unit: m.s.n.m.

Lake	Elevation (m.s.n.m.)	Mean Depth(m)	Mean Area(km^2)
Managua	36.27	7.8	1016
Tiscapa	48.53	7.0	0.13
Nejapa	42.49	0.3	0.95
Masaya	120.72	48.7	8.34
Asososca	36.5	75.0	0.73
Apoyo	72.23	--	21.4

Lake Managua is located North of Managua City and is basically connected with Tipitapa river and Lake Nicaragua, the latter being the biggest lake in Central America. Water inflow, however, is normally not observed in this river due to the absence of inflowing and outflowing rivers.

Given this condition, the variation in the water level of the lake is discussed in the groundwater level section.

Lake Asososca is very important to Managua City as its source of drinking water. The problems on water level and pumping discharge are mentioned in the next section.

(3) Spring

A big spring zone can be found in the Sabana Grande low land area, as mentioned in Section 4.1, and the Tisma Area. Spring elevation almost corresponds to 50-60 m.

Mocuana river is the only perennial river in the Study Area and its water originates from the groundwater recharged by the mentioned spring zone.

4.3.2 Stream Flow

All the rivers in the Study Area are basically dry except during the rainy season, and yet their flow does not last long even in this season - this is the so called flash-out condition. By this reason, investigation on annual runoff - direct outflow amount in the lakes was not accurately conducted, except for some short term studies.

Mocuana River, in the northeastern part of the Study Area, is a perennial river originating from the groundwaters around El Zapotal.

(1) Review of previous studies

- Case 1: Sub-quenca I

Surface runoff in the Study Area was studied in "INFORME SOBRE EL ESTUDIO HIDROGEOLOGICO DEL AREA DE LAS LAGUNAS DE NEJAPA, ASOSOSCA Y ACAHYALINCA",

This Study conducted continuous rainfall and seasonal streamflow observations, and the runoff coefficients of Lake Nejapa and El Arroyo station were calculated as 0.6 % and 0.4 %, respectively.

The outline of these catchment areas is as follows:

	Nejapa	El Arroyo
Total Area(ha)	1430	3500
Land Use (%)		
Forest	71.5	61.5
Albustos	22.7	37
Urban	5.8	1.5
Elevation (m)		
Max.	900	900
Min.	170	145
Slope (%)		
Max.	14	21.8
Min.	1.4	2.2
Longitude (km)	13	12.75

- Case 2: Sub-quenca II

IRENA conducted continuous discharge measurements in 1986-1988 in the study "INFORME SOBRE EL ESTUDIO HIDROGEOLOGICO DEL AREA DE LAS LAGUNAS DE NEJAPA, ASOSOSCA Y ACAHUALINA".

In order to consider run off condition, the discharge records at San Judas Station and the rainfall records at Las Nubes, San Isidro Libertador, Los Pastores, Santa Leonor, Magdalena and Sierra Maestra stations were reviewed (Detailed process is described in the Supporting Report).

unit:m.s.n.m.

Station	item	Elevation
Las Nubes	rainfall	900
San Isidro	rainfall	750
Los Pastores	rainfall	450
Santa Leonor	rainfall	350
Magdalena	rainfall	350
Sierra Maestra	rainfall	240
San Judas	discharge	240

Runoff coefficient calculations based on the area rainfall taken in these stations and the discharge at San Judas are as follows:

unit:%

Year	May	Jun	Jul	Aug	Sep	Oct	Nov
1986	0.2	0	0.1	0.6	-	0	0
1987	2.6	0.4	1.3	3.2	-	0.9	-
1988	0.8	2.3	-	2.1	3.9	7.6	-
1989	-	0.7	0	0.3	2.0	0.3	-

The monthly rainfall data at San Isidro Station are as follows:

unit:mm

Year	May	Jun	Jul	Aug	Sep	Oct	Nov
1986	201	272	114	121	178	159	56
1987	68	92	430	247	274	155	10
1988	391	358	192	549	315	554	86
1989	48	139	180	157	467	64	89

The results indicate that runoff coefficient varies according to the condition of the soil before rain falls and the amount of rainfall. Dry years made negligibly small values of efficiency and wet years made a maximum of 7%.

- Spring rivers

River discharge was measured in the Study "INVESTIGACIONES DE AGUAS SUBTERRANEAS EN LA REGION DEL PACIFICO DE NICARAGUA, NACIONES UNIDOS", in 1973. The results of the spot measurement in this Study are as follows:

Basin	Area (km^2)	Discharge(m^3/sec) Direct	Base	Total	rainfall (mm)
Channel to L.Managua	160.8	0.193	0	0.193	559
Rio Lodoso	41.3	5.57	0.265	5.836	530
Rio El Borbollon	212.8	-	-	0.043	549
Rio La Mocuana	70.3	22.36	1.06	23.417	510
Piedra Quemada	25.5	0	0	0	596
Laguna de Masaya	232.9	0.396	0	0.396	833
Laguna de Apoyo	36.8	0.02	0	0.02	629
Lago de Granada	301.8	0.148	0	0.148	550
Rio Tipitapa	183.8	0.067	0	0.057	517

(2) Monitoring of Streamflow (Mocuana and Sapamaspa River)

(a) Continuous monitoring

- Mocuana River

An automatic water level recorder is installed at the intersection of Mocuana river and Managua-Tipitapa road. Observation works started in March,1992.
The collected water level at the Mocuana river station is converted to monthly discharge. Detailed process is mentioned in the Supporting Report.

Fig.4.3.2 shows a stage-discharge rating curve based on the monthly discharge measurements conducted until October, 1992.

This observation point has two dams upstream, one for the swimming pool at Trapiche park and the other for the irrigation of the El Panama agricultural scheme. Discharge at this point is controlled by gate operation of these facilities. The total amount of discharge, therefore, has to be evaluated instead of a flooding analysis.

Table 4.3.1 shows the average monthly discharge which is estimated at 1.01 m^3/sec and considered to have increased around 1.3 m^3/sec in July, September and October.

- Monitoring Sapasmapa River

In order to estimate the general runoff amount to Lake Masaya, a stuff gauge was installed in Sapasmapa river, around 100 m up from the lake. Gauge reading was performed when flow was observed. Discharge was estimated by using the Manning method with an estimated cross section. The results are shown in Table 4.3.2 including the daily rainfall at Masaya and La Concepción stations. River cross section is also very small in the whole catchment area and the discharge amount was observed to be quite small for a catchment area of around 80 Km^2, because of the presence of numerous banks and planes on the way where water is stored or spread.

(b) Simultaneous discharge measurement

Simultaneous discharge measurement was conducted in Oct. 21, 1992, and is shown in Fig.4.3.3.
The results of the measurement in the dry (February) and rainy (October) seasons are summarized below.

Unit: m^3/sec

Place	Feb.	Oct.	
Santa Elena	0.146	( )	Leaking of dam is not estimated in October.
El Rodeo Pla.	0.052	0.010	
IRENA	0.074	0.097	
El Zapotal	0.093	0.242	
Rio Mocuana	(0.86)	0.108	Different current meter was used.
Las Cruces	N.S.	0.068	

The results clearly show a slight increase in the discharge measured in most of the places. However, the wet condition in spring zones is observed to spread in comparison to the conditions in the dry season.

Table 4.3.1 Estimated Discharge of Mocuana River

DATE	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1	-	1.02	0.97	1.34	-	0.97	1.34	1.28
2	-	1.02	0.99	1.28	1.45	0.97	1.28	1.23
3	-	1.04	1.04	-	-	1.02	1.28	1.23
4	-	1.02	1.04	-	-	1.04	1.12	1.40
5	-	1.07	1.65	-	-	1.07	1.07	1.52
6	-	1.12	1.07	1.17	1.40	1.28	1.07	1.31
7	-	1.65	0.97	1.40	1.28	1.31	1.34	1.84
8	-	1.17	0.97	1.28	1.28	1.28	1.28	1.55
9	-	1.09	1.02	1.28	1.46	1.34	1.58	1.28
10	-	0.97	1.04	1.20	1.23	-	1.23	1.12
11	-	1.02	0.99	1.28	-	-	0.92	1.20
12	-	1.04	0.99	1.34	-	-	0.97	1.37
13	-	1.02	1.04	1.31	-	-	1.02	1.91
14	-	1.04	1.07	1.17	-	-	1.02	1.17
15	-	1.02	1.07	1.07	-	-	1.02	1.20
16	-	1.07	1.02	1.07	-	-	1.26	1.02
17	1.84	1.02	1.04	1.04	-	1.07	1.31	0.97
18	0.97	1.04	1.02	1.07	-	1.78	1.07	1.04
19	0.82	1.09	1.65	0.92	-	1.23	1.04	1.04
20	0.97	1.09	1.23	-	1.37	1.02	1.52	-
21	0.97	1.58	1.28	-	1.23	0.97	1.07	-
22	1.02	1.23	1.40	-	-	1.02	1.12	-
23	1.07	1.02	1.52	-	-	0.99	1.17	-
24	0.94	1.43	1.46	-	-	1.07	1.65	-
25	0.87	0.92	1.31	-	-	1.09	1.52	-
26	1.07	0.94	1.31	-	-	1.07	1.65	-
27	1.02	0.97	1.28	-	-	1.17	1.61	-
28	1.02	1.46	1.23	-	-	0.99	1.46	-
29	0.99	0.97	1.20	-	-	1.12	1.78	-
30	0.99	0.94	1.23	-	1.12	1.84	1.71	-
31	0.57	***	1.23	***	1.12	1.28	***	-
AVE.(M3/s)	1.01	1.10	1.17	1.20	1.29	1.17	1.28	1.30
M3	2700496.	2856023.	3137543.	3117048.	3466320.	3123274.	3323916.	3481741.

Tabel 4.3.2 Estimated Discharge of Sapamaspa River

COMPARATION BETWEEN RAINFALL IN LA CONCEPCION STATION AND MASAYA STATION AND RUNOFF IN SAPASMAPA RIVER

DATE	RAINFALL LA CONCEPCION (mm)	RAINFALL MASAYA (mm)	RUNOFF (M3)
07/07/92	33.00	4.70	12,591
08/07/92	6.50	9.90	1,403
13/07/92	0.00	22.00	9,180
16/07/92	1.00	0.00	8,740
18/07/92	5.00	0.10	1,602
23/07/92	10.50	28.80	3,863
24/07/92	0.50	2.50	1,850
25/07/92	6.00	13.20	2,697
26/07/92	1.50	0.30	1,311
29/07/92	5.00	1.60	5,682
13/08/92	0.50	1.40	1,710
18/08/92	0.00	0.00	3,402
26/08/92	5.00	5.90	2,311
08/09/92	0.00	0.30	838
12/09/92	3.00	3.50	1,134
15/09/92	0.00	8.90	1,274
23/09/92	57.00	47.70	18,837
27/09/92	45.00	18.50	12,627
30/09/92	10.50	37.90	27,093

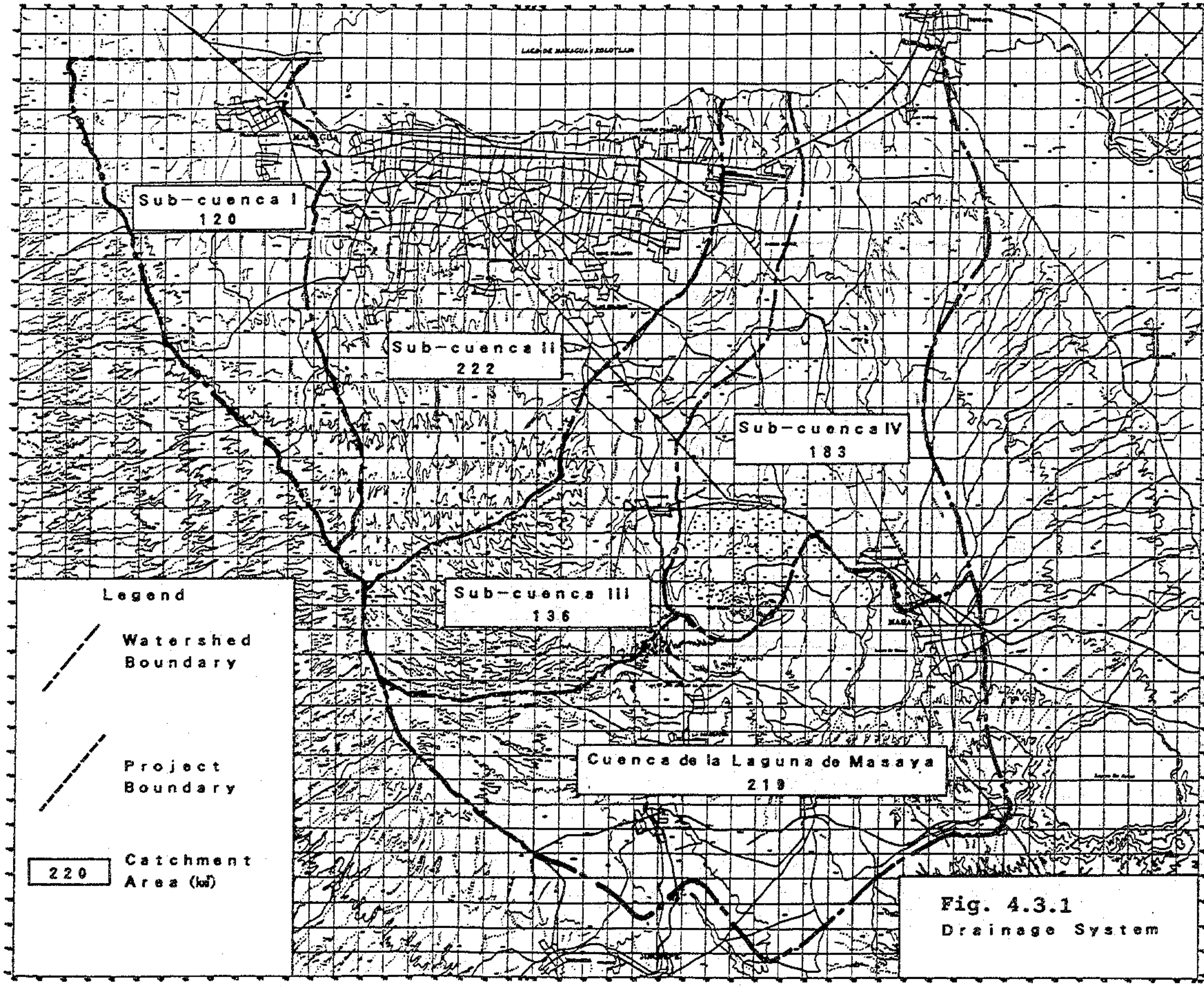
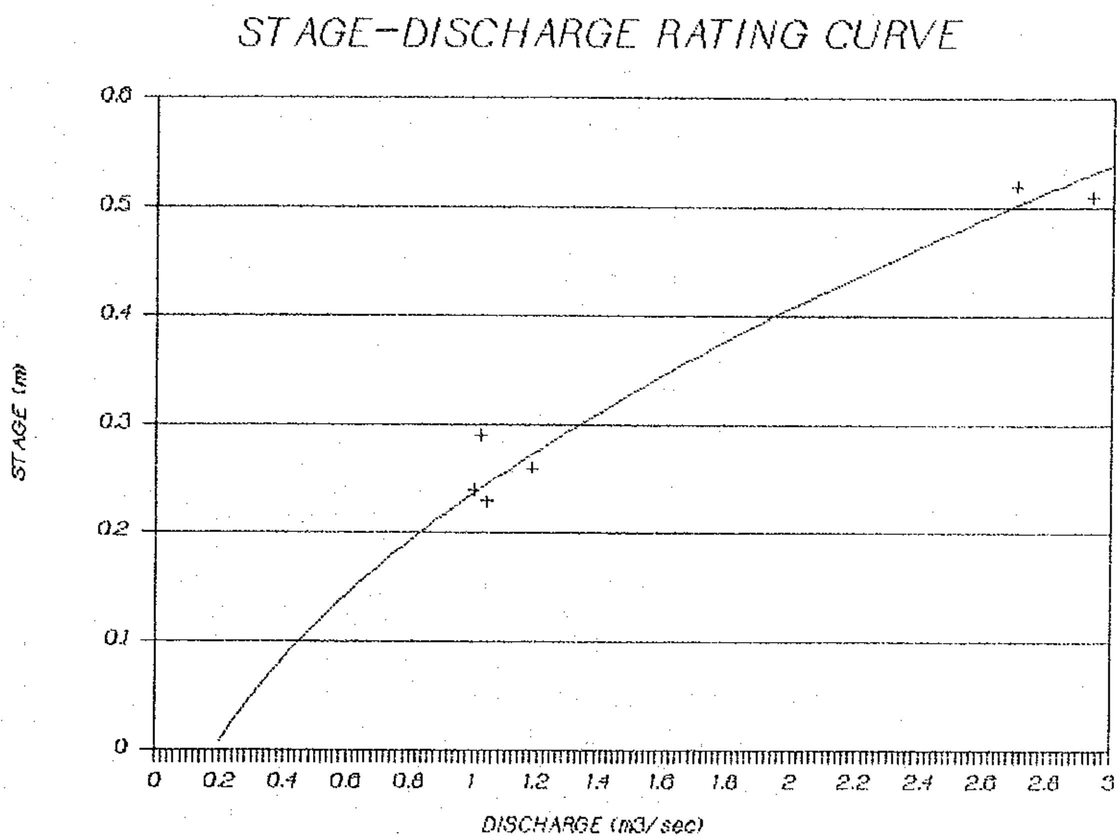


Fig. 4.3.1
Drainage System



(a) RESULTS OF DISCHARGE MEASUREMENT

FECHA	DESCARGA (m3/seg) Q	ALTURA LIMNIMETRICA h
20/5/92	2.71	0.52
30/6/92	1.19	0.26
17/8/92	1.04	0.23
31/8/92	2.94	0.51
16/9/92	1	0.24
1/10/92	1.1	0.29

Q= (a H + b)**2

SQRT(Q)	H
1.646207	0.52
1.090871	0.26
1.019803	0.23
1.714642	0.51
1	0.24
1.048808	0.29

Regression Output:

Constant	0.426338981
Std Err of Y Est	0.057799621
R Squared	0.975882850
No. of Observations	6
Degrees of Freedom	4
X Coefficient(s)	2.420634
Std Err of Coef.	0.190266

SQRT(Q)= (H*2.4206+0.4263)**2

(b) RELATION OF RECORDER & GAGE HEIGHT

DATE	RECORDER	GAGE HEIGHT	
JULY 30	1.87	0.27	0.260198
AUG 28	1.896	0.235	0.233328
AUG 17	1.893	0.23	0.236429
JUN 8	1.84	0.3	0.291202
JUL 6	1.77	0.36	0.363543
OCT 9	1.855	0.27	0.275700
OCT 20	1.885	0.24	0.244696

Regression Output:

Constant	2.192752139
Std Err of Y Est	0.007545971
R Squared	0.977569401
No. of Observations	7
Degrees of Freedom	5
X Coefficient(s)	-1.03345
Std Err of Coef.	0.070009

H = -1.033 x h + 2.193

Fig. 4.3.2 Stage-Discharge Rating Curve

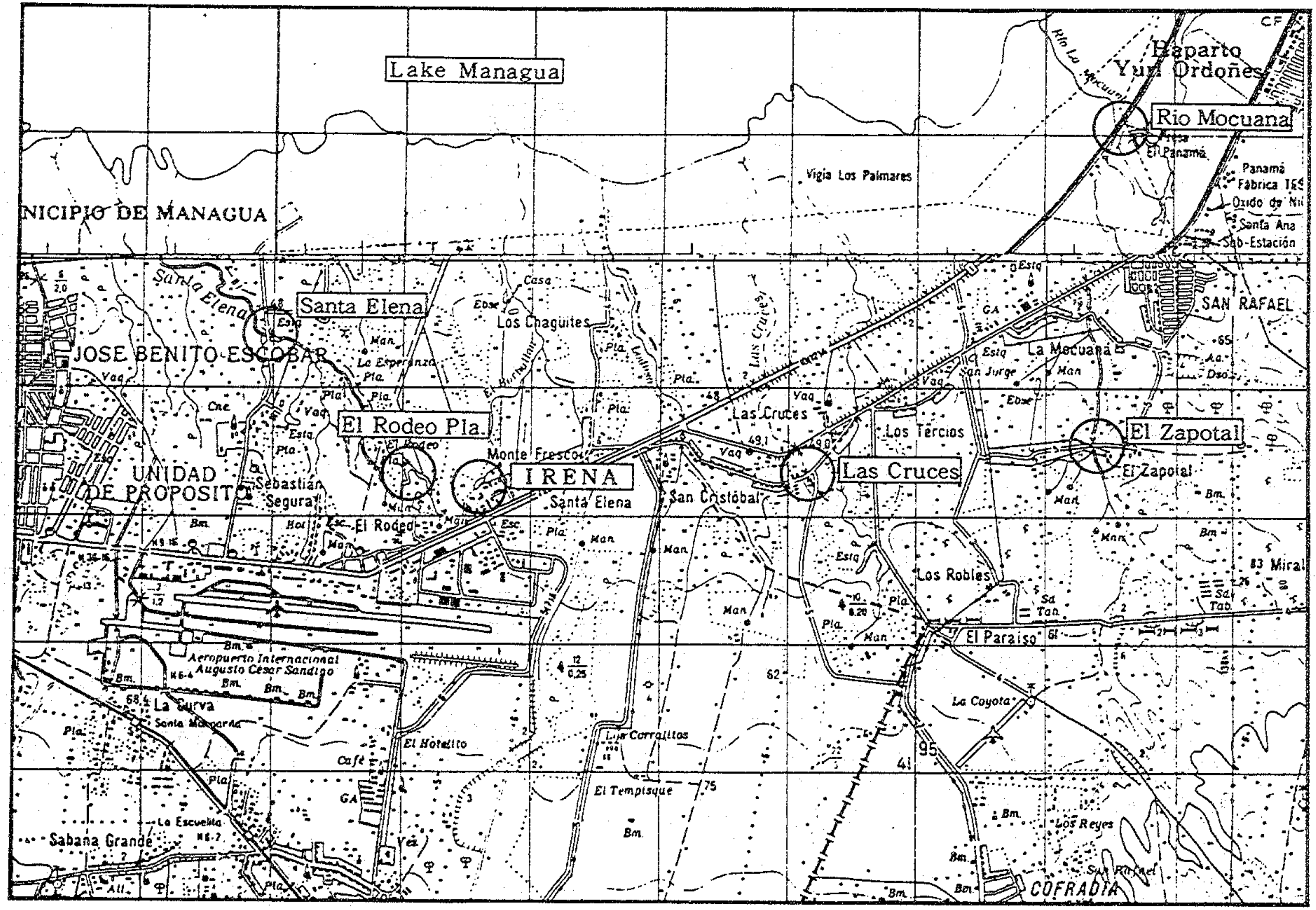


Fig. 4.3.3 Positions of Discharge Measurement

4.4 Well Inventory and Groundwater Level

4.4.1 Well Inventory

Information on wells drilled upto the present are collected from the Inventory of the Hydrogeological section, INETER and Magregor, drilling companies.
The inventory classified the wells into the following:

Items	Managua	L. Mercedes	Masaya	S. Rafael	Total
Industrial	33	22	12	5	72
Domestic	58	20	12	5	96
Municipal	46	6	53	4	109
Irrigation	15	10	5	1	31
Investigation	7	4	-	-	11
Agroindustrial	2	2	1	-	5
Not used	14	152	86	1	253
Abandoned	5	-	-	2	7
No information	50	-	-	29	79
Total	230	216	170	47	663

The above table indicates that a total of 663 drilling wells were found. However, almost half of these wells, 339, are not used or missing. Municipal wells are maintained by INAA under municipal administration. Domestic wells are managed by personal users or local communities.

These informations are 40 years old and except for some parts used in the 1992 hydrogeological mapping works for the whole of Nicaragua, they have not been updated.

4.4.2 Groundwater Level

(1) Water level of Managua and Asososca lakes

Lake Asososca is very important to Managua City because almost one-third of its drinking water supply is pumped up from this lake.

Over-pumping problems surfaced when most of the water demand of the City was supplied from the lake.
Draw-down of lake water level is a very serious problem because Lake Managua has been contaminated by the waste water of industrial and residential areas. It is also possible that the water of Lake Managua flows into Lake Asososca.

The groundwater table of Lake Asososca was prepared based on the detailed leveling work conducted in the "INFORME SOBRE LE ESTUDIO HIDROGEOLOGICO DEL AREA DE LAS LAGUNAS DE NEJAPA, ASOSOSCA Y ACAHUALINCA' in 1979. Three of the lake's groundwater level stages measured in 1963, 1970 and 1978 are shown in Fig. 4.4.1. The figure shows a sharp or radical change in the groundwater table due to over pumping.

On the other hand, the relationship of the water level of Lakes Asososca and Managua is shown in Fig. 4.4.2. Both lakes have no outflow and inflow sources, therefore, their water levels are largely influenced by rainfall, evaporation and groundwater recharge conditions. Variations in the water level of Managua Lake is found to be naturally dependent on rainfall condition, while the water level of Lake Asososca which has constantly decreased from mid 1960 is caused by an increase in pumping.

Fig. 4.4.3 shows the monthly water level of Lake Managua in 1966-1978, including the monthly rainfall observed in A.C. Sandino station. The minimum level was 36.3 m.s.n.m., recorded in 1968, and the maximum was 39.6 m, in 1970. A variation which corresponds to the observed amount of annual rainfall.

It is necessary to point out that a constant decrease in water level was observed in 1971-1972 and 1975-1978. The decrease was observed to gradually start from November to April, the dry season, and the increase was observed to start from May with the onset of the rainy season. The same cycle can be observed all year round.

On the other hand, the water level near the A.C. Sandino Station continuously decreased in the dry or drought years where around 800mm of annual rainfall was measured.

