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IN
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B-III PAMPA DEL TAMARUGAL BASIN

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B-III PAMPA DEL TAMARUGAL BASIN

Chapter I. TOPOGRAPHY AND GEOLOGY

1.1. Topography

The Pampa del Tamarugal basin consists of the parts of Altiplano, Precordillera and Intermediate Depression, as shown in Fig. B-I, 1.1.1. The Pampa del Tamarugal is lying over the Intermediate Depression and bounded by the Coastal Range to the west and the Precordillera to the east. It is located at an altitude between 1,000 and 1,600 m.

Drainage patterns of the basin extracted from LANDSAT images are shown in Fig. B-III, 1.1.2, and these form two different types; a dendritic pattern at the Altiplano and a subparallel pattern at the Precordillera and Intermediate Depression. Main rivers in the basin are Aroma, Tarapaca, Quipisca, Tambillo, Quisma, Chacarilla and Guatacondo rivers. It is a quite interesting feature observed on the images, that all the streams of Aroma, Tarapaca, Quipisca and Tambillo flow into the Salar de Pintados.

1.2. Geology

1.2.1. Methodology of Geological Analysis

On the details of the methodology, refer to the part of San Jose River basin.

1) Interpretation of LANDSAT images

As for the Pampa del Tamarugal Basin, six (6) scenes of images were used, whose path and row are: 001-073; 001-074; 001-075; 002-073; 001-074 and 002-075. Details of the used data are shown in Table B-I, 1.2.1.

2) Interpretation of Aerial Photographs

One hundred ninety seven sheets of black and white aerial photographs taken in 1977 and 1981 were used for the interpretation.

1.2..2. General Geological Features of Basin

A few geological maps published by SERNAGEOMIN are available in Pampa del Tamarugal as mentioned below.

Geological Maps

"Pisagua y Zapiga" (1:100,000) (<1)
"Mamiña" (1:50,000) (<2)
"Juan de Morales" (50,000) (<3)
"Pica, Alca, Matilla y Chacarilla" (<4)

Magnetic Map

"Arica, Pisagua-Huara" (1:250,000) (<5)

The results of the interpretation on the basin were compiled in Fig. B-III, 1.2.1 reviewing these existing data. Stratigraphic classification is given in following table;

Geologic Age	Formation	Lithology	Units
Quaternary	Recent Sediments	alluvial, eolian, fan deposits	Qal, Qc, Qf.
Quaternary / Tertiary	Altos de Pica Formation	continental sedimenatry rocks and pyroclastic rocks, divided into 5 members: - Member 5 : dark to greenish grey and middle to fine grained sandstone. - Member 4 : pinkish orange-grey to white rhyolitic tuff. - Member 3 : yellowish middle to coarse sandstone. - Member 2 : pinkish orange and dark grey rhyolitic welded tuff. - Member 1 : yellowish brown conglomerate and middle to coarse grained sandstone.	TQau TQal
Mesozoic	Longacho Formation	fissible shale, mudstone, fine sandstone, limestone, generally grey in color.	J

1) General Geology of the Basin

Geology of Pampa del Tamarugal Basin is composed of Mesozoic and Cenozoic rocks, as shown in Table. The interpretation resulted in the classification of six geological units is shown in Fig. B-III, 1.2.1. Lithology of each discriminated units were discussed with published references which are mainly from Carlos Gali Oliver and Robert J. Dingman (1962). Lithological characteristics of each unit are as follows:

(1) Mesozoic Unit (J)

It is distributed on the low isolated mountains forming anticlinal structure at the eastern side of Pampa del Tamarugal. Mesozoic rocks outcropping around Pica are called the Longacho Formation which consists of fissible shale, mudstone, fine sandstone and limestone, generally grey in color. In many parts, the rocks of this formation are intensely silicified.

The Mesozoic Formation is intruded by andesite, dacite, diorite, granite porphyry, syenitic porphyry and gabbro.

(2) Altos de Pica Formation (Upper Tertiary to Lower Quaternary) (TQau)

The Formation is divided into three continental sedimentary members, distinguished with the numbers 1,3 and 5, and two members mainly composed of pyroclastic rocks, 2 and 4. The sequence of each members of Altos de Pica Formation in type -locality is as follows:

Member 5 : Dark to greenish grey and middle to fine grained sandstone, containing ventifact, showing cross-bedding. (200 m in thickness).

Member 4 : Pinkish orange-grey to white rhyolitic tuff. (23 m in thickness).

Member 3 : Yellowish middle to coarse sandstone, containing ventifact, showing cross-bedding. (173 m in thickness).

Member 2 : Pinkish orange and dark grey rhyolitic welded tuff. (17 m in thickness).

Member 1 : Yellowish brown conglomerate and middle to coarse sandstone, showing cross-bedding. (322 m in thickness).

Member 5 is easily differenciated from other members on the LANDSAT images and aerial photographs. Member 5, TQau on the interpretation map, shows pinkish grey or dark grey color on LANDSAT images. The welded tuff of extensive distribution between Pica and Salar del Huasco is corresponding to Member 4.

(3) Recent (Upper Quaternary) Unit (Qf, Qe, Qal)

It consists of three units, which are fan deposits, eolian deposits and alluvial deposits. Among these ones, fan deposits have a wide extent in Pampa del Tamarugal.

2) General Geological Structure of the Basin

The results of interpretations revealed the two interesting facts on the structure, which are the successional anticlinal structure with N-S trend and dense fractures developed in the welded tuff of Altos de Pica Formation.

Anticlinal structures can be observed at the low isolated mountains between the area from Tarapaca in the north to Challacollo in the south, where the Mesozoic rocks are exposed in parts (see Fig. B-III, 1.2.1). These structures are supposed to be successional from north to south with culminations and play a part of trap of the groundwater.

Fractures in the welded tuff show two systems in NE-SW and N-S directions, as shown in Fig. B-III, 1.2.2. NE-SW system fractures are extended from Collacagua to Altos de Pica and N-S systems are located in the Altos de Pica. These fractures are thought to control the groundwater system and to be a pathway to lead water to Pica.

1.2.3 Hydrogeological Characteristics of Pampa del Tamarugal

Geology of Pampa del Tamarugal is classified into three (3) units from the hydrogeological point of view;

Recent Sediments
Altos de Pica Formation
Basement Rocks

Pampa del Tamarugal is a closed structural basin and is filled by the basin fill deposits, the Altos de Pica Formation, formed by salty crust, sand, gravel, silt, clay, etc. Basement Rocks are mainly composed of the Mesozoic Formation so that they are impermeable in general. The Altos de Pica Formation is seemed to be permeable considering its lithology. Principal aquifers are occurred in this formation which widely cover the basin. Lithology of the aquifers are mainly sand and gravel. The thickness of the deposits are generally less than 100 m in the north and increase toward the south reaching 700 m in Salar de Pintados.

The aquifers are recharged groundwater mainly form the Quebradas flow into the basin from the east. Channels of the Quebradas are concentrated in the following are as shown in Fig. B-III, 1.1.2;

(1) Huara area
(2) Pozo Almonte area
(3) the lower reaches of the Qda. de Chacarilla

Furthermore, the Altos de Pica formation will supply the groundwater through fissures and faults of ENE-WSW direction in Pica and Matilla area as mentioned in 1.2.2.

The groundwater flows gently from north to south (from Huara to Salar de Bellavista) after entered in the basin.

As the extension of the aquifers are so wide (about 4,000 km^2) that the influence of extraction of groundwater is quite small (Ref. Chapter 3, 3.2).

Fig. B-III, 1.2.5 shows geological structure and a schematic geological profile in Pica and Salar del Huasco area. In Pica area, the Altos de Pica Formation is thickly deposited in the eastern side of the rise of the Basement Rocks. As the Basement Rocks are impermeable, the groundwater flowing in the Altos de Pica Formation is dam up and occurs as the springs in Pica area. The similar hydrogeological condition is recognized along the eastern side of the basin such as Mamiña and Camiña area.

References

<1: Cuadrangulos "Pisagua y Zapiga", Carta Geologica de Chile (Escala 1: 100,000), 1962 for Instituto de Investigaciones Geologicas Chile by Carlos Galli Olivier y Robert J. Dingman.

<2: Cuadrangulos "Mamiña", Carta Geologica de Chile (Escala 1: 50,000), 1967 for Instituto de Investigaciones Geologicas Chile by Arturo Thomas N.

<3: Cuadrangulos "Juan de Morales", Carta Geologica de Chile (Escala 1: 50,000), 1968 for Instituto de Investigaciones Geologicas Chile by Carlos Galli Olivier.

<4 Cuadrangulos Pica, Alca, Matilla y Chacarilla, Carta Geologica de Chile (Escala 1: 50,000), 1962 for Instituto de Investigaciones Geologicas Chile by Carlos Galli Olivier y Robert J. Dingman.

<5: Hojas "Arica, Pisagua-Huara", Carta Magnetica de Chile (Escala 1: 250,000), 1983 by Servicio Nacional de Geologia y Mineria,

<6: Analisis Programa de Desarrollo de Empresa de Servicios Sanitarios de Tarapaca, February 1991 for ESSAT by Bustamante y Schudeck Ingenieros Consultores Ltda.

Table B-III, 1.2.1 Correlation of Strata

<Correlación de Estratos>

AGE / Area	ARICA PROVINCE	CAMARACA and AZAPA	PISAGUA and ZAPIGA	MAMIÑA	JUAN de MORALES	PICA, ALCA, MATILLA, CHACARILLA	QUILLAGUA	PAMPA DEL TAMARUGAL	PAMPA DEL TAMARUGAL
Author (Year)	Salas et al. (1966)	Tobar et al. (1968)	Ignacio Silva (1977)	Thomas (1967)	Galli (1968)	Galli and Dingman (1962)	Skarmeta and Marinovic (1981)	ENAP (1987)	JICA (1994)
CENOZOIC – QUATERNARY – Holocene	Volcanics	Recent Deposits	Recent Deposits	Recent Deposits	Recent Deposits	Recent Deposits	Recent Deposits	Recent Deposits	Recent Deposits
CENOZOIC – QUATERNARY – Pleistocene	Concordia F. Huaylas F.	El Diablo F.	Gravel, Andesitic Clastics [Altos de Pica F.]	Upper [Altos de Pica F.]	Imagua M. [Altos de Pica F.]	TQa 5 TQa4 TQa3 [Altos de Pica F.]	Soledad F.	A B [El Loa Limestone] [Fill Deposit of Pampa]	Q4 Q3 Q2 Q1 [Upper (TQau)] [Altos de Pica F.]
CENOZOIC – TERTIARY – Neogene – P.	Oxaya F.	Oxaya F.	Ignimbrite, Riolites Gravel [Altos de Pica F.]	Ignimbrite, Riolite Lower [Altos de Pica F.]	Tambillo M. Sagasca M. [Altos de Pica F.]	TQa2 TQa1 [Altos de Pica F.]	El Loa F. Ichuno F.	C D E [Altos de Pica] [Fill Deposit of Pampa]	[Lower (TQal)] [Altos de Pica F.]
CENOZOIC – TERTIARY – Neogene – M.	Azapa F.	Azapa F.					Sichal F.		
CENOZOIC – TERTIARY – Paleogene – O.	Putani F. Lupica F.						Tambillo F.		
MESOZOIC	Sausin F. Arica F.	Atajaña F. Los Tarros F. Camaraca F.	(Intrusive) Huantajaya F. Caleta Ligate F. Of. Viz F.	Cerro Empexa F. Chacarilla F.	Cerro Empexa F. Chacarilla F. Duplija F.	Cerro Empexa F. Chacarilla F. Longacho F.	Arca F. Quinchamall F.	Pintados F.	Basement

(Note) : constructed by the JICA Study Team (1994).

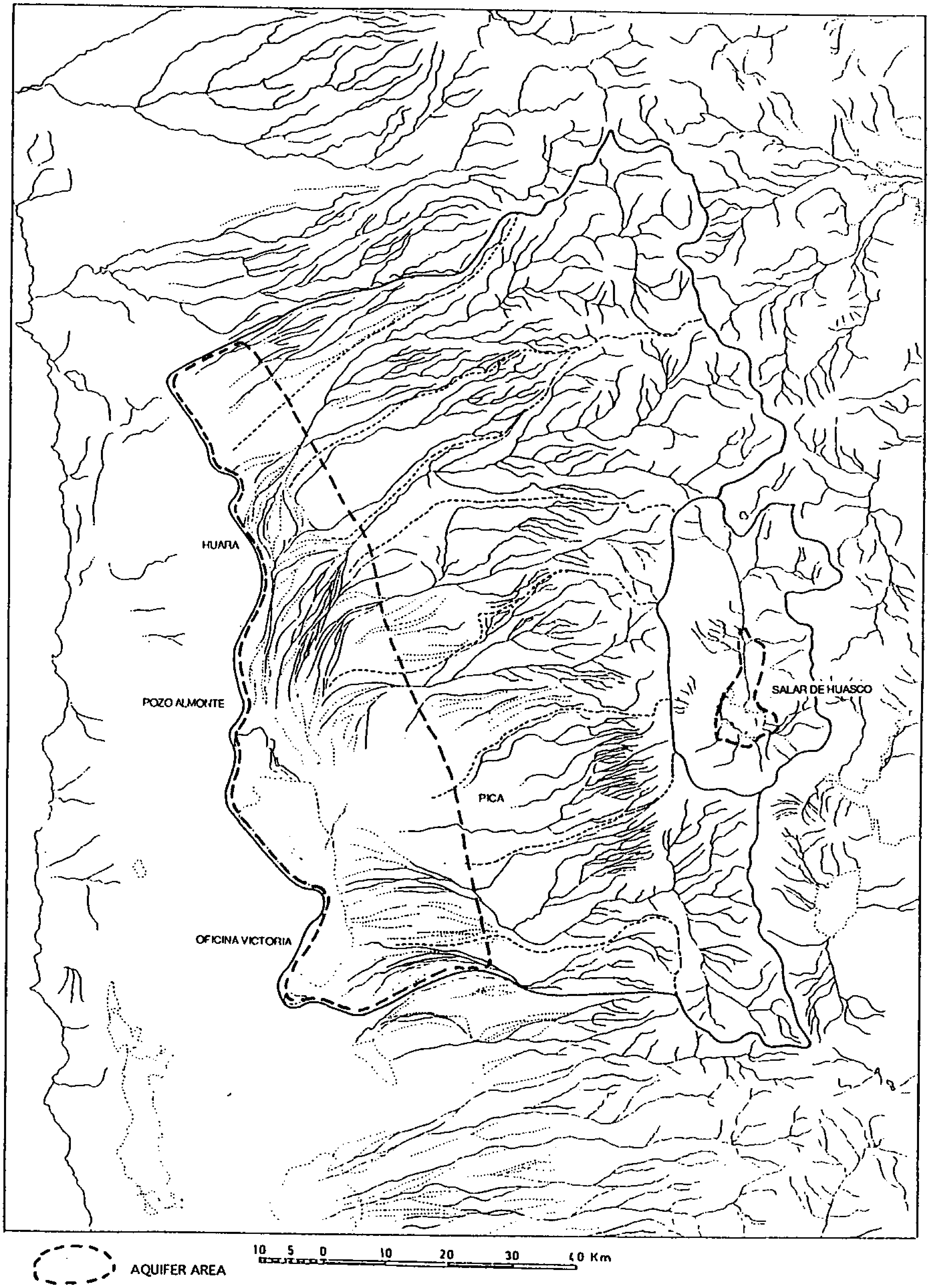

Fig. B-III. 1.1.1 River Network (Pampa del Tamarugal)

< Red Hidrologica (Pampa del tamarugal)>

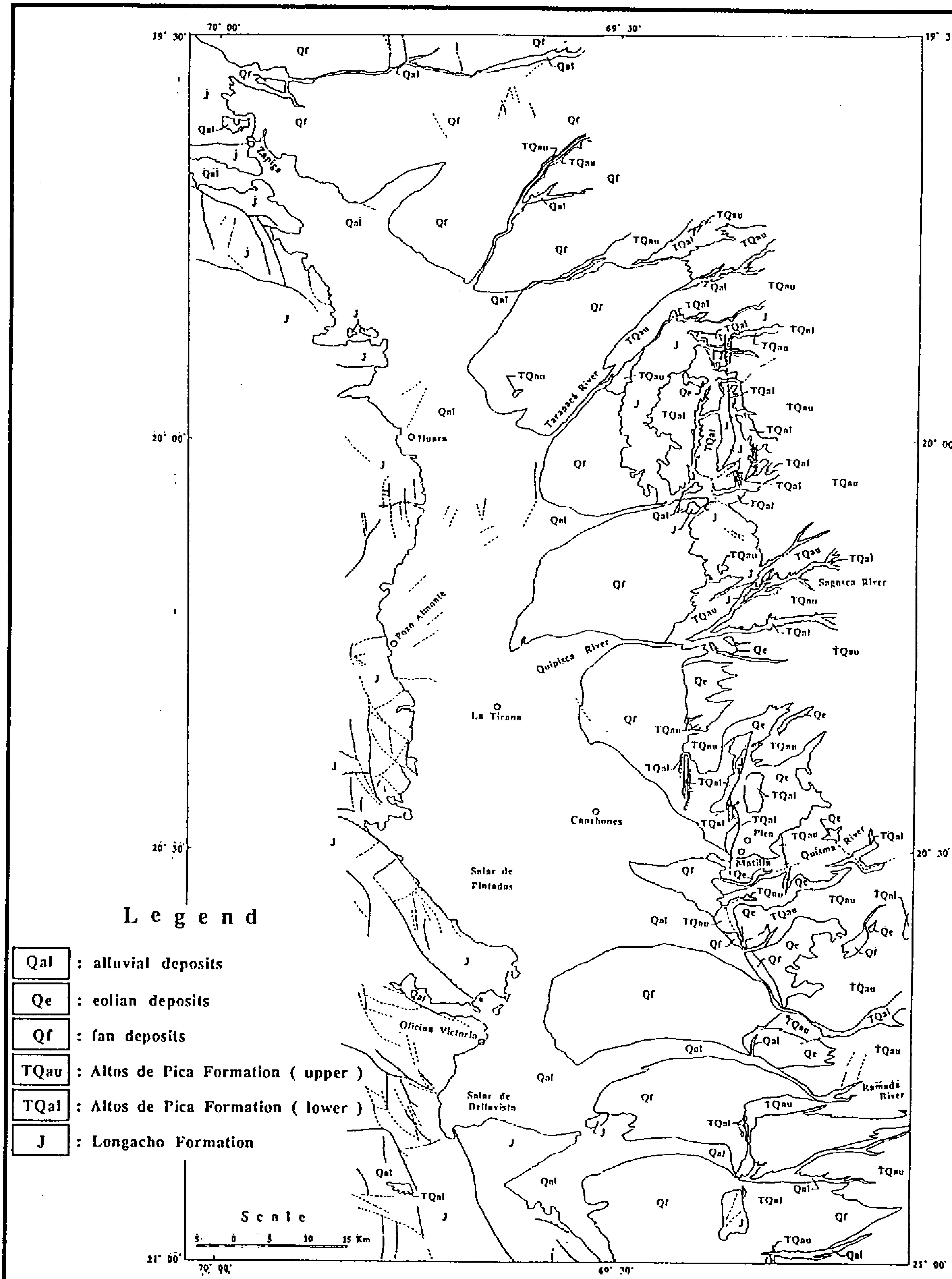

Fig. B-III. 1.2.1 Geological Map (Pampa del Tamarugal)

< Mapa Geologico (Pampa del Tamarugal)>

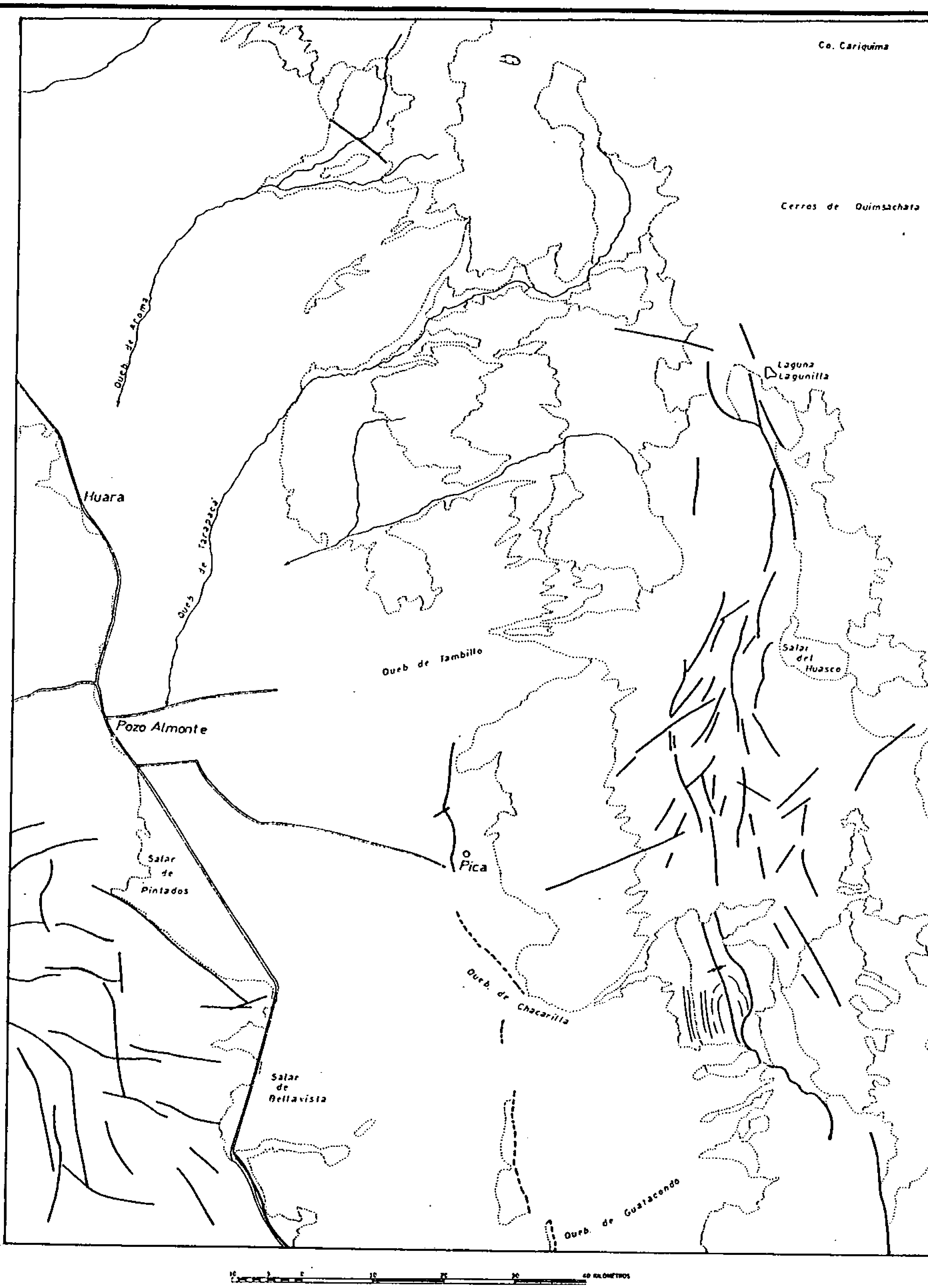

Fig. B-III. 1.2.2 Geological Structure (Pampa del Tamarugal)

<Estructura Geológica (Pampa del Tamarugal>

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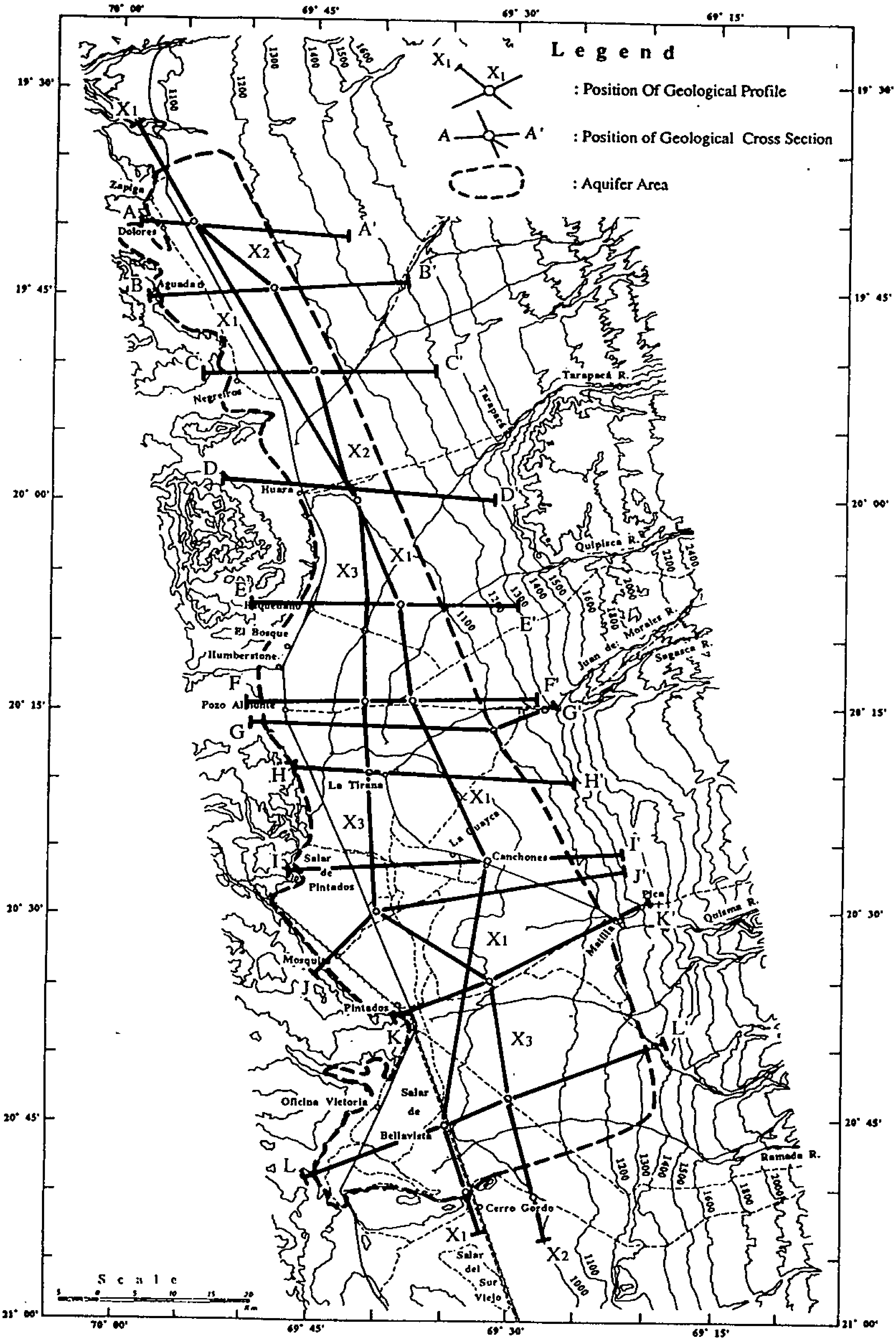

Fig. B-III, 1.2.3 Location of Geological Profile and Cross Section (Pampa del Tamarugal)
< Ubicación Perfil Geológico y Sección Geológica Transversal (Pampa del Tamarugal) >

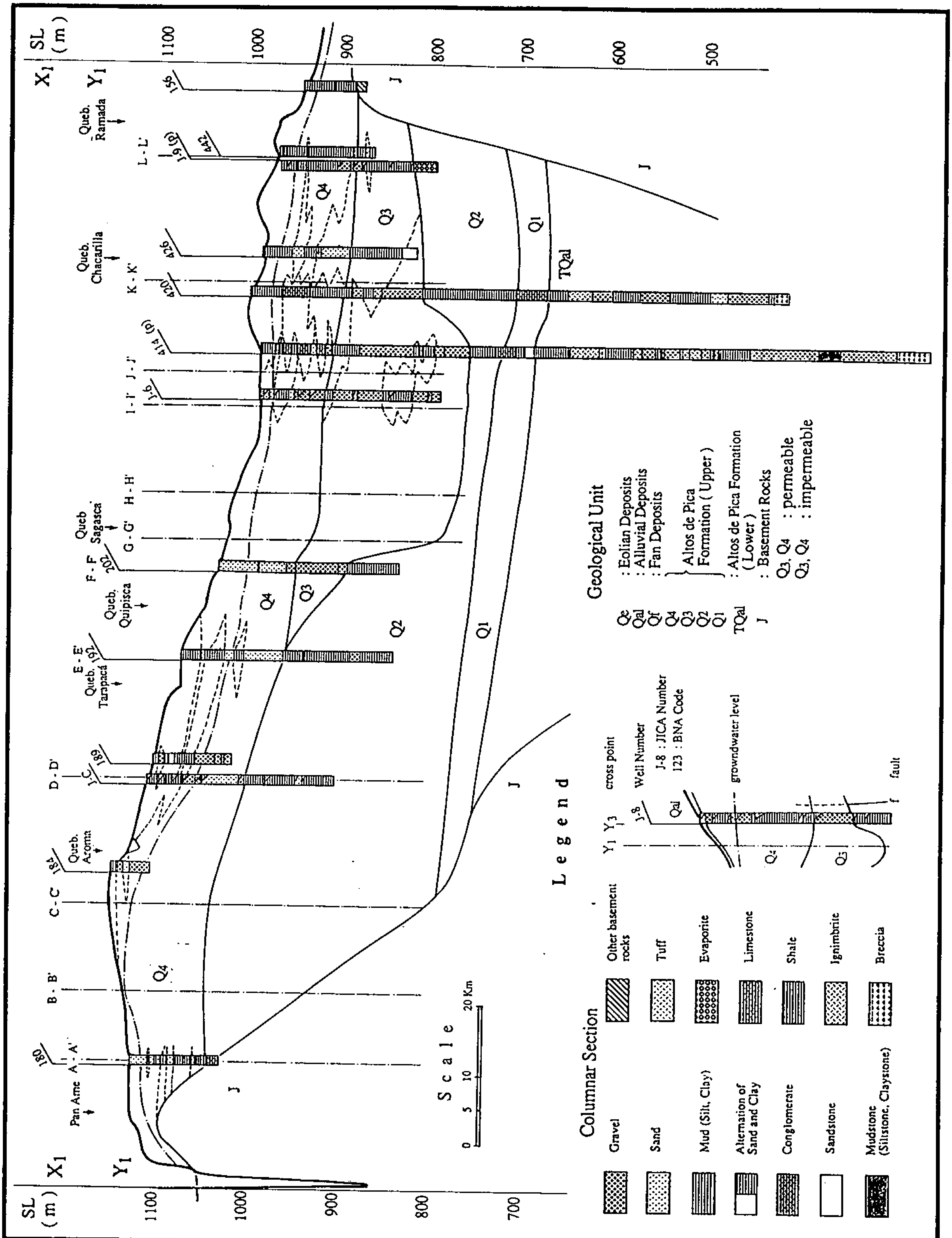

Fig. B-III, 1.2.4 (1) Geological Profile (Pampa del Tamarugal)

< Perfil Geológico (Pampa del Tamarugal)>

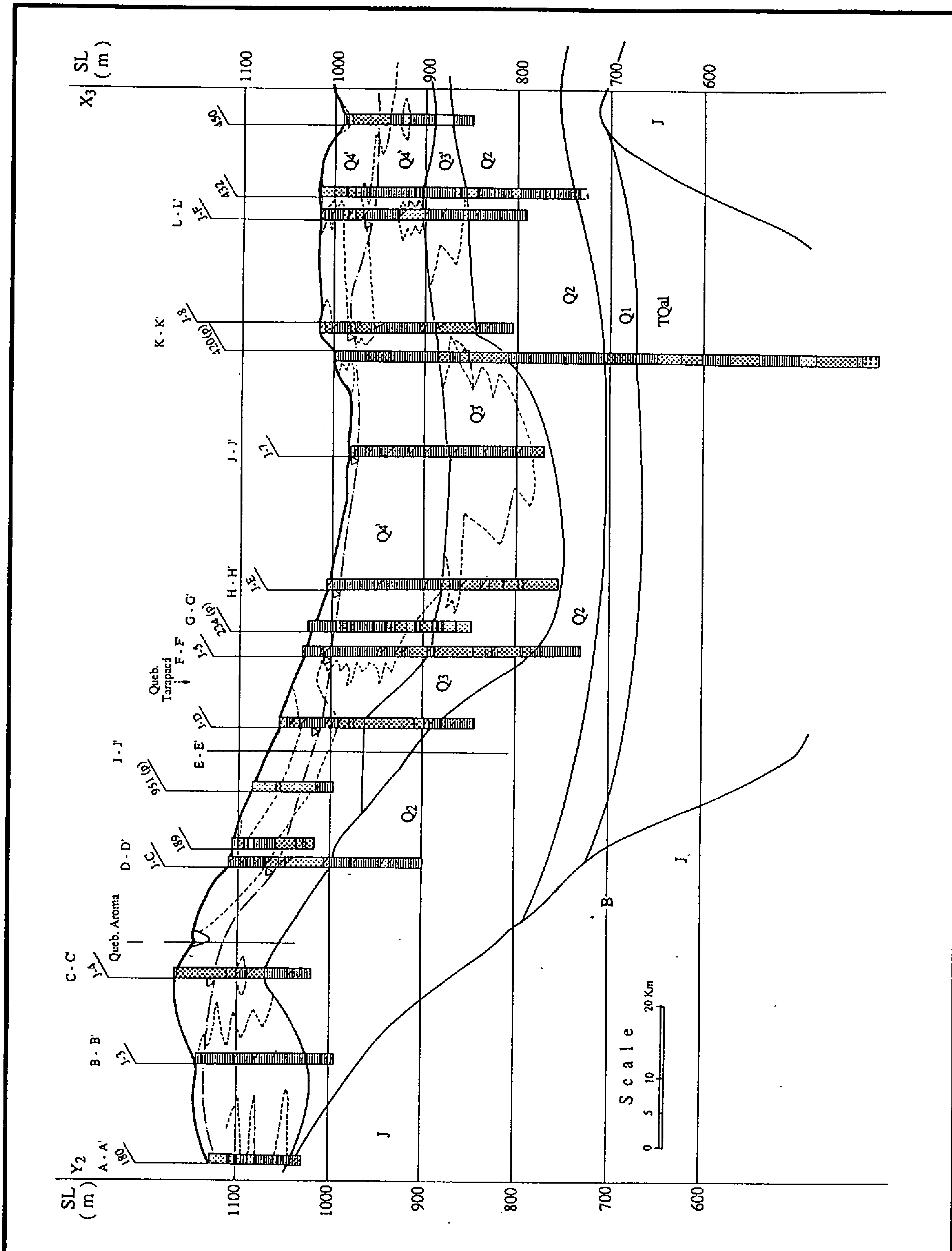

Fig. B-III, 1.2.4 (2) Geological Profile (Pampa del Tamarugal)

< Perfil Geológico (Pampa del Tamarugal)>

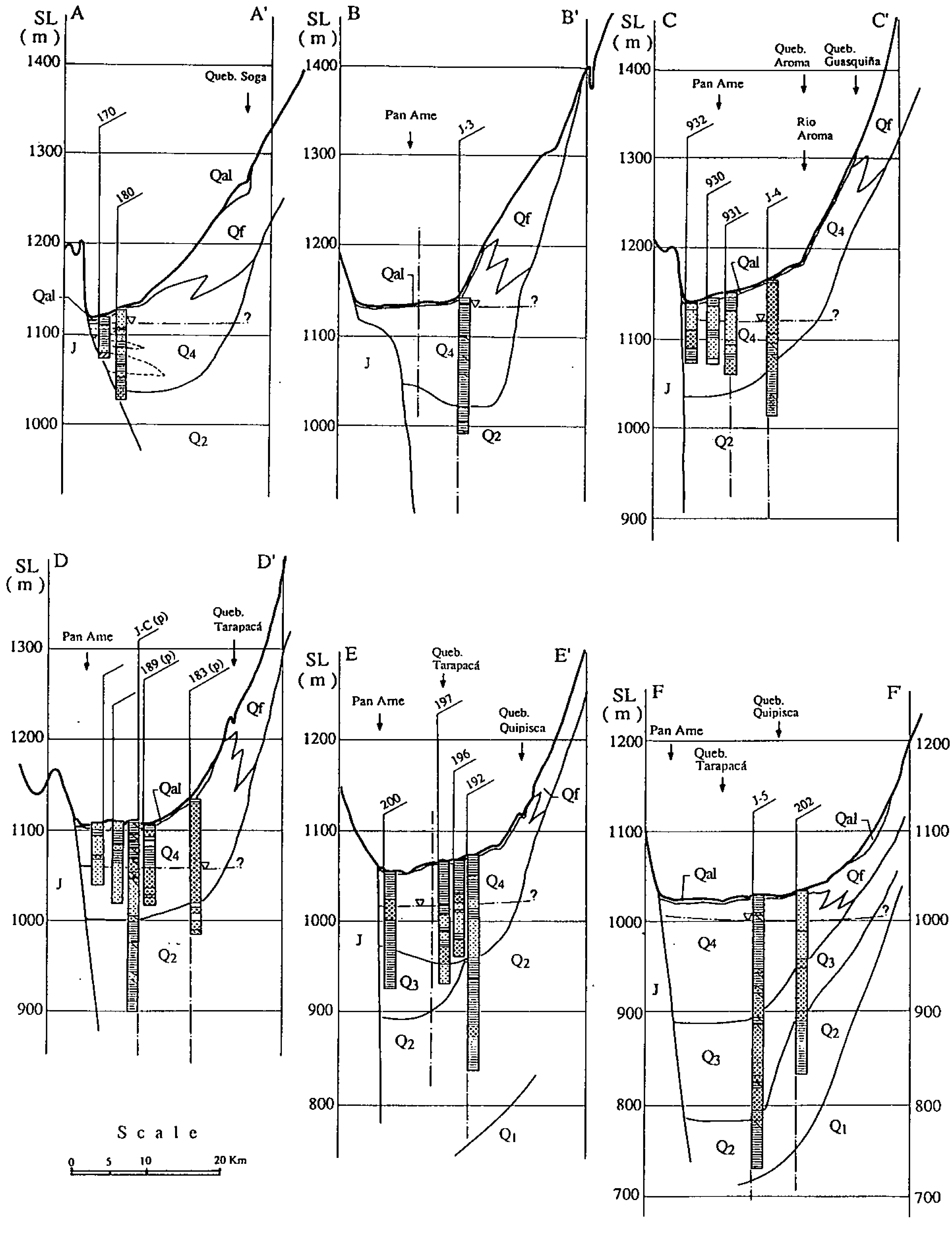

Fig. B-III, 1.2.5 (1) Geological Cross Section (Pampa del Tamarugal)

< Sección Geológica Transversal (Pampa del Tamarugal)>

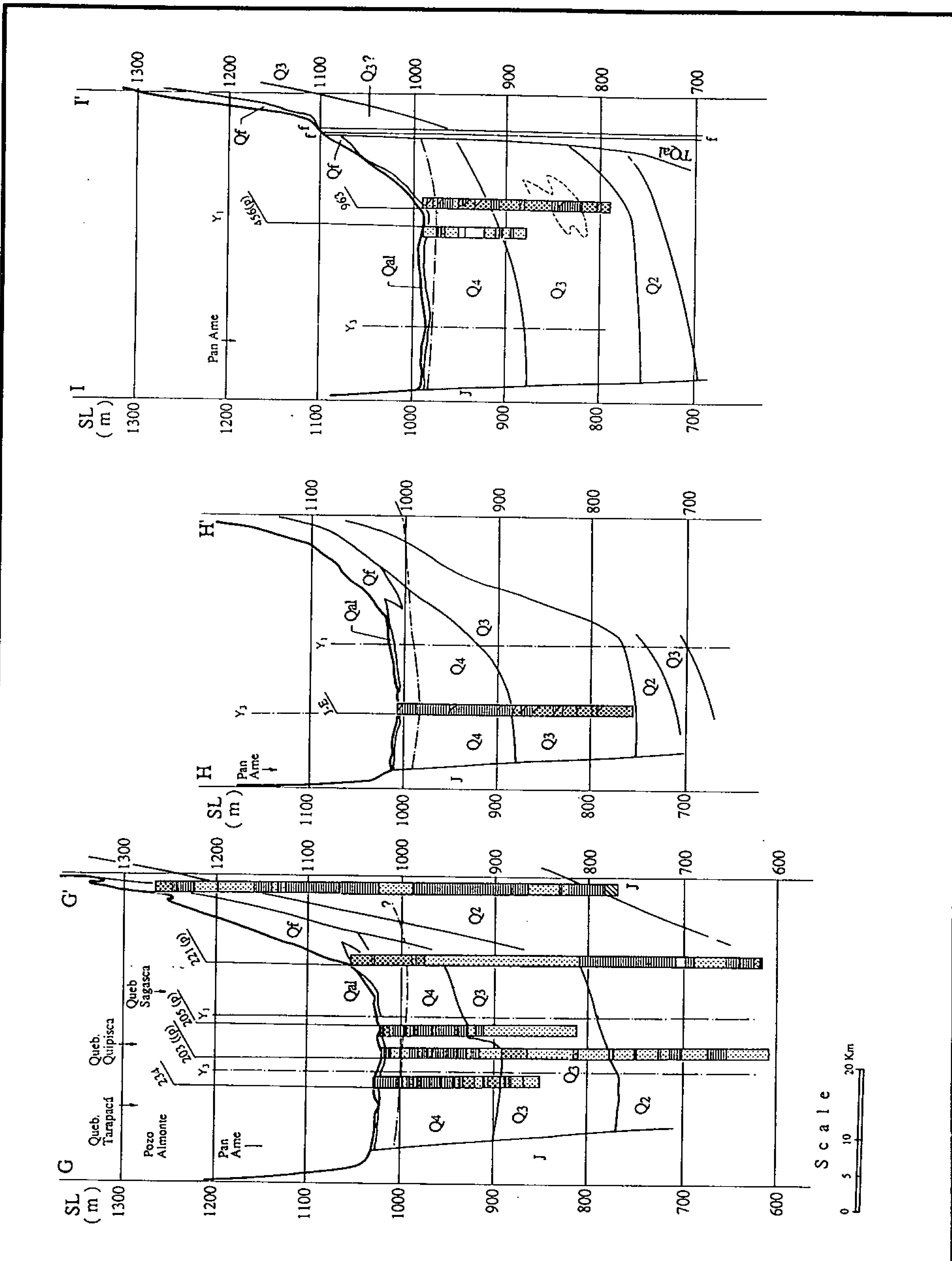

Fig. B-III, 1.2.5 (2) Geological Cross Section (Pampa del Tamarugal)

< Sección Geológica Transversal (Pampa del Tamarugal)>

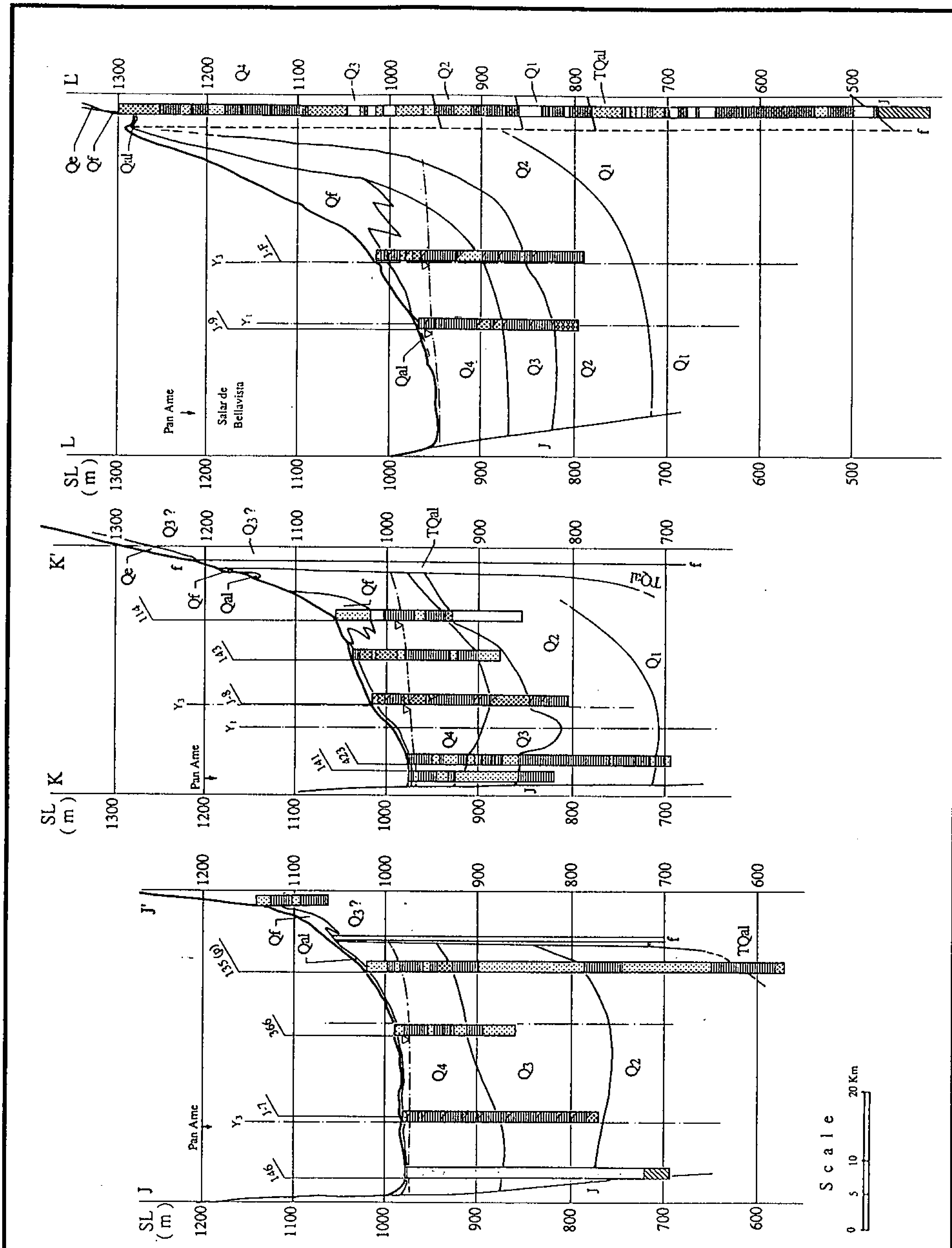

Fig. B-III, 1.2.5 (3) Geological Cross Section (Pampa del Tamarugal)

< Sección Geológica Transversal (Pampa del Tamarugal)>

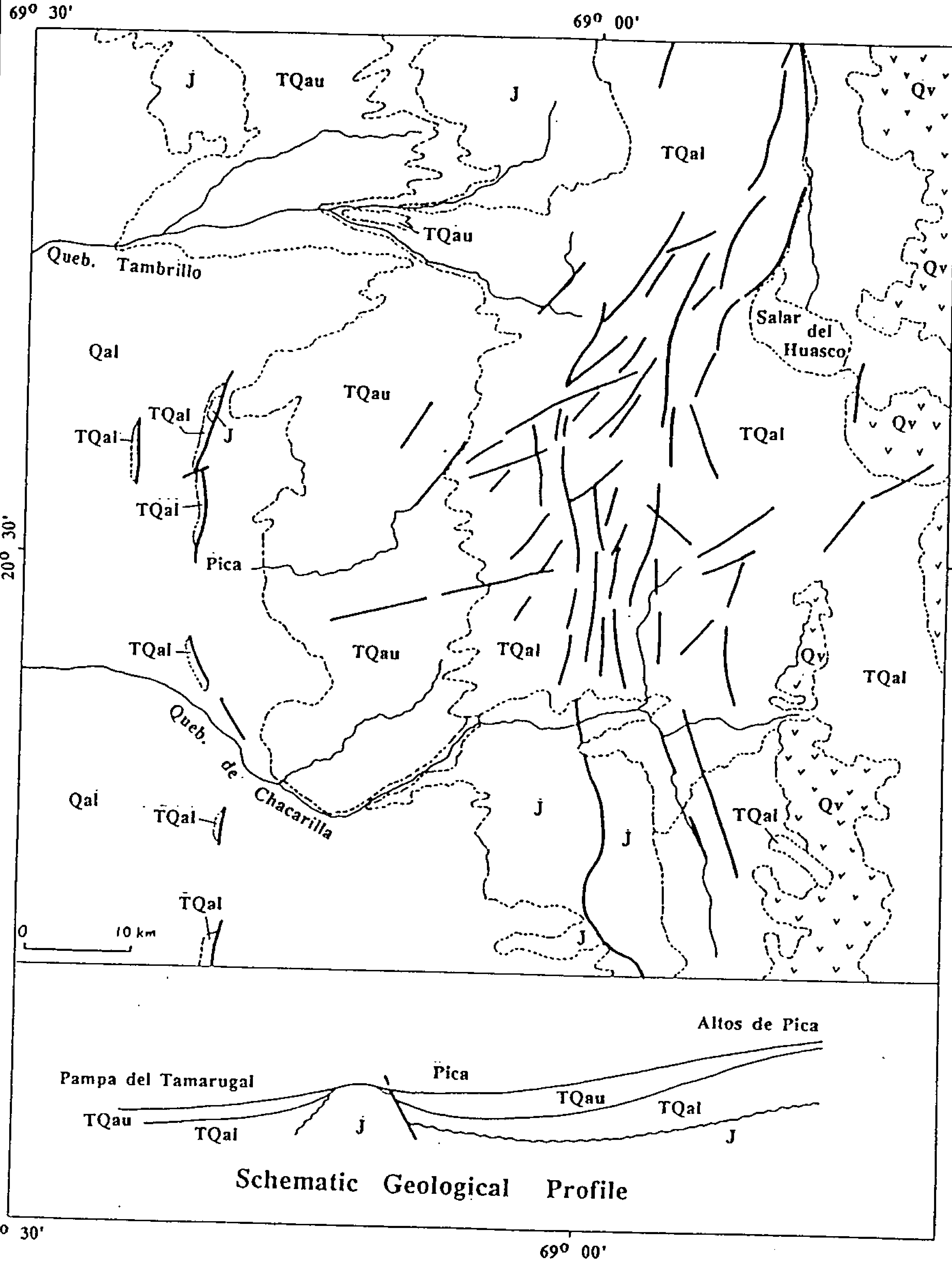

Fig. B-III, 1.2.6 Geological Structure (Pica and Huasco)

<Estructura Geológico (Pica and Huasco)>

Chapter II. AQUIFER OF PAMPA DEL TAMARUGAL BASIN

2.1 Inventory of Existing Wells

The inventory of existing wells was established by the JICA Study Team based on the same method mentioned in Clause 2.1 of Chapter II in B-I reviewing the following reports:

(1) Analisis Critico de la Red de Medicion de Niveles de Agua Subterranea 1 region, October 1987 for DGA by Alamos y Peralta Ingenieros Consultores Ltda.

(2) Modelo de Simulacion Hidrogeologico de la Pampa del Tamarugal, 1988 for DGA by Universidad de Chile.

The wells in Pampa del Tamarugal are given the numbers based on both the BNA code and the CORFO code(1975). Once the DGA code and the CORFO code(1969) were used. The CORFO code(1963) was improved to the CORFO code(1975) and the DGA code is not applied afterward.

In this report, the wells are expressed by the three (3) digits of consecutive numbers on the basis of the BNA code like "188".

The number of wells (sondajes) comes to 458 in the basin, consisting of 256 wells for research including observatory wells, 5 wells for industrial use, 77 wells for potable water supply, 35 wells for irrigation, 49 wells for mining and 36 wells have no data. Out of 458 wells, total number of 68 wells are already abandoned. In addition to this, there are many dug wells in the basin, however, no data are available.

381 wells are already registered to BNA/CORFO(1975) (Table B-III, 2.1.1 (1)). 63 wells were drilled in Pampa del Tamarugal to applicate water right for mainly mining and irrigation use in the second half of 1980s. Those 63 wells' data are collected by DGA. Most of these wells has not yet registered to neither BNA nor CORFO (1975). Therefore, temporary numbers (BNA/CORFO) are given to the wells for the convienience (Table B-III, 2.1.1 (2)). Accordingly, a total number of 458 wells were listed in the Well Lists in Pampa del Tamarugal; 395 well in Table B-III, 2.1.1 (1) and 63 wells in 2.1.1 (2)14.

As for the date of well construction, 285 data are available and 171 wells have no data. The number of well construction and the increase of the wells are shown in Fig. B-III, 2.1.2 (1) and (2). The wells have been constructed every year since 1950. Significant increase suddenly occurred during three (3) years; 1965, 1966 and 1967. Totally 175 wells were constructed in this period; most wells are for water level observation. The number of wells exceeded 200 during 1950 and 1967. A few wells were constructed in 1970s. In 1980s, number of well constraction increased for the water right as mentioned above. Even in 1990s, well constraction have been continued.

Depth of well is shown in Fig. B-III, 2.1.3. 235 wells are drilled up to the depth less than 100 m. 56 wells are in a depth between 100 and 200 m and rest 49 well are penetrated more than 200 m. This means that most well are tapping groundwater from the shallower aquifers..

2.2 Existing Boring Data

2.2.1 Boring Logs

More than 400 boring logs are collected from the existing wells (both registered wells and new wells for appllication of water right). These logs were interpreted from the hydrogeological point of view and constructed geostratigraphic columns which are attached to the Well Inventory (see, Data Book).

2.2.2 Pumping Test

The results of pumping test are shown in Well List (Table B-III, 2.1.1). Aquifer constants are estimated only 36 wels and 40 data show only draw down and pumping rate. Specific yield (Sy) was calcurated based on the 40 pumping data.

2.3 Supplementary Geological Survey

The following geological surveys were executed by the JICA Study Team to supplement the existing geological data. The survey location is shown in Fig. B-III, 2.3.1.

a) Electromagnetic Survey	100 survey points (8 lines)
b) Boring Survey	
(a) Drilling	
Test well drilling	4 wells
Observation well drilling	7 wells
(b) Pumping Test	11 wells
c) Water Quality Analysis	11 wells (JICA wells)
d) C-14 analysis	5 wells

2.3.1 Electromagnetic (TEM)Survey

1) Survey Area

Transient Electro Magnetic (TEM) survey is conducted at Pampa del Tamarugal area as shown in Fig. B-III, 2.3.1. Eight (8) TEM lines were set perpendicular to main axis of Precordillera range. A total of 100 stations were set at interval of 2000m each as shown below.

Quantity of TEM Survey

	Profile	Stations	Station Interval
	PT-1	14	2000 m
	PT-2	9	2000 m
	PT-3	28	2000 m
	PT-4	14	2000 m
	PT-5	8	2000 m
	PT-6	15	2000 m
	PT-7	4	2000 m
	PT-8	8	2000 m
Total		100	

2) Methodology of Survey

For the details of the methodology, see B-II, section 2.3.1 of chapter II.

3) Survey Results

Typical apparent resistivity curves in the area are shown in the Fig. B-II, 2.3.2. Geoelectrical profile are made by the apparent resistivity curve of each station. The geoelectrical profiles along line PT-1 to PT-8 are shown in Fig. B-III, 2.3.3. According to well logging (long normal) data of three (3) existing wells (Pintados No. 1, No. 2 and Dolores No. 1), the resistivity value of aquifer with no contamination is in the range of 10 to 40 ohm-m. Among theses wells, Pintados No.1 is located at near station N0.5 of PT-8. Resistivity calibration was made by logging data of Pintados No.1as shown in Fig. B-III, 2.3.4.

The resistivity structure of the surveyed area is classified as 3 to 4 layers with stratiform structure. The geophysical characteristics of each layer are summarized as follows

a) The first layer (10 m to 120 m thick) shows a resistivity range of 28 to 1400 ohm-m. The layer is distributed in the whole area. In same area, such as at station No. 1 to 3 and 6 to 8 of PT-5, and station No.13 to 16, 21 to 23, and 25 to 28 of PT-3, the layer shows a relatively low resistivity (28 to 100 ohm-m). This is probably due to the wet land conditions by irrigation water. The resistivity of the layers at station 11 to 13 of PT-1 and all stations of PT-7 are extremely high (more than 1000 ohm-m). This is probably due to the hard and dry land conditions. In general, the eastern part of the area, the layer shows higher resistivity than the western part. This resistivity range is between 200 and 1200 ohm-m. It is considered that the surface of eastern part of the area is rather dry than the western part. The thickness of the layer is gradually increased to southeastwards.

   The depth to the boundary of between the first and second layer is almost coincident with the water levels of wells in the area.

b) The second layer (between 20 and 400 m thick) shows a resistivity range of approximately 10 to 50 ohm-m. The layer is distributed in mostly all the stations of profiles. According to the resistivity logging data of the existing well of Pintados No. 1 (located at near station No. 5 on profile PT-8), this layer is considered as expected aquifer. The thickness of the layer is gradually increased from 100m (PT-1) to 400m (PT-7). However, it is rapidly decreased from 200m (PT-8) to less than 100m (PT-4). At the west of PT-4, the layer is divided into two parts by the third layer.

c) The third layer (more than 50 m thick) shows a resistivity value approximately lower than 10 ohm-m. The layer is distributed in the whole area. The layer is presumed to have groundwater potential to same degree. However, its low resistivity would indicate that the layer is contaminated by salt. The depth to the layer is gradually increased southwards.

d) The forth layer shows a resistivity value approximately higher than 100 ohm-m. The layer is distributed in the northern and western part of the area. According to the existing data such as well logging of Dolores No.1 and gravity map of the area, the layer is considered as the geological basement composed of high density rocks. Thus, the layer is classified as impermeable basement.

Lateral discontinuities of resistivity exist between station No. 4 and No. 5 of PT-2, between station No. 4 and No.5 of PT-6, between station No. 2 and No. 3 of PT-3, and between station No. 1 and No. 2 of PT-7. These discontinuities may be coincident with geological boundaries such as faults of fracture zones.

4) Interpretation with Boring Log

Geoelectric profiles, described in above section are analyzed together with boring log including lithology observed and geophysical logging data. Fig B-III, 2.3.5 to 2.3.12 shows analyzed resistivity profiles interpreted by inverted geoelectrical sections and boring logs. Position of screen is also indicated. These figure consisting of Analyzed Layered Model showing analyzed resistivety profile with boring log and Resistivety Inversion showing isoresistivity in the same profile. Interpretation for each analyzed resistivity profile are summarized as follows.

i) Profile PT-1 (see Fig. B-III, 2.3.5)

The profile is analyzed as four (4) layered model except eastern part where the survey point of No. 11 to 13 is located. In this area (location of survey point 11 to 13), the surface is divided by two (2) part; the top surface is high resistivity (1100 to 1300 ohm-m) area because of dry land, and lower surface is averaged resistivity (96 to 300 ohm-m) as first layer. The most of surface layer (first layer) in the profile, is represented by this lower surface. Well No. J-C is located at the survey point No.4. Based on the apparent resistivity and boring log interpretation, the second layer (resistivity range from 8.1 to 27 ohm-m) was expected as most promising aquifer. The screen pips were installed in this layer. Third layer is confirmed at limited position of between second and fourth layer from the survey point 5 to 14. Resistivity range of less than 8.7 ohm-m is confirmed in this layer, however, the boundary for the bottom of layer is unclear. The summary of the interpreted relation between lithological formation and resistivity range is descried in following table.

Layer	Depth (m.bgl)	Resistivity Range(ohm-m)	Lithology	Interpretation
1 st	0 - 90	1100 - 1300	not confirmed	Dry Surface
	0 -40	96 -300	sandy clay	Surface Formation
2 nd	40 - 130	8.1 -27	clayey gravel at upper, clayey sand at middle, clay at lower	Expected Aquifer
3 nd	-	<8.7	not confirmed	Contaminated Aquifer
4 th	>130	>100	sandy clay	Impermeable Bed

ii) Profile PT-2 (see Fig. B-III, 2.3.6)

Four (4) layered model is applied in this profile by the apparent resistivity and boring log of Well No. J-D. The second layer was interpreted as expected aquifer, and its resistivity range is from 7.9 to 14 ohm-m. Screen pipes were installed in this second layer. Lateral discontinuity is confirmed between survey point of 4 and 5. Divided by this lateral discontinuity, two deferent range of the resistivity is obtained. The eastern part of the lateral discontinuity shows very low resistivity range of less than 6.5 ohm-m and western part indicates high resistivity range of more than 100 ohm-m. Therefore, it is classified as third layer for eastern and fourth layer for western area. Result of the interpreted relation between lithological log and resistivity range is summarized as following table.

Layer	Depth (m.bgl)	Resistivity Range(ohm-m)	Lithology	Interpretation
1 st	0 -30	94 -440	mainly clayey gravel (sandy silt at top surface)	Surface formation
2 nd	30 - 160	7.9 -14	clayey gravel to clean gravel	Expected Aquifer
3 rd	-	<6.5	not confirmed	Contaminated Aquifer
4 th	>160	>100	clayey gravel	Impermeable Bed

iii) Profile PT-3 (see Fig. B-III, 2.3.7)

Three (3) main layers are confirmed in the all line by the analysis. Well No. J-E and J-6 are located at survey point of 5 and 6 respectively in this profile. Based on the apparent resistivity and boring logs interpretation, expected aquifer is found at second layer except first layer of the area from survey point of 14 to 16 and 20 to 23. This aquifer at first layer is bounded from dry zone by the small scale lateral discontinuity. Following table shows summery of interpreted relation between lithological formation and resistivity rage (depth referred at the survey point of 5).

Layer	Depth (m.bgl)	Resistivity Range(ohm-m)	Lithology	Interpretation
1 st	0 - 50	77 - 360	sandy to gravely clay	Surface Formation
2 nd	50 - 240	9.1 - 19	gravely clay at upper, clayey gravel at lower	Expected Aquifer
3 rd	>240	<6.7	not confirmed	Contaminated Aquifer

iv) Profile PT-4 (see Fig. B-III, 2.3.8)

Divided by survey point of 4, four (4) layered model at western part and three (3) layered model at eastern part were applied by apparent resistivity. However, considering the apparent resistivity range, it is interpreted that the second layer is divided by the third layer. So that, "fourth layer" which has its resistivity range between 9.2 and 13 ohm-m, of the western part of the profile is classified as part of the "second layer".

Well No. J-F is located at survey point No.8. The second layer was interpreted as expected aquifer, and its resistivity range is from 7.3 to 16 ohm-m. Following table shows summery of interpreted relation between lithological formation and resistivity range.

Layer	Depth (m.bgl)	Resistivity Range(ohm-m)	Lithology	Interpretation
1 st	0 - 80	690 -1000	gravely clay at upper sandy clay at lower	Surface Formation
2 nd	80 -150	7.3 - 16	clayey sand at upper sandy clay at lower	Expected Aquifer
3 rd	150 -300	9.2 - 13	not confirmed	Expected Aquifer
4 th	>150	<6.6	sandy clay	Contaminated Aquifer

v) Profile PT-5 (see Fig. B-III, 2.3.9)

Four (4) main layers are confirmed by the analysis. However, first layer is observed at only central part of the profile and it is bounded by the lateral discontinuity at the survey point No. between 5 and 6. Boring log is obtained by the well no. J-4 located at the survey point of 4. Considering the interpretation of boring log and apparent resistivity, expected aquifer was confirmed at second layer indicating its resistivity range between 52 and 70 ohm-m. Interpreted relation between lithological log and resistivity range are summarized as following table.

Layer	Depth (m.bgl)	Resistivity Range(ohm-m)	Lithology	Interpretation
1 st	0 - 30	110 -120	gravel	Surface Formation
2 nd	30 - 100	52 - 70	gravel at upper part clayey gravel at lower	Expected Aquifer
3 rd	100 - 160	6.3 -9.7	clayey gravel at upper conglomerate at lower	Contaminated Aquifer
4 th	>160	>100	not confirmed	Impermeable bed

iv) Profile PT-6 (see Fig. B-III, 2.3.10)

The profile is analyzed as three (3) layered model from apparent resistivity curves of each point. Divided by lateral discontinuity located between No. 4 and 5 of the survey point, fourth layer which is more than 100 ohm-m resistivity is confirmed under the first and third layer. Second layer is not confirmed in this location. Second layer is also disconnected by the same lateral discontinuity. Well No. J-5 is located at survey point No. 6. Based on the apparent resistivity and boring log interpretation, the second layer was confirmed as expected aquifer. The resistivity range of the layer is from 10 to 17 ohm-m. Following table shows summary of the interpreted relation between lithological formation and resistivity range.

Layer	Depth (m.bgl)	Resistivity Range(ohm-m)	Lithology	Interpretation
1 st	0 -80	690 -1200	sandy clay	Surface Formation
2 nd	80 - 210	10 - 17	clayey gravel to gravel	Expected Aquifer
3 rd	>210	<7.5	gravel at upper sandy clay at lower	Contaminated Aquifer
4 th	-	>100	not confirmed	Impermeable Bed

iiv) Profile PT-7 (see Fig. B-III, 2.3.11)

Three (3) main layers are confirmed except the western part of the profile. Two (2) layer of first and third divided by lateral discontinuity is analyzed in this part. Well No. J-7 is located at survey point No.4. The second layer is interpreted as expected Aquifer, and its resistivity range is from 7.4 to 9.5 ohm-m. This value is relatively low compared with the profile. Result of the interpreted relation between lithological lag and resistivity range is summarized as following table.

Layer	Depth (m.bgl)	Resistivity Range(ohm-m)	Lithology	Interpretation
1 st	0 -10	1000 -1400	sandy clay	Surface Formation
2 nd	10 - 380	7.4 - 9.5	sandy clay to gravely clay, gravel at some part	Expected Aquifer
3 th	>380	2.0 - 2.6	not confirmed	Contaminated Aquifer
4 th	-	1250	not confirmed	Impermeable Bed

iiiv) Profile PT-8 (see Fig. B-III, 2.3.12)

In this profile, five (5) layered model is applied by the apparent resistivity. However based on the boring log obtained by Well No. J-8, three (3) layers between first and third layer is interpreted as second layer and it is expected as most promising aquifer in this area. The third layer is divided by the thick second layer at western part of the profile. Following table shows summery of interpreted relation between lithological formation and resistivity range.

Layer	Depth (m.bgl)	Resistivity Range(ohm-m)	Lithology	Interpretation
1 st	0 -30	920 - 950	sand and gravel at surface clay at lower	Surface Formation
2 nd	30 - 320	25 - 47 8.9 - 9.3 14 -30	alternation of clay and gravel	Expected Aquifer
3 rd	>320	<6.6	not confirmed	Contaminated Aquifer

2.3.2 Boring Test

1) Location and Depth of Each Well

Four (4) Test Wells (J-C, J-D, J-E and J-F) and seven (7) Observation Wells (J-3, J-4, J-5, J-6, J-7, J-8 and J-9) are placed along on the line of the TEM survey (see, Fig. B-III, 2.3.1). Location, drilling depth and casing size of each well are summarized as follows.

