: Sukino

| Propil | Diskripsi | Keterangan |
|---|---|---|
| 0.00 – 0.75 | Tanah penutup, lempung lanau pasiran, coklat kehitaman campur akar, tumbuh-tumbuhan, lunak. | |
| 0.75 – 3.00 | Tufa breksi lapuk sempurna hingga lapuk kuat (CW-HW). lempung lanau pasiran, dipijit membekas, padat. | undistubed sample. 2.60-3.00 m |

Fig.II-4 PLASTICITY CHART OF SOIL



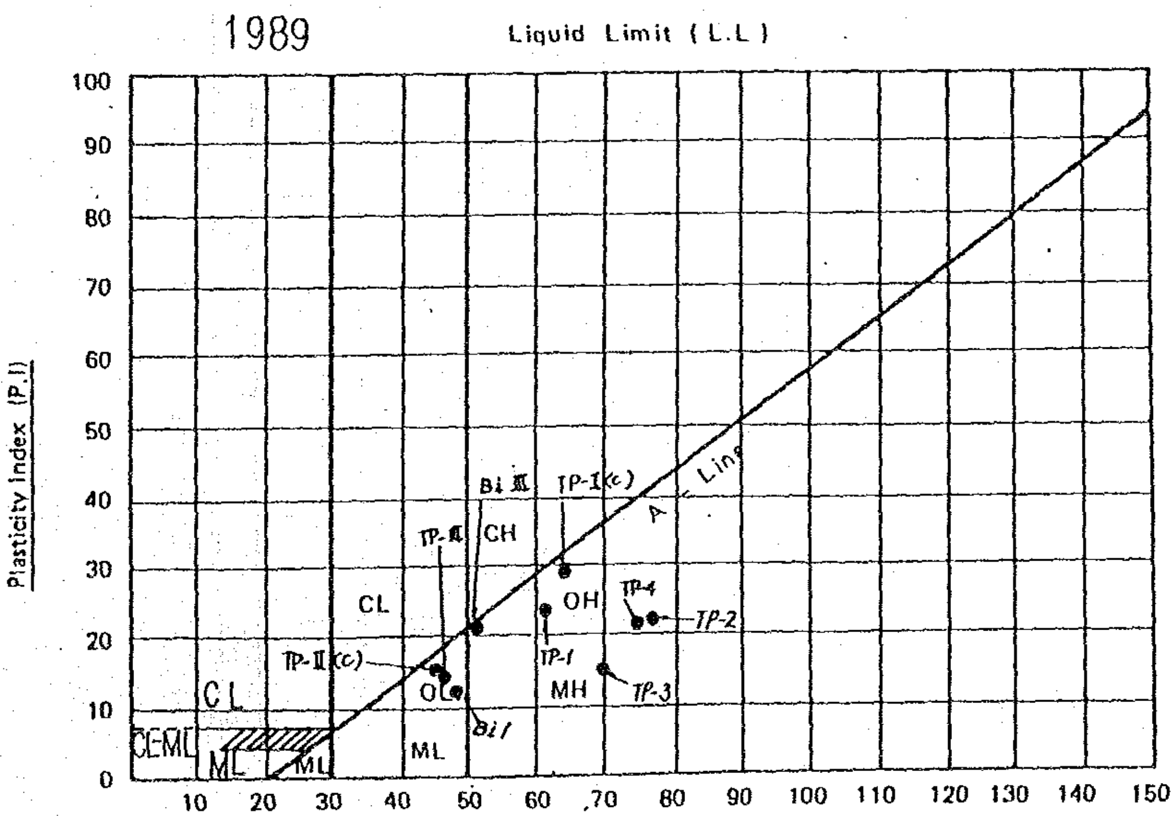
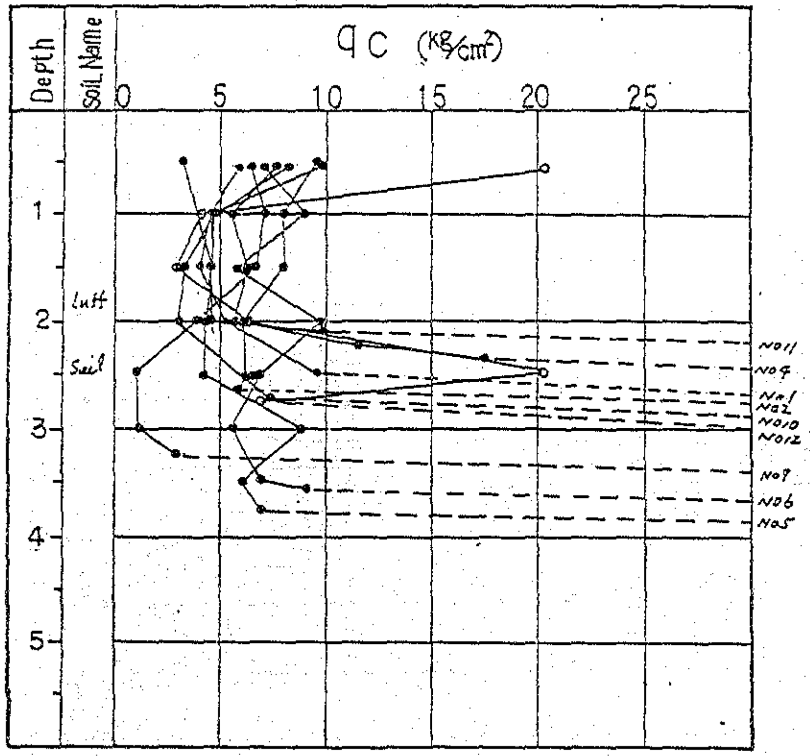