As previously stated in the foregoing paragraphs, the water level of lake Asososca is affected by pumping discharge. Fig. 4.4.4 shows the monthly water level according to the annually pumped amount and rainfall amount in 1972-1991. For example, the water level in 1978-1979 decreased from EL 35 m to EL 34 m in spite of 1979's having a larger rainfall average than 1978. This condition may be attributed to the fact that 1979 had a greater annual pumping amount of 37 million m³ compared to the 28 million m³ in 1978.

Asososca's water level is considered to have been recovered lately because of the shift in pumping places to Sabana Grande and central Managua. Detailed pumping discharge is discussed in the next section.

(2) Continuous water levelling

Records collected at the 3 stations, namely Christian Perez, Masaya and Sabana Grande, were used as daily water level values (see Fig. 4.4.5 (1)-(3)).

Christian Perez station is located in the center of Managua City, and its water level is observed to continuously decrease even in June and July, the rainy season. A very slight increase is observed in the end of July. The water level measured during the simultaneous leveling works was 44.3 m below ground level, while 45.5 m below ground level was recorded in November. One of the reasons may be attributed to the short rainfall in this year as mentioned in section 4.2.

Another factor to consider is the location of the well. The amount of pumping discharge in the central part of Managua City has rapidly increased in recent years. Although the Christian Perez Station is also surrounded by many production wells, it is still difficult to analyze this relationship in detail because of the absence of continuous water level records concerning the area.

Masaya station, which is located southwest of Lake Masaya, has a water level of around 15.5 m below ground level. The lowest water level was in March, and an increase was observed until the end of July. Water level was observed to decrease in September and rapidly increase at the end of October by 200 mm of the daily rainfall amount observed in La Concepción station in October 3, 1992. The change in the water level corresponds to the amount of rainfall in the recharged area.

Sabana Grande station is located south of the Airport and has a water level of around 22 m below ground level. The water level of this station varies according to rainfall amount.

The water level was observed to decrease until the middle of May, but was observed to increase after the first heavy rain (around 60mm) in May. Nevertheless, only 20-30mm increase was observed based on the still dry condition of the soil. This rainfall amount is recorded in A.C. Sandino Station.

(3) Simultaneous water leveling

Simultaneous groundwater leveling was conducted in order to evaluate the groundwater table in the whole Study Area.
This survey was conducted twice, in February (dry season) and October (rainy season).

It was mostly difficult to measure the water level of the industrial and domestic wells because these wells usually have submersible motor pumps without observation holes.

The target wells finally selected for measurement were the INAA investigation wells, UNICEF wells drilled in 1990-1992, and other wells which have no pumping equipment.

Table 4.4.1 shows the list of wells surveyed in this period, and Fig.4.4.6 shows the location of the wells and the groundwater table based on 10 year old groundwater level data of the INAA and other wells.

Water level was observed to decrease in some places mainly due to defects in the detecting equipment. The water level of the 140m deep wells in Masaya and Nindiri show a 0.4-0.5 m decrease. This decrease, however, is considered to be within a reasonable scale.

It was basically difficult to stop the pumping activities conducted on the INAA production wells because of the inavailability of extra water sources. However, some static groundwater level measurements were conducted even when the power was interrupted.

The water level measurements in Carlos Fonseca, Sabana Grande, and other wells are shown in Table 4.4.2.

A maximum decrease in water level was measured in Carlos Fonseca (7.1m), Sabana Grande (7.0-m), and 19.5 m in other areas.

The draw down condition in the Carlos Fonseca well field is discussed in Section 4.8.

Water level observation in the surrounding area of Lake Asososca was performed in October, 1992. As shown in Fig. 4.4.7, the groundwater elevation at the point near Lake Managua was 35.77 m above sea level (m.a.s.l.). The point located north of Landa Vista indicated 37.09 m.a.s.l, around 36.20 m.a.s.l. at MAYCO and ERCASA, and 36.45 m.a.s.l at ESSO. In comparison with these levels, the water level measurements conducted in April 4, 1992 in Lake Asososca and August 25,1992 in Managua were 35.75 and 36.27 m.a.s.l., respectively.

These results suggest that the circle of the pumping cone of Lake Asososca still overlays the industrial area around ESSO-HERCASA-MAYCO, and that additional reduction in discharge from Lake Asososca is required.

(3) Pumping Discharge and Water level of Asososca

The relation of pumping discharge and the water level was discussed in the "FIELD AND MODELLING STUDIES OF GROUNDWATER CONTAMINATION OF LAGUNA ASOSOSCA, MANAGUA, NICARAGUA" by David Norman Bethune in 1991. Maximum annual extraction was calculated by the following formula determined by Montgomery Chan, Consorcio in 1979.

$$W = 7.68 + 0.0002P - 0.079E + 0.828W'$$

where;

W = current year min. annual level
P = annual precipitation
E = annual extraction
W'= min. annual level of previous year

The calculation resulted in 10.13 m^3/yr (2.78 x 10 m^3/day or 7.4 mgd) for an annual rainfall of 1086 mm, a value almost close to the rate in Fig. 4.4.8.

INFORMATION OF VISITED WELL FEB-MAR. 1992 AND OCT. 1992

Table 4.4.1 List of Levelling Wells (1)

Well No.		PLACE	COORDINATE N	COORDINATE W	PROPRIETOR	GROUND LEVEL (m)	DRILLED DEPTH (m)	SCREEN POSITION TOP (GL-m)	SCREEN POSITION BOTTOM (GL-m)	GROUNDWATER LEVEL FEB-MAR 92 S.W.L (m)	FEB-MAR 92 ELEVATION (m)	OCT 92 S.W.L (m)	OCT 92 ELEVATION (m)	COND. (m)	T (C)	pH	WATER QUALITY TURB (mg/l)	DO	SALT %	OBSERVACITNES
1	1	CENIGB. SABANA GRANDE	N1339.10	E592.30	CENIGB															IRRG. PIV. CENTR
2	2	CENIGB. SABANA GRANDE	N1339.70	E591.80	CENIGB	90.00				20.21	69.79									IRRG. PIV. CENTR
3	3	CENIGB. SABANA GRANDE	N1339.88	E592.55	CENIGB					32.36										IRRG. PIV. CENTR
4	4	CENIGB. SABANA GRANDE	N1340.60	E592.80	CENIGB															IRRG. PIV. CENTR
5	1	COFRADIA. VIVEROS IRENA	N1340.75	E595.50	IRENA					14.70										DRILLED WELL
6	2	COFRADIA. VIVEROS IRENA	N1340.75	E595.50	IRENA	88.00				11.18	76.82									
7	1	POBLADO DE COFRADIA	N1340.20	E595.45	INAA															
8	2	POBLADO DE COFRADIA	N1340.20	E595.35	INAA															
9	3	POBLADO DE COFRADIA	N1340.35	E595.40	INAA	90.00				13.98	76.02									
10	-	RANCHO CHICO. TIPITAPA	N1340.30	E598.70	PRIVATE															WATERING PLACE
11	1	FINCA EL PLANTEL	N1339.75	E598.80	U.N.A					50.04										WATER. P. &
12	2	FINCA EL PLANTEL	N1339.60	E599.30	U.N.A	117.00				48.43		51.83	65.17							WITHOUT PUMP
13	1	FINCA SAN MARTIN	N1336.60	E598.45	PRIVATE															DOM. USE&AVICALA
14	1	GUANACASTILLO	N1334.40	E597.80	COMMON	207.00				92.15	114.85									UNICEF. OLD WELL
15	2	GUANACASTILLO	N1334.40	E597.80	COMMON					92.46										UNICEF. NEW WELL
16	12	CAMPO"CARLOS FONSECA"	N1341.65	E588.55	INAA															
17	1	CAMPO"CARLOS FONSECA"	N1341.65	E589.15	INAA															
18		CAMPO"CARLOS FONSECA"	N1341.65	E589.15	INAA															OBS. WELL
19	6	CAMPO"CARLOS FONSECA"	N1341.60	E589.70	INAA															
20	14	CAMPO"CARLOS FONSECA"	N1341.55	E590.30	INAA															
21	-	POBLADO DE SABANA GRANDE	N1340.00	E591.00	INAA	90.02				20.53	69.49	20.85	69.17							INVES. WELL
22	4	SABANA GRANDE	N1340.25	E589.30	INAA															
23	-	Km. 7 CARRETERA A MASAYA	N1338.15	E581.85	INAA															
24	V-7	Km. 14.5 C.A MASAYA. C. VERACRUZ	N1332.70	E587.05	INAA															
25	-	HACIENDA LOS MANGOS. C. VERACRUZ	N1335.50	E591.75	PRIVATE															OBSTRUCT
26	-	QUINTA PANCHITA. C. VERACRUZ	N1336.05	E590.80	COOPERATIVE															CANNOT MEASURE
27	-	VILLA MISERIA	N1343.20	E571.85	COMMON															NO FIND
28	-	BARRIO BELLO AMANECER	N1342.00	E570.90	COMMON	140.00				97.60	42.40									WITHOUT P/M
29	-	BARRIO LAS LOPEZ. CUAJACHILLO =2 ANTIGUA FINCA LA ESPERANZA	N1340.70	E569.25	COMMON	180.00				117.38	62.62									WITHOUT P/M
30	-	TRINIDAD CENTRAL. ESCUELA	N1340.65	E567.25	COMMON															WITH P/M
31	-	TRINIDAD NORTE. ESCUELA ARLEN SIU	N1343.40	E568.15	COMMON	116.00				66.62	49.38									WITHOUT P/M
32	-	COOPERATIVA"JAVIER SOLIS ROCHA" ANTIGUA HACIENDA SAN RAFAEL	N1344.75	E566.95		100.00				55.63	44.37	55.20	44.80							DRILLED. WITH AIR
33	-	FINCA EL DELIRIO	N1344.95	E565.35	PRIVATE	110.00				79.22	30.18	77.45	32.55							DRILLED. WITH AIR
34	-	HACIENDA SAN CARLOS	N1344.05	E573.35	INAA	40.00				5.76	34.24	4.23	35.77							INVES. WELL
35	-	FINCA LOS MARTINEZ	N1344.05	E575.00	INAA	49.00				11.85	37.15	11.91	37.09							INVES. WELL
36	-	BARRIO MONSENOR LEZCANO	N1342.80	E576.10	INAA															WITH P/M
37	-																			INVES. WELL
38	-	BARRIO JOHNATAN GONZALEZ	N1340.45	E577.85	INAA															OBSTRUCT
39	-	VILLA PANAMA. POLITECNICO DE SALUD	N1337.55	E580.00	POLITECNICO															OBSTRUCT P/M
40		BARRIO EDUARDO CONTRERAS	N1343.30	E571.75	COMMON	120.00				76.72	43.28									WITHOUT P
41	3510-1A-81	SAN ISIDRO DE LA CRUZ VERDE	N1335.10	E579.80	ROBERTO TERAN									0.003	27.90	8.70				
42		SAN ISIDRO DE LA CRUZ VERDE	N1335.90	E579.70	E.P.S															OBSTRUCT
43		SAN ISIDRO DE LA CRUZ VERDE CONSULADO DE DINAMARCA	N1335.90	E579.65	RICARDO SOLORZANO	345.00				207.91	137.09	207.96	137.04							NO USE
44		SAN ISIDRO DE LA CRUZ VERDE	N1335.50	E579.50	RAUL ARANA MONTALVAN									0.043	27.40	8.80				COMMON USE
45	3998-1A-86	GUANACASTILLO. HDA. STA. ANA	N1333.40	E597.25	DOMINGO BOLANOS	210.00	137.00			95.90	114.10	98.90	111.10	0.358	28.70	7.34		8.15	0.01	

INFORMATION OF VISITED WELL FEB.-MAR 1992 AND OCT. 1992

Table 4.4.1 List of Levelling Wells (2)

	WELL No.	PLACE	COORDINA N	COORDINA W	PROPRIETOR	GROUND LEVEL (m)	DRILLED DEPTH (m)	SCREEN TOP (GL-m)	POSITION BOTTOM (GL-m)	GROUNDWATER LEVEL FEB-MAR 92 S.W.L (m)	ELEVATION (m)			COND. (m)	T (C)	pH	WATER QUALITY TURB	DO (mg/l)	SALT %	OBSERVATIONES
46	B-1	CAMPUZANO	N 1332.60 E	594.20	COOP. GONZALO GONZALEZ	160.00				32.92	127.08	33.04	126.96	0.004	28.70	8.20				HAND MADE
47	B-2	EL PORTILLO	N 1334.55 E	593.75	JUSTO RIVAS PUERTA	135.00				54.59	80.41			0.004	30.10	8.80				
48		QUINTA LILA, C. VERACRUZ	N 1335.00 E	590.95	HILDA NUNEZ															OBSTRUCT
49	2628 PP-7	SANTA CRUZ. TISMA	N 1339.20 E	602.85	INAA	208.62				24.43	56.22									OBS. WELL
50	TP-6	ANILIB. TISMA	N 1337.80 E	604.10	INETER	68.00				14.22	53.78									OBS. WELL
51	2628 PO-4	CUATRO ESQUINAS, PRORIEDAD DE ARNULFO LOPEZ.	N 1333.15 E	606.25	INAA	80.00	182.90			17.35	62.65									OBS. WELL
52	PRA-M2	BARRIO LAS PIEDRECITAS, CAMPO DE BASE-BALL. REST. RANCHITO 2c. ABAJO	N 1340.75 E	574.60	INAA	144.50				106.82	37.18	106.19	38.31							OBS. WELL
53	PRA-M1	BARRIO LAS PIEDRECITAS.	N 1340.80 E	574.10	INAA	160.00				121.07	45.00	120.17	39.83							OBS. WELL
54	4453 1-A-85	BARRIO RENE CISNEROS	N 1340.50 E	577.65	INAA	140.00				89.28	50.72									WITHOUT PUMP
55		ALTAMIRA	N 1339.60 E	580.65	INAA	155.00				95.43	59.57	96.90	58.10							INSTAL. PIDE
56	62(INAA)	HOSPITAL VELEZ PAIZ	N 1340.66 E	574.95	INAA	145.98	246.95			108.70	37.28	128.80	145.98							INACTIVE MANT
57	67(INAA)	CEMENTERIO ORIENTAL	N 1341.59 E	583.19	INAA	94.10				43.25	50.85									WELL FOR
58	40(INAA)	COLONIA NICARAO POZO No. 2			INAA															OBSTRUCT TOTALY
59	76(INAA)	VERACRUZ No. 5	N 1333.72 E	588.48	INAA	167.68	100.61			57.24	110.44									INACTIVE
60	66(INAA)	VILLA PANAMA. TANQUE	N 1337.16 E	580.79	INAA	247.07	335.37			162.20	84.87									INACTIVE
								114.00	120.00											
61	4833	Km. 17 Carretera a Masaya.	N 1331.45 E	583.00		200.00	182.90	132.00	160.00	103.79	96.22			0.930	28.20	7.87	0	7.78		
62	1658	Ticuantepe.	N 1330.75 E	586.70		242.00	144.20	125.00	143.00	137.91	104.09	137.47	104.53							NO USE
63	INAA I-1	Ticuantepe.	N 1328.00 E	585.00		325.00								0.406	27.20	8.41	1	3.60		
64	1285	Masaya. Avicola La Barranca.	N 1326.40 E	597.35		218.00	133.20	95.40	123.40	96.22	121.78	95.92	122.08	0.379	29.10	8.47	1	4.57		BEFOR STOPTH
65	1397	Masaya.	N 1325.00 E	601.00		230.00														
66	A-1	Masaya.	N 1325.00 E	101.00		220.00				135.26	84.74									NEAR No. 1397
67	2093	Nindiri. Avicola "El Gavilan"	N 1329.05 E	596.20		202.00	137.16	107.00	137.00	81.72 (94.5)	120.28	81.26	120.74	0.522	30.70	8.57	0	5.37		
68	2628 PP-3	Laguna de Masaya.	N 1324.00 E	595.00	INAA	140.00				7.48	132.52									OBS. WELL
69	2628 PO-1	Laguna de Masaya.	N 1325.00 E	595.00	INAA	140.00	155.40	137.00	155.00	CANNOT	BROKEN DRY									OBS. WELL
70	MASAYA LAKE	Laguna de Masaya.	N 1321.00 E	594.00										0.470	27.10	8.79	22	5.22	0.01	
71	2628 PP-1	Laguna de Masaya.	N 1321.00 E	594.00		150.00	113.90	30.48	113.90	14.47	135.53									OBSER. WELL OF JI
72	2109	Catarina. Beneficio San Isidro.	N 1316.85 E	601.30		513.00	349.00	318.50	348.90	MORE THEN	300									
73	APOYO LAKE	Laguna de Apoyo.	N 1316.00 E	603.00										0.469	28.90	8.54	7	5.21		
74	A-1	Quebrada Honda. Apoyo.	N 1322.00 E	604.00		250.00				173.34	76.66	172.74	77.26							NO USE
75	(4-6/89)A-2	Los Sabogales Masaya	N 1322.00 E	99.00	INAA	270.00	171.00	147.40	164.60	121.45	148.55									TANK. NEW WELL
76	A-3	Niquinohomo	N 1315.00 E	98.00		455.00				91.44	363.56									
77	2047	Masatepe	N 1316.00 E	94.30	Ana Luisa P. de Valerio.	469.00	316.99	286.50	316.70	CANNOT	(194.68)	230.87	238.13							
78	(6-67)7		N 1317.00 E	95.00		400.00	274.30	253.00	294.30	(242.9)	(157.1)									NO DATAS
79	A-4	Nandaime.	N 1317.00 E	95.00	INAA	440.00								0.315	27.90	8.57	2		0.01	NEAR No. 7 WELL.
80	2427	Finca el Parque. Masatepe.	N 1315.35 E	91.70	Ing. Eduardo Silva.	455.00	288.04	227.00	288.00	231.24	223.75									NO USE
81	(11/72-2/73)3	San Marcos	N 1316.00 E	86.00	INAA	565.00	342.90	297.20	342.90	264.16	300.84	252.79	302.21	0.430	(31.8)	8.81	3	5.64	0.01	IN STOP
82	1206	San Juan de la Concepcion.	N 1321.00 E	88.00	INAA	450.00				(304.8)	(145.2)			0.514	29.90	8.80	160	12.77	0.02	
83	(1A-90)5198	Avicola San Francisco. Diriamba	N 1315.00 E	80.00		650.00	304.80	237.70	301.70	(232.2)	(417.8)			0.380	29.90	8.57	2	12.40	0.01	
84	5099	Monte Fresco. Coop. C. F. A.	N 1331.00 E	57.00		155.00	64.00			(19.51)	(135.49)									CANNOT
85	SPRING	Monte Fresco.	N 1332.00 E	57.00		135.00				0.00	135.00			0.266	28.70	8.69	162	2.33	0.01	NEAR No. 5099
86	4967	Comarca Las Jaguas.	N 1331.00 E	566.55		460.00	175.80	128.00	170.70	124.97	335.03									
87	36	Crucero. Hda. Santa Julia.	N 1326.00 E	72.00		760.00														NO DATAS

Table 4.4.1 List of Levelling Wells (3)

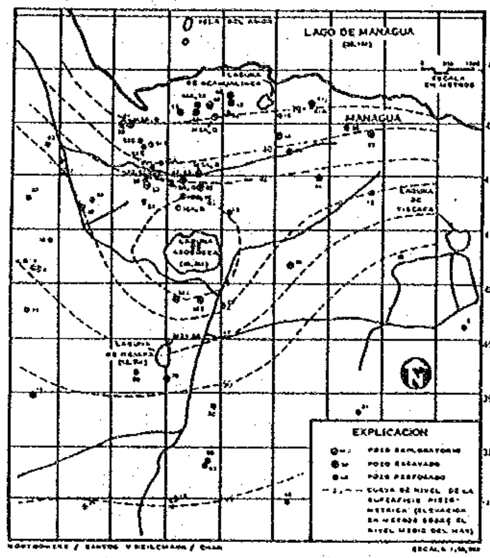
INFORME DE POZOS VISITADOS EN FEB-MARZO 1992 Y OCTUBRE 1992.

No.	POZO	LUGAR	COORDENADAS N	W	PROPIETARIO	ELEVATION TERRENO (msnm)	DRILLED DEPTH (m)	SCREEN POSITION TOP (GL-m)	BOTTOM (GL-m)	GROUNDWATER LEVEL FEB-MAR 92 S.W.L (m)	ELEVATION (msnm)			COND. (msnm)	T (C)	pH	WATER QUALITY TURB	DO (mg/l)	SAL %	OBSERVACIONES
88	A-6	Los Guillen.Padre Fabretto.	N 32.00	E 78.00		500.00								0.375	28.30	9.12	0.00	12.94	0.01	AN ORPHANAGE
89	(2554)A-7	El Crucero.	N 24.00	E 76.00		890.00				DRY HOLL										
90	10		N 28.00	E 77.00			NO WELL													
								262.13	283.50											
								292.60	304.80											
91	(1A-75)1640	Km.14 1/2 Carretera Sur.	N 32.00	E 74.00	INAA	465.00	356.60	313.90	356.60	(247.5)	(217.5)			0.518	27.20	9.30	3-4	0.25	0.02	24 h/day. INAA.
92	4621	INCAE. Km. 15 Carretera Sur.	N 1332.50	E 575.05		490.00	335.00	274.30	332.30	(269.7)	(220.3)			0.508	25.20	9.38	0.00	1.60	0.02	24 h/day.
93	(1A-80)2855	Hacienda El Canon.	N 1331.40	E 573.80		450.00	274.00	201.00	271.00	(198)	(252)			0.539	25.50	9.36	0.00	1.89	0.02	8 h/day.
								277.00	299.00											
94	1859	Los Alpes.	N 1330.59	E 574.22	Ricardo Elizondo Ruiz.	590.00	320.04	305.00	320.00	(250.85)	(339.15)			0.428	25.70	9.48	0.00	5.76	0.01	7 h/day.
										(198.17)										
95	(1A-89)4580		N 1332.56	E 574.25			259.14	204.20	256.00	NO WELL										
96	17		N 28.00	E 79.00		-	NO WELL													
97	JICA-5	BELLO AMANECER			JICA	145.00						99.39	45.61							POZO DE EXPLORACI
98		HACIENDA MONTECRISTO	1337.10	597.90	COOP. OMAR TORRIJOS	158.00						79.78	78.22							SIN BOMBA
99		ZAMBRANO	1342.45	600.20	INAA	80.00						19.76	60.24							SIN BOMBA.
100	JICA-4	LAS AMERICAS. MANAGUA.	1341.80	571.00	JICA	160.00						97.50	62.50							EXPLORATORIO
101	JICA-1	Km. 15.5 Carr. a Masaya	1331.95	587.45	JICA	218.00						105.25	112.75							EXPLORATORIO
102	JICA-2	Veracruz.	1336.10	591.65	JICA	123.00						42.72	80.28							EXPLORATORIO
103	JICA-3	CENIGB. Sabana Grande.	13404.00	592.45	JICA	77.00						14.24	62.76							EXPLORATORIO
104		CARNIC. Managua.	1343.65	589.70	CARNIC	51.00						4.28	46.72							EXPLORATORIO
105		Valle Gothel	1334.65	589.20	Ing. Jose L. Fricciones S.	154.00						48.12	105.88	0.400	29.70				0.01	POZO EXCAVADO
106		Este del Campo Carlos Fonseca.	1341.60	591.05		61.80						8.57	53.23							Pozo de Observaci
107		ESSO	1342.50	574.10	ESSO	60.00						23.55	36.45							ABANDONADO. SIN E
108	G	HERCASA	1343.60	573.60	HERCASA	42.50						6.89	36.13							POZO ACTIVO
109	C	HERCASA	13434.80	573.60	HERCASA	36.27						6.73	29.54							ABANDONADO. SIN E
110		MAYCO	1343.55	573.85	MAYCO	45.00						8.82	36.18							POZO ACTIVO.
111		Santa Teresa. Sabana Grande	1339.25	589.75	Armando Rivas	87.00						25.60	61.40	0.358	26.90	7.54		8.13	0.01	Pozo Excavado a m
112		Santa Margarita	1337.85	589.50	Carlos Alberto Lopez	115.00						34.19	80.81	0.352	27.80	7.66		8.71	0.01	Pozo Excavado a m
113		Hacienda Huaica.	1332.40	596.30		210.00						82.62	127.38	0.400	29.50	7.64		8.50	0.01	Pozo Excavado a m
114		CENIGB. Sabana Grande.	1339.60	593.40	CENIGB. MAG.	90.00						22.27	67.73	1.130	30.40	7.24		8.77	0.05	Pozo sin equipo.
115		Poblado de Sabana Grande.	1339.35	590.80	INAA									0.493	28.10	7.02		8.76	0.02	Pozo para agua po
116		Coop. El Verbo	1335.60	591.40	Coop. El Verbo.									0.980	27.30	6.16	-10	7.35	0.04	Pozo para riego.