Well No.	Location	Latitude	Longitude	Elevation (m.msl)	Casing (inch)	Depth (m.bgl)
J-C	Huara	19° 59' 05.7"	69° 42' 09.8"	1,110.875	8-5/8"	209
J-D	Baquedana	20° 09' 54.2"	69° 41' 10.4"	1,056.686	8-5/8"	210
J-E	La Tirana	20° 19' 53.2"	69° 41' 18.6"	1,006.028	8-5/8"	250
J-F	Ramada	20° 43' 53.2"	69° 30' 17.3"	1,016.158	8-5/8"	200
J-3	Aguada	19° 45' 09.1"	69° 49' 15.3"	1,143.898	5-1/2"	150
J-4	Negreiros	19° 51' 37.2"	69° 44' 51.8"	1,168.043	5-1/2"	150
J-5	Pozo Almonte	20° 15' 10.7"	69° 41' 26.1"	1,030.800	5-1/2"	300
J-6	Canchones	20° 26' 40.9"	69° 31' 15.7"	991.897	5-1/2"	200
J-7	Conaf	20° 30' 44.4"	69° 39' 56.9"	981.635	5-1/2"	210
J-8	Pintados	20° 35' 37.7"	69° 31' 08.2"	1,016.119	5-1/2"	210
J-9	Oficina Victoria	20° 45' 12.6"	69° 35' 26.3"	969.796	5-1/2"	172

2) Methodology of Well Construction

For the details of the methodology, see B-II, section 2.3.2 of Chapter II

3) Result of Boring Test

All the data including lithological observation, well logging and drilling rate are compiled together with casing design in same formatted sheet as shown as Fig. B-III, 2.3.13 , to Fig. B-II, 2.3.16 for Test Well and Fig. B-II, 2.3.17 to Fig. B-II, 2.3.23 for Observation Well with scale of 1:1000.

(1) Well No. J-C (see Fig.B-III, 2.3.13)

i) Lithology

The well was drilled up to 209m depth. In the whole sequence, the unit of Q4 and Q2 of the Upper Altos de Pica Formation of Quaternary is observed. Based on the result of geophysical logging and lithology observed, following five (5) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 40	Shallow Aquifer	sandy to silty clay	Q4	Altos de Pica
2 nd	40 - 100	Deep Aquifer	clayey gravel, clayey sand	Q4	Altos de Pica
3 rd	100 - 160	Impermeable Intercalation	clay, sandy clay	Q2	Altos de Pica
4 th	160 -197	Deep Aquifer	sandy clay	Q2	Altos de Pica
5 th	197 - 209	Impermeable Bed	Clay,	Q2	Altos de Pica

ii) Well Logging

Spontaneous Potential (SP) indicates a range from 800 to 920 mv. From the lithological point of view, relative basement line (relative 0 line) which is boundary between permeable formation (gravel, sand) and impermeable formation (clay) is instituted as 900mv. Resistivity indicates extensive range of 10 - 100 ohm-m at surface, and reversal value (Long normal < Short normal) is observed. On the other hand, short range resistivity between 10 to 30 ohm-m is indicated at below 40m depth, both of Long normal (Lon.) and short normal (Sho.). Classification for mud layer and permeable layer is also well proved by the Gamma Ray.

iii) Determination of Casing Design

In order to determine position to be install the screen pipe, following interpretations were made by both of lithological and well logging data. Scheduled casing design is shown in the Fig. B-III, 2.3.13.

a) 1 st layer (Shallow Aquifer)

The layer consists of mainly sandy clay, which is considered as low permeable deposit at normal case. On the other hand, the value of SP indicates permeable range from the its relative basement line, and Temperature shows small scale infiltration at depth from 20 to 30m. Considering water quality, reversal value of the resistivity (Lon. < Sho.) is an indication of the contamination. Therefore, the layer is classified as shallow aquifer, however, fresh water is yielding is not expected.

b) 2 nd layer (Deep Aquifer)

All the geophysical logging value indicates characteristic of the promising aquifer in this sequence, except depth from 73 to 80m. This range (73 to 80m) has relatively high value of the Gamma Ray (50 - 110 cps), it is estimated as small scale impermeable intercalation. Similar value of resistivity (10 - 30 ohm-m) is obtained as TEM survey range (13 - 23 ohm-m) which is classified as expected aquifer. The interpretation for the aquifer is also proved as low increasing rate of the water temperature.

The screen pipes were installed in this layer except impermeable intercalation. The position of the screen is the depth from 43.01 to 73.01m and 79.01 to 97.02m.

c) 3 rd layer (Impermeable Intercalation)

60m thickness of impermeable deposit of clay and sandy clay is intercalated to the deep aquifer. The value of the SP exceeded relative basement line of 900mv, and 40 to 80 cps which is rather high value of the gamma ray is proved as clay. Blank casing pipes were installed in this layer.

d) 4 th layer (Deep Aquifer)

The value of the SP indicates a approximately 900mv which is boundary value of the permeable and impermeable. However, other logging data, such as resistivity

(10 - 25 ohm-m), gamma ray (less than 40 cps) and slow increasing rate of temperature is shows same characteristics of the second layer. The layer can be classified as deep aquifer which is same formation of the second layer, so that screen pipes were installed in this layer at the depth from 163.02 to 192.99m.

e) 5 th layer (Impermeable Bed)

The clay layer is corresponded to the value of SP which is exceeded 900 mv and high gamma ray. The layer is classified as impermeable, so that, blank casing pipes were installed.

(2) Well No. J-D (see Fig. B-III, 2.3.14)

i) Lithology

Upper Altos de Pica Formation of Quaternary is confirmed from the unit of Q4 to Q2 in this well. The total drilling depth is 210m. Based on the result of geophysical logging and lithological observation, following four (4) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 49	Surface Deposit	sandy silt, gravely clay	Q4	Altos de Pica
2 nd	49 - 98	Shallow Aquifer	Alternation of clayey gravel and gravely clay	Q4	Altos de Pica
3 rd	98 - 161	Deep Aquifer	clayey gravel, gravel	Q3	Altos de Pica
4 th	161 - 210	Deep Aquifer	gravely clay, clayey gravel	Q2	Altos de Pica

ii) Well Logging

Identification of the clay layer is difficult only by the gamma ray, because of limited indication (small range) and gentle changing of the cps value. On the other hand, the value of SP indicate most of permeable range of less than 950 mv which is a relative basement line instituted by the lithological observation. These range both of gamma ray and SP is well proved as a characteristics of the clayey layers at whole sequence. Resistivity indicates high range of 40 to 80 ohm-m at surface 30 m, and short range between 10 and 30 ohm-m at below 50m. Temperature indicates 23 to 28 °C in general, and changing is observed at only surface 50m.

iii) Determination of Casing Design.

Casing design is decided as shown in Fig. B-III, 2.3.14, based on the following interpretation for each classified layers.

a) 1 st layer (Surface Deposit)

The layer consists of mainly gravely clay except sandy silt of top surface. As represented by high value of resistivity and gamma ray, the layer is clearly dry.

b) 2 nd layer (Shallow Aquifer)

All the geophysical logging value shows characteristic of the promising aquifer in general, except high value of gamma ray of the middle part (depth from 90 to 95m). Especially, resistivity range between 7 and 20 ohm-m is very similar value of the TEM survey (7.9 to 14 ohm-m) result which is classified as aquifer. Therefore, it is expected as aquifer, at a shallow layer classified as Q4 unit.

The screen pipes were installed in this layer at two (2) part, one is at the depth from 53.89 to 59.91m and other one is from 71.91 to 89.93m.

c) 3 rd layer (Deep Aquifer)

Almost same value of the well logging measurement is observed with 2nd layer (Shallow Aquifer), and the layer is still within the same sequence of the TEM's expected aquifer. However, geological unit was classified as Q3 of the Altos de Pica Formation. The layer is classified as Deep Aquifer.

The screen pipes were installed in this layer at depth from 101.94 to 150m and 156 to 162m respectively.

d) 4 th layer (Deep Aquifer)

As lithological view point, much clay is observed compared with other layer, and it was classified as impermeable bed by the TEM's result. However, the TEM value shows more than 100 ohm-m. It is big deference with well logging resistivity value (7 to 20 ohm-m). Moreover, cps value of the gamma ray indicates lower range which is expected as permeable layer. Therefore, the layer is classified as part of the Deep Aquifer, because of same result of 3rd layer by the logging measurement.

The screen pipes were installed at depth from 174 to 180.01m and 186.01 to 198.02m.

(3) Well No. J-E (see Fig. B-III, 2.3.15)

i) Lithology

With in 250m of total depth, two (2) unit of Q4 and Q3 are confirmed as the Upper Altos de Pica Formation of Quaternary. According to lithology observed and well logging data, following two (2) major layers are classified

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 70	Surface Deposit	sandy to gravely clay	Q4	Altos de Pica
2 nd	70 - 250	Aquifer	gravely clay at upper, clayey gravel at lower	Q4 Q3	Altos de Pica

i) Well Logging

The range of the resistivity value is rather small (mostly 10 to 30 ohm-m) except at top surface. The gamma ray shows almost same range (unchanged) at surface to bottom, and it is well correspond with clayey materials at whole sequence of the borehole. The relative basement line of the Spontaneous potential is instituted as a line of 950 mv, based on the value of resistivity and lithology observed. Lithology of the well is mostly gravel clay to clayey gravel at whole the sequence, however, ratio of gravel is gradually increases toward the bottom. The permeable range indicated by SP is gradually increased to the bottom and it is coincident with lithological observation. Small scale groundwater flow is observed by the temperature curve at surface.

iii) Determination of Casing Design

Casing design was decided as shown in Fig. B-III, 2.3.5, based on the following interpretations.

a) 1 st layer (Surface Deposit)

The layer is consists of sandy clay at the surface 20m, and gravely clay at the other lower part, which is considered as low permeable deposit. It is confirmed by the SP value which is exceeding 950mv. Small scale water flow is observed by the temperature curve. However, considering the reversal value (Lon.<Sho.) of the resistivity, it is expected that grandwater is contaminated. Based on this situation, the layer is surface deposit with small grandwater potential, however, fresh water yielding is not expected. So that, blank casing pipes were installed.

b) 2 nd Layer (Aquifer)

The layer is consist of mainly clayey gravel at whole sequence. The ratio of gravel and clay is gradually changed toward bottom as low gravel ratio to the high gravel ratio. The curve of SP and resistivity is well coincident with this changing. The value of the resistivity (10 to 20 ohm-m) is very similar with TEM's measurement (9.1 to 19 ohm-m). Based on this interpretation by the SP and resistivity together with lithological observation, the layer is expected as Aquifer.

The screen pipes were installed in this layer at eight (8) separated position, where the much gravel is confirmed as shown in Fig. B-III, 2.3.15.

(4) Well No. J-F (see Fig. B-III, 2.3.16)

i) Lithology

The well drilled up to 224m depth and confirmed three (3) lithological unit of Q4. Q3 and Q2 of the Altos de Pica formation of Quaternary. Following Three (3) major layer is classified by the interpretation of lithology observed and geophysical logging.

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 47	Surface Deposit	clay, clayey gravel and clayey sand	Q4	Altos de Pica
2 nd	47 - 160	Shallow Aquifer	sandy, gravely clay, clayey sand	Q4 Q3	Altos de Pica
3 rd	160 - 224	Deep Aquifer	sandy clay	Q3	Altos de Pica

ii) Well Logging

Gamma ray indicates thick homogeneous range (50 - 70 cps) at all sequence, however, clay layer is well visible by the particular value which is exceeding 100 cps. Considering lithological observation and resistivity curve, a line of 900 mv is estimated as relative basement line of Spontaneous Potential. Temperature curve indicates gentle and gradual increase in general especially the depth from 50 to 180m. Thick sequence of the groundwater flow is expected.

iii) Determination of Casing Design

In order to determine suitable position of screen pipes to be installed, following interpretations were made, and scheduled as shown in Fig. B-III, 2.3.16.

a) 1st layer (Surface Deposit)

The layer is estimated as permeable deposit by the lithological observation and range of the SP showing less than 900mv. However, it is expected as dry, because of high resistivity value (more than 100 ohm-m). This resistivity measurement is well coincident with TEM's result. Blank casing pipes were installed in this layer.

b) 2 nd Layer (Shallow Aquifer)

Based on the permeable indication of SP and typical range (10 - 30 ohm-m) of resistivity, the layer is expected as most promising aquifer in the sequence. The resistivity range indicates rather high value than TEM's measurement (7.3 - 16 ohm-m). However, large scale groundwater flow is confirmed by the temperature curve.

The four (4) separate position was selected for the screen pipes installation as shown in Fig. B-III, 2.3.16.

c) 3 rd layer (Deep Aquifer)

Same interpretation with 2nd layer was made by the very similar well logging result and lithology observed. The layer is classified as 3 rd layer of Aquifer by the TEM result with resistivity range of 9.2 to 13 ohm-m. The resistivity value indicates much similar value (8 to 20 ohm-m) with TEM, in spite of permeable indication by the SP is critical.

The screen pipes were installed three (3) different positions in this layer as shown in Fig. B-III, 2.3.16.

(5) Well No. J-3 (see Fig. B-III, 2.3.17)

The well was drilled up to 150m depth. In the whole sequence, the unit of Q4 and Q2 of the Upper Altos de Pica Formation of Quaternary is observed. Based on the result of geophysical logging and lithology observed, following four (4) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 42	Surface Deposit	clay, sandy clay	Q4	Altos de Pica
2 nd	42 - 100	Shallow Aquifer	sandy clay	Q4	Altos de Pica
3 rd	100 - 131	Impermeable Intercalation	sandy clay clay	Q4 Q2	Altos de Pica
4 th	131 -150	Deep Aquifer	sandy clay	Q2	Altos de Pica

ii) Well Logging

Spontaneous Potential indicates a homogeneous range of 970 to 1030 mv. From lithological point of view, relative basement line (relative 0 line) is estimated as 1015 mv. However, due to much clay predominance in the all sequence, identification of the permeable zone is much difficult by the SP. The range of gamma ray also very limited, the most of value is within 40 to 60 cps. Typical indication of the groundwater is very clear by the Temperature, water flow is visible at the depth from 40 to 90m and from 120 to 145m. No TEM survey is conducted in this area.

iii) Determination of Casing Design

In order to determine position to be install the screen pipe, following interpretations were made by both of lithological and well logging data. Scheduled casing design is shown in the Fig. B-III, 2.3.17.

a) 1 st layer (Surface Deposit)

The layer is consists of clay at surface 7m and sandy clay at other part which is impermeable lithology. It is proved by the SP range which is exceeding more than 1015 mv. Small potential of grandwater is expected by the Temperature.

However, fresh water is not expected, because of the unstable and reversal value (Lon.<Sho.) resistivity range. Blank casing pipes were installed in this layer.

b) 2 nd layer (Shallow Aquifer)

The layer is single and thick bed of sandy clay of Q4 of Altos de Pica Formation. Considering the lithology observed and well logging result, high permeability is not expected in this layer. However, the range of resistivity shows a similar value of the other wells aquifer of 20 to 40 ohm- m. Water flow also indicated by the temperature curve.

The layer is estimated as aquifer, and screen pipes were installed. Two (2) deffrent position were selected for screen installation as shown in Fig. B-III, 2.3.17.

c) 3 rd layer (Impermeable Intercalation)

The layer consists of sandy clay at upper and clay at lower. It is not estimated as aquifer because of much clay predominance.

d) 4 th layer (Deep Aquifer)

The layer is situated at upper Q4 unit of Altos de Pica Formation consists of clay and sandy clay. Much ratio of sand is confirmed at sandy clay layer. The value of resistivity also indicate similar range with 2 nd layer. Therefore, the layer is classified as Deep Aquifer.

The screen pipes were installed at the depth from 132.83 to 144.83m of this layer.

(6) Well No. J-4 (see Fig. B-III, 2.3.18)

i) Lithology

Upper Altos de Pica Formation of Quaternary is confirmed from the unit of Q4 and Q2 in this well. The total drilling depth is 150m. Based on the result of geophysical logging and lithological observation, following three (3) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 45	Surface Deposit	sand, gravel	Q4	Altos de Pica
2 nd	45 - 95	Shallow Aquifer	gravel, clayey gravel and gravely clay	Q4	Altos de Pica
3 rd	98 - 161	Deep Aquifer	clayey gravel, conglomerate	Q2	Altos de Pica

ii) Well Logging

The result of all measurement is well corresponded with high permeability of the lithology. The relative basement line of the SP is estimated as a line of 95m mv, based on the lithological observation and the value of gamma ray. Resistivity shows high and unstable at surface 40m, stable and short rang at below 45m. Small scale infiltration of surface water is visible by the Temperature curve at surface 10m.

iii) Determination of Casing Design

a) 1 st layer (Surface Deposit)

High permeability is easily estimated as lithological observation and SP range which shows less than 900mv. However, water quality is very critical, because of unstable and reversal range of the resistivity. It is expected as small potential surface aquifer with no fresh water yielding. Blank casing pipes were installed in this layer.

b) 2 nd layer (Shallow Aquifer)

The layer was classified as Expected Aquifer by the TEM measurement with 52 to 70 ohm-m resistivity value. The value of the resistivity of logging is rather low (10 to 45 ohm-m). However, compared with other well, this value is still within the range of aquifer. All of the value of each measurement shows typical characteristic of the aquifer, except high value of gamma ray of the middle of layer (75m depth).

Based on the above interpretation the layer is expected as promising aquifer, and two (2) deferent position is selected for screen installation as shown in Fig. B-III, 2.3.18.

c) 3 rd layer (Deep Aquifer)

Same interpretation can be made in this layer because of very similar result of logging measurement.

Screen pipes is installed as the depth from 97.67 to 115.72m and 138.92 to 144.94m of this layer.

(7) Well No. J-5 (see Fig. B-III, 2.3.19)

i) Lithology

With in 300m of total depth, three (3) unit of Q4, Q3 and Q2 are confirmed as the Upper Altos de Pica Formation of Quaternary. According to lithology observed and well logging data, following three (3) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 20	Surface Deposit	silty clay, sandy clay	Q4	Altos de Pica
2 nd	20 - 100	Shallow Aquifer	sandy clay	Q4	Altos de Pica
3 rd	100 - 300	Deep Aquifer	clayey gravel sandy clay	Q3 Q2	Altos de Pica

ii) Well Logging

The relative basement line of the SP value is estimated at a line of 920mv, based on the lithological observation and resistivity. The range of SP is short and stable because of the most of layer is consists of clayey materials. Resistivity shows its range from 10 to 20 ohm-m up to 100m depth and 10 to 30 ohm-m below 100m. It is also very stable and unchanged at all the sequence except top surface.\

iii) Determination of Casing Design

Casing design is decided as shown in Fig. B-III, 2.3.19, based on the following interpretation for each classified layers.

a) 1 st layer (Surface Deposit)

Impermeable deposit consists of silty clay and sandy clay is observed in this layer. It is estimated as dry due to high value of the resistivity. Blank casing pipes were installed.

b) 2 nd layer (Shallow Aquifer)

The layer is expected as aquifer due to the value of the resistivity and SP. Slow increasing rate of the temperature also indicates a characteristic of the aquifer. However, the aquifer with much potential is expected at lower layer (3 rd layer of Deep Aquifer), the screen pipes were not installed in this layer.

c) 3 rd layer (Deep Aquifer)

The layer consists of clayey gravel from 100 to 250m depth and sandy clay at blow 250m depth. Much high permeable lithology than Shallow Aquifer is confirmed in this layer and it is very thick sequence. The range of the resistivity shows similar value with TEM measurement (10 -17 ohm-m), so that the layer is expected as aquifer.

The screen pipes were installed at six (6) deferent position as shown in Fig. B-III, 2.3.19.

(8) Well No. J-6 (see Fig. B-III, 2.3.20)

i) Lithology

The well was drilled up to 200m depth. In the whole sequence, the unit of Q4, Q3 and Q2 of the Upper Altos de Pica Formation of Quaternary is observed. Based on the result of geophysical logging and lithology observed, following three (3) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 35	Surface Deposit	sand, sandy clay, clay	Q4	Altos de Pica
2 nd	35 - 138	Shallow Aquifer	clayey to sandy gravel, gravel	Q4 Q3	Altos de Pica
3 rd	138 - 200	Deep Aquifer	clay, gravely clay, clayey gravel	Q2	Altos de Pica

ii) Well Logging

Intercalation of clay layer is clearly distinguished by high value (more than 100 cps) of the gamma ray, such as depth at 20, 85 and 150m. In other layer, rather stable value of the cps (40 - 70 cps) is observed at whole sequence. Based on the gamma ray curve and lithology observed, relative basement line of the SP is estimated as 870mv. Compared with TEM result, rather high resistivity range was measured by well logging. Flow of the groundwater is visible by the temperature curve at the depth of 35 to 100.

iii) Determination of Casing Design

Casing design was decided as shown in Fig. B-III, 2.3.20, based on the following interpretation.

a) 1 st layer (Surface Deposit)

The layer is consists of sand and sandy clay at upper 16m and clay at lower 19m. The depth and high resistivity range is very similar with first layer classified by TEM survey. It is estimated as dry surface deposit. Blank casing pipes were installed.

b) 2 nd layer (Shallow Aquifer)

The layer is "Expected Aquifer" classified as TEM result, and its resistivity range was 10 - 17 ohm-m. Compared with TEM's result, logging resistivity is rather high value (20 - 40 ohm-m). High permeability is expected by the lithological observation except clay intercalation at depth from 73 to 81m. Typical curve showing groundwater flow at depth from 35 to 100 is observed by the temperature.

The layer is also expected as aquifer, and screen pipes were installed at three (3) position as shown in Fig. B-III, 2.3.20.

c) 3 rd layer (Deep aquifer)

Similar range of resistivity and gamma ray value with 2 nd layer is obtained. The range of SP also indicate permeable side. The layer is also expected as aquifer which is clearly divided by clay intercalation of the depth of 138 to 144m. The layer is classified as Deep Aquifer at Q2 unit.

Two (2) positions for screen installation were selected as shown in Fig. B-III, 2.3.20.

(9) Well No. J-7 (see Fig. B-III, 2.3.21)

i) Lithology

With in 210m of total depth, two (2) unit of Q4 and Q3 are confirmed as the Upper Altos de Pica Formation of Quaternary. According to lithology observed and well logging data, following three (3) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 35	Surface Deposit	sandy clay	Q4	Altos de Pica
2 nd	35 - 106	Shallow Aquifer	sandy to gravely clay	Q4	Altos de Pica
3 rd	100 - 131	Deep Aquifer	sandy to gravely clay	Q3	Altos de Pica

ii) Well Logging

The lithology is much clayey in the whole sequence. Due to this reason, the range of gamma ray is limited and unchanged. Spontaneous Potential indicate a range of 970 mv. From lithological point of view, and gamma ray curve, relative basement line is instituted as 970 mv. The resistivity indicates a very homogeneous range of almost 10 to 20 ohm-m except surface 35m. This value is situated with in a range of aquifer, based on the other well and TEM's resistivity value. So that position of the screen pipes were selected by the small changed SP and gamma ray value as for placed to the permeable position.

iii) Determination of Casing Design

Casing design was decided as shown in Fig. B-III, 2.3.21, based on the following interpretation.

a) 1 st layer (Surface Deposit)

The layer is consists of mainly sandy clay except surface 4m thick of sand, and estimated as dry because of high resistivity value. Blank casing pipes were installed in this layer.

b) 2 nd layer (Shallow Aquifer)

Due to the stable range of 10 to 20 ohm-m resistivity, the layer is expected as Aquifer. High Permeability can not be expected by the almost clayey lithology. The range of SP also narrowly indicate permeable side of less than 970mv. Position of screen pipes were selected by the zone showing narrowly low value of the SP and Gamma ray.

The screen pipes were installed two (2) deferent position of 55.79 to 61.76m and 67.79 to 79.8m depth.

c) 3 rd layer (Deep aquifer)

Almost same interpretation with 2nd layer can be made due to same lithology and logging measurement. However, the layer is estimated as rather permeable than 2 nd layer based on the lower value of SP. The position of screen pipes to be installed is selected as same concept with 2nd layer.

Five (5) deferent positions were selected for screen pipe installation as shown in Fig. B-III, 2.3.21.

(10) Well No. J-8 (see Fig. B-III, 2.3.22)

i) Lithology

The well was drilled up to 210m depth. In the whole sequence, the unit of Q4, Q3 and Q2 of the Upper Altos de Pica Formation of Quaternary is observed. Based on the result of geophysical logging and lithology observed, following three (3) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 50	Surface Deposit	sand, gravel, clay	Q4	Altos de Pica
2 nd	50 - 169	Shallow Aquifer	gravel clayey, clayey gravel	Q4 Q3	Altos de Pica
3 rd	169 - 210	Deep aquifer	gravely clay, sandy clay	Q2	Altos de Pica

ii) Well Logging

Spontaneous Potential indicates a range from 820 to over 1000 mv. Considering the lithology observed and resistivity, relative basement line is estimated as 990 mv. Resistivity indicates high value at surface 40m and stable range of 10 to 30 ohm-m at below 50m. This range is coincided with resistivity of the aquifer in the area. Clay intercalation is easily identified by the gamma ray, it is exceeding 100 cps. Moreover, the layer which has less clay matrix, also identified by the gamma ray showing less than 50cps. Position of the screen pipes were selected by this range.

iii) Determination of Casing Design

Casing design was decided as shown in Fig. B-III, 2.3.22, based on the following interpretation.

a) 1 st layer (Surface Deposit)

The layer consists of sand to gravel at surface 14m and gravely clay at lower part. Very small scale groundwater potential is found at top surface by the temperature curve and resistivity. However, this is limited as thin layer of top surface. Most of the layer is estimated as dry because of high resistivity value. Blank casing pipes were installed in this layer.

b) The layer is classified as Shallow Aquifer based on the stable resistivity range of 10 to 30 ohm-m especially below 55m depth. However high permeability can not expected, because much clayey matrix is observed at whole sequence by cutting sample except bottom 11m of fine gravel. Therefore, the position of the screen pipe were selected by the gamma ray. It is scheduled at zone showing less than 50 cps where estimated rather permeable within the layer.

Based on above descried interpretation, eight (8) short interval position were selected for the screen pipe installation as shown in Fig. B-III, 2.3.22.

c) 3 rd layer (Deep Aquifer)

Same interpretation can be made based on the same value of the resistivity and SP. Two (2) deferent position is selected for screen installation as shown in Fig. B-III, 2.3.22.

(11) Well No. J-9 (see Fig. B-III, 2.3.23)

i) Lithology

Upper Altos de Pica Formation of Quaternary is confirmed from the unit of Q4, Q3 and Q2 in this well. The total drilling depth is 172m. Based on the result of geophysical logging and lithological observation, following three (3) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Unit	Formation
1 st	0 - 55	Surface Deposit	sandy clay, clay	Q4	Altos de Pica
2 nd	55 - 146	Shallow Aquifer	clayey gravel gravely clay, clay	Q4 Q3	Altos de Pica
3 rd	146 - 172	Deep Aquifer	gypsum clay	Q2	Altos de Pica

ii) Well Logging

At surface 50m, Spontaneous Potential curve is not coincident with lithology and gamma ray. Relative basement line of the SP is estimated as 1000mv from below 50m depth by the consideration of lithology and gamma ray. Resistivity range indicate a typical value of the aquifer in the area as 10 to 20ohm-m, and it is stable except surface 30m. Clay intercalation is well founded by the gamma ray as of the zone where shows more than 100cps.

iii) Determination of Casing Design

Casing design is decided as shown in Fig. B-III, 2.3.23, based on the following interpretation for each classified layers.

a) 1 st layer (Surface Deposit)

The most part of layer is consists of clay or sandy clay which is impermeable deposit. The value of gamma ray also indicates rather high range of 50 to 100cps. The layer is interpreted as dry so that blank casing pipes were installed.

b) 2 nd Layer (Shallow Aquifer)

Stable range with 10 to 20 ohm-m resistivity value is observed in the all sequence. The gamma ray shows rather lower value of 20 to 70 cps except clay intercalation. Therefore, the layer is expected as promising aquifer. Position of the screen pipes were examined by the permeability indication of the gamma ray.

The screen pipes were installed at three (3) deferent position as shown in Fig, B-III, 2.2.23.

c) 3 rd layer (Deep Aquifer)

The layer is consists of gypsum clay of Q2 unit. This is impermeable layer by the lithological view point at normal case. However, compared with 2 nd layer, much possibility of the high permeability can be expected by the SP and gamma ray. Moreover, resistivity value indicate still within the range of the aquifer. Therefore, the layer is expected as aquifer.

The screen pipes were installed as shown in Fig. B-III, 2.2.23.

2.3.3 Pumping Test

1) Methodology of Pumping Test

For the details of the methodology, see B-II, section 2.3.3 of Chapter II.

2) Result of Pumping Test

(1) Aquifer Constants

In order to evaluate of capacity and characteristics of the aquifer, the Aquifer Constants were estimated by the data of constant discharge test and recovery test. Two (2) methods, Theis and Jacob, were applied for estimation of the Transmissibility, Storage Coefficient and Permeability.

i) Well No. J-C

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	52.03 m
	Discharge Rate (Q)	2.25 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	75.75 m
	Drawdown (Sw)	23.72 m
	Specific Yield	8.2 m3/d/m
Recovery Test	Duration of Test	1480 min.
	Water Level (s')	52.6 m
	Recovery (S-s')	23.15 m
	Water Level Variation (s'-SWL)	0.57 m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.24 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analyzed Method	Kind of Test	Transmissibility (m3/d/m)	Transmissibility (m3/s/m)	Storage Coefficient
Theis	C/T	4.73	5.47E-05	1.46E-01
	R/T	10.54	1.22E-04	
Jacob	C/T	7.78	9.00E-05	8.25E-03
	R/T	10.11	1.17E-04	
Average		8.29	9.59E-05	7.71E-02

C/T : Constant Discharge Test

R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	7.02E-05	cm/sec	78.01
	R/T	1.56E-04	cm/sec	78.01
Jacob	C/T	1.15E-04	cm/sec	78.01
	R/T	1.50E-04	cm/sec	78.01
Average		1.23E-04	cm/sec	

C/T : Constant Discharge Test

R/T : Recovery Test

ii) Well No. J-D

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	46.05 m
	Discharge Rate (Q)	22.5 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	52.53 m
	Drawdown (Sw)	6.48 m
	Specific Yield	300 m3/d/m
Recovery Test	Duration of Test	360 min.
	Water Level (s')	46.01 m
	Recovery (S-s')	6.52 m
	Water Level Variation (s'-SWL)	-0.04 m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.25 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analyzed Method	Kind of Test	Transmissibility		Storage Coefficient
		(m3/d/m)	(m3/s/m)	
Theis	C/T	560.74	6.49E-03	6.49E-06
	R/T	2462.40	2.85E-02	
Jacob	C/T	660.10	7.64E-03	7.86E-08
	R/T	2341.44	2.71E-02	
Average		1506.17	1.74E-02	3.28E-06

C/T : Constant Discharge Test

R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	6.75E-03	cm/sec	96.12
	R/T	2.97E-02	cm/sec	96.12
Jacob	C/T	7.95E-03	cm/sec	96.12
	R/T	2.82E-02	cm/sec	96.12
Average		1.81E-02	cm/sec	

C/T : Constant Discharge Test

R/T : Recovery Test

iii) Well No. J-E

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	13.73 m
	Discharge Rate (Q)	27 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	17.72 m
	Drawdown (Sw)	3.99 m
	Specific Yield	584.66 m3/d/m
Recovery Test	Duration of Test	720 min.
	Water Level (s')	13.76 m
	Recovery (S-s')	3.96 m
	Water Level Variation (s'-SWL)	0.03 m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.26 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and storage Coefficient

Analyzed Method	Kind of Test	Transmissibility (m3/d/m)	Transmissibility (m3/s/m)	Storage Coefficient
Theis	C/T	1088.64	1.26E-02	8.40E-03
	R/T	317.09	3.67E-03	
Jacob	C/T	844.13	9.77E-03	1.43E-04
	R/T	327.46	3.79E-03	
Average		644.33	7.46E-03	4.27E-03

C/T : Constant Discharge Test

R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	1.23E-02	cm/sec	102.07
	R/T	3.60E-03	cm/sec	102.07
Jacob	C/T	9.57E-03	cm/sec	102.07
	R/T	3.71E-03	cm/sec	102.07
Average		7.31E-03	cm/sec	

C/T : Constant Discharge Test

R/T : Recovery Test

iv) Well No. J-F

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	57.0 m
	Discharge Rate (Q)	20 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	69.15 m
	Drawdown (Sw)	12.15 m
	Specific Yield	142.22 m3/d/m
Recovery Test	Duration of Test	1440 min.
	Water Level (s')	56.78 m
	Recovery (S-s')	12.37 m
	Water Level Variation (s'-SWL)	-0.22 m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.27 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and storage Coefficient

Analyzed Method	Kind of Test	Transmissibility (m3/d/m)	Transmissibility (m3/s/m)	Storage Coefficient
Theis	C/T	43.11	4.99E-04	4.99E-07
	R/T	26.78	3.10E-04	
Jacob	C/T	253.15	2.93E-03	2.63E-44
	R/T	24.19	2.80E-04	
Average		86.81	1.00E-03	4.99E-07

C/T : Constant Discharge Test

R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	4.75E-04	cm/sec	105.01
	R/T	2.95E-04	cm/sec	105.01
Jacob	C/T	2.79E-03	cm/sec	105.01
	R/T	2.67E-04	cm/sec	105.01
Average		9.57E-04	cm/sec	

C/T : Constant Discharge Test

R/T : Recovery Test

v) Well No. J-3

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	9.17 m
	Discharge Rate (Q)	5 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	16.05 m
	Drawdown (Sw)	6.88 m
	Specific Yield	62.79 m3/d/m
Recovery Test	Duration of Test	1440 min.
	Water Level (s')	9.42 m
	Recovery (S-s')	6.63 m
	Water Level Variation (s'-SWL)	0.25 m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.28 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analyzed Method	Kind of Test	Transmissibility		Storage Coefficient
		(m3/d/m)	(m3/s/m)	
Theis	C/T	97.63	1.13E-03	3.16E-04
	R/T	142.56	1.65E-03	
Jacob	C/T	75.95	8.79E-04	5.01E-03
	R/T	139.10	1.61E-03	
Average		113.81	1.32E-03	2.66E-03

C/T : Constant Discharge Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	1.89E-03	cm/sec	59.86
	R/T	2.76E-03	cm/sec	59.86
Jacob	C/T	1.47E-03	cm/sec	59.86
	R/T	2.69E-03	cm/sec	59.86
Average		2.20E-03	cm/sec	

C/T : Constant Discharge Test

R/T : Recovery Test

vi) Well No. J-4

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	46.22 m
	Discharge Rate (Q)	4.4 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	48.2 m
	Drawdown (Sw)	1.98 m
	Specific Yield	192 m3/d/m
Recovery Test	Duration of Test	360 min.
	Water Level (s')	46.26 m
	Recovery (S-s')	1.94 m
	Water Level Variation (s'-SWL)	0.04 m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.29 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analyzed Method	Kind of Test	Transmissibility		Storage Coefficient
		(m3/d/m)	(m3/s/m)	
Theis	C/T	286.85	3.32E-03	7.96E-06
	R/T	336.96	3.90E-03	
Jacob	C/T	124.42	1.44E-03	3.12E-02
	R/T	336.10	3.89E-03	
Average		271.08	3.14E-03	1.56E-02

C/T : Constant Discharge Test
R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	5.53E-03	cm/sec	60.09
	R/T	6.49E-03	cm/sec	60.09
Jacob	C/T	2.40E-03	cm/sec	60.09
	R/T	6.47E-03	cm/sec	60.09
Average		5.22E-03	cm/sec	

C/T : Constant Discharge Test
R/T : Recovery Test

vii) Well No. J-5

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	29.08 m
	Discharge Rate (Q)	5 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	29.68 m
	Drawdown (Sw)	0.6 m
	Specific Yield	720 m3/d/m
Recovery Test	Duration of Test	1560 min.
	Water Level (s')	29.08 m
	Recovery (S-s')	0.6 m
	Water Level Variation (s'-SWL)	0 m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.30 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analyzed Method	Kind of Test	Transmissibility		Storage Coefficient
		(m3/d/m)	(m3/s/m)	
Theis	C/T	1010.88	1.17E-02	1.88E-05
	R/T	338.69	3.92E-03	
Jacob	C/T	1391.04	1.61E-02	9.78E-09
	R/T	337.82	3.91E-03	
Average		769.61	8.91E-03	9.40E-06

C/T : Constant Discharge Test

R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	1.08E-02	cm/sec	108.29
	R/T	3.62E-03	cm/sec	108.29
Jacob	C/T	1.49E-02	cm/sec	108.29
	R/T	3.61E-03	cm/sec	108.29
Average		8.23E-03	cm/sec	

C/T : Constant Discharge Test

R/T : Recovery Test

viii) Well No. J-6

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	14.04 m
	Discharge Rate (Q)	4.04 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	29.7 m
	Drawdown (Sw)	15.66 m
	Specific Yield	22.29 m3/d/m
Recovery Test	Duration of Test	2024 min.
	Water Level (s')	14.4 m
	Recovery (S-s')	15.3 m
	Water Level Variation (s'-SWL)	0.36 m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.31 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analyzed Method	Kind of Test	Transmissibility (m3/d/m)	Transmissibility (m3/s/m)	Storage Coefficient
Theis	C/T	29.72	3.44E-04	1.38E-04
	R/T	18.14	2.10E-04	
Jacob	C/T	21.19	2.45E-04	6.44E-03
	R/T	17.45	2.02E-04	
Average		21.63	2.50E-04	3.29E-03

C/T : Constant Discharge Test
R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	4.40E-04	cm/sec	78.10
	R/T	2.69E-04	cm/sec	78.10
Jacob	C/T	3.14E-04	cm/sec	78.10
	R/T	2.59E-04	cm/sec	78.10
Average		3.20E-04	cm/sec	

C/T : Constant Discharge Test
R/T : Recovery Test

ix) Well No. J-7

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	7.94 m
	Discharge Rate (Q)	5 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	9.78 m
	Drawdown (Sw)	1.84 m
	Specific Yield	234.78 m3/d/m
Recovery Test	Duration of Test	360 min.
	Water Level (s')	7.93 m
	Recovery (S-s')	1.85 m
	Water Level Variation (s'-SWL)	-0.01 m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.32 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analyzed Method	Kind of Test	Transmissibility (m3/d/m)	Transmissibility (m3/s/m)	Storage Coefficient
Theis	C/T	354.24	4.10E-03	1.07E-04
	R/T	283.39	3.28E-03	
Jacob	C/T	619.49	7.17E-03	2.24E-10
	R/T	278.21	3.22E-03	
Average		383.83	4.44E-03	5.35E-05

C/T : Constant Discharge Test

R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	4.89E-03	cm/sec	83.79
	R/T	3.91E-03	cm/sec	83.79
Jacob	C/T	8.56E-03	cm/sec	83.79
	R/T	3.84E-03	cm/sec	83.79
Average		5.30E-03	cm/sec	

C/T : Constant Discharge Test

R/T : Recovery Test

x) Well No. J-8

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	37.99 m
	Discharge Rate (Q)	3.34 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	39.52 m
	Drawdown (Sw)	1.53 m
	Specific Yield	188.61 m3/d/m
Recovery Test	Duration of Test	790 min.
	Water Level (s')	38.56 m
	Recovery (S-s')	0.96 m
	Water Level Variation (s'-SWL)	0.57 m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.33 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analyzed Method	Kind of Test	Transmissibility (m3/d/m)	Transmissibility (m3/s/m)	Storage Coefficient
Theis	C/T	229.82	2.66E-03	2.13E-03
	R/T	469.15	5.43E-03	
Jacob	C/T	344.74	3.99E-03	7.98E-06
	R/T	461.38	5.34E-03	
Average		376.27	4.36E-03	1.07E-03

C/T : Constant Discharge Test

R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	3.17E-03	cm/sec	84.04
	R/T	6.46E-03	cm/sec	84.04
Jacob	C/T	4.75E-03	cm/sec	84.04
	R/T	6.35E-03	cm/sec	84.04
Average		5.18E-03	cm/sec	

C/T : Constant Discharge Test

R/T : Recovery Test

xi) Well No. J-9

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	13.97	m
	Discharge Rate (Q)	5	l
	Duration of Pumping Time (t)	1440	min.
	Dynamic Water Level (S)	16.57	m
	Drawdown (Sw)	2.60	m
	Specific Yield	166.15	m3/d/m
Recovery Test	Duration of Test	1560	min.
	Water Level (s')	14.04	m
	Recovery (S-s')	2.53	m
	Water Level Variation (s'-SWL)	0.07	m

Analysis was made by graphs which is shown in Fig. B-III, 2.3.34 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analized Method	Kind of Test	Transmissibity (m3/d/m)	Transmissibity (m3/s/m)	Storage Coefficient
Theis	C/T	364.00	4.21E-03	2.36E-03
	R/T	251.19	2.91E-03	
Jacob	C/T	219.01	2.53E-03	1.76E-03
	R/T	230.05	2.66E-03	
Average		266.06	3.08E-03	2.06E-03

C/T : Constant Discharge Test

R/T : Recovery Test

b) Permeability

Analized Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	4.84E-03	cm/sec	86.98
	R/T	3.34E-03	cm/sec	86.98
Jacob	C/T	2.91E-03	cm/sec	86.98
	R/T	3.06E-03	cm/sec	86.98
Average		3.54E-03	cm/sec	

C/T : Constant Discharge Test

R/T : Recovery Test

(2) Critical Discharge and Safe Yield

The step drawdown test was conducted to examine the performance of well which represented as critical discharge and safe yield. In the test, the well is pumped as several successively higher pumping rate and the same for each rate, steps and its drawdown is recorded.

The details of critical discharge and safe yield, including method of analysis are descried in part B-II, Lluta River Basin.

Critical discharge and safe yield examined by step drawdown test for each wells are described as following section.

i) Well No. J-C

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.35.

Step NO.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	2.00	72.89	20.86
2	120	2.25	72.69	20.66
3	120	2.50	79.87	27.84
4'	120	2.25	76.00	23.97
3'	120	2.00	75.50	23.47
2'	120	1.75	74.5	22.47
1'	120	1.5	73.62	21.59

1, 2 : Steps for discharge increased
1', 2' : Steps for discharge decreased

Deep static water level and large drawdown is recorded in this well. Considering the setting depth of submersible pump (90 m.bgl), only 3 steps test was conducted. Therefore, 2.5 l/s of step No.3 is estimated as critical discharge.

b) Safe Yield

Well efficiency and area of influence are obtained from following table.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
0.10	98.04	1.20	80.69
0.20	96.16	1.40	78.17
0.30	94.35	1.60	75.81
0.40	92.61	1.80	73.58
0.50	90.93	2.00	71.49
0.60	89.31	2.20	69.50
0.70	87.75	2.40	67.63
0.80	86.24	2.60	65.85
0.90	84.78	2.80	64.17
1.00	83.37	3.00	62.57

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	0.8 l/s	500 l/s	1000 l/s
1			1	10	10
6			3	24	26
12			5	34	36
18			6	42	45
24	1		7	48	51
240	10		21	153	163
720	30		36	265	282
8760	365	1	125	926	982
17520	730	2	177	1,309	1,389
26280	1095	3	217	1,603	1,702
43800	1825	5	280	2,070	2,197
87600	3650	10	396	2,927	3,107

As shown in above table, the rate of 0.8 l/s is maximum rate for keeping more than 85% well efficiency. Moreover, the area of influence by 18 hours pumping operation is only 6m at 0.8 l/s discharge rate. Therefore, safe yield of the well is estimated as 0.8 l/s.

ii) Well No. J-D

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.36.

Step N0.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	7.60	48.89	2.86
2	120	10.00	49.44	3.41
3	120	13.00	49.91	3.88
4	120	16.00	50.68	4.65
5	120	19.00	51.24	5.21
6	120	22.00	51.96	5.93
7	120	25.00	52.41	6.38
6'	120	22.00	51.28	5.25
5'	120	20.13	50.99	4.96
4'	120	16.60	49.97	3.94
3'	120	13.00	49.78	3.75
2'	120	10.00	48.68	2.65
1'	120	7.00	47.96	1.93

1, 2 : Steps for discharge increased

1', 2' : Steps for discharge decreased

The incline of the Q-Sw chart is almost straight line with less than 45 degrees. It is expected that critical discharge is more than 25 l/s, because it can not be obtained by this pump capacity.

b) Safe Yield

Well efficiency and area of influence are obtained from following tables.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
5.00	91.92	15.00	79.14
6.00	90.46	16.00	78.05
7.00	89.04	17.00	76.99
8.00	87.67	18.00	75.97
9.00	86.34	19.00	74.97
10.00	85.05	20.00	73.99
11.00	83.80	21.00	73.04
12.00	82.58	22.00	72.11
13.00	81.40	23.00	71.21
14.00	80.25	24.00	70.33

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	10 l/s	27.5 l/s	30 l/S
1			0	57	84
6			1	139	205
12			1	196	290
18			1	240	355
24	1		1	277	410
240	10		4	877	1,298
720	30		7	1,519	2,248
8760	365	1	26	5,298	7,842
17520	730	2	37	7,493	11,090
26280	1095	3	45	9,177	13,582
43800	1825	5	58	11,847	17,534
87600	3650	10	82	16,754	24,797

Discharge rate of 10 l/s is a maximum rate from well efficient point of view. The area of influence, in case of 10 l/s by 18 hours pumping operation, is only 1m. It is estimated that the rate of 10 l/s is enough for safe yield.

iii) Well No. J-E

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.37.

Step NO.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	180	7.29	14.16	0.83
2	120	7.00	14.53	1.20
3	120	11.51	14.85	1.52
4	120	15.12	15.39	2.06
5	120	18.00	15.79	2.46
6	120	21.00	16.46	3.13
7	120	24.00	17.16	3.83
8	120	27.00	17.78	4.45
7'	120	24.00	17.13	3.80
6'	120	21.00	16.46	3.13
5'	120	18.00	15.95	2.62
4'	120	15.00	15.37	2.04
3'	120	12.00	14.98	1.65
2'	120	9.00	14.46	1.13

An incline of the Q-Sw chart shows less than 45 degrees, and it is almost straight line except first 2 steps of increased rate. Critical discharge can not be obtained by this test, it is expected more than 27 l/s, which is more than submersible pump capacity.

b) Safe Yield

Well efficiency and area of influence are obtained from following table.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
10.00	91.90	60.00	65.40
15.00	88.32	65.00	63.56
20.00	85.01	70.00	61.83
25.00	81.94	75.00	60.19
30.00	79.08	80.00	58.63
35.00	76.41	85.00	57.16
40.00	73.92	90.00	55.75
45.00	71.59	95.00	54.41
50.00	69.40	100.00	53.14
55.00	67.34	105.00	51.92

Area of Influence

Hour	Date	Year	Area of Influence (m)		
			50 l/s	69 l/s	100 l/S
1			40	55	71
6			99	135	174
12			140	190	246
18			172	233	301
24	1		198	269	347
240	10		626	851	1,099
720	30		1,085	1,474	1,903
8760	365	1	3,784	5,142	6,638
17520	730	2	5,352	7,271	9,387
26280	1095	3	6,554	8,906	11,497
43800	1825	5	8,462	11,497	14,843
87600	3650	10	11,967	16,259	20,991

High discharge rate of 20 l/s is obtained at 85% well efficiency. Area of influence of this rate by the 18 hours pumping operation is only 172m. Therefore, Safe yield is estimated as 20 l/s.

iv) Well No. J-F

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.38.

Step NO.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	5.50	59.40	2.40
2	120	8.33	60.63	3.63
3	120	10.00	61.85	4.85
4	120	12.00	63.17	6.17
5	120	14.00	64.36	7.36
6	120	16.00	65.63	8.63
7	120	18.00	67.04	10.04
8	120	20.00	68.30	11.30
7'	120	18.00	66.71	9.71
6'	120	16.00	65.26	8.26
5'	120	14.00	63.99	6.99
4'	120	12.00	62.99	5.99
3'	120	10.00	61.60	4.60
2'	120	8.00	60.57	3.57
1'	120	6.00	59.03	2.03

1, 2 : Steps for discharge increased

1', 2' : Steps for discharge decreased

More than 45 degrees of incline is obtained by Q-Sw chart. The incline is almost straight and same drawdown is observed between increased and decreased step. In this case, the rate of 2nd step is estimated as critical discharge. Because, incline is exceeded from 2nd step and it is a maximum rate for showing same drawdown between increased and decreased rate. So that 8.33 l/s is estimated critical discharge.

b) Safe Yield

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
1.00	97.38	6.00	86.12
1.50	96.13	6.50	85.14
2.00	94.90	7.00	84.17
2.50	93.71	7.50	83.23
3.00	92.54	8.00	82.31
3.50	91.41	8.50	81.41
4.00	90.30	9.00	80.53
4.50	89.22	9.50	79.67
5.00	88.16	10.00	78.83
5.50	87.13	10.50	78.00

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	6.5 l/s	1.8 l/s	1.5 l/S
1			1,271	59	25
6			3,114	144	62
12			4,404	204	87
18			5,393	250	107
24	1		6,228	288	123
240	10		19,694	912	390
720	30		34,111	1,579	676
8760	365	1	118,981	5,508	2,358
17520	730	2	168,264	7,789	3,335
26280	1095	3	206,081	9,540	4,085
43800	1825	5	266,049	12,316	5,273
87600	3650	10	376,250	17,417	7,458

Maximum pumping rate is estimated as 6.5 l/s to keep the range of more than 85% well efficiency. However, in order to save as less than 250m for area of influence, 1.8 l/s is maximum rate. Therefore, safe yield is estimated as 1.8 l/s.

v) Well No. J-3

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.39

Step NO.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	3.50	14.14	4.97
2	120	3.75	14.39	5.22
3	120	4.00	14.68	5.51
4	120	4.25	14.93	5.76
5	120	4.50	15.20	6.03
6	120	4.75	15.46	6.29
7	120	5.00	15.92	6.75
6'	120	4.75	15.69	6.52
5'	120	4.50	15.29	6.12
4'	120	4.25	15.04	5.87
3'	120	4.00	14.79	5.62
2'	120	3.75	14.43	5.26
1'	120	3.50	14.07	4.90

1, 2 : Steps for discharge increased

1', 2' : Steps for discharge decreased

Due to less than 45 degrees incline of Q-Sw chart and almost same drowdown between increased and decreased rate, the critical discharge can not be obtained in this step test. Critical discharge is expected more than 5 l/s, which is more than pump capacity of the well.

b) Safe Yield

Well efficiency and area of influence are obtained from following table.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
2.25	90.86	7.00	76.17
2.50	89.95	8.00	73.66
2.75	89.05	9.00	71.31
3.00	88.18	10.00	69.11
3.25	87.31	11.00	67.04
3.50	86.47	12.00	65.09
3.75	85.64	13.00	63.25
4.00	84.83	14.00	61.51
5.00	81.73	15.00	59.86
6.00	78.85	16.00	58.30

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	3.75 l/s	29 l/s	35 l/S
1			4	59	65
6			10	143	160
12			14	203	227
18			17	248	278
24	1		20	287	321
240	10		63	907	1,014
720	30		109	1,571	1,757
8760	365	1	379	5,482	6,129
17520	730	2	537	7,752	8,667
26280	1095	3	657	9,494	10,615
43800	1825	5	848	12,257	13,704
87600	3650	10	1,200	17,334	19,380

Discharge rate of 3.75 l/s is a maximum rate as for more than 85% well efficiency. This rate is enough to save as within 250m area of influence (only 17m). Thus, 3.75 l/s is estimated safe yield.

vi) Well No. J-4

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.40.

Step N0.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	1.50	46.77	0.38
2	120	2.00	47.07	0.68
3	120	2.50	47.38	0.99
4	120	3.00	47.68	1.29
5	120	3.50	48.15	1.76
6	120	4.00	48.50	2.11
7	120	4.50	48.68	2.29
6'	120	4.00	48.50	2.11
5'	120	3.50	48.14	1.75
4'	120	3.00	47.79	1.40
3'	120	2.50	47.40	1.01
2'	120	2.00	47.07	0.68
1'	120	1.50	46.70	0.31

1, 2 : Steps for discharge increased
1', 2' : Steps for discharge decreased

More than 45 degrees of incline is observed from Q-Sw chart. However, from 6th step, drawdown has been stable to the 7nd step and this incline is almost 45 degrees. Moreover, drawdown of decreased rate of 6'th step is same as increased 6th step. Therefore, critical discharge in this case, is estimated as 4 l/s of 6th step.

b) Safe Yield

Well efficiency and area of influence are obtained from following table.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
0.10	94.56	1.50	53.67
0.20	89.68	2.00	46.49
0.30	85.28	2.50	41.01
0.40	81.29	3.00	36.68
0.50	77.66	3.50	33.18
0.60	74.33	4.00	30.29
0.70	71.28	4.50	27.86
0.80	68.47	5.00	25.79
0.90	65.88	5.50	24.01
1.00	63.47	6.00	22.46

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	10 l/s	180 l/s	200 l/S
1			4	58	60
6			9	141	148
12			12	200	209
18			15	245	256
24	1		17	283	296
240	10		55	894	936
720	30		95	1,549	1,622
8760	365	1	330	5,404	5,656
17520	730	2	467	7,642	7,999
26280	1095	3	572	9,359	9,797
43800	1825	5	739	12,083	12,648
87600	3650	10	1,045	17,088	17,886

High pumping rate of 180 l/s is obtained with in 250m area of influence. However, 0.3 l/s is a maximum rate to meet a criteria of well efficiency. Thus 0.3 l/s is estimated as safe yield.

vii) Well No. J-5

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.41

Step N0.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	2.00	29.33	0.25
2	120	2.50	29.25	0.17
3	120	3.00	29.41	0.33
4	120	3.50	29.48	0.40
5	120	4.00	29.55	0.47
6	120	4.50	29.62	0.54
7	120	5.00	29.69	0.61
6'	120	4.50	29.54	0.46
5'	120	4.00	29.50	0.42
4'	120	3.50	29.45	0.37
3'	120	3.00	29.40	0.32
2'	120	2.50	29.35	0.27
1'	120	2.00	29.30	0.22

1, 2 : Steps for discharge increased

1', 2' : Steps for discharge decreased

According to Q-Sw chart, abnormal incline for increased rate is observed, because high drawdown at 2nd step. It is considered that aquifer is opened by the this pumping test. In general, except 2nd step, the incline is almost or less than 45 degrees. Thus safe yield is estimated as more than 5 l/s, which is more than pump capacity.

b) Safe Yield

Well efficiency and area of influence are obtained from following table.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
1.00	92.10	3.50	76.90
1.25	90.31	3.75	75.65
1.50	88.60	4.00	74.45
1.75	86.94	4.25	73.28
2.00	85.35	4.50	72.14
2.25	83.82	4.75	71.04
2.50	82.34	5.00	69.98
2.75	80.91	5.25	68.94
3.00	79.53	5.50	67.94
3.25	78.19	5.75	66.96

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	15 l/s	17.5 l/s	20 l/S
1			30	56	88
6			74	137	216
12			104	194	306
18			127	238	374
24	1		147	274	432
240	10		465	868	1,366
720	30		805	1,503	2,367
8760	365	1	2,809	5,244	8,256
17520	730	2	3,973	7,416	11,675
26280	1095	3	4,866	9,083	14,299
43800	1825	5	6,282	11,726	18,460
87600	3650	10	8,883	16,583	26,106

In order to meet a both criteria of more than 85% well efficiency and less than 250m area of influence, 2.0 l/s is estimated as safe yield.

viii) Well No. J-6

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.42.

Step NO.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	1.21	18.35	4.31
2	120	1.49	19.05	5.01
3	120	2.11	22.09	8.05
4	120	2.49	23.93	9.89
5	120	2.90	25.43	11.39
6	120	3.34	26.42	12.38
7	120	4.04	29.43	15.39
6'	120	3.34	28.08	14.04
5'	120	2.90	27.23	13.19
4'	120	2.49	25.12	11.08
3'	120	2.11	23.99	9.95
2'	120	1.49	20.67	6.63
1'	120	1.21	19.22	5.18

1, 2 : Steps for discharge increased
1', 2' : Steps for discharge decreased

The incline of Q-Sw chart shows 45 degrees and it is almost straight line. Changing point to more than 45 degrees incline is not obtained. Thus, critical discharge is estimated as more than 4.04 l/s of the 7th step, which is more than pump capacity.

b) Safe Yield

Well efficiency and are of influence are obtained from following table.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
1.00	96.59	6.00	82.53
1.50	94.97	6.50	81.35
2.00	93.41	7.00	80.20
2.50	91.90	7.50	79.08
3.00	90.43	8.00	77.99
3.50	89.01	8.50	76.93
4.00	87.63	9.00	75.90
4.50	86.30	9.50	74.90
5.00	85.01	10.00	73.92
5.50	83.75	10.50	72.97

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	5 l/s	120 l/s	200 l/S
1			22	58	64
6			53	143	157
12			75	202	222
18			92	247	272
24	1		106	285	314
240	10		336	902	992
720	30		582	1,563	1,719
8760	365	1	2,030	5,451	5,995
17520	730	2	2,871	7,709	8,479
26280	1095	3	3,516	9,442	10,384
43800	1825	5	4,540	12,189	13,406
87600	3650	10	6,420	17,238	18,959

High pumping rate of 120 l/s is confirmed with in the 250m area of influence. However, in order to meet a criteria of more than 85% well efficiency, 5 l/s is estimated as safe yield.

ix) Well No. J-7

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.43.

Step N0.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	2.00	8.63	0.76
2	120	2.50	8.80	0.93
3	120	3.00	8.97	1.10
4	120	3.50	9.18	1.31
5	120	4.00	9.35	1.48
6	120	4.50	9.50	1.63
7	120	5.00	9.64	1.77
6'	120	4.50	9.55	1.68
5'	120	4.00	9.38	1.51
4'	120	3.50	9.25	1.38
3'	120	3.00	9.11	1.24
2'	120	2.50	8.93	1.06
1'	120	2.00	8.85	0.98

1, 2 : Steps for discharge increased
1', 2' : Steps for discharge decreased

The incline of Q-Sw chart both of increased and decreased rate is almost or less than 45 degrees. No changing point for high incline is observed. Thus, critical discharge is estimated as more than 5 l/s of 7th step. It is more than pump capacity of the well.

b) Safe Yield

Well efficiency and area of influence are observed from following table.

Well efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
3.00	95.39	13.00	82.68
4.00	93.95	14.00	81.59
5.00	92.54	15.00	80.54
6.00	91.18	16.00	79.50
7.00	89.86	17.00	78.50
8.00	88.58	18.00	77.52
9.00	87.34	19.00	76.56
10.00	86.12	20.00	75.63
11.00	84.94	21.00	74.72
12.00	83.80	22.00	73.83

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	10 l/s	13 l/s	20 l/S
1			28	56	134
6			68	137	328
12			96	193	464
18			117	236	568
24	1		135	273	656
240	10		428	864	2,074
720	30		742	1,496	3,593
8760	365	1	2,588	5,217	12,531
17520	730	2	3,661	7,378	17,722
26280	1095	3	4,483	9,036	21,705
43800	1825	5	5,788	11,666	28,021
87600	3650	10	8,185	16,498	39,627

In order to meet to two (2) criteria of more than 85% well efficiency and less than 250m area of influence, 10 l/s is estimated as safe yield.

x) Well No. J-8

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.44.

Step N0.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	1.00	38.37	0.38
2	120	1.49	38.51	0.52
3	120	1.79	38.57	0.58
4	120	2.11	38.66	0.67
5	120	2.49	38.82	0.83
6	120	2.90	38.99	1.00
7	120	3.34	39.24	1.25
6'	120	2.90	39.16	1.17
5'	120	2.49	39.50	1.51
4'	120	2.11	38.85	0.86
3'	120	1.79	38.60	0.61
2'	120	1.49	38.55	0.56
1'	120	1.00	38.42	0.43

1, 2 : Steps for discharge increased
1', 2' : Steps for discharge decreased

The incline of Q-Sw chart shows almost or less than 45 degrees, except 6' th to 5' th steps of the decreased rate. However, even peak of 5' th step, its drawdown is only 39.5 m.bgl. It is still enough interval to the setting depth of submersible pump (90 m.bgl). Thus critical discharge is estimated as 3.34 l/s, which is more than maximum pumping rate.

b) Safe Yield

Well efficiency and area of influence are obtained from following table.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
1.00	99.74	50.00	88.50
5.00	98.72	55.00	87.50
10.00	97.47	60.00	86.52
15.00	96.25	65.00	85.55
20.00	95.06	70.00	84.61
25.00	93.90	75.00	83.69
30.00	92.77	80.00	82.79
35.00	91.67	85.00	81.91
40.00	90.59	90.00	81.05
45.00	89.53	95.00	80.21

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	65 l/s	29 l/s	20 l/S
1			130	57	33
6			320	140	82
12			452	199	116
18			553	243	142
24	1		639	281	164
240	10		2,021	888	517
720	30		3,500	1,538	896
8760	365	1	12,209	5,365	3,125
17520	730	2	17,266	7,587	4,420
26280	1095	3	21,147	9,293	5,413
43800	1825	5	27,300	11,997	6,988
87600	3650	10	38,609	16,966	9,882

In order to meet to two (2) criteria of 85% well efficiency and less than 250m area of influence, 29 l/s is estimated as safe yield.

xi) Well No. J-9

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-II, 2.3.45.

Step NO.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	1.50	14.86	0.90
2	120	2.00	15.80	1.84
3	120	2.50	15.25	1.29
4	120	3.00	15.46	1.50
5	120	3.50	15.73	1.77
6	120	4.00	15.94	1.98
7	120	4.50	16.19	2.23
8	120	5.00	16.46	2.50
7'	120	4.50	16.25	2.29
6'	120	4.00	15.95	1.99
5'	120	3.50	15.75	1.79
4'	120	3.00	15.48	1.52
3'	120	2.50	15.26	1.30
2'	120	2.00	15.05	1.09
1'	120	1.50	14.87	0.91

1, 2 : Steps for discharge increased

1', 2' : Steps for discharge decreased

The incline of Q-Sw chart shows less than 45 degrees, and almost same drawdown between increased and decreased rate except at 2 nd step on increase.

b) Safe Yield

Well efficiency and area of influence are obtained from following table.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
1.00	95.92	6.00	79.65
1.50	94.00	6.50	78.32
2.00	92.15	7.00	77.04
2.50	90.38	7.50	75.80
3.00	88.67	8.00	74.59
3.50	87.03	8.50	73.43
4.00	85.45	9.00	72.30
4.50	83.92	9.50	71.20
5.00	82.45	10.00	70.14
5.50	81.03	10.50	69.11

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	4 l/s	3.5 l/s	3 l/S
1			69	59	55
6			169	144	134
12			238	203	190
18			292	249	233
24	1		337	288	269
240	10		1,066	909	851
720	30		1,847	1,575	1,473
8760	365	1	6,441	5,493	5,139
17520	730	2	9,110	7,769	7,267
26280	1095	3	11,157	9,515	8,900
43800	1825	5	14,404	12,283	11,490
87600	3650	10	20,370	17,371	16,249

In order to meet two (2) criteria of more than 85% well efficiency and less than 250m area of influence, 3.5 l/s is estimated as safe yield.

2.3.4 Carbon-14 Analysis

ThePurpose of Carbon- 14 Analysis is to decide the age of groundwater for interpretation of groundwater recharge mechanism and for evaluation of the groundwater potential. Five (5) sample were taken in Pampa del Tamarugal; one (1) sample from the JICA Well (J-F) and four (4) samples from the existing wells (see, Fig. B-III, 2.2.1).

Result is shown in the following table;

Well No.	H-3	C-14	Age (YBP)
172 (Dolores)			
193 (Mapocho)			
354 (Canchones)			
470 (Pica)			
J-F (Oficina victoria)			

YBP: year before present

2.4 Configuration of Aquifer

The Study Area, the Pampa del Tamarugal Basin is defined as follows;

(north): divide of basin between the Qda de Aroma and the Qda. de Tiliviche
(south): Cerro Gordo
(east) : western mountain foot of the mountains
(this border was formed by faults that pass west of Pica and Tarapaca)
(west) : eastern edge of the Cordillera de la Costa (the coastal mountains)
(this border was formed by faults)

Detailed geological and hydrogeological information are given by the 11 wells drilled by the Study Team and three (3) wells by ENAP. Results of JICA Wells are mentioned in 2.3 of this chapter. Tertiary to Quaternary formation (Altos de Pica Formation) is accumulated filling the basin of Pampa del Tamarugal. ENAP drilled three (3) wells in the study area, "Dolores 1" in the northern part of the area and, "Pintados 1" and "Pintados 2" in the southern part of the area. These wells give information on the stratigraphy and geological structure of the basin, because ENAP wells penetrated into the Basement Rocks through the Tertiary to Quaternary formation and JICA Wells reached to the base of aquifer.

Geological profiles and cross sections of Pampa del Tamarugal are shown in Fig. B-III, 1.2.3 and 1.2.4 respectively. These are constructed based on the results of drilling by the Study Team and reviewing the existing profile (<2).

As shown in Fig. B-III, 1.2.4 and 1.2.5, aquifers occurre in units Q3 and Q4 of the Altos de Pica Formation. Expected aquifer area is shown in Fig. B-III, 2.4.1 by dotted line. The Altos de Pica Formation is covered by Recent Deposits which increase the thickness toward the east. It means that depth to the aquifer is generally deep in the eastern area; pumping head is large. Therefore, expected aquifer area is limited within this dotted line. Width of the aquifers ranges from 13 km to 46 km, averaging 30 km.

Aquifers occurr in units Q3 and Q4 of the Altos de Pica Formation (Ref. Table B-III, 1.2.1). The unit Q3 is composed of sand and gravel and is uncomformably underlain by Q2. Q4 consists of sand and gravel with mud, and/or intercalated with mud layers. The unit Q4 is deposited overlying the unit Q3. Thus, the distribution of Q4 is wider than that of Q3. The unit Q3 is distributed in the area from Huara to Salar de Bellavista. The unit Q4 is widespread in the aquifer area (Ref. Fig. B-III, 2.4.1). No impermeable layers are appeared between unit Q3 and Q4. Those aquifers are underlain by thick impermeable clayey beds which are the hydrogeological base of aquifer in the basin (Ref. Fig. 1.2.4 and 1.2.5).

