No. 2

THE REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF AGRARIAN REFORM

FEASIBILITY STUDY
ON
INTEGRATED JALA-JALA RURAL DEVELOPMENT PROJECT

ANNEXES

SEPTEMBER, 1990

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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METEOLOGY AND HYDROLOGY

1. GENERAL

The Study area belongs toType - I according to the method of F. Jose Coronas as shown in Fig. I.1.1. The climate of the Study area is characterized by two distinct seasons: a dry and a wet season. The dry season occurs from December to April while the wet season occurs from May to November. The heaviest rainfall usually is caused by typhoon. Temperature ranges from 21.3°C to 32.9°C. The lowest temperature averages 21.3°C and usually occurs in February. The hottest month is May with temperature around 32.9°C.

There exist many small reivers originating from the Mt.Sembrano or other mountaineous region which form the backbone of the Jala Jala peninsula. The rivers in the Study area are generally characterized with steep slopes and small catchment areas less than 4 km^2. Then, runoffs by rainfalls discharge mostly within a short period. Most of the rivers dry up in the dry season except those having springs in their catchment areas.

2. COLLECTED DATA

The geographical extent of the Study area is very limited, being only 4,930 ha. Then, there is no meteorological and hydrological stations in the Study area. The meteorological stations located around the Study area are as shown in Fig. I.2.1. The rainfall data collected from the above-mentioned stations are illustrated in Fig.I.2.2. The daily rainfall data were made available in the following three stations:

(1) IRRI, Los Banos, Laguna Province (1979 to 1988)
(2) Santa Cruz, Laguna Province (1969 to 1988)
(3) PPC, Malaya, Rizal Province (1987 to 1989)

Other than the rainfall data, meteorological data such as temperature, humidity, evaporation sunshine, wind veloeity are available only at the IRRI meteorological station for the period of 10 years.

3. RAINFALL

3.1 Monthly and Daily Rainfall

The rainfall stations which provide the daily rainfall data are (i) PPC, Malaya, (ii) Santa Cruz and (iii) IRRI Los Banos. The PPC Malaya station is located about 5 km north of Jala Jala town, and Santa Cruz station is located about 14 km northeast of Jala Jala town. IRRI Los Banos station is situated about 15 km southeast on the opposite shore of Lake Laguna. In order to estimate the rainfall for the Study area, the correlation of monthly rainfall between three stations was examined. As a result, it is judged that the rainfall pattern and depths are well correlated as shown in the following expressions:

- Relation of monthly rainfall among PPC Malaya and Santa Cruz

$$R\ ml = 12.220 + 1.084 \times R\ sc \qquad (mm)$$

$$Co = 0.916$$

- Relation of monthly rainfall among PPC Malaya and IRRI Los Banos

$$R\ ml = 13.820 + 0.794 \times R\ ir \qquad (mm)$$

$$Co = 0.856$$

Where:

R mll: Monthly rainfall at PPC, Malaya (mm)
R sc: Monthly rainfall at Santa Cruz (mm)
R ir: Monthly rainfall at IRRI, Los Banos (mm)
Co: Correlation coefficient

As shown above, the rainfall characteristics of Santa Cruz are well correlated with those of PPC Malaya, which is located adjacently to the Study area. Then, the long term monthly rainfalls for the Study area were estimated by use of rainfall data of Santa Cruz on the basis of the above-mentioned correlation.

Estimated monthly rainfalls in the Study area for a 20-year period from 1969 to 1988 are summarized below. The monthly rainfall for each year is tabulated in Table I.3.1.

Monthly Rainfall

(Unit: mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	50	24	40	61	153	244	271	264	239	362	283	170	1,161
Max	168	63	112	231	597	517	829	558	401	824	638	554	3,087
Min.	14	0	13	13	33	45	89	114	149	106	128	0	1,322

Based on the estimated monthly rainfall, the daily rainfall were obtained with reference to the characteristics of Santa Cruz daily rainfall data.

3.2 Probable Rainfall

3.2.1 Probable Annual Rainfall

Based on the annual rainfall as stated in the previous section, probable excessive and non-excessive annual rainfall in the Project area is calculated and summarized as below.

Estimated Probable Annual Rainfall

Return Period	Probable Annual Rainfall (mm)	
	Excessive (mm/year)	Non-excessive (mm/year)
2-year	2,114	2,114
5-year	2,543	1,758
10-year	2,802	1,595
20-year	3,034	1,473
50-year	3,319	1,346
100-year	3,525	1,268

3.2.2 Maximum Daily and Continuous Rainfall

Based on the estimated daily rainfall for a 20-year period (1969-1988), the probable maximum daily, 2-day and 3-day rainfall is estimated and summarized below.

Return Period	Maximum Rainfall (mm)		
		Continuous	
	Daily	2-day	3-day
2-year	133	183	204
5-year	182	254	295
10-year	214	302	359
20-year	244	349	423
50-year	283	410	510
100-year	313	456	578
200-year	342	503	648
500-year	382	567	746
1000-year	412	617	824

4. METEOROLOGY

The meteorological data other than the rainfall data were obtained from IRRI meteorological station. Those data were used for the Project Study. The meteorological characteristics are illustrated in Fig. I . 4.1 and summarized below.

4.1 Temperature

The mean annual temperature is 27.1°C. From December to February, the weather is slightly cool with a mean temperature 25.1°C; March to November is the warm season, having a mean temperature of 27.4°C. The daily maximum temperature of more than 32°C is usually recorded between April and June. On the other hand, the average lowest temperature is usually higher than 21°C.

4.2 Humidity

The mean monthly relative humidity varies from 75% to 82%. And the mean annual relative humidity is 79%.

4.3 Evaporation

The mean annual evaporation is 4.5 mm/day or 1,649 mm/year. And the monthly evaporation varies from 3.3 mm/day in December to 6.1 mm/day in April.

4.4 Cyclone

Based upon the rainfall analyses on the Laguna lake basin and tropical cyclone records, it is obvious that rainfall is strongly cyclone influenced. In other words, the fluctuations of annual rainfall are very large. Moreover, the frequency of tropical cyclone which will cross through Jala-Jala peninsula will be slightly more than other areas except Quezon City as shown below. Subsequently, it can be expected that monthly rainfall will fluctuate greatly each year.

Frequency of Tropical Cyclone (A.D. 1948-88)

Place Name	Typhoon Depression (<=63 kph)	Tropical Storm (64-117 kph)	Typhoon (>=118 kph)	Total
Rizal Province	5	3	9	17
Metro Manila	3	2	7	12
Cavite Province	2	5	5	12
Quezon City	12	18	34	65
Laguna Province	2	6	4	12

Note; Source: PAGASA

5 HYDROLOGY

5.1 Observed Discharge

During both the wet and dry seasons, the discharge measurement for the 7 major rivers in the Study area were conducted. The results are as shown in Table I.5.1.

River discharges in the wet season were measured 1 to 3 days after finishing the typhoon occurred on October 11, 1989, and about one month later therefrom. The specific discharges of the wet season constant flows range from 4 to 13 l/sec/km^2.

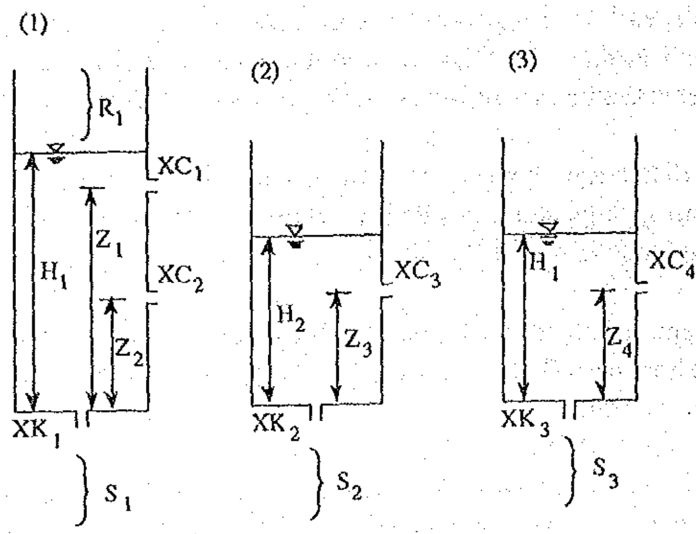
Dry season discharges were meanured in April 1990. The dry season discharges originate mainly from springs located in their catchment areas. The specific discharges in the dry season fall in the range of 1 to 3 l/sec/km^2.

Due to the small catchment areas and steep river courses, major parts of rainfall discharge within a short period after rainfall, and only seven rivers provide riverflows after about one week from rainfall.

Creek Name	Drainage Area	Wet Season *2		Dry Season *2	
	(km^2)	(l/s)	(l/s/km^2)	(l/s)	(l/s/km^2)
Puang	3.0	14	4.2	2.9	1.0
Mapakla	3.4	15	4.4	5.1	1.5
Palay-Palay	3.8	2	0.5	0	0
Ik-Ik	1.1	9	7.8	0	0
Lubo	1.1	5	4.5	3.7	3.4
Turnina	3.45	45	13.0	10.0	2.9

5.2 Estimates of Long-term Daily Runoff

The Study Team estimated the runoff of 5 rivers for a 20-year period (1969-88) by the Tank Model simulation method. The Tank Model structure was established based on the daily rainfall data of Santa Cruz station and observed discharge of Santa Cruz River giving due attention to (i) annual runoff coefficient; (ii) hydrograph shape and (iii) total annual runoff (see Fig. I.5.1). As a result, the tank structure for the Project area is determined, as illustrated below.



The discharge measurements are as shown below.

$H_1 = 30$ mm, $H_2 = 10$ mm, $H_3 = 40$ mm $H_4 = 50$ mm
$C_1 = 0.30$, $C_2 = 0.001$, $C_3 = 0.00001$, $C_4 = 0.0000001$
$S_1 = 0.05$, $S_2 = 0.01$, $S_3 = 0.005$

By using such tank structure, daily runoff for the 20-year period of 1969 to 1988 is estimated for Puang, Mapakla, Palay-Palay, Lubo and Turnina Rivers, and monthly runoff for the same are summarized as shown in Table I.5.2 to I.5.6.

5.3 Flood Discharge

There is not data for continuous discharge during flood at Palay-Palay Creek, therefore, the peak discharge at the proposed dam site is estimated by the rational formula as shown below.

$Q = 1/3.6 \cdot f \cdot R \cdot A$
$R = R_p \cdot (24/t_c)^{1/2}$

Where,
- Q : Estimated flood discharge (m^3/sec)
- f : Runoff coefficient (0.70)
- R : Rate of rainfall for the time of concentration and frequency (mm/hr.)
- A : Area of basin (km^2)
- R_p : Daily probable rainfall (mm)
- t_c : Time of arrival (hr.)

Based on the estimated time of flood concentration of 33 minutes and a river length of 4 kms, the probable flood discharges are obtained below.

Return Period	Flood Discharge (m^3/sec)
5-year	37
10-year	44
100-year	64
200-year	70

TABLES

Table I.3.1 Estimated Monthly Rainfall of Jala-Jala Area

(Unit: mm/month)

A.D.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	29.8	12.7	25.0	22.5	87.1	133.5	405.6	166.1	165.2	146.7	153.7	263.9	1,611.8
1970	45.1	31.4	35.4	53.5	132.5	235.2	289.6	158.2	401.5	568.3	637.9	205.9	2,794.5
1971	25.8	39.9	102.0	32.1	261.1	438.1	356.7	192.0	238.1	465.7	381.9	553.8	3,087.2
1972	82.9	15.5	83.3	53.5	169.8	370.4	828.5	310.3	149.6	258.6	221.8	131.5	2,675.7
1973	49.9	19.0	20.3	22.7	105.4	238.6	213.0	159.0	291.5	360.2	398.8	323.8	2,202.2
1974	16.3	36.4	24.7	21.9	146.0	223.1	170.2	478.1	176.4	365.7	430.9	305.0	2,394.7
1975	133.1	21.4	110.3	231.2	80.0	174.4	105.4	279.0	268.5	304.3	212.2	397.3	2,317.1
1976	39.9	21.6	26.6	54.7	596.8	258.8	231.8	289.7	259.8	150.1	226.6	243.4	2,399.8
1977	168.0	35.7	42.1	24.4	105.0	307.2	207.3	262.2	290.2	157.2	218.7	34.9	1,852.9
1978	35.6	20.2	12.8	43.1	126.6	117.6	149.8	558.1	336.7	824.0	173.5	128.6	2,526.6
1979	22.9	23.8	15.8	216.6	259.8	314.9	159.3	322.5	263.5	263.4	235.6	39.0	2,137.1
1980	17.6	0.0	111.5	28.4	116.6	264.6	277.6	245.8	159.3	(358.0)	405.2	218.5	2,203.1
1981	31.9	16.2	17.7	38.2	129.8	246.6	395.2	201.1	295.3	343.2	355.8	96.9	2,167.9
1982	13.7	28.3	41.3	36.9	83.1	154.8	515.1	175.9	350.9	133.8	185.8	77.2	1,796.8
1983	66.2	15.7	28.2	12.8	32.3	122.1	253.8	218.2	149.1	337.6	128.4	0.0	1,364.4
1984	21.9	14.0	23.8	74.1	205.7	236.0	88.6	362.7	188.8	682.3	145.0	41.9	2,084.8
1985	22.1	25.6	35.9	71.8	136.5	516.7	241.4	113.5	184.4	403.8	137.9	100.2	1,989.8
1986	23.7	21.8	13.4	16.8	131.1	44.8	257.9	382.4	166.9	381.1	337.2	99.4	1,876.5
1987	28.3	13.8	13.3	13.3	48.5	141.8	(106.8)	196.3	277.1	105.6	249.3	128.0	1,322.1
1988	119.2	63.2	13.9	147.5	102.8	334.0	171.6	213.8	171.2	643.5	416.4	20.4	2,417.5
MEAN	49.7	23.8	39.9	60.8	152.8	243.7	271.3	264.2	239.2	362.7	282.6	170.5	2,161.1

Note:
1) Estimated by correlation from the rainfall data observed at Santa Cruz,
Rainfall (Jala-Jala) = 12.220 + 1.084 * Rainfall (Santa Cruz)
Correlation coefficient = 0.916
2) Figures of parenthesis; estimated by correlation from the rainfall data observed at IRRI Wet Land, Los Banos,
Rainfall (Jala-Jala) = 13.820 + 0.794 * Rainfall (IRRI, Los Banos)
Correlation coefficient = 0.856

Table I.5.1 Discharge Measurement

River Name	Discharge (l/sec)	Date	Remarks
1. Puang	354	Oct. 12, '89	1 day after occurrence of typhoon
	14	Nov. 16, '89	Wet season flow
	3	Apr. '90	Dry season flow
2. Mapakla	138	Oct. 12, '89	1 day after occurence of typhoon
	15	Nov. 16, '89	Wet season flow
	5	Apr. '90	Dry season flow
3. Bayugo	6	Oct. 13, '89	2 days after occurrence of typhoon
	0	NOv. 16, '89	Wet season flow
4. Palay-Palay	33	Oct. 13, '89	2 days after occurrence of typhoon
	2	Nov. 17, '89	Wet season flow
	0	Apr. '90	Dry season flow
5. Turnina	165	Oct. 14, '89	3 days after occurrence of typhoon
	45	Nov. 17, '89	Wet season flow
	10	Apr. '90	Dry season flow
6. Ik-Ik	10	Oct. 14, '89	3 days after occurrence of typhoon
	0	Apr. '90	Dry season flow
7. Lubo	5	Nov. 29, '89	Wet season flow
	4	Apr. '90	Dry season flow

Table I.5.2 Estimated Monthly Runoff of Puang River

Drainage Area: 3.0 sq.km

(Unit: m3/s/month)

A.D.	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR
1969									0.093	0.084	0.093	0.090
1969-1970	0.648	1.904	10.784	3.692	4.943	3.138	2.614	6.786	1.319	0	0	0.922
1970-1971	2.089	5.031	7.235	2.007	11.404	13.552	16.290	8.491	1.195	0	2.275	0
1971-1972	4.828	12.264	9.632	3.255	5.664	11.498	7.058	17.065	4.046	0.423	0.835	0.291
1972-1973	2.585	9.074	20.621	8.482	6.751	3.651	6.610	4.432	0.096	0.282	0	0
1973-1974	1.590	5.805	4.971	3.658	6.300	9.020	10.294	9.880	0.442	0	0.420	0
1974-1975	2.294	5.390	3.997	12.274	3.167	9.209	10.348	9.196	2.621	1.390	0.579	1.634
1975-1976	0.306	4.416	1.381	6.667	6.596	8.237	4.680	5.178	6.085	0.094	0	0.328
1976-1977	15.491	6.530	4.707	8.731	4.986	2.682	5.057	7.621	2.488	1.700	0.105	0.282
1977-1978	1.169	6.519	6.352	6.190	7.584	2.755	6.176	0.207	0	0	0	0
1978-1979	1.466	2.682	3.653	14.361	6.422	21.117	8.679	1.648	1.256	0	0	3.287
1979-1980	5.736	7.624	2.817	9.548	4.142	8.804	5.777	0.349	0.112	0	0	2.401
1980-1981	2.000	4.188	8.005	5.452	4.986	2.589	17.852	5.033	0.288	0	0	0
1981-1982	1.851	4.875	12.103	4.565	5.845	5.900	10.703	3.903	1.037	0	0	0.704
1982-1983	1.074	2.877	12.883	5.460	7.085	3.888	3.831	2.452	0.644	0.135	0.185	0
1983-1984	0	2.149	5.270	6.081	1.294	7.720	5.432	0.240	0	0	0	0
1984-1985	4.051	5.301	2.118	5.659	6.828	17.809	2.725	2.797	0	0.099	0.151	0
1985-1986	1.998	10.832	8.631	3.162	4.053	9.927	3.572	2.119	0	0	0	0
1986-1987	2.096	0.148	6.996	9.494	4.064	9.203	7.827	4.097	0.099	0	0	0
1987-1988	0.227	3.237	0.710	5.488	6.372	2.462	2.299	6.557	2.448	0.737	0.264	3.206
1988	1.491	8.475	3.820	5.063	3.660	17.181	12.771	0				
MEAN	2.654	5.466	6.834	6.464	5.607	8.517	7.530	4.907	1.232	0.294	0.296	0.702