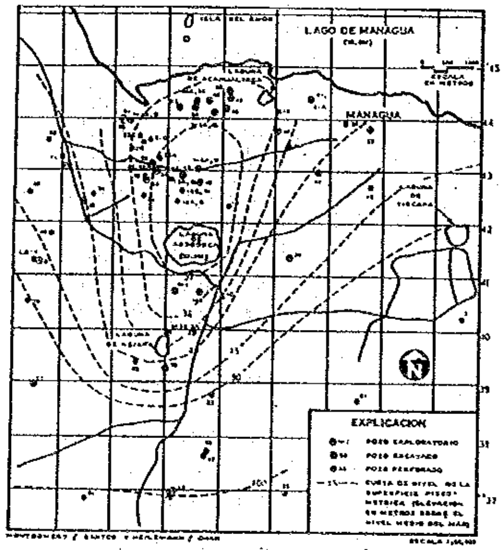
Table 4.4.2 Groundwater Leveling of INAA Production wells

No.	Location	Static Groundwater Level Orig. (feet)	Actual (feet)	Dif. (feet)	Date of Measuremen Orig.	Actual
25	Carlos Fonseca No.14	86.00	37.52	48.48	22-10-82	03-04-92
26	Carlos Fonseca No.15	35.33	37.29	-1.96	20-09-82	03-04-92
24	Carlos Fonseca No.8	32.00	38.38	-6.38	01-07-82	03-04-92
23	Carlos Fonseca No.7	35.00	46.74	-11.74	18-03-74	03-04-92
22	Carlos Fonseca No.6	35.00	49.66	-14.66	25-02-74	03-04-92
21	Carlos Fonseca No.5	35.00	50.08	-15.08	12-06-73	03-04-92
79	Carlos Fonseca No.16	45.00	54.05	-9.05	05-11-90	03-04-92
80	Carlos Fonseca No.17	45.00	55.76	-10.76	90	03-04-92
81	Carlos Fonseca No.18	45.00	46.38	-1.38	90	03-04-92
17	Carlos Fonseca No.1	45.00	54.28	-9.28	-	03-04-92
19	Carlos Fonseca No.3	35.00	58.38	-23.38	13-07-73	03-04-92
16	Carlos Fonseca No.13	61.00	61.17	-0.17	82	03-04-92
15	Carlos Fonseca No.12	65.00	68.58	-3.58	82	03-04-92
27	Sabana Grande No.1	160.00	176.33	-16.33	87	04-04-92
28	Sabana Grande No.2	193.20	199.10	-5.90	11-11-87	04-04-92
29	Sabana Grande No.3	163.00	170.69	-7.69	23-11-87	04-04-92
30	Sabana Grande No.4	56.00	79.08	-23.08	07-08-87	04-04-92
31	Sabana Grande No.5	56.00	59.30	-3.30	19-03-87	04-04-92
69	km14.5 C.Masaya	-	285.46	-	86	13-05-92
44	San Judas No.1	487.50	500.63	-13.13	25-07-85	12-05-92
43	San Judas No.2	-	524.57	-	-	07-05-92
45	Reparto Villa Hermosa	487.51	495.64	-8.13	07-04-88	11-05-92
38	Centro America	310.00	317.37	-7.37	30-03-88	04-05-92
48	Col 14 de Septiembre	252.00	275.95	-23.95	23-06-86	30-04-92
35	Pancansan No.5	270.00	281.95	-11.95	13-11-86	05-05-92
12	Bello Horizonte	97.84	111.13	-13.29	05-09-87	06-05-92
9	Olof Palme	55.30	65.83	-10.53	24-06-87	28-04-92
8	San Antonio	73.34	78.36	-5.02	24-06-87	09-05-92
65	UNAN	-	500.95	-	-	06-05-92
34	Pancansan No.4	-	268.53	-	-	08-05-92
52	Hosp. Mascota	195.00	216.45	-21.45	-	30-04-92
42	San Cristobal No.2	-	162.29	-	-	04-05-92
61	km14.5 C. Leon	296.00	357.03	-61.03	23-04-88	10-05-92
6	Eduardo Contreras	313.40	311.60	1.80	03-12-87	22-05-92
63	Hosp. Bertha Calderon	347.00	353.45	-6.45	11-11-87	06-05-92
50	Rene Schick	420.00	442.00	-22.00	19-05-86	13-05-92
53	Parque Las Madres	195.00	202.00	-7.00	01-03-88	04-05-92
41	San Cristobal No.1	-	166.00	-	88	14-05-92
59	km8 C. Sur	524.00	526.00	-2.00	08-04-88	07-05-92
54	Los Gauchos	117.00	131.00	-14.00	07-08-87	16-05-92
33	Pancansan No.3	266.00	280.00	-14.00	-	15-05-92
49	Villa Cuba No.2	390.00	431.00	-41.00	82	17-05-92

MAYO 1963



MAYO 1970



MAYO. 1978

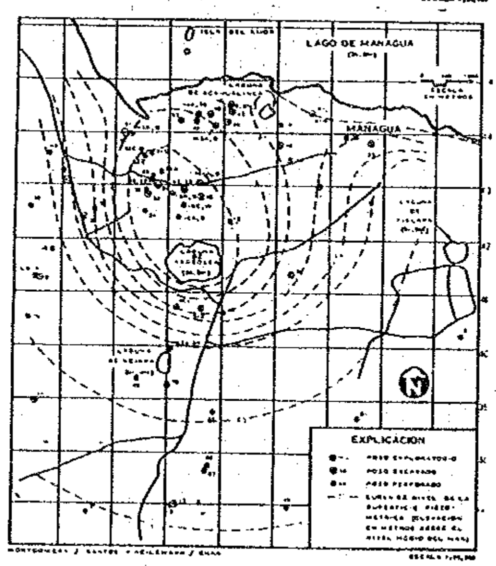
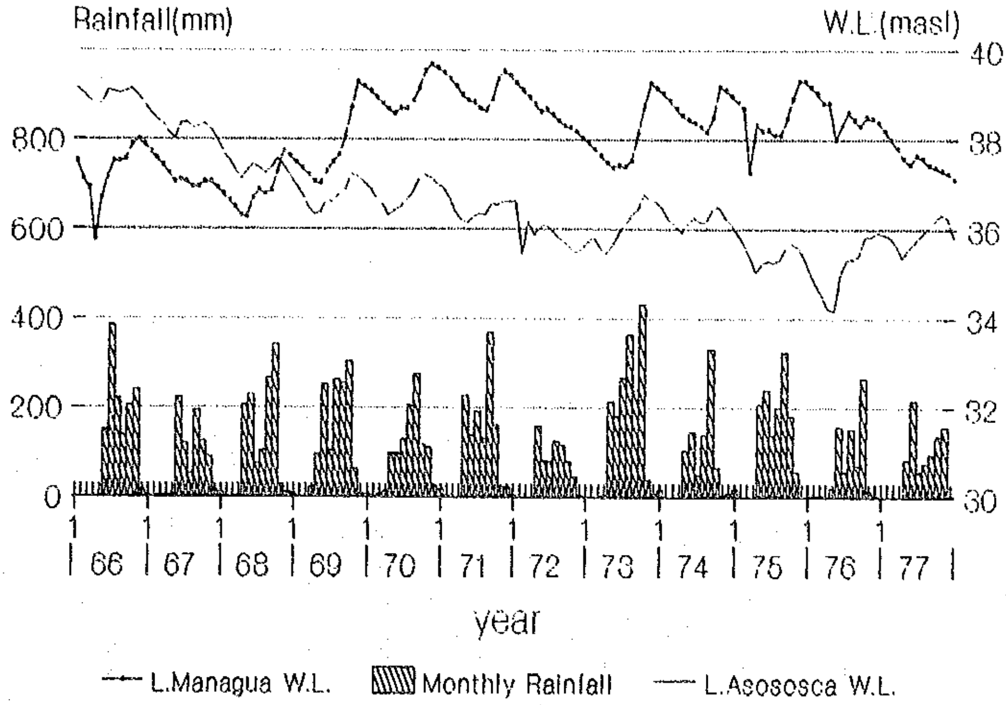


Fig. 4.4.1 Groundwater Level around Lake Asososca in 1963, 1970, 1978



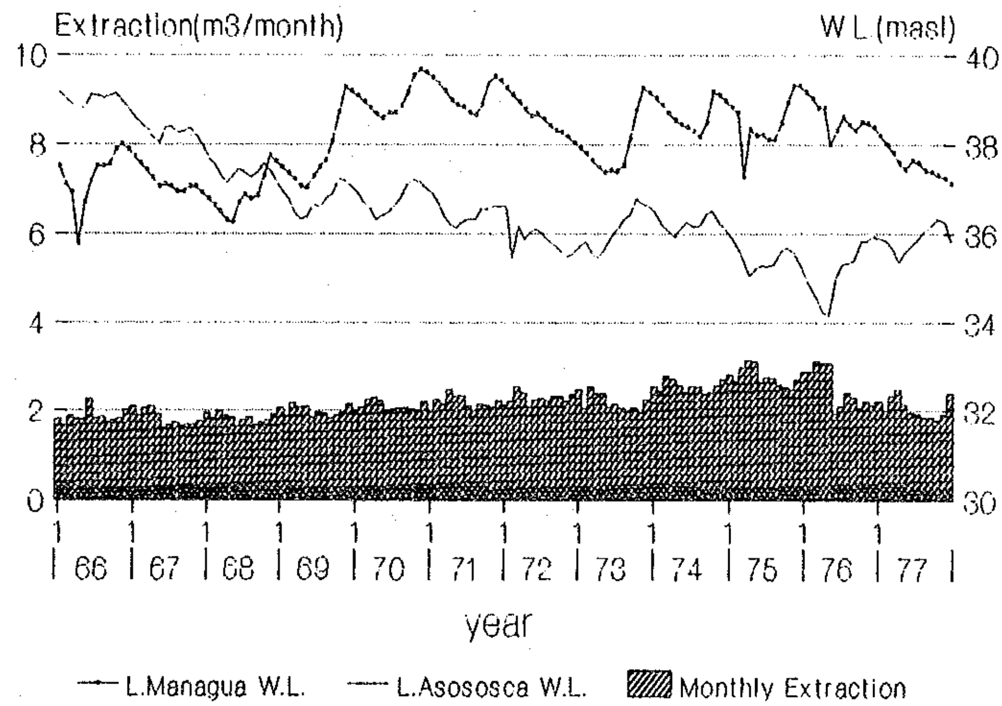


Fig. 4.4.2 Monthly Water level of Managua and Asososca lakes

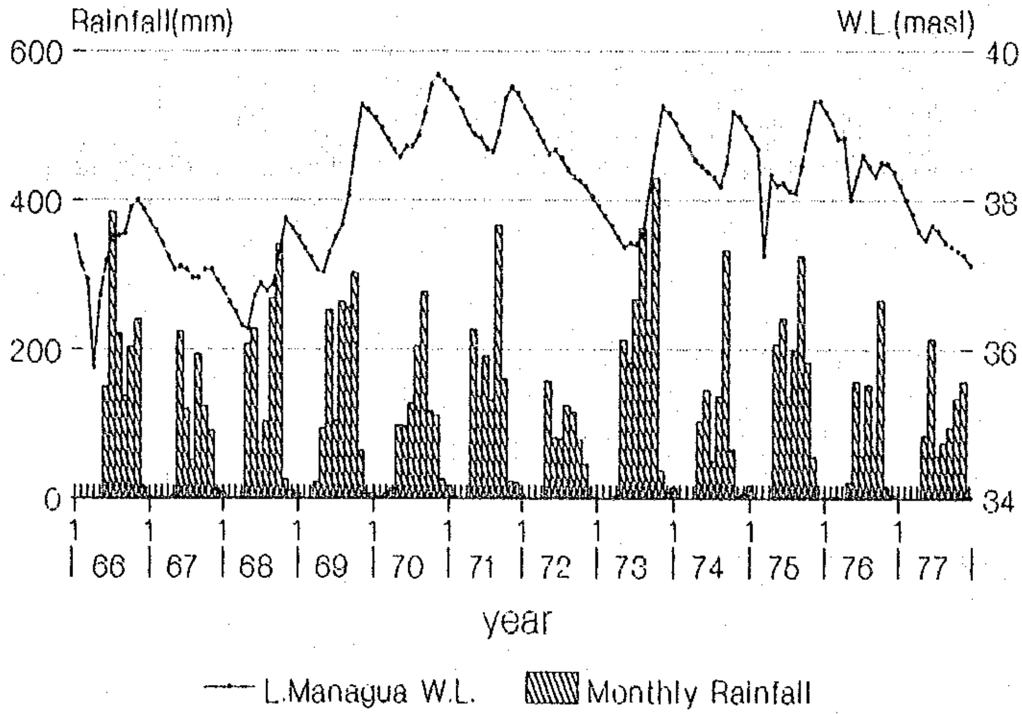


Fig. 4.4.3 Water Level of lake Managua (with Rainfall)

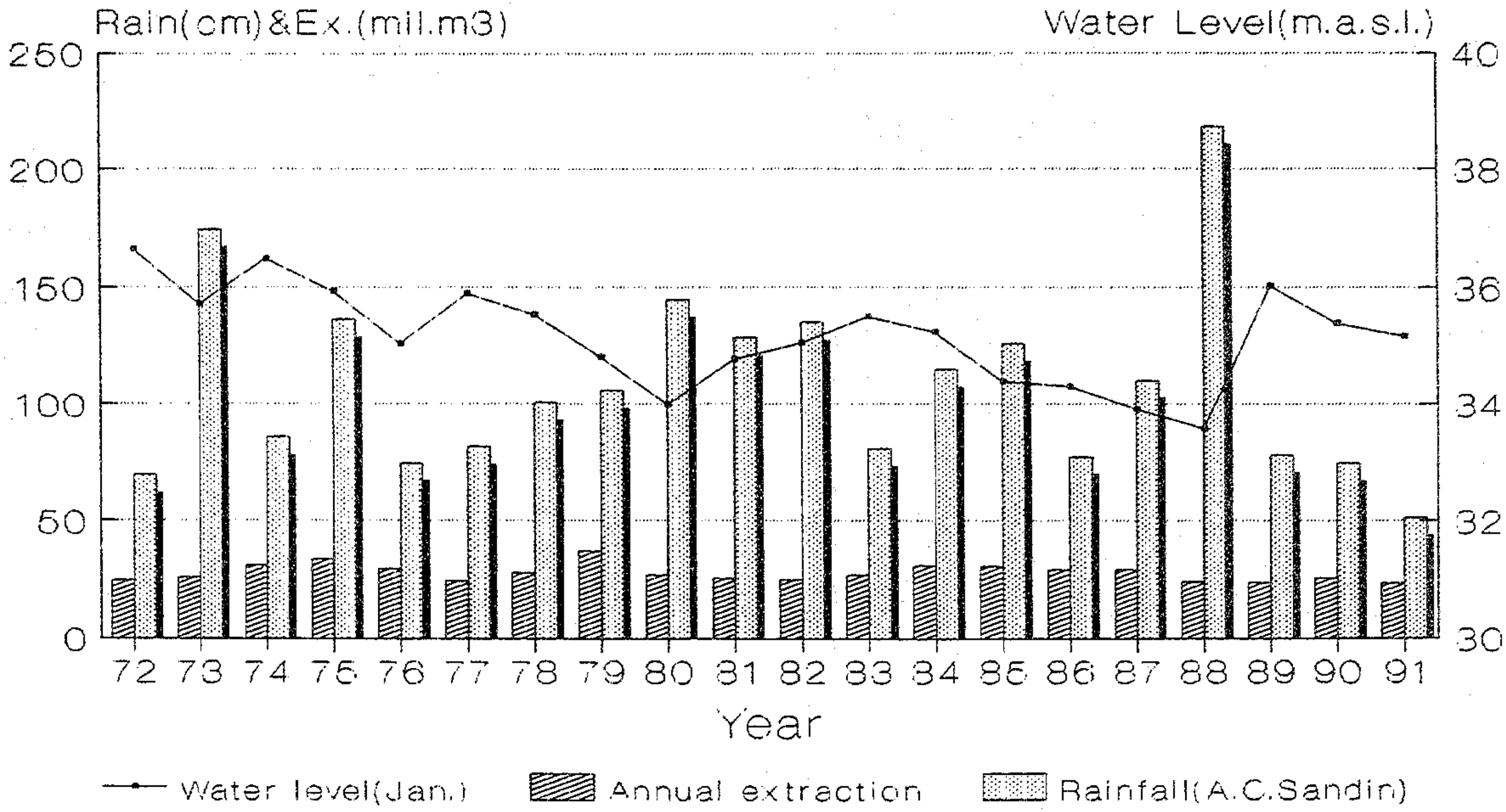


Fig. 4.4.4 Water Level of lake Asososca

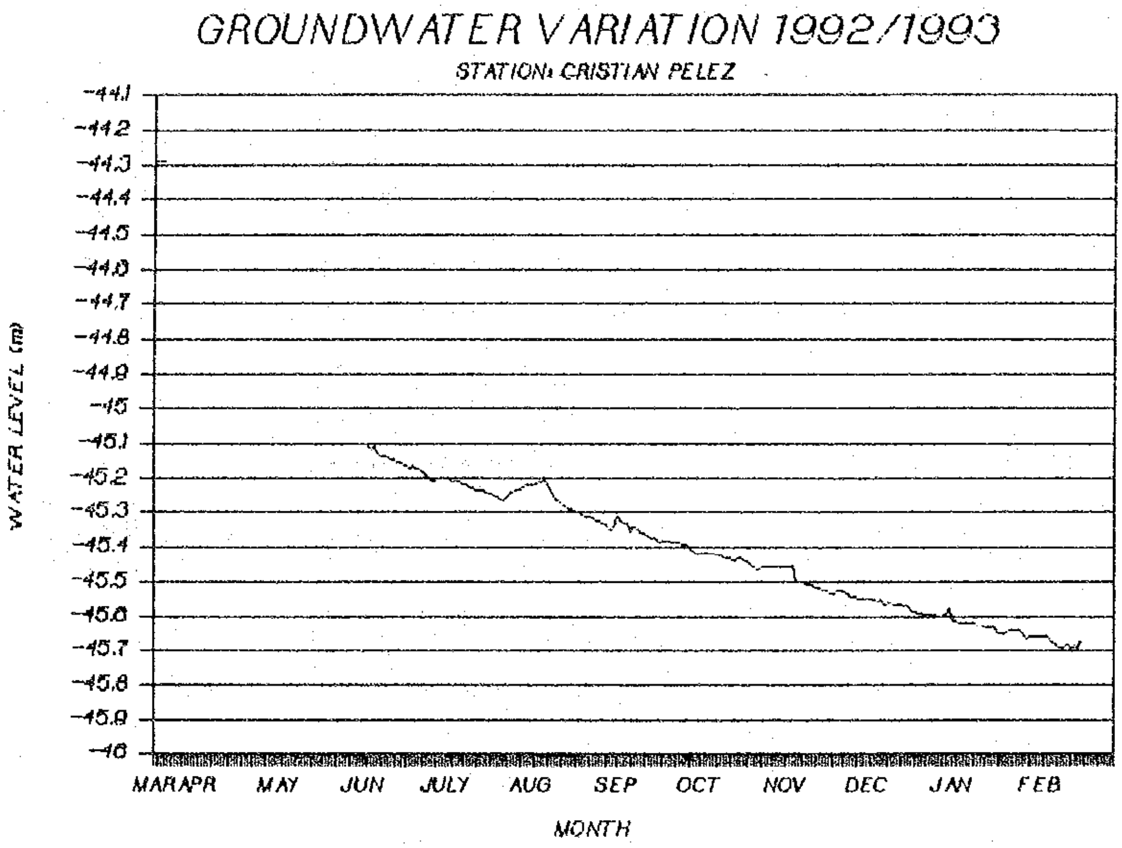


Fig. 4.4.5 **Observed Groundwater Level Cristian Pélez Station**

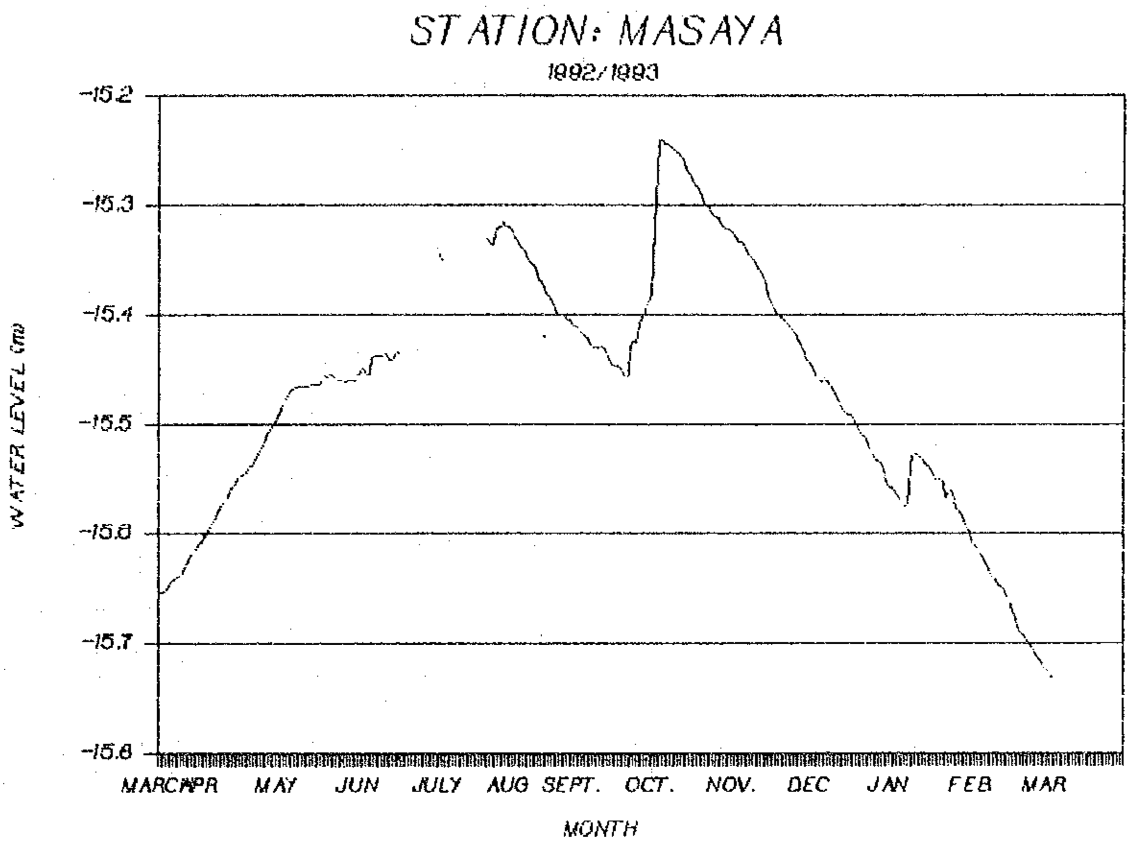


Fig. 4.4.5 Observed Groundwater Level Msaya Station

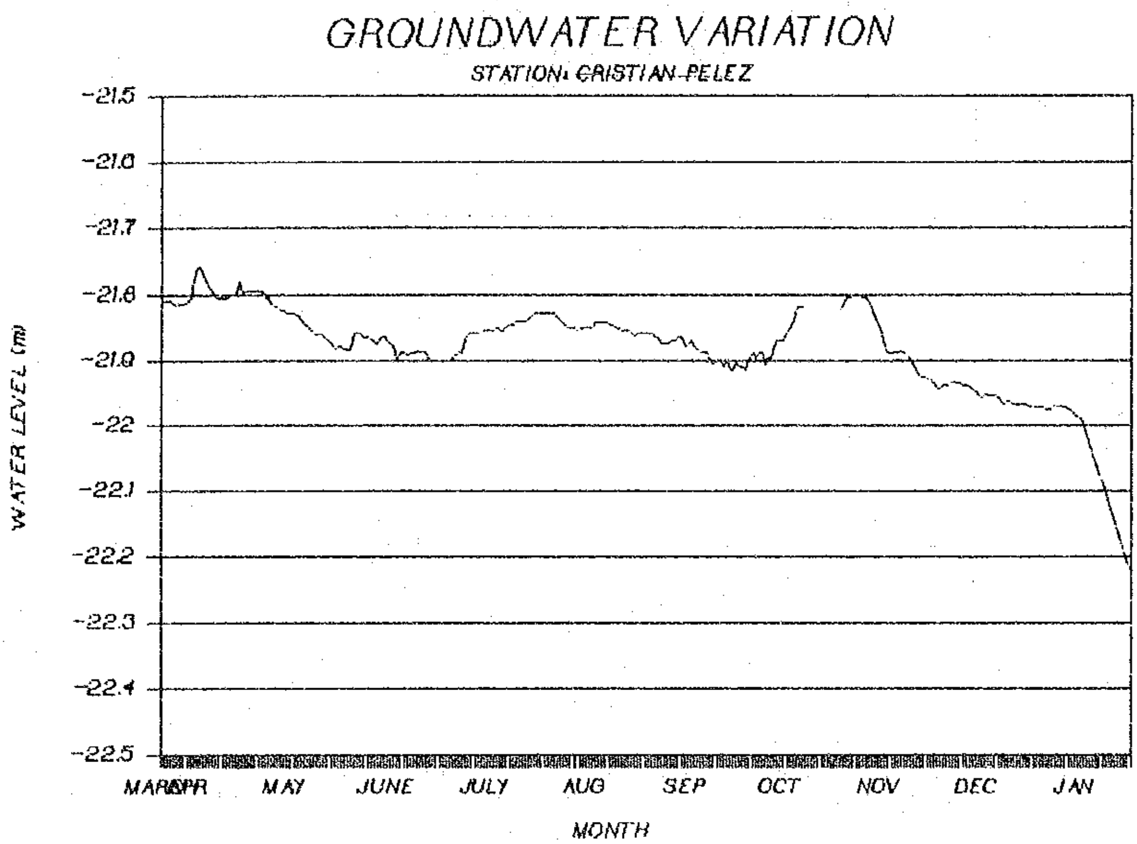


Fig. 4.4.5 Observed Groundwater Level Sbana Grande Station

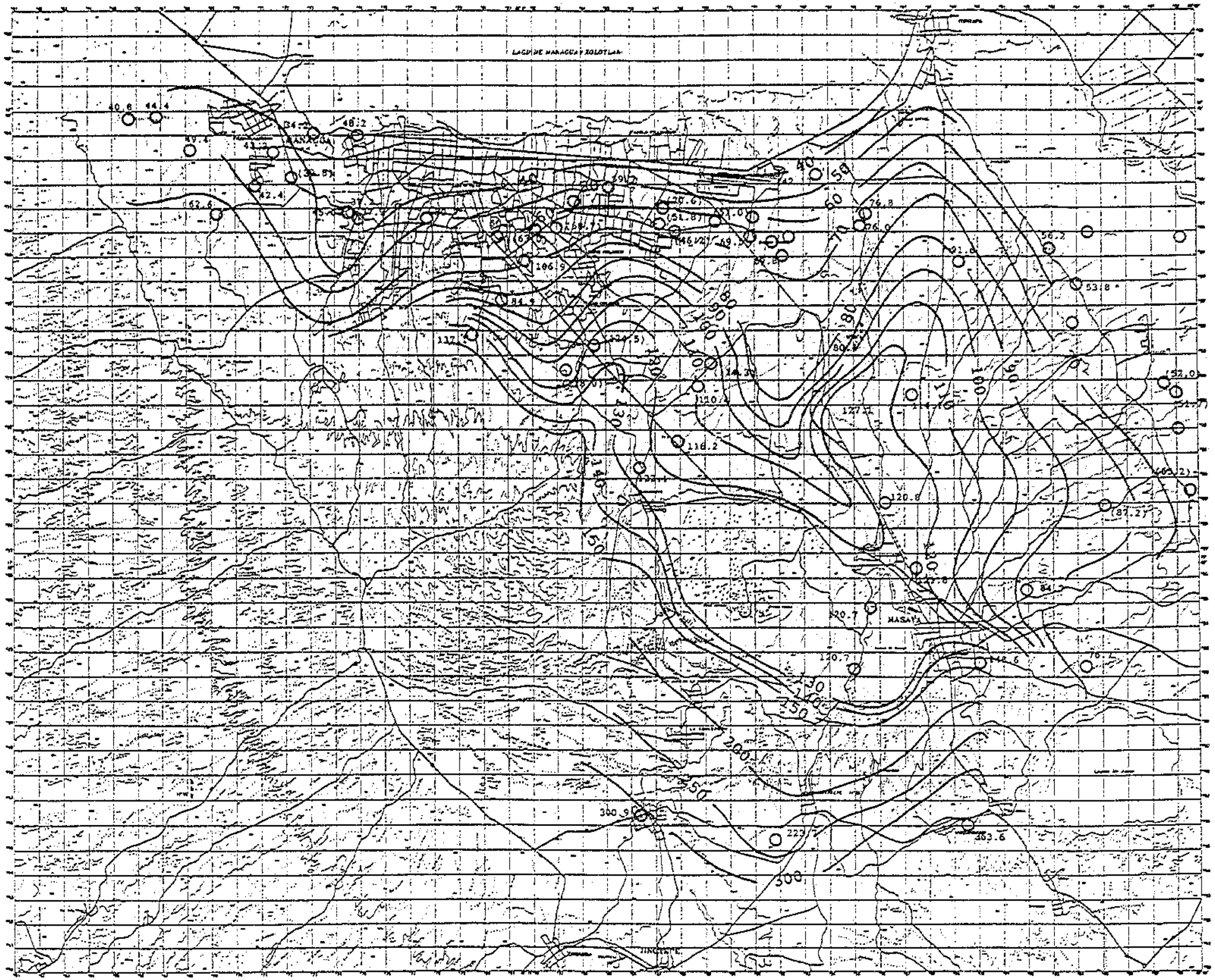


Fig. 4.4.6 Mapa de Curva de Nivel Freático al Final de la Estación Seca del Año 1992