Thickness of deposits is about 100 m near Dolores and increase toward the south reaching to about 700 m in the Salar de Pintados. The deposits are accumulated almost horizontally and sometimes interbedded each other. The thickness of this formation varies in place to place. It is generally thin in the northern area and thick in the southern area; about 90 m in the south and 700 m in the south. The aquifers are occurred in some horizons, mainly in sand and gravel.

Figure of aquifers in Pampa del Tamarugal is summarized as following table;

Area	Thickness (m)		Width	Top of Q3	Base of Aquifers	Water Level
	Q3	Q4	(km)	(mBGL)	(mBGL)	(mBGL)
Zapiga/Dolores	-	90-100	13-17	-	90	<10
Negreiros	-	100	15	-	90	20
Huara	<10	60	15-19	110	110	50
Humberstone	80	60-90	27	120	180-200	40
Pozo Almonte	20	120	26	130	240-260	30
Pintados	60-100	150	30-37	70	220	10
Bellavista	40-50	50-90	30-46	120	170	10

2.5 Hydrogeological Characteristics of Aquifer

Pampa del Tamarugal is basically closed basin from a hydrogeological point of view, although a small river flows out from the southern end of the basin. The pampa area does not recieve any precipitation through the year. Groundwater in pampa is recharged from the surface water of several rivers and some fissure water. Main rivers which flow into the pampa are Qdas. Aroma, Tarapaca, Quipisca, Juan de Morales, Quisma, Chacarilla and Ramada. Surface water of these rivers infiltrate to underground before entering to the pampa. The pampa is sometimes covered by flood water in so called "Bolivian Winter" season. Fissure water reaches to the pampa from the east through faults, joints and fissures developped in the volcanic rocks. One of the possible resources is the water in Salar del Huasco Basin.

The western and southern margin of the pampa is surrounded by the impermeable basement rocks. The aquifers Q3 and Q4 are underlain by thick clay (Q2) and/or basement rocks that are both generally impermeable. Q2 is composed mainly of clay, but sometimes contains sandy materials. Thus, Q2 also shows a certain degree of permeability. This is supposed by logging data of JICA Wells; a part of screens is also installed in Q4 in some wells (J-3, 4, C, D, 5, 6, 8, 9). The groundwater recharged into the units Q3 and Q4 are storaged in these units and gentlly flows toward the south reaching to Salar de Bellavista through Salar de Pintados.

Quantitative character of the aquifers are given by aquifer constants. Aquifer constants are available on 11 JICA Wells and 36 existing wells. Specific yield is estimated on 51 wells including JICA Wells. Data of JICA Wells are given in the following table. Data of existing wells are in Table B-III, 2.5.1.

(JICA Wells)

Area	Well No.	Specific Yield (l/sec/m)	Transmissibility (m³/day/m)	Storage Coefficient	Permeability (cm/sec)
Dolores	J-3	0.73	113.81	2.66×10^{-3}	2.20×10^{-3}
Negreilos	J-4	2.22	271.08	1.56×10^{-2}	5.22×10^{-3}
Huara	J-C	0.09	8.29	7.71×10^{-2}	1.23×10^{-4}
	J-D	3.47	1506.17	3.28×10^{-6}	1.81×10^{-2}
Pozo Almonte	J-5	8.33	769.61	9.4×10^{-6}	8.23×10^{-3}
|	J-E	6.77	644.33	4.27×10^{-3}	7.31×10^{-3}
Canchones	J-6	0.26	21.63	3.29×10^{-3}	3.20×10^{-4}
|	J-7	2.72	383.83	5.35×10^{-5}	5.30×10^{-3}
Pintados	J-8	2.18	376.27	1.07×10^{-3}	5.18×10^{-3}
Bellavista	J-9	1.92	266.06	2.06×10^{-3}	3.54×10^{-3}
	J-F	1.65	86.81	4.99×10^{-7}	9.57×10^{-4}
Average		2.76	404.35	9.65×10^{-3}	5.13×10^{-3}

Specific yield (Sy) of aquifers is 2.13 l/sec/m in average, ranging from 0.03 l/sec/m (well No. 936 at Negreilos) to 10.67 l/sec/m (well No. 202 at Porvenir east from Pozo Ajmonte). Sy is relatively high in Huara area and Pozo Almonte to Pintados area. Low in Zapiga to Negreilos area and Bellavista area.

Transmissibility and permeability are generally high. Average of transmissibility by area is in a range from 154 m^3/day/m to 1102 m^3/day/m. Permeability of aquifers is in same order in the whole area of Pampa; its average is in a 10^{-2} order. This order is high as aquifers.

Characteristics of aquifer constants by area are as follows;

a) Zapiga-Dolores-Negreilos area

Main aquifer of this area is the unit Q4. Productivity of Q4 is low, because Sy is between 0.03 l/sec/m and 2.20 l/sec/m, having average of 0.73 l/sec/m. Relatively high Sy appear in the wells located along the Panamerican Road; this area is in main stream of the groundwater flow. Low Sy appear mainly in the small valleys in the western side of the area. Although permeability is relatively high (10^{-2} order), transmissibility is rather small (154 m^3/day/m).

Two (2) JICA Wells are drilled in the area (J-3, J-4). Both of wells show relatively low Sy and transmissibility.

b) Huara area

The unit Q4 is the main aquifer in this area. The most high average of Sy appears in this area, 3.7 l/sec/m. Transmissibility is also high, 675 m^3/day/m in average. Permeability is lower than average.

Two (2) JICA Wells are drilled in the area (J-C, J-D). J-D shows relatively high Sy (3.47 l/sec/m) and high Transmissibility (1506 m^3/day/m) which is the largest in the Pampa area. In contrary to this, J-C shows low Sy and low transmissibility. Lithology of aquifer is much clayey in J-C, and extreamly poor in sand and gravel beds. Therefore, lithology of aquifers in this area changes in place to place.

c) Pozo Almomte-Canchones-Pintados area

Main aquifers are Q3 and Q4 in this area. Sy is high, 3.26 l/sec/m in average which suceeds to the Huara area. 19 wells, out of 26 wells including JICA Wells, have Sy higher than 2 l/sec/m. Transmissibility and permeability are both the highest value in Pampa; 1102 m^3/day/m and 4.4×10^{-2} respectively.

d) Oficina Victoria-Bellavista area

Main aquifers are Q3 and Q4. Sy is the lowest, 1.30 l/sec/m in average, compared with other area in Pampa. Transmissibility is also low, 219.5 1102 m^3/day/m, while permeability is relatively hig, 1.4×10^{-2}.

Two (2) JICA Wells are drilled in the area (J-9, J-F). Both wells shows higher Sy than average. However, transmissibility is lower than average.

2.6 Estimation of Groundwater Storage

Groundwater storage of Pampa del Tamarugal is shown in Table B-III, 2.6.1 and Fig. B-III, 2.6.1. These present the estimated groundwater storage in the total area of Pampa del Tamarugal shown in Fig. B-III, 2.4.1. Total volume of groundwater storage is estimated as follow;

$$S_{\text{Total Storage}} = 26.9 \times 10^9 \text{ m}^3.$$

The estimation was made based on the two (2) geological profile and 12 geological sections dividing the area into 12 zones. Each profile represent following zone;

Zone	Geological section	Major communities in the zone
1	sect. A-A' to B-B'	Dolores, Negreiros
2	sect. B-B' to C-C'	
3	sect. C-C' to D-D'	
4	sect. D-D' to E-E'	Huara
5	sect. E-E' to F-F'	Baquedano, Humberstone
6	sect. F-F' to G-G'	Pozo Almonte
7	sect. G-G' to H-H'	
8	sect. H-H' to I-I'	La Tirana, Huayca
9	sect. I-I' to J-J'	Canchones
10	sect. J-J' to K-K'	Pintados
11	sect. K-K' to L-L'	Oficina Victoria
12	sect. L-L' to southern end	Cerro Gordo

Conditions applied in the estimation are as follows;

(1) Climate condition will be constant during the estimated period.

(2) The extent of the estimation is limited to the area from the city area of Arica to Cabuza, because no stratigraphic column of well is available toward the upper reaches from Cabuza.

(3) Groundwater stored below the sea level is not included in the storage.

(4) Estimation is made on the groundwater stored in permeable and semi-permeable beds. Although groundwater is stored in impermeable beds, it is not considered as prospective one.

(5) Effective porosity of aquifer is assumed to be 30 % as a whole, considering the materials which compose the aquifer.

References

<1: Cuadrangulos Pica, Alca, Matilla y Chacarilla, Carta Geologica de Chile (Escala 1: 50,000), 1962 for Instituto de Investigaciones Geologicas Chile by Carlos Galli Olivier y Robert J. Dingman.

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<5: Informe Geologico, Pozo : Pintados 2, March 1987 by ENAP

<6: Algunos Antecedentes Tecnicos Hidrogeologicos de los Sondajes en Busca de Agua Ejectadis por en Tarapaca, November 1962 for ENAP by Jorge Alvarez R.

Table B-III, 2.1.1 (1) Well List (Pampa del Tamarugal)

<Lista de Sondajes (Pampa del Tamarugal)>

DGA CODE	BNA CODE	CORFO CODE(1975)			CORFO CODE(1969)			COMMUNITY	LOCATION NAME	NAME OF OWNER	CONSTRUCTOR	ELEVATION	DRILLING DEPTH	SPECIFIC YIELD	DATE OF CONSTRUCTION	STATIC WATER LEVEL (93/ 10-11)	
		LAT.	LONG	NO.	LAT.	LONG	NO.					(mMSL)	(m)	(m3/d/m)		(mBGL)	(mMSL)
5	017 00 161-2	1930	6950	C-1	1930	6930	A-14	HUARA	SALAR ZAPIGA	CORFO-B2	CORFO-658	1128.69	22		67/05		
6	017 00 162-0	1930	6950	C-2	1930	6930	A-15	HUARA	SALAR ZAPIGA	CORFO-B3	CORFO-658	1125.45	14		67/05		
21	017 00 164-7	1940	6940	A-1	1930	6930	A-21	HUARA	SALAR ZAPIGA	CORFO-D7	CORFO-658	1144.30	20		67/07		
23	017 00 165-5	1940	6940	A-2	1930	6930	A-22	HUARA	SALAR ZAPIGA	CORFO-D8	CORFO-658	1145.26	23		67/07	16.96	1128.30
	017 00 473-5	1940	6940	AN-3				HUARA	REMOLINO								
26	017 00 166-3	1940	6940	C-1	1930	6930	C-5	HUARA	SALAR ZAPIGA	CORFO-C8	CORFO-658	1145.70	14		67/05		
29	017 00 167-1	1940	6940	C-2	1930	6930	C-8	HUARA	SALAR ZAPIGA	CORFO-C9	CORFO-658	1132.05	24		67/07		
30	017 00 104-3	1940	6940	C-3	1930	6930	C-9	HUARA	SALAR ZAPIGA	CORFO-B9	CORFO-658	1145.57	20		67/04	14.97	1130.60
16	017 00 168-k	1940	6950	A-1	1930	6930	A-2	HUARA	PTA. AP DOLORES 1	DOS	DOS	1119.18	32	53.3			
15	017 00 169-8	1940	6950	A-2	1930	6930	A-3	HUARA	PTA. AP DOLORES 2	DOS	DOS	1120.97			63/05		
10	017 00 170-1	1940	6950	A-3	1930	6930	A-4	HUARA	PTA. AP DOLORES 3	DOS	DOS	1119.88	45	26.6			
11	017 00 171-k	1940	6950	A-4	1930	6930	A-5	HUARA	PTA. AP DOLORES 4	DOS	DOS	1120.11	49	71.2			
12	017 00 172-8	1940	6950	A-5	1930	6930	A-6	HUARA	PTA. AP DOLORES 5	DOS	DOS	1119.88	40	40.4	64/04		
13	017 00 173-6	1940	6950	A-6	1930	6930	A-7	HUARA	PTA. AP DOLORES 6	DOS	DOS	1120.90	49	79.6		8.92	1111.98
14	017 00 174-4	1940	6950	A-7	1930	6930	A-8	HUARA	PTA. AP DOLORES 7	DOS	DOS	1120.36	46	85.6			
8	017 00 175-2	1940	6950	A-8				HUARA	SALAR EL OBISPO	CORFO	CORFO-658	1121.79	16		67/05		
9	017 00 176-0	1940	6950	B-1	1930	6930	A-9	HUARA	DOLORES	ENAP B-4	ENAP	1127.00	88		67/05	9.99	1117.01
17	017 00 177-9	1940	6950	B-2	1930	6930	A17	HUARA	SALAR DE ZAPIGA	CORFO-C5	CORFO-658	1127.40	20		67/07	14.39	1113.01
18	017 00 101-9	1940	6950	B-3	1930	6930	A18	HUARA	SALAR DE ZAPIGA	CORFO-B5	CORFO-658	1127.99	12		67/05		
19	017 00 178-7	1940	6950	B-4	1930	6930	A-19	HUARA	SALAR DE ZAPIGA	CORFO-C6	CORFO-658	1145.67	17		67/05	12.50	1133.17
20	017 00 179-5	1940	6950	B-5	1930	6930	A-20	HUARA	SALAR DE ZAPIGA	CORFO-B6	CORFO-658	1133.48	12		67/05		
22	017 00 100-0	1940	6950	B-6	1930	6930	A-23	HUARA	SALAR DE ZAPIGA	CORFO-C7	CORFO-658	1142.66	14		67/05		
7	017 00 180-9	1940	6950	B-7				HUARA	DOLORES E1	ENAP	ENAP	1127.00					
24	017 00 181-7	1940	6950	C-1	1930	6930	C-4	HUARA	SALAR EL OBISPO	CORFO-AA5	CORFO-658	1134.15	8		67/05		
25	017 00 102-7	1940	6950	D-1	1930	6930	C-3	HUARA	SALAR DE ZAPIGA	CORFO-B7	CORFO-658	1135.01	9		67/04		
28	017 00 103-5	1940	6950	D-2	1930	6930	C-6	HUARA	SALAR DE ZAPIGA	CORFO-B8	CORFO-659	1140.05	12		67/04		
27	017 00 182-5	1940	6950	D-3	1930	6900	C-7	HUARA	SALAR EL OBISPO	CORFO-AA6	CORFO-658	1133.69	8		67/05		
39	017 30 100-4	1950	6920	A-1	1930	6900	C-1	HUARA	PACHICA 1	CORFO	CORFO-483	1517.50	54	617.1	64/08		
40	017 30 101-2	1950	6920	A-2	1930	6900	C-2	HUARA	PACHICA 2	CORFO	CORFO-494	1537.69	36	351.0	64/11		
41	017 30 102-0	1950	6920	A-3	1930	6930	C-3	HUARA	PACHICA 3	CORFO	CORFO-509	1534.94	51	868.3	65/03		
38	017 00 183-3	1950	6930	C-1	1930	6930	D-3	HUARA	HUARA 2	CORFO	CORFO-729	1135.24	150		69/10		
34	017 00 184-1	1950	6940	A-1	1930	6930	C-2	HUARA	OBDA. AROMA 1	CORFO	CORFO-733	1150.46	43		68/04		
31	017 00 105-1	1950	6940	A-2	1930	6930	C-10	HUARA	SALAR DE ZAPIGA	CORFO-B10	CORFO-658	1150.54	24		67/05		
32	017 00 106-k	1950	6940	A-3	1930	6930	C-11	HUARA	SALAR DE ZAPIGA	CORFO-B11	CORFO-658	1150.83	29		67/05		
33	017 00 185-k	1950	6940	B-1	1930	6930	D-4	HUARA	OBDA. AROMA 2	CORFO	CORFO-737	1120.14	12		68/05		
33A	017 00 186-8	1950	6940	B-2	1930	6930	D-5	HUARA	OBDA. AROMA 3	CORFO	CORFO-740		12		68/05		
36	017 00 187-6	1950	6940	C-1	2000	6930	C-1	HUARA	HUARA 1	DOS	DOS	1106.71	25			53.56	1053.15
35	017 00 188-4	1950	6940	D-1	2000	6930	D-1	HUARA	HUARA-PACHICA 2	DOS	DOS	1108.04	176				
37	017 00 189-2	1950	6940	D-2	2000	6930	D-2	HUARA	HUARA 1	CORFO	CORFO-727	1104.31	161		68/03		
49A	017 00 190-6	2000	6930	A-1				HUARA	BAQUEDANO 2	EJERCITO CHILE	CORFO-1320		175		74/09		
45	017 00 191-4	2000	6930	C-1	2000	6930	B-5	POZO ALMONTE	BAQUEDANO 4	CORFO	RIEGO	1071.00	360				
45A	017 00 192-2	2000	6930	C-2	2000	6930	B-6.	POZO ALMONTE	BAQUEDANO 5	CORFO	RIEGO	1074.00	242		51/06		
42	017 00 193-0	2000	6940	B-1	2000	6930	B-1	POZO ALMONTE	MAPOCHO	RIEGO	RIEGO	1078.60	60		57/04		
48	017 00 194-9	2000	6940	D-1	2000	6930	B-2	POZO ALMONTE	BAQUEDANO 1	CORFO	RIEGO	1055.81					
49	017 00 195-7	2000	6940	D-2	2000	6930	B-3	POZO ALMONTE	BAQUEDANO 2	CORFO	RIEGO	1057.00					
46	017 00 196-5	2000	6940	D-3	2000	6930	B-4	POZO ALMONTE	BAQUEDANO 3	CORFO	RIEGO	1068.92	105		50/08		
43	017 00 197-3	2000	6940	D-4	2000	6930	B-7	POZO ALMONTE	BAQUEDANO 6	RIEGO	RIEGO	1071.06	134		51/10		
44	017 00 198-1	2000	6940	D-5	2000	6930	B-8	POZO ALMONTE	BAQUEDANO 7	RIEGO	RIEGO	1070.00	92		51/12		
47	017 00 199-k	2000	6940	D-6	2000	6930	B-9	POZO ALMONTE	BAQUEDANO 8	RIEGO	RIEGO	1065.00	81		52/06		
48A	017 00 200-7	2000	6940	D-7				POZO ALMONTE	BAQUEDANO 1	EJERCITO CHILE	CORFO-1282		130	10.0	74/04		
169	017 00 201-5	2010	6920	A-1	2000	6930	A-1	POZO ALMONTE	OBDA. J. MORALES	RIEGO	RIEGO	1275.90	462				
53	017 00 202-3	2010	6930	A-1	2000	6930	B13	POZO ALMONTE	PORVENIR	RIEGO	RIEGO	1036.52	202	921.6	63/04	35.43	1001.09
45B	017 00	2010	6930	A-2				POZO ALMONTE	DUPLIZA-1	MILITARY			114	172.8	75/	52.00	
45C	017 00	2010	6930	A-3				POZO ALMONTE	DUPLIZA-2	MILITARY			90	172.8	75/	52.00	
45D	017 00	2010	6930	A-4				POZO ALMONTE	DUPLIZA-3	MILITARY			114	172.8	75/	52.00	
57	017 00 131-0	2010	6930	C-1	2000	6930	D34	POZO ALMONTE	LA TIRANA 1	CORFO	CORFO-544	1019.89	199	331.0	67/06	21.65	998.24
58	017 00 203-1	2010	6930	C-2	2000	6930	D-35	POZO ALMONTE	LA TIRANA 2	CORFO	CORFO-645		412		67/04		
59	017 00 204-k	2010	6930	C-3	2000	6930	D-36	POZO ALMONTE	EL CARMELO 1	CORFO	CORFO-572	1022.79	62		66/07		
60	017 00 132-9	2010	6930	C-4	2000	6930	D-37	POZO ALMONTE	EL CARMELO 2	CORFO	CORFO-592	1022.60	183	225.8	67/07	25.09	997.51
61	017 00 205-8	2010	6930	C-5	2000	6930	D-38	POZO ALMONTE	EL CARMELO 3	CORFO	CORFO-628	1022.79	211		69/01		
62	017 00 206-6	2010	6930	C-6	2000	6930	D-39	POZO ALMONTE	EL CARMELO 4	CORFO	CORFO-754		176	180.0	69/04		
86	017 00 207-4	2010	6930	C-7	2000	6930	D-52	POZO ALMONTE	LA TIRANA	CORFO	CORFO-654	1006.26	30	70.2	67/10	CAPPED	
87	017 00 208-2	2010	6930	C-8	2000	6930	D-53	POZO ALMONTE	LA TIRANA RADIOI	CORFO-1A	CORFO-654	1006.77	21		67/12		
88	017 00 209-0	2010	6930	C-9	2000	6930	D54	POZO ALMONTE	LA TIRANA RADIOI	CORFO-1B	CORFO-654	1006.72	20		67/10		
89	017 00 210-4	2010	6930	C-10	2000	6930	D-55	POZO ALMONTE	LA TIRANA RADIOI	CORFO-1C	CORFO-654	1006.75	20		67/04		
90	017 00 211-2	2010	6930	C-11	2000	6930	D-56	POZO ALMONTE	LA TIRANA RADIOI	CORFO-1D	CORFO-654	1006.85	20		67/04		
91	017 00 212-0	2010	6930	C-12	2000	6930	D-57	POZO ALMONTE	LA TIRANA RADIOI	CORFO-1E	CORFO-654	1006.94	20		67/04		
92	017 00 213-9	2010	6930	C-13	2000	6930	D-58	POZO ALMONTE	LA TIRANA RADIOI	CORFO-1F	CORFO-654	1006.69	20		67/04		
93	017 00 214-7	2010	6930	C-14	2000	6930	D-59	POZO ALMONTE	LA TIRANA RADIOI	CORFO-1G	CORFO-654	1006.54	21		67/08		
69	017 00 215-5	2010	6930	C-15	2000	6930	D-71	POZO ALMONTE	SALAR PINTADOS	CORFO-E1	CORFO-551	1014.64	19		65/07		
70	017 00 216-3	2010	6930	C-16	2000	6930	D-72	POZO ALMONTE	SALAR PINTADOS	CORFO-F1	CORFO-551	1017.41	25		65/07		
71	017 00 217-1	2010	6930	C-17	2000	6930	D-73	POZO ALMONTE	SALAR PINTADOS	CORFO-G1	CORFO-551	1023.24	28		65/07		
94	017 00 218-k	2010	6930	C-18	2000	6930	D-78	POZO ALMONTE	SALAR PINTADOS	CORFO-F2	CORFO-551	1009.38	21		65/07		
95	017 00 219-8	2010	6930	C-19	2000	6930	D-79	POZO ALMONTE	SALAR PINTADOS	CORFO-G2	CORFO-551	1013.10	21		65/07		
85	017 00 220-1	2010	6930	C-20	2000	6930	D-77	POZO ALMONTE	SALAR PINTADOS	CORFO-E2	CORFO-551	1006.54	15		65/07		
63	017 00 221-k	2010	6930	D-1	2000	6930	D42	POZO ALMONTE	O. J. MORALES 1	RIEGO	RIEGO	1063.56	438	589.8	65/01	75.00	988.56
64	017 00 222-8	2010	6930	D-2	2000	6930	D-43	POZO ALMONTE	O. J. MORALES	MIN. SAGASCA	CORFO-775	1079.28	274	382.8	69/11	85.00	994.28
96	017 00 223-6	2010	6930	D-3	2000	6930	D-86	POZO ALMONTE	SALAR PINTADOS	CORFO-H2	CORFO-551	1016.52	14		65/07		
51	017 00 224-4	2010	6940	B-1	2000	6930	B-10	POZO ALMONTE	HUMBERSTONE 3	DOS	DOS-337	1038.20	51		54/10	34.85	1003.35
52	017 00 225-2	2010	6940	B-2	2000	6930	B-11	POZO ALMONTE	HUMBERSTONE 1	RIEGO	RIEGO	1035.92	107		56/07		
50	017 00 226-0	2010	6940	B-3	2000	6930	B12	POZO ALMONTE	HUMBERSTONE 2	RIEGO	RIEGO	1039.22	105	234.7	52/06	35.49	1003.73
54	017 00 227-9	2010	6940	C-1	2000	6930	C-1	POZO ALMONTE	POZO ALMONTE	DOS		1026.50					
65	017 00 107-8	2010	6940	C-2	2000	6930	C-2	POZO ALMONTE	SALARPINTADOS	CORFO-A1	CORFO-551	1020.57	26		65/08		
75	017 00 228-7	2010	6940	D-1	2000	6930	D-1	POZO ALMONTE	PTA. SARA 1	DOS	DOS-338		176		50/03		
73	017 00 108-6	2010	6940	D-2	2000	6930	D-2	POZO ALMONTE	PTA. SARA 1A	DOS	DOS-339	1018.20	161		52/12		
74	017 00 111-6	2010	6940	D-3	2000	6930	D-3	POZO ALMONTE	PTA. SARA 2	DOS	DOS-340		146				
76	017 00 229-5	2010	6940	D-4	2000	6930	D-4	POZO ALMONTE	PTA. SARA 3	DOS	DOS-341	1016.40	53	18.2	52/07		
72	017 00 129-9	2010	6940	D-5	2000	6930	D-5	POZO ALMONTE	PTA. SARA 3A	DOS	DOS-342	1019.43	54	446.3	53/11	21.42	998.01
77	017 00 230-9	2010	6940	D-6	2000	6930	D-6	POZO ALMONTE	PTA. SARA 4	DOS	DOS-343		102		52/11		
78	017 00 231-7	2010	6940	D-7	2000	6930	D-7	POZO ALMONTE	PTA. SARA 5	DOS	DOS-344		73		53/09		
79	017 00 232-5	2010	6940	D-8	2000	6930	D-8	POZO ALMONTE	PTA. SARA 5A	DOS	DOS-345		54	172.8	54/04		
80	017 00 233-3	2010	6940	D-9	2000	6930	D-9	POZO ALMONTE	PTA. SARA 6	DOS	DOS-349		79		53/06		
81	017 00 133-7	2010	6940	D-10	2000	6930	D-10	POZO ALMONTE	SARA TIRANA 8	DOS	DOS-346		84		54/06		
55	017 00 130-2	2010	6940	D-11	2000	6930	D-40	POZO ALMONTE	POZO ALMONTE 1	CORFO	CORFO-612	1026.03	190	143.6	67/07	26.92	999.11
56	017 00 234-1	2010	6940	D-12	2000	6930	D-41	POZO ALMONTE	POZO ALMONTE 2	CORFO	CORFO-632		176.1		67/03		
66	017 00 235-k	2010	6940	D-13	2000	6930	D-68	POZO ALMONTE	SALAR PINTADOS	CORFO-B1	CORFO-551	1019.52	25		65/08	21.50	998.02
67	017 00 236-8	2010	6940	D-14	2000	6930	D-69	POZO ALMONTE	SALAR PINTADOS	CORFO-C1	CORFO-551	1016.79	23		65/08		
68	017 00 237-6	2010	6940	D-15	2000	6930	D-70	POZO ALMONTE	SALAR PINTADOS	CORFO-D1	CORFO-551	1015.10	20		65/07		
82	017 00 109-4	2010	6940	D-16	2000	6930	D-74	POZO ALMONTE	SALAR PINTADOS	CORFO-B2	CORFO-551	1013.49	20		65/08		
83	017 00 238-4	2010	6940	D-17	2000	6930	D-75	POZO ALMONTE	SALAR PINTADOS	CORFO-C2	CORFO-551	1011.37	18		65/08		
84	017 00 239-2	2010	6940	D-18	2000	6930	D-76	POZO ALMONTE	SALAR PINTADOS	CORFO-D2	CORFO-551	1007.89	16		65/08		
81A	017 00 240-6	2010	6940	D-19	2000	6900	D-112	POZO ALMONTE	SARA TIRANA	DOS	DOS-350	1010.55	80	288.0	56/02	15.72	994.83

Table B-III, 2.1.1 (1) Well List (Pampa del Tamarugal)

<Lista de Sondajes (Pampa del Tamarugal)>

DGA CODE	BNA CODE	CORFO CODE(1975) LAT.	LONG	NO.	CORFO CODE(1969) LAT.	LONG	NO.	COMMUNITY	LOCATION NAME	NAME OF OWNER	CONSTRUCTOR	ELEVATION (mMSL)	DRILLING DEPTH (m)	SPECIFIC YIELD (m3/d/m)	DATE OF CONSTRUCTION	STAIC WATER LEVEL (93/ 10-11) (mBGL)	(mMSL)
175	017 00 241-4	2020	6910	A-1	2000	6900	C-6	PICA	PAMPA BRUGGEN 1	RIEGO	RIEGO		325		57/02		
176	017 00 242-2	2020	6910	A-2	2000	6900	C-7	PICA	PMPA BRUGGEN 1A	RIEGO	RIEGO		250		61/02		
177	017 00 243-0	2020	6910	A-3	2000	6900	C-8	PICA	PAMPA BRUGGEN 2	RIEGO	RIEGO		200		61/08		
178	017 00 244-9	2020	6910	A-4	2000	6900	C-9	PICA	PAMPA BRUGGEN 3	RIEGO	RIEGO		151		61/09		
179	017 00 245-7	2020	6910	A-5	2000	6900	C-10	PICA	PAMPA BRUGGEN 4	G. DE CHILE	RIEGO		175		61/12		
181	017 00 246-5	2020	6910	A-6	2000	6900	C-52	PICA	PAMPA PICA 1	G. DE CHILE					56/		
180	017 00 247-3	2020	6910	A-7	2000	6900	C-53	PICA	PAMPA PICA 2	RIEGO					56/		
215	017 00 248-1	2020	6910	C-1	2000	6900	C-54	PICA	PUQUIO LORETO D	RIEGO	RIEGO	1420.00	110		19/		
218	017 00 249-k	2020	6910	C-2	2000	6900	C55	PICA	PUQUIO MIRAF. N	RIEGO	RIEGO		131		31/		
221	017 00 250-3	2020	6910	C-3	2000	6900	C-56	PICA	PUQUIO CONCOV.S	RIEGO	RIEGO	1459.00	54				
228	017 00 251-1	2020	6910	C-4	2000	6900	C-57	PICA	PUQUIO CARMEN E	RIEGO	RIEGO	1350.00			22/		
223	017 00 252-k	2020	6910	C-5	2000	6900	C-58	PICA	CONCOVA 1 P.TT'	CORFO	CORFO-679A	1476.05	218	32.4	68/02		
222	017 00 253-8	2020	6910	C-6	2000	6900	C-59	PICA	CONCOVA 2 C.+3	CORFO	CORFO-698	1476.23	100	12.1	67/12		
216	017 00 254-6	2020	6910	C-7	2000	6900	C-60	PICA	LORETO 1	CORFO	CORFO-720		90		68/02		
217	017 00 255-4	2020	6910	C-8	2000	6900	C-61	PICA	LORETO 2	CORFO	CORFO-724	1446.75	46		68/04		
219	017 00 256-2	2020	6910	C-9	2000	6900	C-62	PICA	LORETO 3	CORFO	CORFO-735	1450.76	208		68/08	39.06	1411.70
218A	017 00 257-0	2020	6910	C-10				PICA	PAMPA MIRAFLO.1	RIEGO	RIEGO		48				
218B	017 00 258-9	2020	6910	C-11				PICA	PAMPA MIRAFLO.M	RIEGO	RIEGO		50				
218C	017 00 259-7	2020	6910	C-12				PICA	PAMPA MIRAFLO.0	RIEGO	RIEGO		50				
219A	017 00 260-0	2020	6910	C-13				PICA	PMPA.CONCOVA R	RIEGO	RIEGO		77				
219B	017 00 261-9	2020	6910	C-14				PICA	PMPA. CONCOVA T	RIEGO	RIEGO		81				
172	017 00 262-7	2020	6920	A-1	2000	6900	C-1	PICA	LA CALERA 1	RIEGO	RIEGO	1057.19	195				
170	017 00 263-5	2020	6920	A-2	2000	6900	C-5	PICA	LA CALERA 3	RIEGO	RIEGO	1300.00	263		61/08	66.13	1233.87
171	017 00 264-3	2020	6920	A-3	2000	6900	C-2	PICA	LA CALERA 2	RIEGO	RIEGO	1046.60	75		61/10	19.34	1027.26
174	017 00 265-1	2020	6920	A-4	2000	6900	C-4	PICA	ESMERALDA 6	RIEGO	RIEGO	1007.00	232	163.5	54/08	17.80	989.20
173	017 00 266-k	2020	6920	A-5	2000	6900	C65	PICA	SALAR PINTADOS	CORFO-J5	CORFO-551	1006.23	20		65/09		
212	017 00 135-3	2020	6920	C-1	2000	6900	C11	PICA	ESMERALDA 1	CORFO	RIEGO	1018.00	448		53/06		
224	017 00 267-8	2020	6920	C-2	2000	6900	C12	PICA	ESMERALDA 2	CORFO	RIEGO	1027.00	178		53/06	BURIED	
227	017 00 268-6	2020	6920	D-1	2000	6900	C-5	PICA	SAUQUECITO	RIEGO	RIEGO	1300.00	263		58/20		
220	017 00 269-4	2020	6920	D-2	2000	6900	C13	PICA	ESMERALDA 4	CORFO	RIEGO	1181.44	349		54/11		
213	017 00 270-8	2020	6920	D-3	2000	6900	C-15	PICA	ESMERALDA 7	CORFO	RIEGO	1087.00	360		. 55/01	42.54	1044.46
214	017 00 271-6	2020	6920	D-4	2000	6900	C-16	PICA	ESMERALDA 8	CORFO	RIEGO	1094.70	450				
225	017 00 272-4	2020	6920	D-5	2000	6900	C-17	PICA	ESMERALDA 9	CORFO	RIEGO	1117.37	312	3.1	55/06		
226	017 00 149-3	2020	6920	D-6	2000	6900	C-20	PICA	ESMERLDA 12	CORFO	RIEGO	1153.91	150		57/12		
210	017 00 273-2	2020	6920	D-7	2000	6900	C-63	PICA	OBDA. SECA 1	CORFO	CORFO-722		18		68/02		
211	017 00 274-0	2020	6920	D-8	2000	6900	C-64	PICA	OBDA. SECA 2	CORFO	CORFO-781	1332.17	183		69/03		
182	017 00 275-9	2020	6920	D-9	2000	6900	C-14	PICA	ESMERLDA 5	CORFO	RIEGO	1113.30	380		55/11		
209A	017 00 276-7	2020	6920	D-10	2000	6900	C-18	PICA	ESMERALDA 10	CORFO	RIEGO						
183	017 00 277-5	2020	6920	D-11	2000	6900	C-19	PICA	ESMERALDA 11	CORFO	RIEGO	1096.60	315		57/05	24.84	1071.76
184	017 00 278-3	2020	6920	D-12	2000	6900	C-21	PICA	ESMERALDA 13	CORFO	RIEGO	1113.30	94				
185	017 00 279-1	2020	6920	D-13	2000	6900	C-22	PICA	ESMERALDA 14	CORFO	RIEGO	1113.34	90				
209B	017 00 280-5	2020	6920	D-14	2000	6900	C-23	PICA	ESMERALDA 15	CORFO	RIEGO	1115.77	100				
186	017 00 281-3	2020	6920	D-15	2000	6900	C-24	PICA	ESMERALDA 16	CORFO	RIEGO	1126.25	120				
187	017 00 282-1	2020	6920	D-16	2000	6900	C-26	PICA	ESMERALDA 18	CORFO	RIEGO	1101.11	150				
188	017 00 283-k	2020	6920	D-17	2000	6900	C-27	PICA	ESMERALDA 19	CORFO	RIEGO	1141.00	130				
189	017 00 284-8	2020	6920	D-18	2000	6900	C-28	PICA	ESMERALDA 20	CORFO	RIEGO	1104.57	150				
190	017 00 285-6	2020	6920	D-19	2000	6900	C-29	PICA	ESMERALDA 21	CORFO	RIEGO	1143.45	150				
191	017 00 286-4	2020	6920	D-20	2000	6900	C-30	PICA	ESMERALDA 22	CORFO	RIEGO	1109.90	150		62/04		
192	017 00 287-2	2020	6920	D-21	2000	6900	C-31	PICA	ESMERALDA 23	CORFO	RIEGO	1132.40	101				
193	017 00 288-0	2020	6920	D-22	2000	6900	C-32	PICA	ESMERALDA 24	CORFO	RIEGO	1130.32	83				
194	017 00 289-9	2020	6920	D-23	2000	6900	C-33	PICA	ESMERALDA 25	CORFO	RIEGO	1123.48	84		62/05		
195	017 00 290-2	2020	6920	D-24	2000	6900	C-34	PICA	ESMERALDA 25A	CORFO		1123.66	61		62/10		
196	017 00 291-0	2020	6920	D-25	2000	6900	C-35	PICA	ESMERALDA 26	CORFO	RIEGO	1110.70	126		62/05		
209D	017 00 292-9	2020	6920	D-26	2000	6900	C-36	PICA	ESMERALDA 27	CORFO	RIEGO		78		62/07		
197	017 00 293-7	2020	6920	D-27	2000	6900	C-37	PICA	ESMERALDA 28	CORFO	RIEGO	1130.92	83		62/07	40.30	1090.62
198	017 00 294-5	2020	6920	D-28	2000	6900	C-38	PICA	ESMERALDA 29	CORFO	RIEGO	1112.03	102		62/06		
199	017 00 295-3	2020	6920	D-29	2000	6900	C-39	PICA	ESMERALDA 30	CORFO	RIEGO	1118.99	70		62/07		
200	017 00 296-1	2020	6920	D-30	2000	6900	C-40	PICA	ESMERALDA 31	CORFO	RIEGO	1111.77	85		62/07	49.50	1062.27
201	017 00 297-k	2020	6920	D-31	2000	6900	C-41	PICA	ESMERALDA 32	CORFO	RIEGO	1115.48	92		62/08		
202	017 00 298-8	2020	6920	D-32	2000	6900	C-42	PICA	ESMERALDA 33	CORFO	RIEGO	1113.45	90		62/08		
203	017 00 299-6	2020	6920	D-33	2000	6900	C-43	PICA	ESMERALDA 34	CORFO	RIEGO	1118.72	85		62/09	45.75	1072.97
204	017 00 300-3	2020	6920	D-34	2000	6900	C-44	PICA	ESMERALDA 35	CORFO	RIEGO	1121.31	83		62/10		
205	017 00 301-1	2020	6920	D-35	2000	6900	C-45	PICA	ESMERALDA 36	CORFO	RIEGO	1120.60	82		62/10		
206	017 00 302-k	2020	6920	D-36	2000	6900	C-46	PICA	ESMERALDA 37	CORFO	RIEGO	1119.98	62		62/09		
207	017 00 303-8	2020	6920	D-37	2000	6900	C-47	PICA	ESMERALDA 38	CORFO	RIEGO	1119.24	82		62/10		
208	017 00 304-6	2020	6920	D-38	2000	6900	C-48	PICA	ESMERALDA 39	CORFO	RIEGO	1122.57	52		62/11		
209	017 00 305-4	2020	6920	D-39	2000	6900	C-49	PICA	ESMERALDA 40	CORFO	RIEGO	1124.97	55		62/11		
209E	017 00 306-2	2020	6920	D-40	2000	6900	C-50	PICA	ESMERALDA 41	CORFO	RIEGO	1122.44	52		62/11		
209F	017 00 307-0	2020	6920	D-41	2000	6900	C-51	PICA	ESMERALDA 42	CORFO	RIEGO	1120.72	50		62/11		
209C	017 00 308-9	2020	6920	D-42	2000	6930	C-25	PICA	ESMERALDA 17	CORFO	RIEGO	1120.16	100		66/07		
110	017 00 309-7	2020	6930	A-1	2000	6930	D-108	PICA	BOSOUE JUNOY 16	CORFO	CORFO-551		12		66/07		
77A	017 00 310-0	2020	6930	A-2	2000	6930	D-11	POZO ALMONTE	LA TIRANA 8A	DOS-347	DOS-347	1008.00	61				
77B	017 00 311-9	2020	6930	A-3	2000	6930	D-12	POZO ALMONTE	LA TIRANA 104A	DOS-439	DOS-439	1007.24	42		58/11		
100	017 00 312-7	2020	6930	A-4	2000	6930	D-83	POZO ALMONTE	SALAR PINTADOS	CORFO-E3	CORFO-551	1000.78	13		65/07	13.06	987.72
101	017 00 313-5	2020	6930	A-5	2000	6930	D-84	POZO ALMONTE	SALAR PINTADOS	CORFO-F3	CORFO-551	1001.56	12		65/07		
102	017 00 314-3	2020	6930	A-6	2000	6930	D-85	POZO ALMONTE	SALAR PINTADOS	CORFO-G3	CORFO-551	1002.49	15		65/07		
108	017 00 315-1	2020	6930	A-7	2000	6930	D-106	POZO ALMONTE	BOSOUE JUNOY 4	CORFO	CORFO-551	1001.16	12		66/07		
107	017 00 316-k	2020	6930	A-8	2000	6930	D-107	POZO ALMONTE	BOSOUE JUNOY 15	CORFO	CORFO-551		12		66/07	9.59	
	017 00 463-8	2020	6930	A-9				POZO ALMONTE									
	017 00 148-5	2020	6930	A-10				POZO ALMONTE									
	017 00 464-6	2020	6930	A-11				POZO ALMONTE									
	017 00 465-4	2020	6930	A-12				POZO ALMONTE									
	017 00 466-2	2020	6930	A-13				POZO ALMONTE	LA TIRANA	DOS			100	135.4	89/04		
	017 00 901-	2020	6930	A-14													
103	017 00 317-8	2020	6930	B-1	2000	6930	D-86	POZO ALMONTE	SALAR PINTADOS	CORFO-H3	CORFO-551	1007.01	14		65/07		
104	017 00 318-6	2020	6930	B-2	2000	6930	D-87	POZO ALMONTE	SALAR PINTADOS	CORFO-I3	CORFO-551		11		65/09		
105	017 00 319-4	2020	6930	B-3	2000	6930	D-88	POZO ALMONTE	SALAR PINTADOS	CORFO-H4	CORFO-551	996.98	10		65/07		
106	017 00 320-8	2020	6930	B-4	2000	6930	D-89	POZO ALMONTE	SALAR PINTADOS	CORFO-14	CORFO-551	996.23	11		65/09		
111	017 00 134-5	2020	6930	B-5	2000	6930	D-94	POZO ALMONTE	SALAR PINTADOS	CORFO-H5	CORFO-551	988.03	8		65/07		
112	017 00 321-6	2020	6930	B-6	2000	6930	D-96	POZO ALMONTE	SALAR PINTADOS	CORFO-15	CORFO-551	991.14	13		65/09		
	017 00 461-1	2020	6930	B-7				POZO ALMONTE									
	017 00 462-K	2020	6930	B-8				POZO ALMONTE									
139	017 00 322-4	2020	6930	C-1	2000	6930	D-13	POZO ALMONTE	PTA. AP HISPANIA	DOS-246	SONDA		100			8.54	
140	017 00 323-2	2020	6930	C-2	2000	6930	D-14	POZO ALMONTE	PTA. AP HISPANIA	DOS-247	SONDA	989.69	106		59/12	9.43	980.26
141	017 00 324-0	2020	6930	C-3	2000	6930	D-15	POZO ALMONTE	PTA. AP HISPANIA	DOS-248	SONDA	989.49	103		60/02		
142	017 00 325-9	2020	6930	C-4	2000	6930	D-16	POZO ALMONTE	PTA. AP HISPANIA	DOS-249	SONDA	989.14	101		60/03		
143	017 00 326-7	2020	6930	C-5	2000	6930	D-17	POZO ALMONTE	PTA. AP HISPANIA	DOS-250	SONDA	989.07	100		59/11		
144	017 00 158-2	2020	6930	C-6	2000	6930	D-18	POZO ALMONTE	PTA. AP HISPANIA	DOS-290	SONDA	988.70	106				
145	017 00 327-5	2020	6930	C-7	2000	6930	D-19	POZO ALMONTE	PTA. AP HISPANIA	DOS-291	SONDA	989.05					
146	017 00 328-3	2020	6930	C-8	2000	6930	D-93	POZO ALMONTE	SALAR PINTADOS	CORFO-O1	CORFO-551	985.42	9		65/10		
151	017 00 329-1	2020	6930	C-9	2000	6930	D-103	POZO ALMONTE	BOSOUE JUNOY 12	CORFO	CORFO-551	988.86	13		66/08		
148	017 00 330-5	2020	6930	C-10	2000	6930	D-104	POZO ALMONTE	BOSOUE JUNOY 6	CORFO	CORFO-551		12		66/07		

Table B-III, 2.1.1 (1) Well List (Pampa del Tamarugal)

<Lista de Sondajes (Pampa del Tamarugal)>

DGA CODE	BNA CODE	CORFO CODE(1975)			CORFO CODE(1969)			COMMUNITY	LOCATION NAME	NAME OF OWNER	CONSTRUCTOR	ELEVA-TION	DRILLING DEPTH	SPECIFIC YIELD	DATE OF CONST-	STAIC WATER LEVEL (93/ 10-11)	
		LAT.	LONG.	NO.	LAT.	LONG.	NO.					(mMSL)	(m)	(m3/d/m)	RUCTION	(mBGL)	(mMSL)
166	017 00 331-3	2020	6930	C-11	2000	6930	D109	POZO ALMONTE	BOSQUE JUNOY 14	CORFO	CORFO-551	981.00	9		66/08		
165	017 00 332-1	2020	6930	C-12	2000	6930	D-110	POZO ALMONTE	BOSQUE JUNOY 1	CORFO	CORFO-551		10		66/08		
164	017 00 333-K	2020	6930	C-13	2000	6930	D-111	POZO ALMONTE	BOSQUE JUNOY 10	CORFO	CORFO-551	983.67	13		66/08		
161	017 00 334-8	2020	6930	C-14	2000	6930	D112	POZO ALMONTE	BOSQUE JUNOY 9	CORFO	CORFO-551	986.78	15		66/07		
153	017 00 335-6	2020	6930	C-15	2000	6930	D-119	POZO ALMONTE	BOSQUE JUNOY 7	CORFO	CORFO-551		13		65/12		
152	017 00 336-4	2020	6930	C-16	2000	6930	D-120	POZO ALMONTE	SALAR PINTADOS	CORFO	CORFO-551	986.74	13		66/08		
109	017 00 337-2	2020	6930	C-17	2000	6930	D-105	POZO ALMONTE	BOSQUE JUNOY 2	CORFO	CORFO-551		10				
	017 00 902-	2020	6930	C-18					LA HUAICA								
	017 00 903-	2020	6930	C-28													
111A	017 00 338-0	2020	6930	D-1	2000	6930	D-44	POZO ALMONTE	LA HUAICA	CORFO-1	CORFO-659	988.96	30		67/11		
111B	017 00 339-9	2020	6930	D-2	2000	6930	D-45	POZO ALMONTE	LA HUAICA	CORFO-1A	CORFO-659	989.20	11		67/12		
111C	017 00 340-2	2020	6930	D-3	2000	6930	D-46	POZO ALMONTE	LA HUAICA	CORFO-1B	CORFO-659	989.06	11		67/11		
111D	017 00 341-0	2020	6930	D-4	2000	6930	D-47	POZO ALMONTE	LA HUAICA	CORFO-1C	CORFO-659	988.99	23		67/11		
111E	017 00 342-9	2020	6930	D-5	2000	6930	D-48	POZO ALMONTE	LA HUAICA	CORFO-1D	CORFO-659	989.21	11		67/12		
111F	017 00 343-7	2020	6930	D-6	2000	6930	D-49	POZO ALMONTE	LA HUAICA	CORFO-1E	CORFO-659	989.21	11		67/12		
111G	017 00 344-5	2020	6930	D-7	2000	6930	D-50	POZO ALMONTE	LA HUAICA	CORFO-1F	CORFO-659	989.33	23		67/11		
111H	017 00 345-3	2020	6930	D-8	2000	6930	D-51	POZO ALMONTE	LA HUAICA	CORFO-1G	CORFO-659	988.81	15		67/12		
125	017 00 346-1	2020	6930	D-9	2000	6930	D-33	POZO ALMONTE	ESMER. CALERA 3	CORFO	RIEGO	996.00	226				
127	017 00 347-K	2020	6930	D-10	2000	6930	D-25	POZO ALMONTE	P. CANCHONES A	DOS 656	DOS -656	993.90	110				
128	017 00 348-8	2020	6930	D-11	2000	6930	D-26	POZO ALMONTE	P. CANCHONES B	DOS 657	DOS -657	996.21	108				
131	017 00 349-6	2020	6930	D-12	2000	6930	D-29	POZO ALMONTE	P. CANCHONES E	DOS 660	DOS - 660	995.10	54				
126	017 00 350-K	2020	6930	D-13	2000	6930	D-24	POZO ALMONTE	P. CANCHONES G	DOS	RIEGO	989.00	96				
129	017 00 351-8	2020	6930	D-14	2000	6930	D-27	POZO ALMONTE	P. CANCHONES C	DOS- 658	DOS-658	997.33	101				
132	017 00 352-6	2020	6930	D-15	2000	6930	D-30	POZO ALMONTE	P. CANCHONES F	DOS	DOS	998.00	102				
130	017 00 353-4	2020	6930	D-16	2000	6930	D-28	POZO ALMONTE	P. CANCHONES D	DOS-659	DOS-659	997.24	54				
134	017 00 354-2	2020	6930	D-17	2000	6930	D-32	POZO ALMONTE	P. CANCHONES H	DOS	DOS	994.27	100			32.74	961.53
147	017 00 355-0	2020	6930	D-18	2000	6930	D-95	POZO ALMONTE	SALAR PINTADOS	CORFO-H6	CORFO-551	994.71	10		65/07		
126A	017 00 356-9	2020	6930	D-19	2000	6930	D116	POZO ALMONTE	SALAR PINTADOS	CORFO-I6	CORFO-551	993.97	18		65/09		
158	017 00 357-7	2020	6930	D-20	2000	6930	D23	POZO ALMONTE	PTA. CUMINALLA	DOS-496	DOS-496	988.11	108	462.9			
157	017 00 358-5	2020	6930	D-21	2000	6930	D22	POZO ALMONTE	PTA. CUMINALLA	DOS-495	DOS-495	986.06	110				
156	017 00 359-3	2020	6930	D-22	2000	6930	D-21	POZO ALMONTE	PTA. CUMINALLA	DOS-494	DOS-494	986.01	100		61/11		
155	017 00 360-7	2020	6930	D-23	2000	6930	D-20	POZO ALMONTE	PTA. CUMINALLA	DOS-493	DOS-493	986.36	112		61/11		
154	017 00 361-5	2020	6930	D-24	2000	6930	D-114	POZO ALMONTE	SALAR PINTADOS	CORFO-H7	CORFO-551	982.26	6		65/07		
159	017 00 362-3	2020	6930	D-25	2000	6930	D-117	POZO ALMONTE	SALAR PINTADOS	CORFO-I7	CORFO-551	994.37	12		65/09		
167	017 00 363-1	2020	6930	D-26	2000	6930	D-115	POZO ALMONTE	SALAR PINTADOS	CORFO-H8	CORFO-551	985.24	10		65/06	10.50	974.74
168	017 00 364-K	2020	6930	D-27	2000	6930	D-118	POZO ALMONTE	SALAR PINTADOS	CORFO- I8	CORFO-551	997.41	18		65/09		
133	017 00 365-8	2020	6930	D-28	2000	6930	D-31	POZO ALMONTE	PTA. AP CANCHON	DOS	DOS		12		66/07		
126B	017 00 366-6	2020	6930	D-29				POZO ALMONTE	CANCHONES 1	CORFO	CORFO-872		183	408.2	70/04		
	017 00 454-9	2020	6930	D-30				POZO ALMONTE	CANCHONES 1	DOS			110	141.7	81/05		
	017 00 455-7	2020	6930	D-31				POZO ALMONTE	CANCHONES 2	DOS							
	017 00 456-5	2020	6930	D-32				POZO ALMONTE	CANCHONES 3	DOS			110				
	017 00 457-	2020	6930	D-33				POZO ALMONTE	CANCHONES 4	DOS							
	017 00 458-	2020	6930	D-34				POZO ALMONTE	CANCHONES 5	DOS							
	017 00 459-	2020	6930	D-35				POZO ALMONTE	CANCHONES 6	DOS			120		85/09		
	017 00 460-	2020	6930	D-36				POZO ALMONTE	CANCHONES 7	DOS			120				
97	017 00 367-4	2020	6940	A-1	2000	6930	C-3	POZO ALMONTE	SALAR PINTADOS	CORFO T-1	CORFO-551	1007.16	18		65/12		
98	017 00 147-7	2020	6940	B-1	2000	6930	D-81	POZO ALMONTE	S. PINTADOS	CPRFO P-1	CORFP-551	1004.59	15		65/09		
99	017 00 368-2	2020	6940	B-2	2000	6930	D-82	POZO ALMONTE	SALAR PINTADOS	CORFO D-3	CORFO-551	1033.93	13		65/08		
121	017 00 110-8	2020	6940	C-1	2000	6930	C-4	POZO ALMONTE	SALAR PINTADOS	CORFO T-2	CORFO-551	997.75	15		65/11		
162	017 00 112-4	2020	6940	C-2	1930	6930	A-2	POZO ALMONTE	SALAR PINTADOS	CORFO T-3	CORFO-551	990.74	13		65/11	9.28	981.46
113	017 00 136-1	2020	6940	D-1	2030	6930	D-60	POZO ALMONTE	REFRESCO RADIOI	CORFO-1	CORFO-655	994.58	32	34.6	67/10		
114	017 00 369-0	2020	6940	D-2	2030	6930	D-61	POZO ALMONTE	REFRESCO RADIOI	CORFO-1A	CORFO-655	994.97	16		67/04		
115	017 00 370-4	2020	6940	D-3	2030	6930	D-62	POZO ALMONTE	REFRESCO RADIOI	CORFO-1B	CORFO-655	994.98	12		67/10		
116	017 00 371-2	2020	6940	D-4	2030	6930	D-63	POZO ALMONTE	REFRESCO RADIOI	CORFO-1C	CORFO-655	995.01	12		67/10		
117	017 00 272-0	2020	6940	D-5	2030	6930	D-64	POZO ALMONTE	REFRESCO	CORFO-1D	CORFO-655	995.01	12		67/04		
118	017 00 373-9	2020	6940	D-6	2030	6930	D-65	POZO ALMONTE	REFRESCO	CORFO-1E	CORFO-655	995.02	13		67/04		
119	017 00 374-7	2020	6940	D-7	2030	6930	D-66	POZO ALMONTE	REFRESCO	CORFO-1F	CORFO-655	994.93	12		67/10		
120	017 00 375-5	2020	6940	D-8	2030	6930	D-67	POZO ALMONTE	REFRESCO	CORFO-1G	CORFO-655	995.06	12		67/10		
122	017 00 138-8	2020	6940	D-9	2030	6930	D-90	POZO ALMONTE	SALAR PINTADOS	CORFO-P2	CORFO-551	998.20	15		65/09		
123	017 00 139-6	2020	6940	D-10	2030	6930	D-91	POZO ALMONTE	SALAR PINTADOS	CORFO-2	CORFO-551	993.84	15		65/11		
124	017 00 376-3	2020	6940	D-11	2030	6900	D-92	POZO ALMONTE	SALAR PINTADOS	CORFO-G2	CORFO-551	991.72	12		65/10		
135	017 00 377-1	2020	6940	D-12	2030	6900	D-97	POZO ALMONTE	BOSQUE JUNOY	CORFO-W	CORFO-551	993.41	13		66/09		
133	017 00 378-K	2020	6940	D-13	2030	6900	D-102	POZO ALMONTE	BOSQUE JUNOY	CORFO-I1	CORFO-551	991.83	16		66/08		
136	017 00 379-8	2020	6940	D-14	2030	6900	D-98	POZO ALMONTE	SALAR PINTADOS	CORFO-D1	CORFO-551	989.84	15		65/12		
137	017 00 140-K	2020	6940	D-15	2030	6900	D-101	POZO ALMONTE	BOSQUE JUNOY	CORFO-8	CORFO-551		16		66/07	13.51	
150	017 00 380-1	2020	6940	D-16	2030	6900	D-100	POZO ALMONTE	SALAR PINTADOS	CORFO-P3	CORFO-551	989.29	16		65/09		
149	017 00 381-K	2020	6940	D-17	2030	6900	D-99	POZO ALMONTE	BOSQUE JUNOY	CORFO X	CORFO-551	999.61	12		66/09	13.17	986.44
160	017 00 382-8	2020	6940	D-18	2030	6900	D-113	POZO ALMONTE	SALAR PINTADOS	CORFO-P3	CORFO-551	985.45	15		65/11		
163	017 00 383-6	2020	6940	D-19	2030	6900	D-121	POZO ALMONTE	SALAR PINTADOS	CORFO-T 3	CORFO-551	987.48	8		66/07		
	017 00 137-K	2020	6940	D-20				POZO ALMONTE									
308	017 00 384-4	2030	6910	A-1	2030	6900	A-2	PICA	P.CHIANTAGUAY C	DOS	DOS	1420.00	265				
307	017 00 385-2	2030	6910	A-2	2030	6900	A-3	PICA	P.CHIANTAGUAY G	DOS	DOS	1312.00	67				
306	017 00 386-0	2030	6910	A-3	2030	6900	A-4	PICA	P.CHIANTAGUAY H	DOS	DOS	1305.00	182				
305	017 00 387-9	2030	6910	A-4	2030	6900	A-5	PICA	P.CHIANTAGUAY I	DOS	DOS	1303.00	66				
304	017 00 388-7	2030	6910	A-5	2030	6900	A-6	PICA	P.CHIANTAGUAY J	DOS	DOS	1289.00	35				
312	017 00 389-5	2030	6910	A-6	2030	6900	A15	PICA	MATILLA 2	CORFO	CORFO-676	1307.70	185	13.8	67/09		
313	017 00 390-9	2030	6910	A-7	2030	6900	A-16	PICA	MATILLA 3	CORFO	CORFO-697	1316.54	141	3.3	67/12		
317	017 00 391-7	2030	6910	A-8	2030	6900	A-14	PICA	MATILLA 1	CORFO	CORFO-547	1283.48	159		66/04		
318	017 00 392-5	2030	6910	A-9	2030	6900	A-26	PICA	PUOUIO NUNEZ A	RIEGO	RIEGO	1352.00	52				
319	017 00 393-3	2030	6910	A-10	2030	6900	A-10	PICA	PUOUIO NUNEZ 1	RIEGO	RIEGO	1526.50	378		57/02		
321	017 00 394-1	2030	6910	A-11	2030	6900	A-25	PICA	PUOUIO NUNEZ 2	CORFO	CORFO-734	1288.10	206	5.2	68/08		
322	017 00 395-K	2030	6910	C-1	2030	6900	A-24	PICA	PUOUIO NUNEZ 1	CORFO	CORFO-716	1253.70	230		68/04		
320	017 00 143-4	2030	6920	A-1	2030	6900	A-22	PICA	PINTADOS PICA 2	CORFO	CORFO-671	1039.38	159		67/07		
315	017 00 114-0	2030	6920	A-2	2030	6900	A-23	PICA	PINTADOS PICA 3	CORFO	CORFO-674	1057.89	201		67/07	71.56	986.33
301	017 00 142-6	2030	6920	B-1	2030	6900	A-17	PICA	MATILLA 4	CORFO	CORFO-711	1136.60	59				
302	017 00 117-5	2030	6920	B-2	2030	6930	A-18	PICA	MATILLA 5	CORFO	CORFO-764	1136.60	184	6.6	68/11	3.76	1132.84
309	017 00 396-8	2030	6920	B-3	2030	6930	A9	PICA	MATILLA 1A	RIEGO	RIEGO	1113.24	372		61/02		
311	017 00 397-6	2030	6920	B-4	2030	6930	A8	PICA	P.CHIANTAGUAY P	DOS		1208.00					
303	017 00 398-4	2030	6920	B-5	2030	6930	A7	PICA	P. CHIANTAGUAY O	DOS		1213.00					
310	017 00 399-2	2030	6920	B-6	2030	6930	B-13	PICA	POUIO NUNEZ 4	RIEGO	RIEGO	1165.00	112		61/12		
314	017 00 400-K	2030	6920	B-7	2030	6930	A-12	PICA	PUOUIO NUNEZ 3	RIEGO	RIEGO	1169.40			61/12		
316	017 00 401-8	2030	6920	B-8	2030	6930	A-11	PICA	PUOUIO NUNEZ 2	RIEGO	RIEGO	1120.10	187		62/01		
	017 00 469-7	2030	6920	BN-9				PICA	GRANJA MA.JOSE								
	017 00 470-0	2030	6920	BN-10	2030	6930	B-28	PICA	E. ARROYO								
	017 00 471-9	2030	6920	BN-11	2030	6930	B-25	PICA	A. NAPOLI P-1								
324	017 00 402-6	2030	6920	C-1	2030	6930	A-20	PICA	CHACARILLA 1	CORFO	CORFO-659	1083.92	267		67/05	62.79	1021.13
325	017 00 403-4	2030	6920	C-2	2030	6930	A21	PICA	CHACARILLA 2	CORFO	CORFO-665	1083.49	194	37.6	68/03	62.25	1021.24
323	017 00 404-2	2030	6920	D-1	2030	6930	A-1	PICA	PUOUIO NUNEZ B	RIEGO	RIEGO	1205.00	52			20.63	1184.37
	017 00 909-	2030	6920	D-2					P.NUNEZ								
	017 00 910-	2030	6920	D-3					P.NUNEZ								
238	017 00 113-2	2030	6930	A-1	2030	6930	B-11	POZO ALMONTE	PINTADOS RADIO	CORFO-1	CORFO-656	975.64	30		67/10	6.56	969.08
239	017 00 405-0	2030	6930	A-2	2030	6930	B-12	POZO ALMONTE	PINTADOS RADIO	CORFO-1A	CORFO-656	975.91	7		67/12		

Table B-III, 2.1.1 (1) Well List (Pampa del Tamarugal)