Table I.5.3 Estimated Monthly Runoff of Mapakula River

Drainage Area: 3.4 sq.km

(Unit: m3/s/month)

A.D.	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR
1969									0.166	0.143	0.155	0.150
1969-1970	0.787	2.213	12.273	4.247	5.652	3.613	3.023	7.746	1.557	0	0	1.106
1970-1971	2.425	5.754	8.253	2.329	12.979	15.417	18.514	9.679	1.415	0	2.638	0
1971-1972	5.533	13.955	10.974	3.742	6.472	13.087	8.052	19.395	4.646	0.532	1.010	0.387
1972-1973	2.984	10.341	23.428	9.671	7.705	4.192	7.548	5.075	0.179	0.380	0	0
1973-1974	1.853	6.637	5.686	4.200	7.194	10.280	11.719	11.253	0.566	0	0.535	0
1974-1975	2.657	6.161	4.583	13.966	3.640	10.494	11.779	10.474	3.030	1.631	0.716	1.913
1975-1976	0.408	5.054	1.624	7.610	7.529	9.389	5.354	5.923	6.956	0.167	0	0.425
1976-1977	17.610	7.453	5.387	9.950	5.707	3.092	5.782	8.691	2.874	1.987	0.183	0.386
1977-1978	1.381	7.441	7.254	7.074	8.653	3.181	7.052	0.303	0	0	0	0
1978-1979	1.717	3.094	4.197	16.338	7.330	23.990	9.901	1.926	1.490	0	0	3.776
1979-1980	6.556	8.696	3.248	10.876	4.746	10.037	6.605	0.458	0.185	0	0	2.780
1980-1981	2.319	4.799	9.129	6.231	5.707	2.989	20.285	5.766	0.386	0	0	0
1981-1982	2.152	5.579	13.772	5.230	6.681	6.741	12.180	4.481	1.235	0	0	0.853
1982-1983	1.270	3.314	14.658	6.244	8.084	4.464	4.394	2.842	0.792	0.206	0.269	0
1983-1984	0	2.492	6.028	6.946	1.529	8.806	6.209	0.328	0	0	0	0
1984-1985	4.646	6.062	2.464	6.471	7.796	20.237	3.143	3.233	0	0.166	0.227	0
1985-1986	2.316	12.334	9.838	3.637	4.649	11.309	4.102	2.462	0	0	0	0
1986-1987	2.430	0.228	7.986	10.818	4.663	10.484	8.923	4.704	0.169	0	0	0
1987-1988	0.313	3.727	0.860	6.277	7.276	2.849	2.658	7.490	2.835	0.893	0.357	3.683
1988	1.741	9.657	4.384	5.799	4.202	19.526	14.531	0				
MEAN	3.063	6.250	7.801	7.383	6.410	9.709	8.588	5.620	1.456	0.385	0.392	0.849

Table I.5.4 Estimated Monthly Runoff of Palay-Palay River

Drainage Area: 3.8 sq.km

(Unit: m3/s/month)

A.D.	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR
1969									0	0	0	0
1969-1970	0.702	2.298	13.543	4.557	6.149	3.851	3.191	8.476	1.546	0	0	1.052
1970-1971	2.528	6.259	9.052	2.418	14.335	17.054	20.523	10.638	1.397	0	2.760	0
1971-1972	5.994	15.430	12.090	3.999	7.063	14.448	8.827	21.500	5.003	0.418	0.939	0.248
1972-1973	3.154	11.384	26.009	10.629	8.440	4.506	8.267	5.495	0.002	0.246	0	0
1973-1974	1.897	7.245	6.175	4.520	7.867	11.313	12.926	12.402	0.439	0	0.410	0
1974-1975	2.791	6.708	4.937	15.430	3.891	11.553	12.995	11.534	3.200	1.647	0.613	1.953
1975-1976	0.268	5.481	1.625	8.327	8.243	10.318	5.813	6.436	7.582	0.006	0	0.298
1976-1977	19.507	8.160	5.837	10.943	6.199	3.275	6.282	9.538	3.026	2.043	0.012	0.242
1977-1978	1.362	8.139	7.929	7.727	9.493	3.368	7.711	0.139	0	0	0	0
1978-1979	1.741	3.281	4.511	18.076	8.017	26.635	10.891	1.970	1.466	0	0	4.051
1979-1980	7.151	9.544	3.446	11.979	5.132	11.037	7.205	0.318	0.020	0	0	2.926
1980-1981	2.418	5.190	10.022	6.789	6.207	3.152	22.497	6.261	0.246	0	0	0
1981-1982	2.229	6.061	15.216	5.662	7.29	7.353	13.443	4.822	1.189	0	0	0.772
1982-1983	1.240	3.528	16.208	6.795	8.862	4.805	4.738	2.985	0.690	0.062	0.115	0
1983-1984	0	2.607	6.561	7.582	1.517	9.665	6.764	0.181	0	0	0	0
1984-1985	5.009	6.599	2.565	7.050	8.537	22.443	3.332	3.421	0	0.016	0.069	0
1985-1986	2.409	13.605	10.815	3.888	5.021	12.457	4.408	2.560	0	0	0	0
1986-1987	2.535	0.070	8.743	11.908	5.030	11.535	9.800	5.075	0.005	0	0	0
1987-1988	0.165	3.985	0.763	6.833	7.956	2.998	2.785	8.185	2.980	0.817	0.216	3.947
1988	1.769	10.615	4.719	6.302	4.518	21.647	16.062	0				
MEAN	3.243	6.809	8.538	8.071	6.988	10.671	9.423	6.097	1.440	0.263	0.257	0.774

Table I.5.5 Estimated Monthly Runoff of Lubo River

Drainage Area: 1.1 sq.km

(Unit: m3/s/month)

A.D.	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR
1969									0.124	0.112	0.124	0.120
1969-1970	0.327	0.778	4.031	1.438	1.890	1.232	1.042	2.571	0.569	0	0	0.422
1970-1971	0.850	1.923	2.734	0.817	4.261	5.054	6.052	3.193	0.526	0	0.920	0
1971-1972	1.854	4.578	3.616	1.272	2.157	4.300	2.668	6.341	1.566	0.234	0.395	0.190
1972-1973	1.035	3.406	7.644	3.191	2.553	1.419	2.504	1.706	0.124	0.182	0	0
1973-1974	0.671	2.209	1.901	1.424	2.389	3.389	3.855	3.702	0.249	0	0.240	0
1974-1975	0.924	2.055	1.546	4.584	1.238	3.459	3.873	3.453	1.045	0.585	0.299	0.682
1975-1976	0.201	1.698	0.588	2.526	2.501	3.101	1.794	1.980	2.312	0.117	0	0.205
1976-1977	5.766	2.473	1.808	3.282	1.910	1.063	1.929	2.874	0.992	0.701	0.127	0.190
1977-1978	0.516	2.468	2.410	2.350	2.862	1.093	2.344	0.163	0	0	0	0
1978-1979	0.624	1.063	1.420	5.351	2.434	7.824	3.264	0.688	0.547	0	0	1.292
1979-1980	2.188	2.876	1.115	3.582	1.598	3.308	2.198	0.215	0.130	0	0	0.961
1980-1981	0.819	1.615	3.018	2.082	1.909	1.032	6.625	1.927	0.194	0	0	0
1981-1982	0.763	1.867	4.520	1.757	2.226	2.243	4.004	1.517	0.467	0	0	0.339
1982-1983	0.481	1.135	4.806	2.083	2.676	1.510	1.482	0.985	0.320	0.129	0.157	0
1983-1984	0	0.869	2.012	2.309	0.556	2.913	2.070	0.176	0	0	0	0
1984-1985	1.567	2.022	0.863	2.156	2.586	6.612	1.079	1.110	0	0.116	0.143	0
1985-1986	0.819	4.053	3.245	1.240	1.567	3.723	1.388	0.859	0	0	0	0
1986-1987	0.855	0.140	2.647	3.563	1.570	3.456	2.952	1.588	0.125	0	0	0
1987-1988	0.169	1.269	0.342	2.092	2.418	0.987	0.924	2.485	0.983	0.351	0.185	1.259
1988	0.634	3.187	1.481	1.940	1.422	6.379	4.761	0				
MEAN	1.059	2.084	2.587	2.452	2.136	3.205	2.840	1.883	0.538	0.188	0.198	0.343

Table I.5.6. Estimated Monthly Runoff of Turnina River

Drainage Area: 3.45 sq.km

(Unit: m3/s/month)

A.D.	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR
1969									0.318	0.282	0.310	0.300
1969-1970	0.949	2.391	12.606	4.458	5.884	3.817	3.210	8.009	1.730	0	0	1.265
1970-1971	2.609	5.984	8.527	2.513	13.310	15.792	18.929	9.970	1.582	0	2.827	0.000
1971-1972	5.762	14.307	11.283	3.949	6.713	13.426	8.315	19.831	4.865	0.679	1.173	0.538
1972-1973	3.178	10.635	23.924	9.959	7.960	4.402	7.803	5.298	0.323	0.521	0	0
1973-1974	2.032	6.878	5.920	4.412	7.447	10.581	12.033	11.569	0.723	0	0.694	0
1974-1975	2.844	6.398	4.801	14.320	3.840	10.796	12.100	10.778	3.221	1.788	0.873	2.090
1975-1976	0.561	5.273	1.798	7.871	7.787	9.677	5.580	6.160	7.207	0.308	0	0.577
1976-1977	18.020	7.707	5.614	10.249	5.936	3.288	6.012	8.971	3.064	2.154	0.333	0.534
1977-1978	1.554	7.695	7.509	7.326	8.922	3.377	7.303	0.455	0	0	0	0
1978-1979	1.892	3.284	4.410	16.723	7.581	24.492	10.186	2.105	1.664	0	0	3.982
1979-1980	6.803	8.965	3.447	11.188	4.964	10.335	6.846	0.612	0.336	0	0	2.963
1980-1981	2.508	5.014	9.413	6.476	5.933	3.183	20.728	5.999	0.542	0	0	0
1981-1982	2.335	5.805	14.125	5.460	6.924	6.989	12.504	4.696	1.400	0	0	1.014
1982-1983	1.441	3.507	15.026	6.484	8.350	4.679	4.601	3.032	0.955	0.345	0.420	0
1983-1984	0	2.673	6.266	7.197	1.694	9.082	6.443	0.483	0	0	0	0
1984-1985	4.864	6.296	2.650	6.715	8.055	20.686	3.333	3.429	0	0.303	0.383	0
1985-1986	2.502	12.662	10.128	3.844	4.863	11.624	4.307	2.648	0	0	0	0
1986-1987	2.616	0.373	8.251	11.128	4.875	10.789	9.201	4.924	0.322	0	0	0
1987-1988	0.469	3.925	1.024	6.514	7.527	3.038	2.842	7.847	3.025	1.044	0.512	3.884
1988	1.919	9.943	4.600	6.030	4.408	19.963	14.890	0				
MEAN	3.258	6.486	8.066	7.641	6.649	10.001	8.858	5.852	1.627	0.528	0.548	1.008