Fig.II-5 CONE INDEX BY CONE PENETRATION TESTS (1/3)

LOCATION : Weir site




LOCATION : Test pit

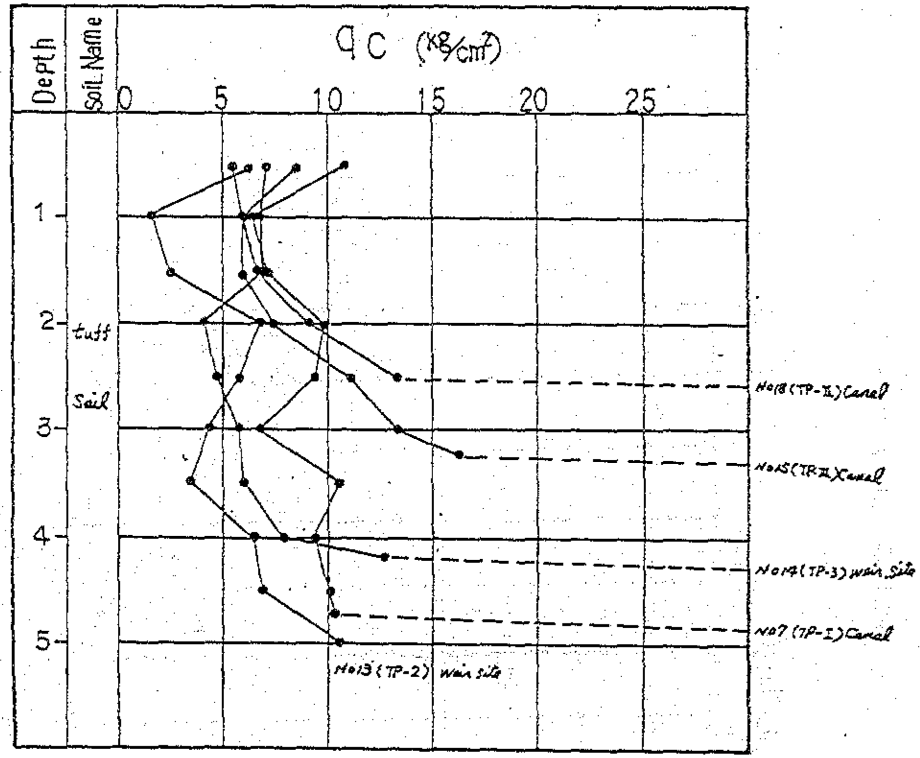