<Lista de Sondajes (Pampa del Tamarugal)>

DGA CODE	BNA CODE	CORFO CODE(1975) LAT.	CORFO CODE(1975) LONG	CORFO CODE(1975) NO.	CORFO CODE(1969) LAT.	CORFO CODE(1969) LONG	CORFO CODE(1969) NO.	COMMUNITY	LOCATION NAME	NAME OF OWNER	CONSTRUCTOR	ELEVATION (mMSL)	DRILLING DEPTH (m)	SPECIFIC YIELD (m3/d/m)	DATE OF CONSTRUCTION	STATIC WATER LEVEL (93/ 10-11) (mBGL)	STATIC WATER LEVEL (93/ 10-11) (mMSL)
240	017 00 406-9	2030	6930	A-3	2030	6930	B-13	POZO ALMONTE	PINTADOS RADIO	CORFO-1B	CORFO-656	975.81	7		67/12		
241	017 00 407-7	2030	6930	A-4	2030	6930	B-14	POZO ALMONTE	PINTADOS RADIO	CORFO-1D	CORFO-656	975.83	16		67/12		
242	017 00 123-K	2030	6930	A-5	2030	6930	B-15	POZO ALMONTE	PINTADOS RADIO	CORFO-1D	CORFO-656	975.97	7		67/12		
243	017 00 408-5	2030	6930	A-6	2030	6930	B-16	POZO ALMONTE	PINTADOS RADIO	CORFO-1E	CORFO-656	975.94	7		67/12		
244	017 00 409-3	2030	6930	A-7	2030	6930	B-17	POZO ALMONTE	PINTADOS RADIO	CORFO-1F	CORFO-656	975.99	16		67/12		
245	017 00 410-7	2030	6930	A-8	2030	6930	B-18	POZO ALMONTE	PINTADOS RADIO	CORFO-1G	CORFO-656	975.22	7		67/12		
237	017 00 411-5	2030	6930	A-9	2030	6930	B-28	POZO ALMONTE	SALAR PINTADOS	CORFO-P5	CORFO-656	975.34	6		65/10	6.21	969.13
230	017 00 412-3	2030	6930	A-10	2030	6930	B-25	POZO ALMONTE	BOSQUE JUNOY	CORFO-13	CORFO-551	981.16	8		66/08	11.39	969.77
248	017 00 413-1	2030	6930	A-11	2030	6930	B-48	POZO ALMONTE	SALAR PINTADOS	CORFO-P1	CORFO-551	980.25	8		66/01		
232	017 00 414-K	2030	6930	B-1	2030	6930	B-10	POZO ALMONTE	SALAR PINTAD E2	ENAP	ENAP	988.80	1255				
231	017 00 415-8	2030	6930	B-2	2030	6930	B-9	POZO ALMONTE	SALAR PINTAD 2	ENAP	ENAP	988.80	132	267.8		13.61	975.19
233	017 00 416-6	2030	6930	B-3	2030	6930	B-26	POZO ALMONTE	SALAR PINTADOS	CORFO-H9	CORFO-551	980.58	13		65/06		
234	017 00 417-4	2030	6930	B-4	2030	6930	B-27	POZO ALMONTE	SALAR PINTADOS	CORFO-I9	CORFO-551	1005.18	31		65/09		
246	017 00 418-2	2030	6930	B-5	2030	6930	B-29	POZO ALMONTE	SALAR PINTADOS	CORFO-H10	CORFO-551	990.56	19		65/06		
250	017 00 419-0	2030	6930	B-6	2030	6930	B-35	POZO ALMONTE	SALAR PINTADOS	CORFO-H11	CORFO-551	991.45	21				
252	017 00 420-4	2030	6930	B-7	2030	6930	B-8	POZO ALMONTE	SALAR PINTA. E1	ENAP	ENAP	1001.70	2475			24.04	977.66
251	017 00 421-2	2030	6930	B-8	2030	6930	B-7	POZO ALMONTE	SALAR PINTADOS 1	ENAP	ENAP	1001.70	120	237.6			
254	017 00 118-3	2030	6930	C-1	2030	6930	B-33	POZO ALMONTE	SALAR PINTADOS	CORFO-S1	CORFO-551	975.43	12		65/11	5.34	970.09
255	017 00 422-0	2030	6930	C-2	2030	6930	B-34	POZO ALMONTE	SALAR PINTADOS	CORFO-P7	CORFO-551	978.03	12		65/10		
256	017 00 141-8	2030	6930	C-3	2030	6930	B-19	POZO ALMONTE	SALAR PINTADOS 2	CORFO	CORFO-661	978.29	158		67/06	8.79	969.50
257	017 00 144-2	2030	6930	C-4	2030	6930	B-22	POZO ALMONTE	SALAR PINTADOS 3	CORFO	CORFO-686		84		67/08	8.87	
258	017 00 423-9	2030	6930	C-5	2030	6900	B-21	POZO ALMONTE	SALAR PINTADOS 4	CORFO	CORFO-688		285	118.6	68/06		
265	017 00 151-5	2030	6930	C-6	2030	6900	B-37	POZO ALMONTE	SALAR PINTADOS	CORFO-P8	CORFO-551	976.73	15		65/11		
249	017 00 120-5	2030	6930	C-7	2030	6900	B-30	POZO ALMONTE	SALAR PINTADOS	CORFO-P6	CORFO-551	975.86	7		65/10		
259	017 00 119-1	2030	6930	D-1	2030	6930	B-36	POZO ALMONTE	SALAR PINTADOS	CORFO-H12	CORFO-551	990.05	21		65/12		
253	017 00 121-3	2030	6930	D-2	2030	6930	B-22	POZO ALMONTE	PINTADOS PICA 1	CORFO	CORFO-668	1006.26	110		67/06		
261	017 00 424-7	2030	6930	D-3	2030	6930	B-4	POZO ALMONTE	ESTACION PINTA.3	CO.AG.JEHOVA	RIEGO	987.99	315		66/04		
262	017 00 425-5	2030	6930	D-4	2030	6930	B-6	POZO ALMONTE	ESTACION PINTA.5	CO.AG.JEHOVA	RIEGO	987.99	326				
260	017 00 426-3	2030	6930	D-5	2030	6930	B-5	POZO ALMONTE	ESTACION PINTA.4	CO.AG.JEHOVA	RIEGO	987.43	395			11.97	975.46
263	017 00 150-7	2030	6930	D-6	2030	6930	B-2	POZO ALMONTE	ESTACION PINTA.1	CO.AG.JEHOVA	RIEGO	987.61	172			18.22	969.39
264	017 00 427-1	2030	6930	D-7	2030	6930	B-3	POZO ALMONTE	ESTACION PINTA.2	CO.AG.JEHOVA	RIEGO	983.48					
266	017 00 428-K	2030	6930	D-8	2030	6930	B-40	POZO ALMONTE	SALAR B. VISTA	CORFO-SB3	CORFO-621	984.28	24		66/04		
	017 00 116-7	2030	6930	D-9				POZO ALMONTE									
229	017 00 429-B	2030	6940	B-1	2030	6930	B-24	POZO ALMONTE	SALAR PINTADOS	CORFO-P4	CORFO-551	983.48	10		65/10		
235	017 00 430-1	2030	6940	B-2	2030	6930	B-31	POZO ALMONTE	SALAR PINTADOS	CORFO-S3	CORFO-551	983.07	8		65/11	6.35	976.72
247	017 00 145-0	2030	6940	B-3	2030	6930	B-32	POZO ALMONTE	SALAR PINTADOS	CORFO-S2	CORFO-551	977.04	9		65/11		
236	017 00 146-9	2030	6940	B-4	2030	6930	B-1	POZO ALMONTE	MOSQUITOS 1		RIEGO	978.71	285		57/05	4.20	974.51
326	017 00 122-1	2040	6910	A-1	2030	6930	A-19	PICA	CHACARILLA 1	RIEGO			338			86.00	
327	017 00 431-k	2040	6920	C-1	2030	6930	C-1	POZO ALMONTE	RAMADA 1	CORFO	CORFO-704	1019.26	202		68/07		
328	017 00 432-8	2040	6920	C-2	2030	6930	C-2	POZO ALMONTE	RAMADA 2	CORFO	CORFO-731	1019.55	290	130.1	68/07		
267	017 00 125-6	2040	6930	A-1	2030	6930	B-38	POZO ALMONTE	SALAR BELAVISTA	CORFO-SB1	CORFO-621	970.71	15		66/03	11.15	959.56
268	017 00 433-6	2040	6930	A-2	2030	6930	B-41	POZO ALMONTE	SALAR BELAVISTA	CORFO-SB4	CORFO-621	965.56	10		66/03		
269	017 00 126-4	2040	6930	A-3	2030	6930	B39	POZO ALMONTE	SALAR BELAVISTA	CORFO-SB2	CORFO-621	974.13	18		66/03		
271	017 00 434-4	2040	6930	A-4	2030	6930	B-42	POZO ALMONTE	SALAR BELAVISTA	CORFO-SB5	CORFO-621	970.38	16		66/04	11.56	958.82
273	017 00 435-2	2040	6930	A-5	2030	6930	B-45	POZO ALMONTE	SALAR BELAVISTA	CORFO-SB8	CORFO-621	960.63	10		66/03		
275	017 00 436-0	2040	6930	A-6	2030	6930	B-46	POZO ALMONTE	SALAR BELAVISTA	CORFO-SB9	CORFO-621	968.08	15		66/04	11.30	956.78
276	017 00 157-4	2040	6930	A-7	2030	6930	B-47	POZO ALMONTE	SALAR BELAVISTA	CORFO-SB10	CORFO-621	974.35	20		66/04	16.39	957.96
274	017 00 437-9	2040	6930	A-8	2030	6900	B-23	POZO ALMONTE	OF. VICTORIA 4	SOQUIMICH	RIEGO	954.55	85				
270	017 00 438-7	2040	6930	B-1	2030	6930	B43	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB6	CORFO-621	995.09	25		66/06		
280	017 00 128-0	2040	6930	C-1	2030	6930	D-7	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB12	CORFO-621	958.88	12		66/04	8.73	950.15
283	017 00 152-3	2040	6930	C-2	2030	6930	D-10	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB15	CORFO-621	949.40	8		66/04	2.96	946.44
285	017 00 439-5	2040	6930	C-3	2030	6930	D-11	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB16	CORFO-621	953.50	10		66/04		
287	017 00 440-9	2040	6930	C-4	2030	6930	D-14	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB19	CORFO-621	947.50	7		66/06	3.10	944.40
288	017 00 441-7	2040	6930	C-5	2030	6930	D-15	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB20	CORFO-621	947.15	7		66/06		
278	017 00 442-5	2040	6930	D-1	2030	6930	D-2	POZO ALMONTE	OF. VICTORIA 2	SOQUIMICH	RIEGO	973.05	106		55/02	15.87	957.18
277	017 00 443-3	2040	6930	D-2	2030	6930	D-3	POZO ALMONTE	OF. VICTORIA 3	SOQUIMICH	RIEGO	972.04	335		69/09		
281	017 00 444-1	2040	6930	D-3	2030	6930	D-8	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB13	CORFO-621	974.30	23		66/04	18.82	955.48
282	017 00 445- K	2040	6930	D-4	2030	6930	D-1	POZO ALMONTE	OF. VICTORIA O	SOQUIMICH	RIEGO	973.09	156		54/06		
286	017 00 127-2	2040	6930	D-5	2030	6930	D-12	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB17	CORFO-621	972.54	24		66/04	19.85	952.69
289	017 00 446-8	2040	6930	D-6	2030	6930	D-16	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB21	CORFO-621	966.91	12		66/05		
272	017 00 447-6	2040	6940	B-1	2030	6930	B-44	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB7	CORFO-621	962.60	12		66/03	5.80	956.80
279	017 00 448-4	2040	6940	D-1	2030	6930	D-6	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB11	CORFO-621	953.09	15		66/03		
284	017 00 449-2	2040	6940	D-2	2030	6930	D-9	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB14	CORFO-621	946.28	9		66/03		
329	017 00 450-6	2050	6920	A-1	2030	6900	C-3	POZO ALMONTE	CERRO GORDO 1	CORFO	CORFO-703	992.70	140		67/11		
	017 00 467-0	2050	6920	C-1				POZO ALMONTE									
	017 00 472-7	2050	6920	D-2				POZO ALMONTE									
296	017 00 153-1	2050	6930	A-1	2030	6930	D-20	POZO ALMONTE	SALAR SUR VIEJO	CORFO-SV3	CORFO-621	923.82	16		66/10		
298	017 00 451-4	2050	6930	A-2	2030	6930	D-22	POZO ALMONTE	SALAR SUR VIEJO	CORFO-SV6	CORFO-621	923.30	16		66/10		
291	017 00 452-2	2050	6930	B-1	2030	6930	D-17	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB22	CORFO-621	948.28	10		66/06		
293	017 00 156-6	2050	6930	B-2	2030	6930	D-4	POZO ALMONTE	CHALLACOLLO 1	CORFO	CORFO-675	945.35	68		67/07		
292	017 00 453-0	2050	6930	B-3	2030	6930	D-5	POZO ALMONTE	CHALLACOLLO 2	CORFO	CORFO-677	945.80	21			36.85	908.95
294	017 00 155-8	2050	6930	B-4	2030	6930	D-18	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB23	CORFO-621	945.73	31		66/06	27.17	918.56
295	017 00 154-K	2050	6930	B-5	2030	6930	D-19	POZO ALMONTE	SALAR SUR VIEJO	CORFO-SV2	CORFO-621	930.87	22		66/10		
297	017 00 159-0	2050	6930	B-6	2030	6930	D-21	POZO ALMONTE	SALAR SUR VIEJO	CORFO-SV5	CORFO-621	931.40	24		66/10		
299	017 00 160-4	2050	6930	D-1	2030	6930	D-23	POZO ALMONTE	SALAR SUR VIEJO	CORFO-SV7	CORFO-621	923.21	19		66/10		
300	017 00 163-9	2050	6930	D-2	2030	6930	D-24	POZO ALMONTE	SALAR SUR VIEJO	CORFO-SV11	CORFO-621	927.11	24		66/10		
	017 00 917-6	2050	6930	D-3													
290	017 00 124-8	2050	6940	B-1	2030	6930	D-13	POZO ALMONTE	SALAR BELLAVISTA	CORFO-SB18	CORFO-621	947.56	7		66/06	3.18	944.38
								ZAPIGA		DGA-JICA	JICA J-3	1143.90	150	62.79	93/11	9.17	1134.73
								ZAPIGA	CAMINA	DGA-JICA	JICA J-4	1168.04	150	169.40	93/12	46.16	1121.88
								ZAPIGA	HUARA	DGA-JICA	JICA J-C	1110.86	209	8.20	93/11	52.03	1058.83
								POZO ALMONTE	BAQUEDANO	DGA-JICA	JICA J-D	1056.69	210	300.00	93/12	46.05	1010.64
								POZO ALMONTE	POZO ALMONTE	DGA-JICA	JICA J-5	1030.80	300	720.00	93/12	29.08	1001.72
								POZO ALMONTE	LA TIRANA	DGA-JICA	JICA J-E	1006.03	250	584.60	93/12	13.73	992.30
								POZO ALMONTE	CANCHONES	DGA-JICA	JICA J-6	991.90	200	22.30	93/12	14.04	977.86
								POZO ALMONTE	CONAF	DGA-JICA	JICA J-7	981.64	210	234.80	93/12	7.94	973.70
								POZO ALMONTE	PINTADOS	DGA-JICA	JICA J-8	1016.12	210	188.61	93/12	37.99	978.13
								POZO ALMONTE	OFICINA VICTORIA	DGA-JICA	JICA J-F	1016.16	224	142.20	93/01	57.00	959.16
								POZO ALMONTE	OFICINA VICTORIA	DGA-JICA	JICA J-9	969.80	172	166.10	93/01	13.97	955.83

NOTE

(PUNPING TEST)
D/W: DYNAMIC WATER LECEL
S/W: STATIC WATER LEVEL

Table B-III, 2.1.1 (2) Well List (Pampa del Tamarugal)
<Lista de Sondajes (Pampa del Tamarugal)>

BNA CODE		MAP	CORFO CODE(1975)			UTM		COMMUNITY	LOCATION NAME	NAME OF OWNER	CONSTRUCTOR	ELEVATION (mASL)	DRILLING DEPTH (m)	WELL DEPTH (m)	SPECIFIC YIELD (m2/d)	DATE OF CONSTRUCTION	STAIC WATER LEVEL	
			LAT.	LONG.	NO.	North (m)	East (m)										(mBGL)	(mMSL)
017 00	919	ZP-1	1940	6950	B-8	7.819.853	405.341	HUARA	STA. CATALINA	LUIS PAPIC	--		7.20	7.20	414.7		4.72	
017 00	920	ZP-2	1940	6950	D-4	7.815.343	407.751	HUARA	AGUADA	LUIS PAPIC	--		15.00	15.00	267.9		12.35	
017 00	928	ZP-3	1950	6950	B-1	7.805.763	411.189	HUARA	NEGREROS	SAL. RENACER	CRUZAT		30.25	30.25	154.7	07.89	12.43	
017 00	926	ZP-4	1940	6950	D-10	7.807.004	411.249	HUARA	NEGREROS	SAL. RENACER	CRUZAT		18.50	18.50		07.89	11.10	
017 00	925	ZP-5	1940	6950	D-9	7.807.322	412.083	HUARA	NEGREROS	SAL. RENACER	CRUZAT		26.70	26.70	104.9	07.89	13.73	
017 00	923	ZP-6	1940	6950	D-7	7.808.191	410.724	HUARA	NEGREROS	SAL. RENACER	CRUZAT		20.20	20.20	60.3	07.89	11.24	
017 00	922	ZP-7	1940	6950	D-6	7.808.640	411.377	HUARA	NEGREROS	SAL. RENACER	CRUZAT		45.00	45.00	76.5	06.89	12.98	
017 00	924	ZP-8	1940	6950	D-8	7.807.767	410.395	HUARA	NEGREROS	SAL. RENACER	CRUZAT		12.90	12.90			12.63	
017 00	921	ZP-9	1940	6950	D-5	7.809.917	410.789	HUARA	NEGREROS	SAL. RENACER	CRUZAT		25.40	25.40	95.3	06.89	10.45	
017 00	934	ZP-10	1950	6950	B-4	7.804.136	411.169	HUARA	NEGREROS	MERCK OCA	SAACOL		24.00	24.00	7.3	02.88	13.19	
017 00	936	ZP-11	1950	6950	B-6	7.803.975	411.520	HUARA	NEGREROS	MERCK OCA	SAACOL		44.00	44.00	2.4	03.88	14.77	
017 00	935	ZP-12	1950	6950	B-5	7.804.000	412.001	HUARA	NEGREROS	MERCK OCA	SAACOL		32.00	32.00	5.5	02.98	15.60	
017 00	932	ZP-13	1950	6950	B-3	7.804.613	411.223	HUARA	NEGREROS	MERCK OCA	SAACOL		66.00	35.00	94.1	12.87	13.50	
017 00	938	ZP-14	1950	6950	B-8	7.803.243	411.275	HUARA	NEGREROS	MERCK OCA	SAACOL		40.00	40.00	7.4	12.87	14.20	
017 00	939	ZP-15	1950	6950	B-7	7.803.374	411.526	HUARA	NEGREROS	MERCK OCA	SAACOL		20.40			12.87	17.60	
017 00	941	ZP-16	1950	6950	B-11	7.802.270	409.971	HUARA	NEGREROS	MERCK OCA	SAACOL		40.00	40.00	21.0	02.98	14.52	
017 00	929	ZP-17	1950	6950	B-2	7.804.584	410.455	HUARA	OF. MERCEDES	MERCK OCA	SAACOL		22.20		16.4	11.89	14.35	
017 00	937	ZP-18	1950	6950	B-9	7.803.184	410.275	HUARA	NEGREROS	MERCK OCA	SAACOL		17.00		43.2	11.89	15.00	
017 00	940	ZP-19	1950	6950	B-10	7.802.564	410.126	HUARA	NEGREROS	MERCK OCA	SAACOL		19.00		933.1	11.89	14.75	
017 00	943	ZP-20	1950	6950	B-13	7.801.776	409.889	HUARA	OF. AGUA SANTA	MERCK OCA	SAACOL		17.80		95.4	11.89	15.92	
017 00	942	ZP-21	1950	6950	B-12	7.802.217	411.492	HUARA	OF. PROGRESO	MERCK OCA	SAACOL		17.75		259.2	11.89	15.44	
017 00	947	ZP-22	1950	6940	D-5	7.789.697	421.676	HUARA	STA. ROSA HUARA	MERCK OCA.	SAACOL	1106.25	68.00	68.00	10.3	12.87	48.70	1057.55
017 00	948	ZP-23	1950	6940	D-4	7.789.856	423.320	HUARA	STA. ROSA HUARA	MERCK OCA	SAACOL	1106.37	93.00	90.00	187.5	04.89	50.97	1055.40
017 00	946	ZP-24	1950	6940	D-3	7.790.940	422.661	HUARA	STA. ROSA HUARA	MERCK OCA	SAACOL	1110.74	90.00	90.00	352.9	05.89	51.44	1059.30
017 00		ZP-25	1940	6950	A-8	7.824.465	396.974	HUARA	OF. LOS POZOS	INV. JUNIN	CORFO							
017 00		ZP-26	1950	6940	A-9	7.801.445	419.049	HUARA										
017 00	930	ZP-27	1950	6940	A-5	7.804.585	413.392	HUARA	JOSEFINA	MERCK OCA	SAACOL	1146.28	73.00	68.00	52.1	07.88	18.19	1128.09
017 00	931	ZP-28	1950	6940	A-4	7.804.797	415.920	HUARA	JOSEFINA	MERCK OCA	SAACOL	1151.35	90.00	70.00	121.2	09.88	25.23	1126.12
017 00	944	ZP-29	1950	6940	A-7	7.800.973	416.060	HUARA	BARCELONA	MERCK OCA	SAACOL	1146.21	27.00	27.00	28.8		22.00	1124.21
017 00	927	ZP-30	1940	6940	D-1	7.808.558	429.151	HUARA	CURANA	LUIS PAPIC	CRUZAT		45.00	45.00	13.3	07.89	7.50	
017 00	933	ZP-31	1950	6940	A-6	7.804.581	416.317	HUARA	NEGREROS	MERCK OCA	SAACOL		62.50	61.50	190.5	08.39	25.39	
017 00	955	PA-1				7.758.701	419.112	P. ALMONTE	CARMEN BAJO	W. GONZALEZ	--		28.80	28.80	385.0	05.90	24.99	
017 00	954	PA-2				7.758.732	418.926	P. ALMONTE	CARMEN BAJO	PETROMIN.	--		29.30	29.30	514.9	05.90	25.63	
017 00	950	PA-3				7.787.146	423.456	P. ALMONTE	HORNILLOS	S. RENACER	CRUZAT		84.00	84.00	91.5	05.89	50.00	
017 00	949	PA-4				7.787.242	424.929	P. ALMONTE	HORNILLOS	S. RENACER	CRUZAT		87.00	87.00	347.6	05.89	53.75	
017 00	951	PA-5				7.780.049	425.590	P. ALMONTE	MAPOCHO	M. MAPOCHO	SAACOL		79.00	79.00	250.8	05.91	55.00	
017 00	960	PA-6				7.741.050	442.800	P. ALMONTE	LA GUAYCA	TITO BARRERA	I. CARVAJAL		60.00	60.00	153.5	08.88	11.80	
017 00	963	PA-10				7.739.918	446.226	P. ALMONTE	CANCHONES	SENDOS	SENDOS		54.00	54.00	122.8		18.90	
017 00	962	PA-11				7.740.763	446.244	P. ALMONTE	CANCHONES	SENDOS	SAACOL		110.00	110.00	360.2	05.81	20.35	
017 00	961	PA-12				7.741.082	446.082	P. ALMONTE	CANCHONES	SENDOS	SAACOL		110.00	110.00	496.3	05.81	19.00	
017 00	959	PA-13				7.741.360	446.312	P. ALMONTE	CANCHONES	SENDOS	SAACOL		110.00	110.00	339.9	05.81	17.35	
017 00	953	PA-15				7.765.700	417.250	P. ALMONTE	EL BOSQUE	RECO	RECO	1050.00	67.00			11.86	27.00	1023.00
017 00	952	PA-16				7.768.500	419.200	P. ALMONTE	EL BOSQUE	RECO	RECO	1050.00	100.50			10.86		
017 00	968	GT-6				7.716.100	466.900	P. ALMONTE	CHACARILLA	CORFO	CORFO	1300.00	882.00	882.00		02.80	130.00	1170.00
017 00		MM-1				7.708.425	478.260											
017 00	982	VC-1				7.702.276	437.721	P. ALMONTE	SALAR BELLAVISTA	SOQUIMICH	CAPTAGUA		23.80	23.80	48.8	05.88	12.47	
017 00	975	VC-3				7.706.670	431.740	P. ALMONTE	OF. VICTORIA	SOQUIMICH	--						3.30	
017 00	976	VC-4				7.706.641	431.862	P. ALMONTE	OF. VICTORIA	SOQUIMICH	--		109.30	109.30	57.5	10.87	3.75	
017 00	980	VC-5				7.703.192	437.030	P. ALMONTE	OF. VICTORIA	SOQUIMICH	--		17.05	17.05	218.1	10.87	10.33	
017 00	983	VC-6				7.702.321	440.093	P. ALMONTE	OF. VICTORIA	SOQUIMICH	--		20.70	20.70	105.4	05.88	15.11	
017 00	978	VC-7				7.705.620	439.700	P. ALMONTE	OF. VICTORIA	SOQUIMICH	--		24.00	24.00	227.4	08.87	16.30	
017 00	972	VC-8				7.711.636	425.158	P. ALMONTE	OF. VICTORIA	SOQUIMICH	--	959.30	6.50	6.50	51.1	04.88	4.54	954.76
017 00	973	VC-9				7.711.375	426.925	P. ALMONTE	OF. VICTORIA	SOQUIMICH	--	959.22	20.00	20.00	255.4	04.88	4.54	954.68
017 00	977	VC-10				7.706.547	431.728	P. ALMONTE	OF. VICTORIA	SOQUIMICH	--	973.87	6.40	6.40	79.5	05.88	1.64	972.23
017 00	984	VC-12																
017 00	974	VC-14				7.711.363	438.022	P. ALMONTE	OF. VICTORIA	SOQUIMICH	--		34.50	34.50	83.4	05.88	13.80	
017 00	981	VC-15				7.702.448	427.250	P. ALMONTE	OF. VICTORIA	JULIAN NINA	--		8.00	8.00		07.88	2.00	
017 00	986	VC-16				7.698.050	443.960	P. ALMONTE	OF. GRANJA	URRUTICOEC.	CRUZAT		25.30	25.30	262.5	10.91	22.62	
017 00	987	VC-17	107			7.696.890	443.925	P. ALMONTE	OF. GRANJA	URRUTICOEC.	CRUZAT		26.00	26.00	27.8	10.91	19.25	
017 00	985	VC-18				7.699.080	444.500	P. ALMONTE	OF. GRANJA	URRUTICOEC.	CRUZAT		24.45	24.45	162.0	10.91	23.30	
017 00	988	VC-19				7.689.900	439.100	P. ALMONTE	OF. LA GRANJA	URRUTICOEC.	CRUZAT		37.70	37.70	79.2	10.91	17.23	
017 00	989	VC-20				7.688.843	435.598	P. ALMONTE	OF. LA GRANJA	URRUTICOEC.	CRUZAT		28.30	28.30	9.1	10.91	18.65	
017 00	990	VC-21				7.687.799	434.339	P. ALMONTE	CAMPAM. IRIS	URRUTICOEC.	CRUZAT		27.40	27.40	9.4	10.91	13.48	

Note: BNA Code and CORFO Code mentioned in this list are all temporary ones.

(STAIC WATER LEVEL)
mBGL: m BELOW THE GROUND LEVEL
mMSL: m ABOVE THE SEA LEVEL

Table B-III, 2.5.1 Aquifer Constants of Existing Wells

<Coeficientes de Acuíferos>

(Zapiga-Dolores-Negreiros Area)

BNA NO.	Discharge Rate (l/s)	Specific Yield (l/sec/m)	Transmissibility (m3/d/m)	Permeability (cm/sec)	Storativity	Remarks
170	4.0	0.31				J
172	5.0	0.47				J
168	9.0	0.62				J
171	7.0	0.82				J
173	7.0	0.92				J
174	7.5	0.99				J
928	6.0	1.79	520	4.15E-02		C
925		1.21	164	1.89E-02		C
923	3.0	0.70	398	5.12E-02		C
922	3.0	0.89	135	1.30E-02		C
921	3.0	1.10	258	2.99E-02		C
941	1.0	0.24	53	3.06E-03	9.99E-10	J
930	8.0	0.60	110	4.55E-03	2.84E-04	J
927		0.15	23	1.75E-03		C
933	5.5	2.20	173	9.02E-03		J
Average		0.87	204	0.0192	0.0142	

(Huara Area)

BNA NO.	Discharge Rate (l/s)	Specific Yield (l/sec/m)	Transmissibility (m3/d/m)	Permeability (cm/sec)	Storativity	Remarks
190-6			1440			C
946	2.2	4.1	39	1.56E-04	5.26E-07	J
949		4.0	935	3.37E-02	6.00E-04	C
951	18.0	2.9	284	2.35E-02		J
Average		3.7	675	0.0191	0.0003	

(Pica-Matilla Area)

BNA NO.	Discharge Rate (l/s)	Specific Yield (l/sec/m)	Transmissibility (m3/d/m)	Permeability (cm/sec)	Storativity	Remarks
117-5	6.0	0.08				J
252-k	7.5	0.38				J
253-6	1.1	0.14				J
265-1	42.0	1.89				J
272-4	2.0	0.04				J
389-5	8.0	0.16	6	8.43E-05	2.81E-01	J
390-9	1.0	0.04	312	1.39E-02	4307	J
391 or 392			155			C
394-1	1.5	0.06				J
401-8			49			C
403-4	5.0	0.43				J
Average		0.36	130	6.99E-03	2.15E+03	

(Pozo Almonte-Canchones-Pintados Area)

BNA NO.	Discharge Rate (l/s)	Specific Yield (l/sec/m)	Transmissibility (m3/d/m)	Permeability (cm/sec)	Storativity	Remarks
129-9	36.0	5.14				J
130-2		1.66	47		4.29E-02	C
131-0	60.0	3.82				J
132-9	30.0	2.61				J
136-1	3.8	0.40	9	8.51E-04	4.14E-01	J
200-7	6.0	0.12				J
202-3	64.0	10.67				J
206-6	25.0	2.08				J
207-4	3.5	0.81	1094	1.06E-01	2.62E-03	J
221-k	40.0	6.78				J
222-8	70.0	4.43	450			C
226-0	47.0	2.72				J
229-5	4.0	0.21				J
232-5	24.0	2.00				J
234-1			4280			C
240-6	20.0	3.33				J
357-7	120.0	5.36				J
366-6	120.0	4.72				J
415-8	9.3	3.10				J
421-2	5.5	2.75				J
423-9	70.0	1.37	920			C
955		4.46	915	2.52E-02	5.00E-04	C
Average		3.26	1102	0.044	0.115	

(Oficina Victoria-Bellavista Area)

BNA NO.	Discharge Rate (l/s)	Specific Yield (l/sec/m)	Transmissibility (m3/d/m)	Permeability (cm/sec)	Storativity	Remarks
432-b	25.0	1.51				J
445-k	26.0		420	1.39E-02	3.30E-01	J
985		3.04	220		3.00E-03	C
986		0.32	81		5.00E-02	C
987		0.32	157		1.00E-01	C
Average		1.30	219.5	0.014	0.121	

(TOTAL PAMPA AREA: except Pica-Matilla Area)

BNA NO.	Discharge Rate (l/s)	Specific Yield (l/sec/m)	Transmissibility (m3/d/m)	Permeability (cm/sec)	Storativity	Remarks
Average		2.27	547	0.024	0.081	

(Note) C: Existing Data.
J: Estimated by the Study Team on the basis of existing test data.

Table B-III, 2.6.1 Estimation of Groundwater Storage

<Estimacion de Reservas de Agua Subterraneas>

DEPTH	ZONE 1		ZONE2		ZONE 3		ZONE4		ZONE 5		ZONE 6	
(mBSL)	(Sect. A-B)		(SECT. B-C)		(Sect. C-D)		(Sect.D-E)		(Sect. E-F)		(Sect. F-G)	
	(x million m3)		(x million m3)		(x million m3)		(x million m3)		(x million m3)		(x million m3)	
		SUM		SUM		SUM		SUM		SUM		SUM
10	537	537	128	128	163	163	161	161	175	175	68	68
20	502	1,039	120	248	154	317	154	315	169	344	67	135
30	460	1,499	109	357	144	461	147	462	163	507	65	200
40	425	1,924	99	456	130	591	135	597	156	663	64	264
50	404	2,328	92	548	110	701	115	712	147	810	62	326
60	365	2,693	86	634	78	779	83	795	136	946	60	386
70	330	3,023	80	714	43	822	49	844	126	1,072	58	444
80	249	3,272	71	785	33	855	47	891	119	1,191	56	500
90	163	3,435	50	835	12	867	44	935	111	1,302	54	554
100	123	3,558	31	866	0	867	41	976	104	1,406	53	607
110	80	3,638	20	886	0	867	37	1,013	96	1,502	51	658
120	0	3,638	0	886	0	867	31	1,044	88	1,590	49	707
130	0		0	886	0	867	13	1,057	69	1,659	48	755
140	0	0	0	886	0	867	0	1,057	56	1,715	47	802
150	0	0	0	886	0	867	0	1,057	54	1,769	46	848
160	0	0	0	886	0	867	0	1,057	52	1,821	45	893
170	0	0	0	886	0	867	0	1,057	50	1,871	43	936
180	0	0	0	886	0	867	0	1,057	48	1,919	42	978
190	0	0	0	886	0	867	0	1,057	46	1,965	41	1,019
200	0	0	0	886	0	867	0	1,057	43	2,008	37	1,056
210	0	0	0	886	0	867	0	1,057	40	2,048	30	1,086
220	0	0	0	886	0	867	0	1,057	29	2,077	22	1,108
230	0	0	0	886	0	867	0	1,057	0	2,077	8	1,116
240	0	0	0	886	0	867	0	1,057	0	2,077	0	1,116
	3,638		886		867		1,057		2,077		1,116	

DEPTH	ZONE 7		ZONE 8		ZONE 9		ZONE 10		ZONE 11		ZONE 12		TOTAL	
(mBSL)	(Sect. G-H)		(Sect. H-I)		(Sect. I-J)		(Sect. J-K)		(Sect. K-L)		(Sect.L-C.Gordo)		(Whole Area)	
	(x million m3)		(x million m3)		(x million m3)		(x million m3)		(x million m3)		(x million m3)		(x million m3)	
		SUM		SUM		SUM		SUM		SUM		SUM		SUM
10	113	113	229	229	74	74	153	153	351	351	161	161	2,316	2,316
20	110	223	224	453	116	190	218	371	321	672	160	321	2,317	4,633
30	107	330	221	674	116	306	209	580	305	977	156	477	2,204	6,837
40	105	435	218	892	116	422	205	785	294	1,271	152	629	2,102	8,939
50	103	538	215	1,107	116	538	198	983	281	1,552	148	777	1,991	10,930
60	101	639	213	1,320	115	653	193	1,176	271	1,823	145	922	1,848	12,778
70	99	738	211	1,531	115	768	191	1,367	262	2,085	140	1,062	1,704	14,482
80	98	836	207	1,738	115	883	188	1,555	251	2,336	132	1,194	1,567	16,049
90	96	932	205	1,943	114	997	185	1,740	235	2,571	122	1,316	1,393	17,442
100	94	1,026	203	2,146	114	1,111	181	1,921	214	2,785	108	1,424	1,268	18,710
110	93	1,119	202	2,348	114	1,225	177	2,098	193	2,978	94	1,518	1,157	19,867
120	92	1,211	200	2,548	113	1,338	171	2,269	173	3,151	50	1,568	967	20,834
130	90	1,301	198	2,746	113	1,451	154	2,423	133	3,284	41	1,609	859	21,693
140	88	1,389	195	2,941	112	1,563	137	2,560	62	3,346	15	1,624	714	22,407
150	86	1,475	193	3,134	111	1,674	131	2,691	26	3,372	0	1,624	647	23,054
160	84	1,559	189	3,323	109	1,783	123	2,814	19	3,391	0	1,624	621	23,675
170	82	1,641	183	3,506	106	1,889	112	2,926	7	3,398	0	1,624	586	24,261
180	80	1,721	178	3,684	103	1,992	104	3,030	0	3,398	0	1,624	556	24,817
190	78	1,799	171	3,855	100	2,092	101	3,131	0	3,398	0	1,624	537	25,354
200	71	1,870	163	4,018	95	2,187	98	3,229	0	3,398	0	1,624	508	25,862
210	61	1,931	153	4,171	88	2,275	91	3,320	0	3,398	0	1,624	464	26,326
220	52	1,983	134	4,305	70	2,345	67	3,387	0	3,398	0	1,624	374	26,700
230	38	2,021	80	4,385	28	2,373	24	3,411	0	3,398	0	1,624	178	26,878
240	10	2,031	20	4,405	0	2,373	0	3,411	0	3,398	0	1,624	30	26,908
	2,031		4,405		2,373		3,411		3,398		1,624		26,908	

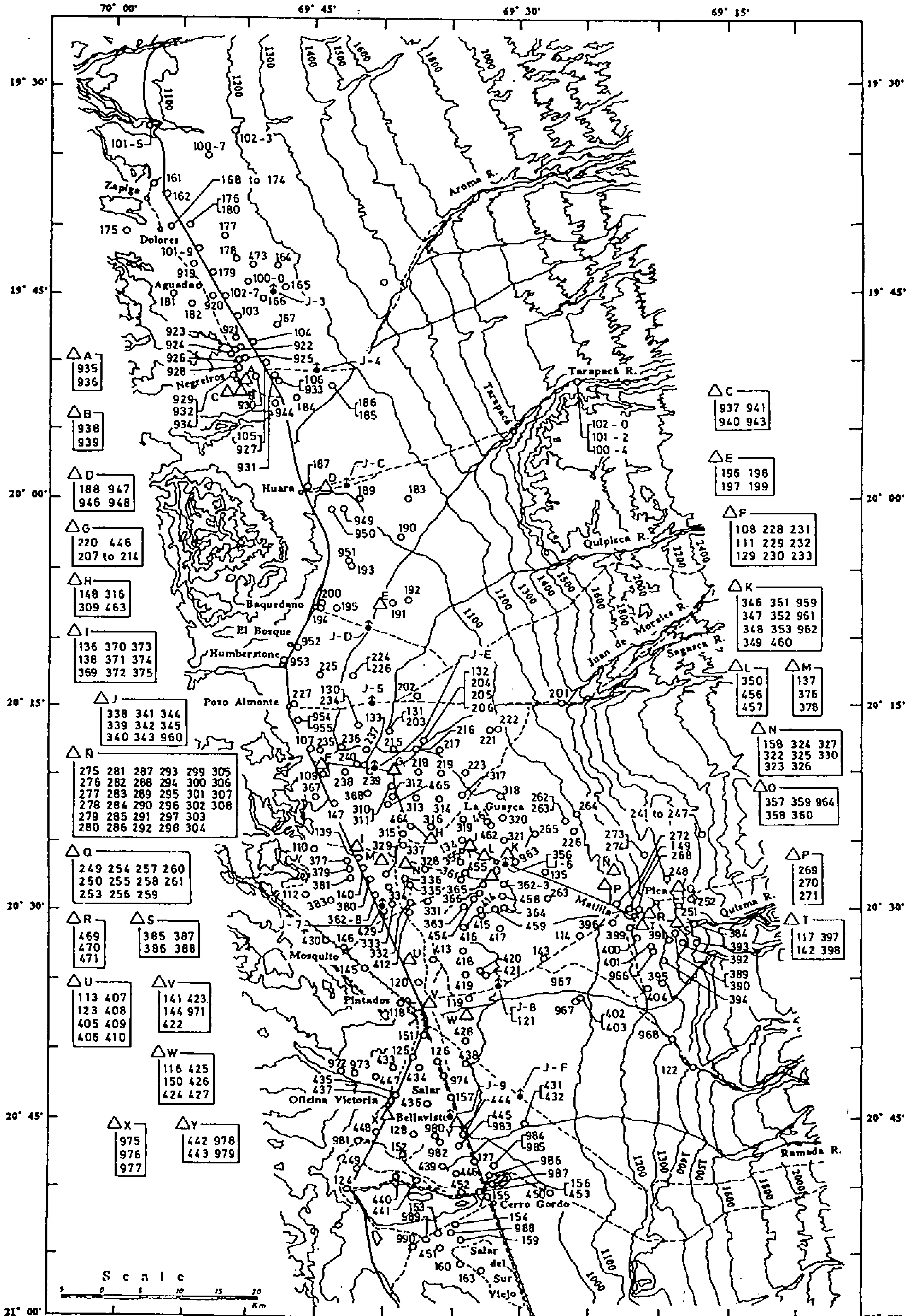


Fig. B-III. 2.1.1 (1) Well Location (Pampa del Tamarugal)

< Ubicación de Sondajes (Pampa del Tamarugal)>

THE STUDY ON THE DEVELOPMENT OF WATER RESOURCES IN NORTHERN CHILE	JICA

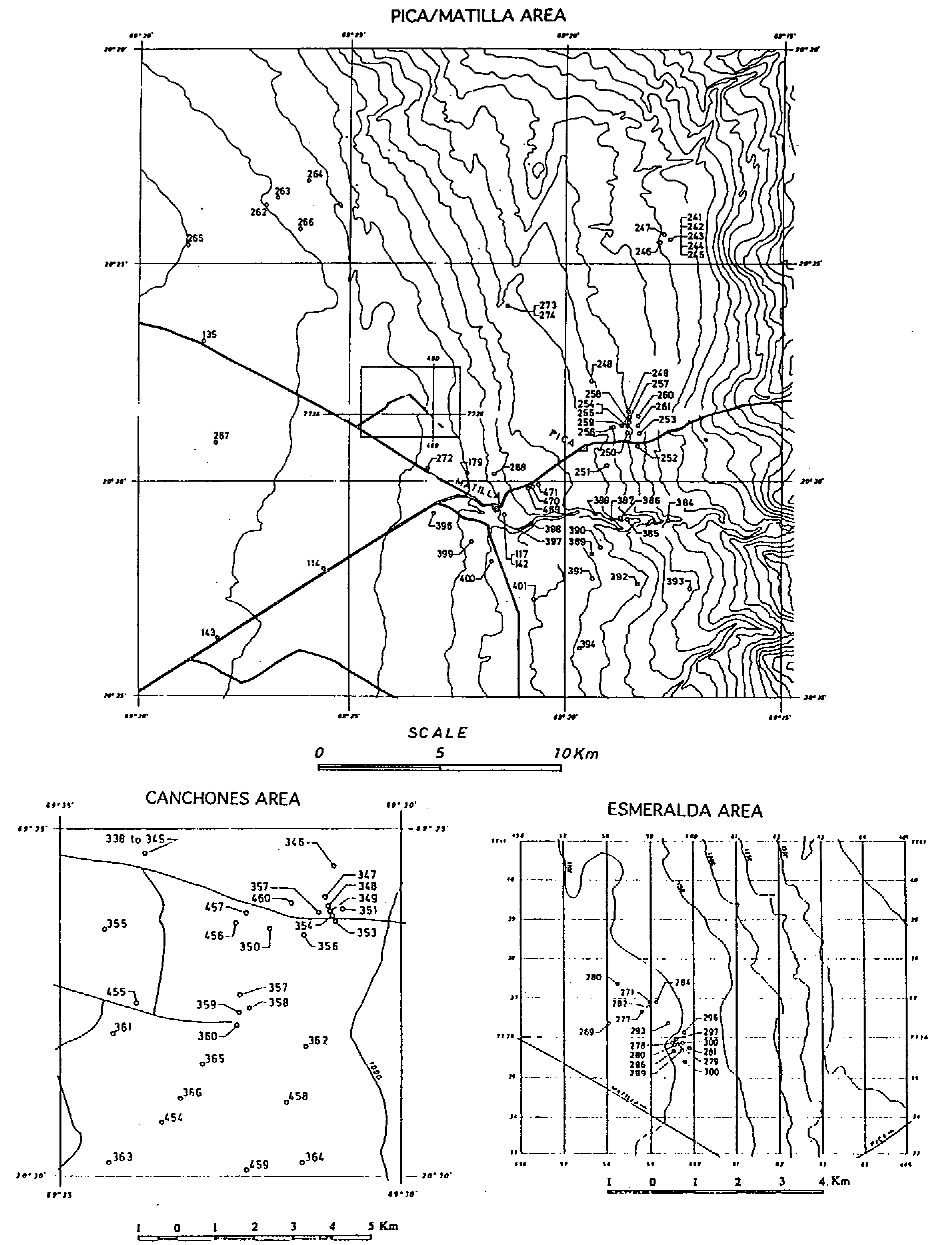
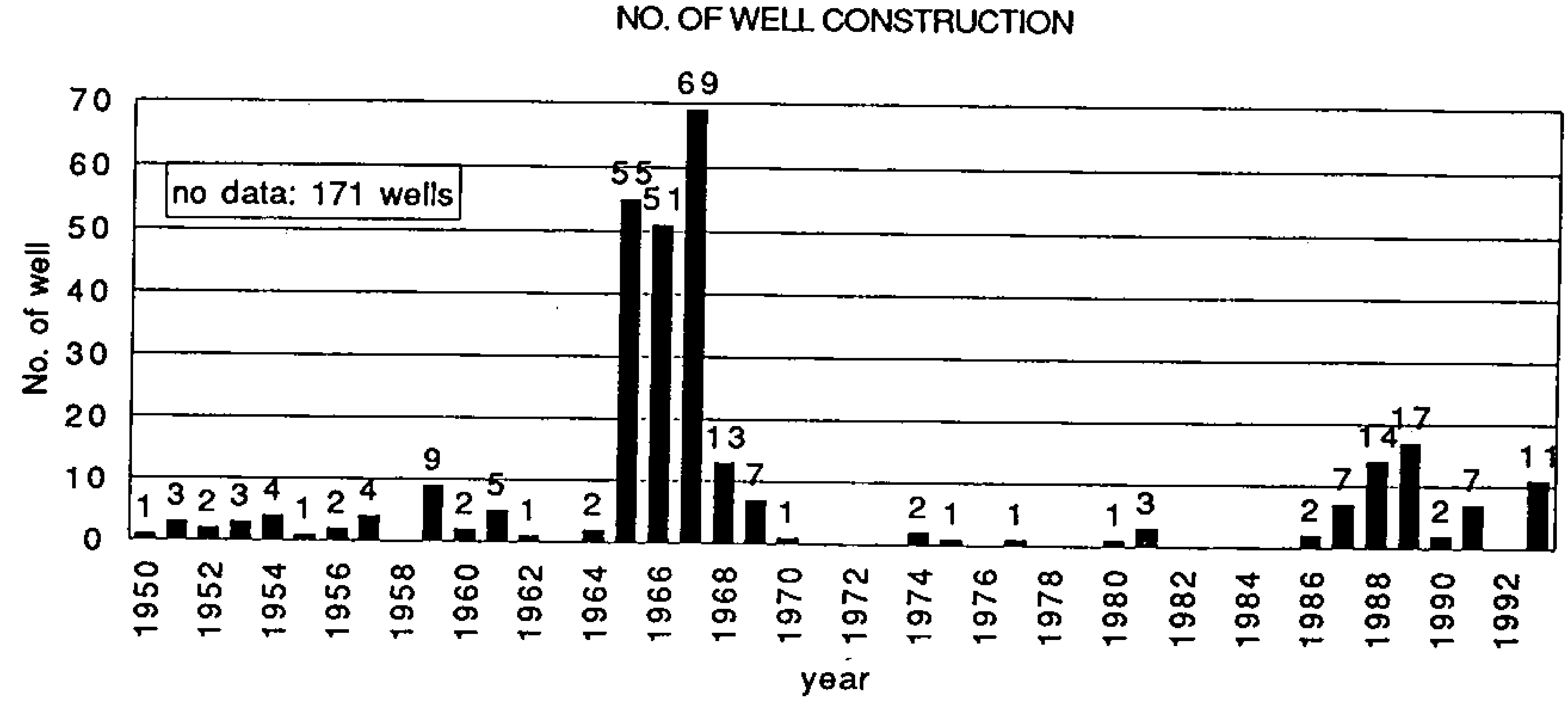


Fig. B-III. 2.1.1 (2) Well Location (Canchones and Pica Area)

< Ubicación de Sondajes (Area de Canchones y Pica)>



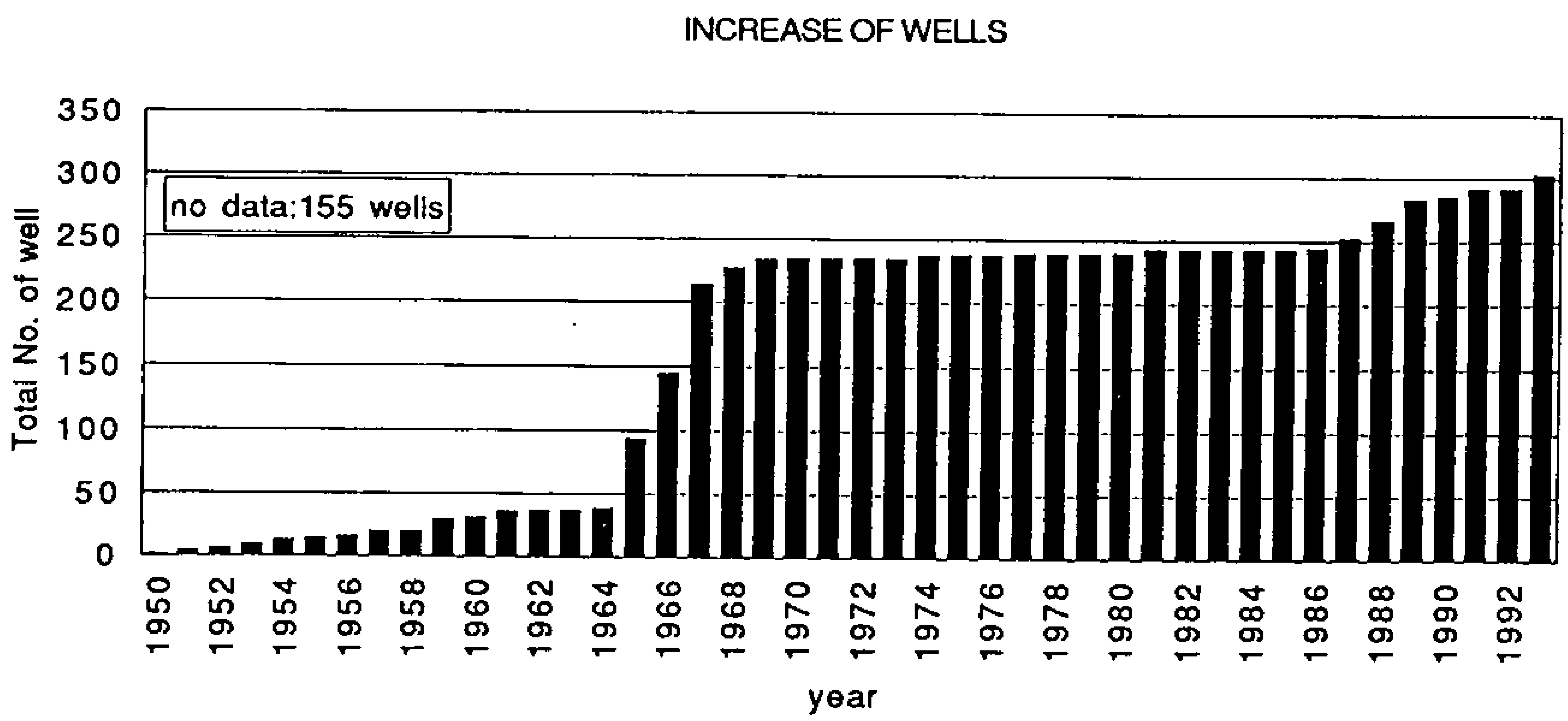


Fig. B-III. 2.1.2 Well Construction (Pampa del Tamarugal)

< Construcción de Sondajes (Pampa del Tamarugal)>

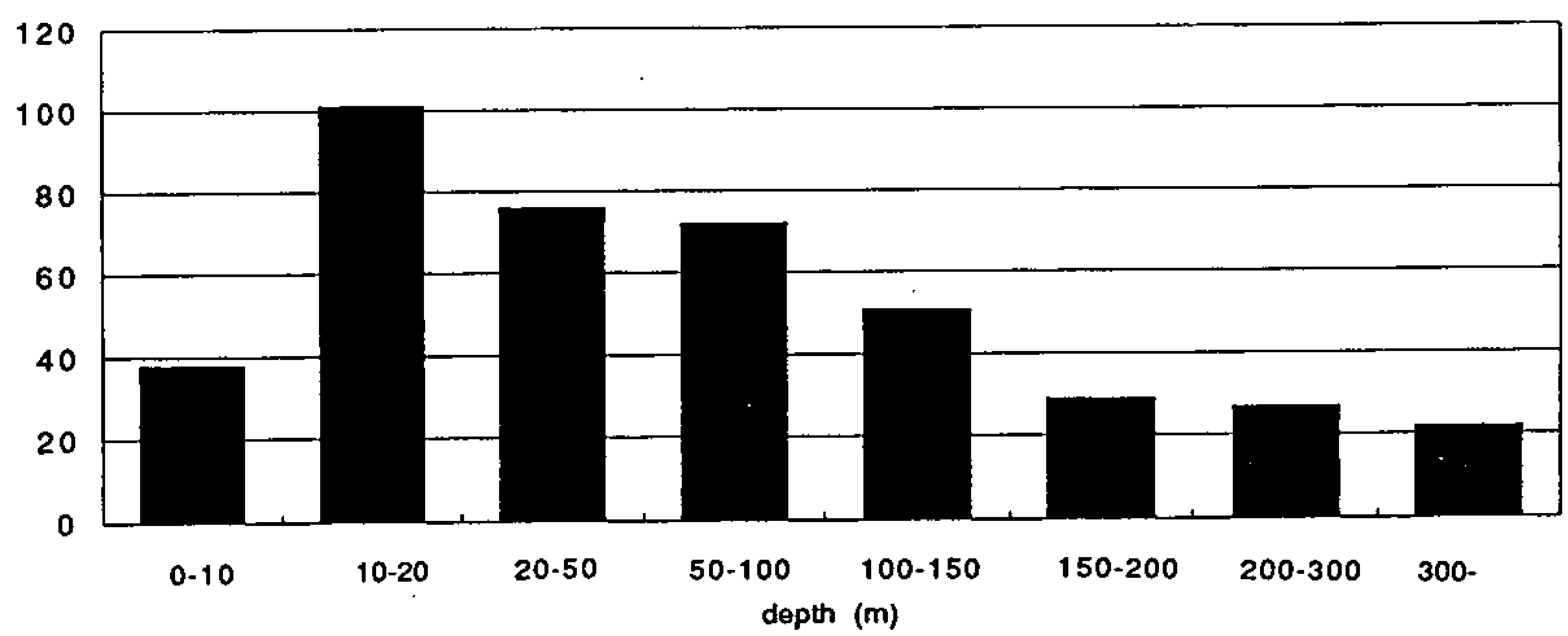


Fig. B-III, 2.1.3 Depth of Well (Pampa del Tamarugal)

<Profundidad de Pozos (Pampa del Tamarugal)>

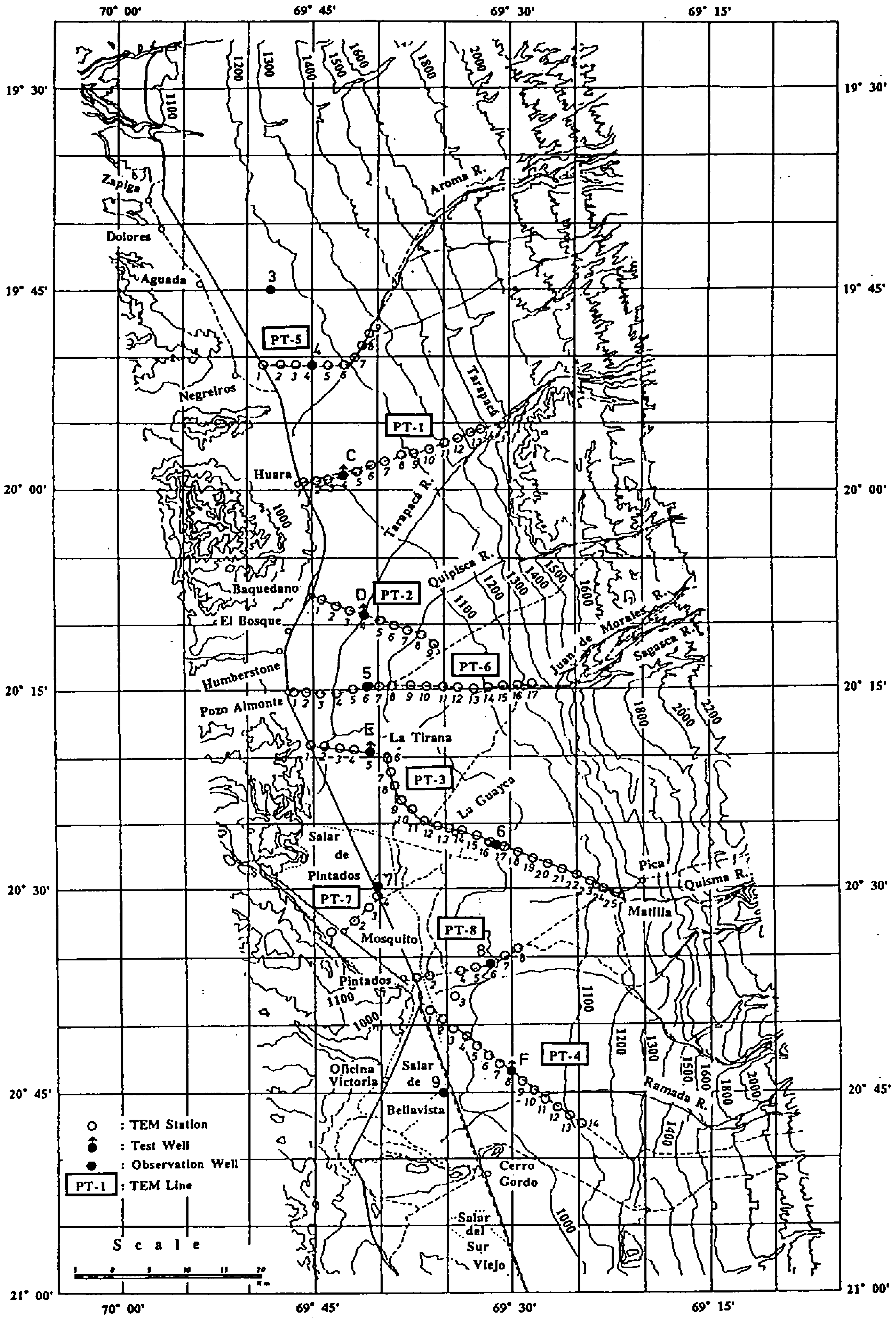


Fig. B-III,2.3.1 Location of TEM Station and Test/Observation Well in Pampa del Tamarugal Area

< Ubicación de las Estaciones TEM y pozos de Prueba y Observación en el Area de la Pampa del Tamarugal >

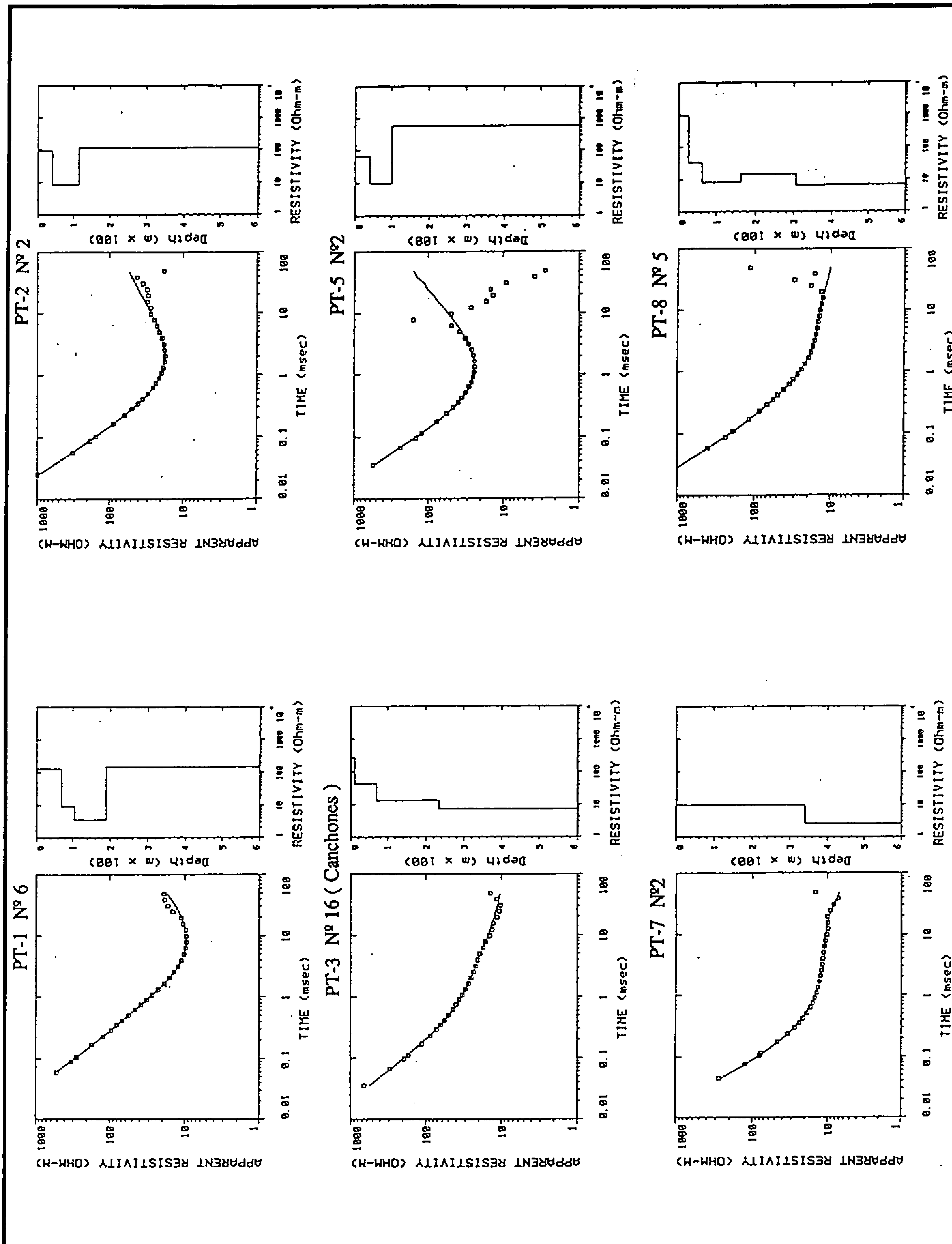


Fig. B-III, 2.3.2 Measured Apparent Resistivity Curves and Inverted Geoelectrical Section in Pampa del Tamarugal Area

< *Curvas de Resistividad Aparente Medidas y Secciones Geoeléctricas Invertidas en el Area de la Pampa del Tamarugal* >

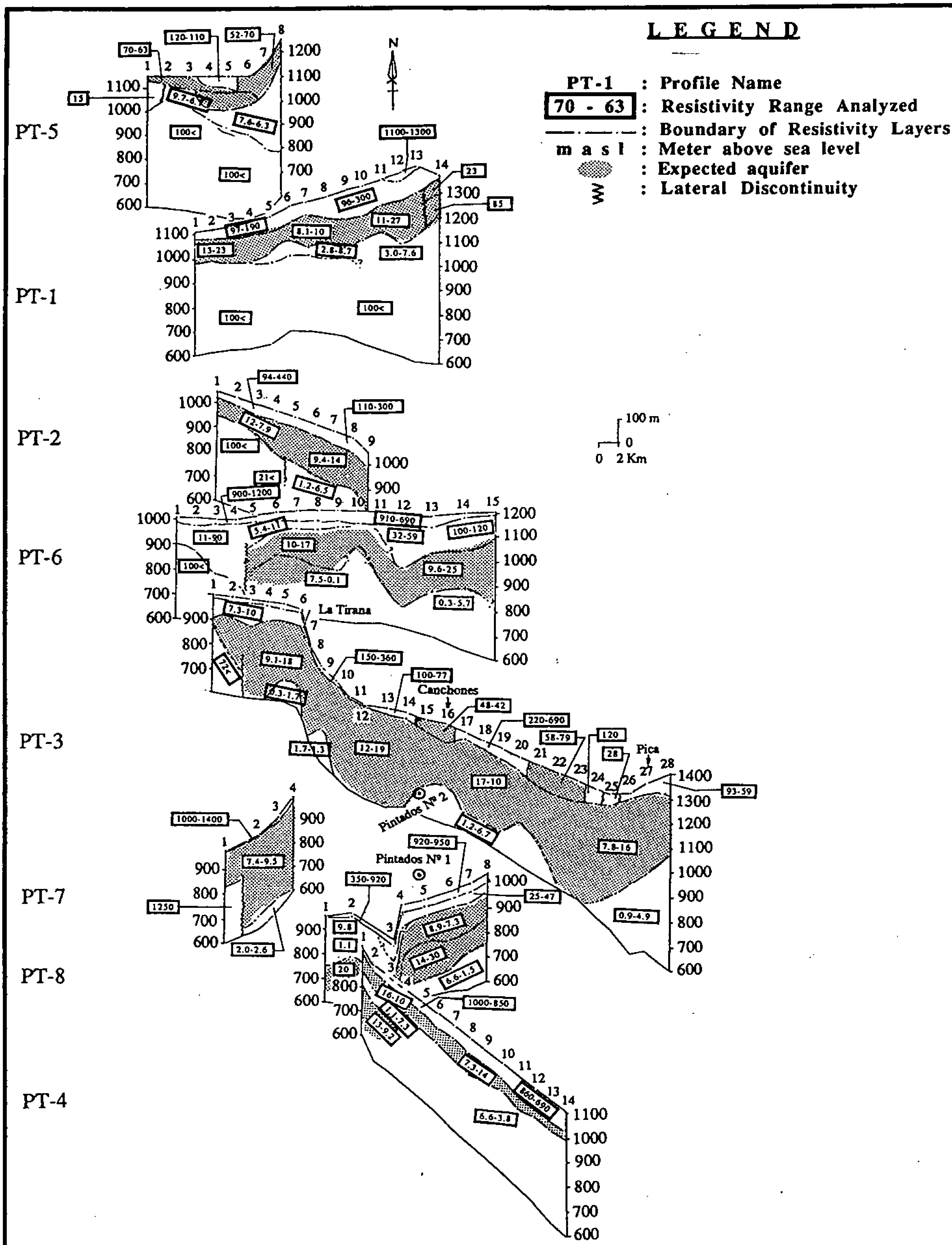


Fig. B-III, 2.3.3 Geoelectric Profiles Contructed from all TEM Soundings in Pampa del Tamarugal Area

< Perfiles Geoeléctricos Construídos de todos los Sondeos TEM del Area de la Pampa del Tamarugal >

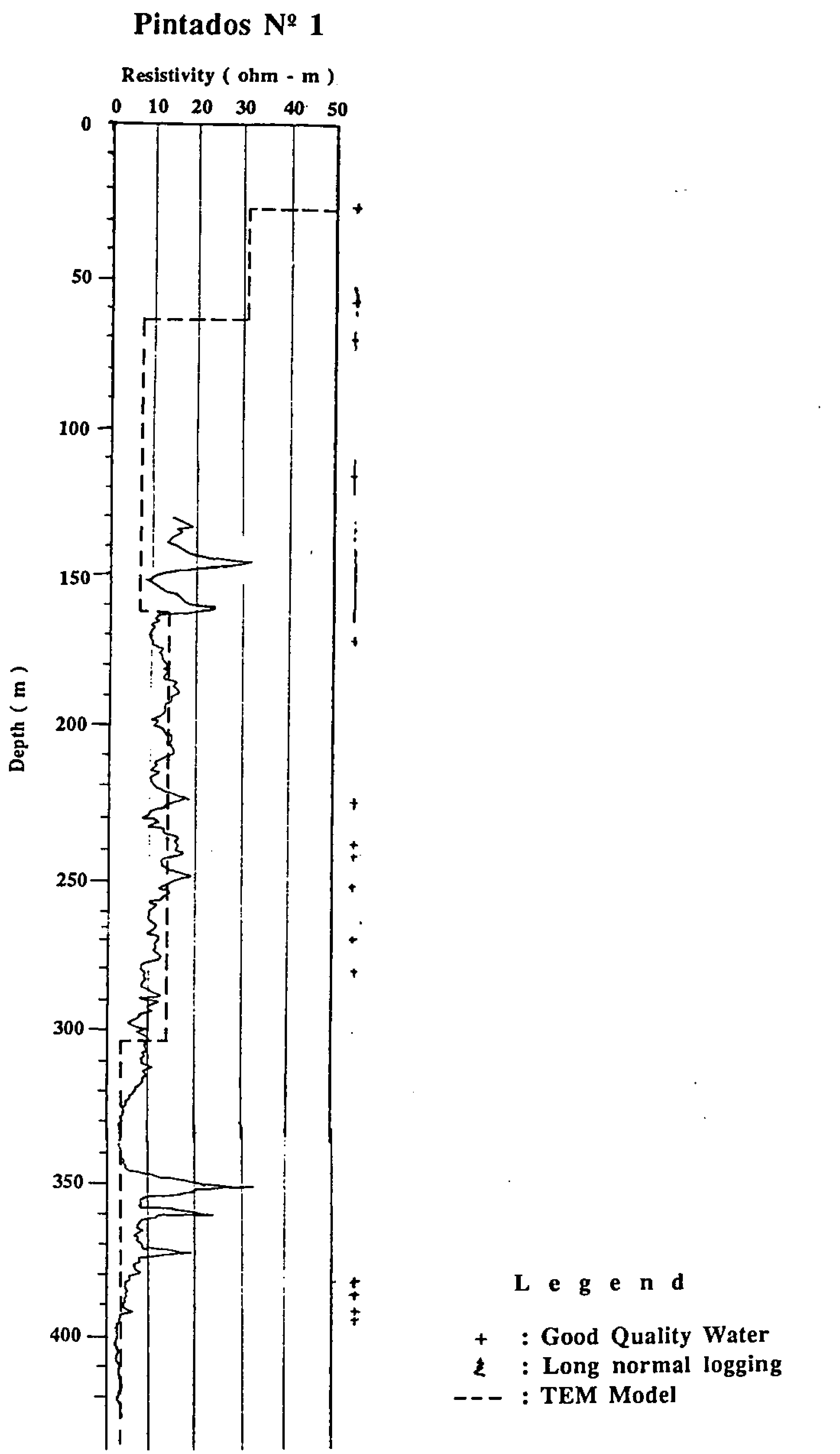


Fig. B-III, 2.3.4 Comparison of Geoelectric Section Derived from Well and TEM Sounding

< Comparación de la Sección Geoeléctrica derivada de Sondeo de Pozo y Sondeo TEM >