Fig. 4.4.6 Groundwater Table

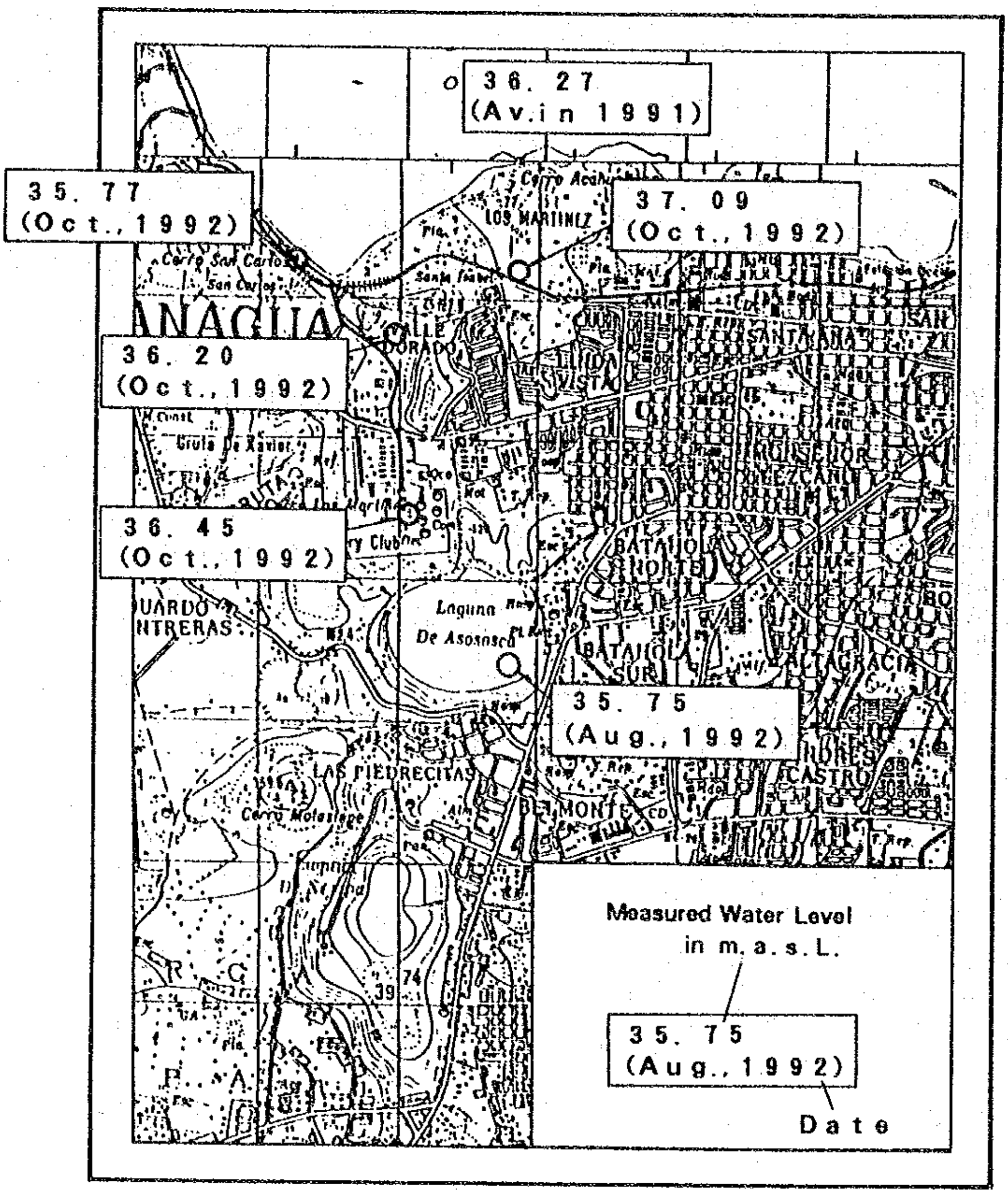


Fig. 4.4.7 Groundwater Level around Lake Asososca, 1992

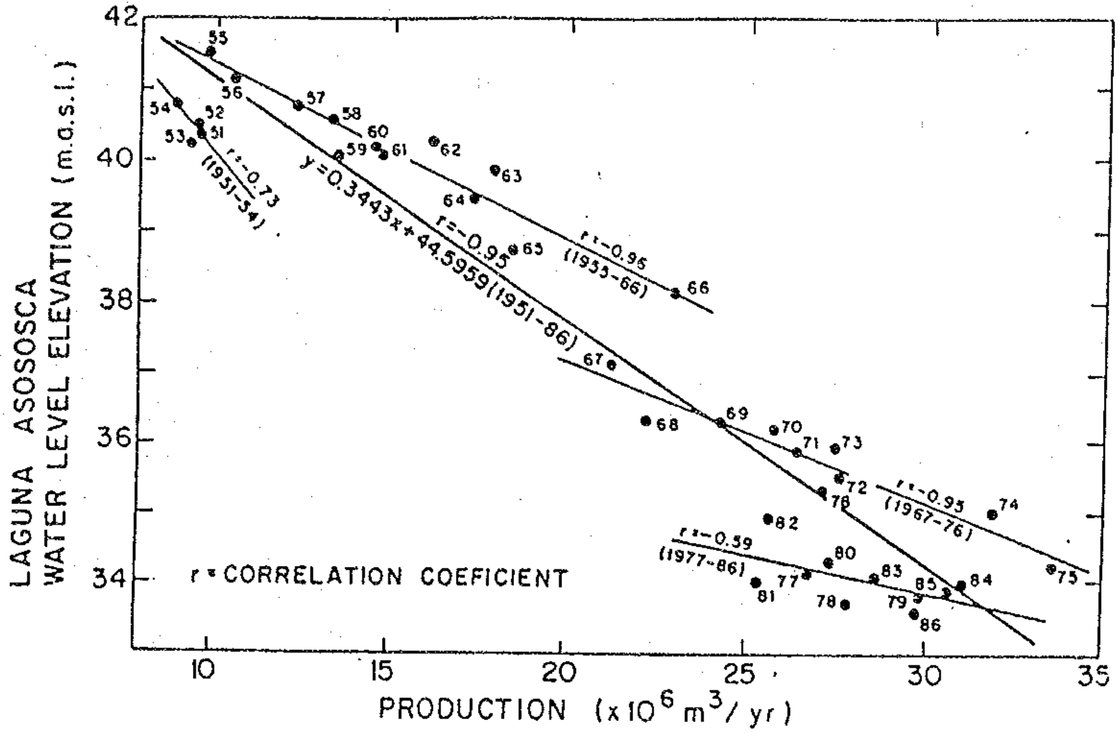


Fig. 4.4.8 Previous Water Level and Extraction at Lake Asososca

Source: Laguna Asososca Water Level Elevation Versus Production from 1951 to 1986

4.5 Groundwater Use

4.5.1 Review of Previous Survey

Groundwater use was investigated in the "ESTUDIO DE LA DEMAND DE AGUA DE LA POBLACION ESPERADA DE LA CIUDAD DE MANAGUA EN EL ANO 2000", by SOGREAH in 1982.
The results are summarized below:

Water Supply Source	Type	Consumption Annual(10^6 m^3)	Daily (10^3 m^3)
Domestic	C.S.P.	34.64	94.90
Public line	S.S.P.	1.85	5.08
	(S-total)	36.49	99.98
	Public & Commercial	5.94	16.26
	Industrial	0.11	0.30
	Irrigation	0.78	2.12
	(s-total)	6.83	18.68
Private line	Industrial	9.68	26.53
	Irrigation	2.16	5.91
	(s-total)	11.84	32.44
	Grand Total	55.16	151.10

* C.S.P --- Población sin servicio particular
S.S.P --- Población con servicio particular

Public line in the Table refers to INAA's production wells and other sources provided by private wells.

4.5.2 Water Use in 1972-1991

(1) Main wells of INAA Central Managua

The study on groundwater use was based on data collected by INAA in 1972-1991.

Table 4.5.1 shows the annual pumping discharge of Lake Asososca, Carlos Fonseca well field, Sabana Grande well field and other wells in central Managua in 1972-1991.

The following table summarizes the annual production and its percentage to the total number of INAA's main well fields in 1972-1991.

unit:million m³ & (%)

Location	1972	1975	1980	1985	1990	1991
Lake Asososca	25.10	33.90	27.20	31.09	25.94	24.00
	(100)	(100)	(49)	(48)	(27)	(24)
Carlos Fonceca	-	-	20.07	21.39	20.20	21.99
	(0)	(0)	(38)	(33)	(21)	(22)
Sabana Grande	-	-	-	-	4.73	5.45
	(0)	(0)	(0)	(0)	(5)	(5)
Veracruz	-	-	2.05*	2.05*	3.21	3.89
	(0)	(0)	(4)	(3)	(3)	(4)
Other	-	-	5.14	10.12	40.82	46.69
	(0)	(0)	(9)	(16)	(44)	(46)
Total	25.10	33.90	55.09	64.65	97.04	102.02

* Annual production in Veracruz is estimated according to operation hours.

The table shows how water sources have shifted within the past 20 years. The location of the pumping positions in 1 km meshes are shown in Fig.4.5.1.

Annual pumping discharge has rapidly increased in the past 20 years, from 25 million m³ in 1972 to 102 million m³ in 1991, along with the expansion of Managua City.

Almost 100% of the drinking water supply until 1976 was taken from Lake Asososca.

The Carlos Fonceca well-field was developed and used from 1977 and its share in the total production of water supply has increased rapidly. Almost one-third of the total demand in 1980 and one-fourth in 1990 were provided from this well field.

The development and use of the Veracruz and Sabana Grande well fields started in 1976 and 1988, respectively. The production of other wells in central Managua has also rapidly increased from mid 1980, amounting to around half of the total amount in 1991.

These well developments kept the pumping discharge from Asososca Lake at 30 million m^3 in 1984-1986 and 25 million m^3 in 1987-1991.

(2) Other wells of INAA

Table 4.5.2 shows the production of INAA wells in other departments and municipalities. Only a few data was recorded, therefore, most of the production estimate was based on pumping capacity.

The annual production in 1991 is about 8.9 million m^3 and in comparison to the available records of 1972, the annual production has largely increased, a fact attributed to the improvements in the local water supply services of INAA.

(3) Other wells

(a) Industrial wells

Interviews were conducted to survey the main industrial and some commercial wells. Table 4.5.3 shows the results of the survey including the 1982 records.

The total well pumping discharge has decreased because many factories were closed down and due to the public water supply services provided by INAA. The following table summarizes the condition of the wells in 1982.

unit:No.

Condition	No. of well
Factory is closed down or non-existent	19
No use of pump/changed to INAA services	10
Functioning wells	24
Total	53

A Water Demand survey was conducted in the following studies in 1972 and 1982.

- "ESTUDIO DE LA DEMAND DE AGUA DE LA POBLACION ESPERADA DE LA CIUDAD DE MANAGUA EN EL ANO 2000", SOGREAH in 1982
- "INVESTIGACIONES DE AGUAS SUBTERRANEAS EN LA REGION DEL PACIFICO DE NICARAGUA", NACIONES UNIDOS in 1973

The total pumping discharge in 1972,1982 and 1992 was compared assuming that the wells surveyed in 1972 and 1982 are still functioning.

unit:million m^3

Year	Annual pumping discharge
1972	10.90
1982	9.55
1992	5.88

The above Table shows that almost half of the pumping discharge in 1972 is discharged in 1992.

(b) Agricultural wells

The large-scale irrigation scheme, CENTRO NACIONAL DE INVESTIGACION DE GRANOS BASICOS, was conducted in San Cristobal. Other big schemes within the surrounding area are also conducted in Tisma and Los Brasiles.

CNIGB is a public scheme which mainly produces seeds for farmers. The main crops are Maize, Sorgo and Frijol, and their cropping area varies annually according to market conditions.

The cultivable area amounts to 584 ha, but only 247 ha is irrigable through the center pivot irrigation system.

According to the interview conducted with the irrigation engineer of this scheme, the total area irrigated this season was around 170 ha and the annual pumping hours totaled 1700 hrs.

The capacity of the 4 pumps used for irrigation purposes are as follows:

- Well 1: 900 G/min
- Well 2: 900 G/min
- Well 3: 800 G/min
- Well 4: 600 G/min

With an annual pumping hour of 1700, the annual pumping discharge is about 1.24 million m³.

Irrigation is basically conducted for crop consumption and the methods vary by soil and rainy conditions.

Water use is calculated based on the following concepts:

(a) Cropping pattern --- two season (Nov-Feb, May-Aug)
(b) Rainfall --- Average rainfall 1,100 mm in A.C. Sandino Station
(c) Water consumption -- Maize, 6.25 mm/day, 120 days, neglect difference in growing stage
(d) Cropping area ------ 150 ha
(e) Efficiency --- 90 %

unit:mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(1) Day	31	28	31	30	31	30	31	31	30	31	30	31
(2) Consumption	194	175	194	188	194	188	194	194	188	194	188	194
(3) Cropping	*	*			*	*	*	*	*		*	*
(4) Rain	4	2	4	6	128	208	141	146	207	205	51	11
(5) Water Req.	190	173	-	-	66	-	53	48	-		137	183

From this balance, the annual water requirement is estimated at about 850 mm in water depth, i.e. 8,500 m³/ha/year(amount of water to be utilized).

A cropping area of 150 ha would require an annual water use of 1.275 million m³. The forementioned annual pumping discharge is observed to closely meet the irrigation water demand.

Table 4.5.1 Annual Pumping Discharge of Central Managua in 1972-1991

ANNUAL PUMPING DISCHARGE IN 1972-1991

(1) Annual pumping discharge in million m3	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Asososca	25.095	26.303	31.432	33.897	29.977	24.842	28.320	37.403	27.204	25.939	25.378	27.243	31.406	31.093	29.689	29.477	24.354	24.284	25.944	24.004
Carlos Fonseca	-	-	-	-	-	5.608	16.008	16.099	20.700	18.898	18.975	21.546	21.714	21.390	21.749	20.311	17.718	16.065	20.196	21.987
Sabana Grande	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.116	3.994	4.730	5.445
Veracruz	-	-	-	-	2.053	2.053	2.053	2.053	2.053	2.053	2.053	2.053	2.053	2.053	2.053	2.053	2.053	2.053	3.205	3.889
Other	-	-	-	-	-	-	0.304	3.744	5.135	6.330	7.746	8.829	9.317	10.117	12.804	15.171	26.734	40.818	42.966	46.694
GRAND TOTAL	25.095	26.303	31.432	33.897	32.030	32.503	46.684	59.299	55.091	53.219	54.152	59.671	64.489	64.652	66.295	67.012	72.974	87.213	97.042	102.020
(2) Ratio to total pumping discharge																				
Asososca	1.00	1.00	1.00	1.00	0.94	0.76	0.61	0.63	0.49	0.49	0.47	0.46	0.49	0.48	0.45	0.44	0.33	0.28	0.27	0.24
Carlos Fonseca	0.00	0.00	0.00	0.00	0.00	0.17	0.34	0.27	0.38	0.36	0.35	0.36	0.34	0.32	0.33	0.30	0.24	0.18	0.21	0.22
Sabana Grande	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.05	0.05
Veracruz	0.00	0.00	0.00	0.00	0.06	0.06	0.04	0.03	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.04
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.09	0.12	0.14	0.15	0.14	0.16	0.19	0.23	0.37	0.47	0.44	0.46
GRAND TOTAL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 4.5.2 Water Use of INAA s Well in Departments

TABLE-I

PRODUCTION IN M3 PER DAY IN LOCALS WELL OF MASAYA AND MANAGUA.
VALLE GOTHEL Y VERACRUZ

LOCATION NUMBER	START YEAR	PLACE	NAME OF WELL	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
-	-	MASAYA	TWO WELLS	2,887	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	1974	MASAYA	C.LEÑA #4	-	-	-	-	-	-	-	-	-	-	-	-	2,361	2,190	2,918	2,449	2,368	2,691	1,584	1,331
2	MAY 1976	MASAYA	INCA #5	-	-	-	-	-	-	-	-	-	-	-	-	2,295	1,983	2,257	2,106	1,787	2,431	284	-
2	MAY 1976	MASAYA	INCA #6	-	-	-	-	-	-	-	-	-	-	-	-	2,032	2,638	2,319	3,309	3,173	3,361	1,992	3,255
1	1976	MASAYA	P.CARR #7	-	-	-	-	-	-	-	-	-	-	-	-	1,247	1,894	1,912	2,146	2,570	2,806	2,233	2,097
1	1974	MASAYA	P.MUNIC #8	-	-	-	-	-	-	-	-	-	-	-	-	1,884	2,216	2,752	2,557	2,626	1,352	2,543	2,606
3	1990	MASAYA	B.MONGE #9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,019	2,280
3	1990	MASAYA	B.MONGE #10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,404	2,353
5	DECEM.'81	MASATEPE	TANQUE #1	-	-	-	-	-	-	-	-	-	-	-	-	766	1,188	1,225	1,218	1,145	1,262	1,250	1,496
5	1991	MASATEPE	MONDONGO #2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24
6	29/7/87	NINDIRI	NINDIRI #1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	957	998	1,296	1,305
7	NOV. '84	PIO XII	PIO XII	-	-	-	-	-	-	-	-	-	-	-	-	-	360	501	734	686	816	561	604
8	-	NANDASMO	NANDASMO	-	-	-	-	-	-	-	-	-	-	-	-	119	139	182	232	267	359	308	238
9	-	CONCEPCION	CONCEPCION	-	-	-	-	-	-	-	-	-	-	-	-	60	109	76	77	230	-	-	-
11	1982	S.J.CONCEPCION	S.J.CONCEPCION	-	-	-	-	-	-	-	-	-	-	-	-		18	259	204	260	309	305	329
13	-	SAN MARCOS	SAN MARCOS	504	-	-	-	-	-	-	-	-	-	-	-	2,117	2,162	2,243	2,368	2,471	2,390	2,681	2,632
21	-	ESQUIPULAS	ESQUIPULAS	103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	VERACRUZ	VERACRUZ	93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	TICUANTEPE	#1	336	-	-	-	-	-	-	-	-	-	-	-	-	363	609	297	494	498	494	522
12	-	TICUANTEPE	#2		-	-	-	-	-	-	-	-	-	-	-	932	698	780	1,735	1,324	1,600	1,718	1,584
16	-	COFRADIA	#1	37	-	-	-	-	-	-	-	-	-	-	-			75	57	16	63	75	102
16	NOV. '82	COFRADIA	#2		-	-	-	-	-	-	-	-	-	-	-	119	114	95	81	116	102	110	149
16	1983	COFRADIA	#3		-	-	-	-	-	-	-	-	-	-	-	39	76	76	128	124	105	105	104
15	MARCH '68	SABANA GRANDE	#1	135	-	-	-	-	-	-	-	-	-	-	-	207	204	194	254	249	273	270	272
15	MARCH '68	SABANA GRANDE	#2		-	-	-	-	-	-	-	-	-	-	-	235	233	224	222	261	320	297	325
14	-	LAS NUBES	(PRESA #2) SPRING		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	209
14	-	LAS NUBES	(PRESA #3) SPRING		-	-	-	-	-	-	-	-	-	-	-	222	228	301	420	404	471	577	256
17	-	ZAMBRANO	#1	21	-	-	-	-	-	-	-	-	-	-	-	115	128	115	103	66	103	113	138
18	1981	SAN LUIS	#1		-	-	-	-	-	-	-	-	-	-	-	65	78	71	81	74	84	78	84
19	-	S.I.CRUZ VERDE	S.I.CRUZ VERDE	33	-	-	-	-	-	-	-	-	-	-	-	-	-	586	151	150	37	-	-
10	-	BELLA CRUZ	BELLA CRUZ	-	-	-	-	-	-	-	-	-	-	83	140	185	98	104	79	-	-	-	-
23	1976	VALLE GOTHEL	VALLE GOTHEL #1	-	-	-	-	2,259	2,259	2,259	2,259	2,259	2,259	2,259	2,259	2,259	2,259	2,259	2,259	2,259	2,259	2,259	1,673 **
22	1976	VALLE GOTHEL	VALLE GOTHEL #2	-	-	-	-	1,415	1,415	1,415	1,415	1,415	1,415	1,415	1,415	1,415	1,415	1,415	1,415	1,415	1,415	1,415	1,664 **
23	1976	VALLE GOTHEL	VALLE GOTHEL #3	-	-	-	-	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950 **
25	1990	VERACRUZ	VERACRUZ #4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,429	1,571 **
24	1990	VERACRUZ	VERACRUZ #5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,728	1,987 **
24	1991	VERACRUZ	VERACRUZ #6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,811 **

NOTES: ** ESTIMATED WITH FLOW AND PUMPING HOURS DAILY AVERAGES
REMAINDED DATES WAS OBTAINED OF INAA OFFICES.