FIGURES

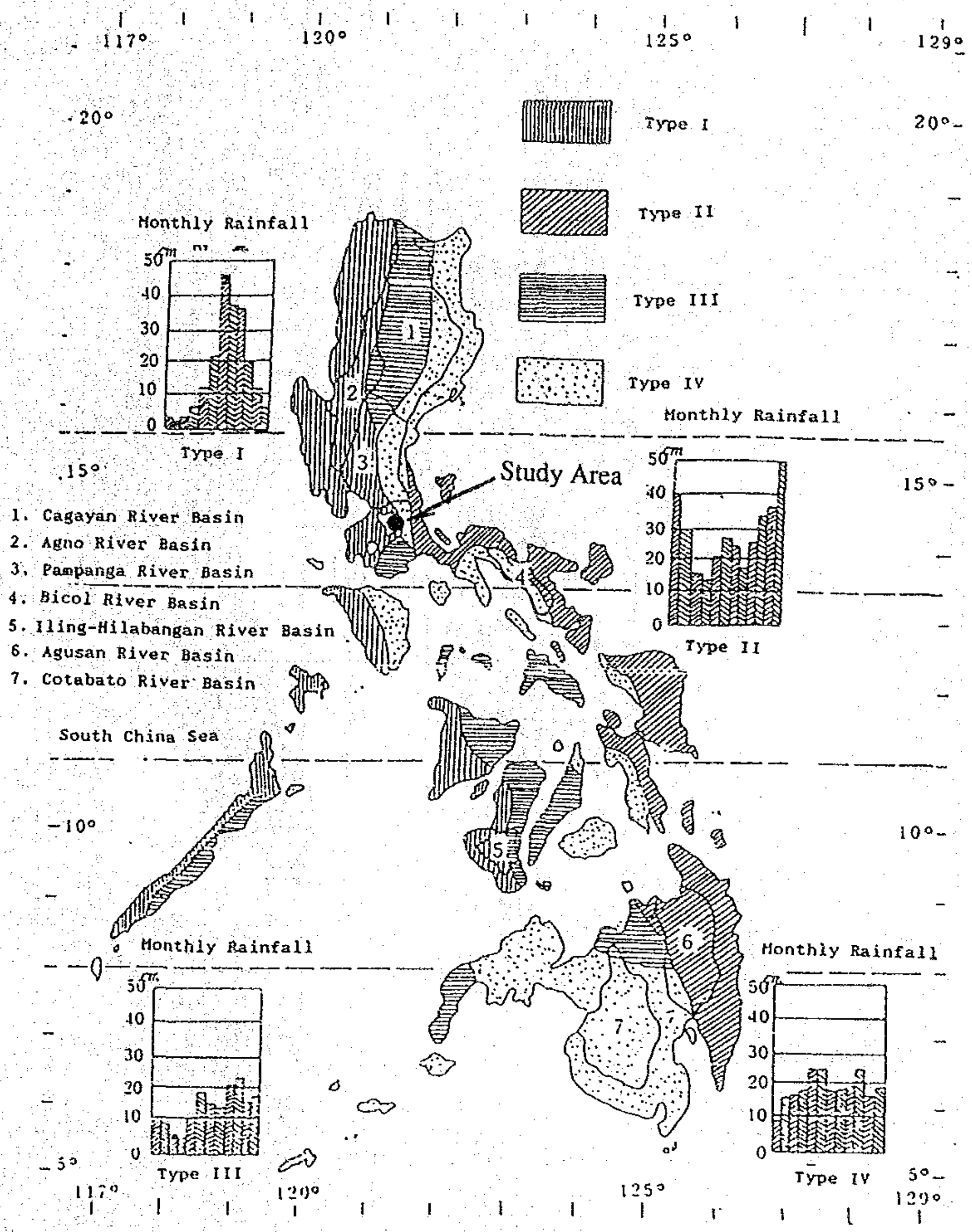


Fig. I.1.1 Philippine Meteorological Classification

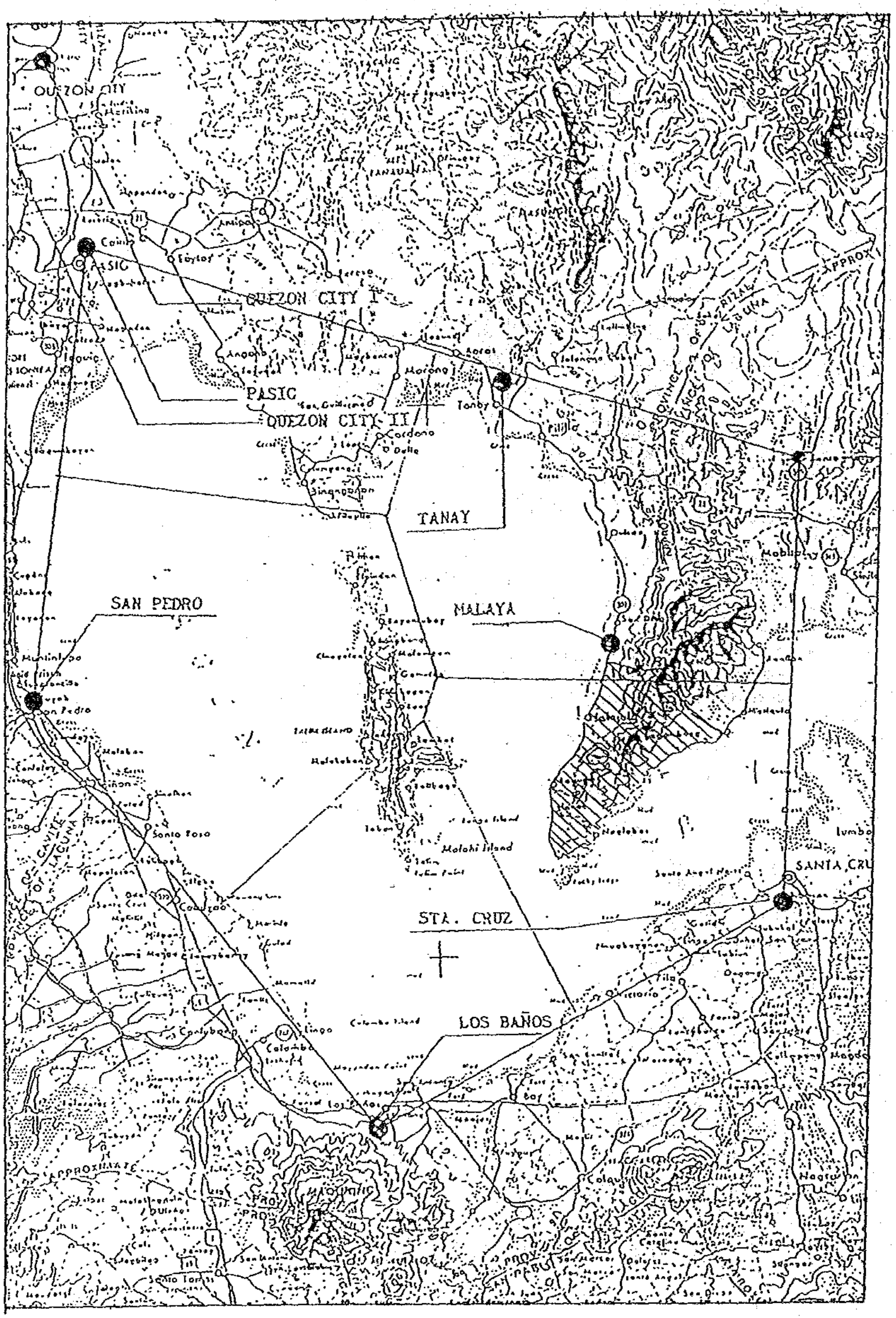


Fig. I.2.1 Location of Meteorological Station

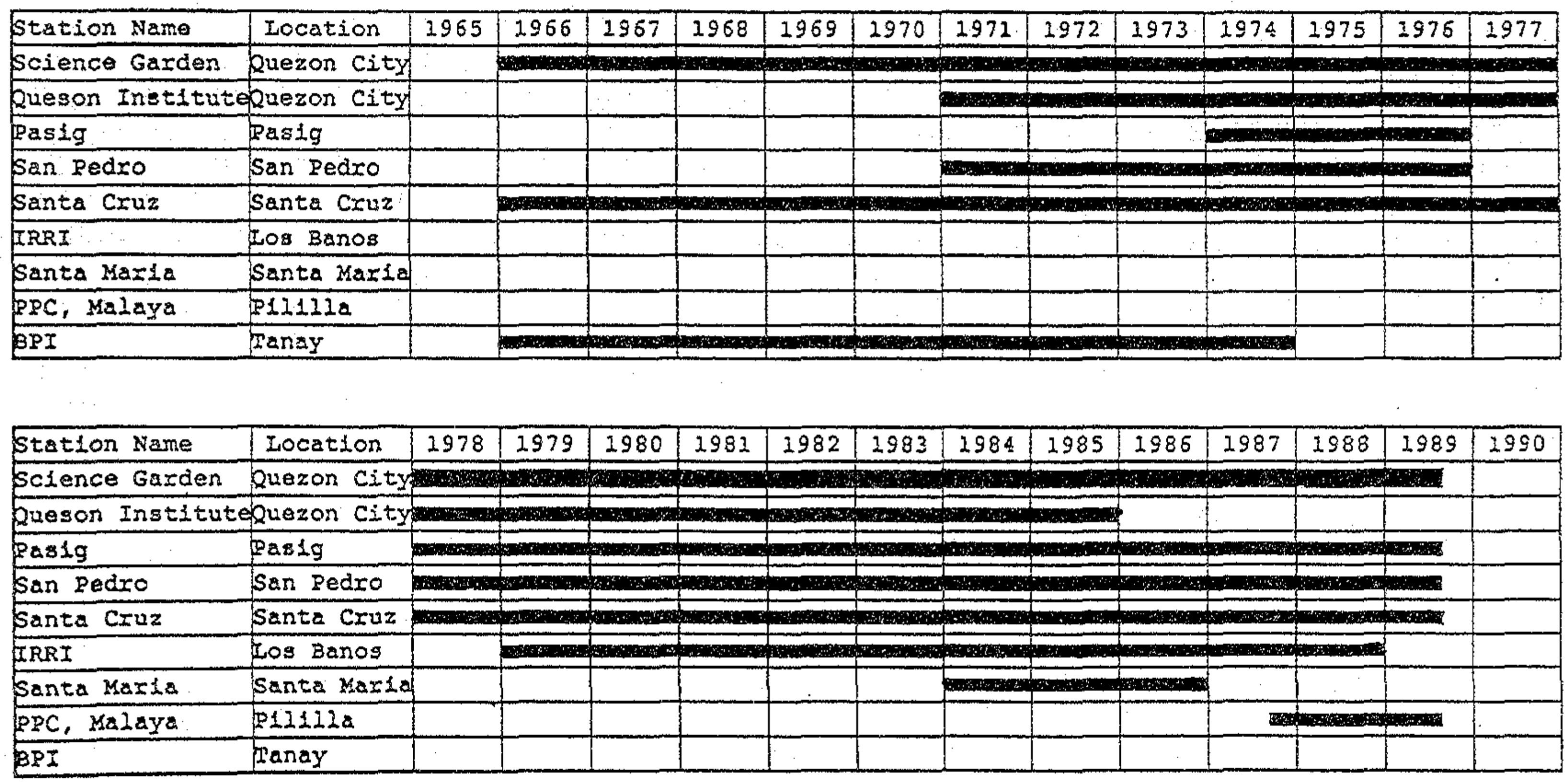
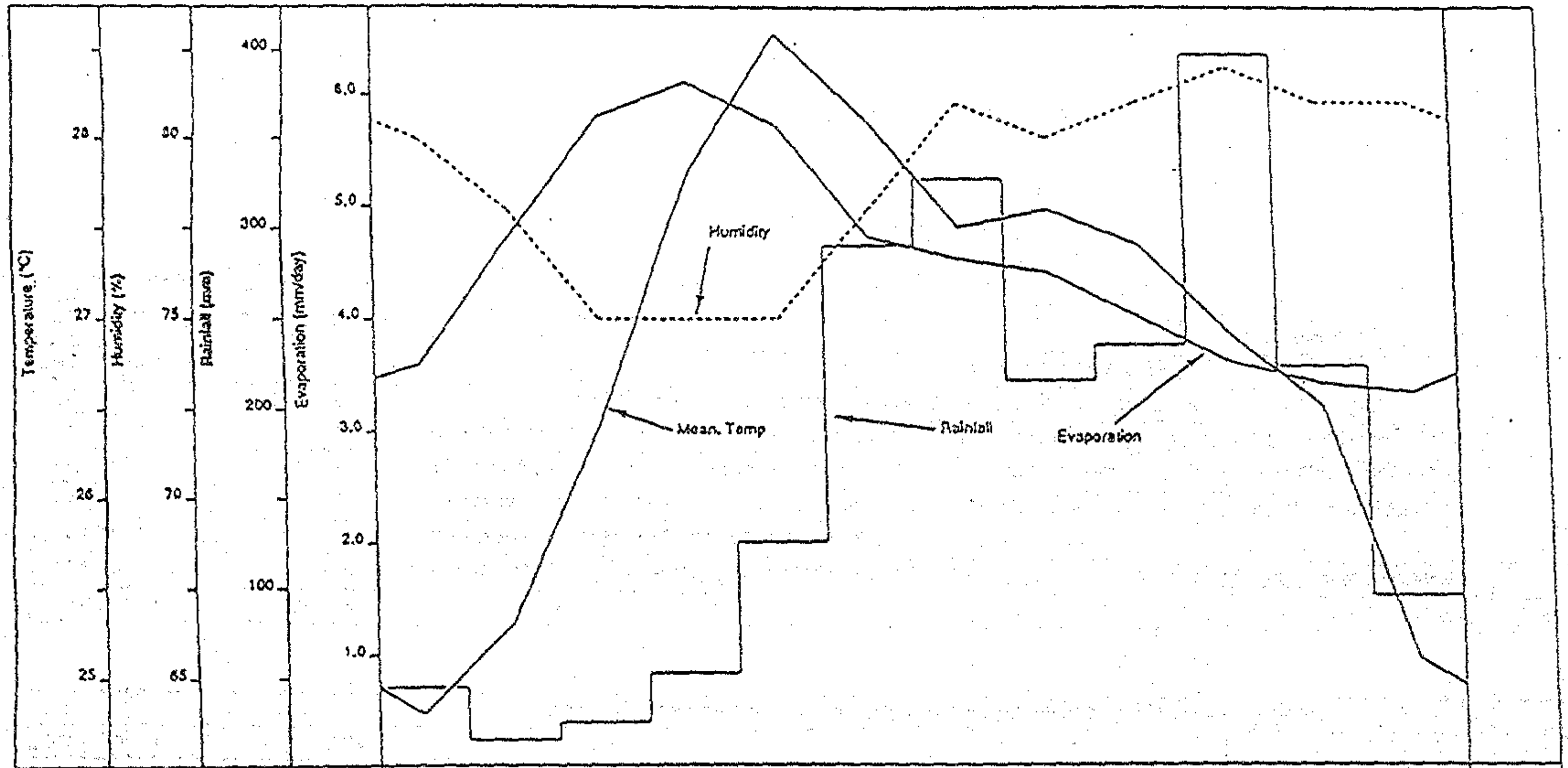


Fig. I.2.2 Summary of Collected Data



		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Max. Temp.	(°C)	28.0	29.3	30.7	32.2	32.9	32.0	31.2	31.1	31.1	30.3	29.7	28.1	30.6
Min. Temp.	(°C)	21.5	21.0	22.1	23.4	24.2	24.2	23.7	23.9	23.7	23.5	23.2	22.0	23.6
Mean. Temp	(°C)	24.8	25.3	28.4	27.8	28.6	28.1	27.5	27.6	27.4	26.9	26.5	25.1	27.1
Humidity	(%)	80	78	75	75	75	78	81	80	81	82	81	81	79
Rainfall	(mm)	45.6	14.8	23.9	52.8	125.6	280.8	301.3	215.4	233.9	396.4	221.7	95.4	2015.4
Evaporation	(mm/day)	3.6	4.7	5.8	6.1	5.7	4.7	4.5	4.4	4.0	3.6	3.4	3.3	4.5

Fig. I.4.1 Average Meteorological and Hydrological Data

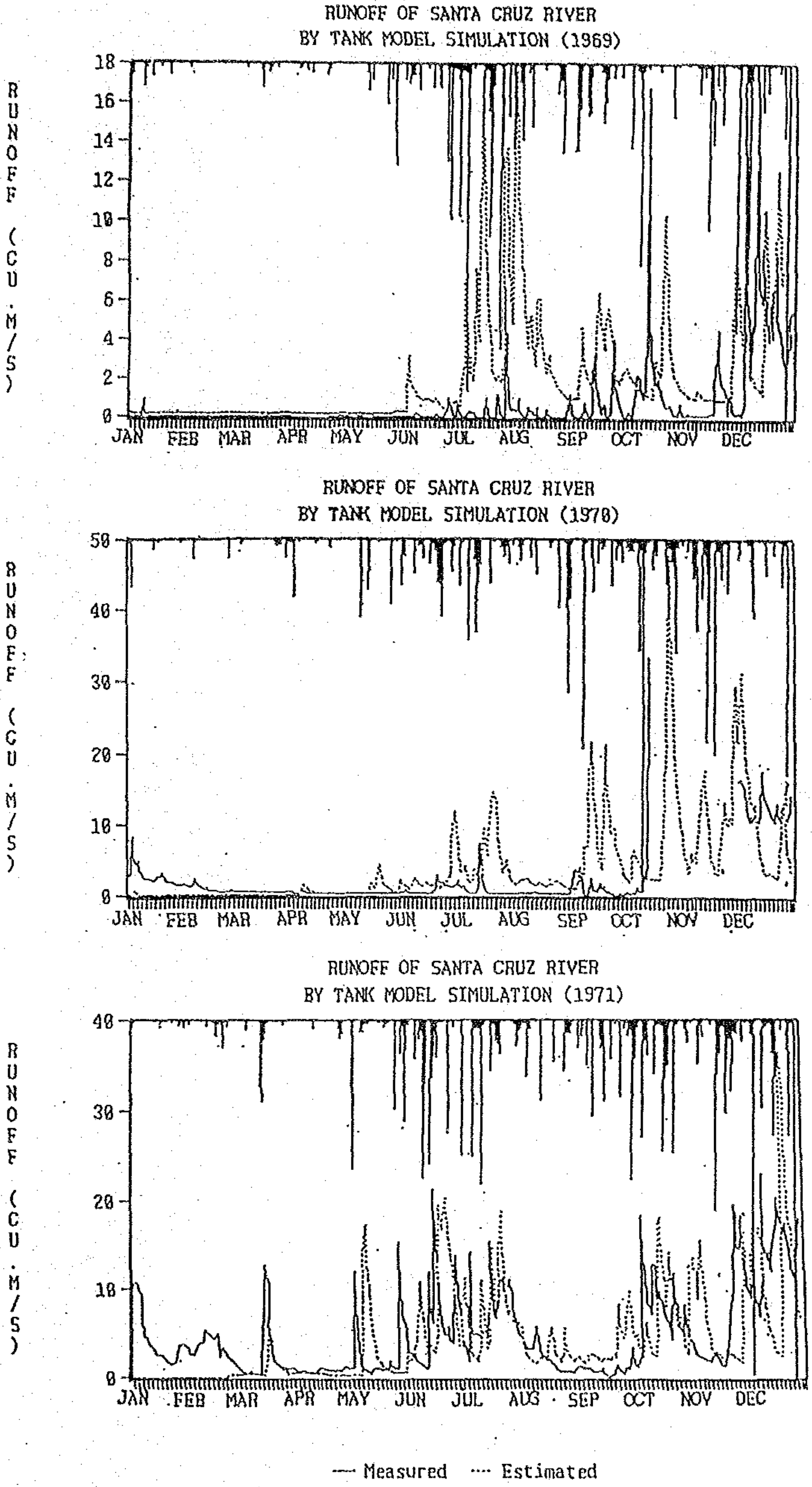


Fig. I.5.1 Simulation Results of Santa Cruz River

ANNEX-II

GEOLOGY AND GEO-HYDROLOGY

ANNEX- II

GEOLOGY AND GEO-HYDROLOGY

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GEOLOGY AND GEO-HYDROLOGY

1. GENERAL

Geological and geo-hydrological investigations were carried out from October to December 1989 and April to May 1990, aiming at disclosing the characteristics of groundwater aquifers for groundwater development and foundation conditions of major structure sites for engineering design.

In order to achieve the objectives, the following works were carried out.

(1) Surface geological investigation based on available topographic maps
(2) Geo-electric prospecting for whole study area
(3) Pumping test by use of existing wells
(4) Water level and electric conductivity measurement of existing well
(5) Chemical and biological analysis of well water
(6) Inventory survey of use of the existing wells in the study area

The above mentioned items b, c and d were carried out under the contract with Aqua-Dyne Technological Services, Inc.

The study on each item mentioned above are described hereunder.

2. GENERAL GEOLOGY IN THE STUDY AREA

2.1 General Features

The geological constitution of the study area is of the volcanic flow and pyroclastic rocks in the Plio-Pleistocene. The volcanic flow (lava) is composed of basaltic andesites. This volcanic flow mainly lies in the steeply sloped and/or rolled mountain area. Pyroclastic rocks are mostly found out in lower terraces particularly in the south and south-western parts of the study area. The recent alluvial fans developed in the lakeshore plain of Bagumbong, Sipsipin and Jala-Jala poblacion areas constitute the colluvial and/or alluvial deposits.

Volcanic activities in this area were considered to be so intensive during the Plio-Pleistocene. These volcanic activities brought about faulting at many locations. The prominent trend of faulting is mostly N-S and NE-SW in directions. The general geology of the Study area is shown in Fig. II.2.1.

2.2 Geological Formation

Structure features of each basement are as follows:

(1) Volcanic Flow (Lava)

Volcanic flow is generally dark gray to grayish black basaltic andesites. In the vicinity to the summit of Mt. Sembrano, dark grayish andesites are predominant, while the composition of rocks changed to basaltic andesites to the spur of peninsula.

(2) Pyroclastic Rocks (Tuff/Tuffaceous Rocks)

Pyroclastic rocks are mainly composed of gray to grayish brown sandy tuff and tuffaceous sandstones. The sequences of these tuff and tuffaceous rocks are formed clearly with interbedding of thin clay layers. It is supposed that each layer has almost flat horizon formation.

(3) Recent Colluvium and Alluvium

The colluvium and alluvium are the recent deposits, and then not consolidated yet. These deposits include numerous cobbles, boulders, gravels, fragments of weathered rocks.

3. FOUNDATION OF PROPOSED MAJOR STRUCTURES

3.1 Palay-Palay Dam Site

The proposed dam site is located across the Palay-Palay river at about 40 m upstream from the point where the general river flow changes direction from southwest to southeast. The slope on the left abutment is about 25 degrees up to elevation 15 m becoming more gentle to almost flat towards the east. The right abutment, however, is steeper with a slope of about 35 degrees and with the flat portion occurring at higher elevations.

The dam site is underlain by an interbedded sequence of tuff and tuffaceous sandstone of pliocene to Pleistocene age. Based on outcrops on both river banks, the tuffaceous sandstone is light grey to brownish-grey. It is moderately consolidated and slightly undulated making the rock friable and permeable. On the other hand, fresh tuff is generally grey, light grey to hard and is similarly friable.

The interbedded sequence strikes generally to the north-north west and dips 10 - 25 degrees to the west-northwest. Thus at the dam site, the beds dip into the slope on the right abutment. This situation has probably caused the difference in abutment slopes as bedding on the left side is almost parallel to the slope.

Considering the above observations, the following are the possible geotechnical problems, that may be encountered in the construction of the proposed dam.