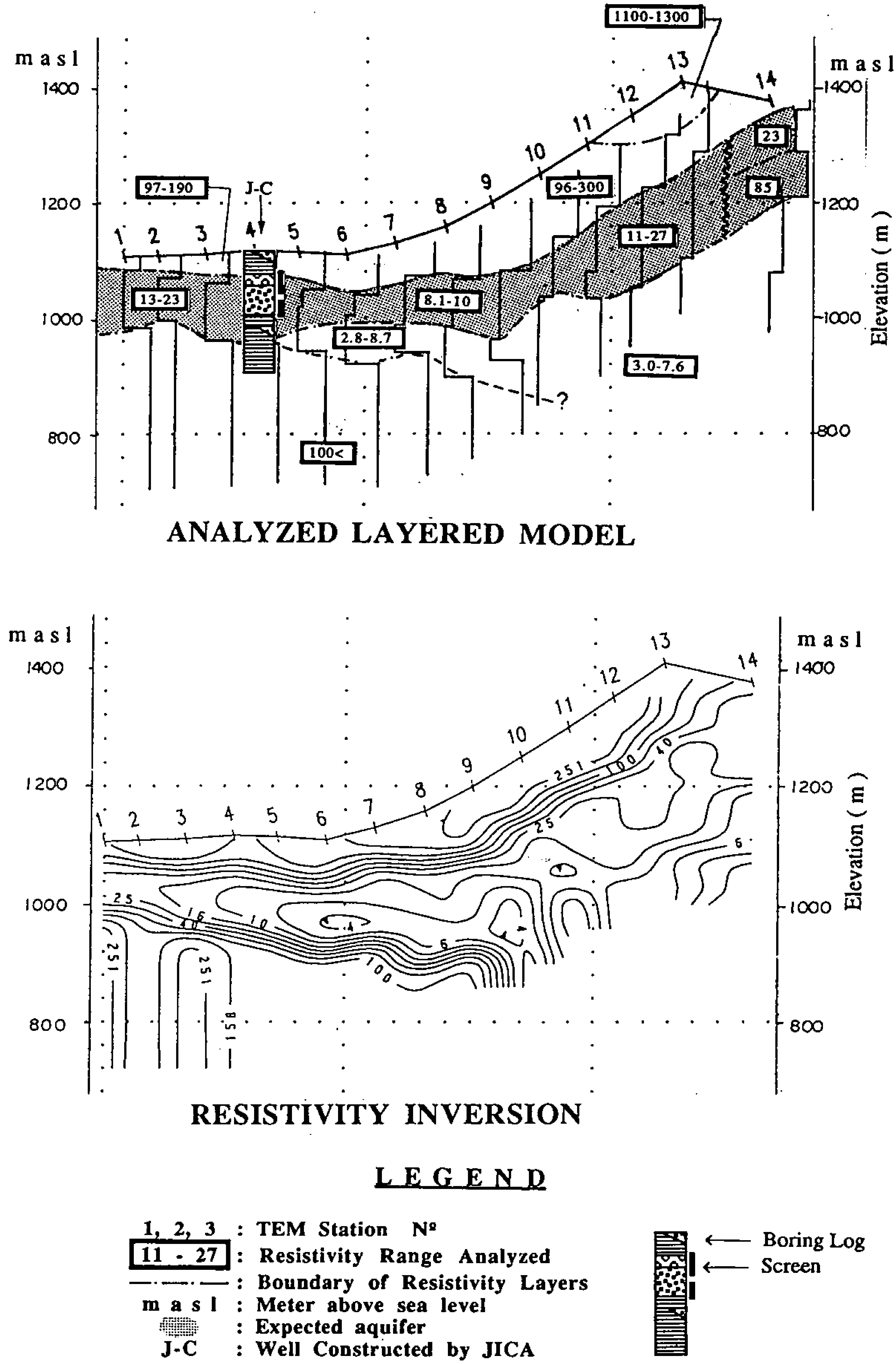
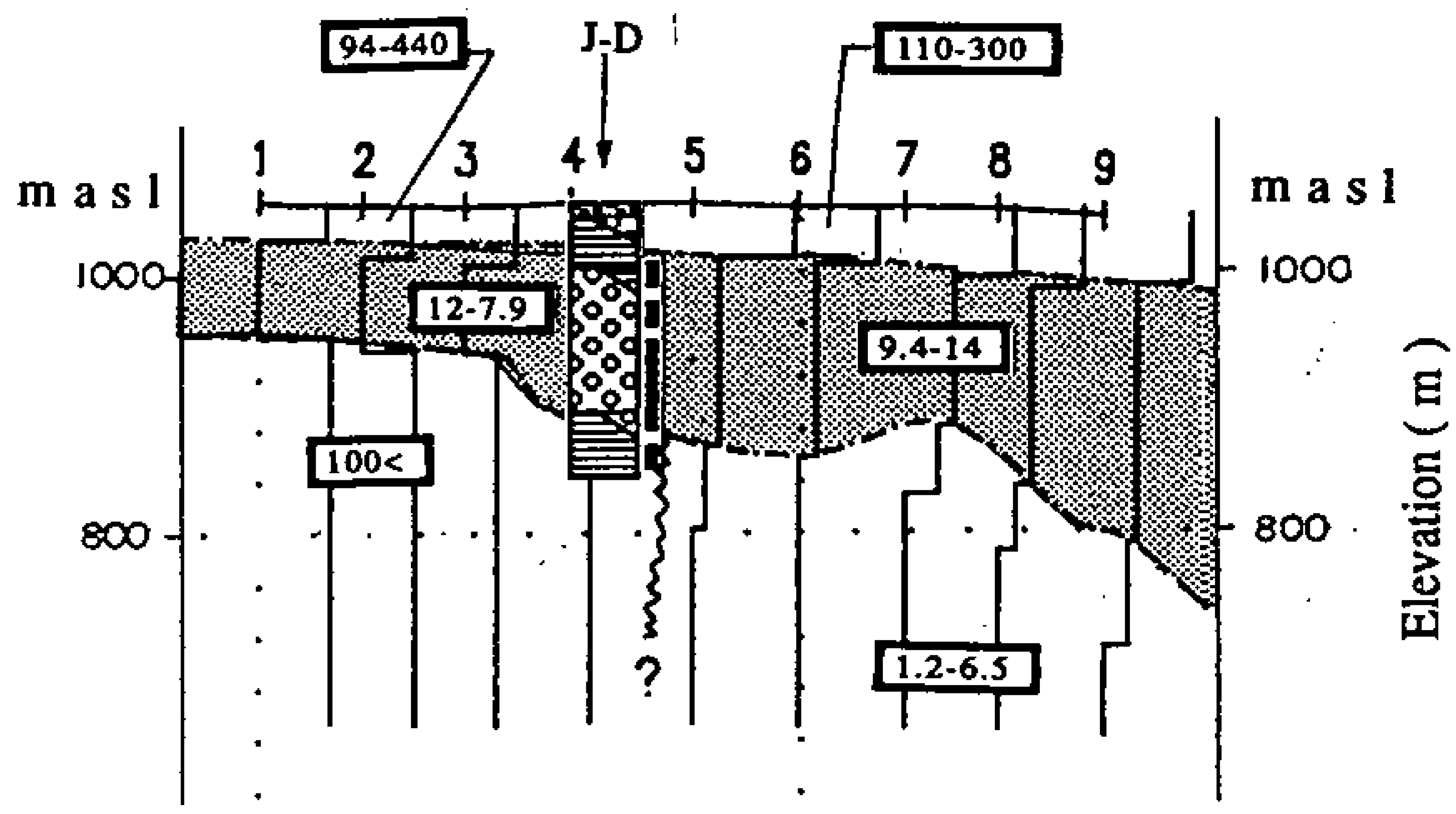
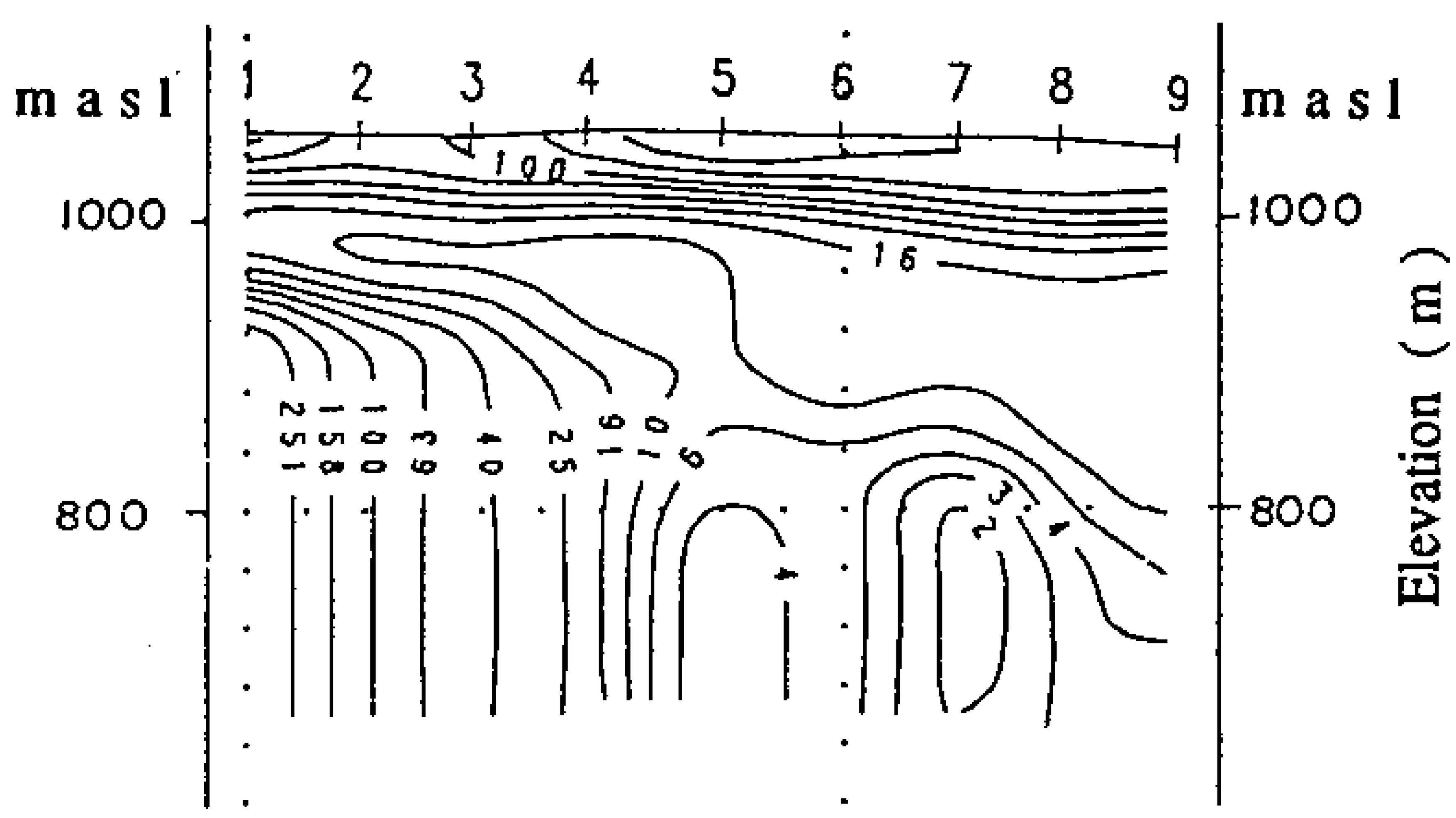


Fig. B-III, 2.3.5 Analyzed Resistivity Profile of PT-1 in Pampa del Tamarugal Area

< Perfil de Resistividad Analizado del PT-1 en el Area de la Pampa del Tamarugal >



ANALYZED LAYERED MODEL



RESISTIVITY INVERSION

LEGEND

1, 2, 3 : TEM Station Nº
12 - 9.9 : Resistivity Range Analyzed
—·—·— : Boundary of Resistivity Layers
m a s l : Meter above sea level
: Expected aquifer
J-D : Well Constructed by JICA
: Lateral Discontinuity

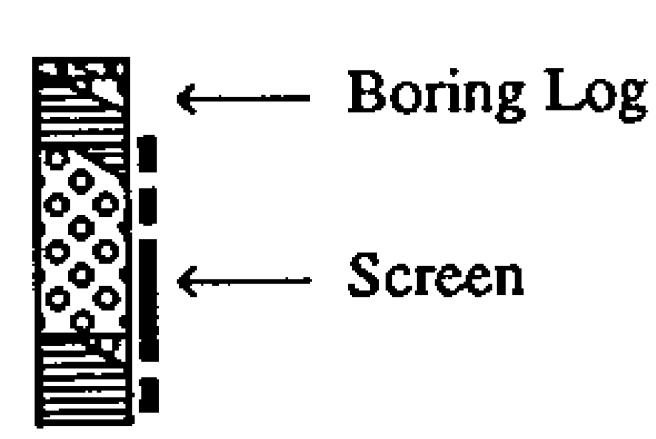


Fig. B-III,2.3.6 Analyzed Resistivity Profile of PT-2 in Pampa del Tamarugal Area

< Perfil de Resistividad Analizado del PT-2 en el Area de la Pampa del Tamarugal >

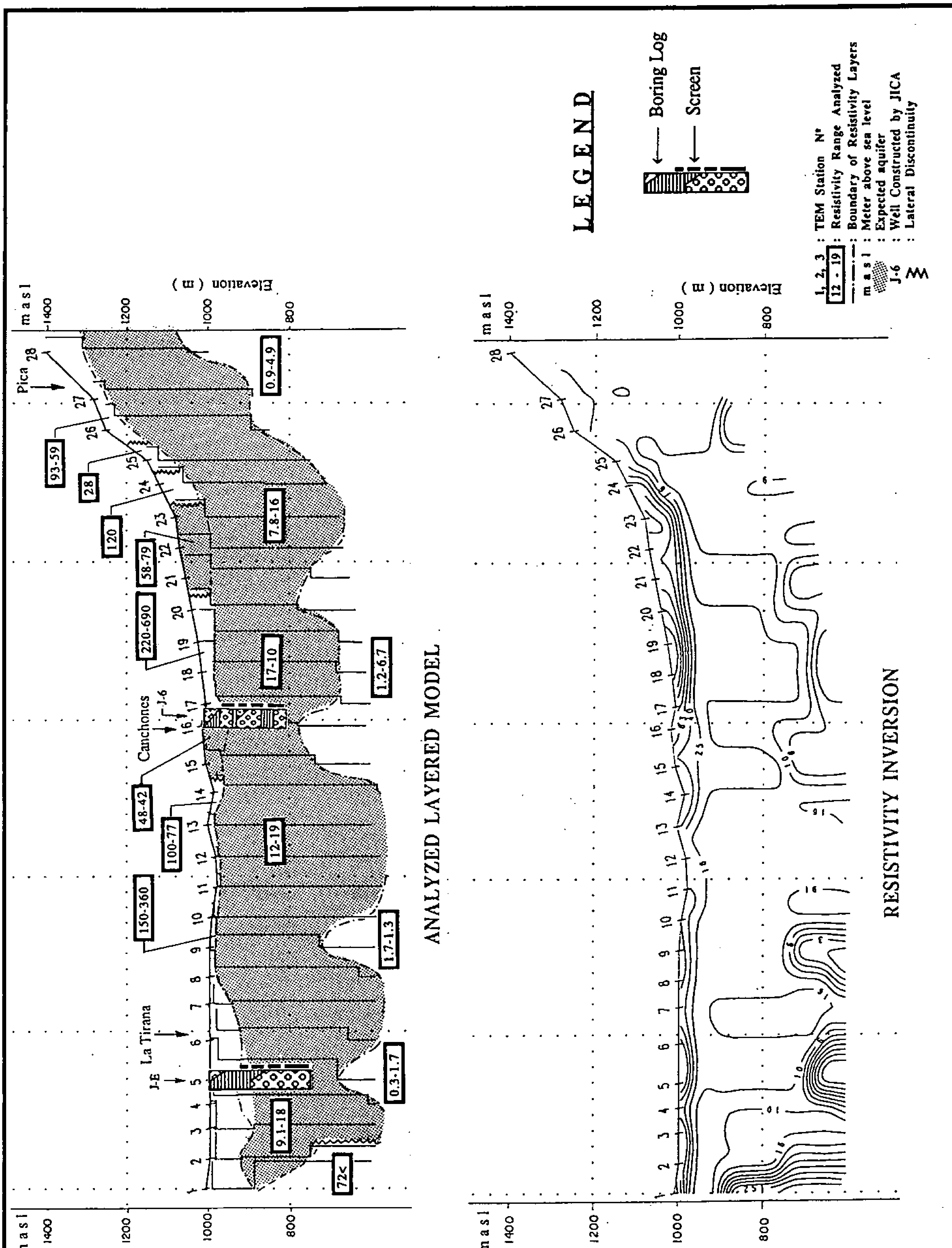


Fig. B-III, 2.3.7 Analyzed Resistivity Profile of PT-3 in Pampa del Tamarugal Area

< Perfil de Resistividad Analizado del PT-3 en el Area de la Pampa del Tamarugal >

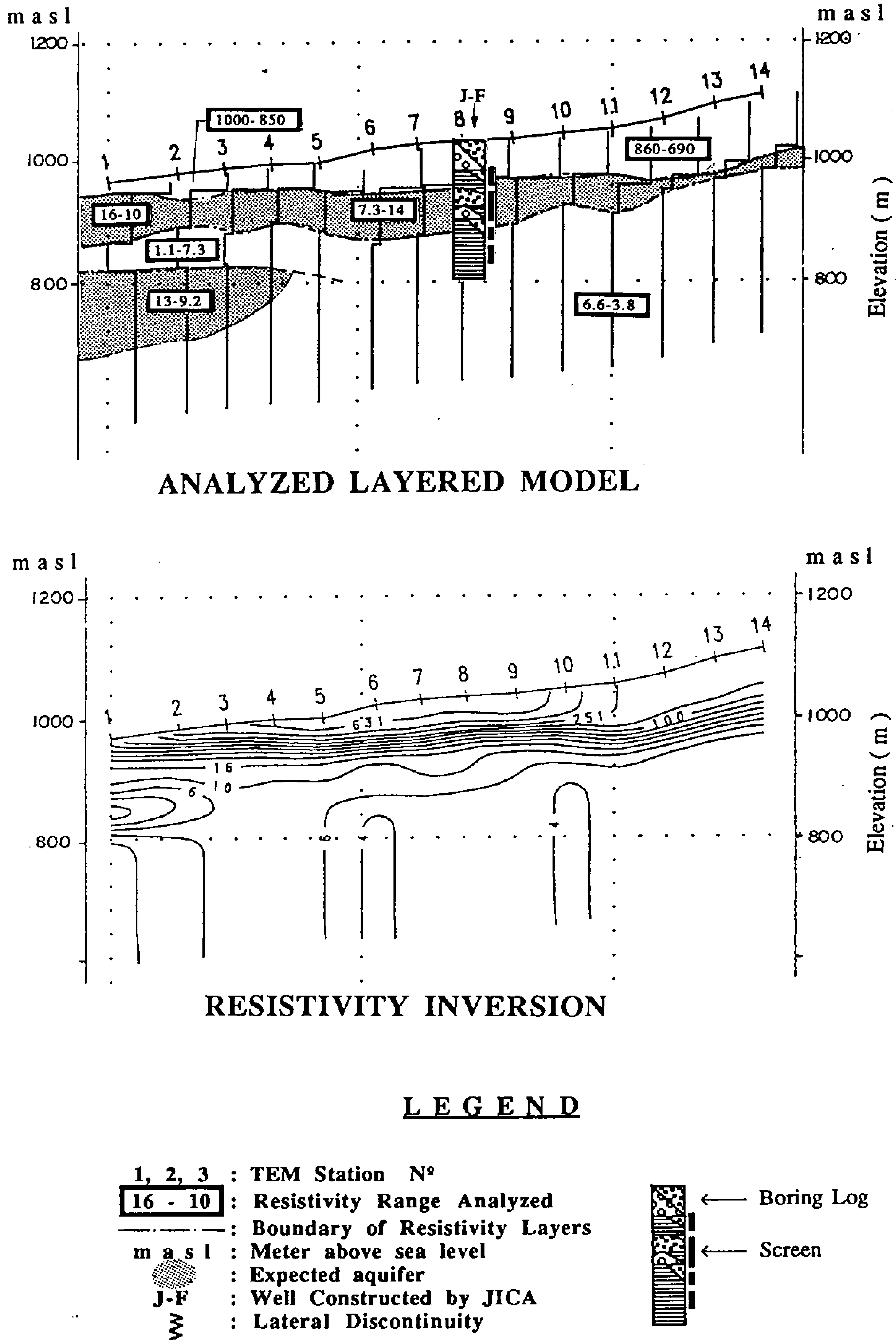
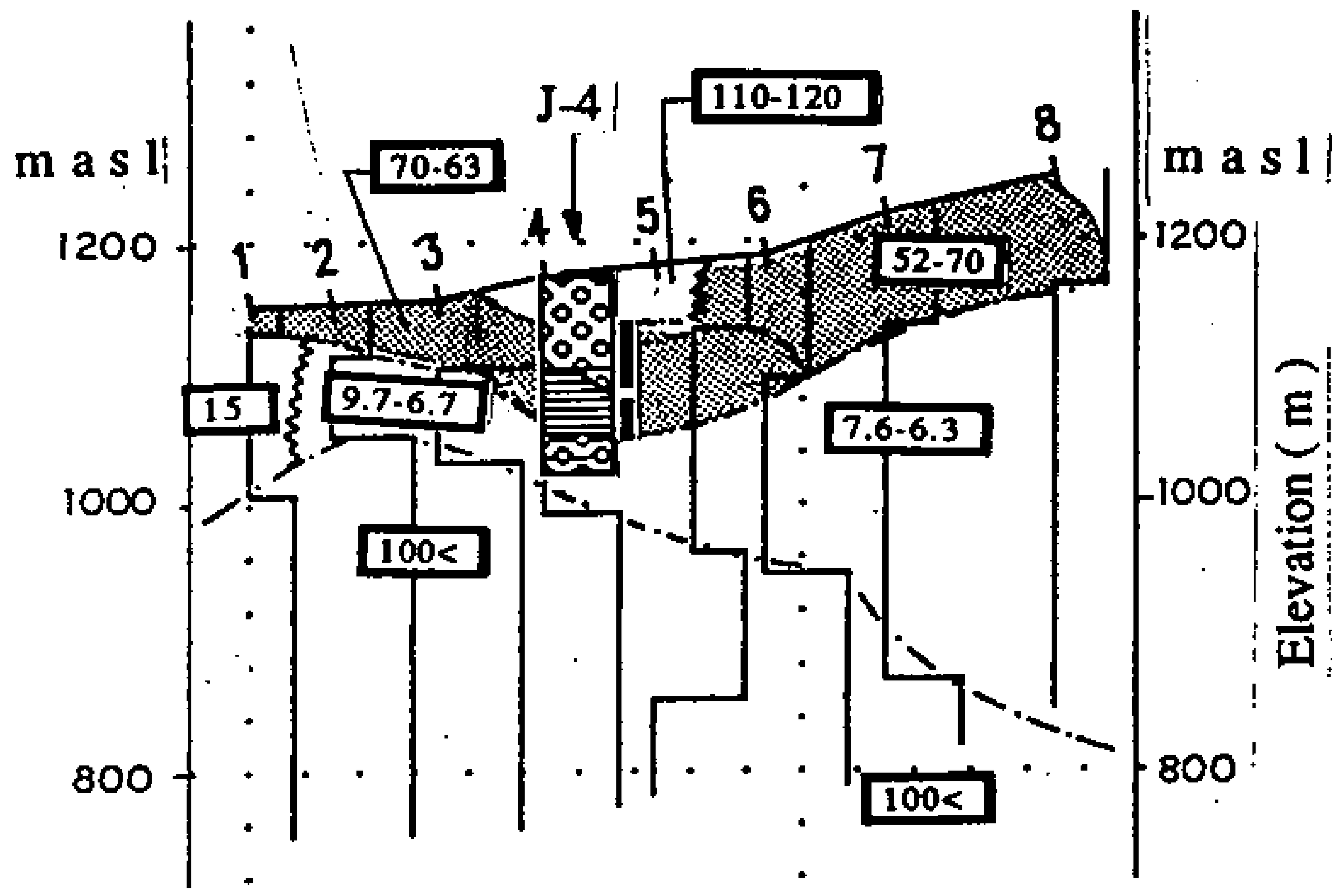
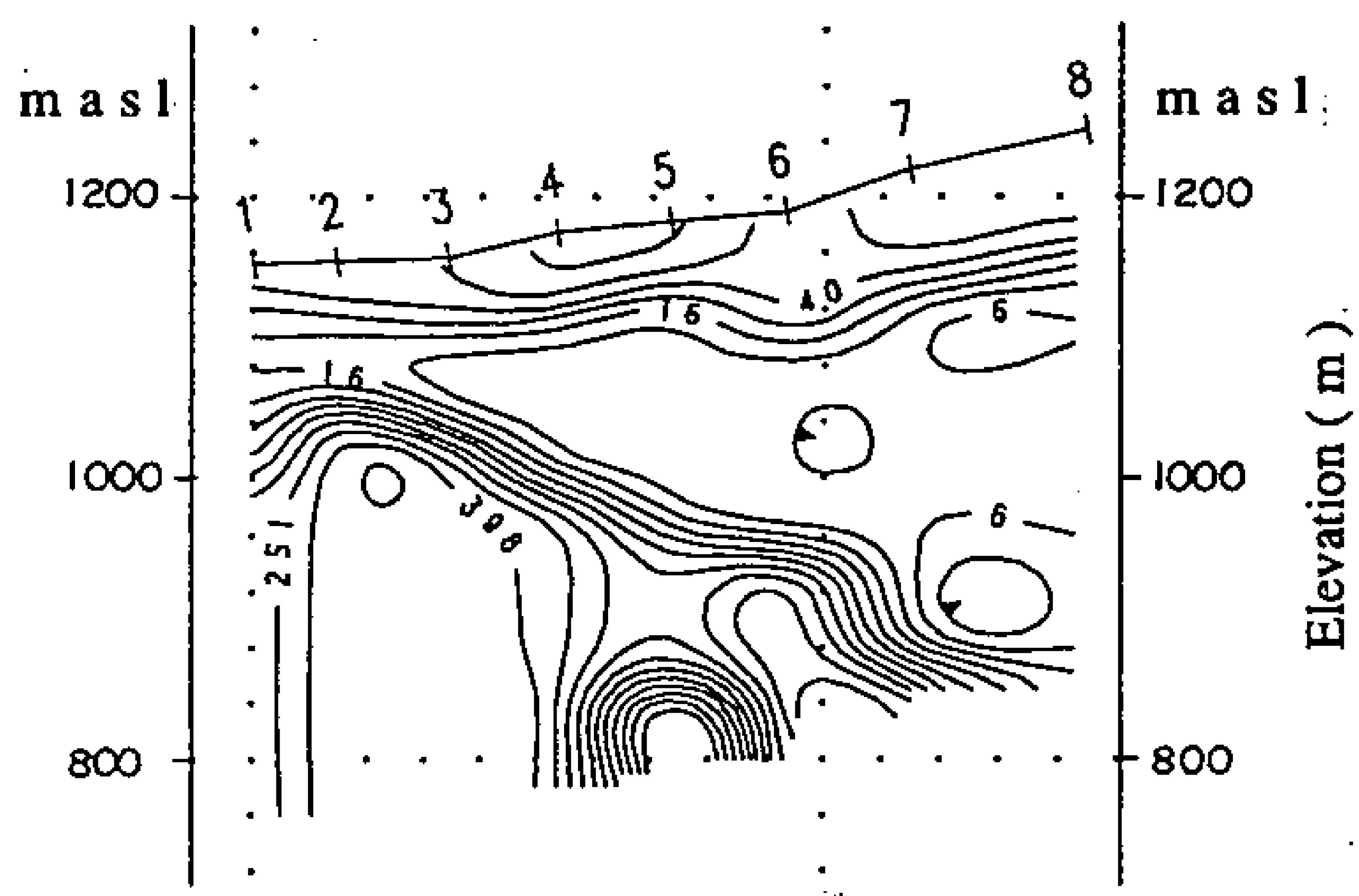


Fig. B-III,2.3.8 Analyzed Resistivity Profile of PT-4 in Pampa del Tamarugal Area

< Perfil de Resistividad Analizado del PT-4 en el Area de la Pampa del Tamarugal >



ANALYZED LAYERED MODEL



RESISTIVITY INVERSION

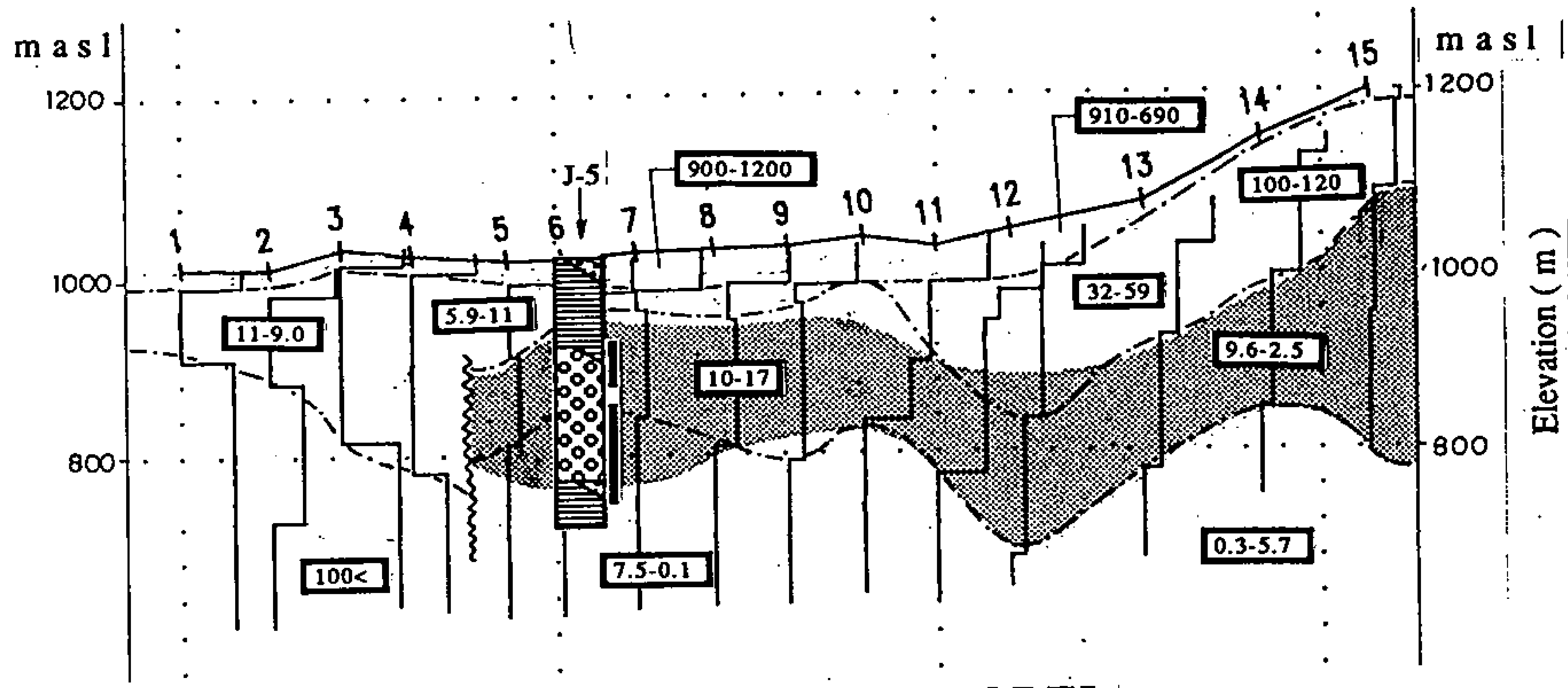
<u>L E G E N D</u>

1, 2, 3 : TEM Station Nº
90 - 63 : Resistivity Range Analyzed
—·—·— : Boundary of Resistivity Layers
m a s l : Meter above sea level
: Expected aquifer
J-4 : Well Constructed by JICA
: Lateral Discontinuity

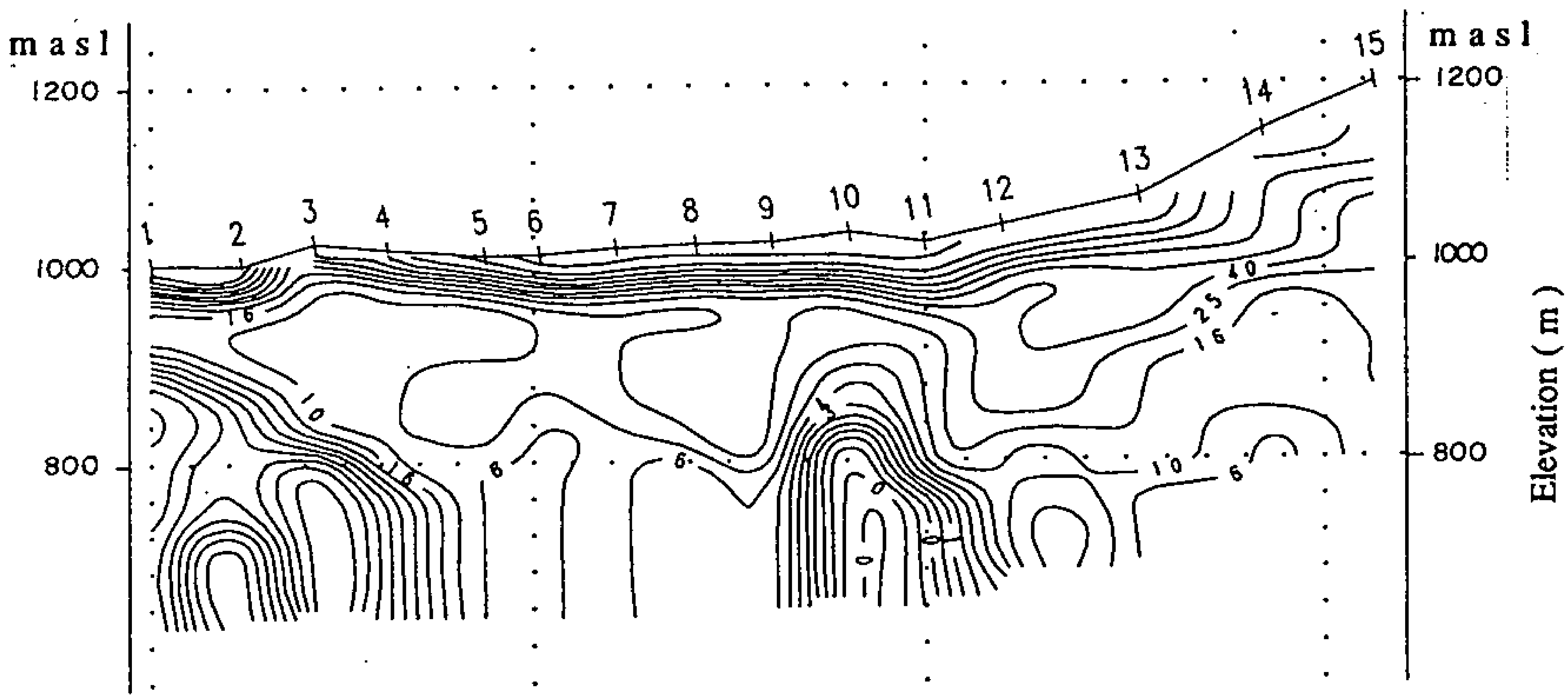
← Boring Log
← Screen

Fig. B-III, 2.3.9 Analyzed Resistivity Profile of PT-5 in Pampa del Tamarugal Area

< Perfil de Resistividad Analizado del PT-5 en el Area de la Pampa del Tamarugal >



ANALYZED LAYERED MODEL



RESISTIVITY INVERSION

LEGEND

1, 2, 3 : TEM Station Nº

10 - 17 : Resistivity Range Analyzed

—·—·— : Boundary of Resistivity Layers

m a s l : Meter above sea level

: Expected aquifer

J-5 : Well Constructed by JICA

: Lateral Discontinuity

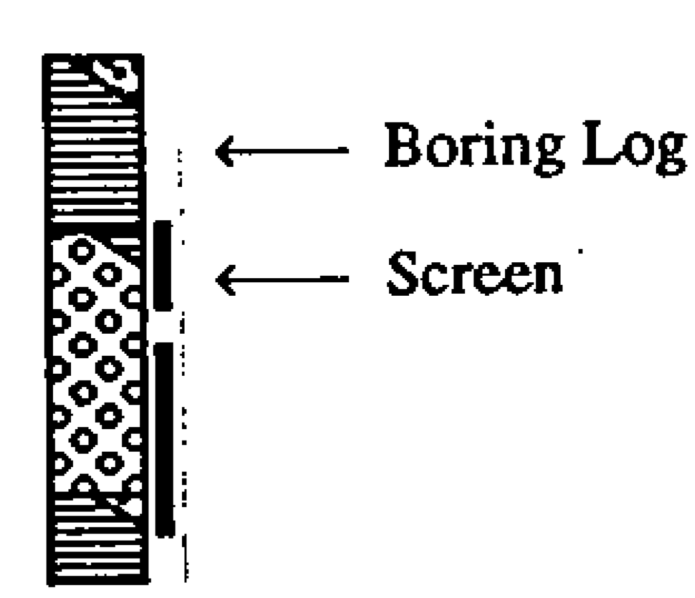
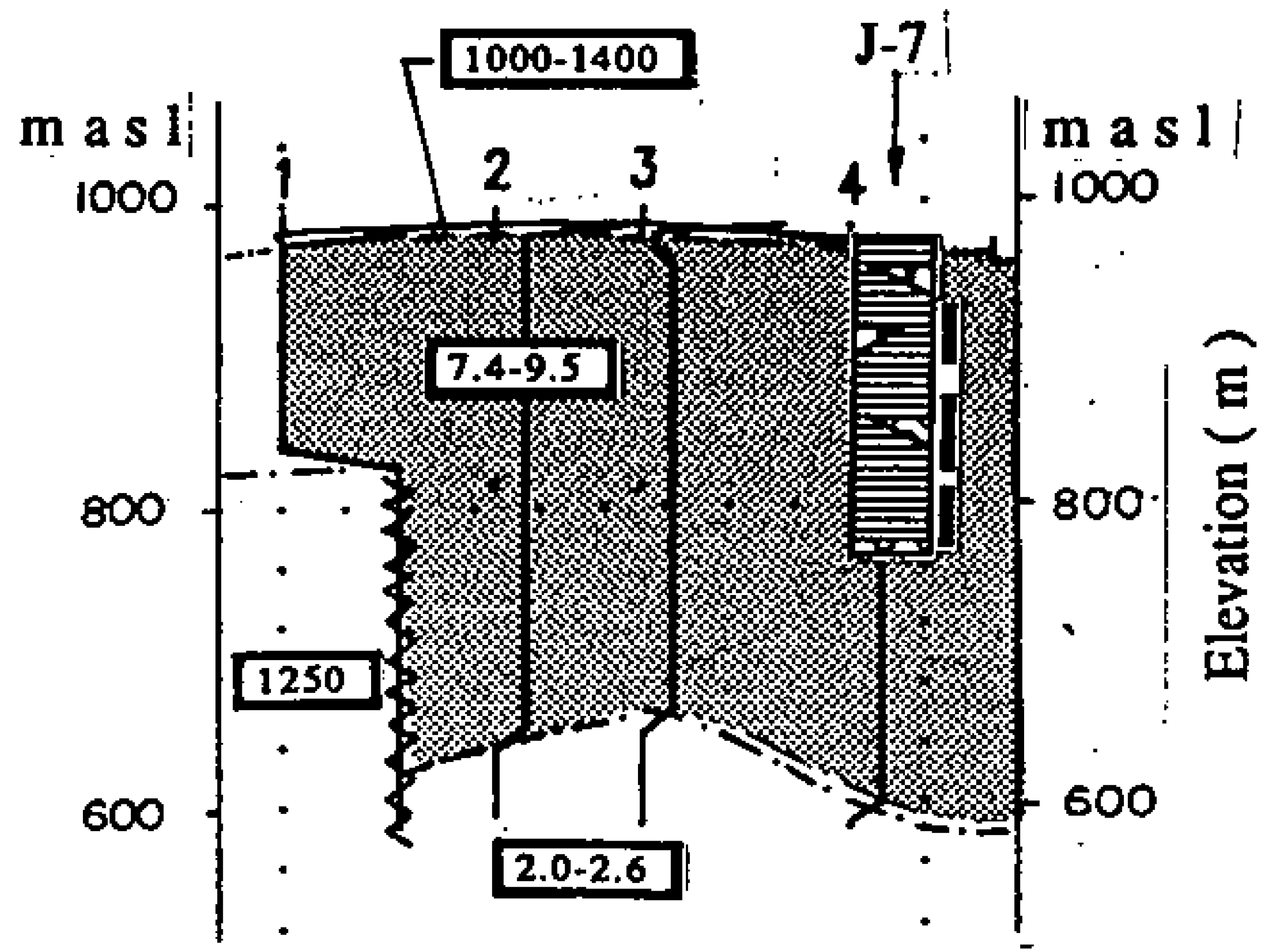
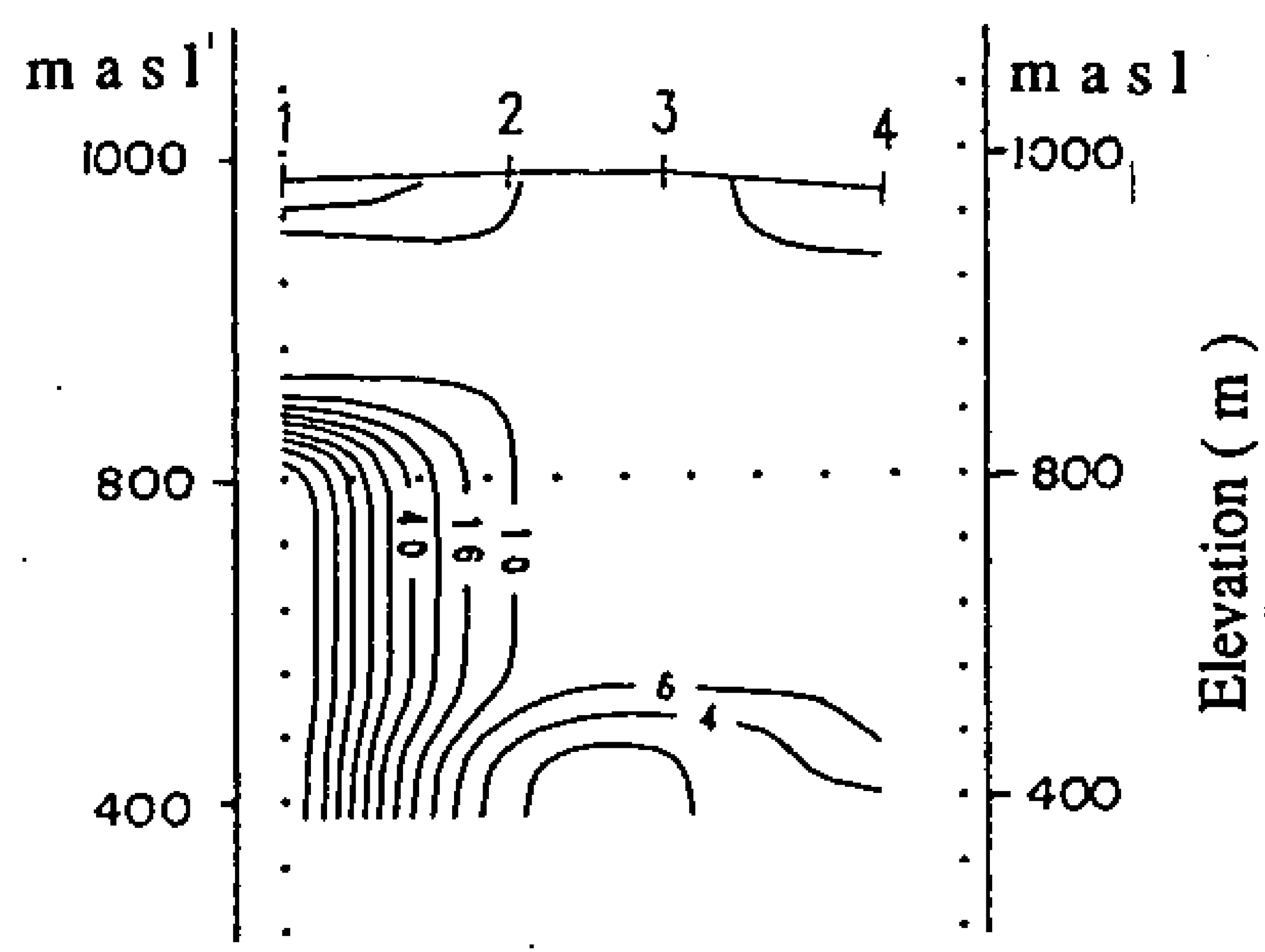


Fig. B-III, 2.3.10 Analyzed Resistivity Profile of PT-6 in Pampa del Tamarugal Area

< Perfil de Resistividad Analizado del PT-6 en el Area de la Pampa del Tamarugal >



ANALYZED LAYERED MODEL



RESISTIVITY INVERSION

LEGEND

1, 2, 3 : TEM Station Nº
7.4 - 9.5 : Resistivity Range Analyzed
—·—·—· : Boundary of Resistivity Layers
m a s l : Meter above sea level
: Expected aquifer
J-7 : Well Constructed by JICA
: Lateral Discontinuity

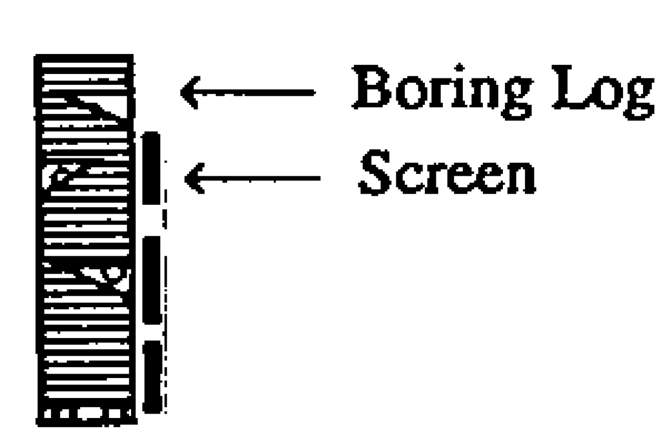
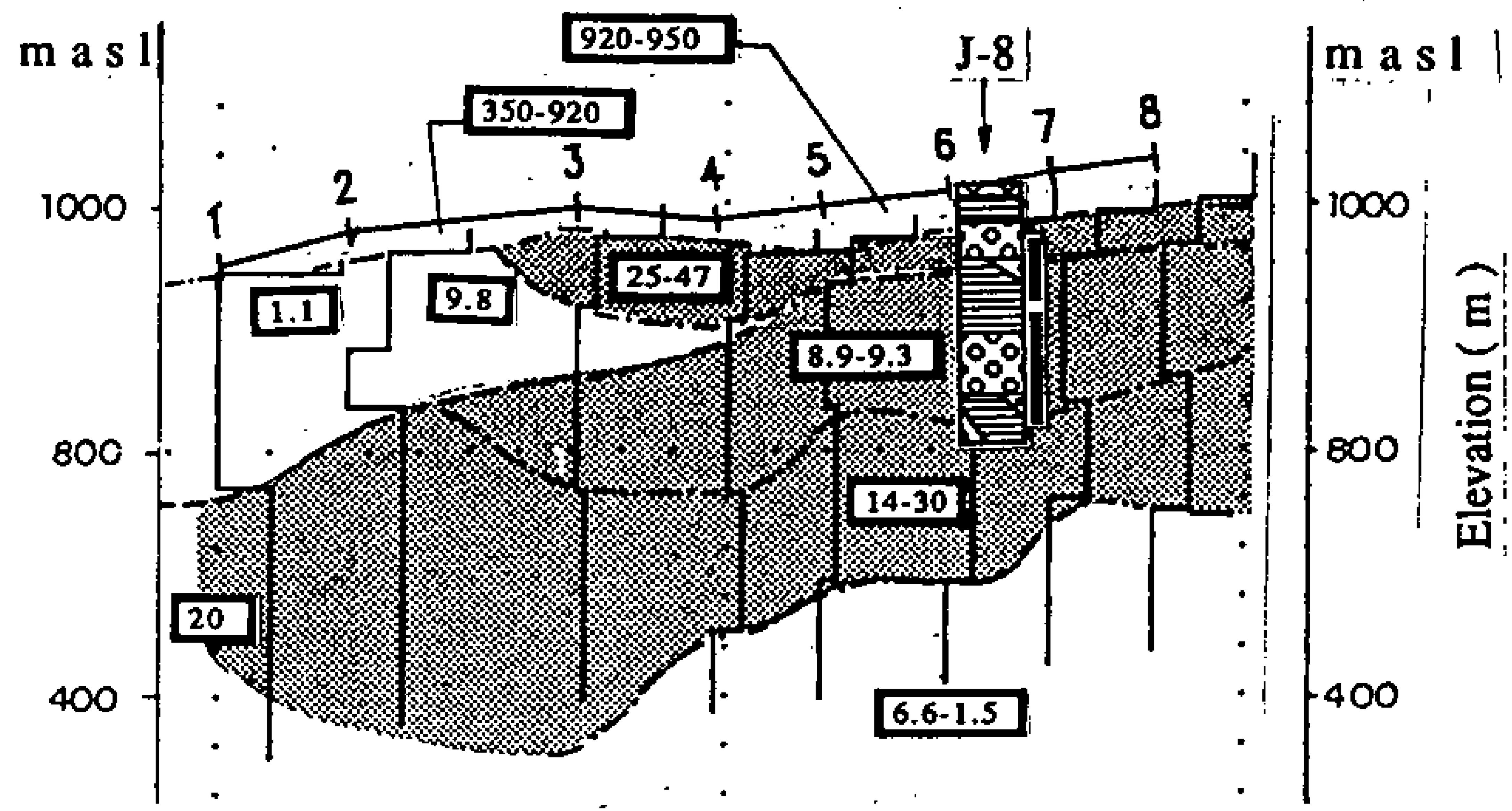
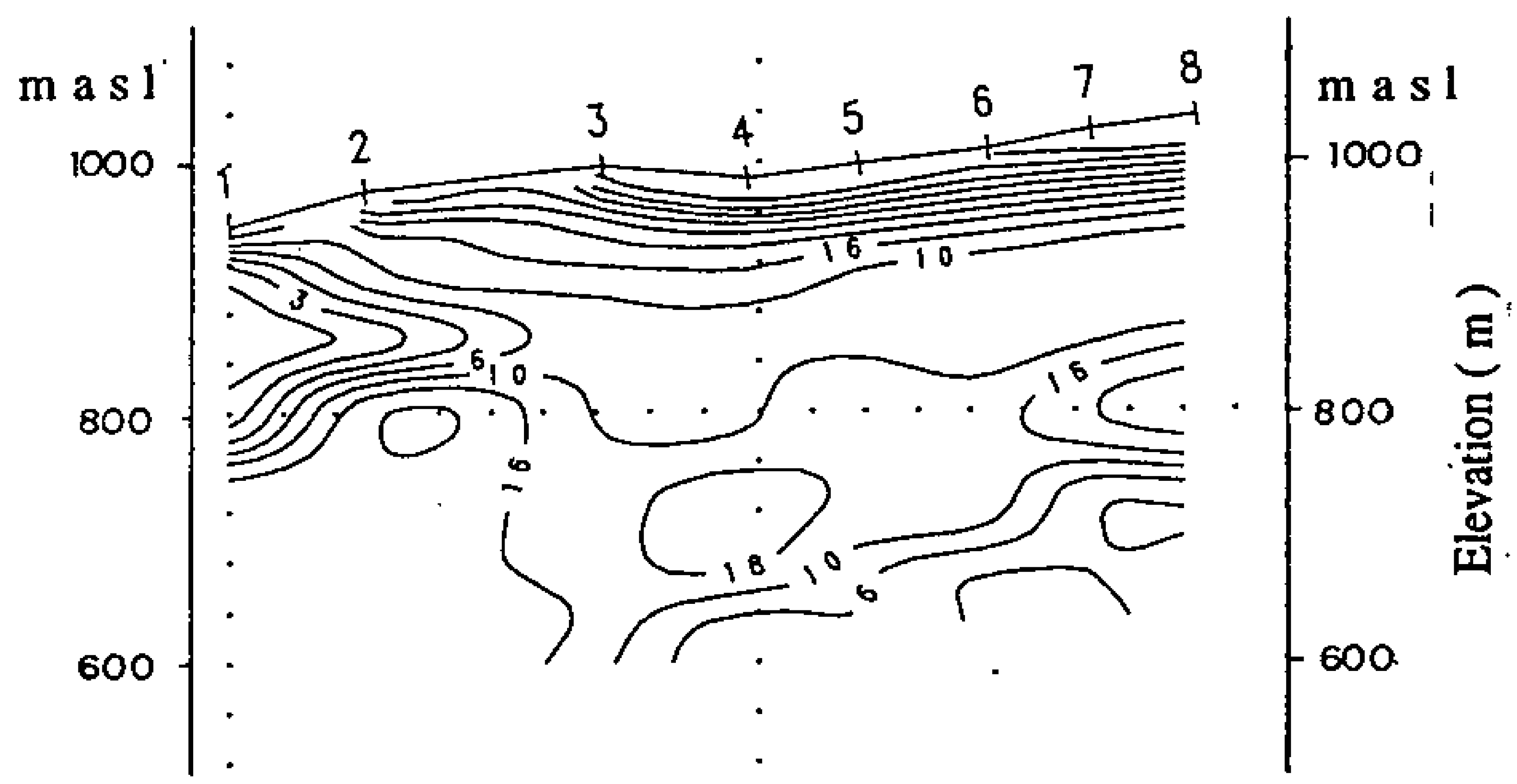


Fig. B-III, 2.3.11 Analyzed Resistivity Profile of PT-7 in Pampa del Tamarugal Area

< Perfil de Resistividad Analizado del PT-7 en el Area de la Pampa del Tamarugal >



ANALYZED LAYERED MODEL



RESISTIVITY INVERSION

LEGEND

1, 2, 3 : TEM Station Nº
8.9-9.3 : Resistivity Range Analyzed
—·—·— : Boundary of Resistivity Layers
m a s l : Meter above sea level
: Expected aquifer
J-8 : Well Constructed by JICA
: Lateral Discontinuity

← Boring Log
← Screen

Fig. B-III, 2.3.12 Analyzed Resistivity Profile of PT-8 in Pampa del Tamarugal Area

< Perfil de Resistividad Analizado del PT-8 en el Area de la Pampa del Tamarugal >

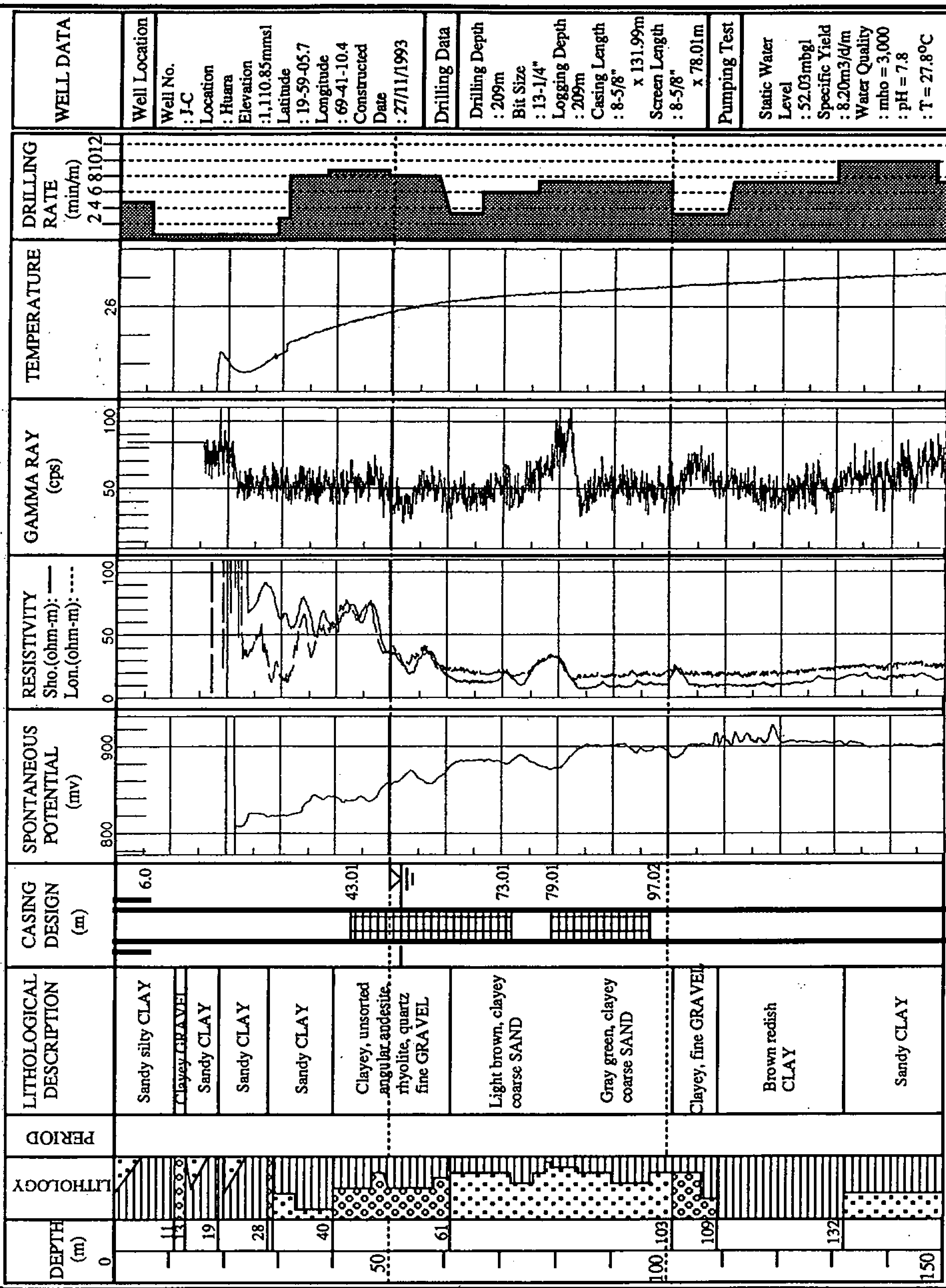


Fig. B-III, 2.3.13 Well Data for J-C (Sheet No. 1)

< Información del Pozo J-C (Hoja Nº 1) >

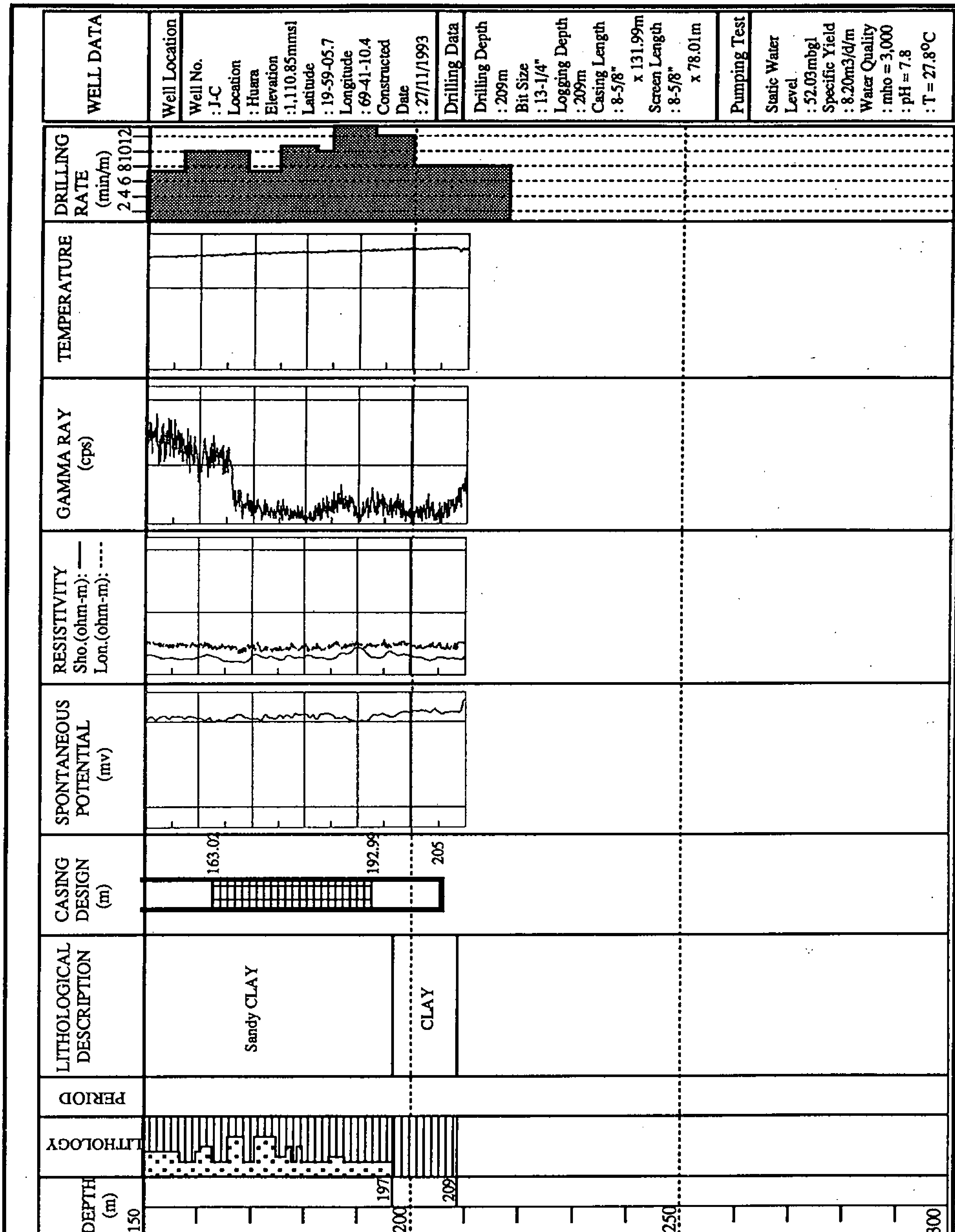


Fig. B-III, 2.3.13 Well Data for J-C (Sheet No. 2)

< Información del Pozo J-C (Hoja Nº 2) >

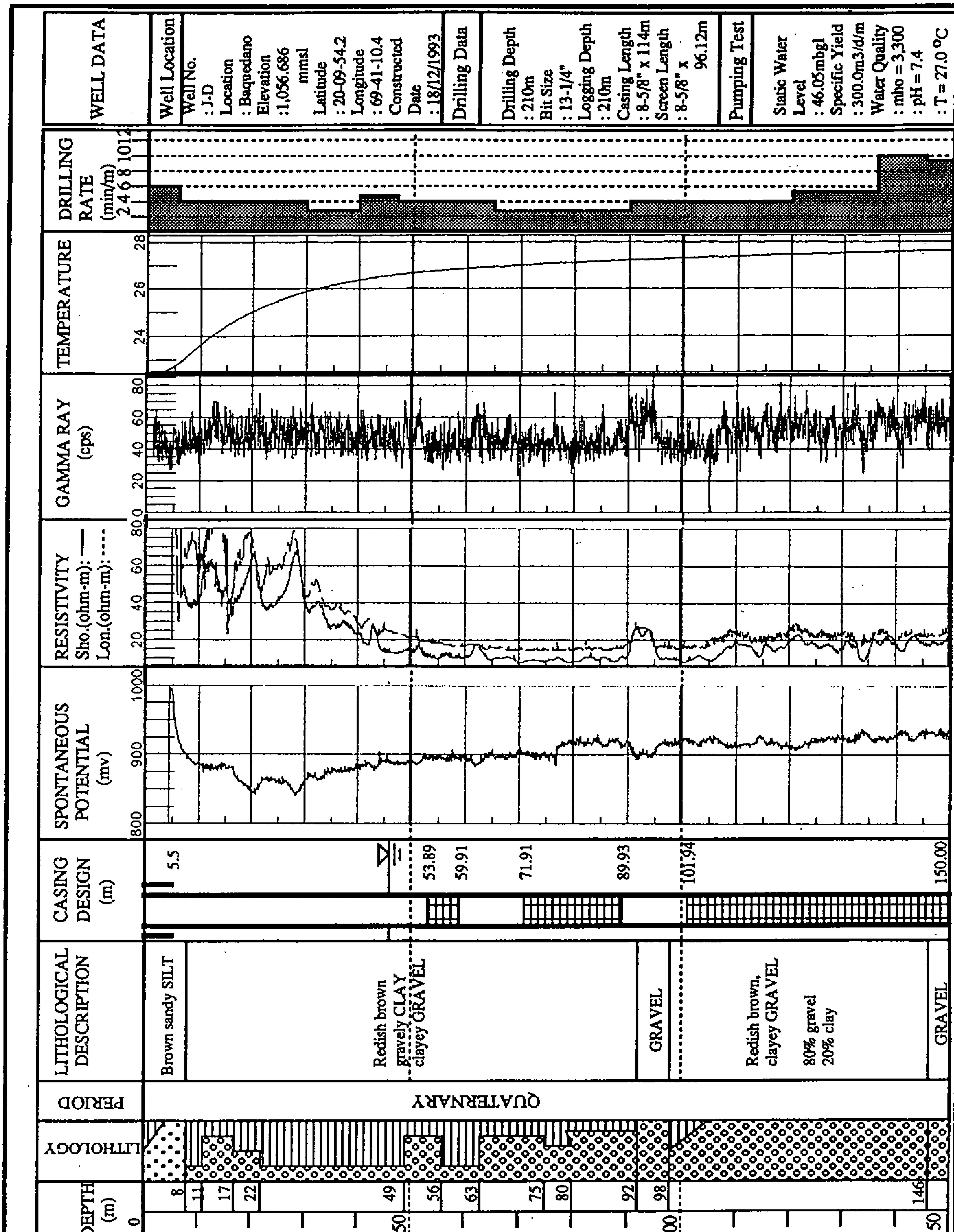


Fig. B-III, 2.3.14 Well Data for J-D (Sheet No. 1)