Table 4.5.3 Industrial Groundwater Use in 1982 & 1992 (1)

Industrial Use in 1982 & 1992 (1)

NO.	MAP No.	Location	Survey in 1982 No.of Well	Survey in 1982 Consump in GPD	Survey in 1982 in m3/d	BM	Survey in 1992 No.of Well	Survey in 1992 Consump in GPD	Survey in 1992 in m3/d	BM	Remarks
1	4	Lecheria La Completa	3	3000	11.37	B	2	-	-	-	no operation since 1989
2	10	IFAGAN	4	1500000	5685	U	6	-	-	-	for domestic use
3	8	Plantel Shell	2	25000	94.75	A	1	30000	113.7	U	
4	-	Granero Enabas	1	25000	94.75	A	1	-	-	-	no exist
5	6	HERCASA-ELPESA	4	1200000	4548	U	2	320000	1212.8	U	
6	9	ESSO	2	150000	568.5	A	5	1008000	3820.32	U	
7	11	Hieleria Polar	1	20000	75.8	U	1	15300	57.987	U	
8	7	Plantel Mayco	3	20000	75.8	A	1	9000	34.11	U	for domestic use
9	5	CONADECO	2	20000	75.8	A	1	50000	189.5	U	
10	3	ENENSA	1	10000	37.9	A	1	-	-	A	for domestic use
11	-	ALUMEX	1	10000	37.9	A	-	-	-	-	
12	14	Lecheria La Selecta	3	12000	45.48	U	2	93000	352.47	A	
13	32	Matadero CARNIC	3	1000000	3790	B	2	110000	416.9	A	
14	-	Cerveceria El Aguila	4	-	0		-	-	-		No operation
15	-	Plasticos Maber	1	10000	37.9	A	-	-	-		Closed
16	-	Plasticos Modernos	1	10000	37.9	A	1	-	-		Closed
17	-	Azulejos Cerisa	1	10000	37.9	A	1	200	0.758	U	
18	27	FANATEX	3	200000	758	B	2 ?		-		no information
19	38	Laboratorios SOLKA	1	20000	75.8	A	1	-	-		Public Line
20	-	CYNAMIO	2	100000	379	A	-	-	-		Public line
21	-	Procesa	1	10000	37.9	A	-	-	-		no exist
22	-	El Porvenir	1	20000	75.8	A	-	-	-		no exist
23	26	PEPSI COLA	2	500000	1895	B	3	410000	1553.9	U	
24	39	Nicar Quimica	1	5000	18.95	A	1	-	-		Public Line
25	36	Kola Shaler	1	10000	37.9	B	1	18000	68.22	U	
26	-	Beneficio San Francisco	1	5000	18.95	A	-	-	-		closed
27	-	Fabrica Fibra de Vidrio	1	5000	18.95	A	-	-	-		closed
28	37	TRICOTEXTIL	2	50000	189.5	B	2	90000	341.1		half production
29	-	FINSA	1	10000	37.9	A	-	-	-		closed
30	20	Hilados Las Tres	1	10000	37.9	A	1	10000	37.9		
31	19	Lecheria La Perfecta	2	40000	151.6	U	1	180000	682.2	B	
32	18	COCA COLA	3	500000	1895	U	3	574000	2175.46	B	estimation from pepsi
33	-	Nabisco Cristal	2	12000	45.48	U	1	30000	113.7		
34	21	Muebles Pierson Jackman	1	5000	18.95	A	1	165	0.62535		
35	17	RARPE	2	20000	75.8	A	2	37000	140.23	B	for garden irrigation
36	-	NICATEX	2	50000	189.5	B	2	-	-		no use
37	22	I Mep	1	5000	18.95	A	1	3000	11.37		
38	29	Cafe Presto	2	50000	189.5	U	2	80000	303.2	B	
39	-	Hielo Syf	1	20000	75.8	B	-	-	-		no exist
40	23	Cerveceria Tona	2	400000	1516	B	2	150000	568.5	U	

Table 4.5.3 Industrial Groundwater Use in 1982 & 1992 (2)

Industrial Use in 1982 & 1992 (2)

NO.	MAP No.	Location	Survey in 1982 No.of Well	Consump in GPD	in m3/d	EM	Survey in 1992 No.of Well	Consump in GPD	in m3/d	EM	Remarks
41	-	Desano Tadors Inagor	1	20000	75.8	A	-	-	-		Closed
42	-	Parque Industrial INUSA	1	25000	94.75	A	-	-	-		Closed
43	-	ELSA	1	10000	37.9	A	-	-	-		Closed
44	24	Prod. Atmosfericos	2	15000	56.85	A	2	-	300		
45	25	TANIC	3	50000	189.5	A	-	-	-		no information
46	-	Conos Victoria	1	5000	18.95	A	-	-	-		Closed
47	28	Candelas Llanes	1	5000	18.95	A	1	-	-		Closed
48	16	Baterias Willard	1	5000	18.95	A	1	-	-		no use
49	-	Tejidos Nicarao	1	10000	37.9	A	1	-	-		no use
50	-	El Lechon	2	20000	75.8	A	-	-	-		Closed
51	-	Bielera Wking	2	20000	75.8	E	-	-	-		Closed
52	12	aceitera Coronaaceitera Coro	1	50000	189.5	A	3	1500	5.685		
53	13	Cervecerua Victoria	3	600000	2274	U	4	700000	2653		
54	2	POLYCASA	-	-	-	-	2	-	-		No operation
55	1	MACEN	-	-	-	-	1	6000	22.74		
56	-	NICATEX	-	-	-	-	2	-	-		no use
57	-	CRISCASA	-	-	-	-	1	-	-		no use
58	-	ENISUBRO	-	-	-	-	1	-	-		no use
59	38	INCAE	-	-	-	-	1	25000	94.75		
60	30	EMPROSEM	-	-	-	-	1	-	-		no use
61	-	ALUMISA	-	-	-	-	1	###	-		for domestic use
62	35	SAIMSA	-	-	-	-	1	-	-		no use
63	-	ESC. NACIONAL AGRI.	-	-	-	-	2	###	-		for irrigation
64	40	TIPTOP	-	-	-	-	3	120000	454.8	E	
65	-	GRANJA LA TRINIDAD	-	-	-	-	1	160000	606.4	E	
66	31	HOTEL CAMINO REAL	-	-	-	-	1	270000	1023.3	U	
67	34	HOTEL LAS MERCEDES	-	-	-	-	1	300000	1137	U	
68	-	EL CANON	-	-	-	-	1	8000	30.32		for domestc
69	-	SANTA ANA	-	-	-	-	1	1315	4.98385		for domestc
70	-	GRANJA EL MADERAL MINDRI	-	-	-	-	1	3900	14.781		for domestc
71	-	COOPERATIVA JULIO RODORIGEZ	-	-	-	-	1	-	-		no use
72	-	GRANJA LA BARRANCA	-	-	-	-	1	5000	18.95		for domestc
73	-	BUENOS AIRES QUINTA MEDISON	-	-	-	-	1	-	-		no use
74	-	HACIENDA LOS AIPES	-	-	-	-	1	260	0.9854		for domestc
75	-	SANTAJULIA	-	-	-	-	1	260	0.9854		for domestc
TOTAL				6907000	26177.53			4818900	18563.63		

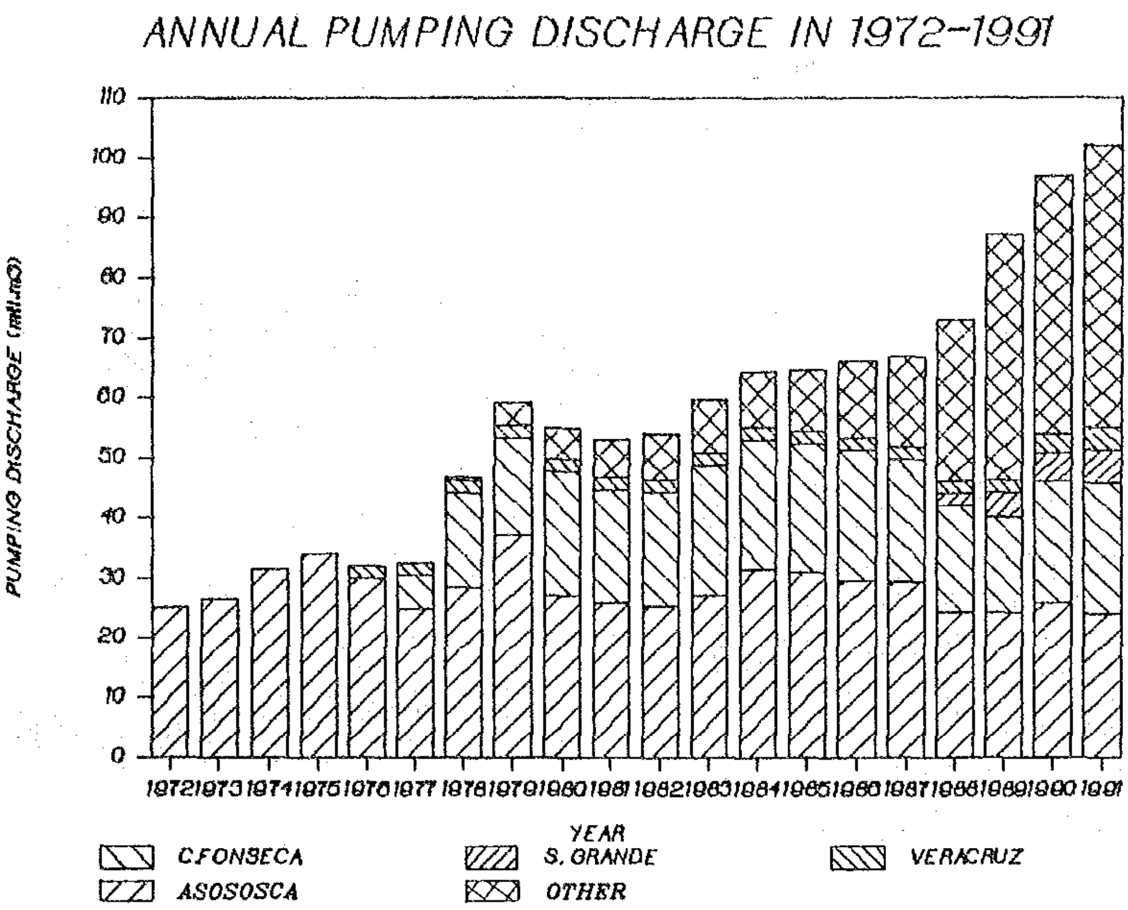


Fig. 4.5.1 Annual Pumping Discharge in 1972-1991

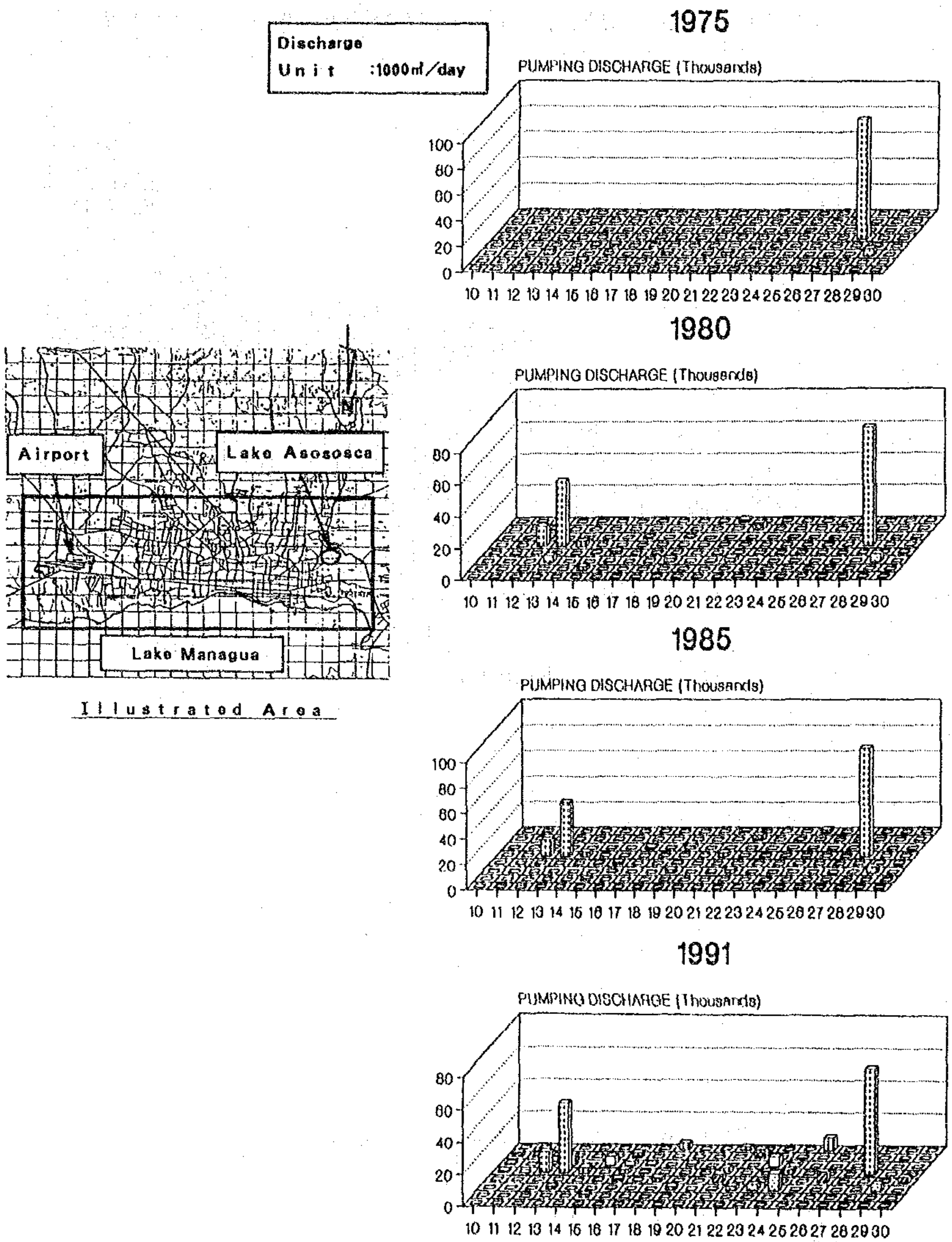


Fig. 4.5.2 Histry of Daily Pumping Discharge in 1km x 1km

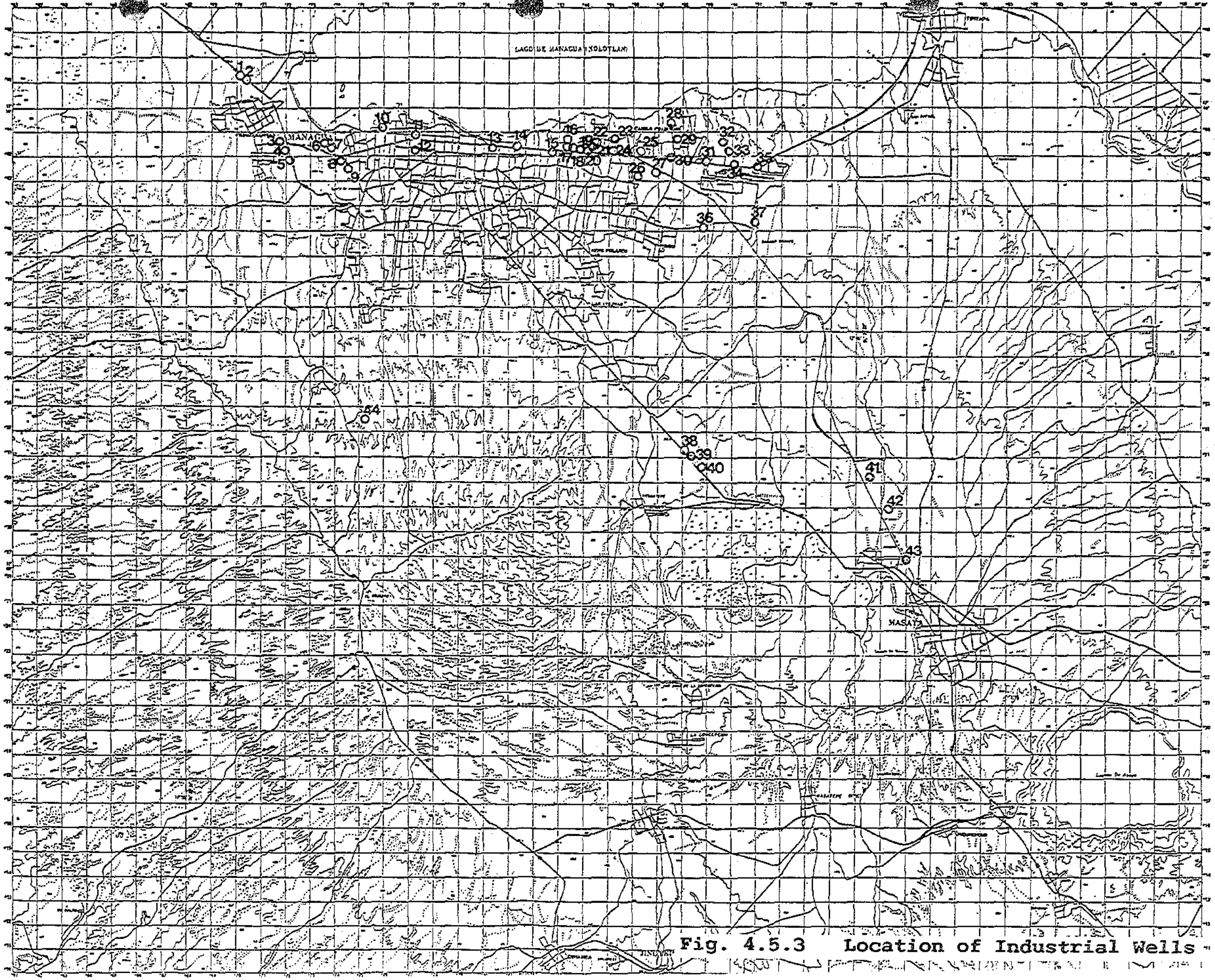


Fig. 4.5.3 Location of Industrial Wells

4.6 Test Well Drilling and Pumping Test

4.6.1 Test well drilling

After the completion of the necessary investigations for Phase I and Phase II, the target sites for test drilling were finally selected, as shown in Figure 4.1.3, seeking to achieve the following purposes:

a) To investigate groundwater occurrence and hydraulic aquifer characteristics and to evaluate the overall potential of groundwater resources in the Study area.

b) To examine groundwater suitable as drinking water, and to clarify the groundwater flow mechanism by comparing the chemical components of groundwater in different geohydrologic sub-areas and aquifers.

c) To select priority areas and to formulate a groundwater development plan for the selected priority areas.

The test well construction accompanied by pumping test started on June 10th, 1992 and was finished on November 18th 1992 (see Table 4.6.1). The cumulative drilling depth of 5 test wells was 1,266 meters. The test drilling results are summarized in Table 4.6.1 and 4.6.2, and the detailed drilling records and well logs are presented in Supporting Report.

The following major findings were obtained from test well drilling.

(1) JI-1 Well

This test well was drilled to investigate groundwater occurrence and hydraulic aquifer characteristics of the Middle Las Sierras Group, and to confirm existence of hydrogeologically impermeable basal layers from electric prospecting results.

Although this test well drilled from June 10th 1992 was supposed to be 400 meters, it was only drilled to a depth of 300 meters due mainly to a very unstable formation of very loose ash flow with more than 150 meters thickness. Therefore, the existence of a hydrogeologically impermeable basal layer was not confirmed, but new geological findings, as shown in Figures 4.6.1 and 4.6.2 were obtained.

Based on existing geological data and information, it is believed that the Middle Las Sierras Group is composed mainly of basaltic compact agglomerate, and partially of thin beds of porous scoria like the aquifers. However, this test well has revealed the existence of a formation somewhat different from the commonly known Middle Las Sierras Group. The compact agglomerate of the Middle Las Sierras Grop from the ground surface is only 80 meters thick, and a very thick formation of volcanic materials composed of scoria flow with fossil soils, basaltic porous lava and pyroclastic flows and ash flows more than 220 meters thick are underlain. These volcanic materials underlying the well known Middle Las Sierras Group are considered to be one of the initial volcanoes of the Las Sierras Group, although it is not sure whether it is widely distributed as a member of the Middle Las Sierras Group. A presumed geological structure and a schematic geological section of the area are shown in Figures 4.6.1 and 4.6.2. If the presumed structure is correct, this would prove the area to be hydrogeologically promising as it forms a good groundwater reservoir (Sc:19,464.48 m^3/day/m).

(2) JI-2 Well

This test well was drilled to investigate groundwater occurrence and hydraulic aquifer characteristics of the Masaya Group Volcanics and Middle Las Sierras Group.

The drilling works started on June 17th 1992 and was finished on November 18th 1992. The target depth was 200 meters. The drilling of this test well took about 59 days due to hard rock formations such as basaltic lavas and compact tuff brecia, which caused frequent equipment breakdown.

This test drilling work confirmed that the principal water bearing formation in the area is the Masaya Group Volcanics composed of fissured and porous basaltic lava, auto-brecciated basaltic lava and pyroclastic flows such as porous scoria and ash beds (Fig. 4.6.1).

This study carried out a pumping test for the existing well at El Pique located between JI-2 and JI-3 wells. The drilled depth of the existing well is 138.4 meters and its lithologic facies is presumably similar to that of the JI-2 well. However, the screen position of this existing well is unknown, and rather poor pumping test results suggest that the screens have not been properly placed.

The results of pumping test of the above two wells were as follows:

	JI-2	El Pique
Discharge (m^3/day)	2,469.12	2,469.12
Static Wat. Lev.(Gl-m)	43.47	39.80
Drawdown (m)	3.59	8.37
Specific Capacity (m^3/day/m)(g/m/feet)	687.77 38.47	295.10 16.50

(3) JI-3 Well

Test well drilling was carried out mainly for the following three reasons:

a) To investigate groundwater occurrence and hydraulic aquifer characteristics of the Masaya Group Volcanics and Middle Las Sierras Group.

b) To confirm existence of hydrogeologically impermeable basal layers, inferring from electric prospecting results.

c) To investigate geothermal conditions at the deeper portion of the area in connection with the hot spring at Tipitapa and its surroundings.

The drilling works of this test well started on June 15th 1992 and was finished on November 4th 1992. Although a depth of 400 meters was primarily intended, the actual drilled depth was only 366 meters because of the achievements of the above mentioned study purposes.

The major findings of this test well drilling works are the following:

(a) As shown in Figure 4.6.3, the existence of the Upper Coyol Group, which is composed of purplish brown weathered dacitic ignimbrite with fossil soil bed and pale greenish blue aphanitic dacite underlying the Middle Las Sierras Group, was confirmed at a depth between 266 and 366 meters.

(b) The above information was collected from the observation of drill cuttings and rock fragments (7 X 7 X 4 cm) taken from the borehole.

The lithologic characteristics were confirmed to be very similar to those of an outcrop of the Upper Coyol Group. The confirmation of the existence of aphanitic dacite, supposedly an intrusive rock extended in the NNW-SSE direction, was also anticipated from the electric prospecting results.

(c) Weathered dacitic ignimbrite is accompanied by very loose clayey materials, and aphanitic dacite has a network of small cracks showing signs of weak weathering.

(d) The principal aquifers of the area are pyroclastic fall and flow beds consisting of scoria and rock fragments of the Masaya Group Volcanics, interfingered deposits of the Masaya Group Volcanics and diluvium consisting of fine to coarse sand with silt, and weathered agglomerate with fossil soil and thin scoria beds of the Middle Las Sierras Group.

The pumping test showed the following results:

Screen length in the QvM & Qdl(m)	60.96
Screen length in the TQps(M)(m)	40.29
Discharge (m^3/day)	2,998.08
Static Water Level (GL-m)	14.52
Drawdown (m)	2.68
Specific Capacity (m^3/day/m)	1,118.64

Geothermal conditions were studied according to the following information:

a) Temperature of groundwater

13.70-240 m	35 °C
240-250 m	35-36 °C
250-255 m	36-38 °C
255 - ? m	38-39.5 °C

b) As shown above, the temperature of groundwater in this test well increased from 35 °C at the drilled depth of 240 meters to 39.5 °C. The lithology in this test well varies from the Middle Las Sierras Group to dacitic ignimbrite and dacitic intrusive rock of the Upper Coyol Group at the depth of 266 meters, and in this connection, the temperature in the well increased from 35 °C to 39.5 °C. The gamma ray value increased also from 3 c.p.s. order in the Middle Las Sierras Group to 15-16 c.p.s. order in the Upper Coyol Group.

c) In this test well, 4 water samples were taken at depths of 164.59, 214.58, 264.57 and 314.55 meters. The results of chemical analysis is described in the section "Groundwater Quality".

(4) JI-4 Well

This drilling site was selected to investigate the hydraulic aquifer characteristics of a zone in the Middle Las Sierras Group with a low yielding capacity.

The main aquifers of the area are weathered agglomerate with fossil soil beds, with a total thickness of 28.10 meters, and fractured agglomerate below. The pumping test results are as follows:

Total screen length (m)	71.00
Discharge (m^3/day)	1471.68
Static Water Level	94.28
Drawdown (m)	11.89
Specific Capacity (m^3/day/m)	123.77

(5) JI-5 Well

This test well was drilled to investigate hydrogeological structure of the Los Brasiles Valley and aquifer characteristics of the Middle Las Sierras Group, and to investigate lithological conditions of El Salto Formation supposedly clarified from prospecting results.

The main aquifers of the area are weathered agglomerate with fossil soil beds (30.50m), fractured agglomerate (37.75 m), and basal layer of tuffaceous coarse sandstone and fine conglomerate on top surface of the El Salto Formation (6m).

The existence of the El Salto Formation has been confirmed at depths between 167.64 and 200 meters, and was found to consist of tuffaceous sandstone and siltstone with sandy tuff, tuffaceous fine sandstone with fine fragments of shell fossil, and tuffaceous fine conglomerate with calcareous gravel.

The hydrogeological structure of the Los Brasiles Valley is represented in Fig. 4.1.8. Since the estimated depth of El Salto Formation was proven accurate by the electric prospecting results, this prospecting method is sure to be very useful to confirm the depth of the Tertiary formations such as El Salto and Brito underlying the Las Sierras Group.

The following pumping test results were obtained from this test well. The high yielding capacity of the well, which is contrary to what was expected, is presumably due to the good quality of the aquifer of basal layer of tuffaceous coarse sandstone and fine conglomerate overlying the top surface of the El Salto Formation.

Total screen length (m)	54.00
Discharge (m^3/day)	1,471.68
Static Water Level (GL-m)	100.18
Drawdown (m)	1.83
Specific Capacity (m^3/day/m)	804.19

4.6.2 Pumping test

Step drawdown, the constant rate and recovery tests were carried out in the 5 drilled wells and in 2 existing wells, using a submersible motor pump provided by JICA and a vertical turbine pump prepared by the contractor, in order to estimate aquifer properties.

The number of steps, the pumping duration and other pumping conditions are as follows:

(a) Step Drawdown Test

Five (5) step drawdown tests were conducted in order to estimate optimum discharge, formation loss and well loss of a single well. During the test, the pumping rate was increased in all five (5) steps at regular intervals. This pumping rate at each interval was determined based on the results of the preliminary pumping test. The pumping duration of each step was 2 hours.

(b) Constant Rate Test

This test was conducted after the step drawdown test when the water level recovered up to the original static water level. The constant pumping rate was determined from the results of the step drawdown test. The pumping duration was 48 and 24 hours.

(c) Recovery Test

Time-recovery measurement of water level was carried out for 24 hours, immediately after constant rate pumping was completed.

Prior to the normal pumping test on the borehole mentioned above, swabbing and bailing were carried out as parts of well development work. Bailing work lasted for about 24 hours.