(1) Seepage in sandstone beds on the right abutment
(2) Sliding along bedding planes on the left abutment
(3) Bearing capacity and shear of the foundation materials

The reservoir area is about 3 km long following the main river course in a northeast-southeast direction. The rock types within the reservoir are essentially the same as the rocks at the dam site but with more gentle dips to the northwest to almost flat bedding. At about 300 m downstream from the tip of the reservoir, diatomite was observed to interbed with the tuff/tuffaceous sandstone sequence.

The friable and permeable tuffaceous sandstone is exposed along the river bed and valley walls in several places. To seal the seepage zone, clay blanketing of the exposed tuffaceous sandstone will be an effective measure. The geological conditions of the Palay-Palay dam site are as shown in Fig. II.3.1.

3.2 Pump Station Sites

Fourteen (14) irrigation pump stations are proposed along the coast of Laguna lake. Foundation conditions of the proposed pump station sites were investigated by means of test pitting. The following foundation conditions are revealed.

The pump stations are proposed at the locations about 100 m far from the dry season shoreline of Laguna lake. The geological conditions of pump station sites are broadly classified into the following two groups; (1) foundation underlain by tuff or tuffaceous sandstone, and (2) foundation underlain by sand and gravel/boulder layers.

(1) Foundation underlain by tuff or tuffaceous sandstone

Manggahan, Bayugo, Llano, Punta, Pagkalinawan, Ik-Ik and Lubo pump station sites lie in this foundation condition. Tuff outcrops at Bayugo, Llano, Punta pump station sites. The other sites are underlain by tuff 1 - 2 m below the ground surfaces. At Lubo site, a boulder layer of 20 - 30 cm in thickness is lain on the tuff layer.

(2) Foundation underlain by sand and sand stones

Sipsipin, Mapakla, Lumang Nayon, Pulong Ligaya and Bagumbong pump station sites belong to this foundation conditions.

4. GEO-HYDROLOGY

4.1 Geo-hydrological Investigation

The geo-hydrological investigation was carried out under the contract with Aqua-Dyne Technological Services, Inc. in order to clarify the geo-hydrological conditions in the Study area during April and May 1990. The geo-hydrological investigation involved the following items:

(1) Geo-electric prospecting
- 5 line; 20 points

(2) Pumping test by use of existing wells
- 2 deep wells
- 3 shallow wells

(3) Water level and electric conductivity measurements
- 30 existing wells

The locations of the measurements are as shown in Fig. II.4.1.

4.2 Geo-electric Profile

Based on analyzed results of geo-electric sounding, 5 geo-electric profiles are prepared, as presented in Fig. II.4.2 (1) to 4.2 (5) and tabulated in Table II.4.1 (1) to 4.1 (5). Characteristics for each profile are briefly described as follows:

(1) Resistivity Profile A-A'

Station A-1 indicates a sequence of clayey layers near the surface followed by a high resistivity layer which corresponds to boulders or talus deposits to a total depth of about 38 meters below ground surface (mbgs). This high resistivity layer is separated from the true bedrock by a layer of clay or tuff. The bedrock occurs at a depth of about 76 mbgs.

In stations A-2 and A-3, the computations show a sequence of sandy materials in the first four layers and hard rocks in the fifth layer. It will be observed that the depth of the bedrock is deeper in station A-3 and the sandy layers are correspondingly thicker. The fourth layer in station A-2 and the third layer in station A-3 should be water-bearing.

(2) Resistivity Profile B-B'

The resistivity soundings (stations B-1 to B-3) on the western side of the peninsula reveal similar layers. Alternating layers of high and low resistivities are found consistently in the three stations. Layer 3 is significant. This layer is characterized by increasing resistivity value from stations B-1 to B-3. This increase may be interpreted as a reduction in the hardness and grain size towards the west.

The rocks corresponding to the third layer are more clayey towards the shore of Laguna lake. The third layer is thinnest at B-1 and at least 30 m thick in B-2 and B-3. Layer 5 probably represents the bedrock at B-3. However, in B-1 and B-2, the fifth layer does not possess the high resistivity indicative of massive volcanic rocks. It may be interpreted as pyroclastic rocks or bouldery rocks on top of the bedrock.

On the eastern side (stations B-4 to B-6), the true resistivity values tend to increase after the first surface layer. The abnormally high resistivity value of the fourth layer in station B-4 is similar to the fourth layer of station A-1. The layer may be considered as another thick talus deposit which consists of boulders and very coarse materials. The fifth layers in B-5 and B-6 probably correspond to the fourth layer in B-4. The relatively lower resistivity value beneath these layers could correspond to some talus deposits which contain finer fragments. It may be inferred from these occurrences that there were probably two periods of uplift of the central highlands along the faults.

(3) Resistivity Profile C-C'

It will be noticed that the resistivity of the soft layers in western Jala-Jala is generally lower than in the eastern side. It may suggest that the uplift of the central highlands during the periods of faulting was asymmetrical, the eastern portion of the highland being raised higher than the western edge. The highlands, being the source of sediments for the coastal areas, contributed generally finer grains to the western side. Talus deposits on the eastern side tend to consist of coarser boulders and cobbles.

Six resistivity layers were identified in stations C-1 and C-2. The first four layers are generally clayey tuff with minor sand content. The fifth layer in station C-1 is either a basal conglomerate on top of the bedrock or fine talus deposits.

The layering in stations C-3 and C-4 corresponds roughly to the stratification in stations A-1 and B-4. The third layers appear to be fine talus deposits followed by a sandy tuff layer and the bedrock or another talus deposit.

(4) Resistivity Profile D-D'

The characteristics of stations D-2 and D-3 are essentially the same but very different from D-1 and D-4. The difference in characteristics may be the effect of faulting which divided the tip of the peninsula.

Stations D-2 and D-3 show alternating sequence of high and low resistivity layers with the third layer being markedly more resistive than any of the four top layers. The last layer probably represents the bedrock or hard massive volcanic rocks. The third layer could also be a thick sequence of pyroclastic rocks, either agglomerate or sandy pyroclastic rocks.

The 1,200 ohm-m resistivity fifth layer in station D-1 denotes a 50-meter thick section of sandy and clayey tuff lying on massive bedrock. The fifth layer may correspond to some sandy and bouldery pyroclastic rock.

Station D-4 shows similar characteristics as D-1. However, the thickness of the soft formations above the bedrock is considerably thinner (41 m) than on the other side of the peninsula.

(5) Resistivity Profile E-E'

The resistivity values obtained from stations E-1 to E-3 corresponds to tuff and other pyroclastic rocks. The layers with 10 to 50 ohm-m resistivity represents sandy and clayey tuff. The higher values (>300 ohm-m) represents agglomerative tuff while the bedrock, possibly volcanic rocks, have resistivity values exceeding 10,000 ohm-m.

4.3 Pumping Test

A pumping test was carried out to determine the characteristics of the aquifers and to get information on the yield and drawdown of the well. The pumping test was executed at the following two deep wells and three shallow wells as shown in Fig. II.4.4.

(1) Deep well

(1)-1 Test Well - Jala-Jala Elementary School
(1)-2 Test Well - Meralco Center, Bayugo

(2) Shallow well

(2)-1 Test Well - Salvador Vergara, Sipsipin
(2)-2 Test Well - Mariano Bonita's Well, Bagumbong
(2)-3 Test Well - Pedro Barrion's Well, Bagumbong

The modified non-equilibrium formula as derived by Jacob was used in the analysis of the pumping test results. The time-drawdown relation is shown in Fig. II.4.3 (1) to 4.3 (8). The coefficient of the transmissibility is calculated by the following formula:

$$T = 0.183 \frac{Q}{\Delta s}$$

where, T = Coefficient of transmissibility (m^2/day)
Q = Average pumping rate (m^3/day)
Δs = Drawdown per log cycle (m)

The aquifer characteristics are analyzed, using T-value obtained from the pumping tests and resistivity results. The result is as shown below.

Results of Pumping Test Analysis

Test Well No.	Water level (m)	Transmission-bility (m^2/day)	Effective aquifer depth (m)	Permeability (m/day)
1.1	7.94	20	28	0.7
1.2	4.50	83	25	3.3
2.1	5.39	13	3.5	3.7
2.2	2.28	10	4.0	2.0
2.3	12.24	16	13	1.2

4.4 Water Level Measurements and Electric Conductivity

The static water level in thirty wells distributed throughout Jala-Jala were measured in May 1990. The location of these wells are plotted in Fig. II.4.4.

The results of the water level measurements are shown in Table II.4.2. Water level measurements derived from the pumping tests were also included in the table.

The groundwater contour map was prepared as shown in Fig. II.4.5 based on the elevation of the static water level.

It will be noted that several wells in Pagkalinawan and Bayugo had water levels more than 1.0 meter below sea level. The elevation of the static water level in other wells located close to Laguna lake in Punta, Palay-Palay and Jala-Jala were also below mean sea level. In all the other wells the static water level elevations were above mean sea level.

The groundwater contour lines are more widely spaced in Bagumbong and Mapakla. Widely spaced water level contours suggest the presence of more permeable rocks. The groundwater contours are more closely spaced in Sipsipin and the town of Jala-Jala. These conditions indicates poorly permeable rocks underneath these areas.

Electric conductivity was measured for water samples which were obtained from the control wells before the pumps were dismantled for water level measurements.

The conductivity values were plotted in Fig. II.4.6 at the same location as the control wells. Contour lines showing equal conductivity were drawn through these points.

The electric conductivity map shows that the groundwater in Bagumbong has the best quality. The area east and south of Llano also contains water with relatively low conductivity. However, those wells located close to the faults have normally higher conductance, ranging from an average of 1,200 uS to about 3,500 uS in Pagkalinawan.

The areas with low conductivity are probably those places where direct rainfall infiltration can possibly recharge the groundwater body. In those areas near the faults, warm water coming from great depths and containing more dissolved solids joint the water-bearing layers near the surface and increase the electric conductivity.

4.5 Aquifer Characteristics

(1) Groundwater characteristics

The ability of a rock unit to yield water is determined by its porosity and permeability. In Jala-Jala, the possible water-bearing formations are the sandy tuff and agglomerative tuff. These rocks would normally have low porosity and permeability because the fine volcanic ash (tuff) fills up some of the pore spaces between the coarse grains. Thus the storage volume of the water-bearing formations will be reduced because of the fine materials. Likewise, groundwater will find it difficult to flow through the rock units because of tight passageways.

The pumping tests gave indications of the water-yielding capacity of the aquifers in the area. The values obtained during the tests indicate poor to fair capacity except for the Meralco well.

(2) Recharge characteristics

Jala-Jala is a very small community and recharge to the groundwater originates from a short distance anywhere in the municipality. However, the recharge areas are very small (generally the highlands). The amount of recharge can therefore sustain low discharge rates in wells. It is also possible that Laguna lake can supplement the recharge to the aquifers which extend towards Laguna lake. This amount has not been quantified and would only be significant if the groundwater levels are pulled down below the water level of Laguna lake.

(3) Quality of water

The quality of the groundwater also determines whether the water may be suitable for the intended use of the water. The physical and chemical quality of the water is considered at this time.

The high conductivity and temperature of the water in the Pagkalinawan area is not suitable for domestic use. In Bangumbong, the southern portion of the valley is affected by high iron content which may affect agricultural crops and may tend undesirable color in domestic and laundry use.

The groundwater on the western side of Jala-Jala has a fairly high conductivity but are normally acceptable for domestic and irrigation uses.

5. DEVELOPMENT POTENTIALITY OF GROUNDWATER

With division of the study area into four major sub-areas, the possible yield of groundwater aquifers are estimated using the transmissibility and resistivity investigation result as shown in Table II.5.1. The result is illustrated in Fig. II.5.1 as shown below.

Area	Effective Depth of Deep Aquifer (m)	Transmis-sibility (m^2/day)	Specific Capacity (m^2/hr)	Potential Yield (l/sec)
Sipsipin - Jala-Jala	28	20	0.5	3
Bagumbong - Lubo (1)	13	16	1	3
Bagumbong - Lubo (2)	20	60	2	3
Bayugo-Punta	25	83	3	5
Palay-Palay - Pagkalinawan	26	78	3	5

Note: (1): for aquifer of alluvium
(2): for aquifer of Tuffaceous sandstone or sandy tuff

According to the above values, the pumping yield is estimated to be in the range of 3 to 5 l/sec. Therefore, groundwater resource in the Study area is judged sufficient for rural water supply but poor for the irrigation purpose.

TABLES

Table II.4.1 (1) Result of Geo-electric Survey along Line A

RESISTIVITY STATION	RESISTIVITY LAYER	RESISTIVITY (ohm-m)	THICKNESS (m)	DEPTH (mbgs)	INTER-PRETATION
A-1	1	11.5	1.1	1.1	Clay soil
	2	5.0	7.6	8.7	Clay
	3	2,010.1	29.6	38.3	Coarse talus deposit
	4	5.4	37.3	75.6	Clay
	5	10,004.2	-	-	Bedrock
A-2	1	58.2	0.5	0.5	Sandy soil
	2	9.7	1.7	2.3	Clay
	3	97.7	3.0	5.2	Sandy tuff with water
	4	33.5	24.5	29.7	Clayey tuff or sand
	5	4,303.4	-	-	Talus deposit
A-3	1	40.2	0.9	0.9	Sandy soil
	2	13.8	2.0	2.9	Sandy clay
	3	269.7	14.2	17.1	Bouldery rock
	4	497.3	47.5	64.6	Agglomerate
	5	21,591.2	-	-	Bedrock

Table II.4.1 (2) Result of Geo-electric Survey along Line B

RESISTIVITY STATION	RESISTIVITY LAYER	RESISTIVITY (ohm-m)	THICKNESS (m)	DEPTH (mbgs)	INTER-PRETATION
B-1	1	21.5	1.1	1.1	Sandy clay soil
	2	5.7	20.3	21.5	Clay
	3	36.8	2.7	24.2	Sandy tuff
	4	10.4	15.2	39.4	Clay
	5	3,907.8	-	-	Bedrock/talus deposit
B-2	1	85.6	1.6	1.6	Sandy soil
	2	7.6	9.3	10.9	Clay
	3	260.7	36.5	47.3	Conglomeratic sand
	4	22.6	65.6	113.0	Clayey tuff
	5	498.5	-	-	Talus deposit
B-3	1	46.7	0.8	0.8	Sandy soil
	2	8.8	4.7	5.5	Clay
	3	444.0	32.7	38.2	Talus deposit, bouldery
	4	168.4	41.8	80.0	Sandy talus deposit
	5	10,199.8	-	-	Bedrock
B-4	1	62.7	0.6	0.6	Sandy soil
	2	5.9	1.2	1.8	Clay
	3	44.4	16.1	17.9	Sandy clay/tuff
	4	2,607.2	24.0	41.8	Talus deposit
	5	883.2	36.0	77.8	Weathered bedrock or sandy talus deposit
	8	7,598.5	-	-	Bedrock
B-5	1	31.3	0.8	0.8	Sandy soil
	2	9.1	0.3	1.1	Clay
	3	117.3	5.7	6.8	Sandy tuff
	4	108.3	15.6	22.4	Sandy tuff with water
	5	18,988.3	35.9	58.3	Coarse talus deposit
	6	1,202.0	-	-	Fine talus deposit
B-6	1	75.5	0.8	0.8	Sandy soil
	2	14.5	5.8	6.6	Sandy clay
	3	637.9	9.7	16.3	Fine talus deposit
	4	1,394.2	11.9	28.2	Coarse talus deposit
	5	22,764.3	-	-	Bedrock

Table II.4.1 (3) Result of Geo-electric Survey along Line C

RESISTIVITY STATION	RESISTIVITY LAYER	RESISTIVITY (ohm-m)	THICKNESS (m)	DEPTH (mbgs)	INTER-PRETATION
C-1	1	17.2	0.9	0.9	Sandy clay soil
	2	4.8	1.8	2.7	Clay
	3	56.0	8.0	10.8	Clayey sand
	4	9.4	1.6	12.3	Clay
	5	798.2	47.6	59.9	Fine talus deposit
	6	11,049.5	-	-	Bedrock
C-2	1	6.6	0.8	0.8	Clay
	2	12.3	1.8	2.5	Sandy clay
	3	1.1	2.7	5.2	Clay
	4	127.3	8.6	13.9	Sandy tuff
	5	78.5	9.6	23.5	Clayey sand
	6	3,357.5	-	-	Talus deposit/bedrock
C-3	1	77.9	4.6	4.6	Dry sandy soil
	2	38.4	30.1	34.7	Clayey sand
	3	766.6	17.0	51.7	Fine talus deposit
	4	99.1	31.3	83.0	Sand tuff
	5	15,217.7	-	-	Bedrock
C-4	1	292.5	0.4	0.4	Bouldery top soil
	2	10.4	1.2	1.7	Clay
	3	265.6	6.0	7.6	Sandy tuff with cobbles
	4	113.5	34.4	42.0	Sandy tuff
	5	12,588.3	-	-	Bedrock

Table II.4.1 (4) Result of Geo-electric Survey along Line D

RESISTIVITY STATION	RESISTIVITY LAYER	RESISTIVITY (ohm-m)	THICKNESS (m)	DEPTH (mbgs)	INTER-PRETATION
D-1	1	24.7	0.5	0.5	Sandy clay soil
	2	4.7	0.9	1.5	Clay
	3	44.5	3.1	4.6	Clayey sandy tuff
	4	30.0	12.0	16.6	Clayey sandy tuff with water
	5	1,203.1	48.8	65.4	Fine talus deposit
	6	16,646.9	-	-	Bedrock
D-2	1	82.6	2.5	2.5	Sandy tuff
	2	40.2	36.5	39.0	Clayey tuff
	3	267.3	35.6	774.5	Sandy tuff with coarse fragments
	4	60.9	11.7	86.3	Sandy tuff
	5	10,722.6	11.7	86.3	Bedrock
D-3	1	107.6	0.9	0.9	Sandy soil
	2	34.4	3.6	4.6	Sandy clay
	3	605.6	26	30.6	Sandy tuff with coarse fragments
	4	21.5	18	48.6	Clay/tuff
	5	10,016.8	-	-	Bedrock/pyroclastic rocks
D-4	1	20.5	0.9	0.9	Sandy clay soil
	2	49.7	0.4	21.3	Clayey sand
	3	10.4	5.1	6.4	Clay
	4	220.7	34.9	41.3	Sandy tuff
	5	15,641.7	-	-	Bedrock