< Información del Pozo J-D(Hoja Nº 1) >

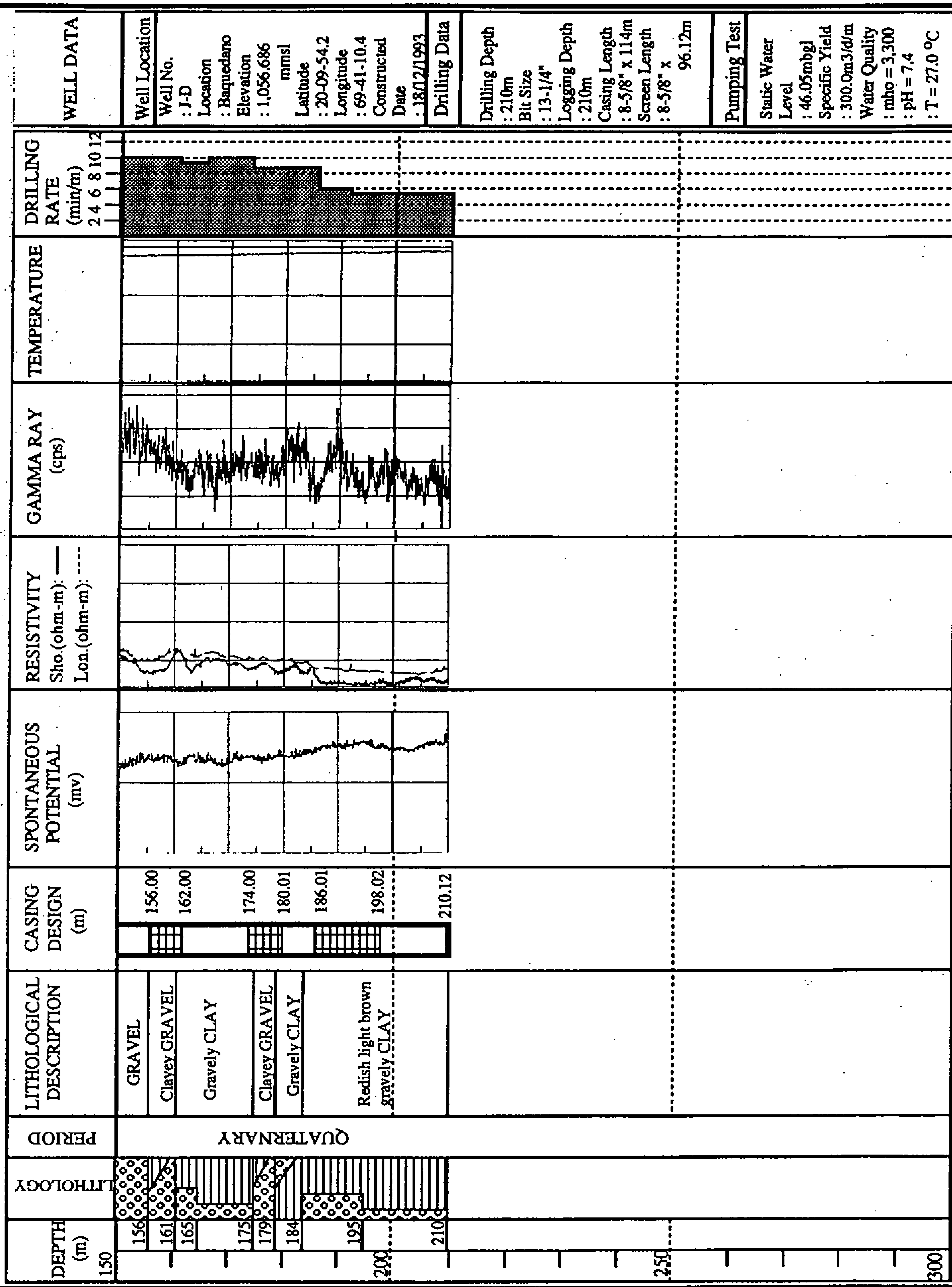


Fig. B-III, 2.3.14 Well Data for J-D (Sheet No. 2)

< Información del Pozo J-D (Hoja Nº 2) >

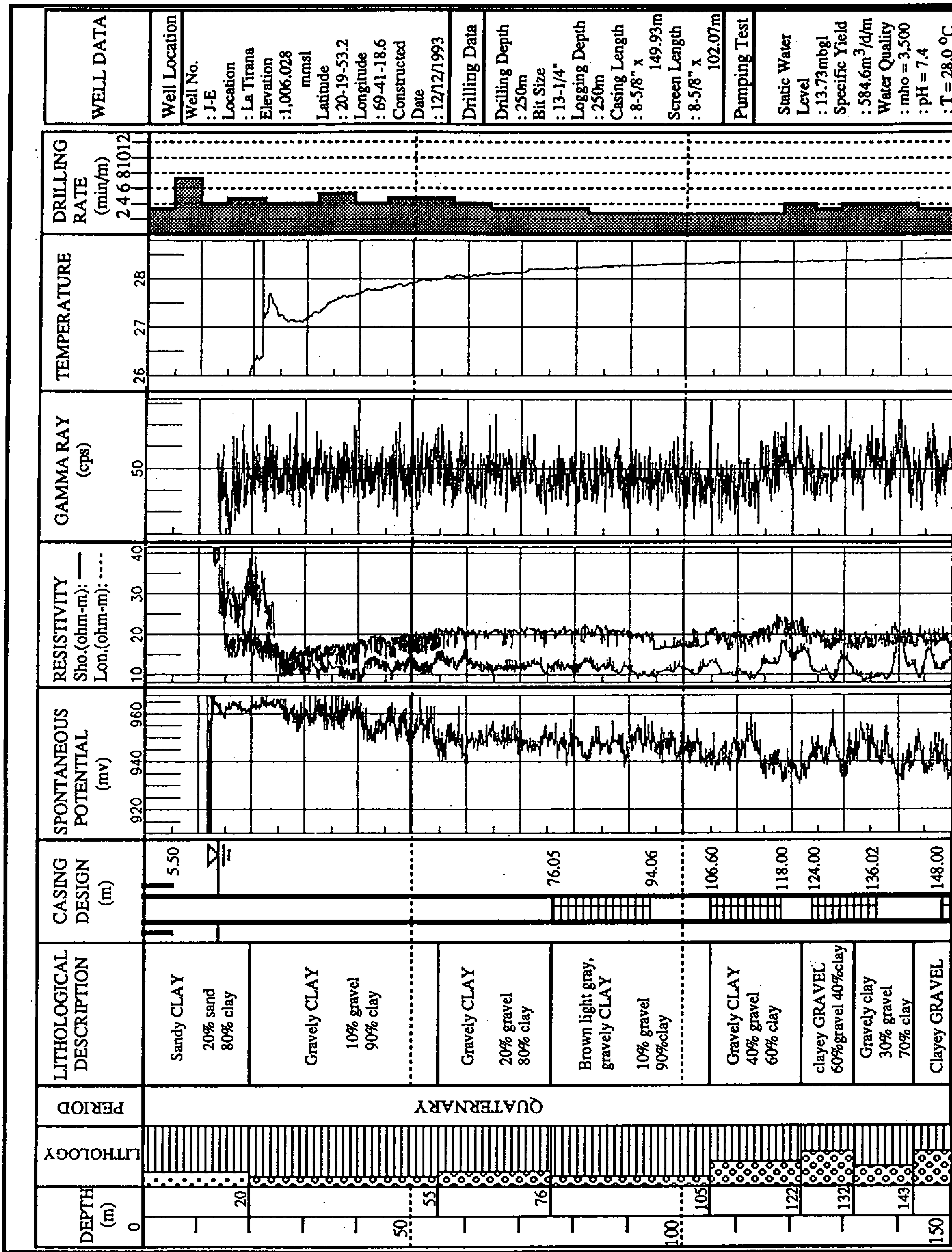


Fig. B-III, 2.3.15 Well Data for J-E (Sheet No. 1)

< Información del Pozo J-E (Hoja Nº 1) >

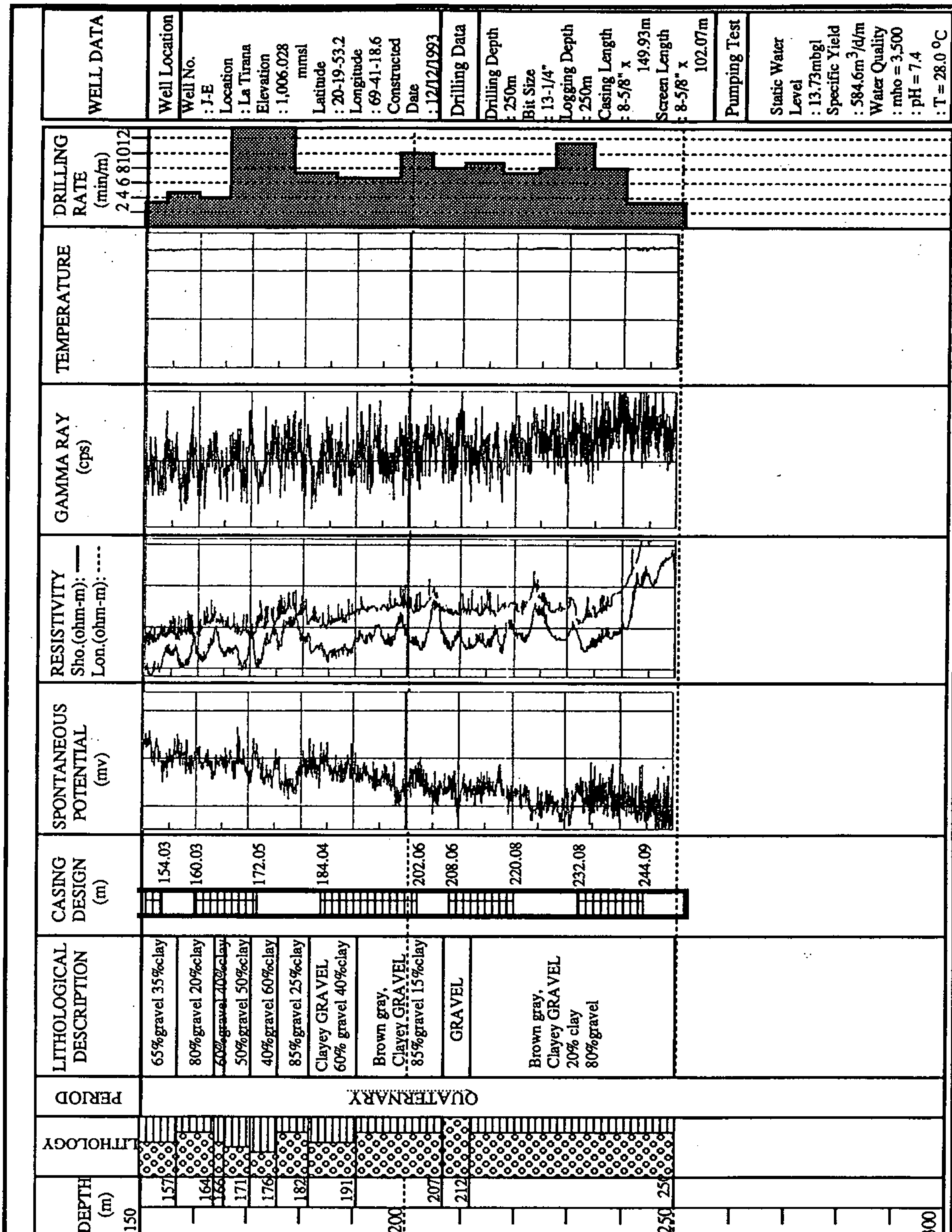


Fig. B-III, 2.3.15 Well Data for J-E (Sheet No. 2)

< Información del Pozo J-E(Hoja Nº 2) >

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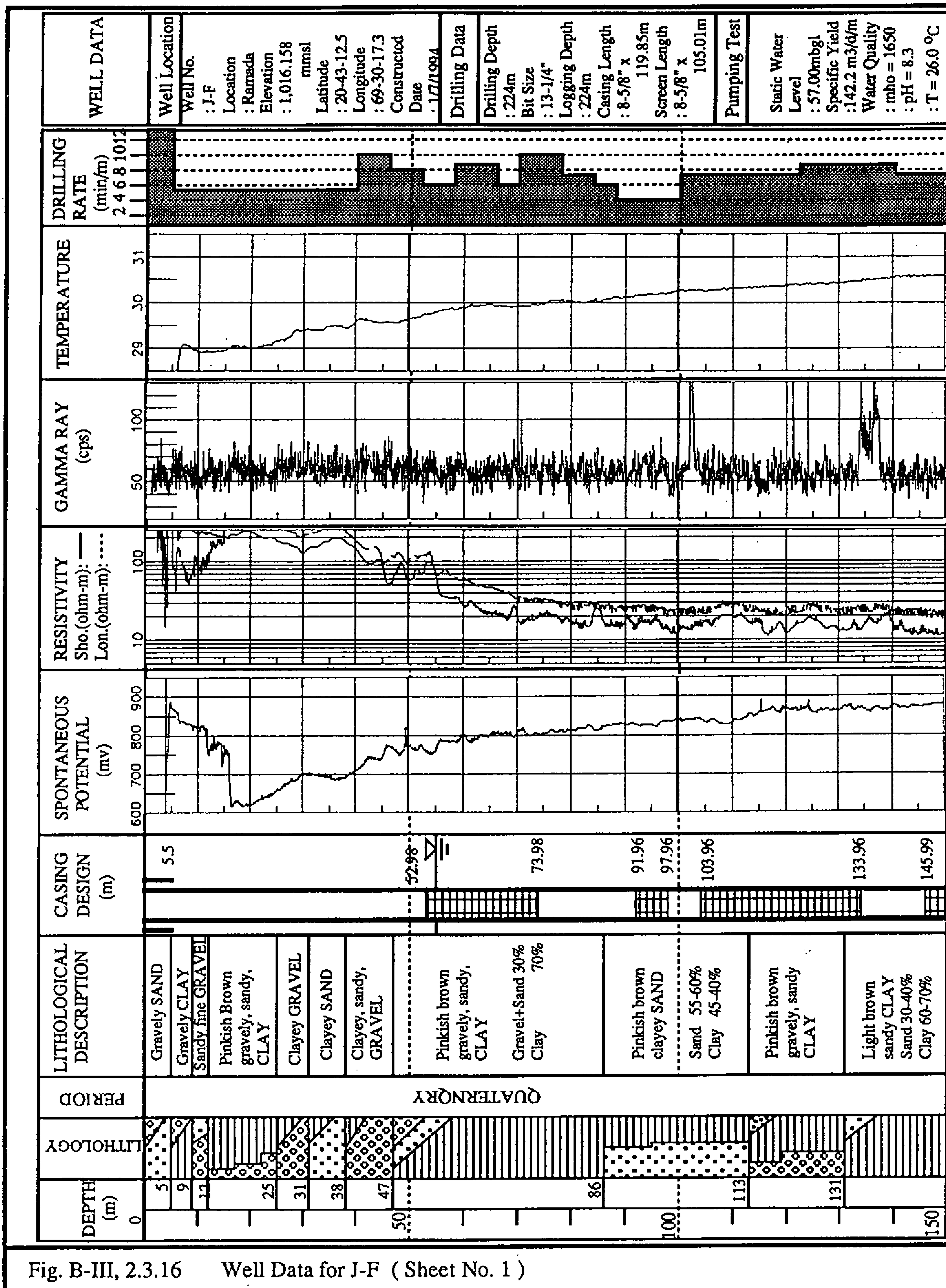

Fig. B-III, 2.3.16 Well Data for J-F (Sheet No. 1)

< Información del Pozo J-F (Hoja Nº 1) >

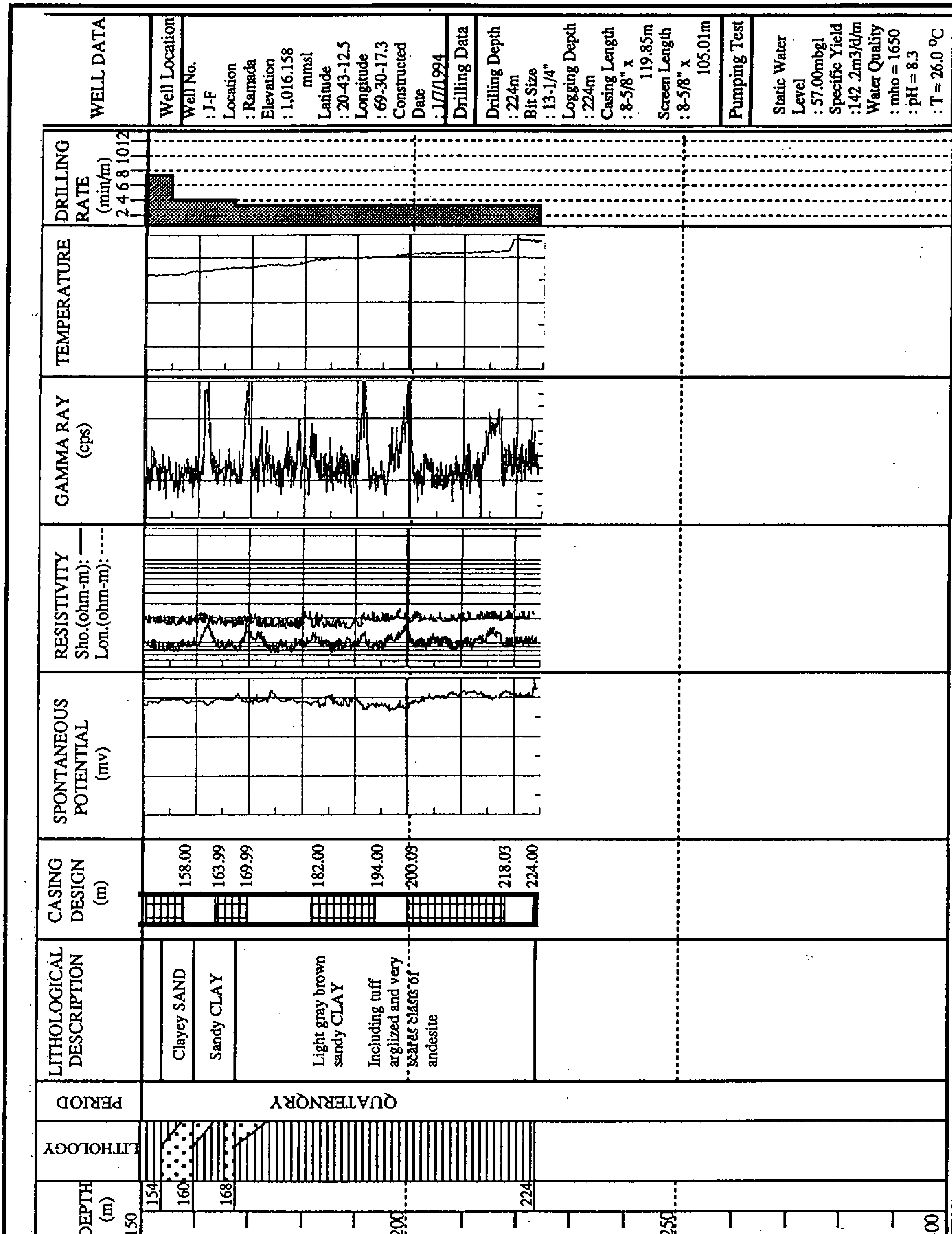

Fig. B-III, 2.3.16 Well Data for J-F (Sheet No. 2)

< Información del Pozo J-F (Hoja Nº 2) >

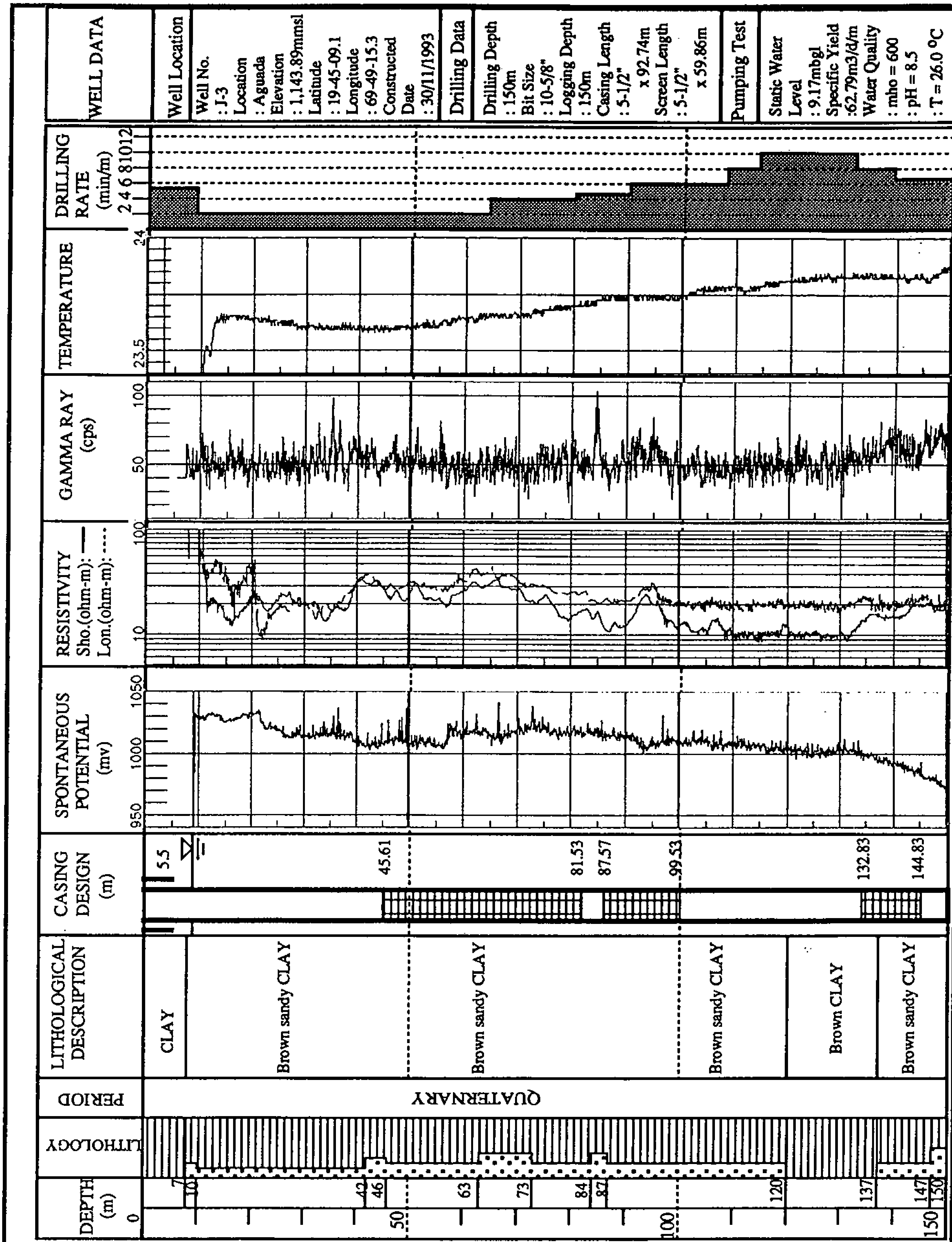

Fig. B-III, 2.3.17 Well Data for J-3

< Información del Pozo J-3 >

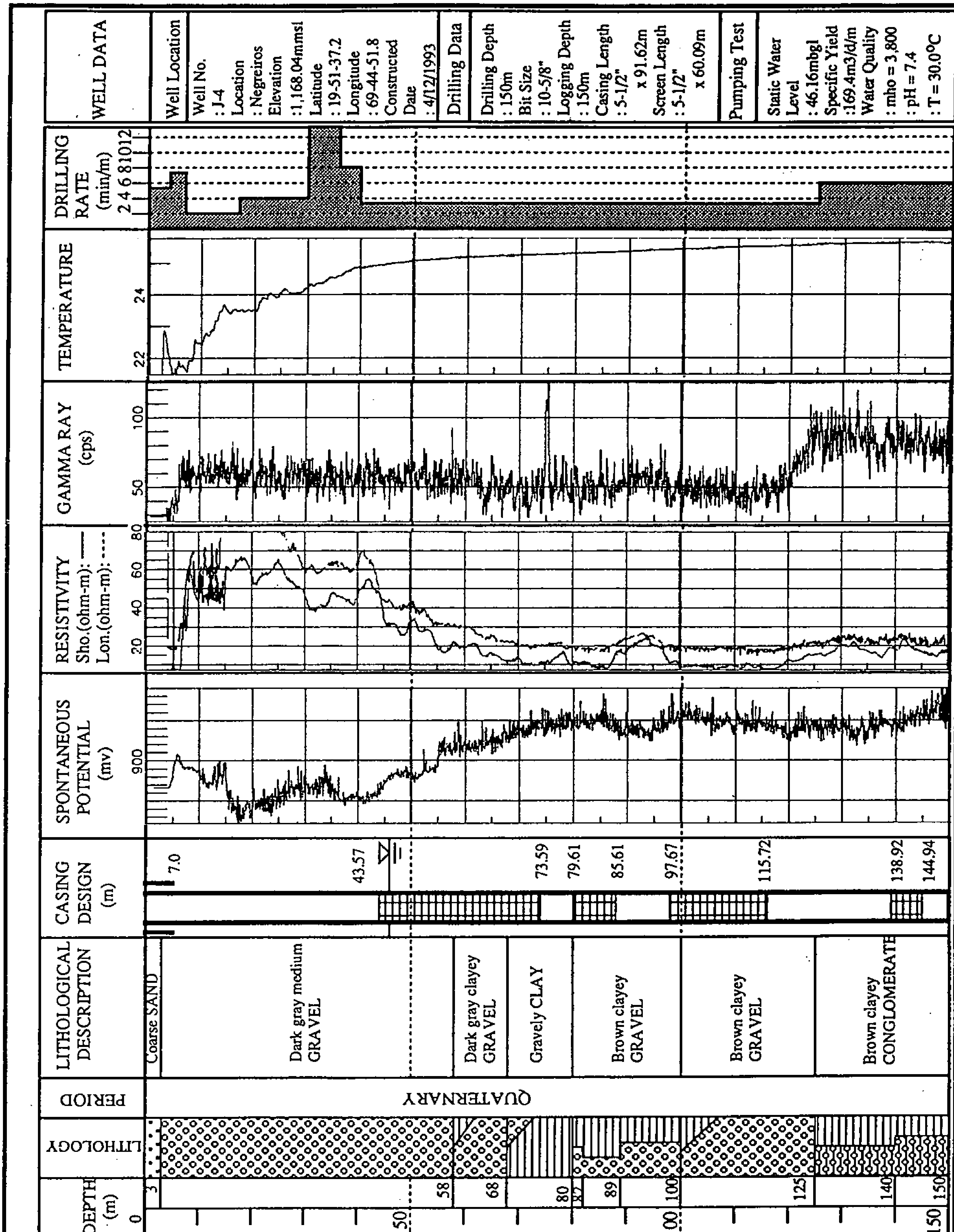

Fig. B-III, 2.3.18 Well Data for J-4

< Información del Pozo J-4 >

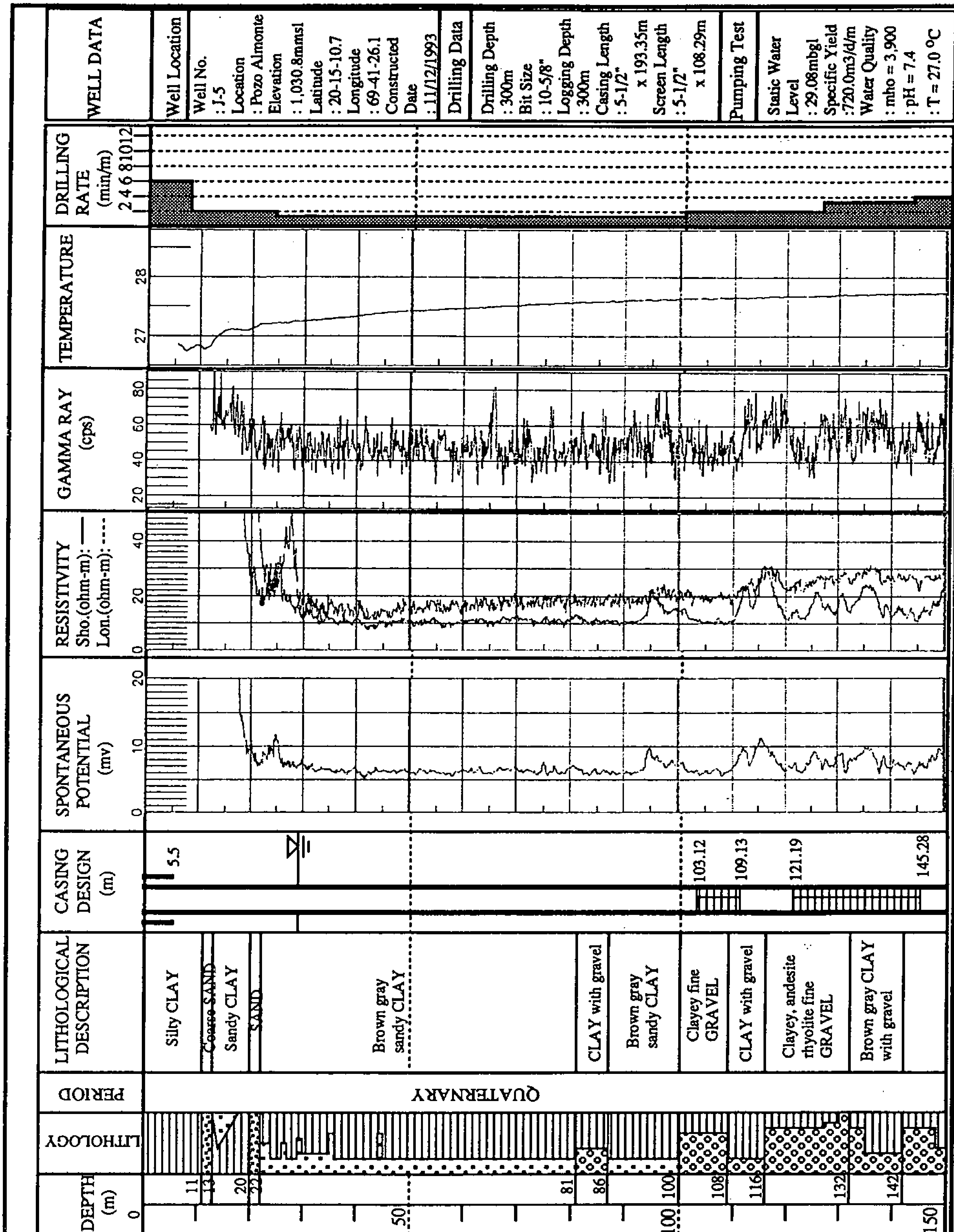

Fig. B-III, 2.3.19 Well Data for J-5 (Sheet No. 1)

< Información del Pozo J-5 (Hoja Nº 1) >

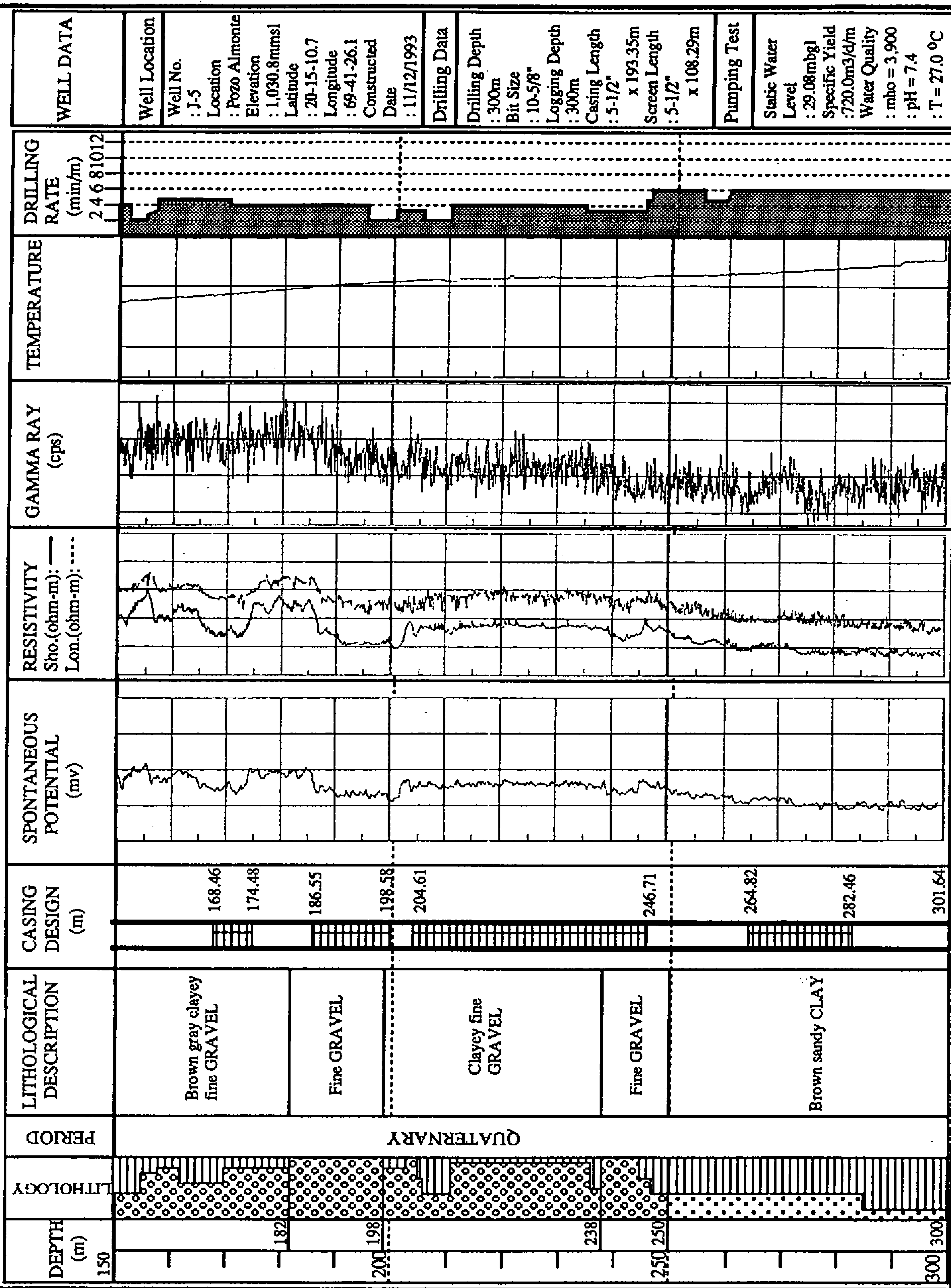

Fig. B-III, 2.3.19 Well Data for J-5 (Sheet No. 2)

< Información del Pozo J-5 (Hoja Nº 2) >

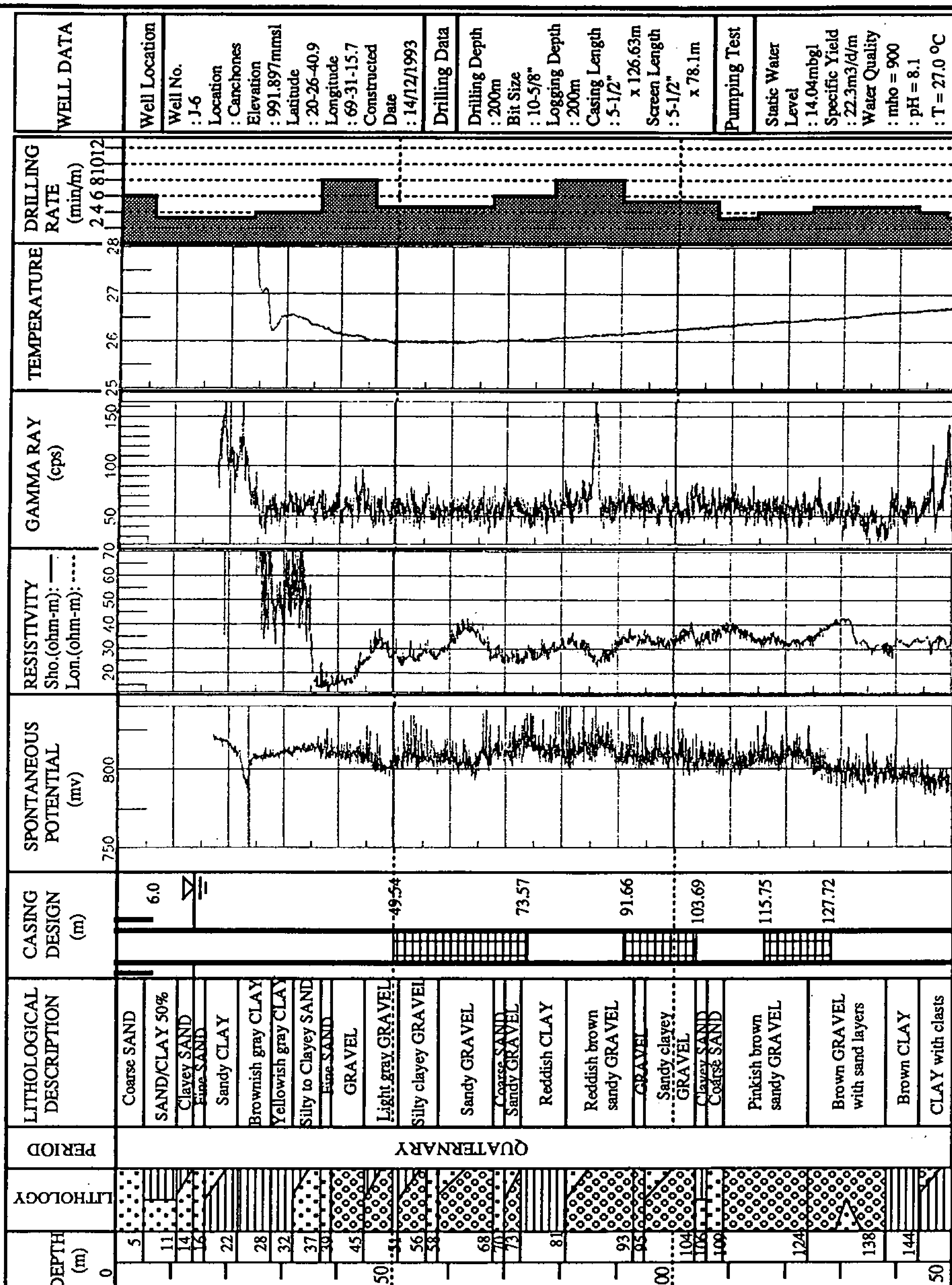

Fig. B-III, 2.3.20 Well Data for J-6 (Sheet No. 1)

< Información del Pozo J-6 (Hoja Nº 1) >

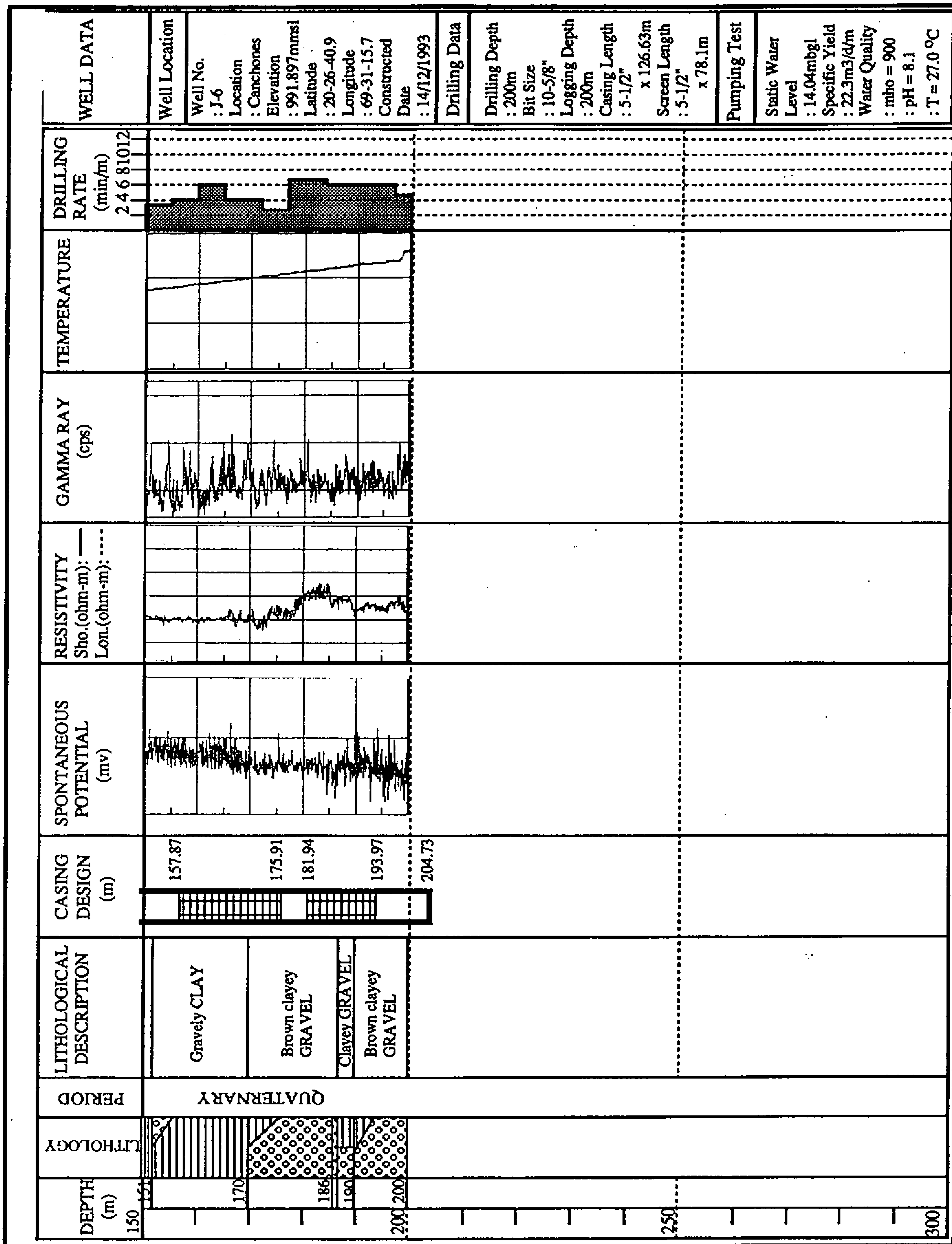

Fig. B-III, 2.3.20 Well Data for J-6 (Sheet No. 2)

< Información del Pozo J-6 (Hoja Nº 2) >

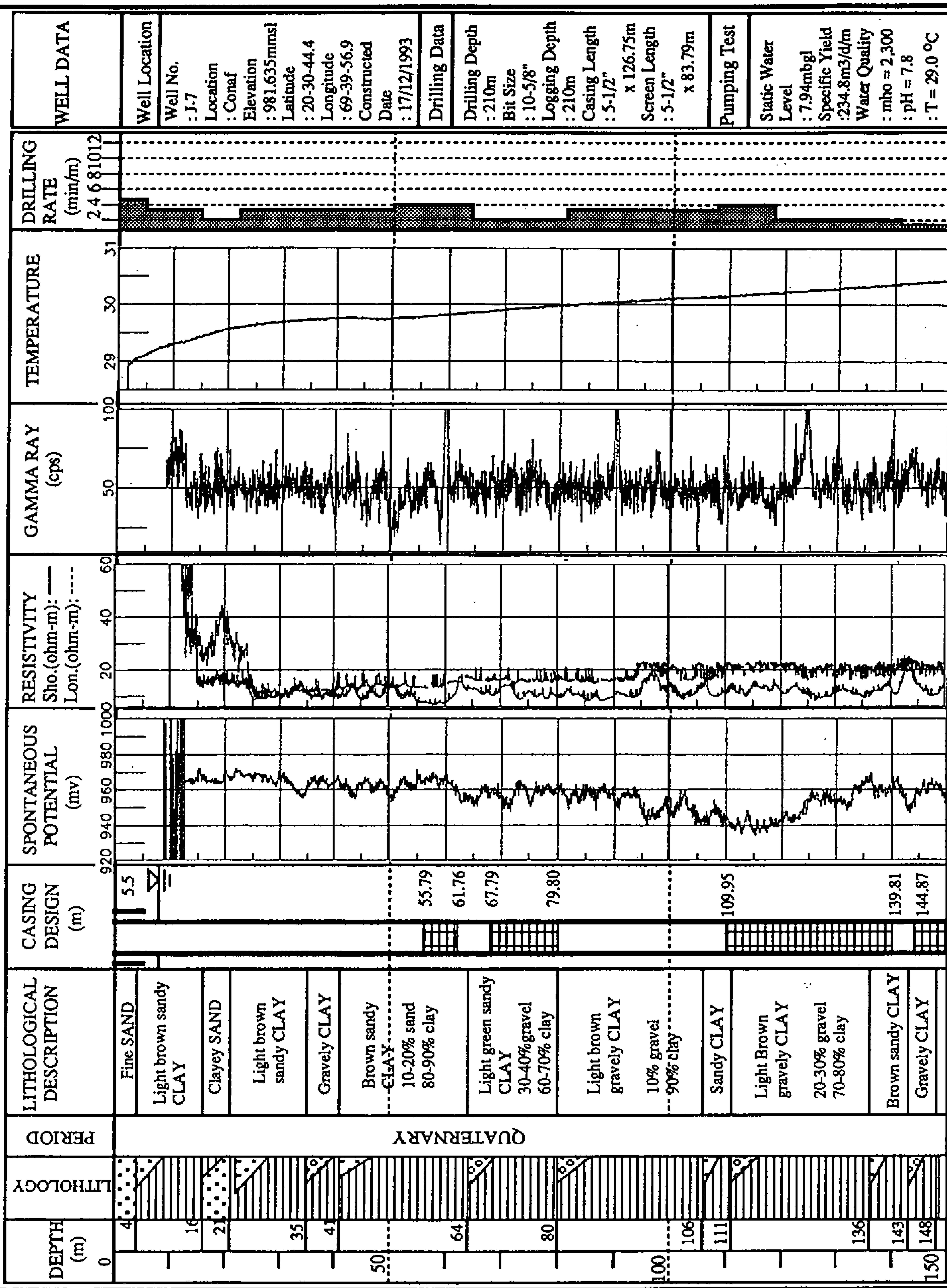

Fig. B-III, 2.3.21 Well Data for J-7 (Sheet No. 1)

< Información del Pozo J-7 (Hoja Nº 1) >

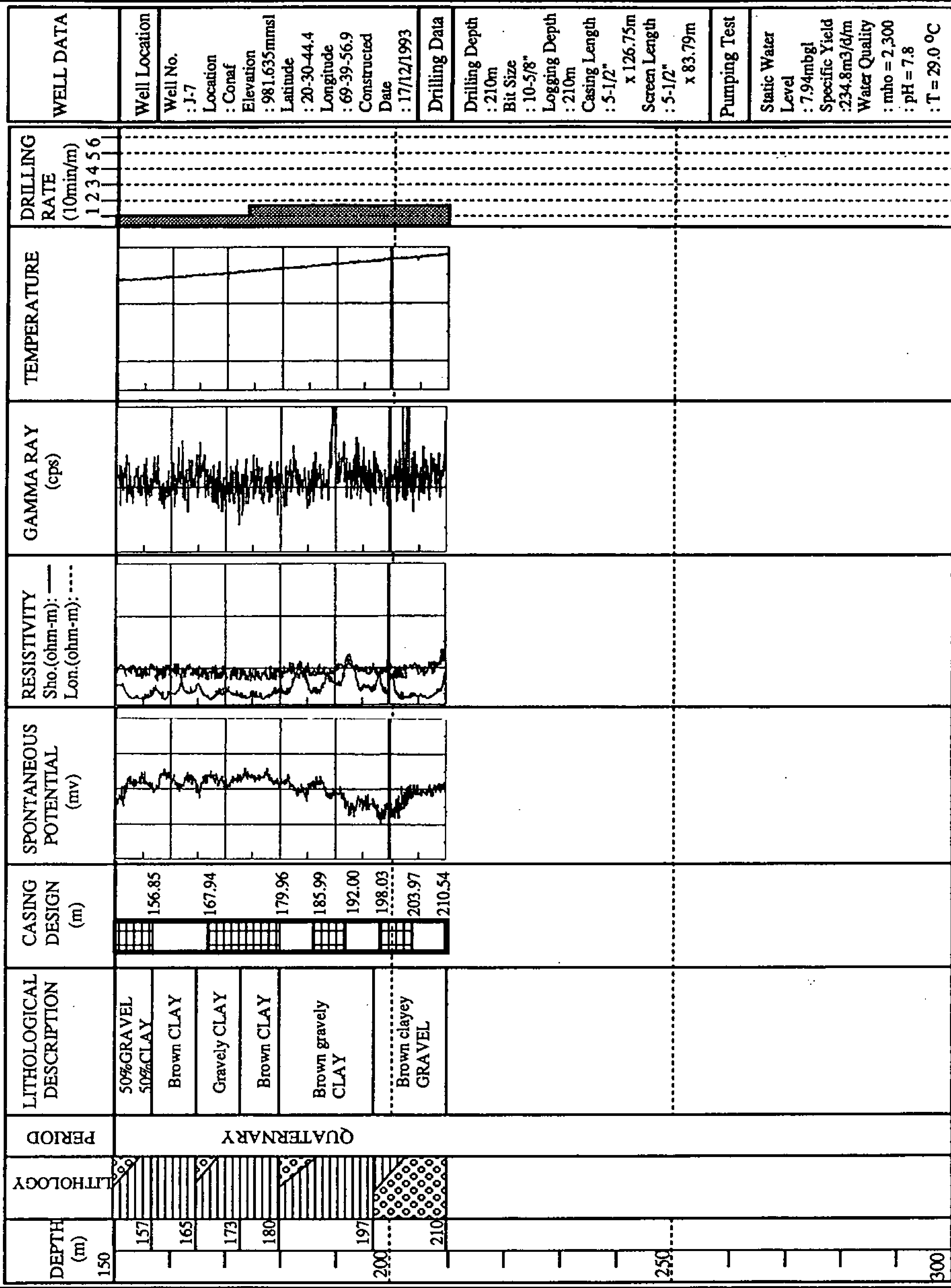

Fig. B-III, 2.3.21 Well Data for J-7 (Sheet No. 2)

< Información del Pozo J-7 (Hoja Nº 2) >

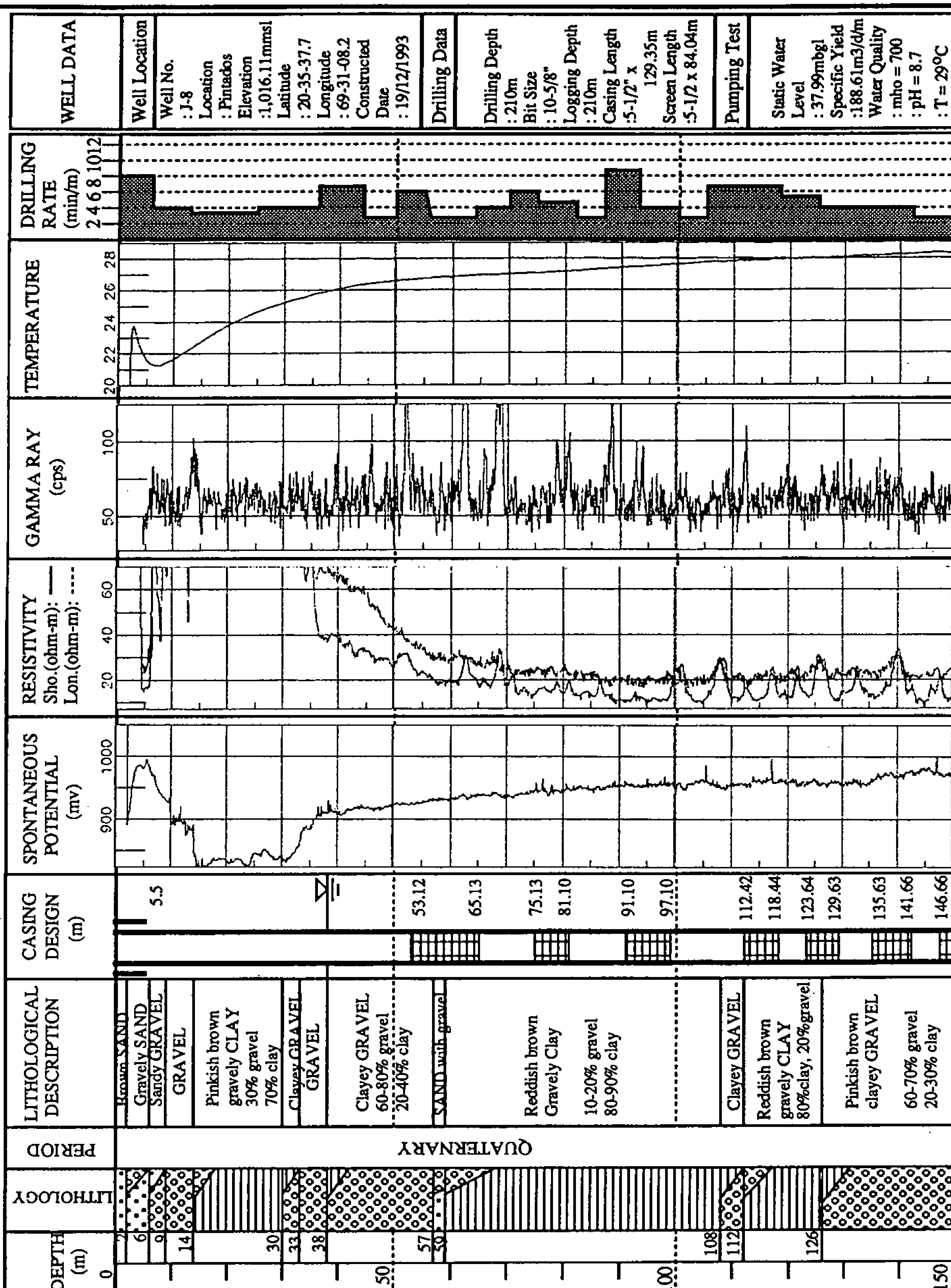

Fig. B-III, 2.3.22 Well Data for J-8 (Sheet No. 1)

< Información del Pozo J-8 (Hoja Nº 1) >

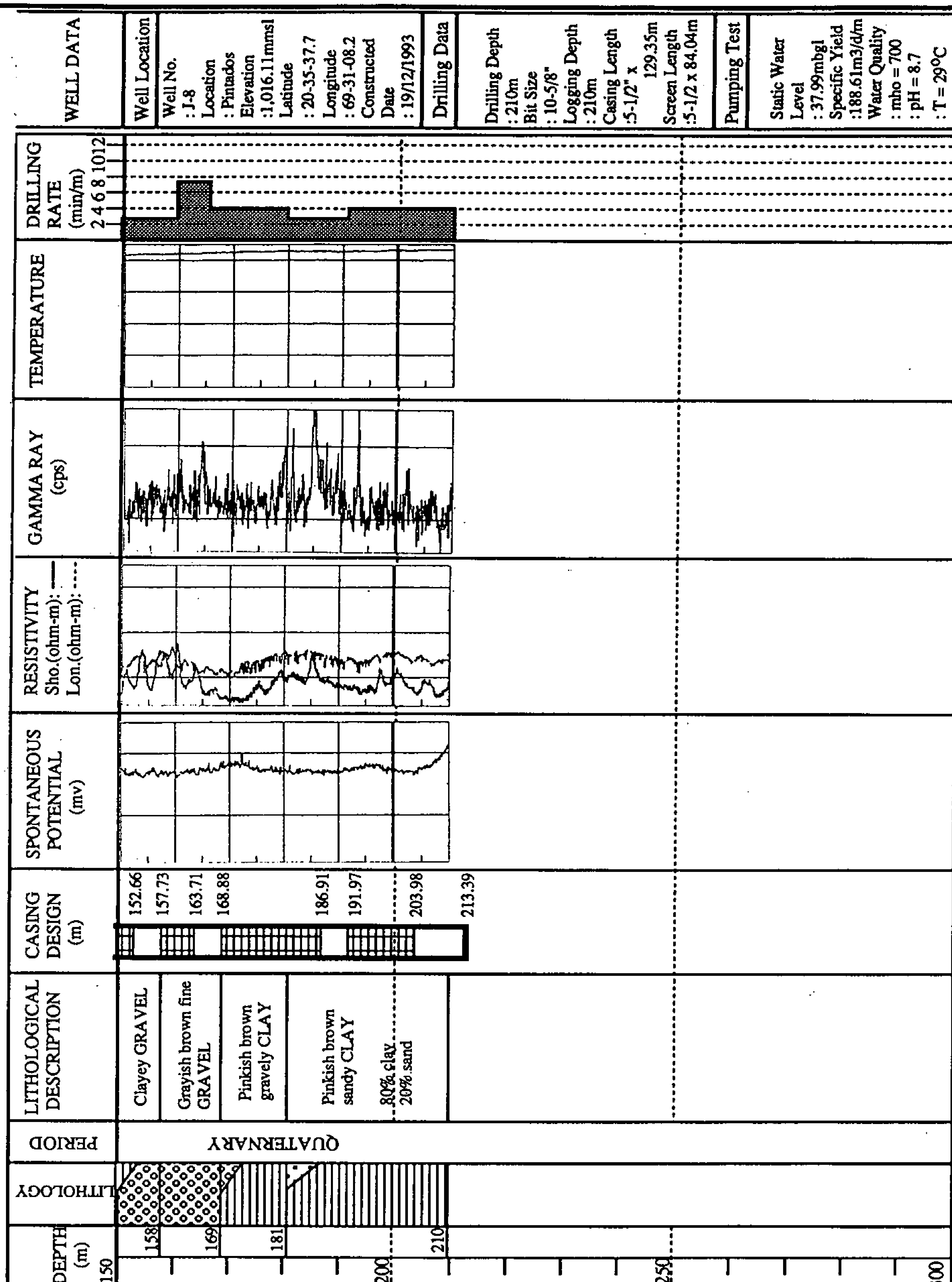

Fig. B-III, 2.3.22 Well Data for J-8 (Sheet No. 2)

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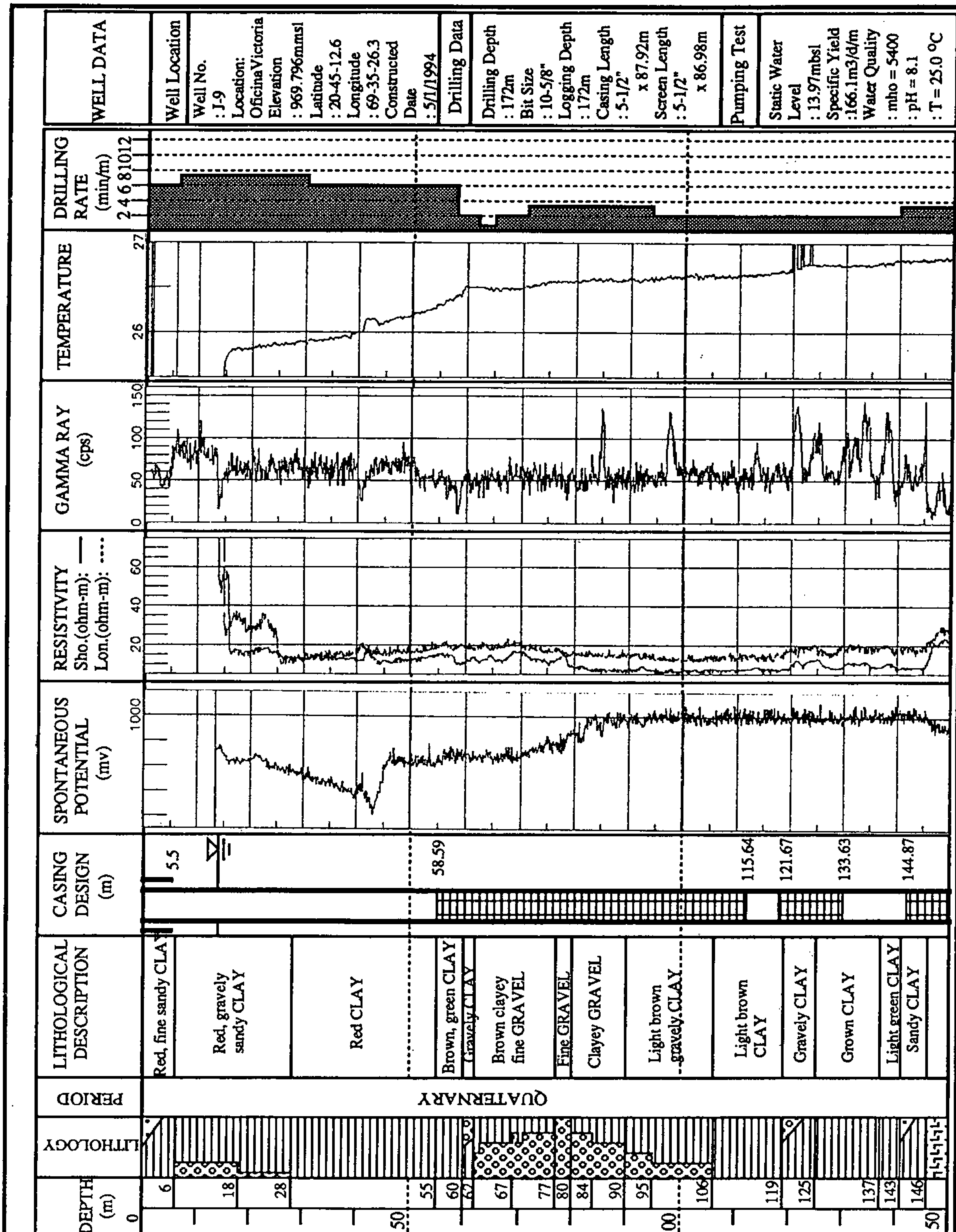


Fig. B-III, 2.3.23 Well Data for J-9 (Sheet No. 1)

< Información del Pozo J-9 (Hoja Nº 1) >

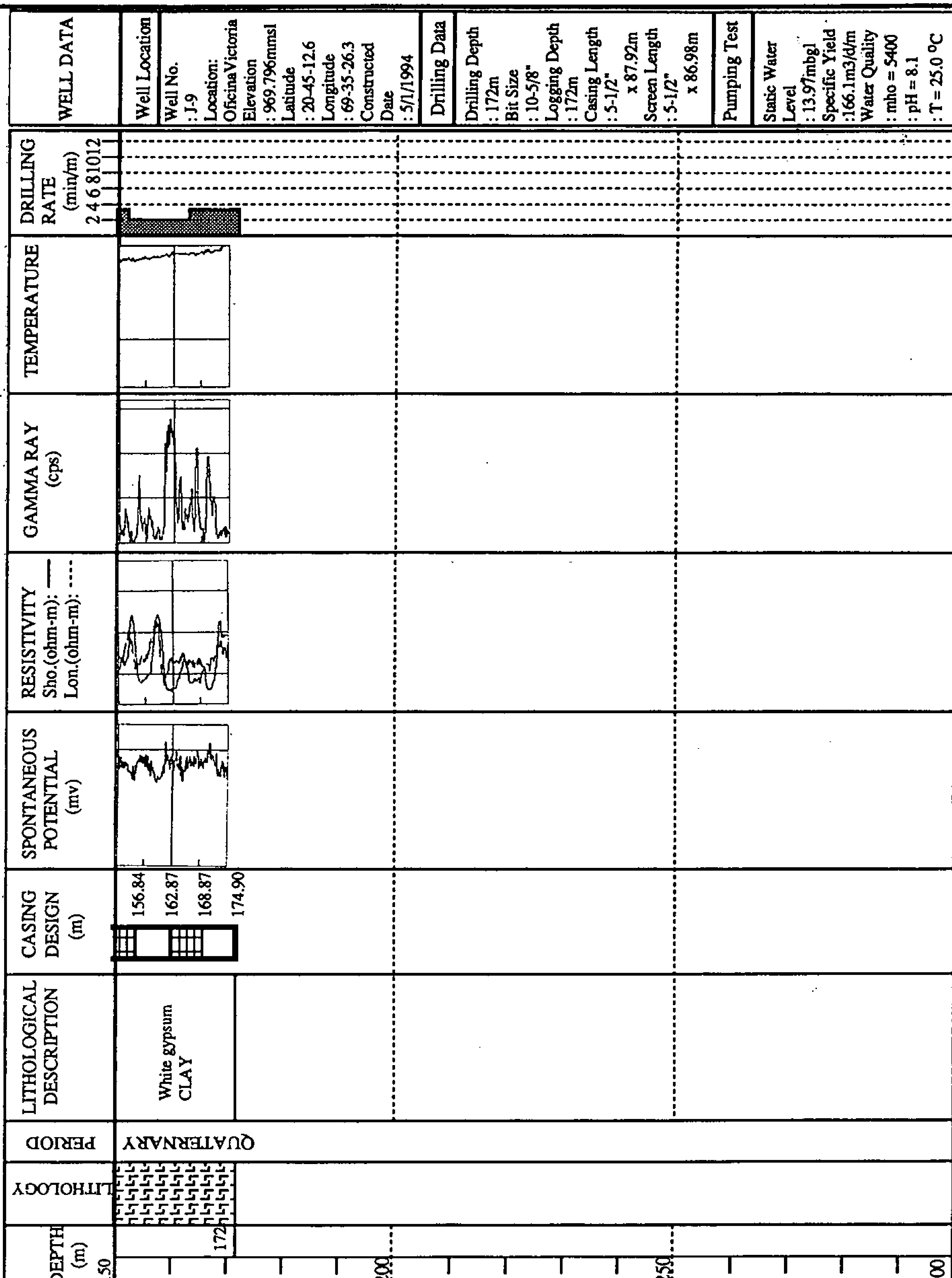


Fig. B-III, 2.3.23 Well Data for J-9 (Sheet No. 2)