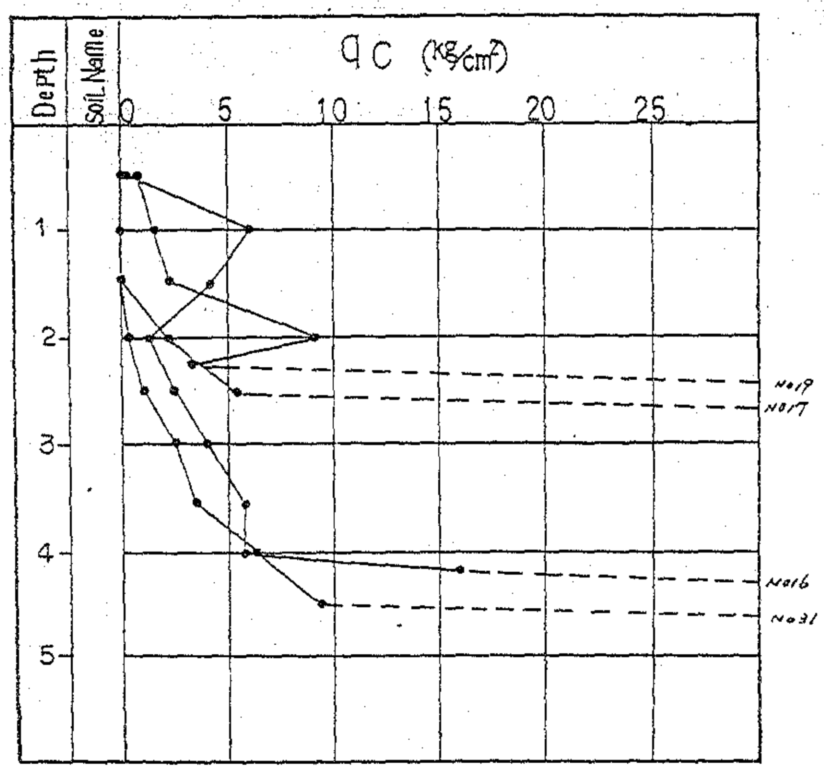
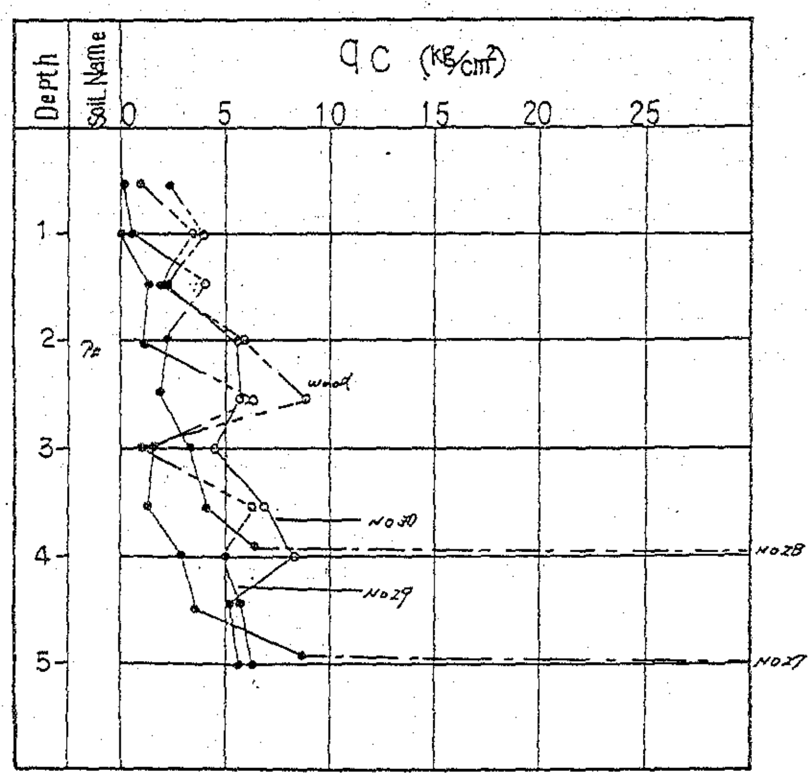


Fig.II-5  CONE INDEX BY CONE PENETRATION TESTS (2/3)