Time-drawdown and time-recovery measurements were plotted on log-log and semi-log graph paper in order to calculate transmissivity, permeability, and storage coefficients. Methods of analysis used in this study were Theis' and Jacob's which are applicable to unconfined aquifers in unstable conditions.

The detailed pumping test results are given in Supporting Report and summarized aquifer parameters are shown in Table 4.6.1.

The main aquifer properties in the study area are described in the section "Hydrogeological Features of the Study Area".

Cuadro 4.6.1 Caracteristicas generales de 7 pozos exploratorios

Table 4.6.1 General Feature of Seven Test Wells

Nombre de Pozo (Well Name)	JICA No. 1	JICA No. 2	JICA No. 3	JICA No. 4	JICA No. 5	Juan Ramon Robles	No.1285
1.Direccion (Address)	Las Madrigales	Veracruz	Sabana Grande	Socrates Sandino	Bello Amanecer	El Pique	Hermanos Rosales
2.Latitud (Latitude) Longitud (Longitude)	12° 03′ 30″ 86° 11′ 43″	12° 06′ 08″ 86° 09′ 32″	12° 08′ 50″ 86° 08′ 59″	12° 06′ 43″ 86° 12′ 51″	12° 08′ 22″ 86° 20′ 51″	12° 05′ 53″ 86° 09′ 44″	11° 59′ 40″ 86° 06′ 29″
3.Elevacion (Elevation)	Aprox. 220m	Aprox. 125m	Aprox. 78m	Aprox. 86m	Aprox. 145m	Aprox. 109m	Aprox. 255m
4.Diametro del ademe (Diameter of Casing Pipes)	12″ 3/4	12″ 3/4	12″ 3/4	12″ 3/4	12″ 3/4	13″ 1/2	6″
5.Perforado por (Drilled by)	JICA Study Team	JICA Study Team	JICA Study Team	JICA Study Team	JICA Study Team	—	—
6.Fecha de inic.y final de la perfor (Bigining and Completion Date of Drilling)	Jun.10 1992 Nov.16 1992	Jun.17 1992 Nov.18 1992	Jun.15 1992 Nov.14 1992	Jun.19 1992 Oct.20 1992	Jun.18 1992 Oct.23 1992	— —	— —
7.Tiempo que tomo(Spent days) (dias:days)	160	155	153	116	63	—	—
8.Posicion de rejilla (Screen Position) 1)Tipo puente(Bridge Type) (Nivel de tierra -m) (Ground Level -m)	107.28 ~156.05 174.80 ~186.99	88.84 ~105.91 118.16 ~152.30 170.68 ~182.58	19.46 ~ 29.21 41.71 ~ 92.92 141.12 ~155.75 218.13 ~220.59	109.00 ~130.90 137.20 ~156.70 162.90 ~175.10	114.80 ~151.40	—	—
2)Jhonson (Nivel de tierra -m) (Ground Level -m)	186.99 ~210.16	71.44 ~ 88.84	105.42 ~128.62	175.10 ~192.50	163.60 ~181.00	—	—
9.Longitud de rejilla (Screen Length) 1)Tipo puente (Bridge Type) 2)Johnson (m)	60.96 23.17	63.74 17.40	78.05 23.20	53.60 17.40	36.60 17.40	— —	— —
10.Temperatura de agujero (Temperarure of Borehole)(℃)	—	34.0 (200m)	35.3 (280m)	32.0 (200m)	40.7 (200m)	—	—
11.Temperatura de agua (Temperature of Water) (℃)	—	28.6	33.5	30.9	35.0	30.3	—
12.Conductividad(Conductivity) (mS/cm)	—	1.180	—	0.361	1.000	1.003	—

Cuadro 4.6.2 Resultados de pruebas de bombeo

Table 4.6.2 Results of Pumping Test

Nombre de Pozo (Well Name)	JICA No. 1	JICA No. 2	JICA No. 3	JICA No. 4	JICA No. 5	Joan Ramon Robles	No. 1285
1. Profundidad (Well depth) (m)	300	200	366	200	200	138	—
2. Longitud de rejilla (Total Screen Length) (m)	84.13	81.14	101.25	71.00	54.00	—	—
3. Principal formacion acuifera (Main Formation of Aquifer)	TQps(M)	QvM, TQps(M)	QvM, TQps(M)	TQps(M)	TQps(M)	QvM	TQps(M)
4. Fecha de bombeo (Pumping Test Date)	Nov. 14~16 1992	Nov. 16~18 1992	Nov. 12~14 1992	Oct. 14~18 1992	Oct. 21~23 1992	Oct. 03~05 1992	Jul. 08 1992
5. Nivel estatico de agua (Static Water Level) (G.L.-m)	104.24	43.47	14.52	94.28	100.18	39.80	96.73
6. Caudal (Discharge Rate) (m^3/d)	1,483	2,469	2,998	1,472	1,472	2,470	87
7. Descenso (Drawdown) (m)	0.076	3.59	2.68	11.89	1.83	8.37	0.47
8. Capacidad Especifica (C.E.) (Specific Capacity) (m^2/d)	19,464	688	1,119	124	804	295	183
9. Transmisivilidad (Transmissivity)							
1) a. Theis	—	915	—	147	50	123	323
b. Jacob	—	1,291	3,658	150	267	192	354
2) Recuperacion (Recovery Test)	—	1,290	3,429	112	—	105	332
3) T=1.22×C.E.	23,746	839	1,364	151	981	360	223
10. Storage Coefficient	—	3.24×10^{-5}	—	1.82×10^{-4}	—	—	—
11. Aquifer Loss Coefficient (d/m^2)	—	—	5.92×10^{-6}	4.42×10^{-3}	—	—	—
12. Well Loss Coefficient (d^2/m^5)	—	—	1.10×10^{-7}	2.57×10^{-6}	—	—	—

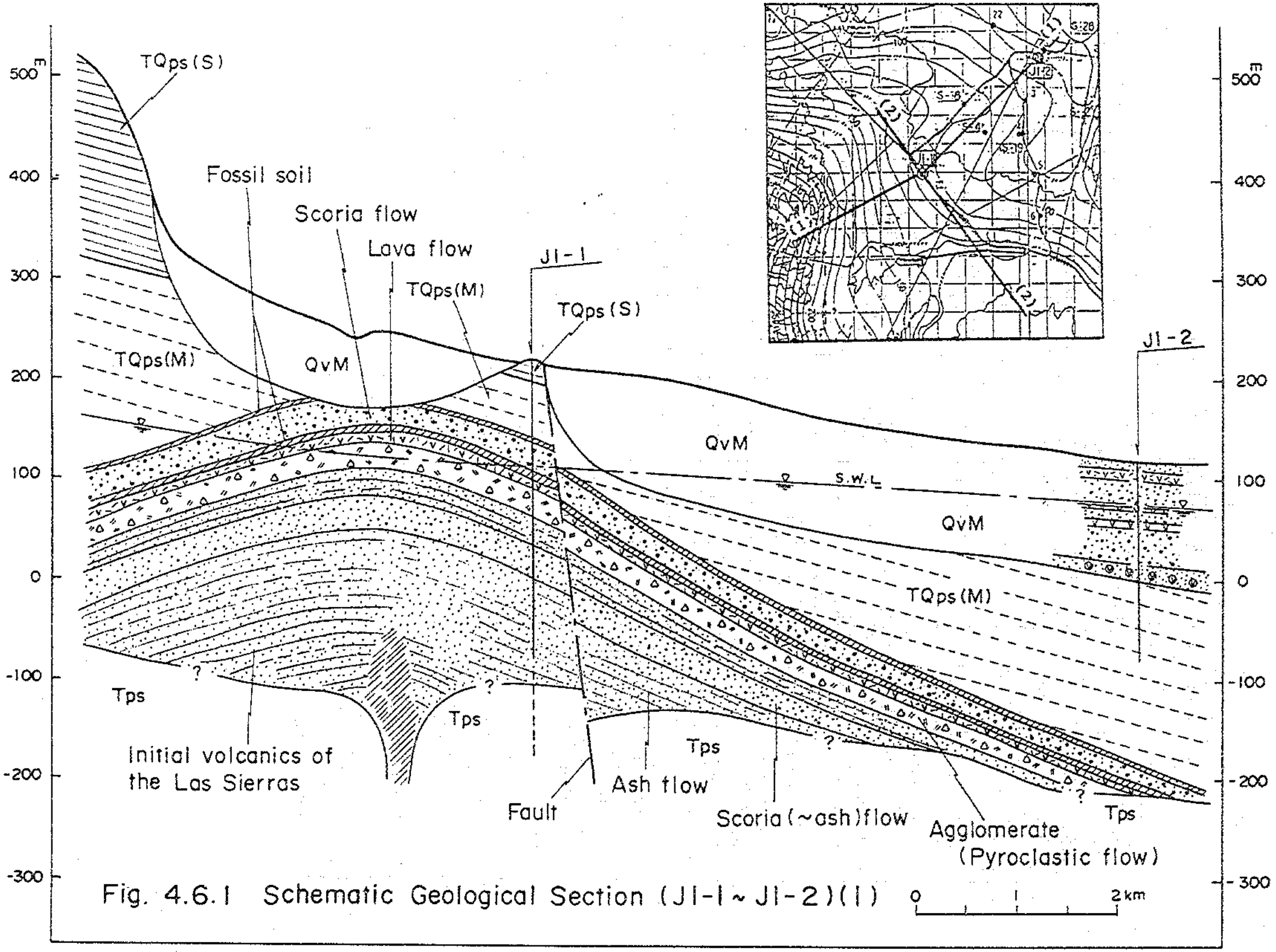


Fig. 4.6.1 Schematic Geological Section (JI-1 ~ JI-2)(1)

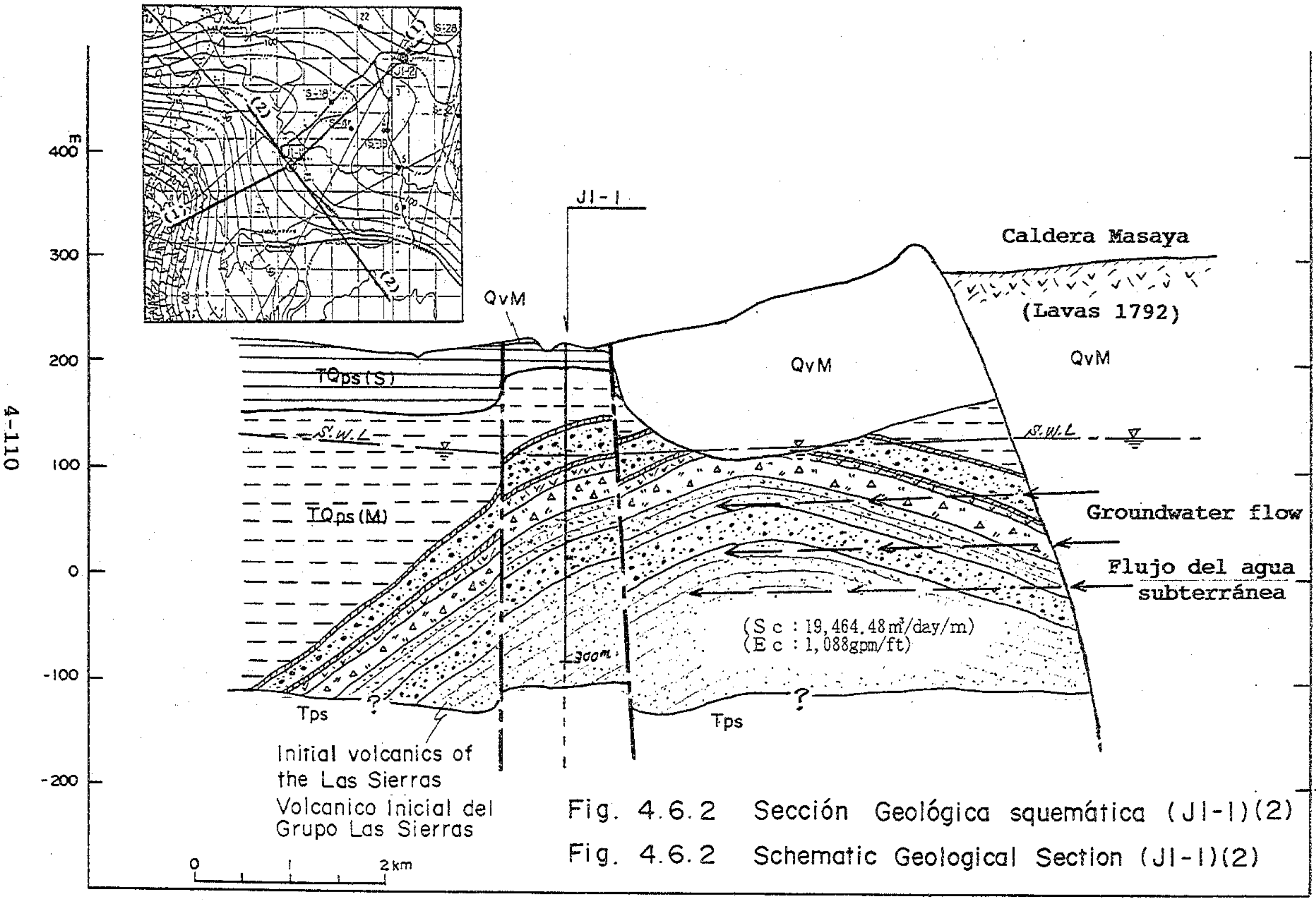


Fig. 4.6.2 Sección Geológica squemática (JI-1)(2)

Fig. 4.6.2 Schematic Geological Section (JI-1)(2)

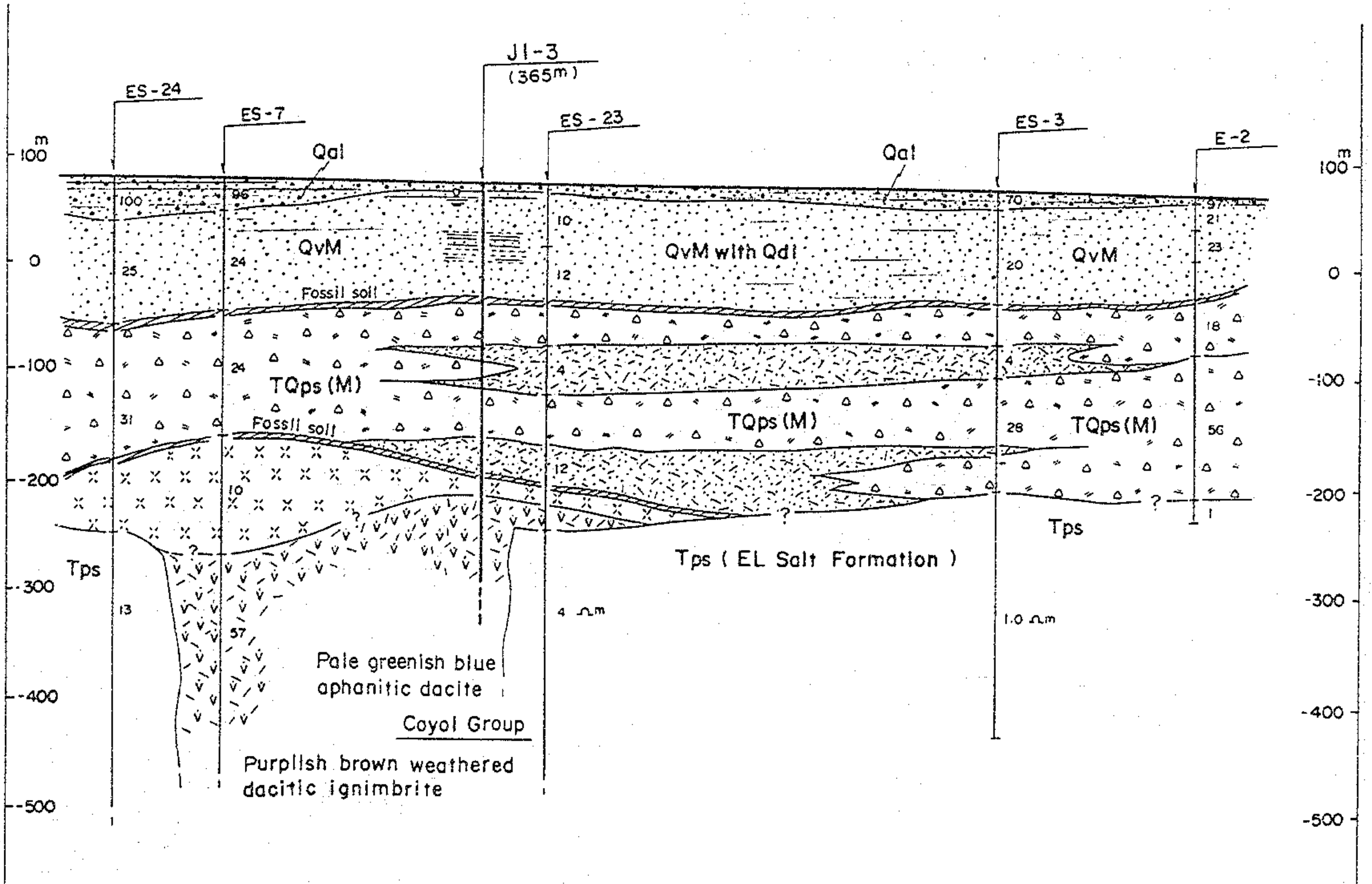


Fig. 4.6.3 Schematic Geological Section (JI-3)

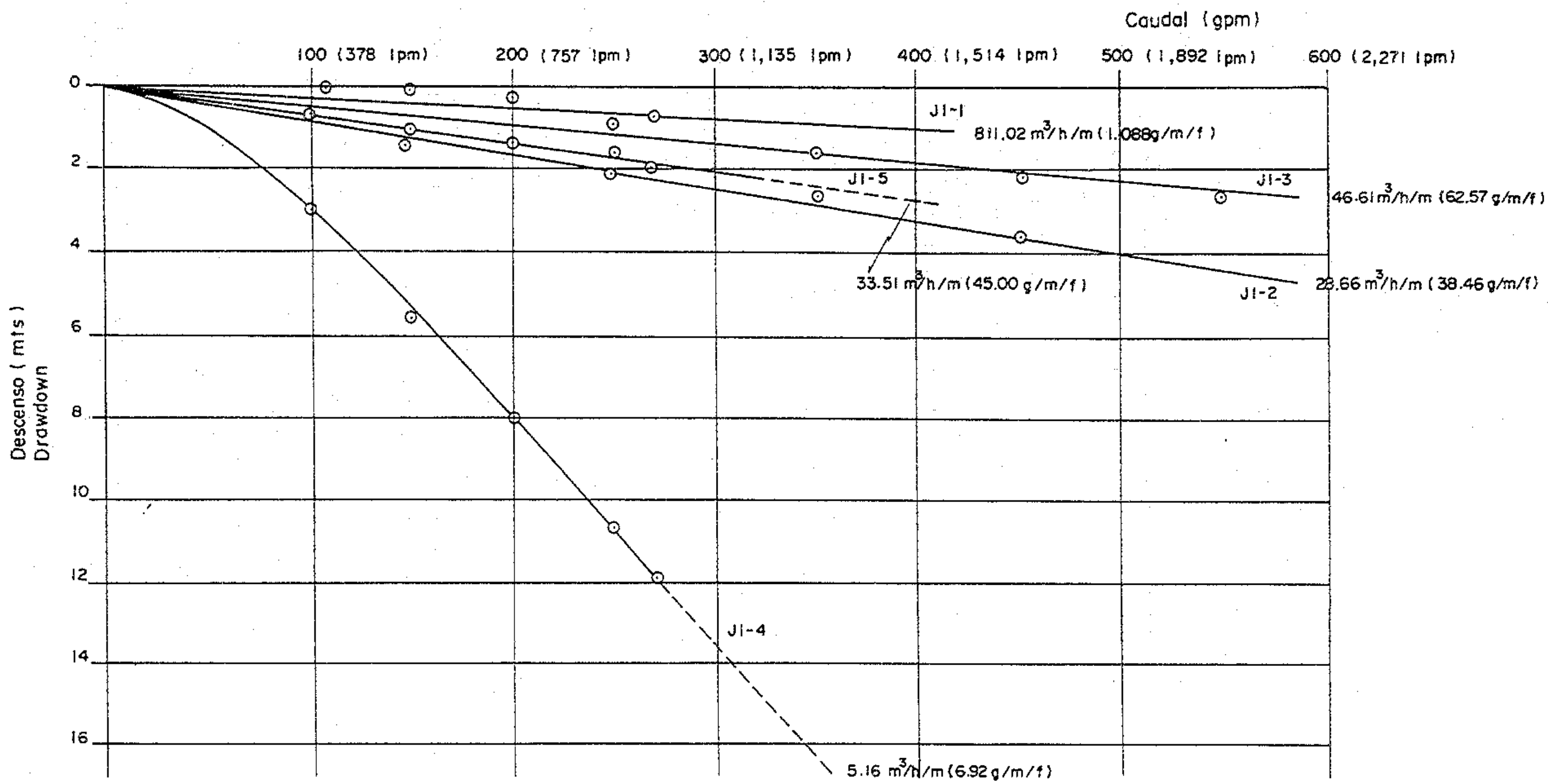


Fig. 4.6.4 Pruebas de Bombeo a Descarga Variable

Fig. 4.6.4 Step Drawdown (Discharge) Test

4.7 Water Quality

4.7.1 Review of Previous Reports

Previous reports were reviewed in order to evaluate water quality condition in the Study Area. Many physical analysis were conducted through hydrogeological investigations.

"FUENTES ALTERNAS DE ABASTECIMIENTO DE AGUA DEL COMPLEJO INDUSTRIAL HERCASA-ELPESA, 1988" reported the groundwater quality in the industrial area located North of Lake Asososca. In this Study, physical, bacteriological and isotopical water quality analyses were conducted.

The results of the analyses showed problems in shallow aquifers near the ground surface and that confined or semi-confined aquifers in deeper zones have not yet been contaminated. The results are as summarized below:

(a) The chemical components of Lake Managua, Nejapa and Tiscapa are considered carbonated and high in pH. On the other hand, the wells in the industrial area are found to contain high Ca and Cl concentrations due to industrial waste water intrusion. However, Cl is considered to come from industrial products while Ca is from the soil.

(b) Lake Aachualinga area is considered as a source of contamination to the surrounding wells.

(c) Asososca lake generally contains low Zn, B, Cu, Cd, Hg and Pb concentrations in comparison with the Water Quality Standard. High Fe concentration is found in some points of the industrial area.

(d) According to the results of the analysis of B, the aquifer in the industrial area has never been affected by the water of Managua Lake.

(e) Some wells in the industrial area are contaminated with pesticides.

(f) The results of the bacteriological analysis show no problems concerning the use of this water for drinking.

(g) According to the isotopical analysis of water pumped in the industrial area, the water of Managua lake has not intruded the deep aquifers.

4.7.2 General Component

Water quality analysis was conducted to evaluate groundwater flow system in the Study Area and suitability for drinking.

Water sampling to evaluate the distribution in the whole area was principally conducted in February-May, while supplementary sampling was conducted in July-October. Samples were taken from every 50m deep well through test drillings and after completion of pumping test. Laboratory tests were conducted in the INAA laboratory.

Table 4.7.1 shows the results of the analysis, and Fig.4.7.1(1)-(4) and 4.7.2 show the Triliniar diagram and pattern diagram, respectively.
Results of the Tritium analysis are discussed in Section 4.8.

Table 4.7.2 shows the World Health Organization (WHO) standard quality for drinking water.

Surface water of lakes and rivers contain similar characteristics because they are almost recharged by groundwater. The Ph value found in the surface water ranges from 7.2-8.2, while conductivity and dissolved solid values range from 230-800 micro S/cm and 110-700, respectively. These values are largely distributed in the northern part of Sabana Grande-Cofradia-San Rafael area. On the other hand, a maximum amount of major ionic species were also observed, except in Lake Apoyo.

4.7.3 Triliniar and pattern diagrams

The locations plotted in the trilinear diagram show the characteristics of water with respect to the groundwater flow system. In the case of the Study Area, most of the points are distributed in areas high in (CO3+HCO3), except for Lake Apoyo and Lake Nejapa, both considered to be largely influenced by volcanic activity. The hot spring water in Tipitapa is also located in the same position.

Moreover, samples taken from the upstream area (where the period of stay is short) like Km 16 Leon and San Marcos are located in areas where the Ca+Mg ratio is small. The samples taken downstream (where the period of stay is longer), on the other hand, are located in areas were the Na+K ratio is big. This may be attributed to the ion cation exchange process, wherein an Na^{2+}, K^{+}, Mg^{2+}, to Ca^{2+} exchange process is generally considered favorable.

Most of the plotted conditions clearly indicate similar conditions.

The stiff pattern diagram also shows the same condition above, and an increase in ion concentration was observed in the samples from Sabana Grande-Cofradia-San Rafael.