< Información del Pozo J-9 (Hoja Nº 2) >

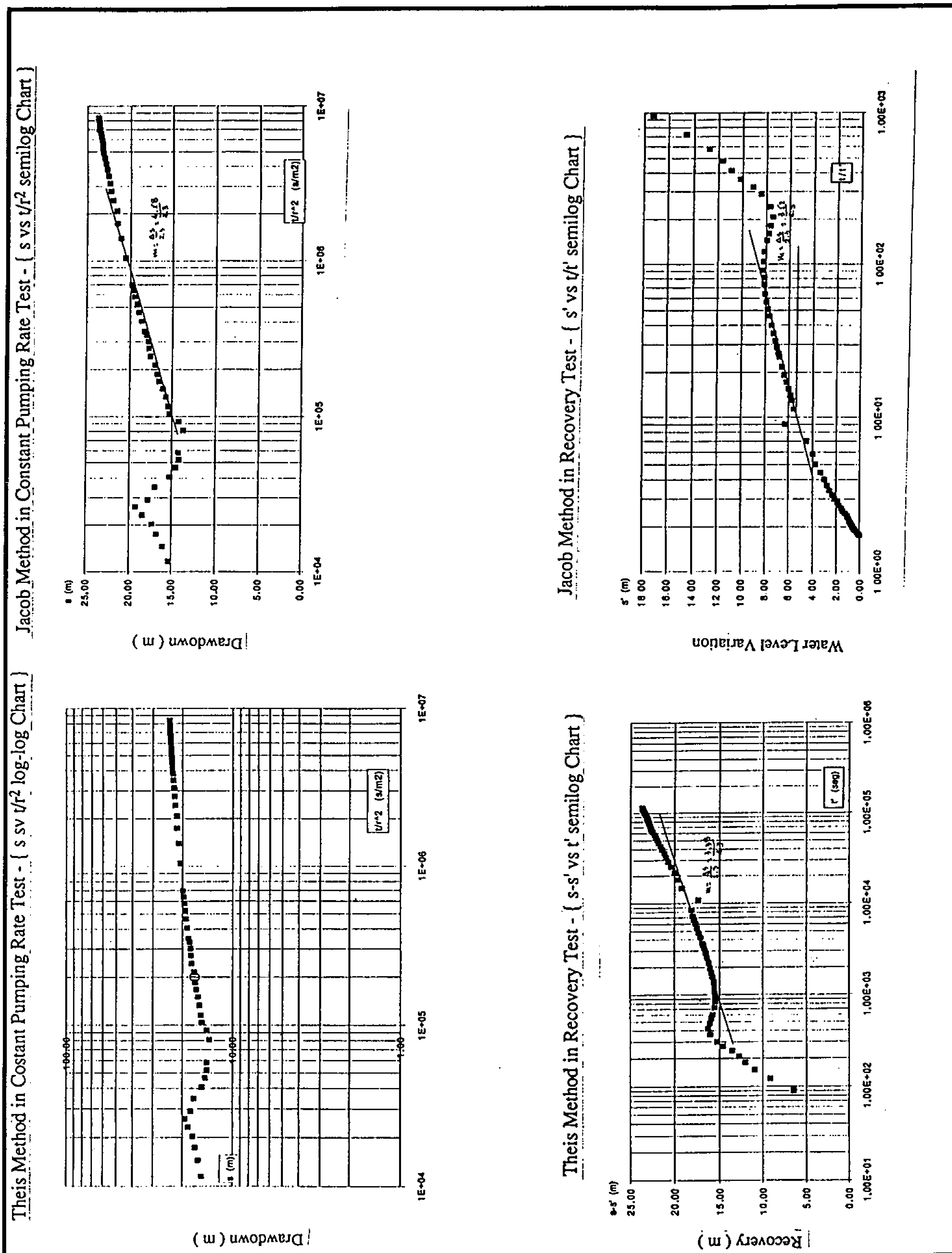


Fig. B-III, 2.3.24 Graphs for Theis and Jacob Method Analysis (Well No.J-C)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº J-C) >

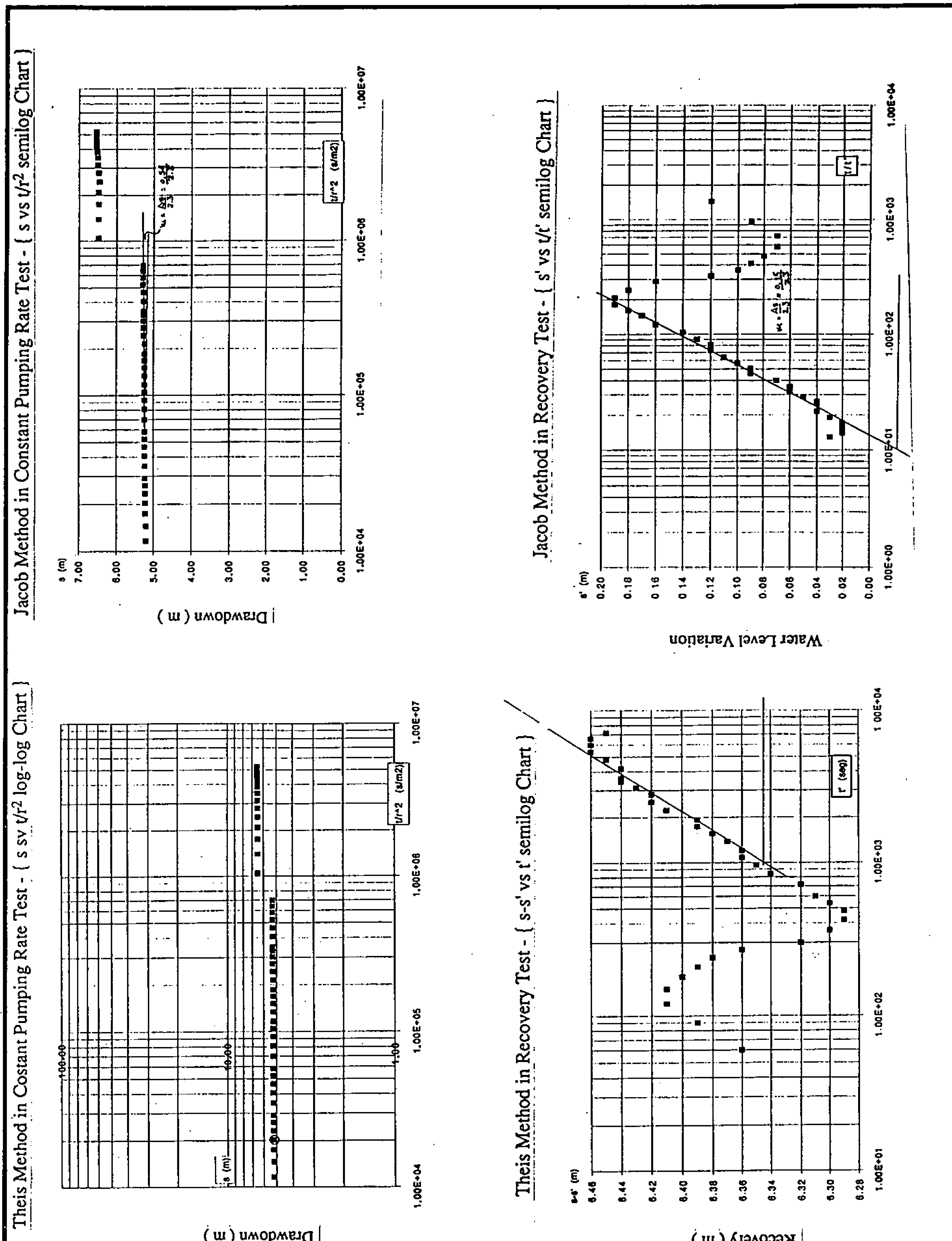


Fig. B-III, 2.3.25 Graphs for Theis and Jacob Method Analysis (Well No.J-D)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº J-D) >

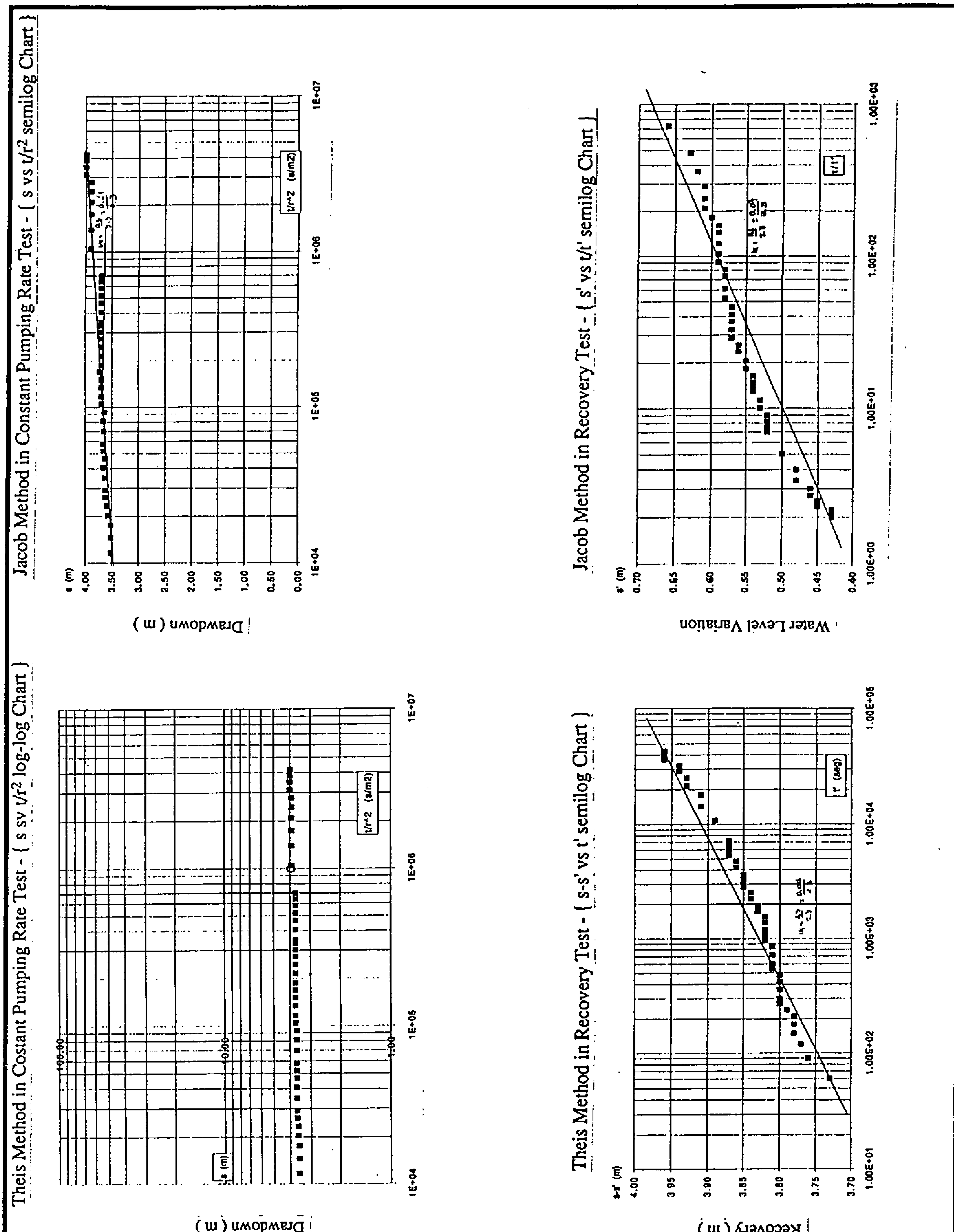


Fig. B-III, 2.3.26 Graphs for Theis and Jacob Method Analysis (Well No.J-E)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº J-E) >

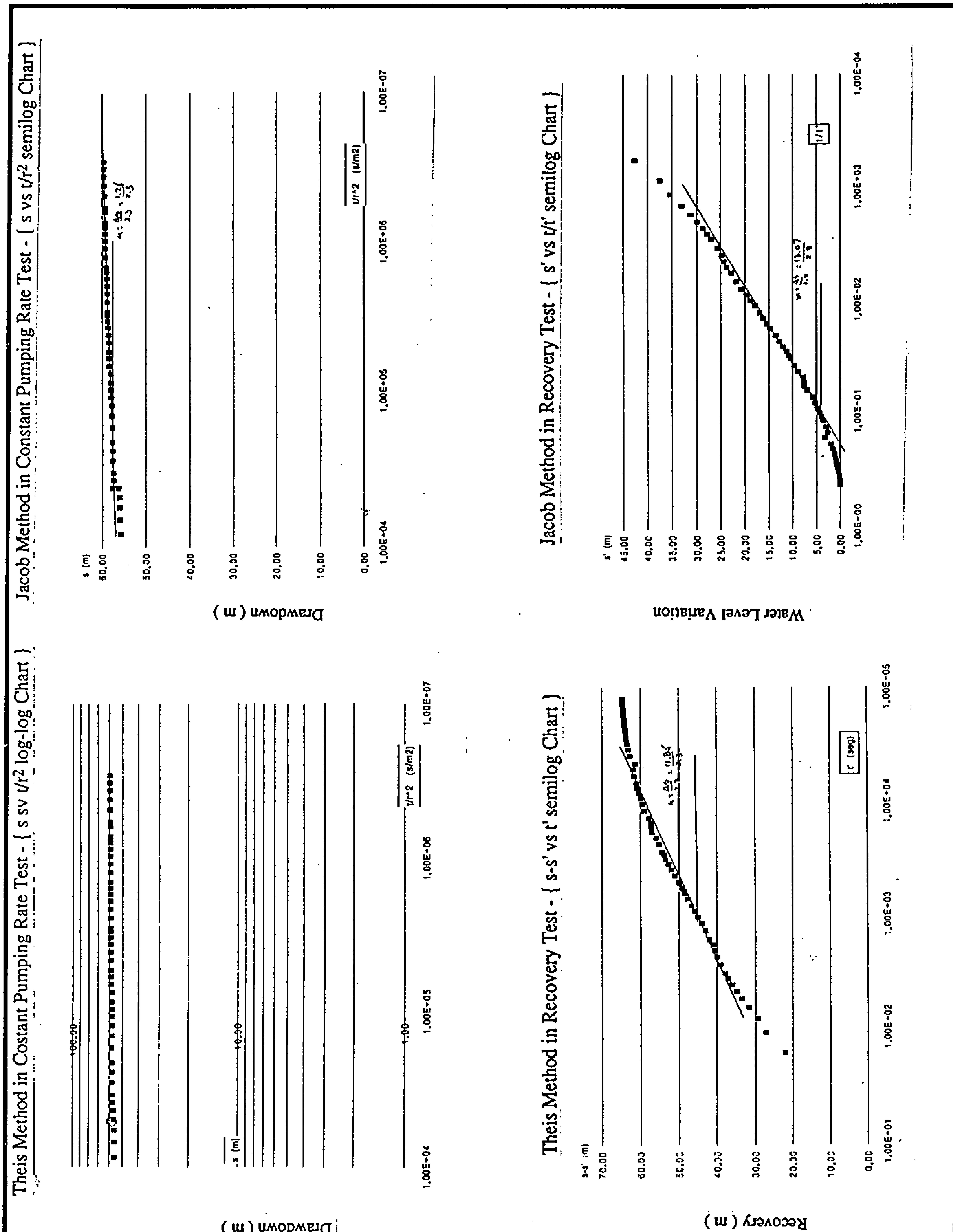


Fig. B-III, 2.3.27 Graphs for Theis and Jacob Method Analysis (Well No.J-F)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº.J-F) >

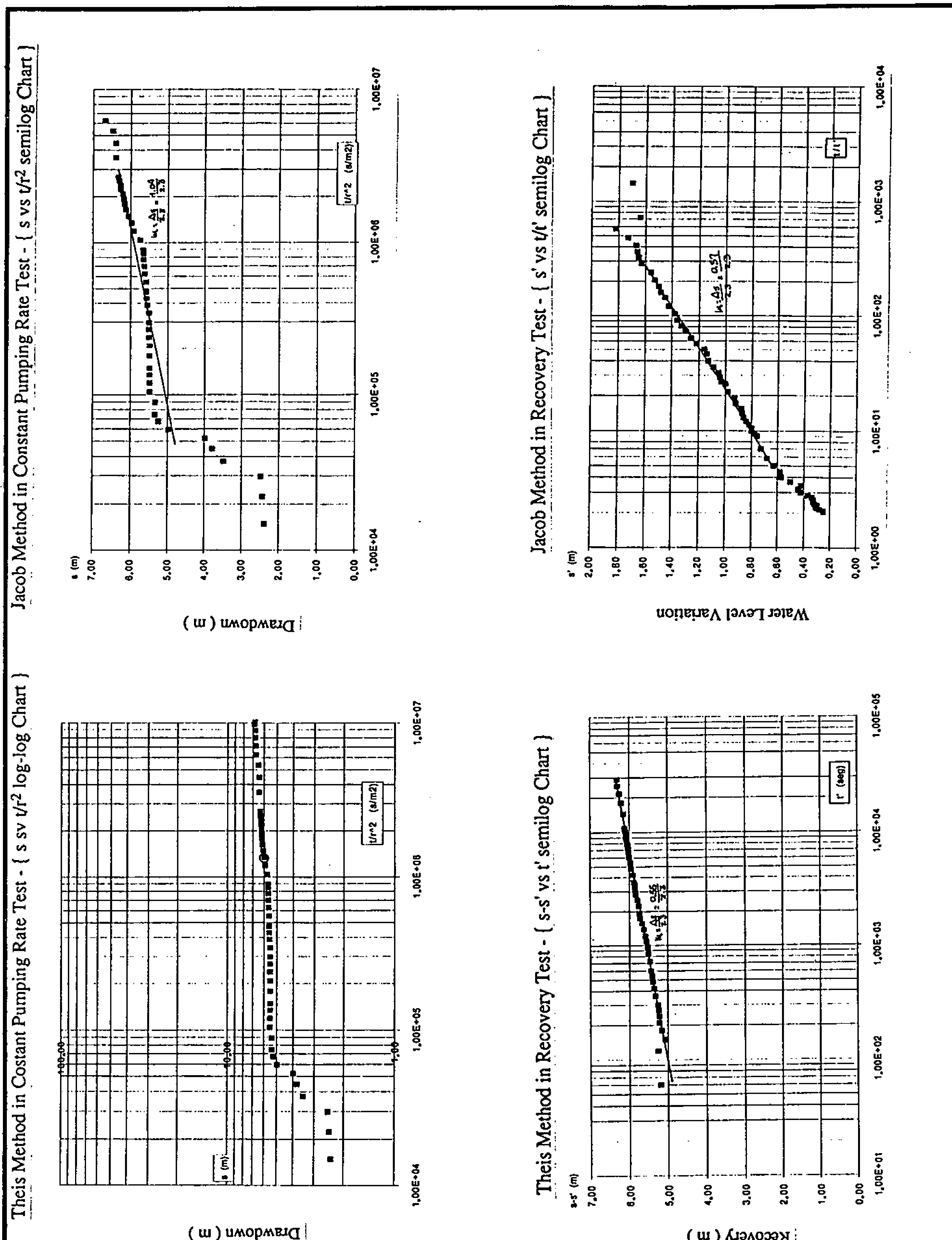


Fig. B-III, 2.3.28 Graphs for Theis and Jacob Method Analysis (Well No.J-3)

< Gráficos par los Métodos de Análisis Theis y Jacob (Pozo Nº J-3) >

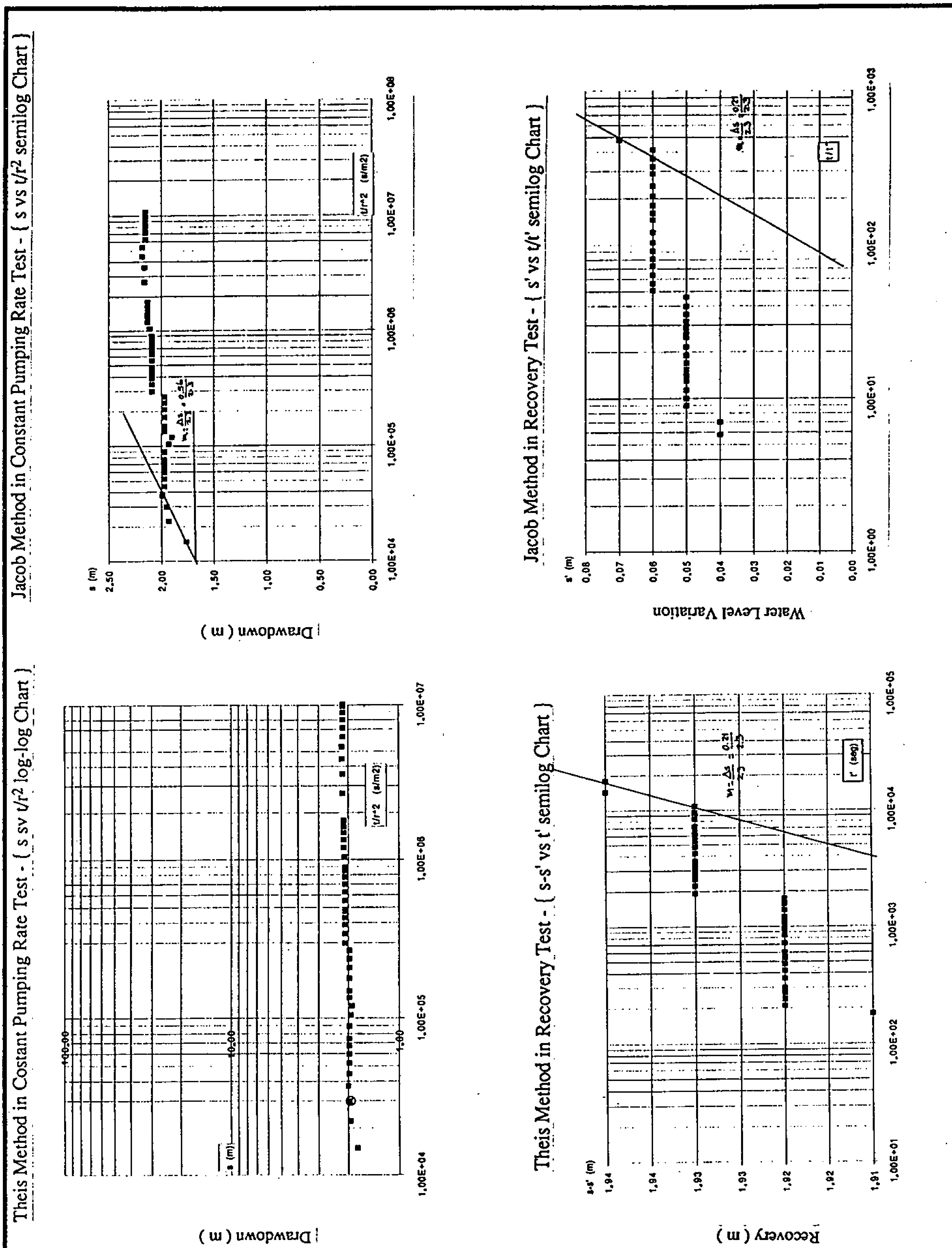


Fig. B-III, 2.3.29 Graphs for Theis and Jacob Method Analysis (Well No.J-4)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº J-4) >

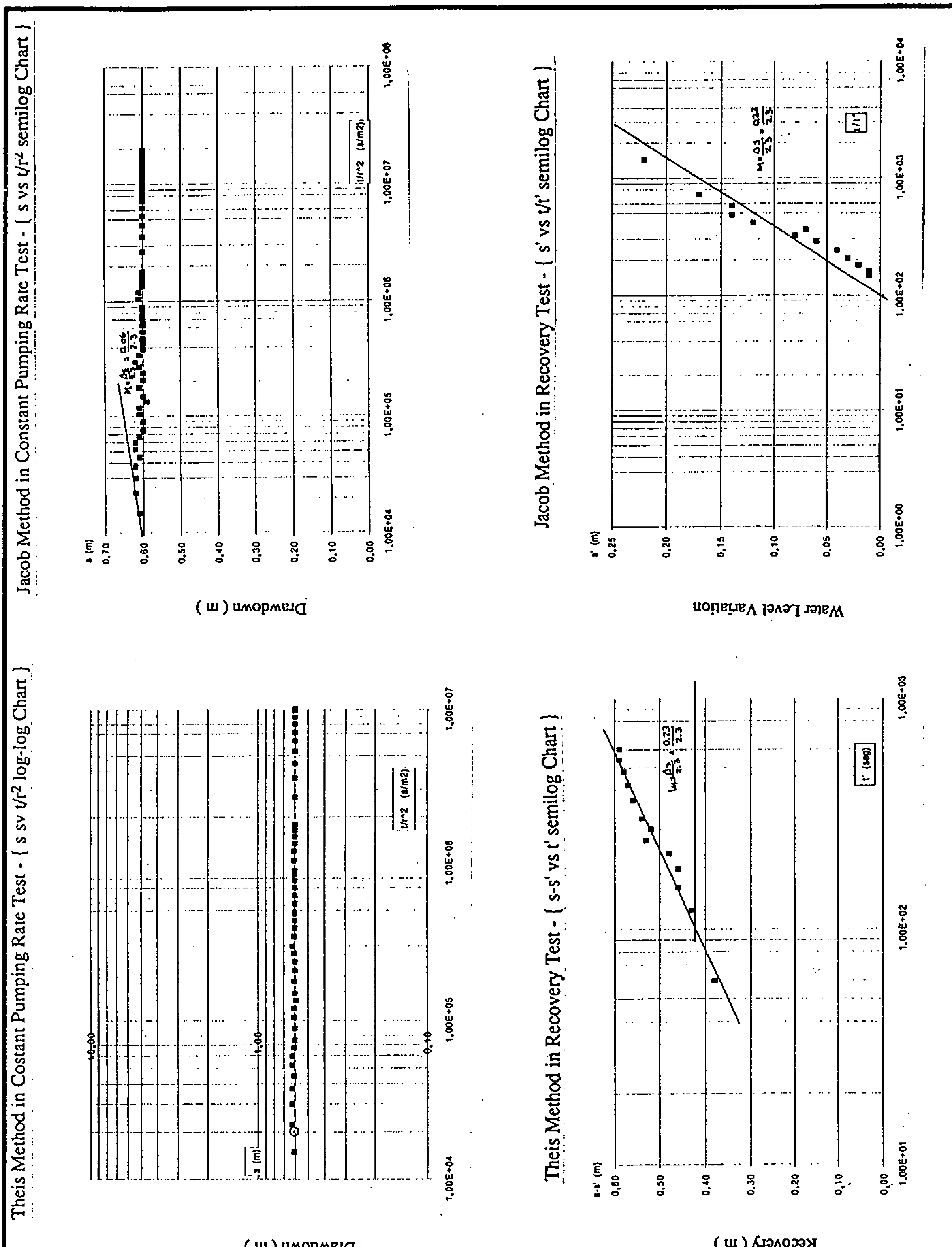
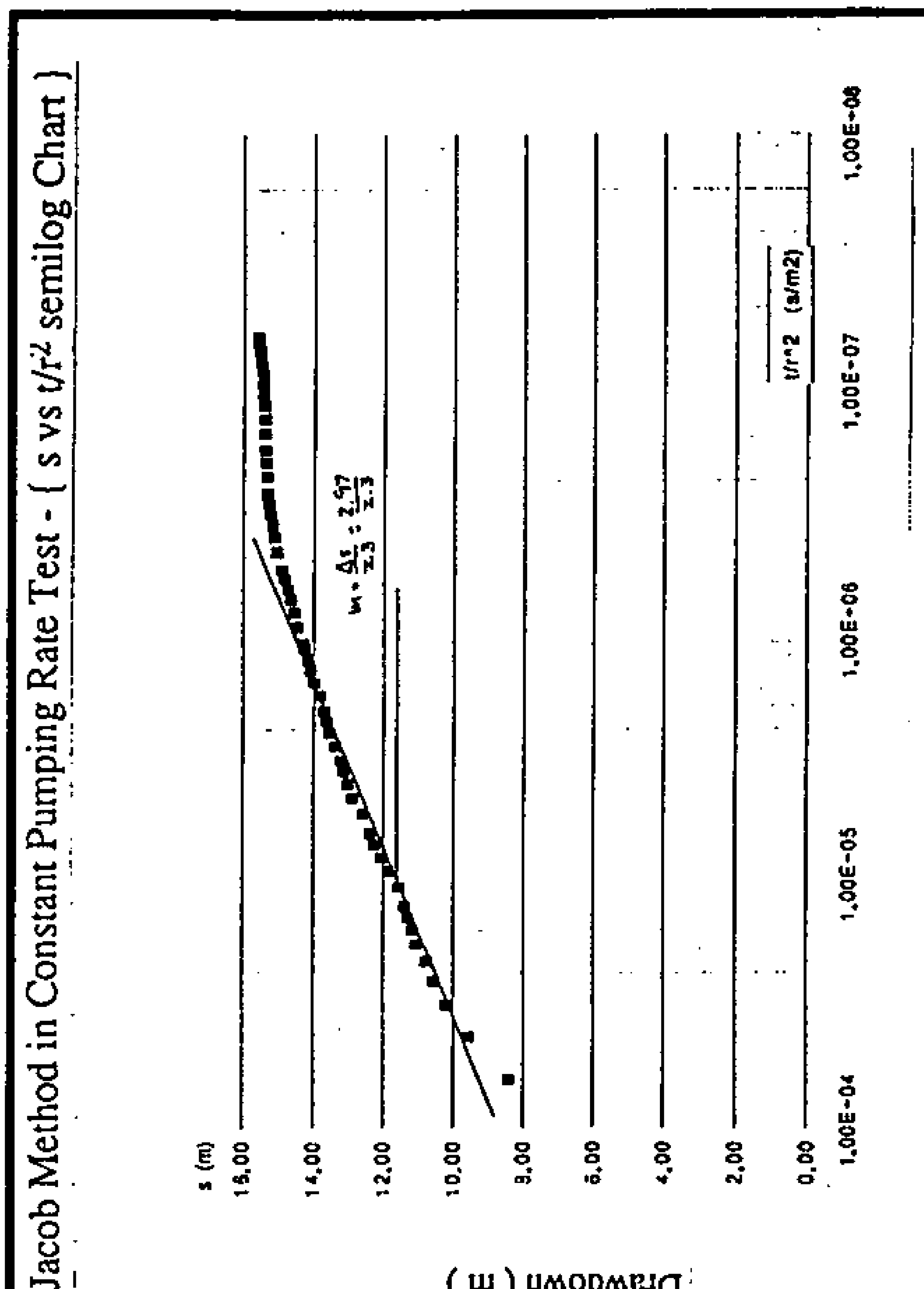
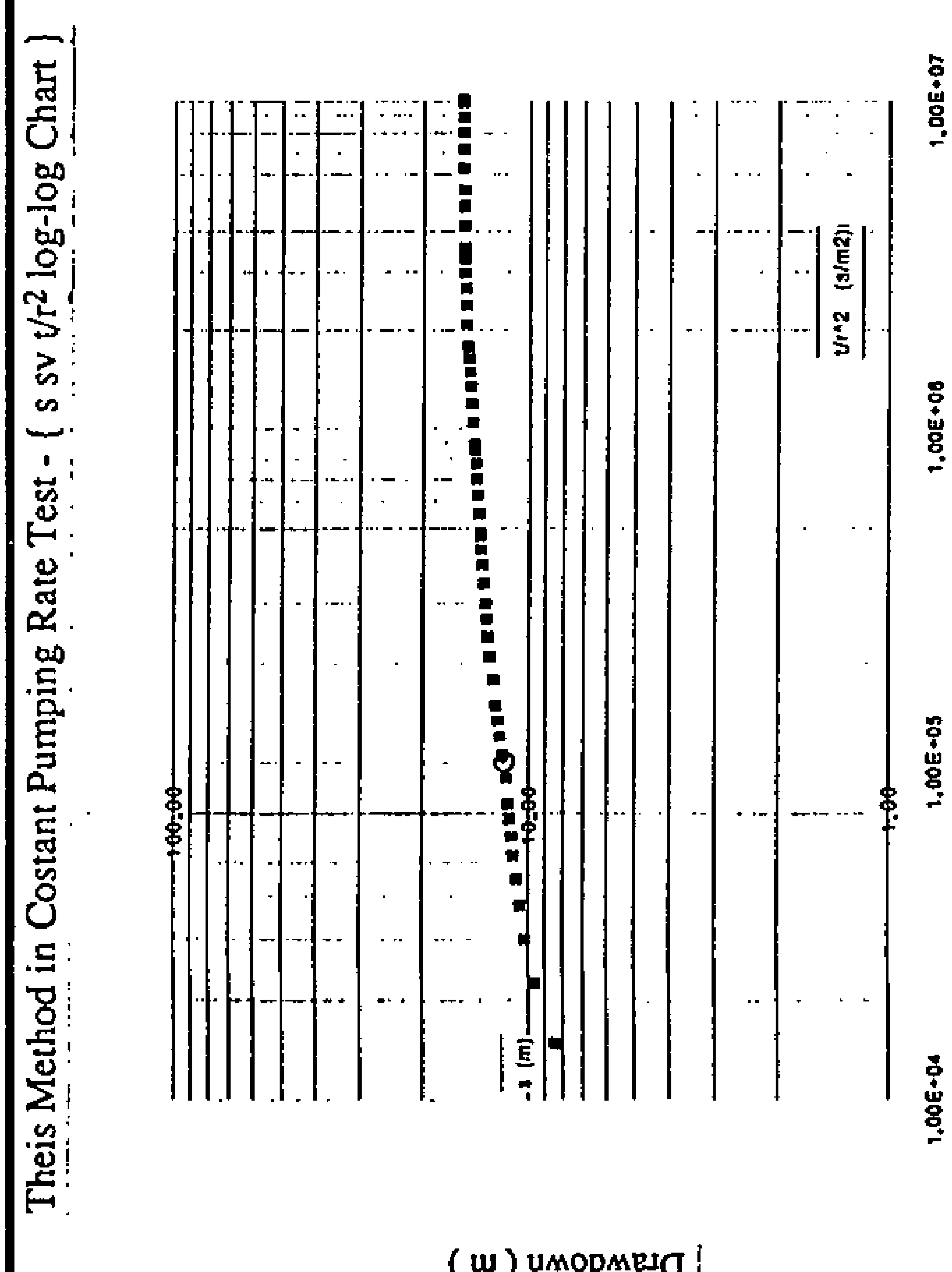
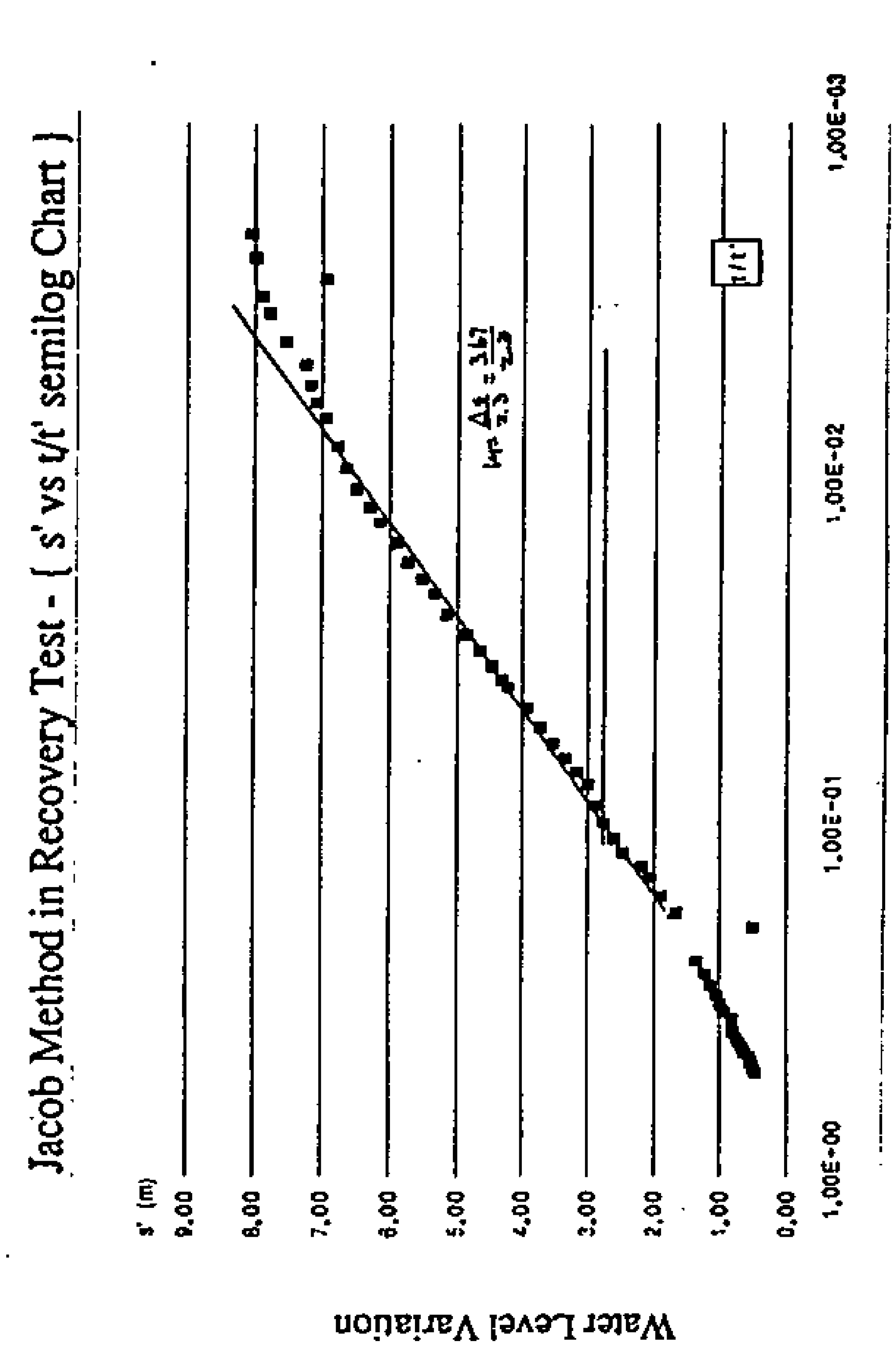


Fig. B-III, 2.3.30 Graphs for Theis and Jacob Method Analysis (Well No.J-5)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº J-5) >







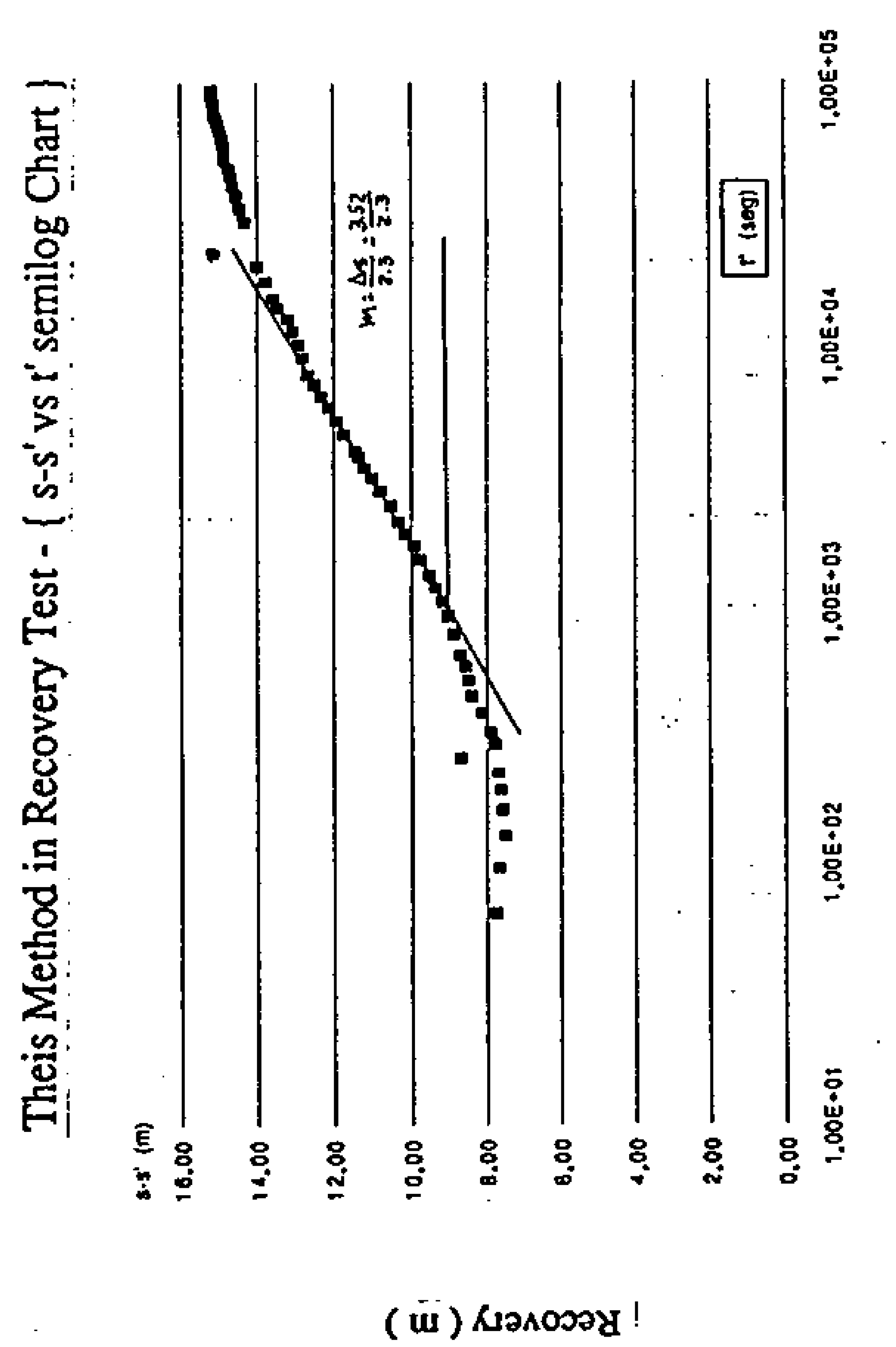


Fig. B-III, 2.3.31 Graphs for Theis and Jacob Method Analysis (Well No.J-6)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº.J-6) >

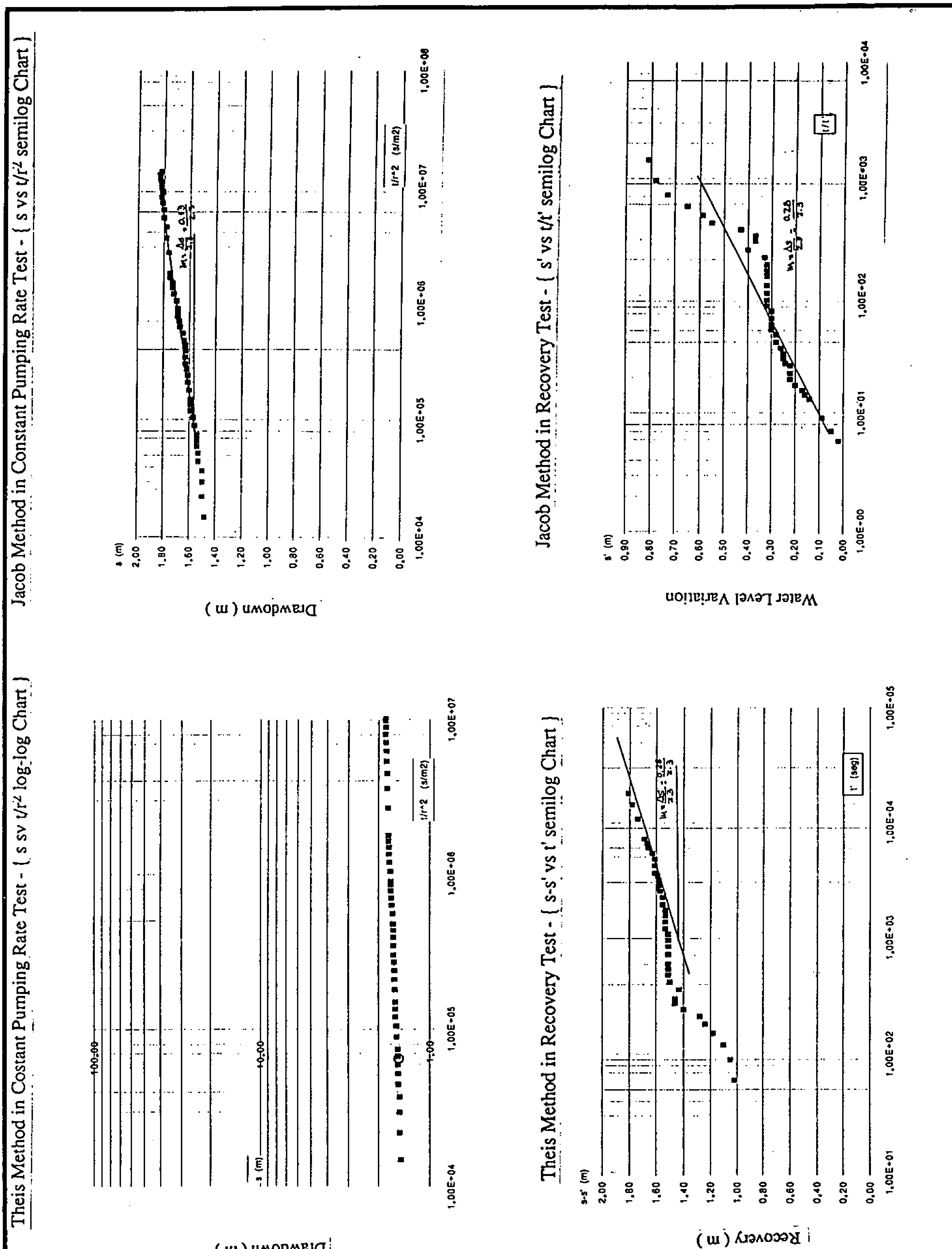


Fig. B-III, 2.3.32 Graphs for Theis and Jacob Method Analysis (Well No.J-7)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº J-7) >

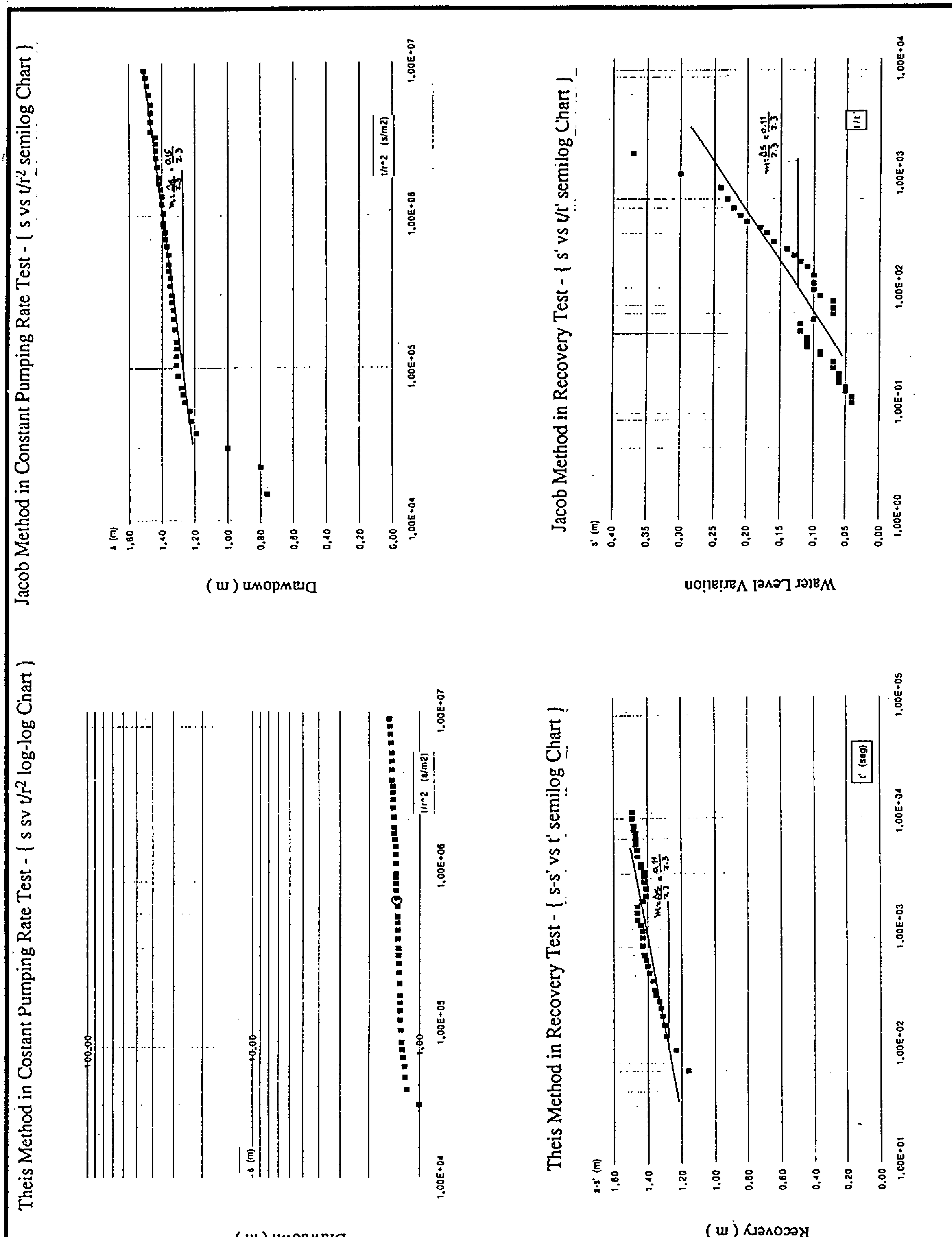


Fig. B-III, 2.3.33 Graphs for Theis and Jacob Method Analysis (Well No.J-8)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº J-8) >

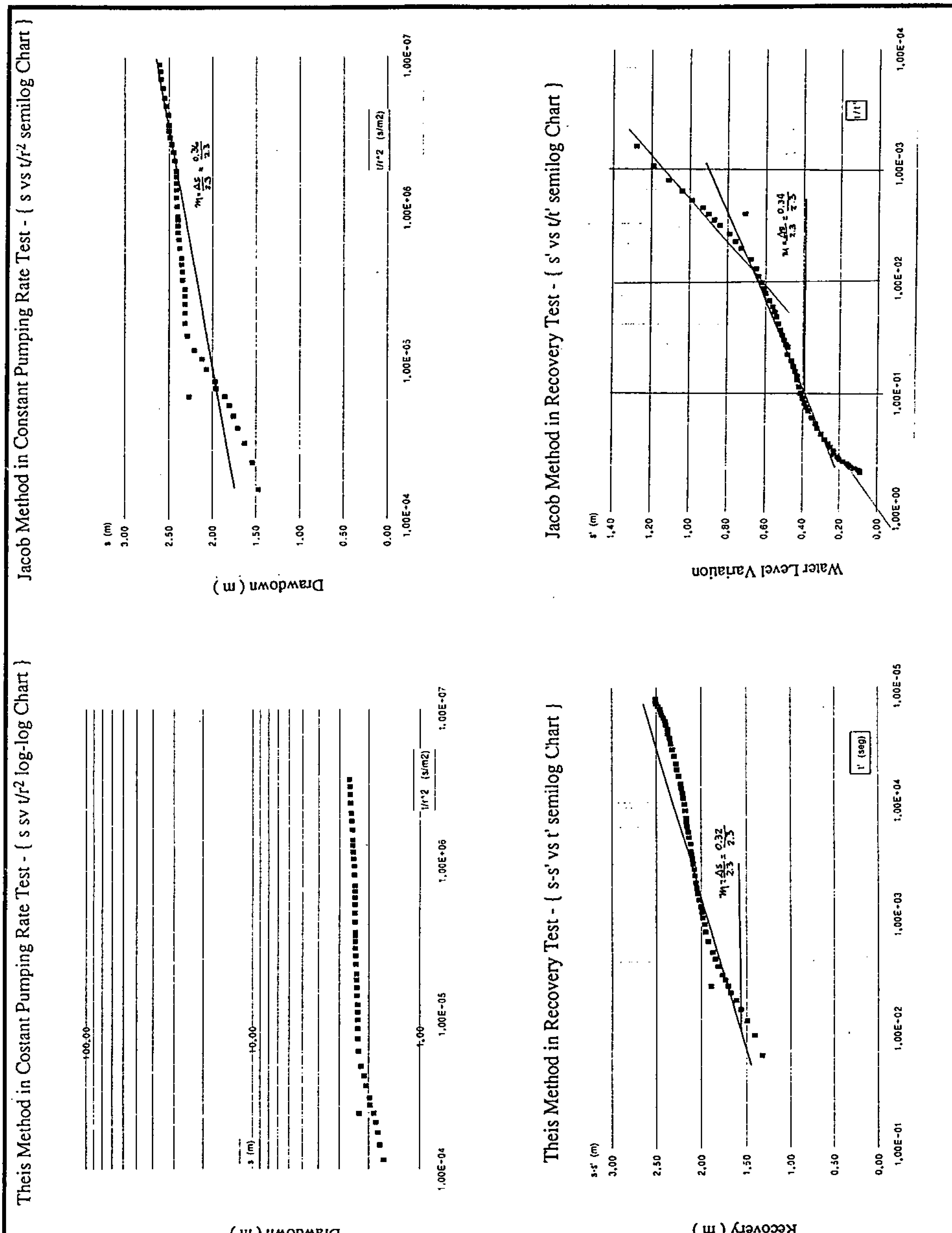
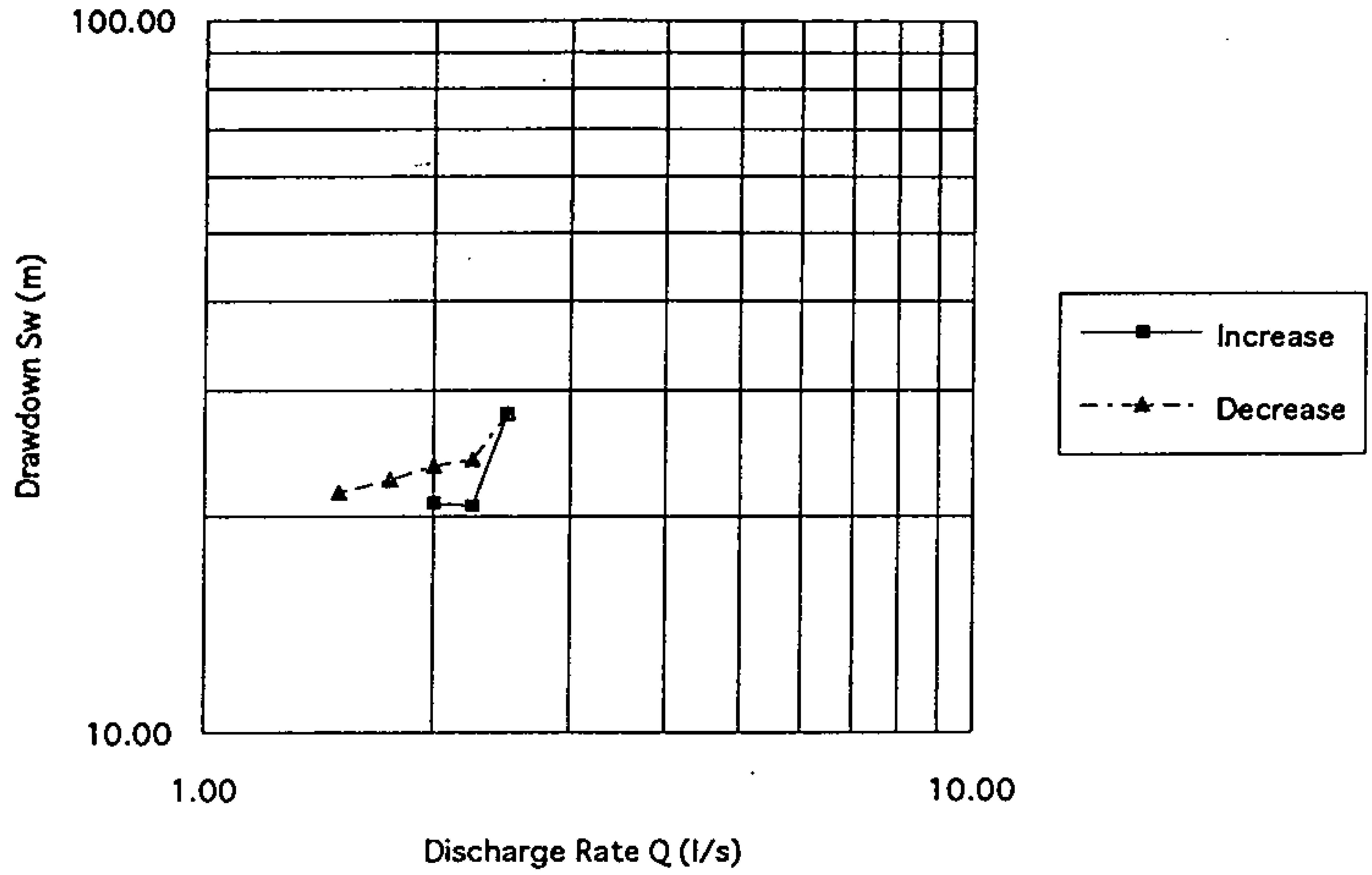


Fig. B-III, 2.3.34 Graphs for Theis and Jacob Method Analysis (Well No.J-9)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº J-9) >

Q - Sw Chart



Q - s/Q Chart

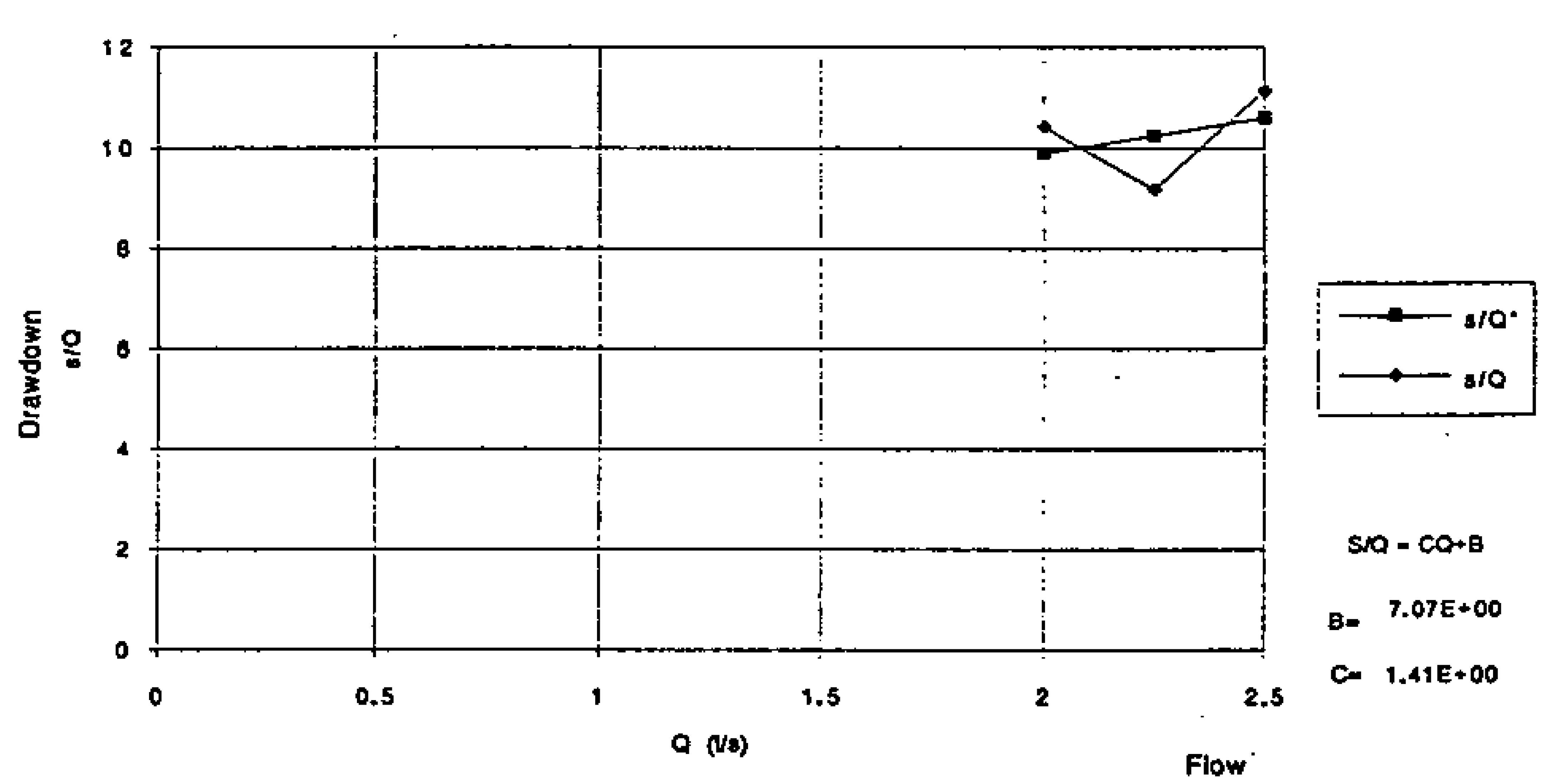
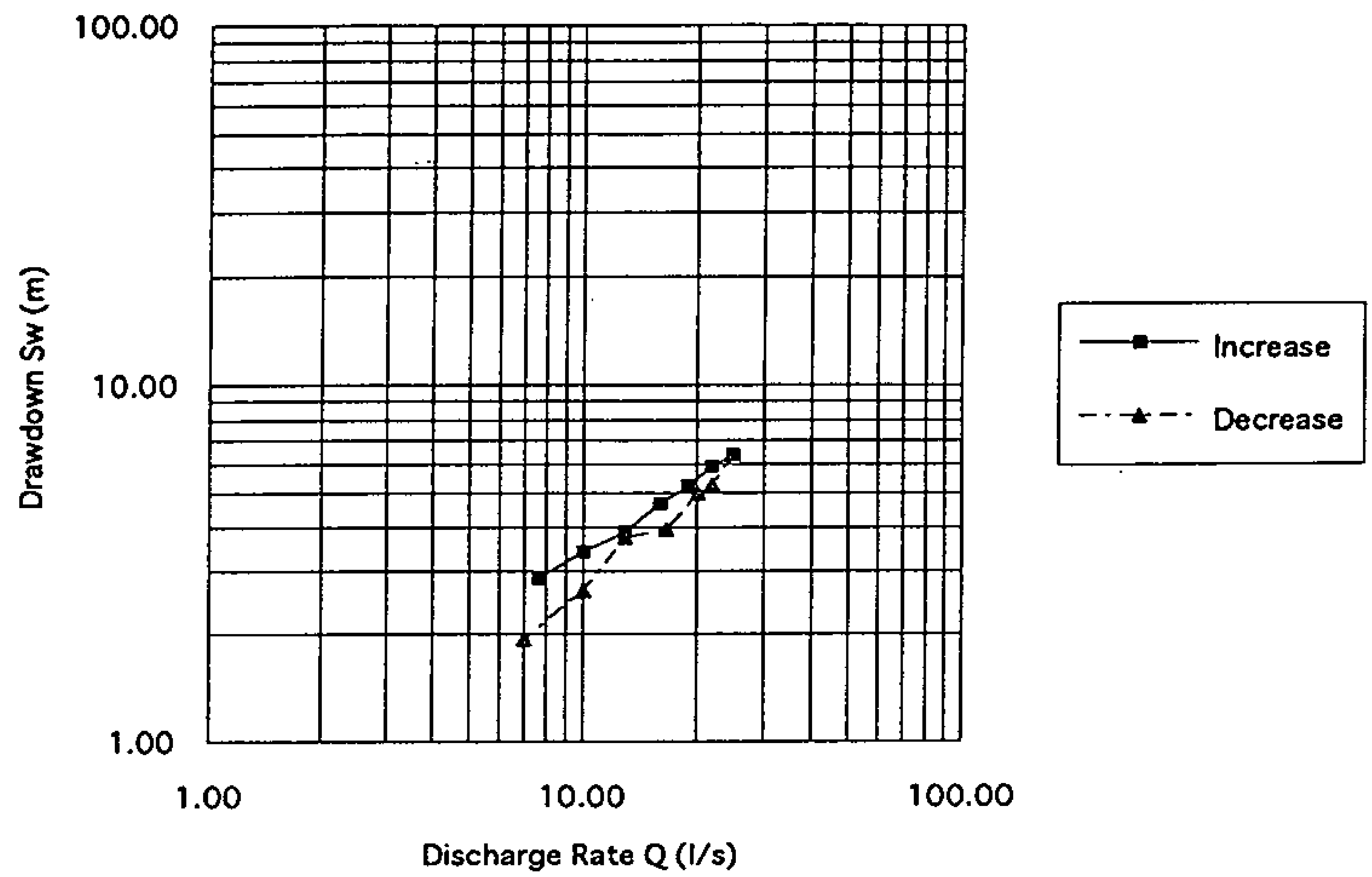


Fig. B-III, 2.3.35 Graphs for Step Drawdown Test (Well No.J-C)