LOCATION : SP-IV

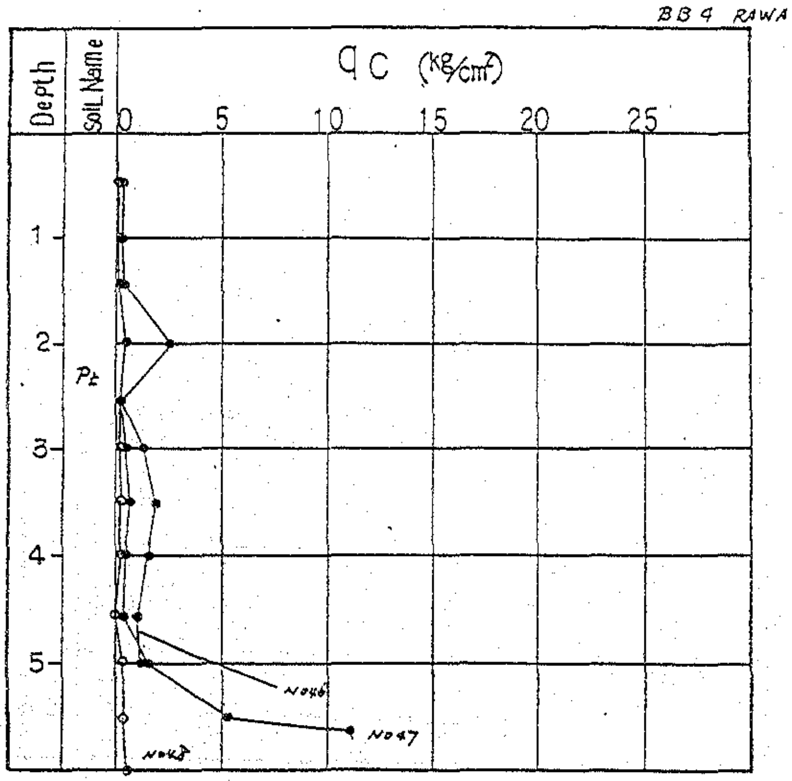



LOCATION : B.B 5

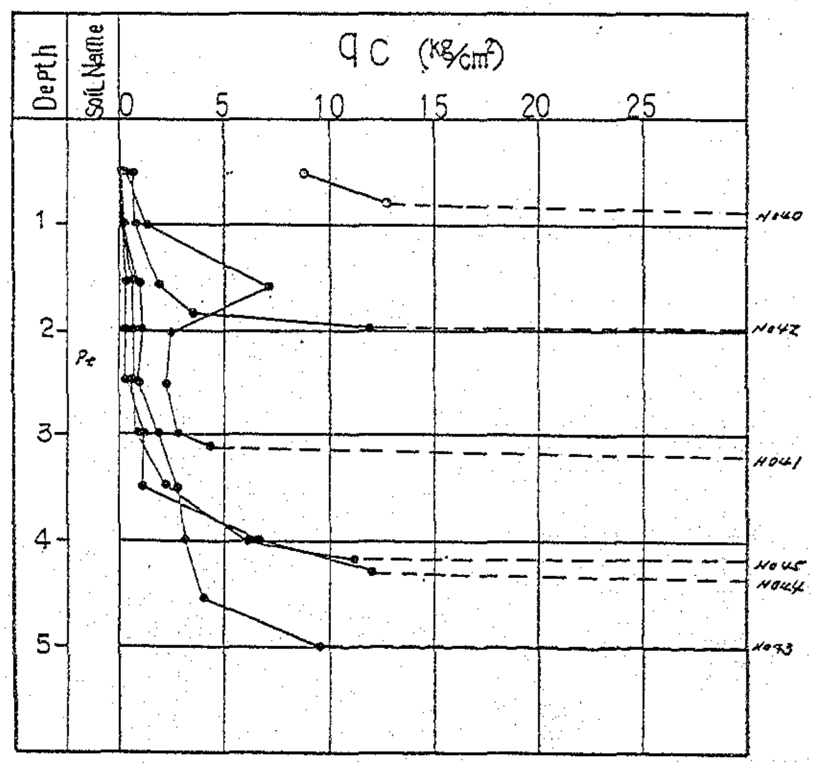


## Fig.II-5 CONE INDEX BY CONE PENETRATION TESTS (3/3)