Table 4.7.1 (1) Results of Water Quality Analysis

NO.	No. INAA	LOCATION	NUMERO EN EL PLANO	FECHA DE CAPTACION	ASPECTO	TEMP. (C)	COLOR (UC)	TURB. (UNT)	CONDUCT. (uS/cm)	SOLID. TOTAL. (mg/L)	SOLID. DISUE. (mg/L)	pH	DUREZA TOTAL (mg/L)	ALCAL. (mg/L)	CALCIO (mg/L)	Mg (mg/L)	HIERRO (mg/L)	BICAR. (mg/L)	CARB. (mg/L)	Cl (mg/L)	SULP. (mg/L)	FLUOR. (mg/L)	NITRA. (mg/L)	NITRI. (mg/L)
1	55	SANDYS (SHELL)	19	09/03/92	CLARO	30.6	2.5	0.5	410		206	8.1	76	132	13	11	0.28	131	16	46	31	1.2	2.7	0
2	86	Km. 11 1/2 C. SUR	18	09/03/92	CLARO	28.5	2.5	1	526		263	8.2	212	208	48	22	0.36	215	21	26	28	0.72	8	0
3	49	VILLA CUBA #2	15	09/03/92	CLARO	29.2	2.5	0.3	450		235	8	120	160	19	17	0.085	176	10	48	23	1.3	3	0
4		VALLE GOTHEL	22	09/03/92	CLARO	27.6	2.5	0.3	470		235	8.1	140	188	27	17	0.17	210	10	38	27	1.38	3	0
5	62	HOSP. VELEZ PAIZ	17	09/03/92	CLARO	27.6	2.5	1.1	420		210	8	156	196	33	17	0.23	219	10	44	27	1	6	0
6	69	Km.14 C.MASAYA	21	09/03/92	CLARO	27.6	2.5	2	410		206	7.9	60	160	16	5	0.58	166	16	42	29	1.38	3	0
7	28	SABANA GRANDE #2	14	09/03/92	CLARO	30.4	2.5	0.3	500		250	8	40	184	8	5	0.085	185	21	46	27	1.03	3	0
8	10	MERCADO ORIENTAL	12	11/03/92	CLARO	29.7	2.5	0.2	490		244	8.1	136	196	24	18	0.03	210	16	56	34	0.8	31	0
9		ROBERTO TERAN (SAN ISIDRO) PP	27	10/03/92	CLARO	27.9	2.5	1.8	350		176	8	120	212	34	9	0.36	239	10	38	27	1.03	4	0
10		RANCHO CHICO	31	02/03/92			2.5	1.5	471		350	8.1	80	248	29	2	0.23	264	10	26	9	0.32	4.2	0
11		SAN CRISTOBAL	29	02/03/92			2.5	0.5	1145		1050	8.3	336	700	57	47	0.17	707	78	54	71	0.63	0.66	0
12		SAN MARTIN P.P.	32	02/03/92			2.5	0.3	385		290	8	60	228	16	5	0.13	210	10	39	2.25	0.55	2.7	0
13		COFRADIA 2	30	02/03/92			2.5	0.3	1005		790	8.1	316	620	38	53	0.23	561	10	50	71	0.64	6.4	0
14	13	RAFAELA HERRERA	13	09/03/92	CLARO	30	2.5	1	420		304	8	92	148	21	10	0.28	102	42	44	25	0.86	60	0
15		ASOSOSCA MP-22	4	23/2/92	CLARO		2.5	5.8	453			8	136	192	29	15	3.8	215	10	62	29	1.58	1.5	0
16		ASOSOSCA MP-10		23/2/92	LODOSO		10	38	1240			8.1	640	800	128	78	0.6	780	104	112	2	1.1	0.66	0
17		ASOSOSCA MP-30		23/2/92	LECHOSA		12	35	650			8.2	140	204	35	13	0.13	210	21	104	40	1.25	0.66	0
18		ASOSOSCA MP-28		23/2/92	CLARO		2.5	1.5	395			8.1	134	176	34	12	0.68	185	16	44	27	1.48	8	0
19		AVICOLA LA BARRANCA	37	18/03/92	CLARO		3	0.3	395		198	8.2	88	196	19	9.7	0.13	210	15.6	24	1	0.63	3	0
20		SAN MARCOS (#2 INAA)	41	18/03/92	CLARO	31.8	3	0.4	289		145	8.1	84	152	29	3	0.08	165	10	16	1	0.32	0.04	0
21		AVICOLA SAN FRANCISCO	43	19/03/92	CLARO	29.9	2.5	0.3	372	186		8.1	124	164	35	9	0.32	180	10	24	6	0.72	11	0
22		HDA. EL CAÑON	26	19/03/92	CLARO		3	0.3	557			8.3	208	200	46	22	0.13	215	16	46	30	0.38	4	0
23		MASATEPE (INAA)	40	19/03/92	CLARO		2.5	0.5	400			8.1	128	188	32	11	0.17	209	16	20	2	0.46	6	0
24		IFAGAN P.P.		22/04/92	CLARO		2.5	0.4	829			7.3	204	240	54.4	17	0.01	292	0	90	39	0.8	39	0
25		LOS ALTOS DE MASAYA(HDA. STA. ANA PP)	33	22/04/92	CLARO		2.5	0.5	446			7.6	96	224	22.4	9.7	0.01	173	0	30	1	0.07	0.04	0
26		LOS GUILLEN(PADRE FABRETTO)	28	22/04/92	CLARO		2.5	0.3	388			7.5	160	156	36.8	16.5	0.03	190	0	36	16	1.27	1	0
27	61	Km 14 1/2 c. LEON	16	22/04/92	CLARO		2.5	0.4	501			7.2	172	200	44.8	15	0.23	244	0	54	30	0.31	8	0
28		TICUANTEPE	35	22/03/92	CLARO		3.5	0.3	369		184	8	108	136	16	16.5	0.13	156	5	36	2	1.52	2	0
29		ENENSA.CAMINO SAN ANDRES DE LA PALANCA	24	8/4/92	CLARO		2.5	0.13	521		370	8	104	192	40	1	0.02	234	0	40	42	0.57	10.56	0.0132
30		ESC. COMARCA TRINIDAD CENTRAL	25	8/4/92	CLARO		2.5	0.15	471		340	7.8	100	216	38	0.97	0.01	253	0	36	22	0.46	11.8	0.0231
31		SAN ANDRES HDA. EL DELIRIO	23	8/4/92	CLARO		2.5	0.6	463		400	7.6	128	236	43	5		287	0	28	26	0.55	7.48	0.0132
32		CAMPO C.F.A,POZO #6	20	29/05/92	CLARO	27.9	< 2.5	0.5	490		460	8.4	65.6	192	13	8	0.02	234.2	0	44	36	0.69	4.4	0.02
33		IRENA MANANTIAL STA.ELENA	10	29/05/92	CLARO	30.2	2.5	0.7	1082		1000	8	262.4	560	45.9	35.8	0.01	683	0	58	0.65	0.57	3	0.03
34		FINCA SAN MARTIN,TIPITAPA	32	29/05/92	CLARO	33.1	< 2.5	0.7	412		385	8.3	106.6	220	14.8	16.9	0.01	220	25	28	1	0.46	4	0.02
35		SAN CRISTOBAL,POZO EXCAVADO	50	8/7/92	CLARO	27	2.5	2.5	1337		1380	7.3	396	700	80	48	0.13	854	0	102	117	0.04	13	0.03
36		TERMALES DE TIPITAPA	43	7/7/92	CLARO	>75	2.5	0.5	1585		1430	8	73.8	128	26.2	2.4	0.36	156.2	0	430	75	0.53	0.9	0.013
37		SAN RAFAEL,TIPITAPA,POZO EXCAVADO	47	7/7/92	CLARO	26.7	2.5	0.5	550		480	7.2	200	252	56	15	0.28	307	0	26	16	0.27	6	0.025
38		TIPITAPA,POZO EXCAVADO	45	7/7/92	CLARO	30.7	7.5	1.5	895		660	7.8	268	220	80	16	0.17	268	0	102	57	0.04	45	0.02
39		POZO FABRICA METASA	46	7/7/92	CLARO	30	2.5	0.8	569		450	8.1	112	164	24	13	0.43	200	0	82	29	0.34	10	0
40		ENTRADA A ZAMBRANO, POZO EXCAVADO	48	7/7/92	CLARO	29.9	2.5	1	481		420	7.6	100	220	21	12	0.32	268	0	24	3.25	0.07	12	0.014

Table 4.7.1 (2) Results of Water Quality Analysis

NO.	No. INAA	LOCATION	NUMERO EN EL PLANO	FECHA DE CAPTACION	ASPECTO	TEMP. (C)	COLOR (UC)	TURB. (UNT)	CONDUCT. (uS/cm)	SOLID. TOTAL. (mg/L)	SOLID. DISUE. (mg/L)	pH	DUREZA TOTAL (mg/L)	ALCAL. (mg/L)	CALCIO (mg/L)	Mg (mg/L)	HIERRO (mg/L)	BICAR. (mg/L)	CARB. (mg/L)	Cl (mg/L)	SULF. (mg/L)	FLUOR. (mg/L)	NITRA. (mg/L)	NITRI. (mg/L)
41		HILARIO SANCHEZ, POZO PROFUNDO	49	7/7/92	CLARO	28.4	2.5	0.5	498		450	7.7	116	240	22	15	0.085	293	0	28	3.25	0.11	11	0
42		EL PAPAYAL,SABANA GRANDE,POZO EXCAVADO	38	7/7/92	MATERIA EN	30.6	13	35	471		440	7.7	56	228	10	8	0.36	278	0	30	6	0.07	6	0
43	71	VALLE GOTHEL #3,INAA	39	7/7/92	CLARO	30.6	2.5	1	489		430	7.8	80	186	18	9	0.13	244	0	36	25	0.53	4	0
44		COFRADIA,POZO EXCAVADO	51	7/7/92	CLARO	30.2	2.5	2.5	694		620	7.7	152	328	26	21	0.02	400	0	28	19	0.01	11	0.004
45		PPOBLADO SABANA GRANDE, INAA	54	8/7/92	CLARO	26.1	2.5	0.5	575		525	7.8	100	248	26	9	0.01	303	0	40	31	0.01	6	0
46		LAGUNA DE APOYO	8	02/03/92			2.5	1.5	4880		3037	8.2	300	204	67	32	0.03	200	26	1466	225	1.2	0.66	0
47		LAGUNA MASAYA	7	02/03/92			2.5	2.2	430			8.2	132	296	22	18	0.13	331	16	22	2.25	0.46	0.66	0
48		LAGO DE MANAGUA	2	27/02/92		26.2			1510		746	7.8	144	740	19.2	23	0.48	658.8	130	270	12	1.11	0.04	0
49		LAGUNA NEJAPA	6	27/02/92		26.4			1068		534	8	192	204	40	22	0.76	209.8	21	310	1	1.62	0.66	0
50		LAGO DE MANAGUA	3	27/02/92		26.5			2190		1093	8.6	168	760	19.2	29	0.13	634.4	156	360	42	1.24	0.66	0
51		LAGO DE MANAGUA	1	27/02/92		26.4			2080		1038	8.4	124	740	14.4	21	0.23	512.4	208	400	44	1.19	0.04	0
52		LAGUNA ASOSOSCA	4	27/02/92		26.2			489		244	8.1	156	176	24	23	0.23	195.2	10	58	31	0.4	0.66	0
53		LAGUNA TISCAPA	5	27/02/92		26.1			235		113	7.9	80	136	25.6	3.8	0.23	146	10	18	3	0.3	1.5	0
54		RIO MOCUANA	9	27/02/92		26.1			781		390		160	520	28.8	21	0.23	488	5	160	33	1.58	0.66	0
55		RIO EL ZAPOTAL	11	27/02/92		26.1			870		435	8.3	184	520	35.2	23	0.02	636.8	48	40	42	0.65	1.5	0
56		STA MARGARITA(TIPITAPA)	36	13/10/92		27.8			460		477	8.1	32	238	8	3	0.23	290	0	32	16.25	0.32	3.1	0
57		CHIGB(TIPITAPA)	53	13/10/92		30.4			1050		1134	7.5	264	644	40	40	2.26	785	0	24	32.5	0.12	1.5	2.5
58		HUAICA(NINDIRI)	34	13/10/92		29.5			564		594	7.9	80	342	19	8	0.32	418	0	14	0	0.24	3.1	0
59		STA TERESA(TIPITAPA)	55	13/10/92		26.9			480		426	8	48	231	10	6	0.28	248	18	30	5	0.42	1.5	0
60		COFORADIA "GRANJA PORCINA"	52	13/10/92		29.8			1410		1669	7.2	424	973	64	64	0.23	1187	0	32	32.5	0.11	1.5	0

Table 4.7.2 Water Quality Standard

O. M. S.

NORMAS INTERNACIONALES APLICABLES AL AGUA DE BEBIDA

Substancias tóxicas

Substancias	*Concentración límite* (mg/l)
Plomo	0,10
Arsénico	0,05
Selenio	0,01
Cromo (en Cr hexavalente)	0,05
Cianuros	0,05
Cadmio	0,01
Bario	1,0
Nitratos (en NO_3)	45

Substancias y propiedades químicas que influyen en la potabilidad del agua

Substancias	*Concentración máxima aceptable*	*Concentración máxima admisible*
Materias sólidas totales ...	500 mg/l	1 500 mg/l
Color	5 unidades *	50 unidades
Turbidez	5 unidades **	25 unidades
Gusto	Límite subjetivo de aceptación	—
Olor	Límite subjetivo de aceptación	—
Hierro (Fe)	0,3 mg/l	1,0 mg/l
Manganeso (Mn)	0,1 mg/l	0,5 mg/l
Cobre (Cu)	1,0 mg/l	1,5 mg/l
Cinc (Zn)	5,0 mg/l	15 mg/l
Calcio (Ca)	75 mg/l	200 mg/l
Magnesio (Mg)	50 mg/l	150 mg/l
Sulfatos (SO_4)	200 mg/l	400 mg/l
Cloruros (Cl)	200 mg/l	600 mg/l
*p*H	$7{,}0 < pH < 8{,}5$	$6{,}5 < pH < 9{,}2$
Sulfato magnésico + sulfato sódico	500 mg/l	1 000 mg/l
Compuestos fenólicos (en fenol)	0,001 mg/l	0,002 mg/l
Extracto clorofórmico sobre carbón (ECC: contaminantes orgánicos)	0,2 mg/l	0,5 mg/l
Alquilbencensulfonatos (ABS: agentes tensioactivos)	0,5 mg/l	1,0 mg/l

(*) Escala colorimétrica al platino-cobalto.
(**) Unidades turbidimétricas.

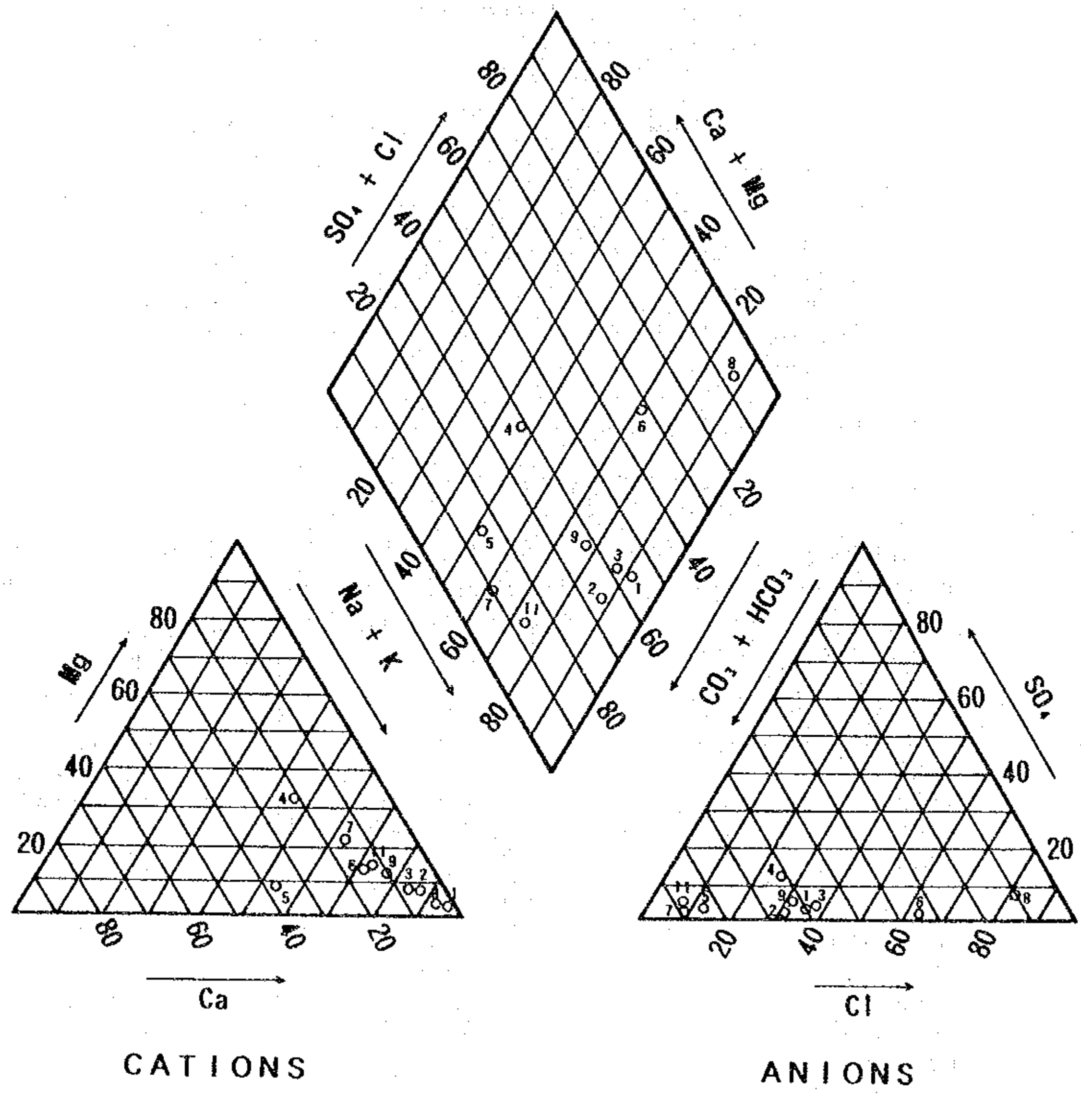


Fig. 4.7.1 Triliniar Diagram (River, Spring, Lakes)

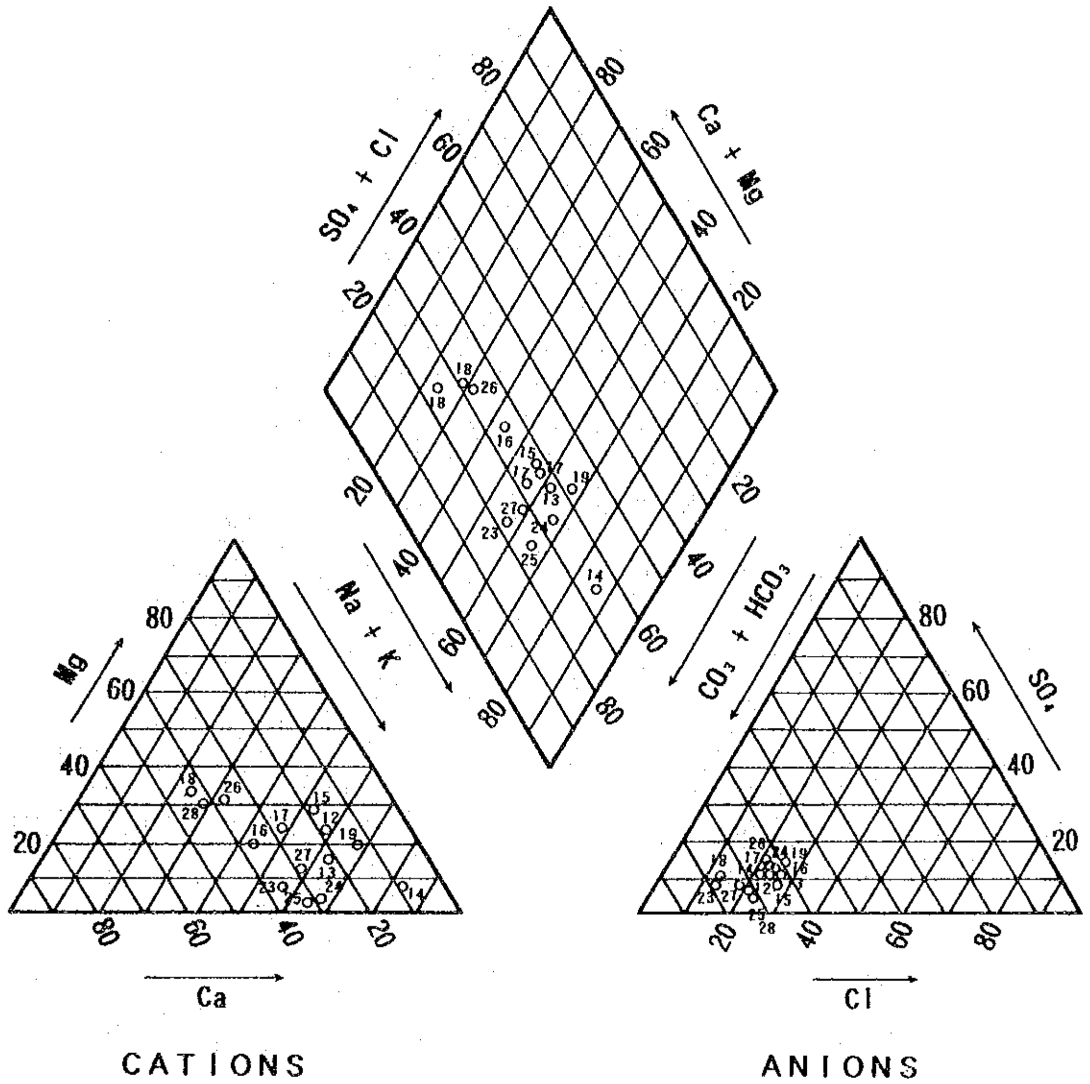


Fig. 4.7.1 Triliniar Diagram
(Western & Central Hydrogeological Basin

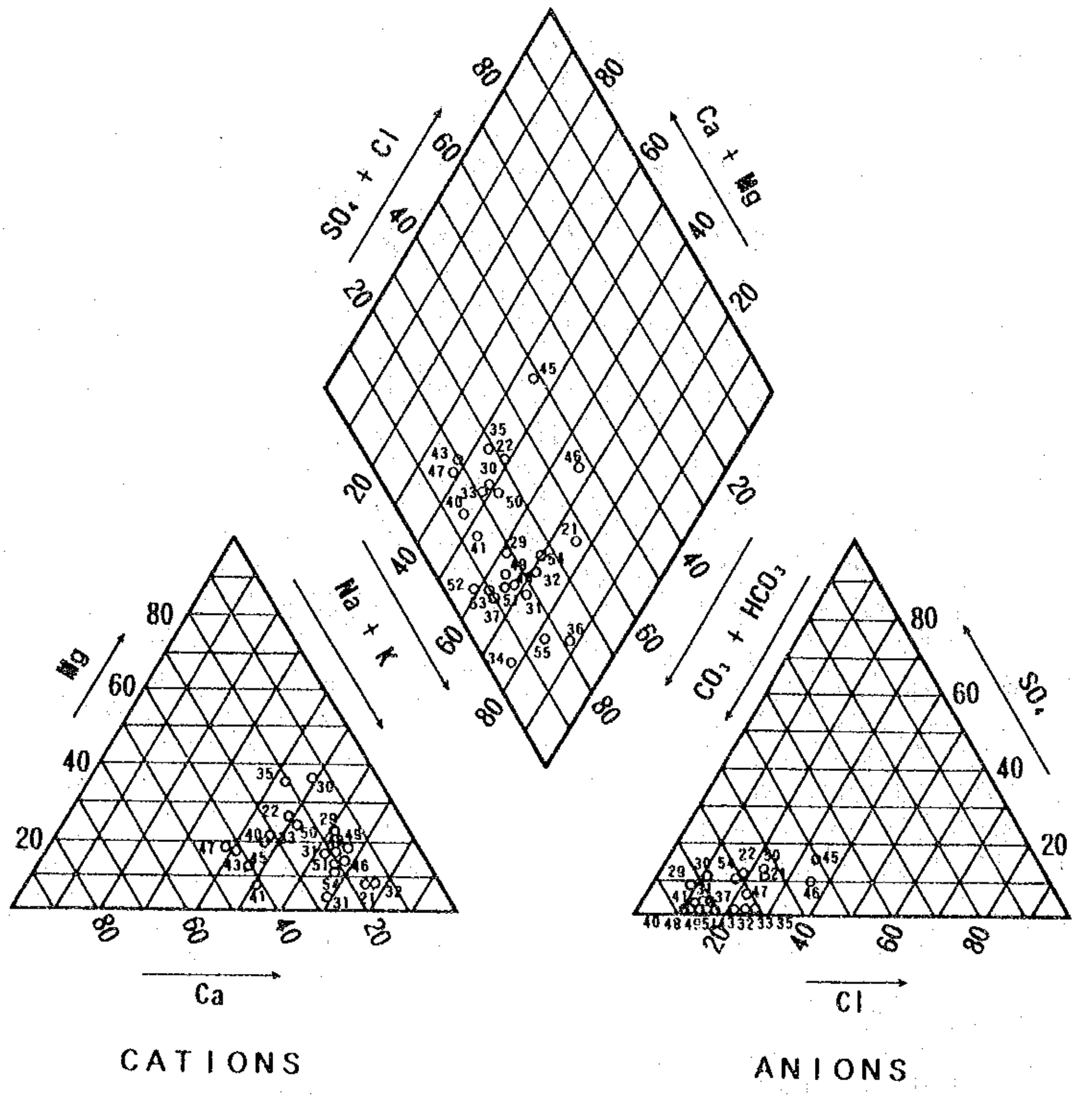


Fig. 4.7.1 Triliniar Diagram
(Eastern Hydrogeological Basin)