Table II.4.1 (5) Result of Geo-electric Survey along Line E

RESISTIVITY STATION	RESISTIVITY LAYER	RESISTIVITY (ohm-m)	THICKNESS (m)	DEPTH (mbgs)	INTER-PRETATION
E-1	1	29.6	1.0	1.0	Clayey tuff
	2	9.5	1.9	2.9	Clay
	3	158.4	1.9	4.8	Sandy tuff
	4	6.3	3.1	7.9	Clay
	5	495.1	42.0	49.9	Sandy tuff with coarse fragments
	6	16,332.8	-	-	Bedrock
E-2	1	63.0	0.9	0.9	Sandy tuff
	2	21.7	12.6	13.6	Clayey tuff
	3	729.3	35.1	48.6	Sandy tuff with coarse fragments
	4	169.2	8.8	57.5	Sandy tuff with water
	5	13,714.7	-	-	Bedrock
E-3	1	28.9	1.1	1.1	Clayey tuff
	2	10.8	2.4	3.5	Clay
	3	355.7	15.5	19.0	Sandy tuff with coarse fragments
	4	834.3	27.4	46.4	Sandy tuff with coarse fragments
	5	14,298.6	-	-	Bedrock

Table II.4.2 Summary of Well Water Measurement

WELL NUMBER	WELL OWNER	BARANGAY	DEPTH OF WELL (meters)	GROUND ELEVATION (masl)	MEASURING POINT (mags)	DEPTH TO WATER LEVEL (meters)	STATIC WATER LEVEL ELEVATION (m/msl)	CONDUCTIVITY (uS/cm)
1	Mrs. Fonda	Sipsipin	7.60	8.25	0.00	5.62	2.63	1,000
2	Mr. Austria	Sipsipin	10.66	4.40	0.56	2.76	2.20	860
3	Mrs. Anacleta Cupuz	Sipsipin	12.19	17.00	0.27	4.74	12.53	1,200
4	ABANDONED							
5	Mr. Arturo Lemon	Town Proper	9.14	2.50	0.32	3.35	-0.53	710
6	Public Well	Mapakla	12.19	21.00	0.62	4.08	17.54	1,200
7	Mrs. Marina Merinaveno	Bayugo	21.33	17.50				670
8	Mr. Antonio Halitie	Bayugo	9.14	3.00	0.55	5.00	-1.45	780
9	Mr. Jose Rose	Bayugo	6.09	4.00	0.78	3.01	1.77	1,800
10	Mr. Porferio Estrella	Bayugo	6.09	2.00	0.53	2.79	-0.26	900
11	Mr. Eduardo Binalugo	Bayugo	9.14	5.00	0.58	3.48	2.10	1,200
12	Mr. Francisco Rino	Punta	9.14	2.50	0.76	4.24	-0.98	990
13	Public Well	Palaypalay	48.77	29.50				600
14	Mr. Serafin Manalo	Palaypalay	12.19	3.25	0.40	4.55	-0.90	1,200
15	Mr. Florendo Braza	Pagkalinawan	9.00	7.00	0.44	9.00	-1.56	1,000
16	Mr. Segundo Gagesta	Pagkalinawan	12.00	10.00	0.38	7.90	2.48	610
17	Mr. Rufino de Ocampo	Pagkalinawan	12.00	10.00	0.35	2.25	8.10	3,200
18	Mr. Delfin Regalado	Lubo	6.00	5.00	0.88	5.75	0.13	900
19	Mr. Lope Calderon	Lubo	9.00	6.00	0.37	4.48	1.89	2,000
20	Mr. Enriquez	Lubo	9.00	5.00	0.39	4.40	0.99	1,000
21	Mr. L. Salgatar	Lubo	9.14	3.00	0.35	3.26	0.09	690
22	Mr. Marciano Escarmosa	Lubo	7.62	12.50	0.79	7.00	6.29	625
23	Mr. Jesus Salles	Lubo	12.19	16.00	0.58	3.06	13.52	1,220
24	Mr. Q. Malabanan	Bagumbong	6.00	2.00	0.59	3.33	-0.74	880
25	Mrs. Placida Galano	Bagumbong	9.14	6.80	0.35	4.20	2.95	560
26	Mr. Serfin Obando	Bagumbong	9.14	14.20	0.74	5.43	9.51	870
27	Mrs. Nina Bonita	Bagumbong	9.14	12.50	0.17	8.50	4.17	640
28	Mrs. Zenaida Endon	Bagumbong	6.00	8.00	0.65	4.56	4.09	650
29	Brgy. Capt. Delos Santos	Bagumbong	6.00	4.00	0.75	3.16	1.59	750
30	Mr. Fernando Sta. Ana	Palaypalay	12.19	7.50	0.44	7.42	0.52	1,900
31	Mr. Salvador Vergara	Sipaipin		22.00	1.00	5.39	17.61	650
32	Jala-Jala Elem. School	Town Proper		8.30	0.41	7.94	0.77	1,600
33	Meralco	Bayugo		5.50	0.25	4.50	1.25	560
34	Mr. Mariano Bonita	Bagumbong		5.00	0.44	2.28	3.16	630
35	Mr. Pedro Barrion	Bagumbong		21.50				

Table II.5.1 General Features of Aquifer Characteristics

AREAR/ AQUIFER UNIT	GEO-ELECTRIC RESISTIVITY (omh-m)	UNIT THICKNESS (A (m)	THICKNESS (60% * A) (m)	AQUIFER TRANSMIS-SIBILITY T (m2/d)	CHARACTERISTIC SPECIFIC CAPACITY SC(m2/hr)	PERMEA-BILITY K (m/d)	GROUNDWATER POTENTIAL IRRIGATION	DOMESTIC	POTENTIAL YIELD (l/sec)	REMARKS
SIPSIPIN-JALA-JALA AREA										
Tuffaceous Sandstone or Sandy tuff	798	47	28	20	0.53	less than 1	Poor	Good	3	Pumping test was conducted only on the tuffaceous sandstone aquifer
BAYUGO-PUNTA AREA										
Tuffaceous Sandstone or Sandy tuff	495	42	25	83	3.29	3	Poor	Good	5	Conducted pumping test
PAGKALINAWAN-PALAY PALAY AREA										
Tuffaceous Sandstone or Sandy tuff	356 to 834	43	26	78	3	3	Poor	Good	5	Permeability is based on Bayugo-Punta area since both have similar geologicak condition
BAGUMBONG-LUBO AREA										
Alluvium (Sand and gravel with some boulders)	117 to 108	21	13	16	0.97	1	Poor	Good	3	Pumping test was conducted only on the alluvium
Tuffaceous Sandstone or Sandy tuff	113	34	20	60	2	3	Poor	Good	3	

FIGURES

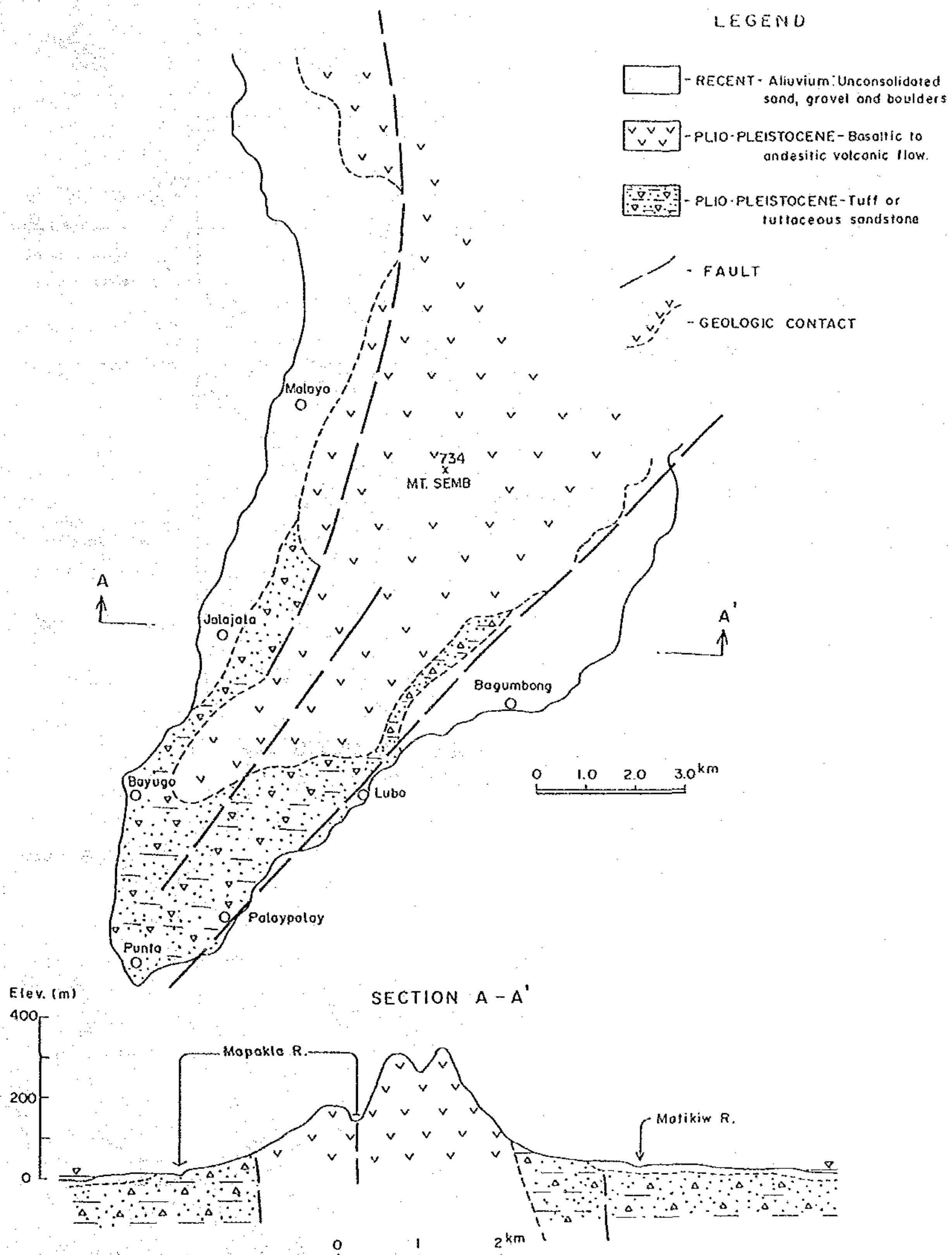
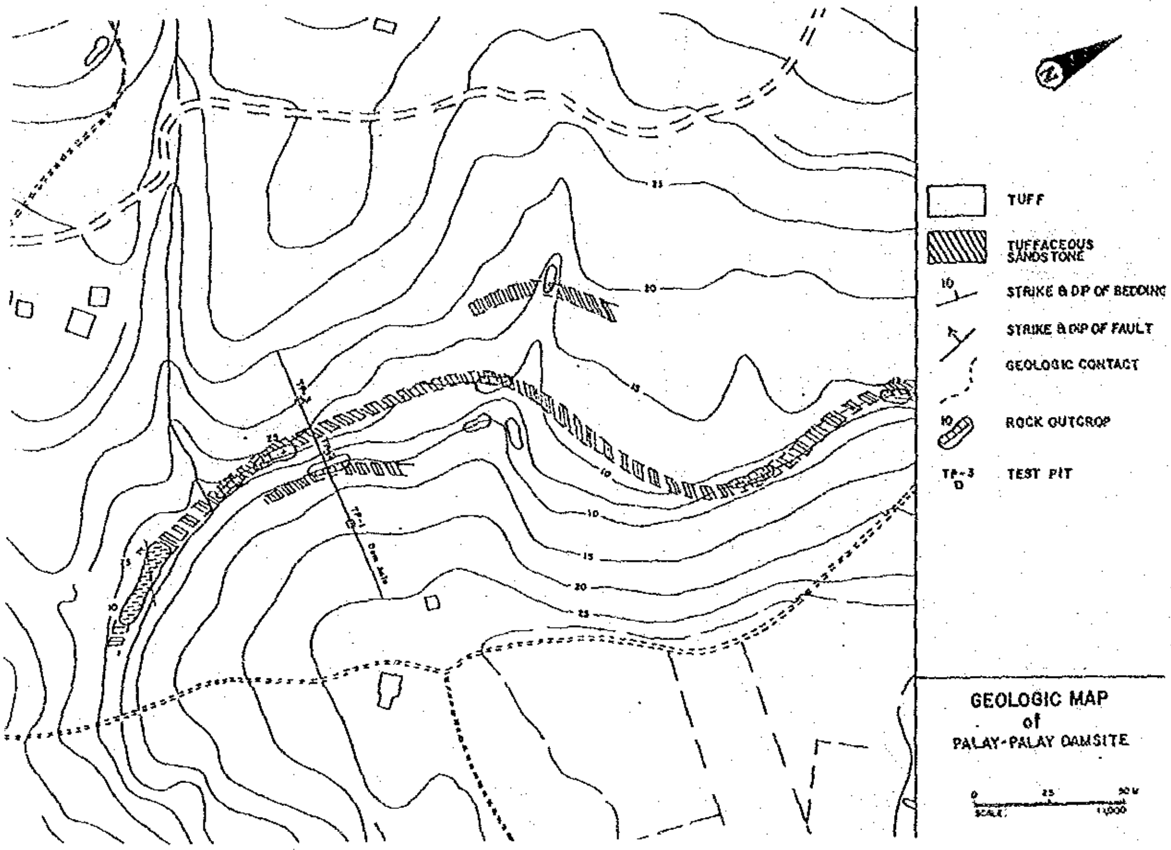


Fig. II.2.1 Geological Map



GEOLOGIC CROSS-SECTION ALONG DAM AXIS

(Looking Downstream)