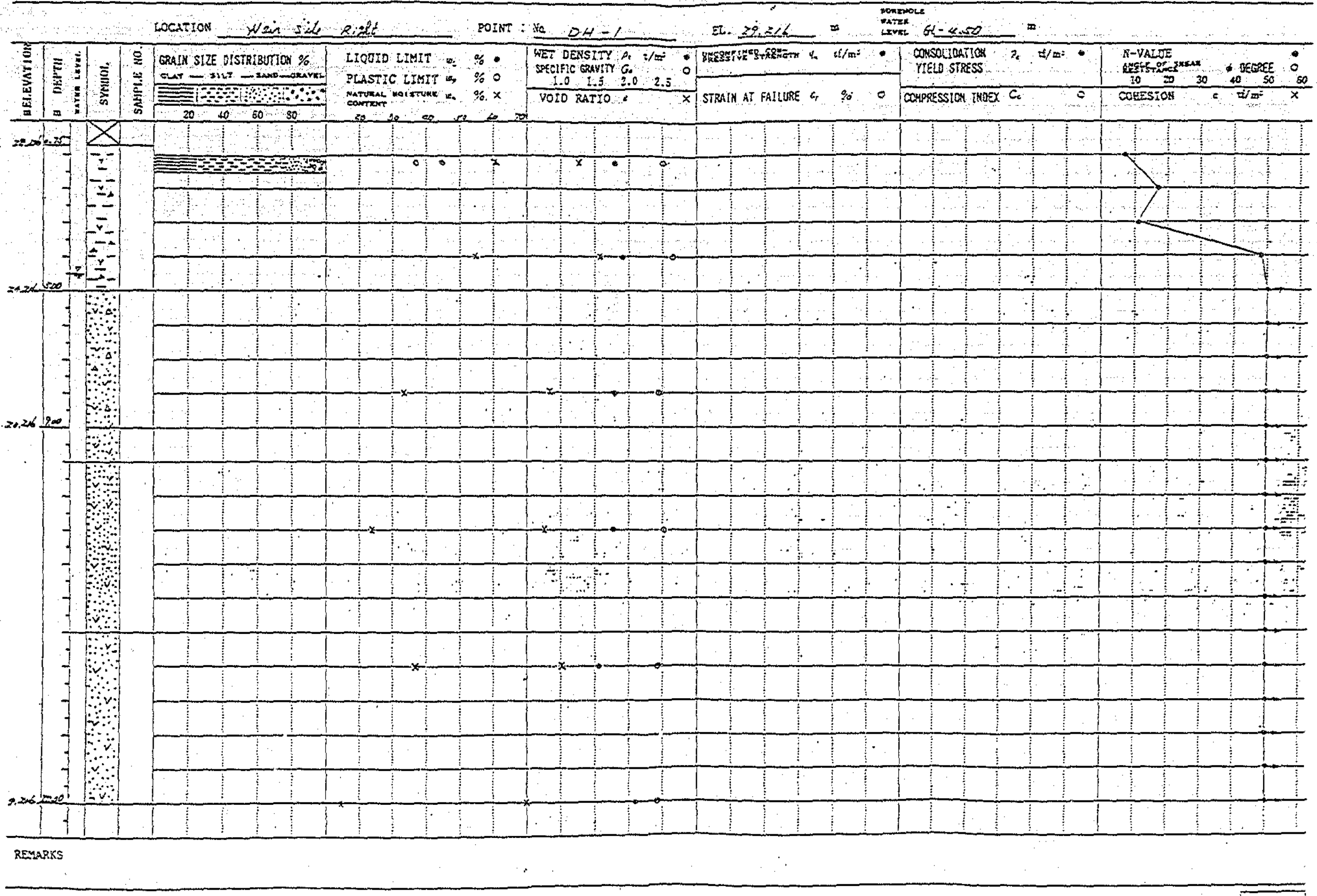
LOCATION : B.B 4 (Swamp)




LOCATION : SP-VII (Swamp)



# Fig.II-6 SOIL PROPERTY CHART (1/5)



# Fig.II-6 SOIL PROPERTY CHART (2/5)