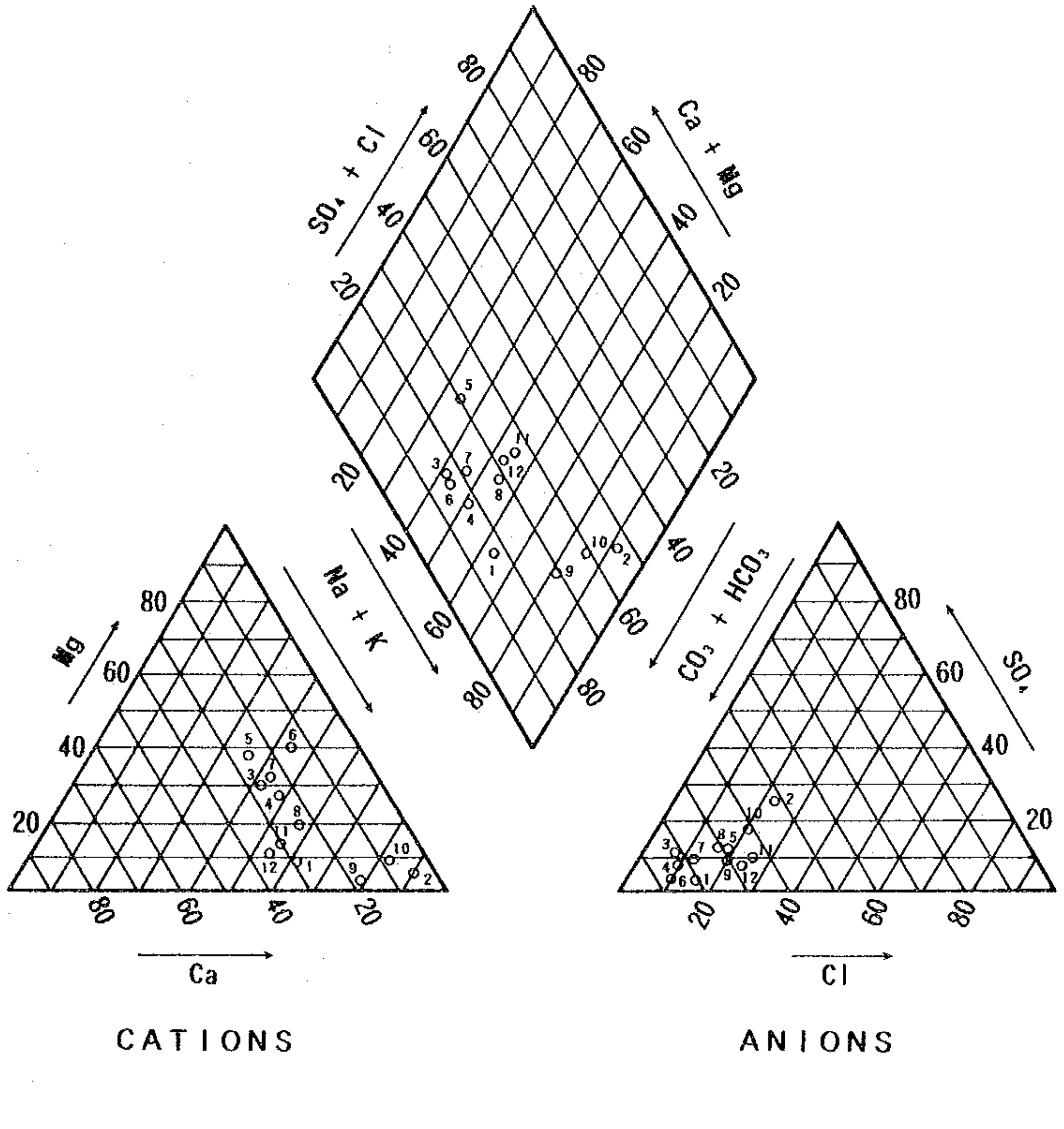


Fig. 4.7.1 Triliniar Diagram
(Test Drilling Sites)

Stiff Pattern Diagram (Diágrama Patrón de Stiff)

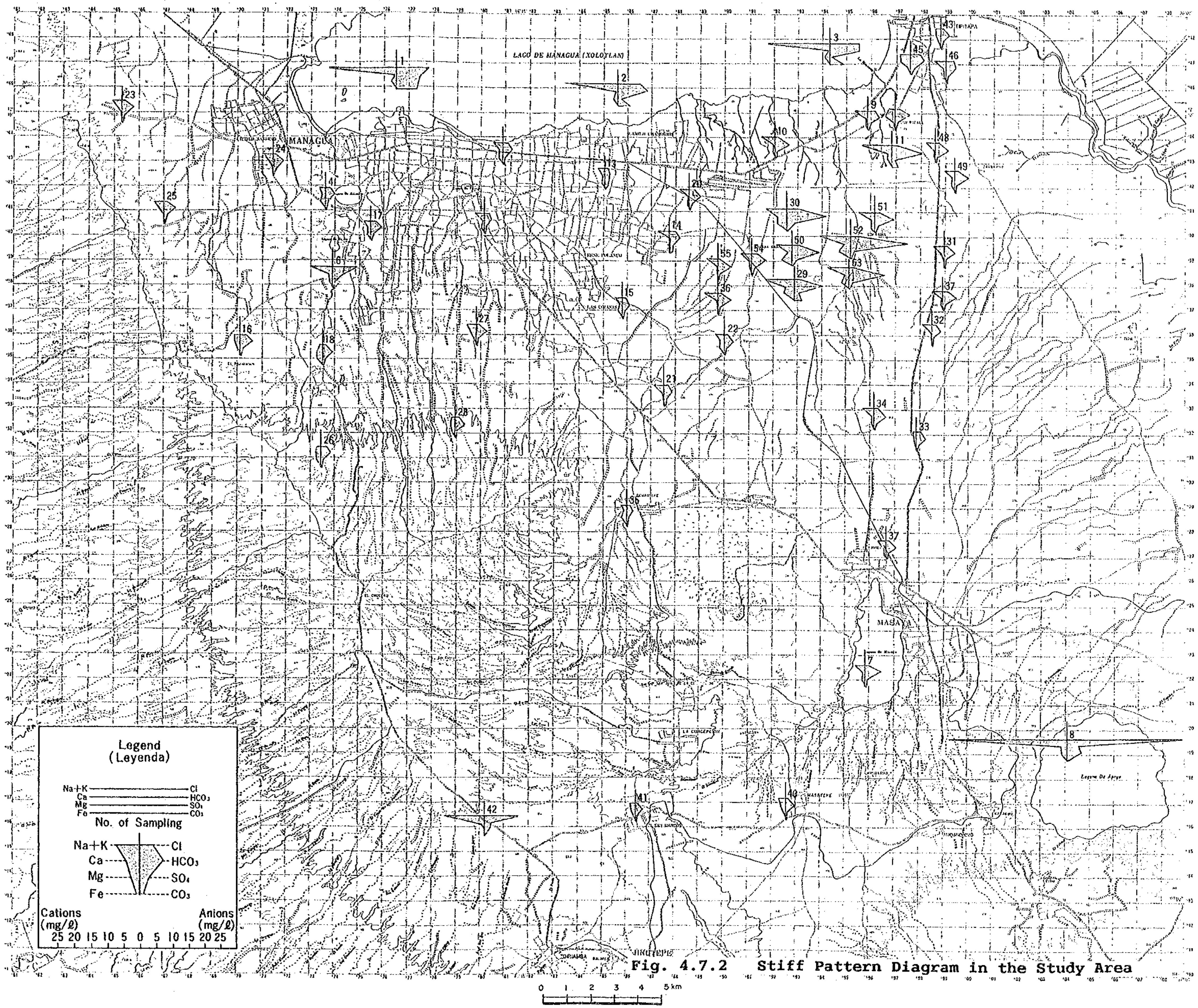


Fig. 4.7.2 Stiff Pattern Diagram in the Study Area

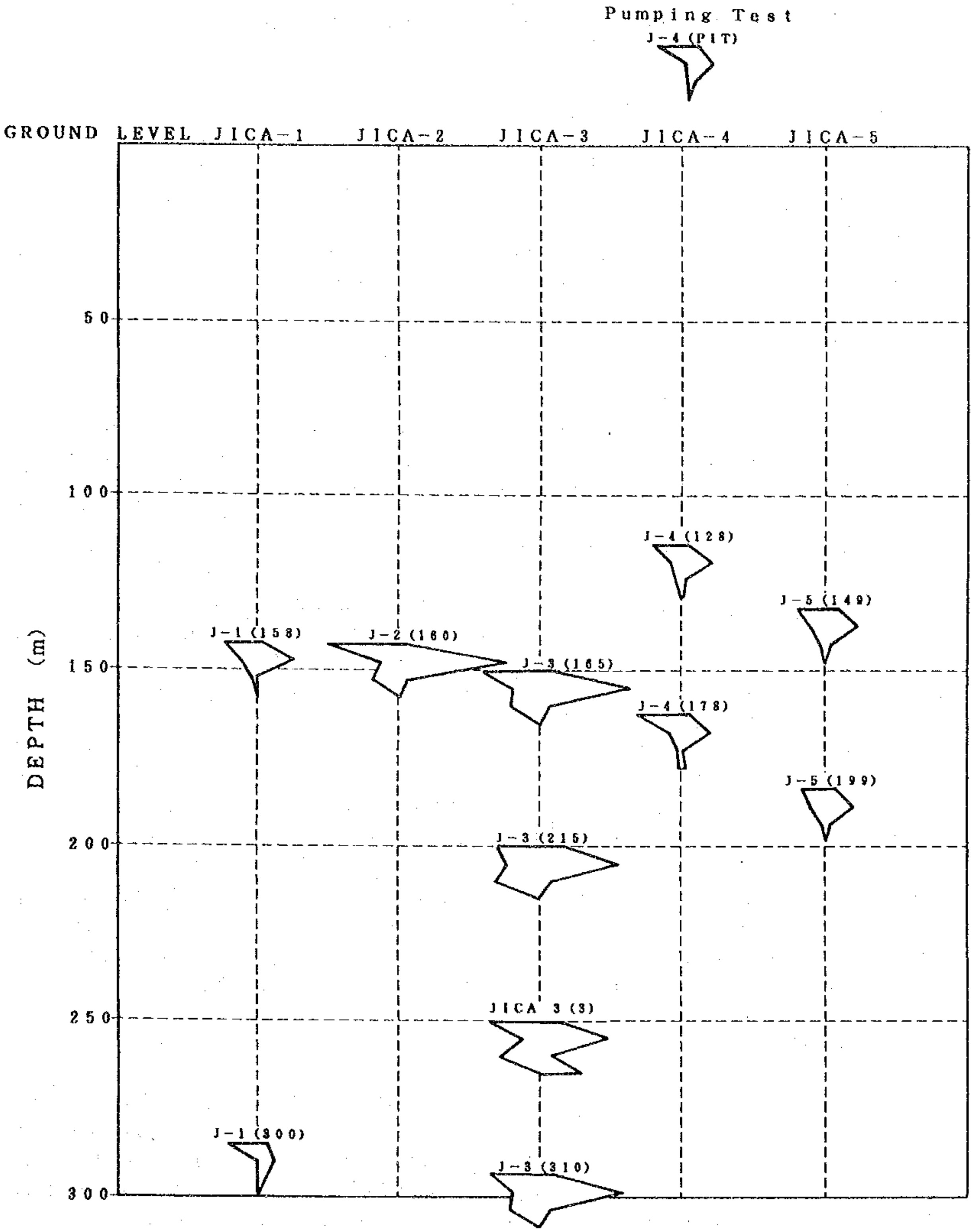


Fig. 4.7.3 Stiff Diagram of the Test Drilling Samples

4.8 Hydrogeological Features of the Study Area

4.8.1 Hydrogeological aspects

There are three principal water-bearing formations in the Study area: Alluvial deposits with Quaternary pyroclastic materials; Masaya Group Volcanics, and Middle Las Sierras Group. The El Salto formation and other Tertiary formations are regarded as hydrogeologically impermeable layers (aquitard or aquiclude).

(1) Alluvial deposits with Quaternary pyroclastic materials

The alluvial deposits are mainly distributed in the Los Brasiles Valley between the Mateare fault scarp and the volcanic chain of Apoyeque, Asososca, Nejapa and Ticomo, and the surroundings of the Las Mercedes shore area.

1) Los Brasiles Valley

The valley is filled up with debris deposits mainly from the Mateare fault scarp, lake deposits composed of sand, silt and clay, and the Quaternary pyroclastic materials such as pumice and scoria. These deposits show relatively high yielding capacity as shown in Table 4.8.1 (1). The principal aquifer in alluvial deposits is estimated to be found in coarse sand, pumice and scoria layers. For example, the existing wells with a depth of around 120-150 meters produce 2,000-6,000 m^3/day by a drawdown of around 5 meters in the northwestern part of the valley.

However, the alluvial deposits in the southern half of the valley are found above the layer where groundwater flow is observed. Thus, saturated groundwater areas within the alluvial deposits are only limited to the northern half of the valley.

2) Las Mercedes shore area

The shore area of Lake Managua surrounding Las Mercedes is underlain by alluvial deposits and Quaternary pyroclastic materials. According to the electric prospecting results and from the review of existing borehole records, the alluvial deposits in this area are estimated to mainly contain fine sand, silty and clayey materials with lenticular or thin beds of coarse sand and gravel, while the Quaternary pyroclastic materials are presumably composed of volcanic ash and debris flow deposits from the Masaya Group Volcanics and the Las Sierras Group.

From the above mentioned lithological characteristics, it is estimated that the alluvial deposits and the Quaternary pyroclastic materials in the area show relatively low yielding capacity as shown in Table 4.8.1 (10), and control the springs of groundwater from the Masaya Group Volcanics, as shown in the iso-value line map of specific capacity (Fig.4.8.3) and hydrogeological map (Fig.4.1.7).

(2) Masaya Group Volcanics

The principal aquifers of the Masaya Group Volcanics are basaltic-andesitic porous and auto-brecciated lava flows, permeable pyroclastic flow and pyroclastic fall deposits consisting mainly of coarse-grained scoria with rock fragments.

These water-bearing volcanic deposits are mainly underlain in an old valley which is estimated to be formed along Ticuantepe, Veracruz, Sabana Grande and Las Mercedes in the Middle Pleistocene, and generally have a high yielding capacity, as shown in Figure 4.8.3. In this Study, two test wells were drilled in Veracruz (J-2) and the eastern part of Sabana Grande (J-3) for the hydrogeological investigation of the Masaya Group Volcanics condition in an underground valley; the results of the test well drillings are as follows:

	J-2	J-3
Screen length in QvM (m)	34.47	60.96
Screen length in TQps(M)(m)	51.21	40.29
Discharge (Q= m^3/day)	2,469.12	2,998.08
Static water level (GL-m)	43.47	14.52
Drawdown (s= m)	3.59	2.68
Specific capacity (Sc = m^3/day/m)	687.77	1,118.64

The existing main well fields of the Masaya Group Volcanics are in Carlos Fonseca, Sabana Grande and Veracruz. However, the water-bearing formations of these well fields also characterize the Middle Las Sierras Group, as many wells drilled through the Masaya Group Volcanics penetrate the Middle Las Sierras Group. These well fields produce the following quantities of water.

Carlos Fonseca	(16 wells)	73,808 m^3/day	(4,613 m^3/day/well)
Sabana Grande	(5 wells)	14,913 m^3/day	(2,982 m^3/day/well)
Veracruz	(7 wells)	13,205 m^3/day	(1,886 m^3/day/well)
Total	(28 wells)	101,926 m^3/day	(3,641 m^3/day/well)

As mentioned before, there are many springs of groundwater from the Masaya Group Volcanics nearly along the hydrogeological boundary zone it shares with alluvial deposits (Fig. 4.1.7). These springs, however, are of lithologically different Masaya Group Volcanics (highly permeable) and alluvial deposits (relatively low permeability, see Fig. 4.8.3). The total discharge quantity from these springs is about 1.3 m^3/sec (February 1992).

From the above mentioned hydrogeological point of view, the Masaya Group Volcanics is expected to be the most important source for future groundwater development in the Study area.

(3) Middle Las Sierras Group

The Las Sierras Group (TQps) in the Study area consists of the Middle Las Sierras Group [TQps(M)] and the Upper Las Sierras Group [TQps(s)]. The former is distributed in all sub-areas in the Study area while the latter, the object of concern, is only distributed above the layer where groundwater exists.

TQps(M) yields large quantities of groundwater from porous permeable layers such as pyroclastic flows and pyroclastic fall deposits of scoria with rock fragments, as well as from weathered zones with fossil soils and fractured zones of basaltic-andesitic compact agglomerate with tuffbreccia and tuff. The existing wells of INAA drilled into TQps(M) are concentrated in the Managua central geohydrolic sub-area and produce large quantities of groundwater from aquifers of TQps(M).

Wells (53)	179,788 m^3/day	(3,392 m^3/day/well)
Lake Asososca	39,743 m^3/day	
Total	219,531 m^3/day	

Aquifer characteristics of TQps(M) obtained from the results of test well drilling in this Study are summarized in Table 4.8.2.

There is a hot spring naturally flowing out from the outcrops of TQps(M) at the river side of Tipitapa. Besides, it is known that some of the boreholes drilled near the areas of Tipitapa and Los Robles in the northeastern part of the Study area have encountered the hot spring aquifer of TQps(M). As shown in the hydrogeological map (Fig. 4.1.7), these hot spring aquifers are estimated to be controlled by a fault zone extending in the NNE-SSW direction. The chemical components of the hot spring at Tipitapa are as follows:

Temperature	:	97°C	SO_4	:	10 mg/l
PH	:		HCO_3	:	146 mg/l
Na	:	233 mg/l	Mg	:	1.2 mg/l
K	:	15 mg/l	SiO_2	:	150 mg/l
Ca	:	24 mg/l	CO_3	:	6 mg/l
Cl	:	316 mg/l	TDS	:	1002 mg/l

One of the purposes of test well drilling (J-3,400 meters) was to investigate geothermal conditions in the area in connection with the above mentioned hot spring. The result was already described in the "Test Well Drilling" section.

4.8.2 Geophysical features of hydrogeology

In this Study, 83 points of electric resistivity sounding were carried out. This electric prospecting employed the Gish-Rooney method with Wenner's and Schlumberger's electrode configurations and McOHM type resistivity meter. An outline of this prospecting method is given in Supporting Report and the breakdown of the field work is as follows:

Wenner's electrode configuration

	Prospecting depth (Gl-m)	Survey points
Phase I	100 - 200	44
Phase II	215	6
Total	(10,005 m)	50

Schlumberger's electrode configuration

	Prospecting depth (Gl-m)	Survey points
Phase I	400 - 500	8
Phase II	500 - 750	25
Total	(20,250 m)	33

These survey points were selected based on the hydrogeological conditions resulting from geological and hydrogeological reconnaissance with aero-photo interpretation, and the review and analysis of existing hydrogeological data. The major purposes of this electric prospecting work were:

- To investigate the hydrogeological conditions of an old valley fully distributed with Masaya Group Volcanics.
- To get detailed information on aquifers of the Middle Las Sierras Group.
- To investigate hydrogeological characteristics of the El Salto Formation and other Tertiary sedimentary rocks within hydrogeologically impermeable basal layers of the Managua geohydrolic area.

The electric prospecting results were hydrogeologically analyzed and the outcome of the analysis were correlated with the apparent electric resistivity values and lithofacies, as shown in Table 4.8.3. The result of the correlation was used as a basis in the formulation of hydrogeological cross sections shown in Fig. 4.1.8 to 4.1.12. The top elevation map of hydrogeologically impermeable basal layers underlying the Las Sierras Group shown in Fig. 4.8.2 was prepared for water balance analysis, which should be based mainly on the results of electric prospecting and its geological and hydrogeological analyses (Table 4.8.4). The hydrogeological analysis of the electric prospecting results, briefly mentioned above, will be detailed in a later section.

4.8.3. Permeability of aquifer

In this Study, existing boreholes data containing discharge or pumping test records were collected as much as possible, and were analyzed and reevaluated hydrogeologically by type of aquifers and by geohydrolic sub-areas. As a result of this work, Table 4.8.1 and the iso-value line map of specific capacity shown in Fig. 4.8.3 were prepared to evaluate permeability of aquifers in the study area.

The major hydraulic characteristics of aquifer that affect groundwater movement and development potential are the ability to transmit and to yield water from storage, and both characteristics are evaluated by pumping test. The specific capacity is the amount of yield divided by drawdown, and empirically, transmissivity is given by:

$$T = aQ/s = aXSc \text{----------------} (A)$$

Where:

T = Transmissivity (m^2/day)

Sc = Specific capacity (m^3/day/m)

s = Drawdown in the borehole (m)

Q = Yield of borehole (m^3/day)

a = Dimension-less constant

(Based on field experience, Logan in 1964 suggested a = 1.22).

The existing records of transmissivity resulting from proper pumping tests are limited to a few well fields such as Carlos Fonseca, Sabana Grande and Veracruz. Therefore, transmissivity in Table 4.8.1 involves estimated values from the existing records of specific capacity by use of the above equation (A).

As shown in Table 4.8.1 and Fig. 4.8.3, remarkably different features of aquifer permeability is found throughout local geological and topographical conditions of every geohydrolic sub-areas. The Masaya Group Volcanics rank first in high permeability, followed by alluvial deposits and the Middle Las Sierras Group.

Areal features of aquifer permeability are summarized as follows:

(1) Western sub-area

The principal water-bearing formations are alluvial deposits, Quaternary pyroclastic materials and the Middle Las Sierras Group. As shown in Fig. 4.8.3, there is a zone of relatively high permeability and high yielding capacity in the northern half of the sub-area. It is estimated that water-bearing layers of this highly permeable zone consist mainly of weakly consolidated and porous pyroclastic materials (scoria and pumice), and sand or sandy beds of the Quaternary. The average transmissivity (T) and specific capacity (Sc) values of the 11 existing wells in this highly permeable zone are as follows:

T : 821 m^2/day

Sc : 673,44 m^3/day/m

According to the results of electric prospecting and test well drilling (J-5), the Middle Las Sierras Group of this sub-area unconformably overlies the El Salto Formation and the Brito Formation, as shown in the hydrogeological cross section in Fig. 4.1.8. Apparent resistivity values of these Tertiary formations are as follows:

El Salto Formation	3 - 24 ohms (in general, 3 - 10 ohms)
Brito Formation	133 - 990 ohms

From the electric resistivity values and existing borehole records (Table 4.8.1 (12)), these Tertiary formations are regarded as hydrogeologically permeable basal layers. The shape of the top surface of Tertiary formation is estimated as shown in Fig. 4.8.2.

(2) Managua central sub-area

The principal water-bearing formation in this sub-area is the Middle Las Sierras Group. According to some of the existing borehole records and the results of test well drilling such as J-1, J-4 and J-5 in this Study, the main aquifers of the Middle Las Sierras Group in the sub-area consist of fractured and weathered zones with fossil soils of basaltic-andesitic compact agglomerate with tuffbreccia and tuff, and local porous and permeable layers of pyroclastic flows and pyroclastic fall deposits (scoria beds).

As shown in Table 4.8.1, the existing data on the specific capacity of the 19 wells in the Asososca -Ticomo Volcanoes well field and 47 wells in the Managua Central well field were used. Average values of specific capacity and estimated transmissivity of these areas are as follows:

	Sc (m^3/day/m)	T(m^2/day)
Asososca-Ticomo Volcanoes Well field (19 wells)	417.60	509
Managua central well field (47 wells)	320.64	391
Total (Managua central sub-area) (66 wells)	348.48	425

Fig. 4.8.4 was prepared to analyze the relation between specific capacity and drilled depth in the saturated zone of the Middle Las Sierras Group, based on existing borehole records on drilled depth, static water level and specific capacity. The Figure indicates no correlation between specific capacity and drilled depth in the saturated zone, and that specific capacity values of those existing borehole records are mainly influenced by local geological and hydrological conditions affecting the Middle Las Sierras Group.

Resulting from the above analysis and consideration, highly permeable zones, with a specific capacity similar to the Middle Las Sierras Group in the sub-area shown in Fig. 4.8.3, are estimated to be strongly affected by fractured zones of NE-SW fault systems, rather than by lithological conditions of the Middle Las Sierras Group itself.

The probable existence of Tertiary formations regarded as hydrogeologically impermeable basal layers, presented in the hydrogeological cross sections shown in Fig. 4.1.8 and 4.1.10, and the shape of those top surfaces is presented in Fig. 4.8.2.

(3) Eastern sub-area

As mentioned before, the principal water-bearing formations in the sub-area consist of alluvial deposits and Quaternary pyroclastic materials, the Masaya Group Volcanics and the Middle Las Sierras Group. Of these formations, Masaya Group Volcanics was considered to have potential for groundwater development, followed by Middle Las Sierras Group and the alluvial.

The total existing borehole records of 44 wells in this sub-area were collected to evaluate permeability of those water-bearing formations shown in Table 4.8.1. Meanwhile, the iso-value live map of specific capacity shown in Fig. 4.8.3 was prepared, based on the above mentioned borehole records and the geological and hydrological conditions of the sub-area.

As shown in Table 4.8.1, the majority of the specific capacity values in this sub-area are composite specific capacity values of multiple water-bearing formations such as a combination of the Masaya Group Volcanics and the Middle Las Sierras Group. Therefore, Fig. 4.8.3 was tentatively prepared as the average and representative distribution map of the specific capacity value of all water-bearing formations of this geohydrolic sub-area, for convenience of water balance analysis.

Average values of specific capacity and estimated transmissivity of the main local well fields in the sub-area are as follows:

Western area of Sabana Grande and Carlos Fonseca (8 wells)

Main water-bearing formation : TQps(M)

Sc : 363 ms2^3/day/m(252 l/min./m)

T : 443 m^2/day (3.07 X 10^{-1} m^2/min.)

Sabana Grande - Carlos Fonseca - Cofradía (15 wells)

Main water-bearing formations : QvM and TQps(M)

Sc : 1,597 m^3/day/m (1,109 l/min./m)

T : 1,948 m^2/day (1,35 m^2/min)

Las Mercedes including part of Carlos Fonseca (7 wells)

Main water-bearing formations : Qal, QvH/P and QvM

Sc : 184 m^3/day/m (128 l/min./m)

T : 215 m^2/day (1.49 X 10^{-1} m^2/min.)

Veracruz and its surroundings (4 wells)

Main water-bearing formations : QvM and TQps(M)

Sc : 1,466 m^3/day/m (1,018 l/min./m)

T : 1,794 m^2/day (1.21 m^2/min.)

Southwestern area of Veracruz (6 wells)

Main water-bearing formations : QvM and TQps (M)

Sc : 279 m^3/day/m (194 l/min./m)

T : 340 m^2/day (2.36 X 10^{-1} m^2/min)