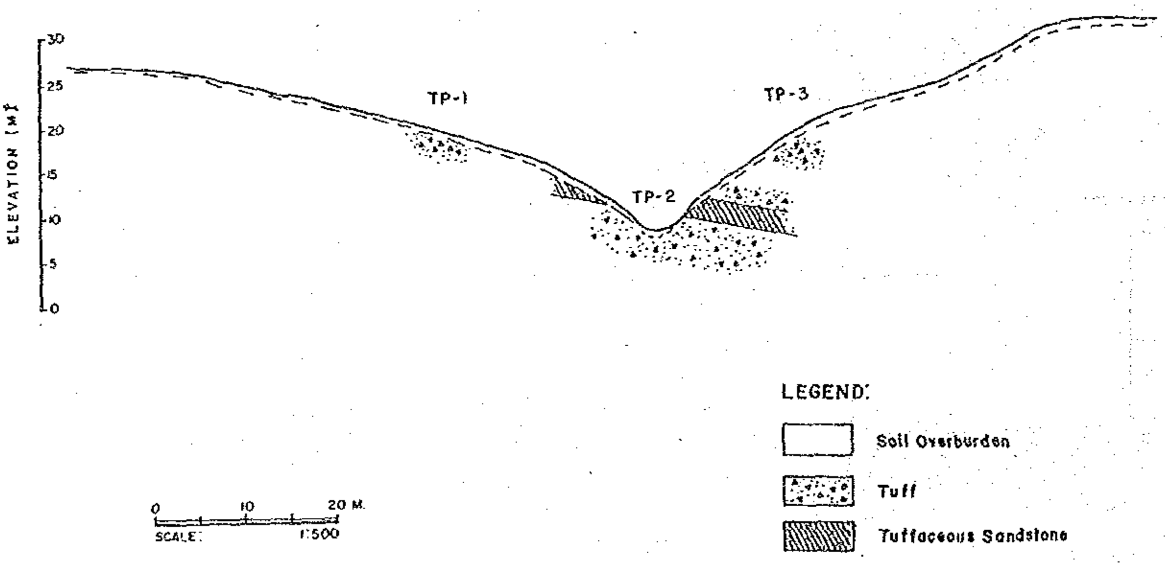


Fig. II.3.1 Geological Conditions of Palay-Palay Dam Site

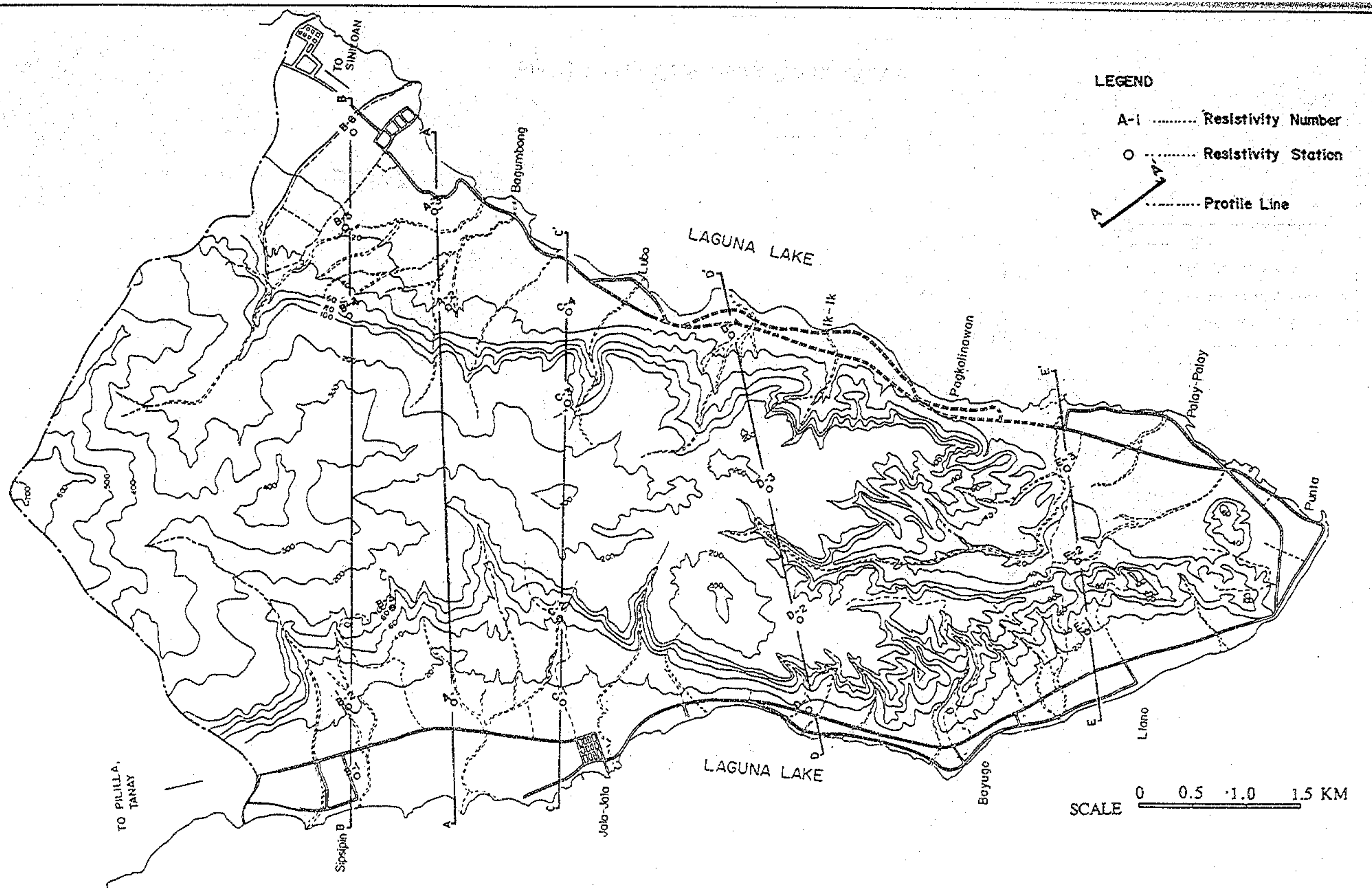


Fig. II.4.1 Location of Geo-electric Prospecting and Pumping Test

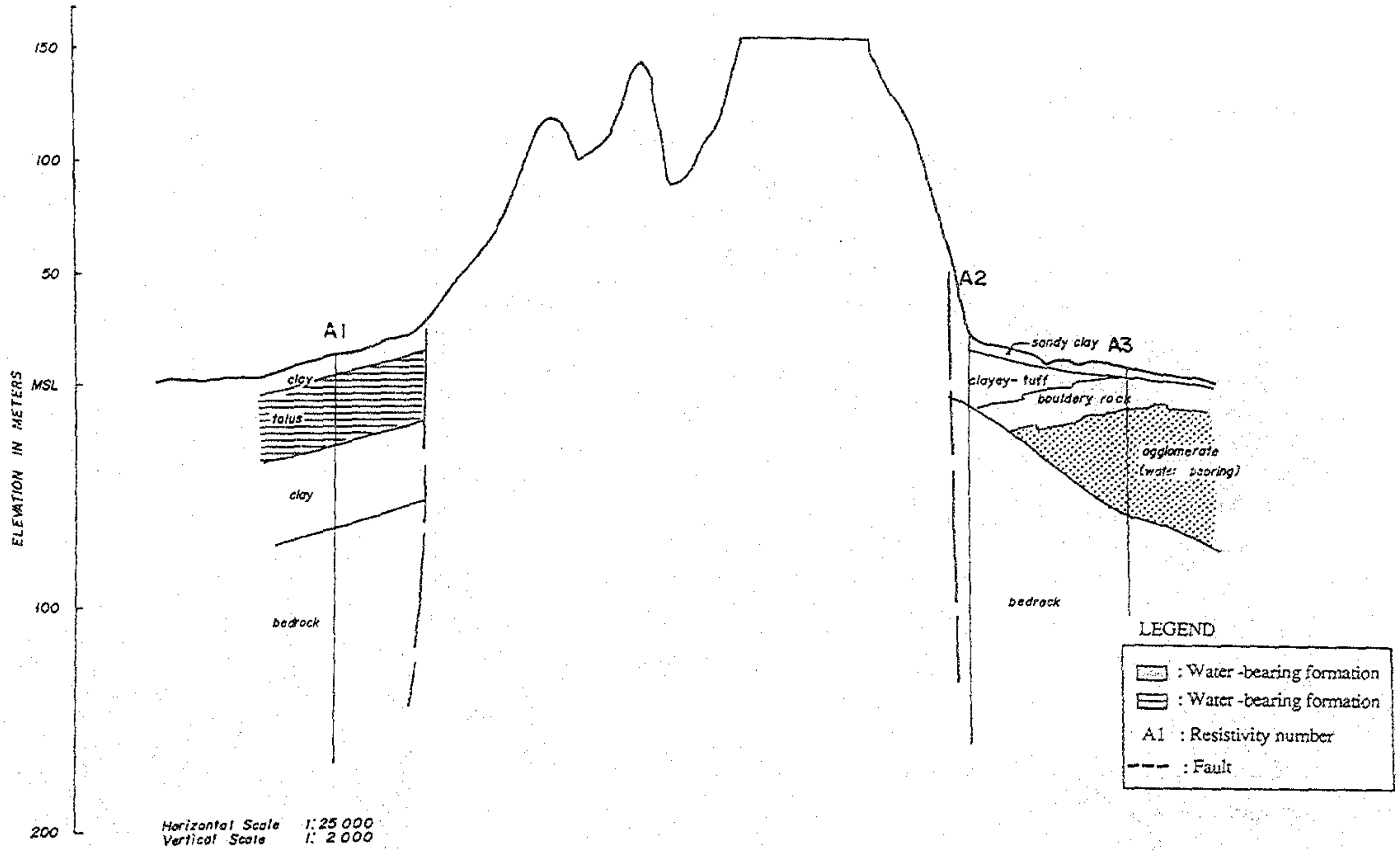


Fig. II.4.2 (1) Geo-electric Profile (A-A')

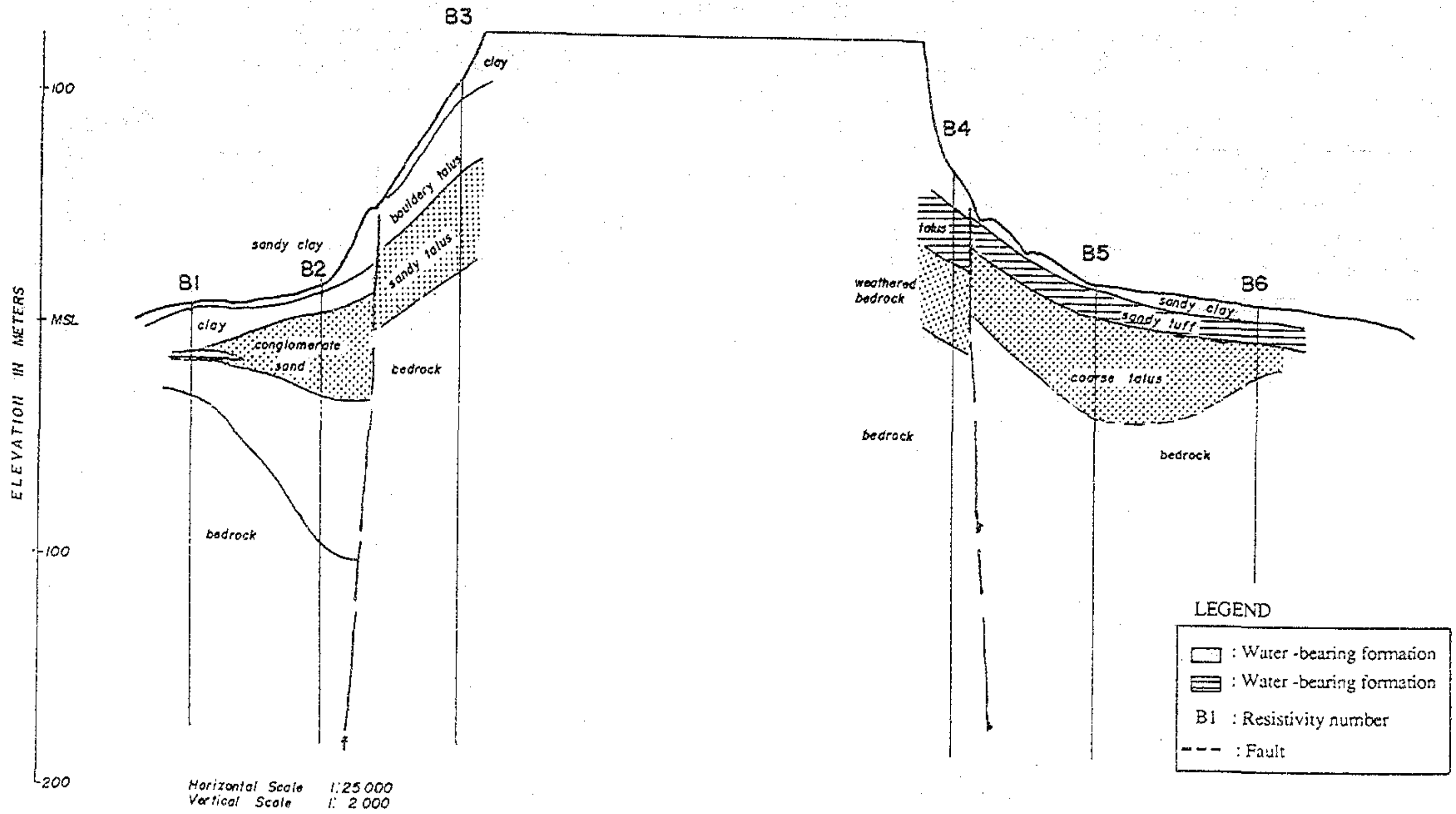


Fig. II.4.2 (2) Geo-electric Profile (B-B')

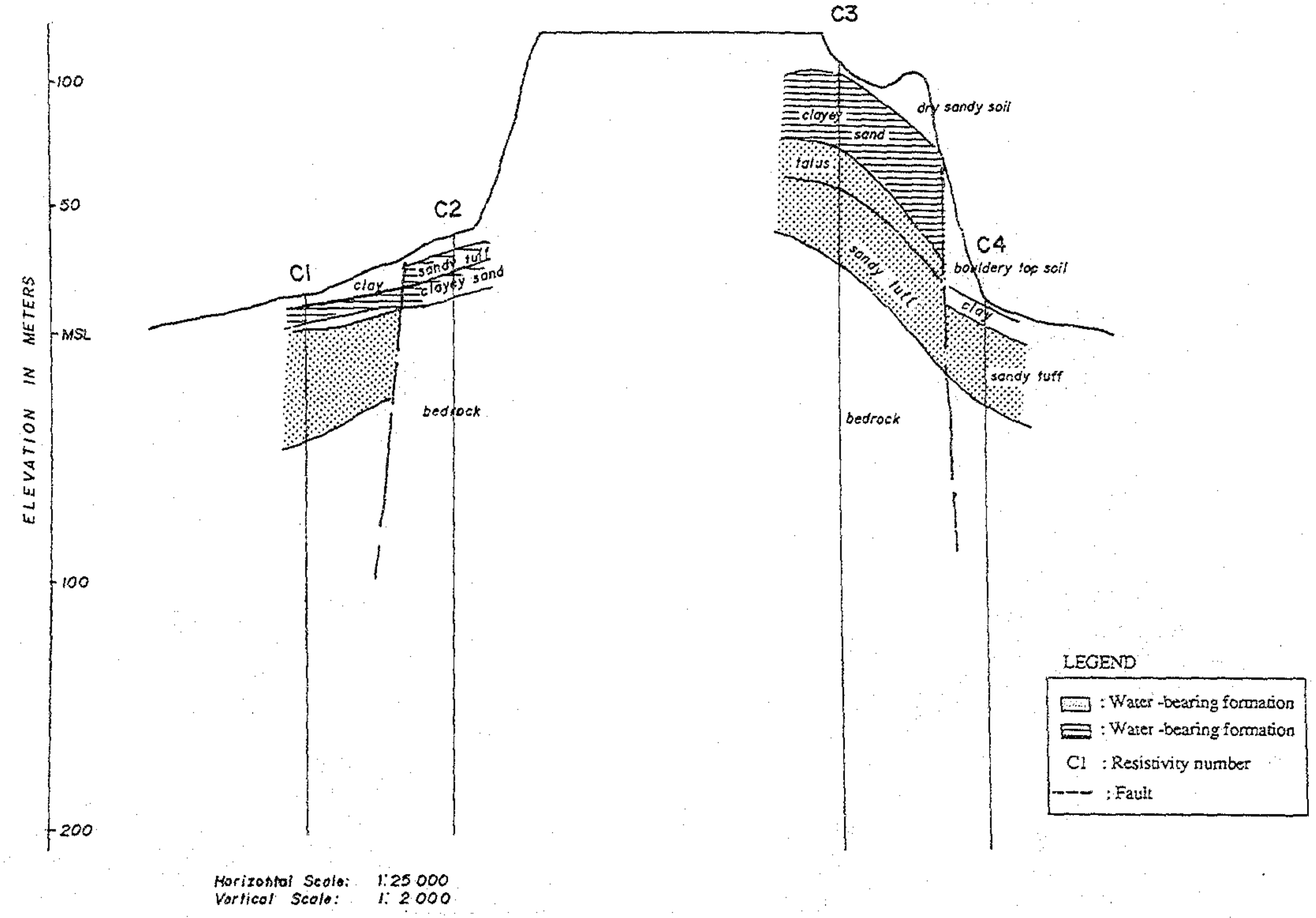


Fig. II.4.2 (3) Geo-electric Profile (C-C')

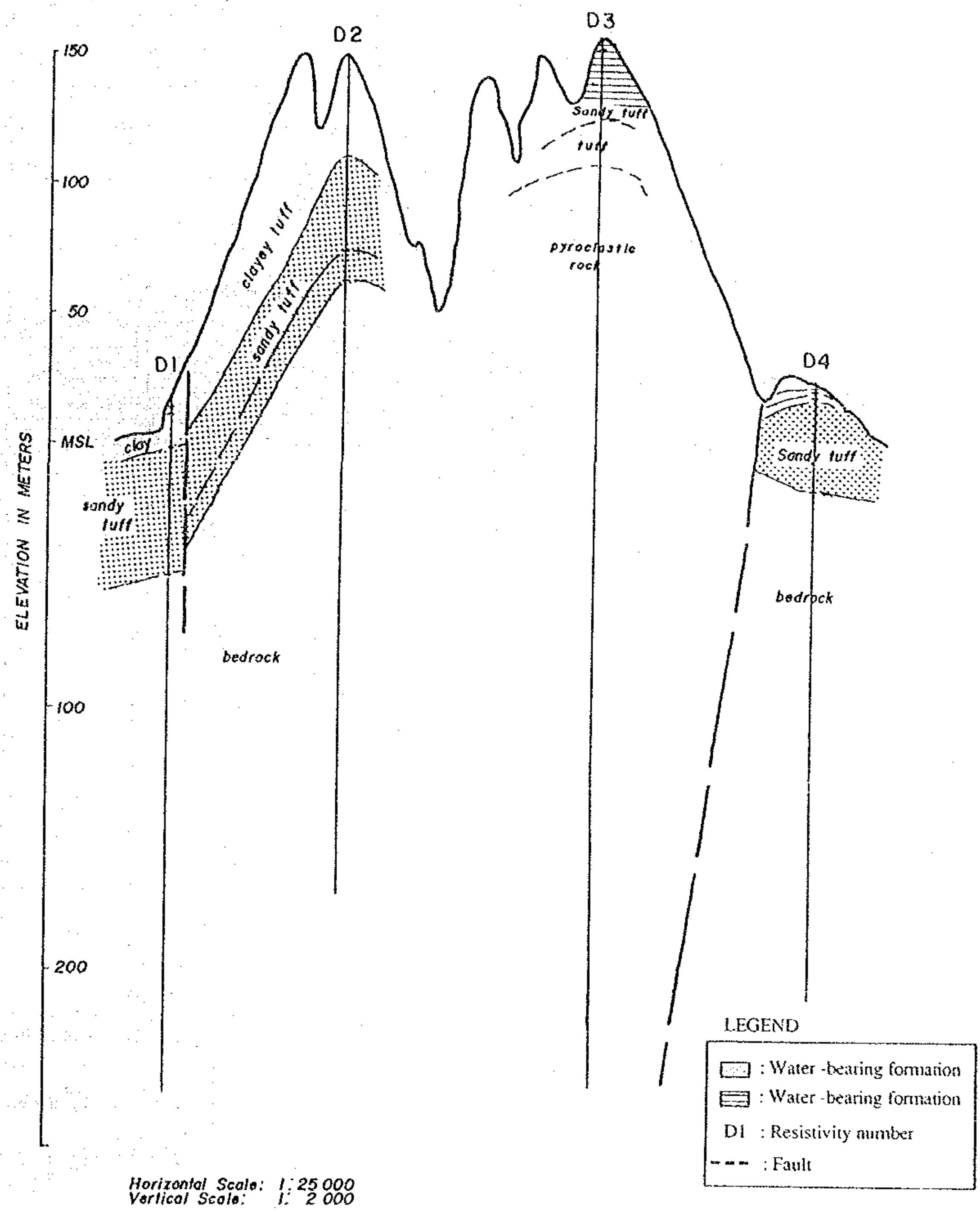


Fig. II.4.2 (4) Geo-electric Profile (D-D')

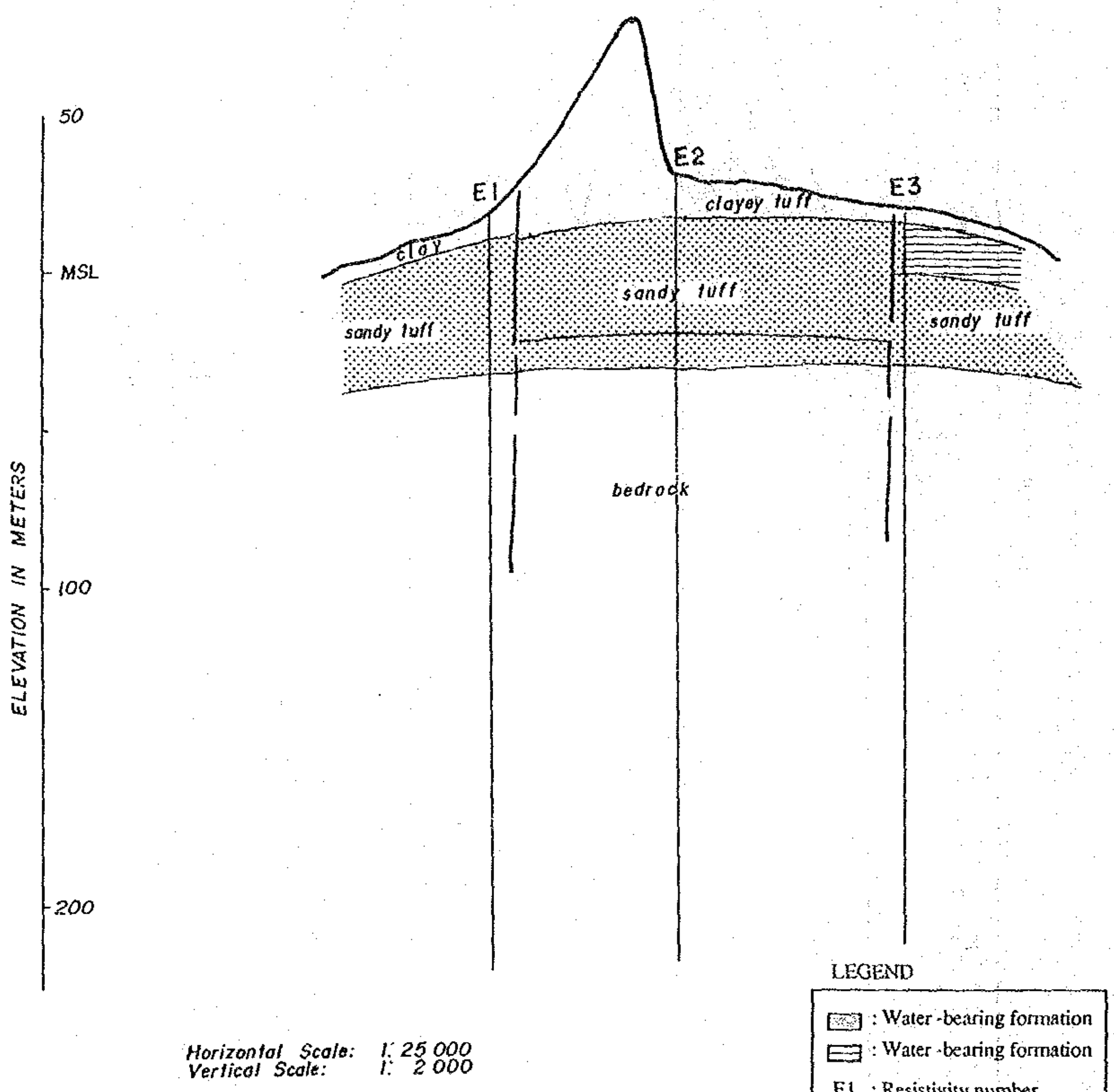


Fig. II.4.2 (5) Geo-electric Profile (E-E')

Test Well - Jala-Jala Elementary School, Jala-Jala

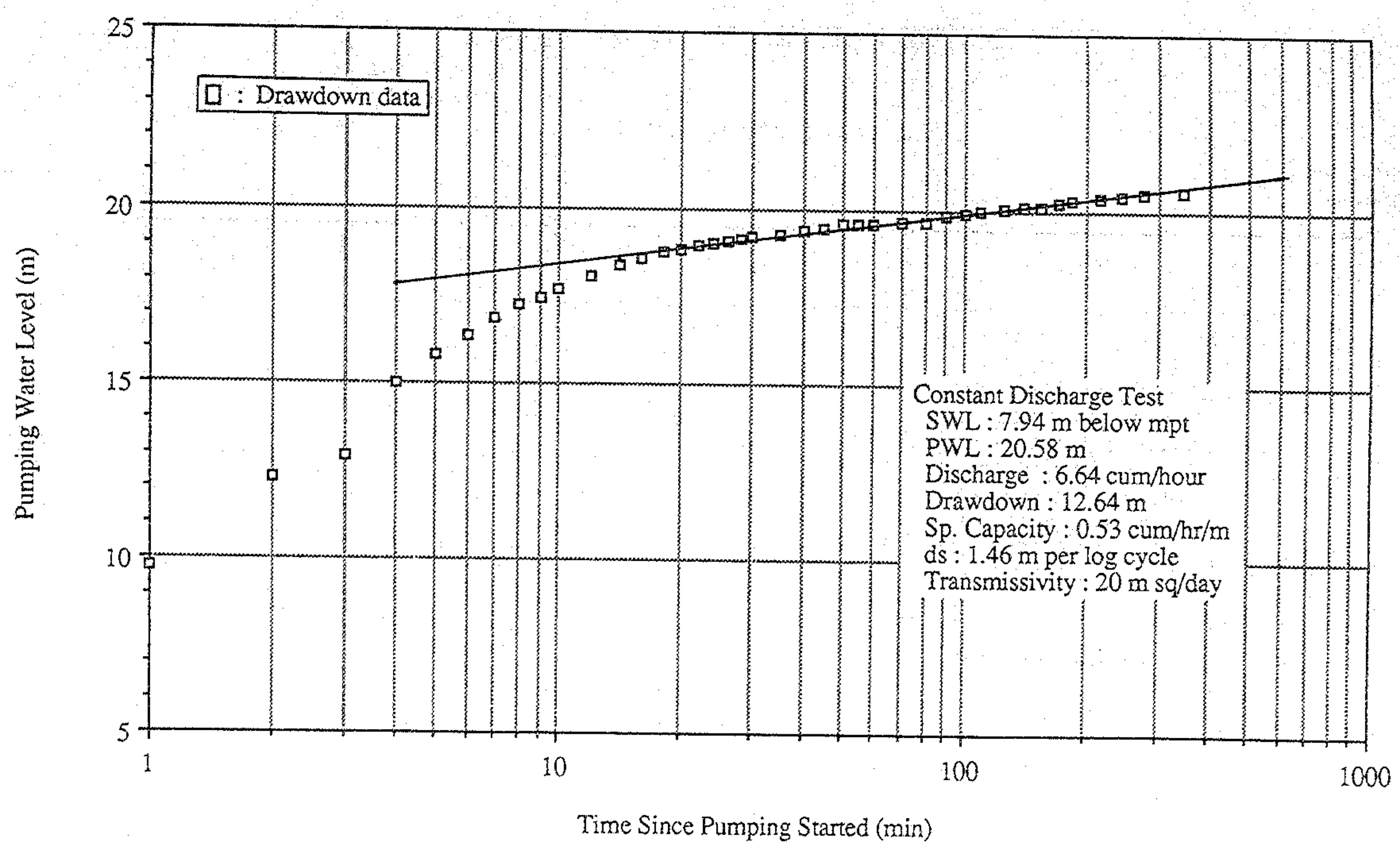


Fig. II.4.3 (1) Pumping Test Result - Drawdown

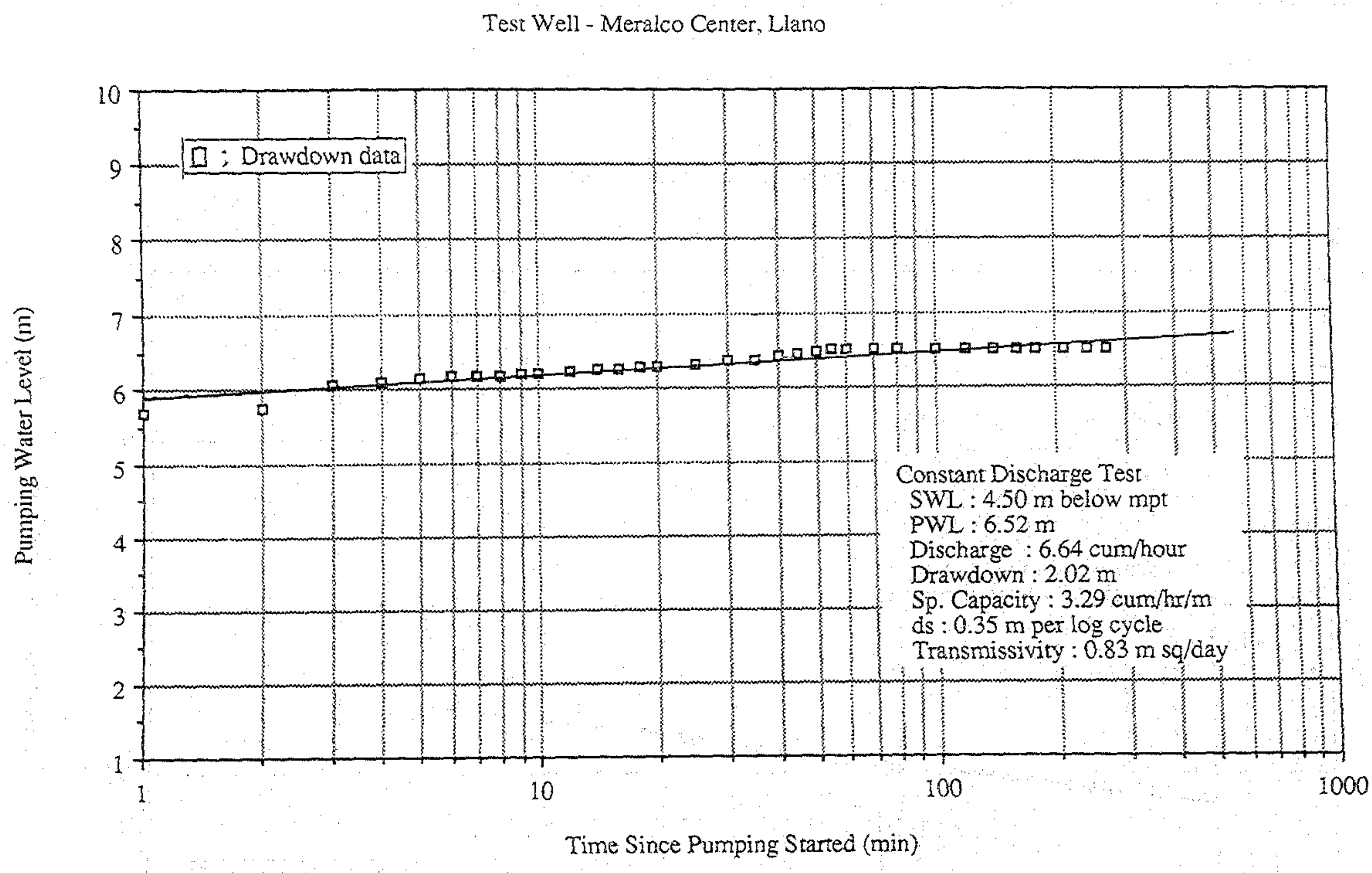


Fig. II.4.3 (2) Pumping Test Result - Drawdown

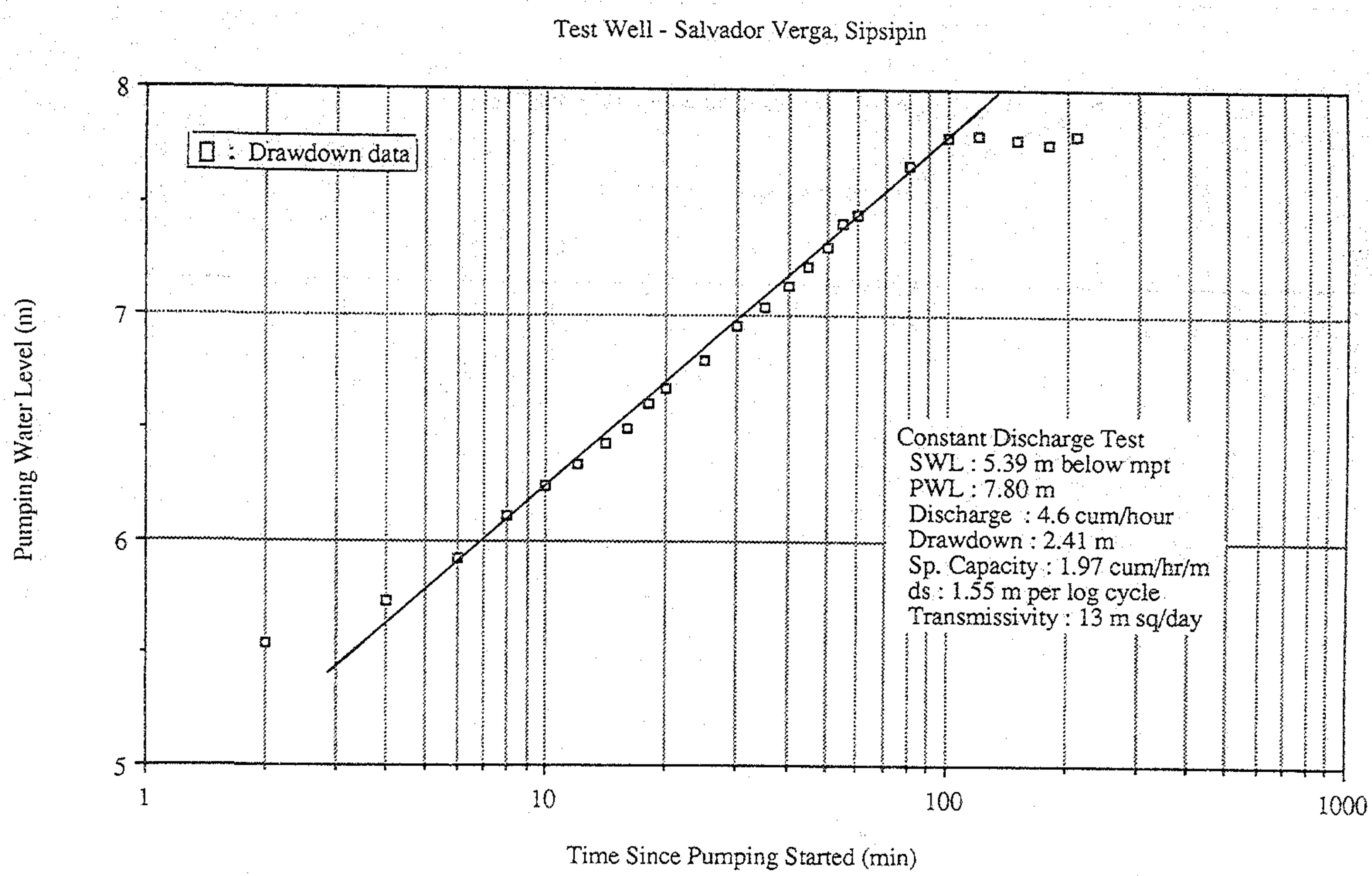


Fig. II.4.3 (3) Pumping Test Result - Drawdown

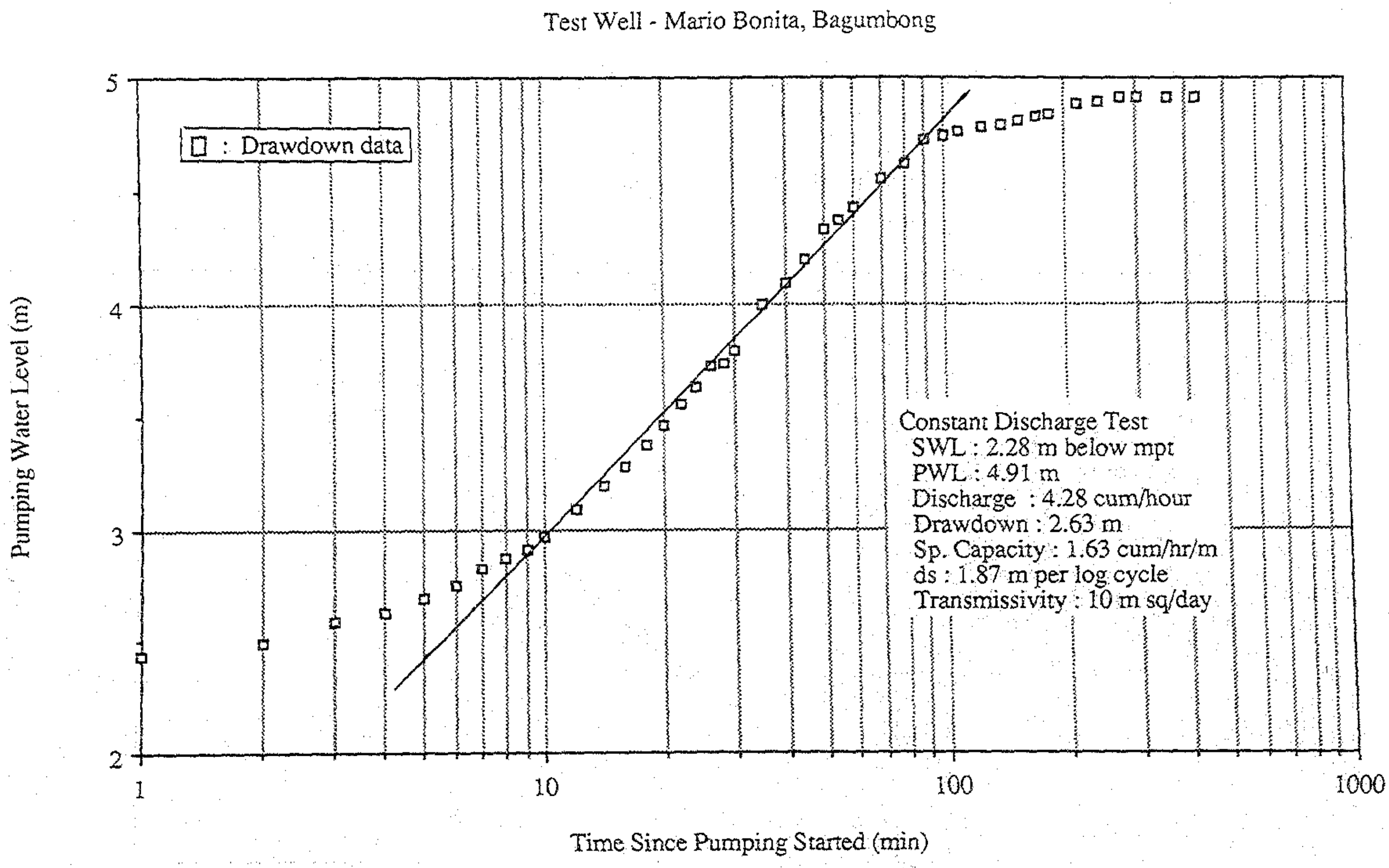


Fig. II.4.3 (4) Pumping Test Result - Drawdown

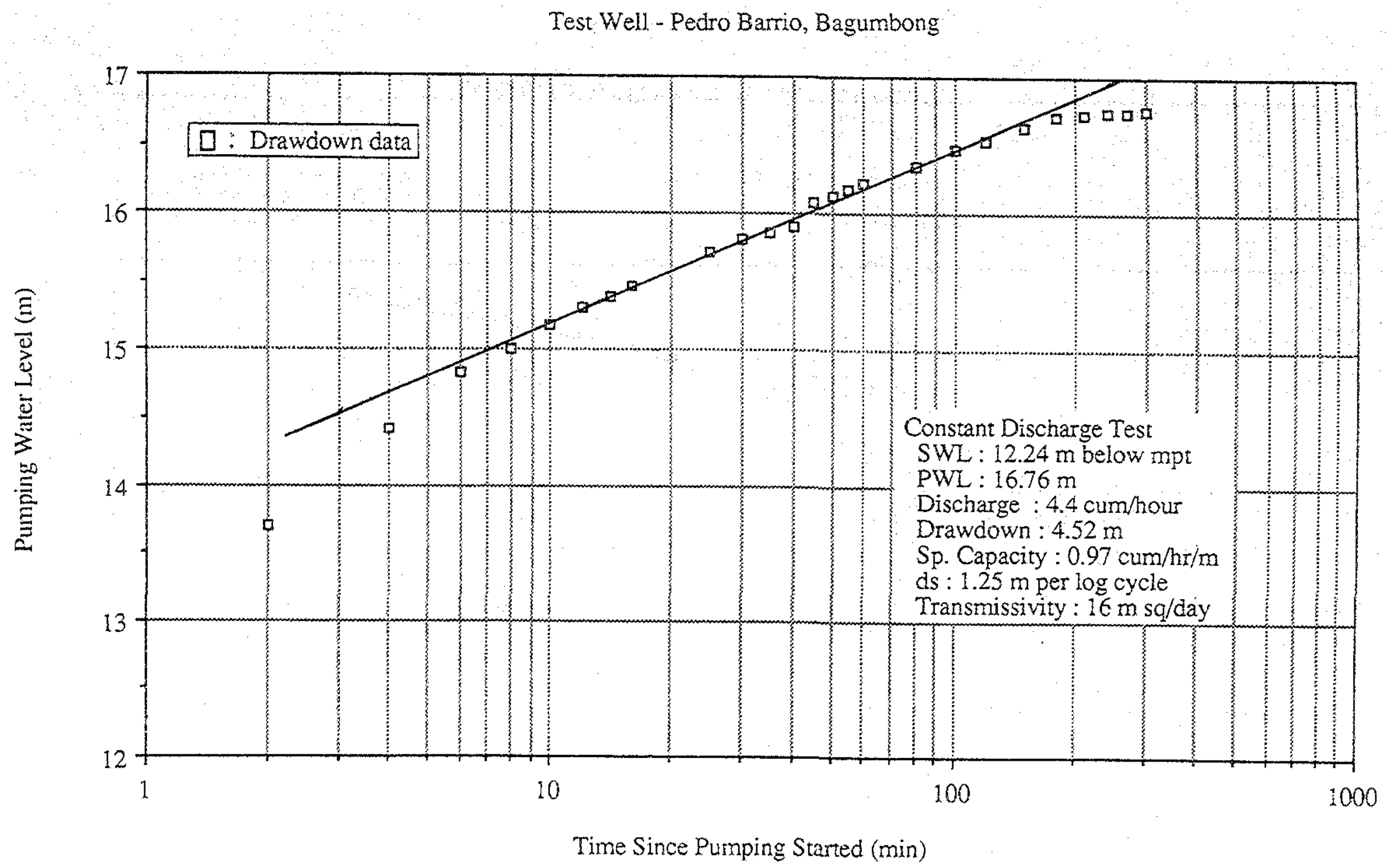


Fig. II.4.3 (5) Pumping Test Result - Drawdown

Test Well - Jala-Jala Elementary School, Jala-Jala

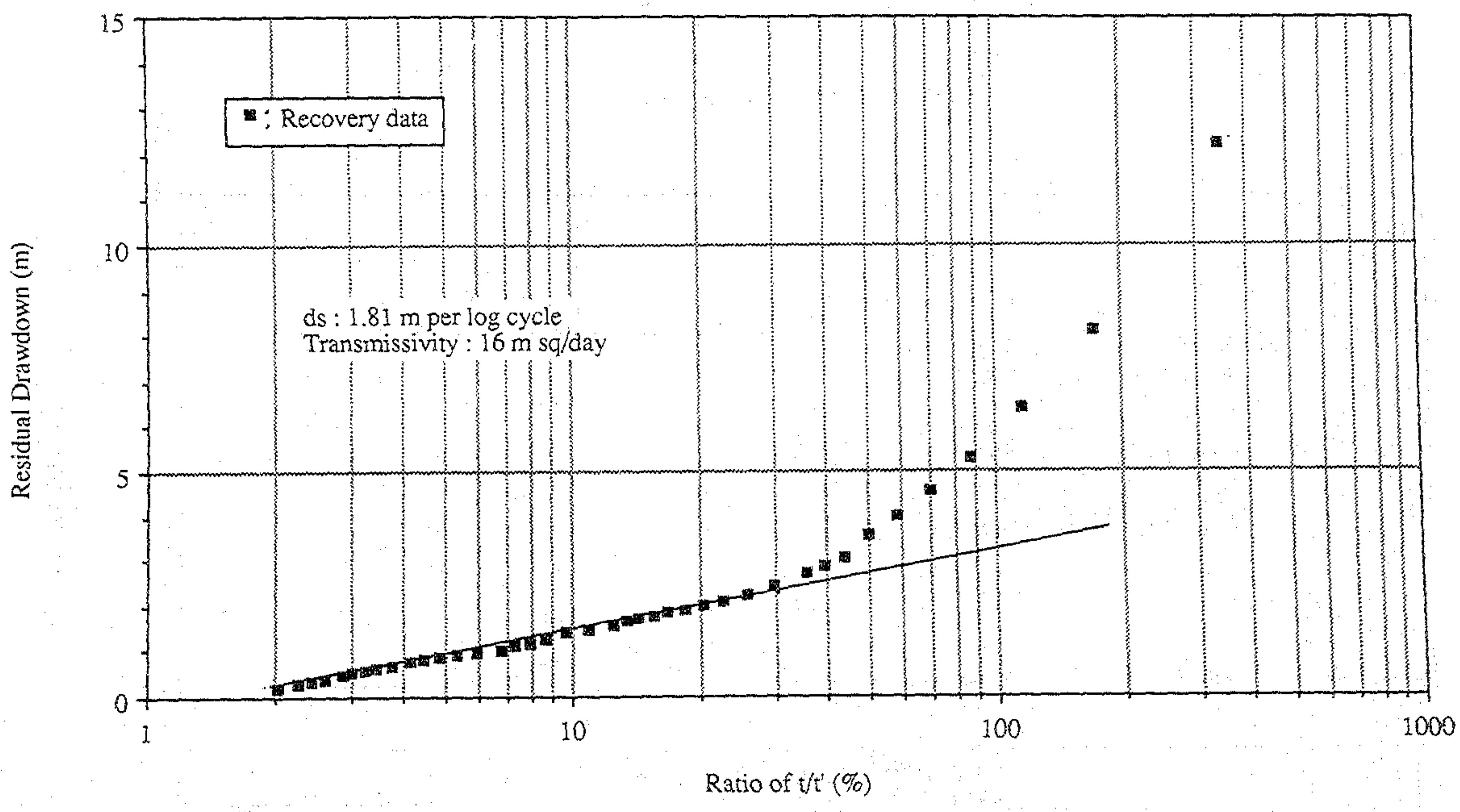


Fig. II.4.3 (6) Pumping Test Result - Recovery

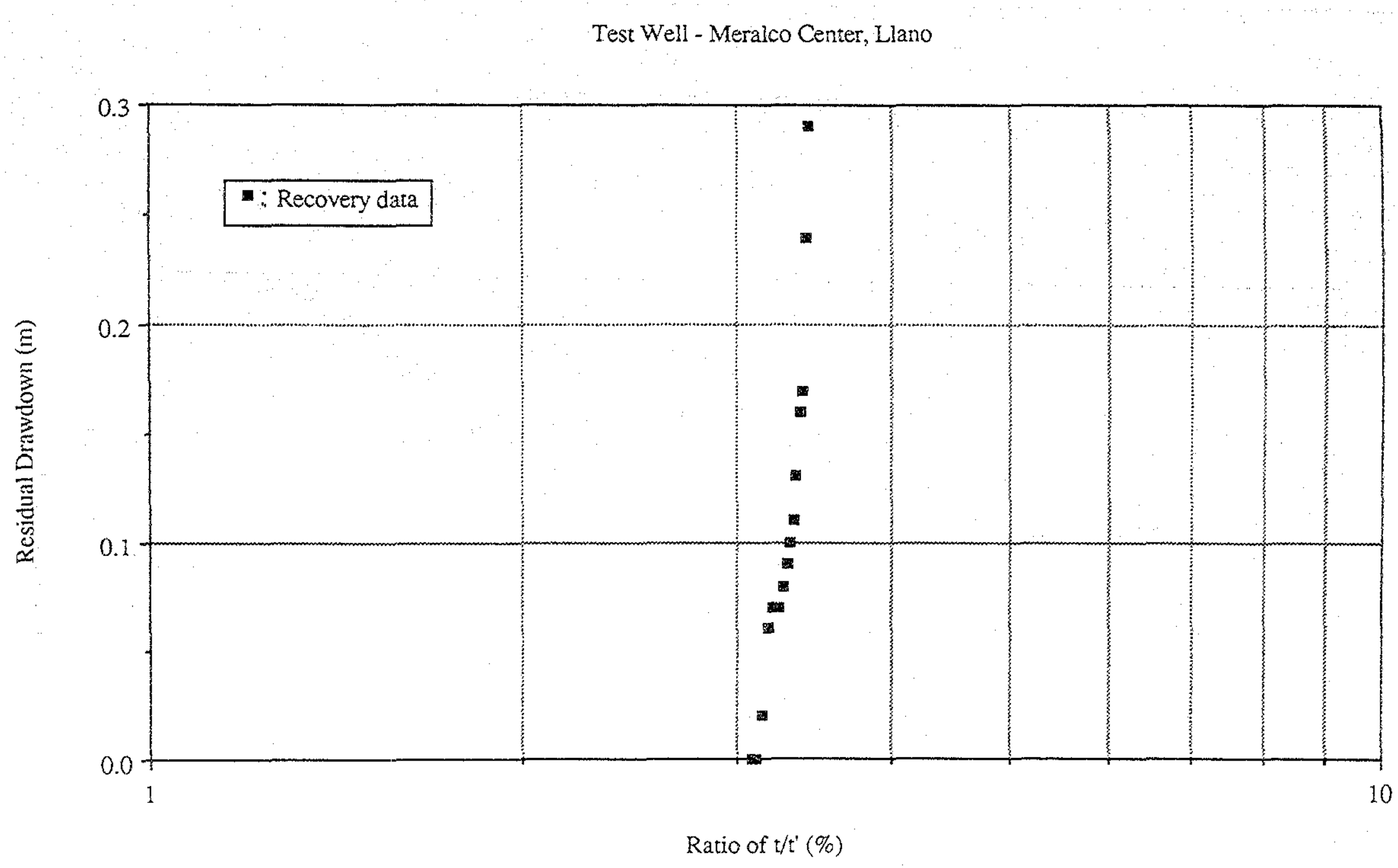


Fig. II.4.3 (7) Pumping Test Result - Recovery

Test Well - Mario Bonita, Bagumbong

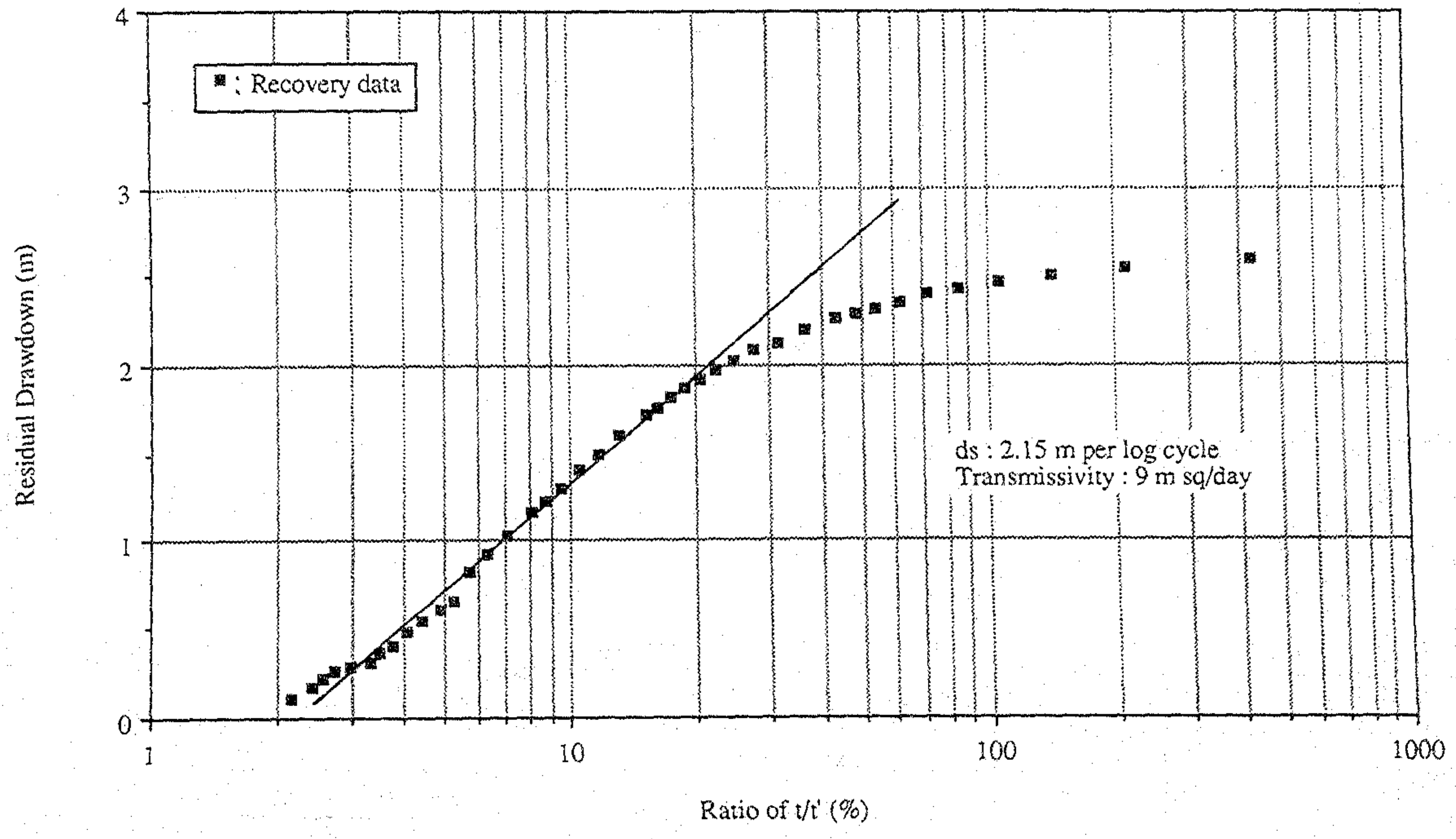


Fig. II.4.3 (8) Pumping Test Result - Recovery