< Gráficos Prueba de Gasto Variable (Pozo Nº J-C) >

Q - Sw Chart



Q - s/Q Chart

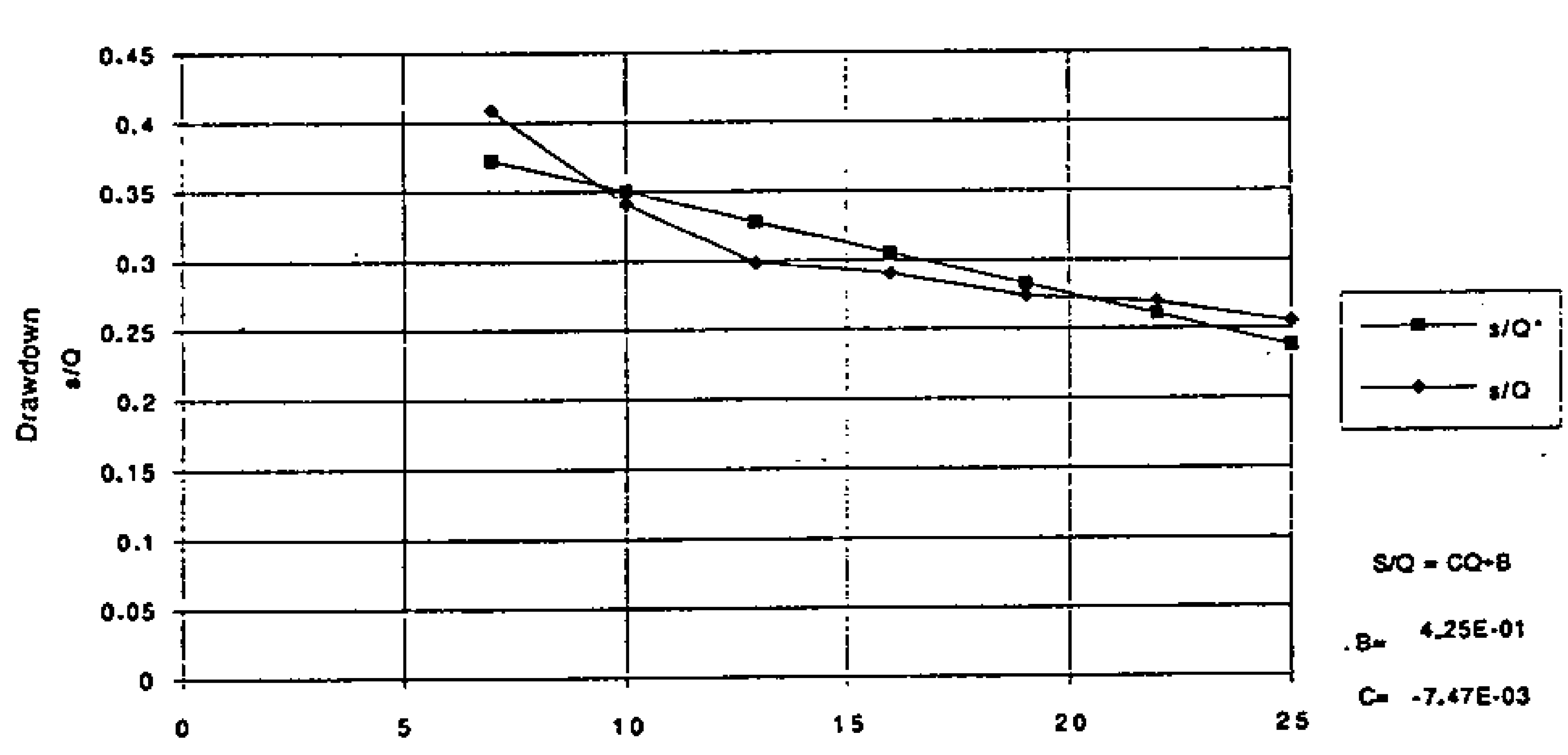
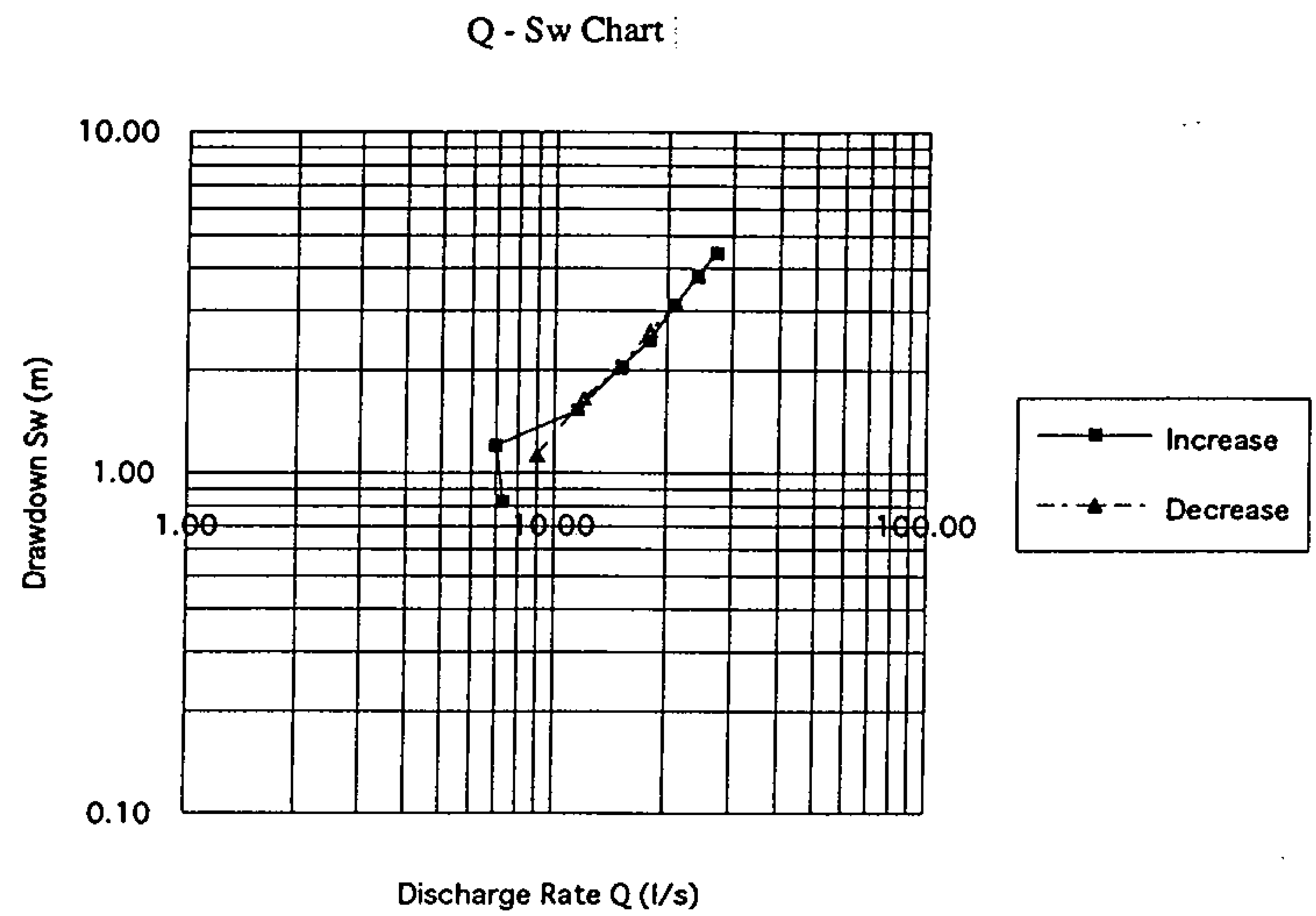


Fig. B-III, 2.3.36 Graphs for Step Drawdown Test (Well No.J-D)

< Gráficos Prueba de Gasto Variable (Pozo Nº.J-D) >



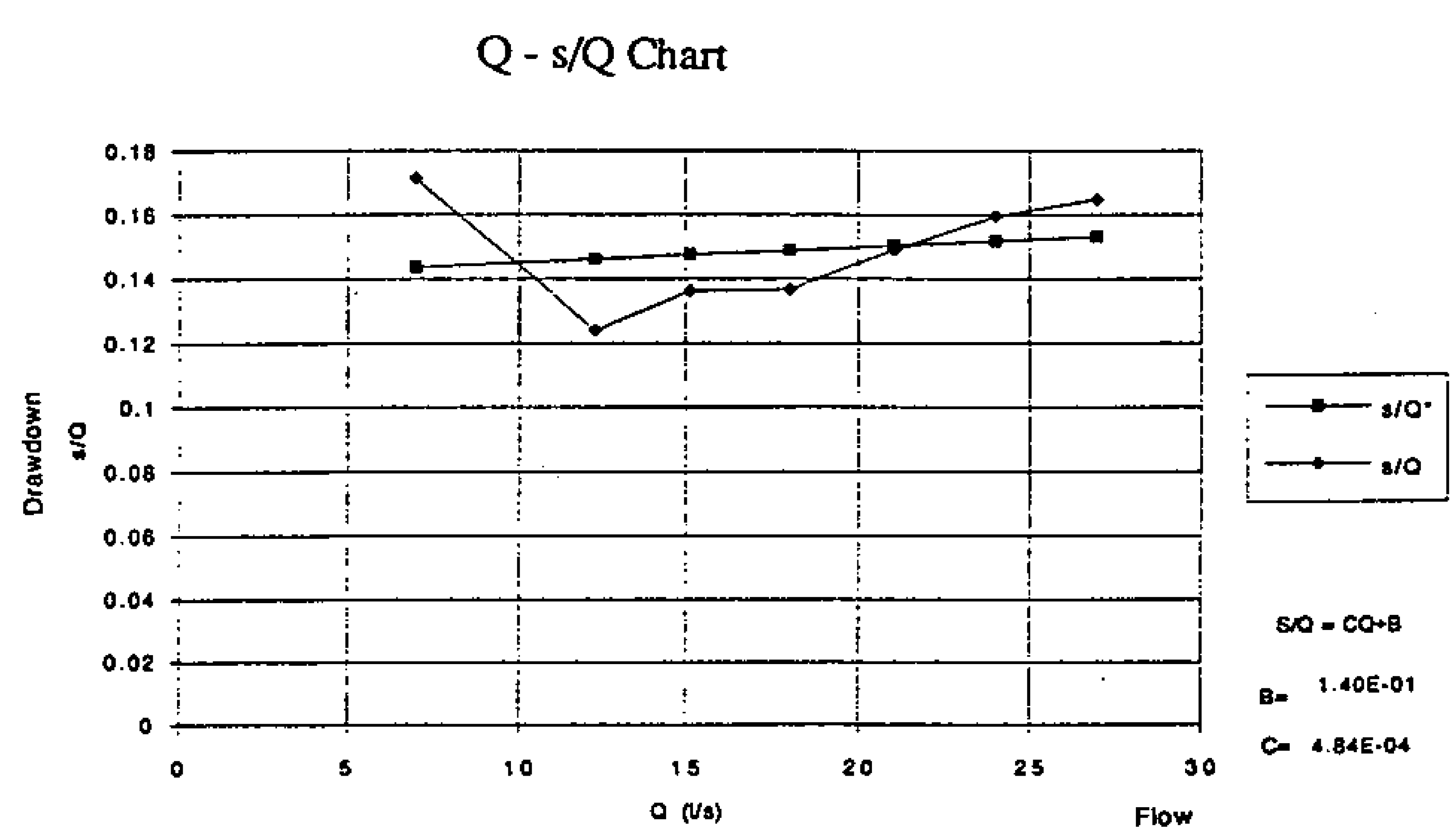
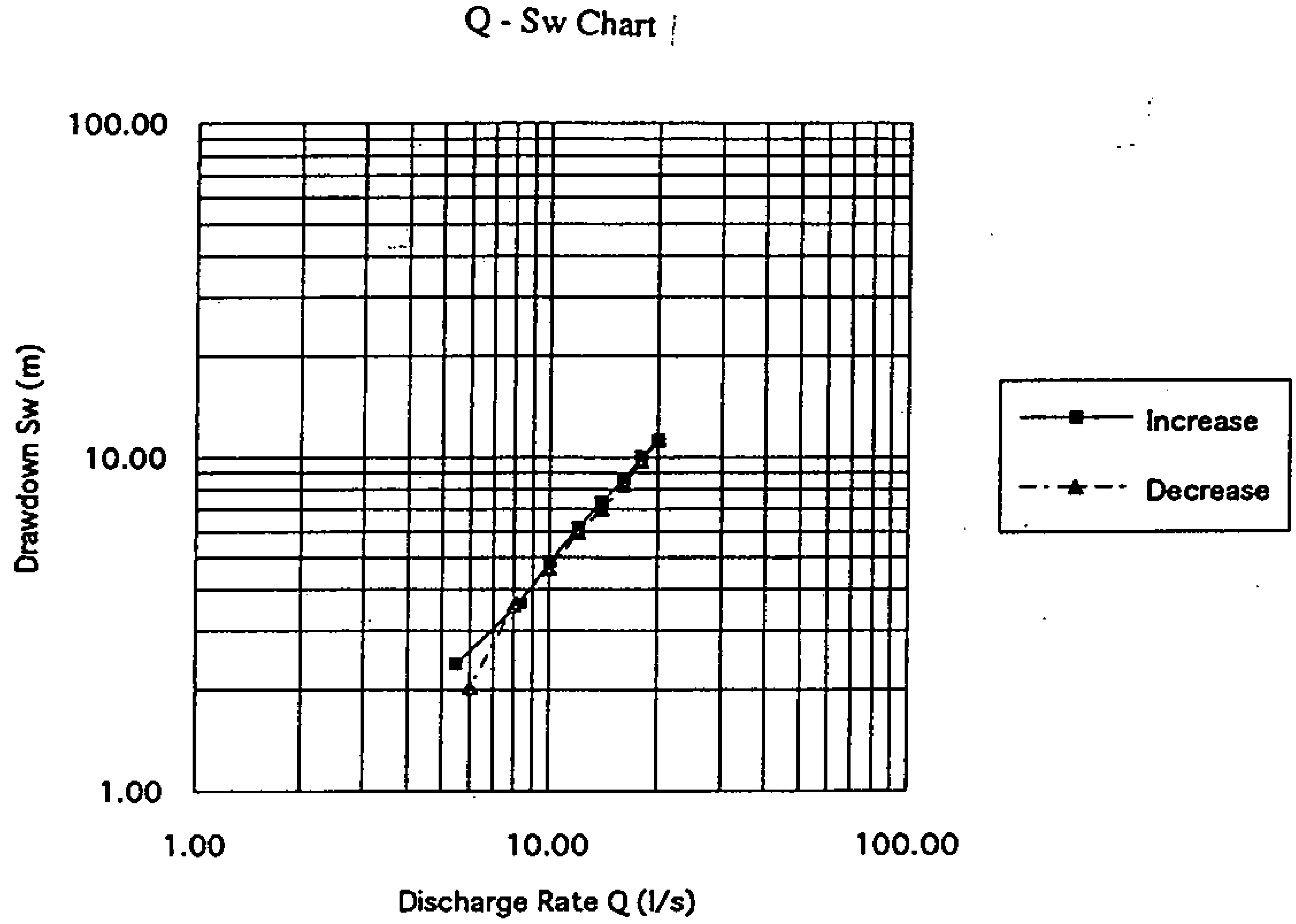


Fig. B-III, 2.3.37 Graphs for Step Drawdown Test (Well No.J-E)

< Gráficos Prueba de Gasto Variable (Pozo Nº.J-E) >



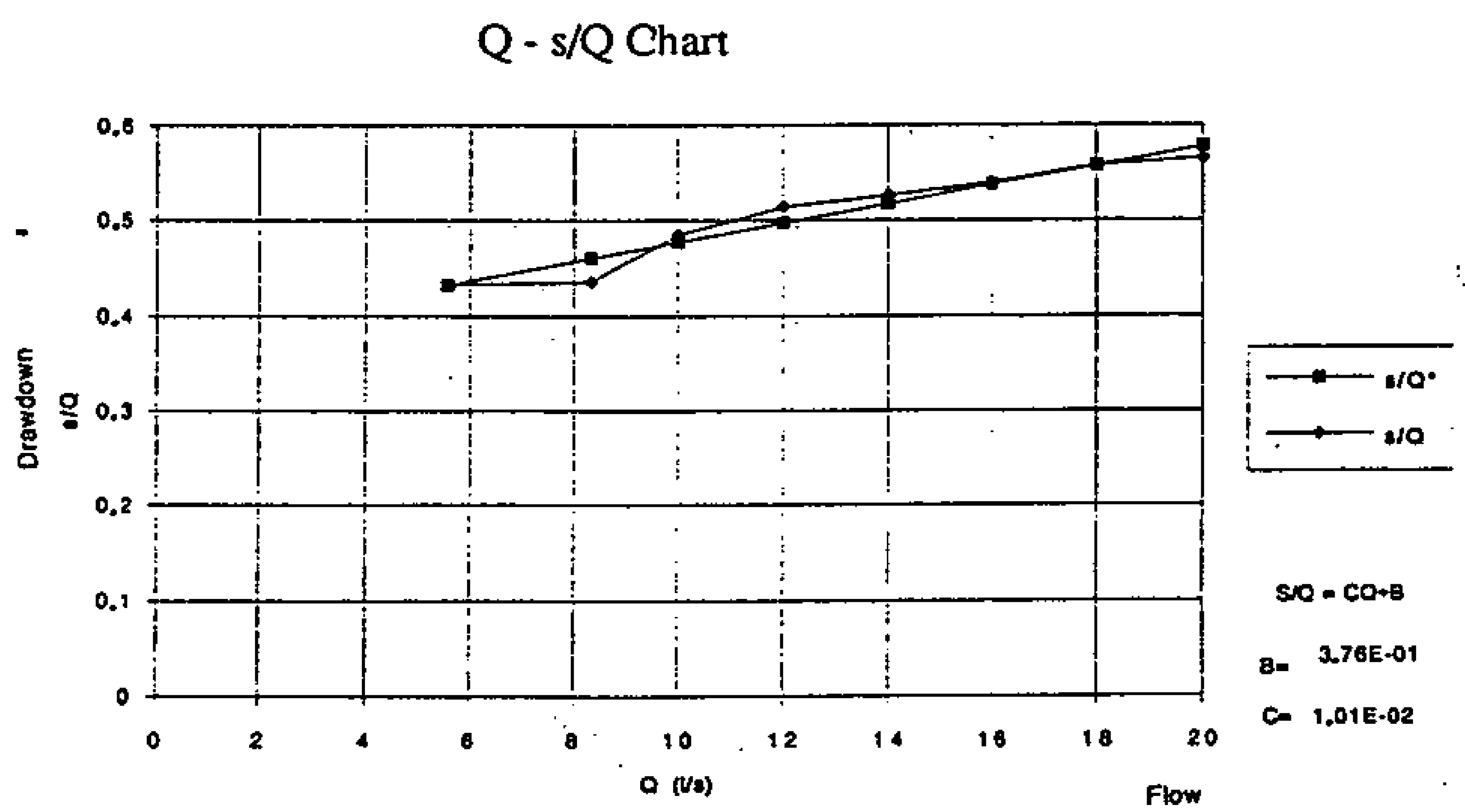
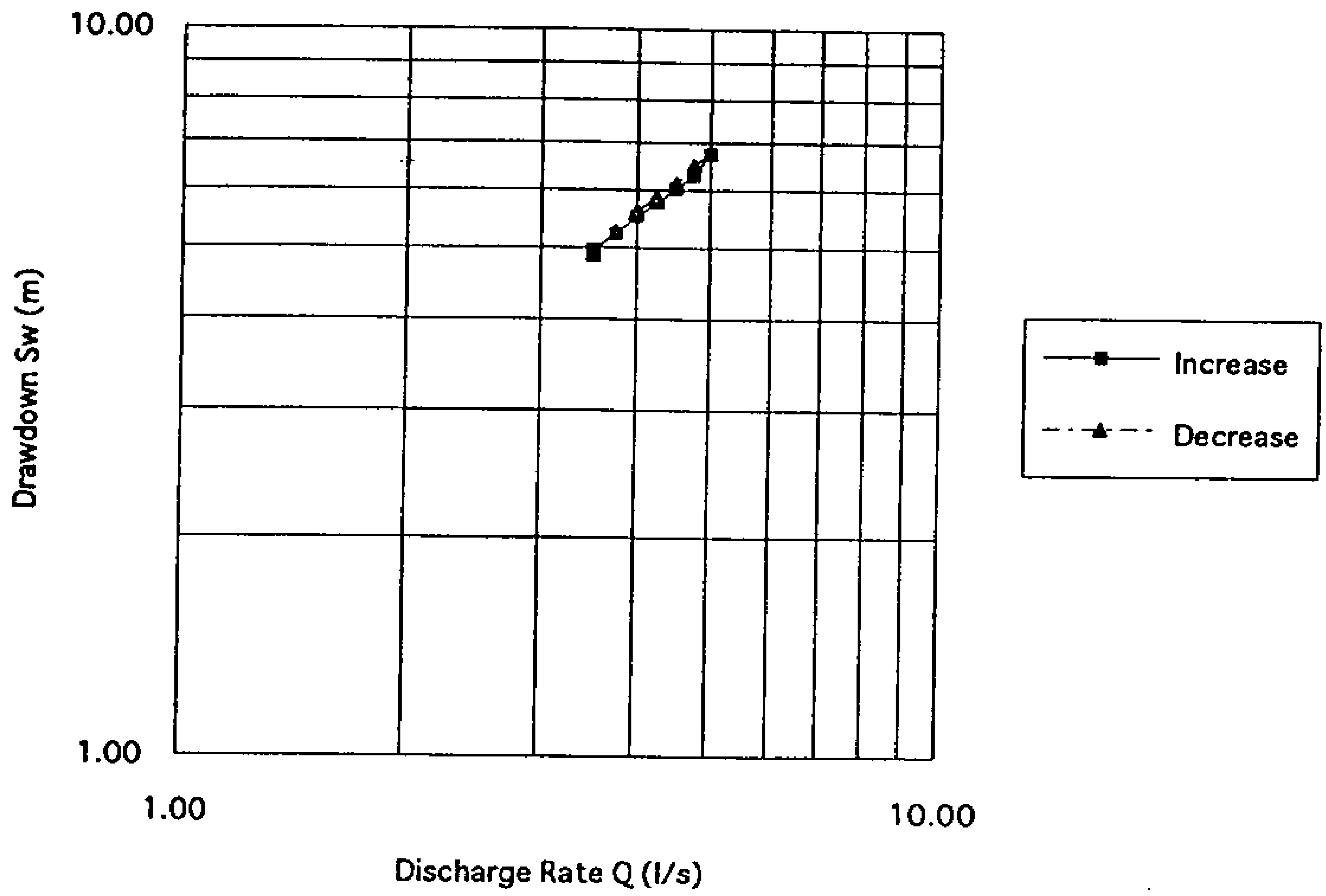


Fig. B-III, 2.3.38 Graphs for Step Drawdown Test (Well No.J-F)

< Gráficos Prueba de Gasto Variable (Pozo Nº J-F) >

Q - Sw Chart



Q - s/Q Chart

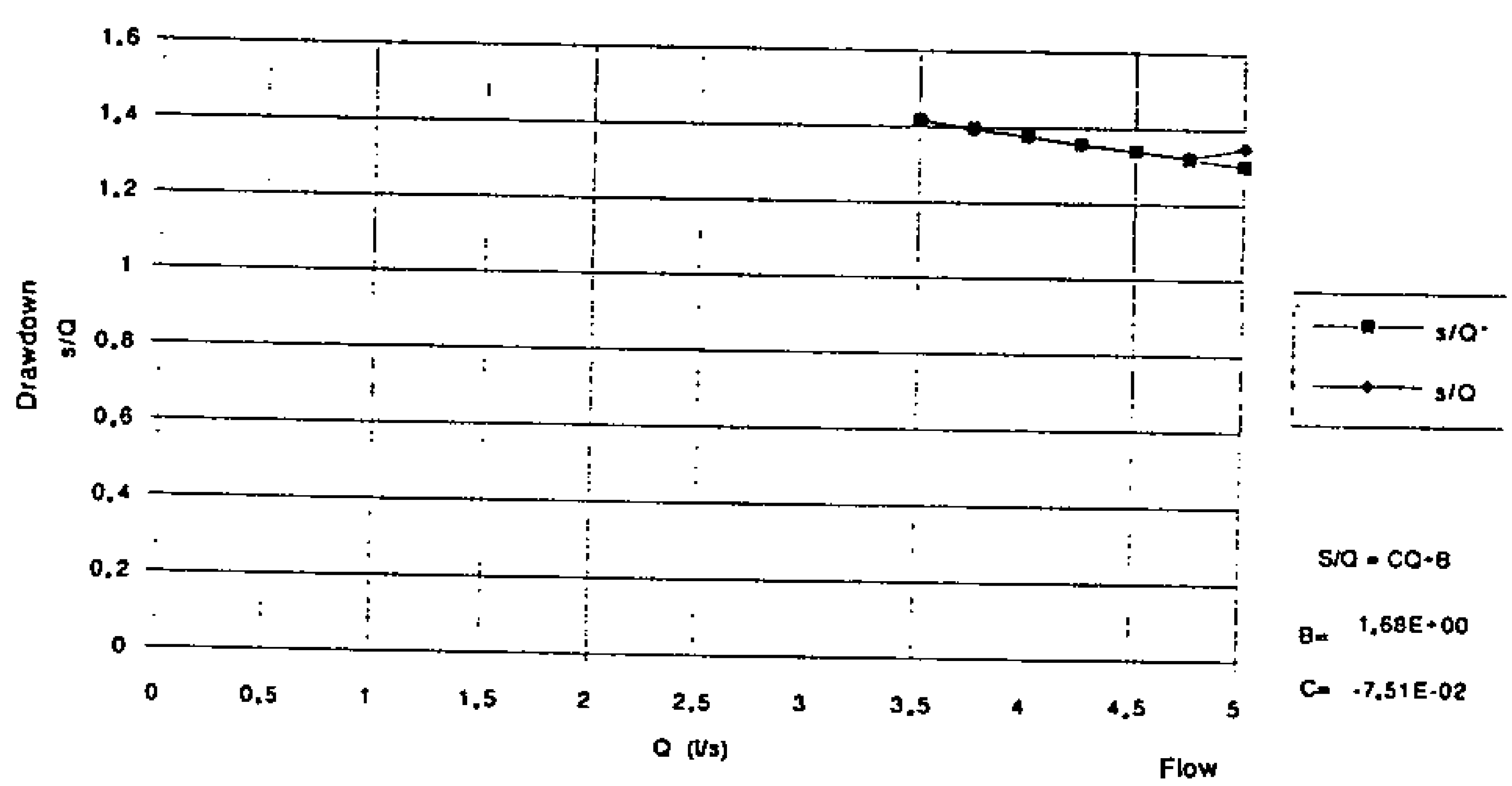
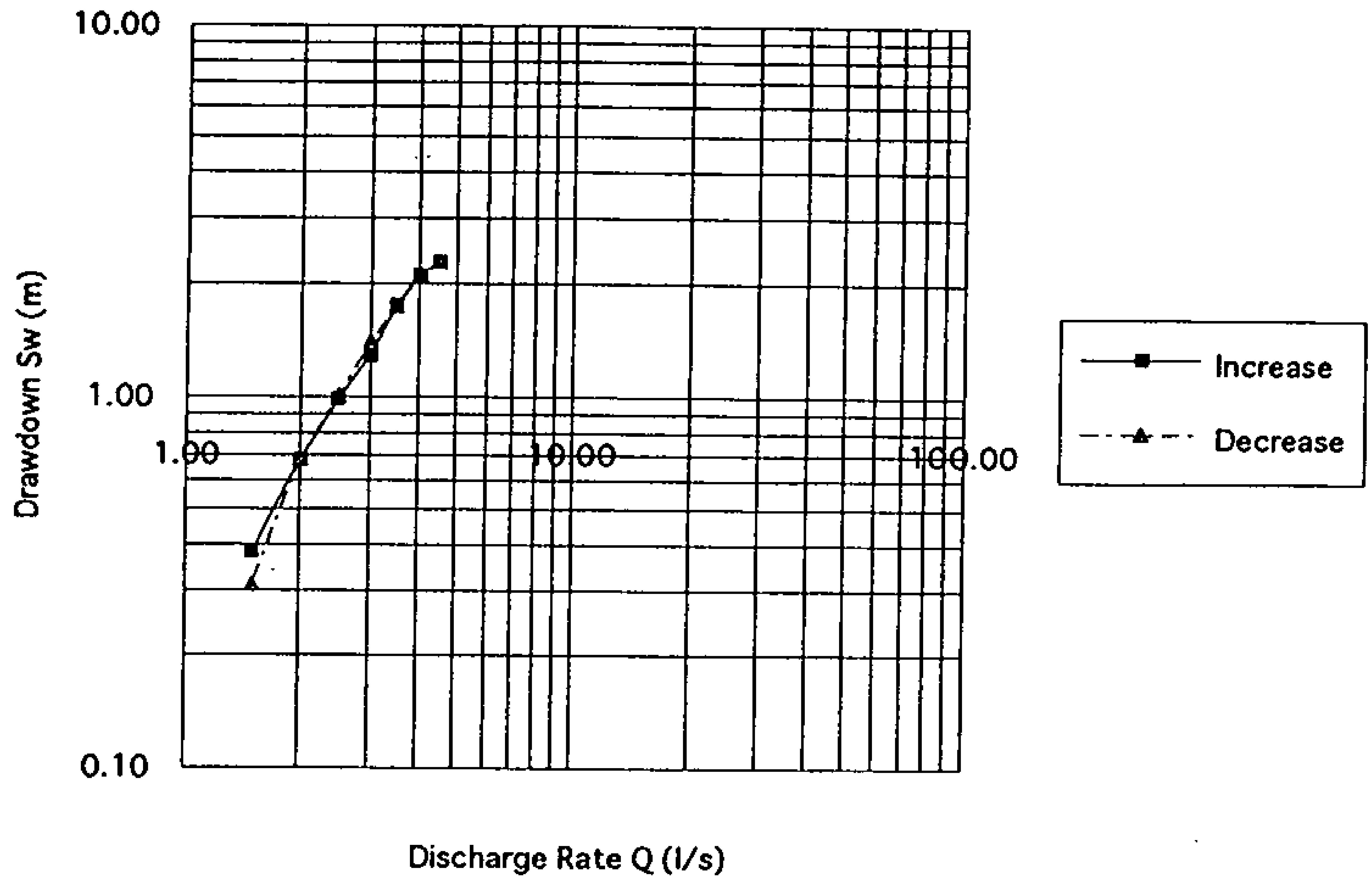


Fig. B-III, 2.3.39 Graphs for Step Drawdown Test (Well No.J-3)

< Gráficos Prueba de Gasto Variable (Pozo Nº.J-3) >

Q - Sw Chart



Q - s/Q Chart

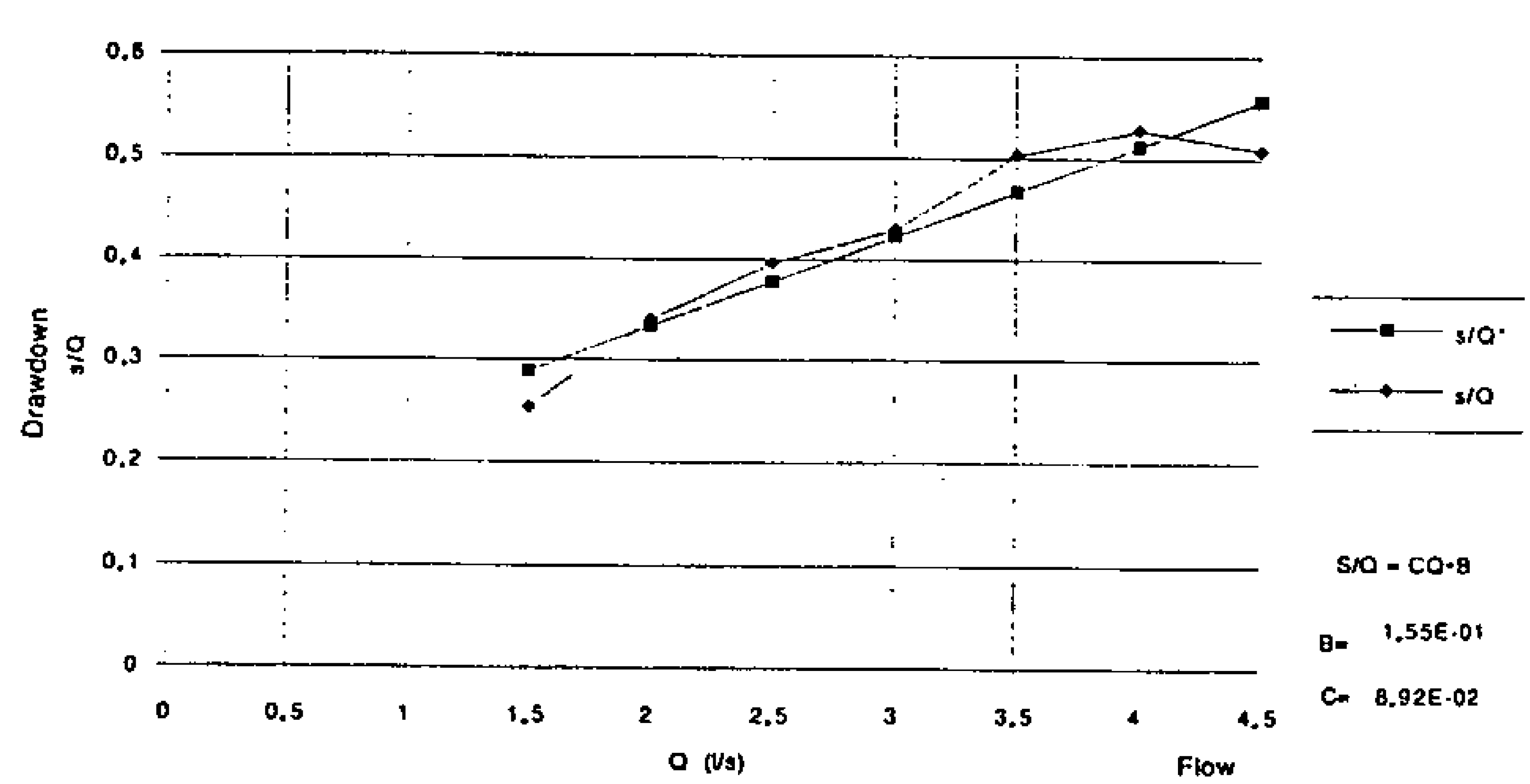
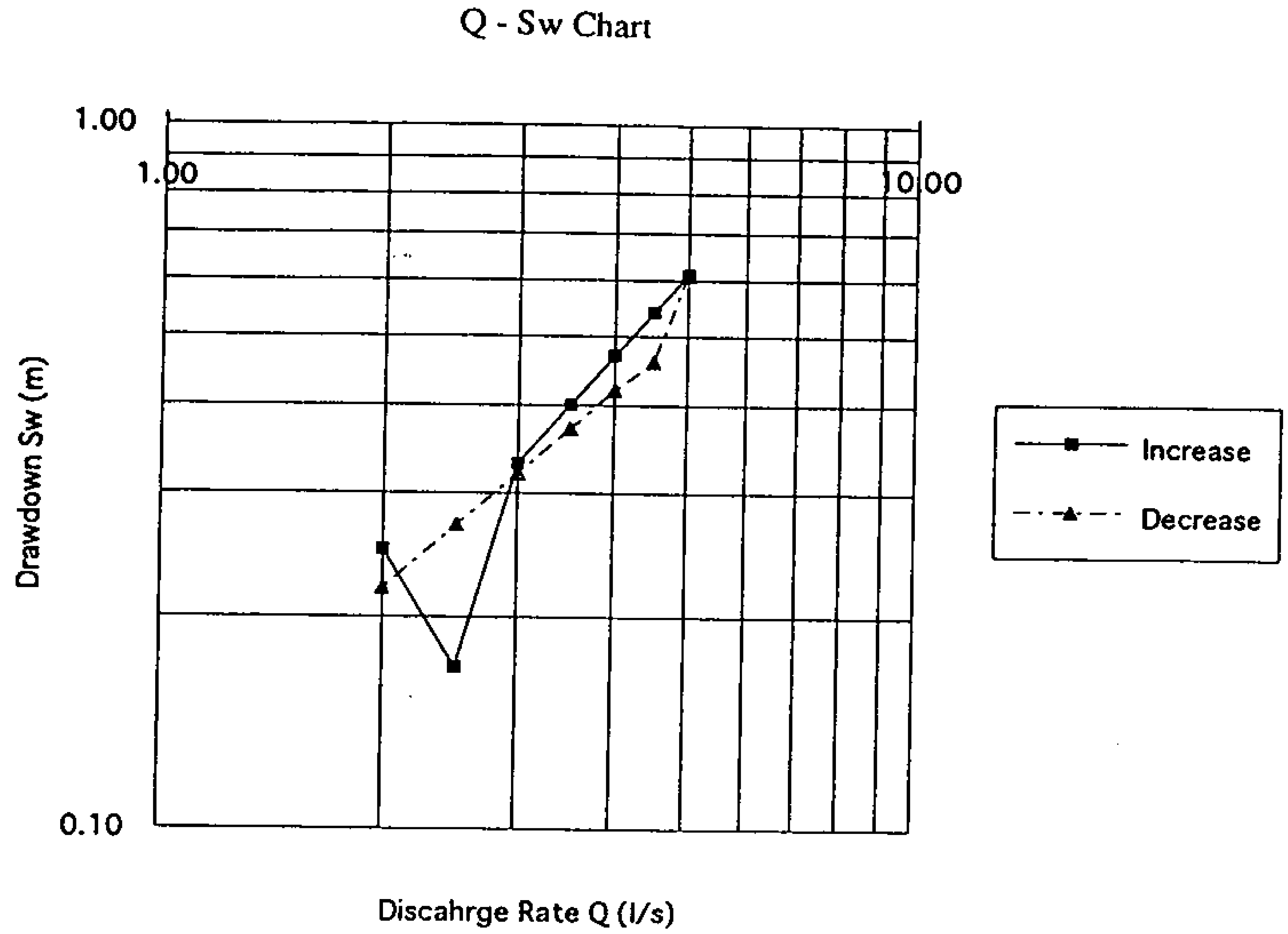


Fig. B-III, 2.3.40 Graphs for Step Drawdown Test (Well No.J-4)

< Gráficos Prueba de Gasto Variable (Pozo Nº.J-4) >



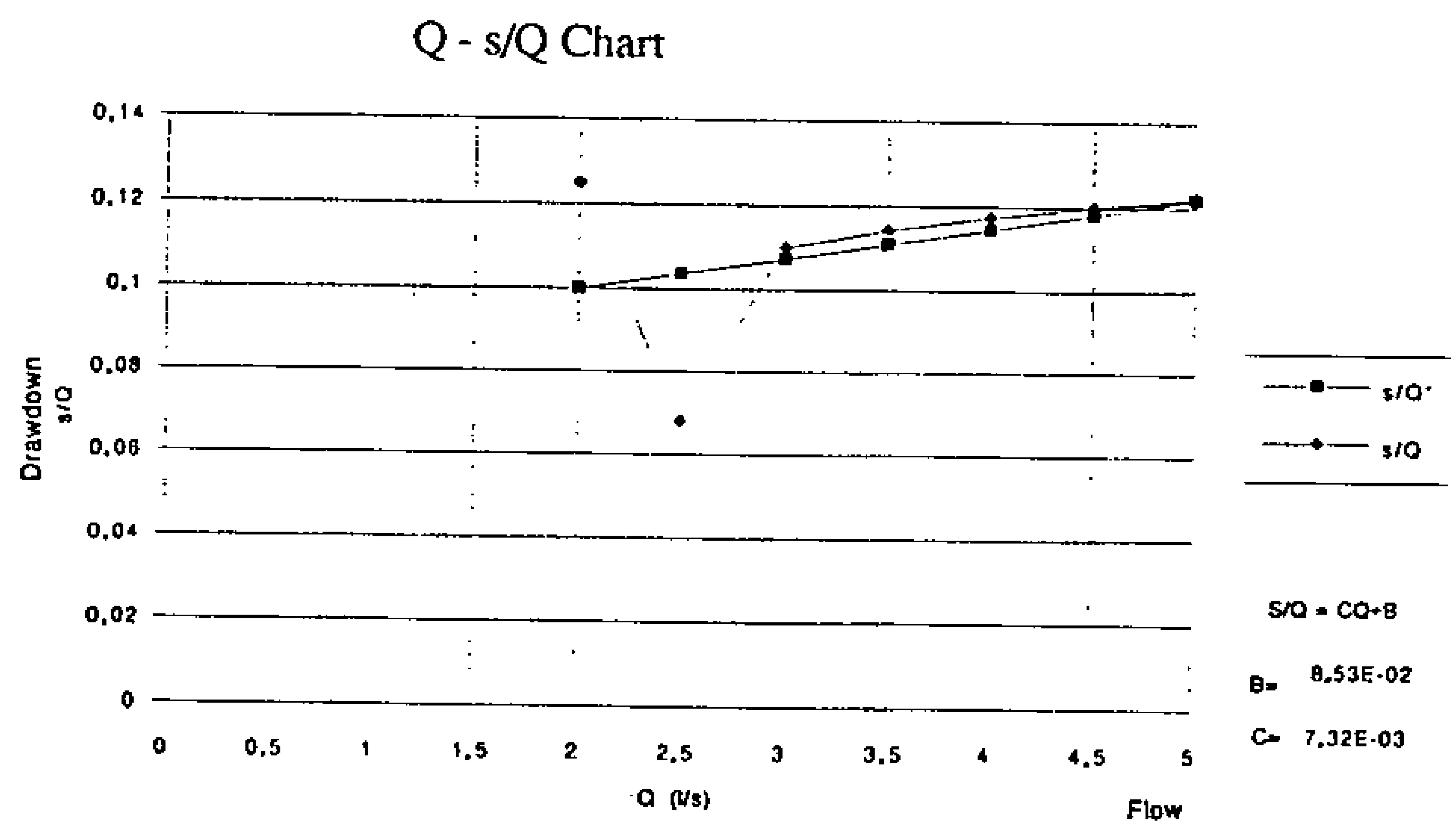
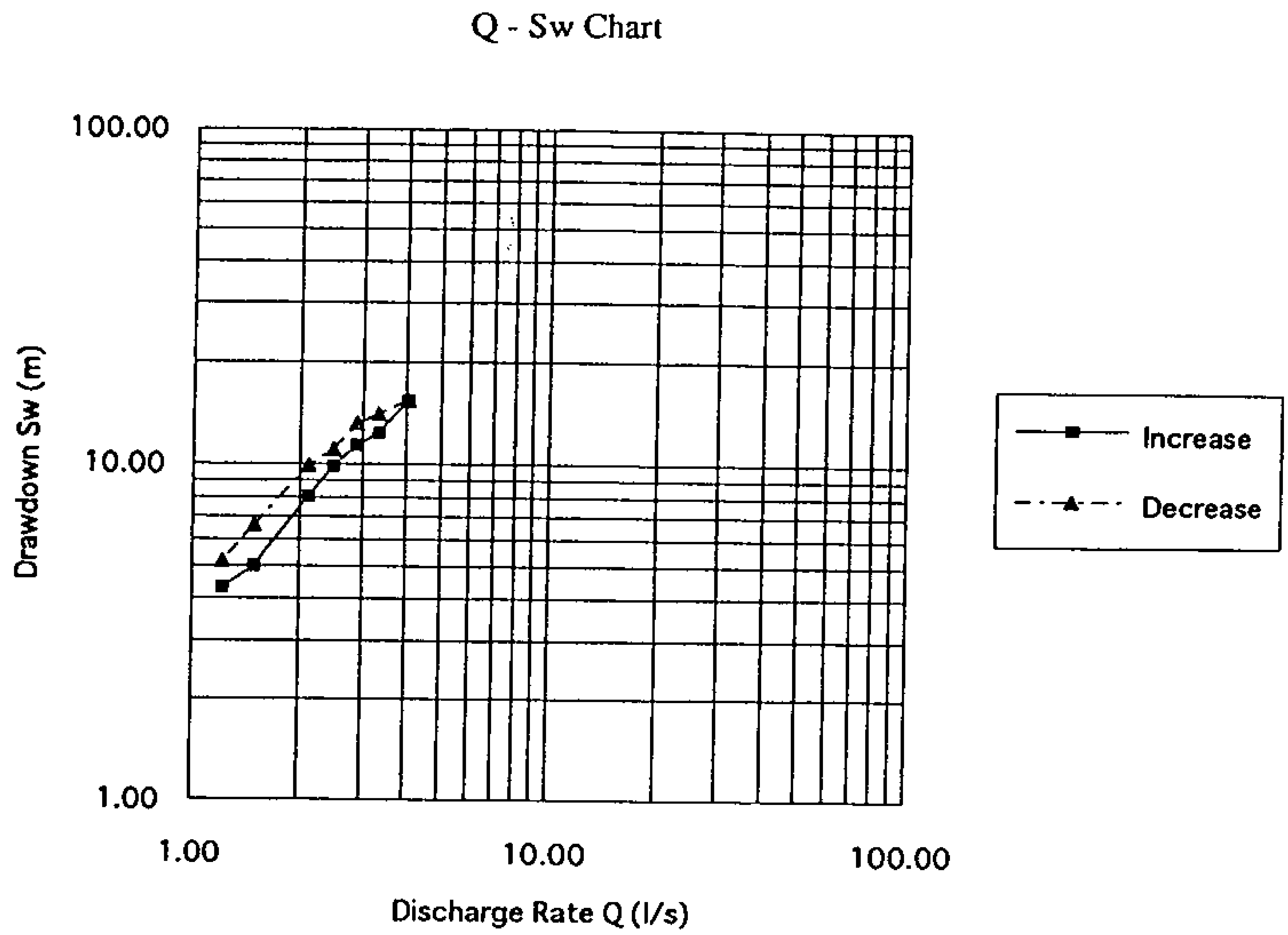


Fig. B-III, 2.3.41 Graphs for Step Drawdown Test (Well No.J-5)

< Gráficos Prueba de Gasto Variable (Pozo Nº J-5) >



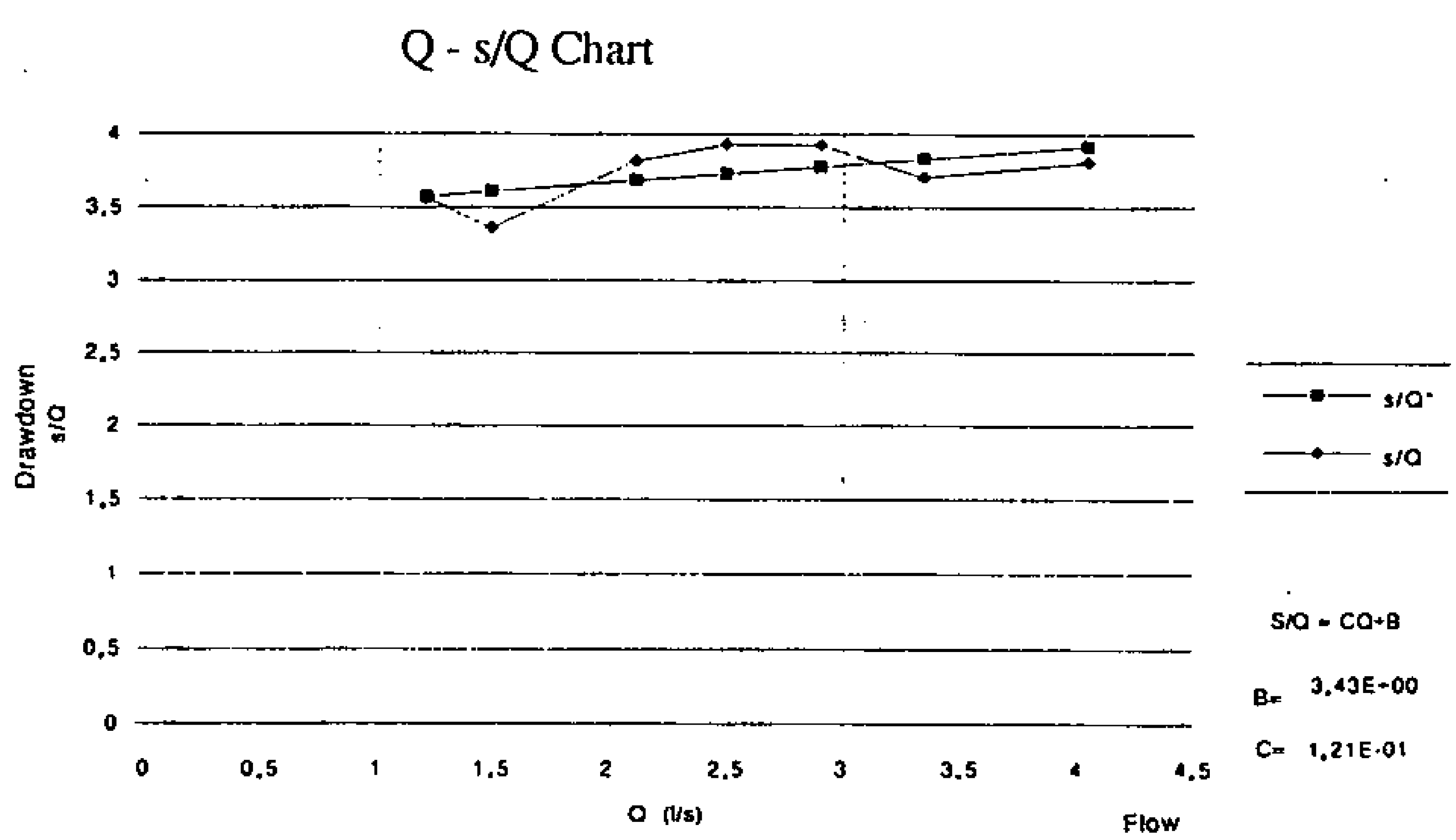
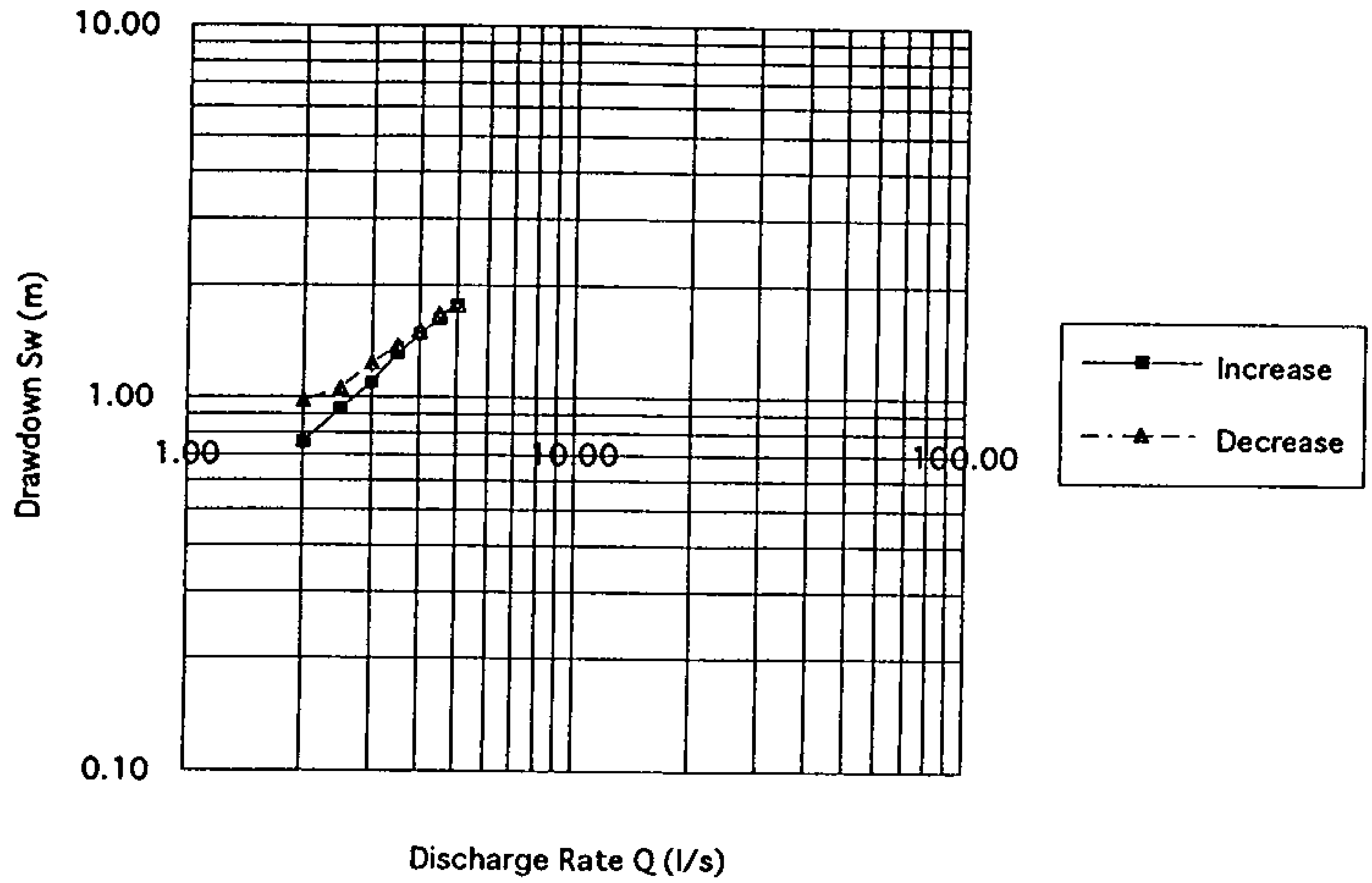


Fig. B-III, 2.3.42 Graphs for Step Drawdown Test (Well No.J-6)

< Gráficos Prueba de Gasto Variable (Pozo Nº J-6) >

Q - Sw Chart



Q - s/Q Chart

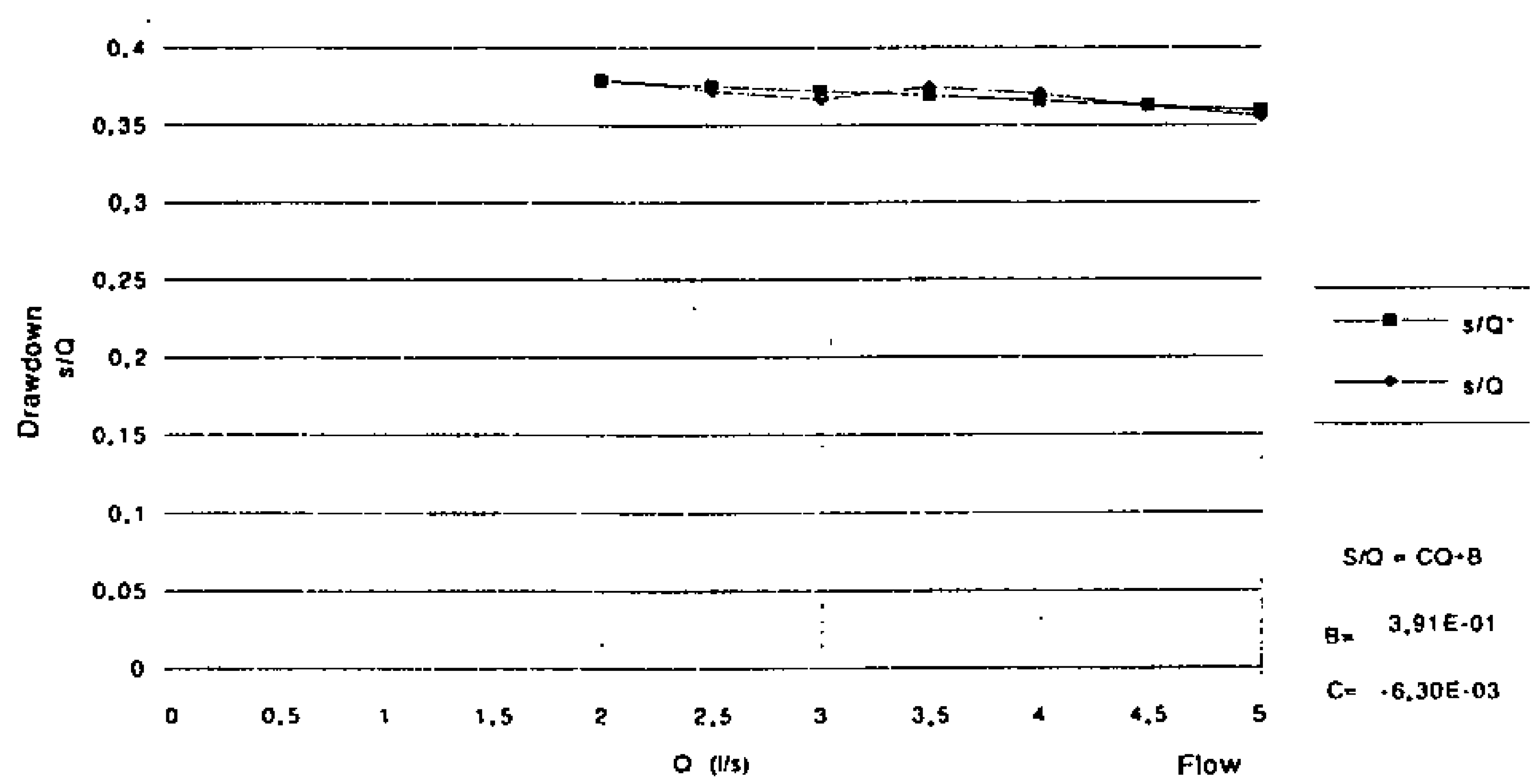
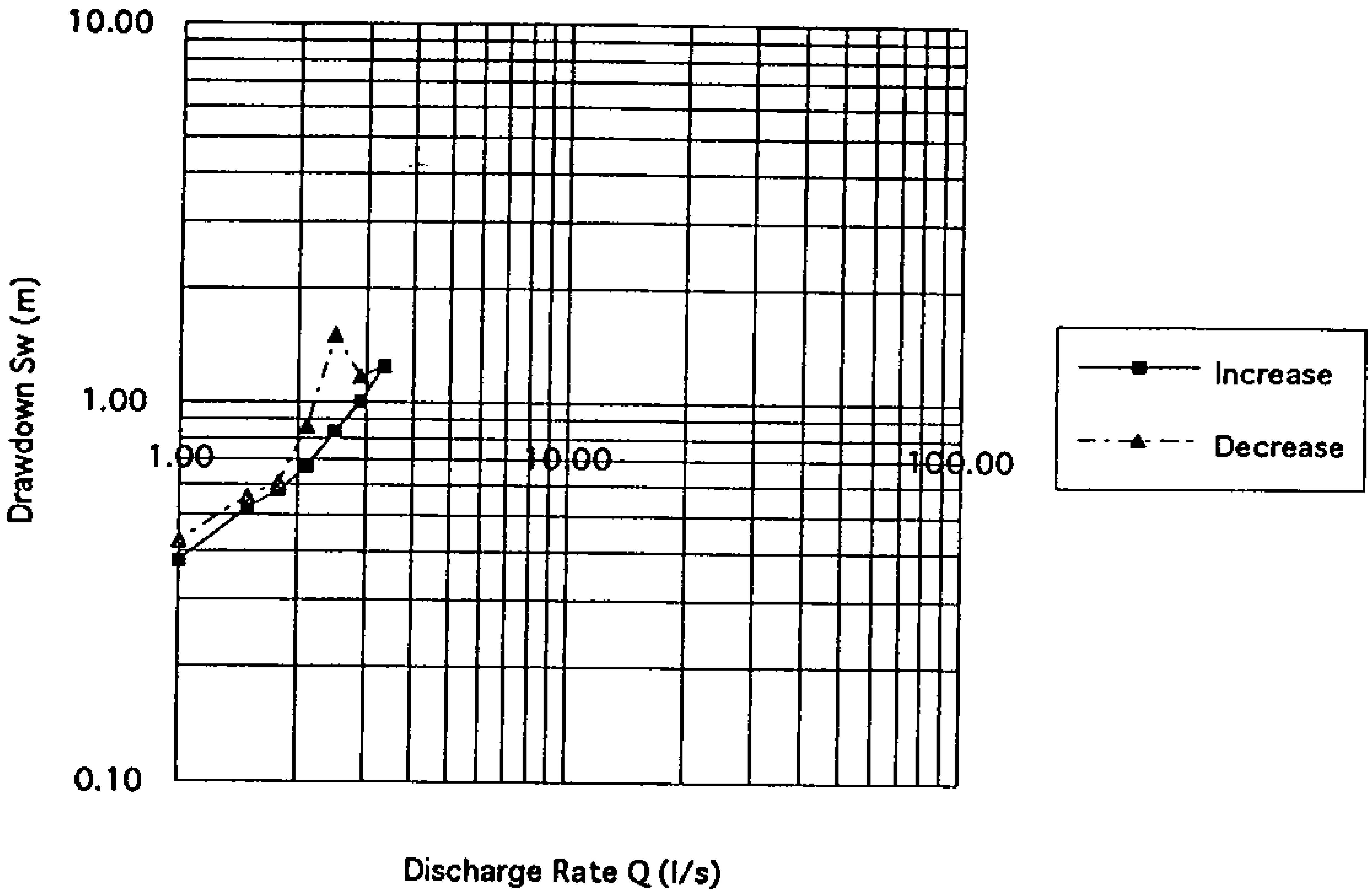


Fig. B-III, 2.3.43 Graphs for Step Drawdown Test (Well No.J-7)

< Gráficos Prueba de Gasto Variable (Pozo Nº J-7) >

Q - Sw Chart



Q - s/Q Chart

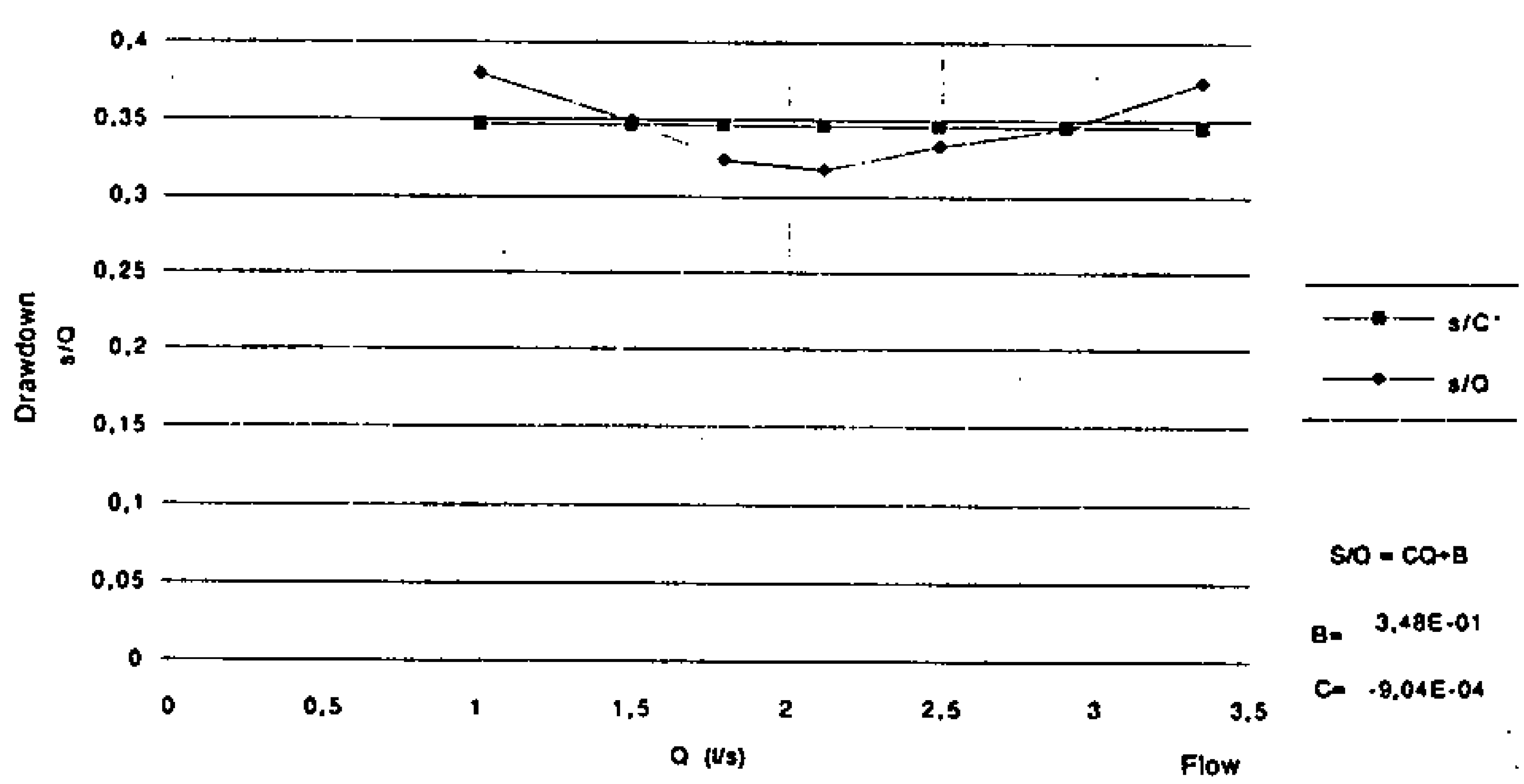
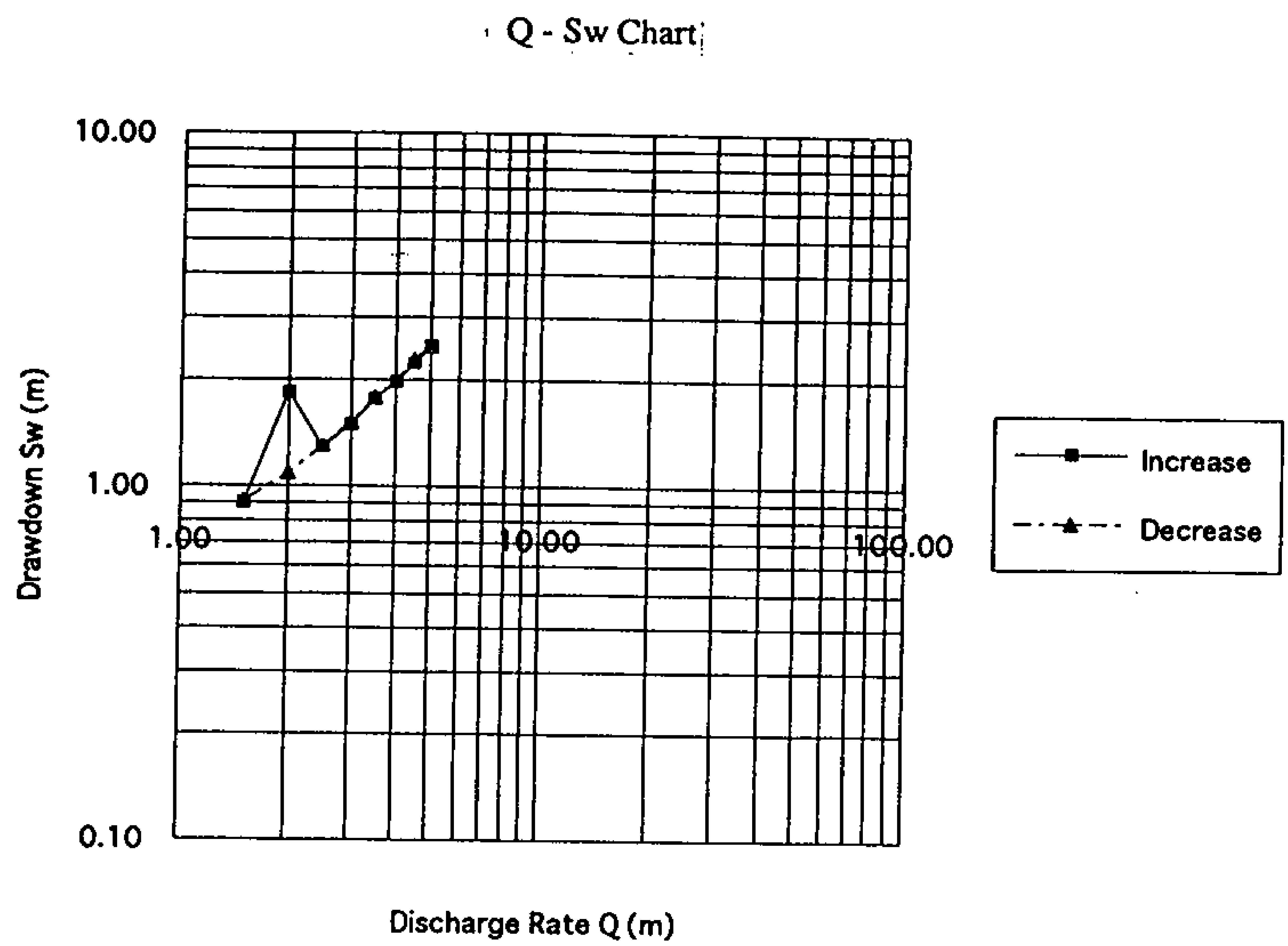


Fig. B-III, 2.3.44 Graphs for Step Drawdown Test (Well No.J-8)

< Gráficos Prueba de Gasto Variable (Pozo Nº J-8) >



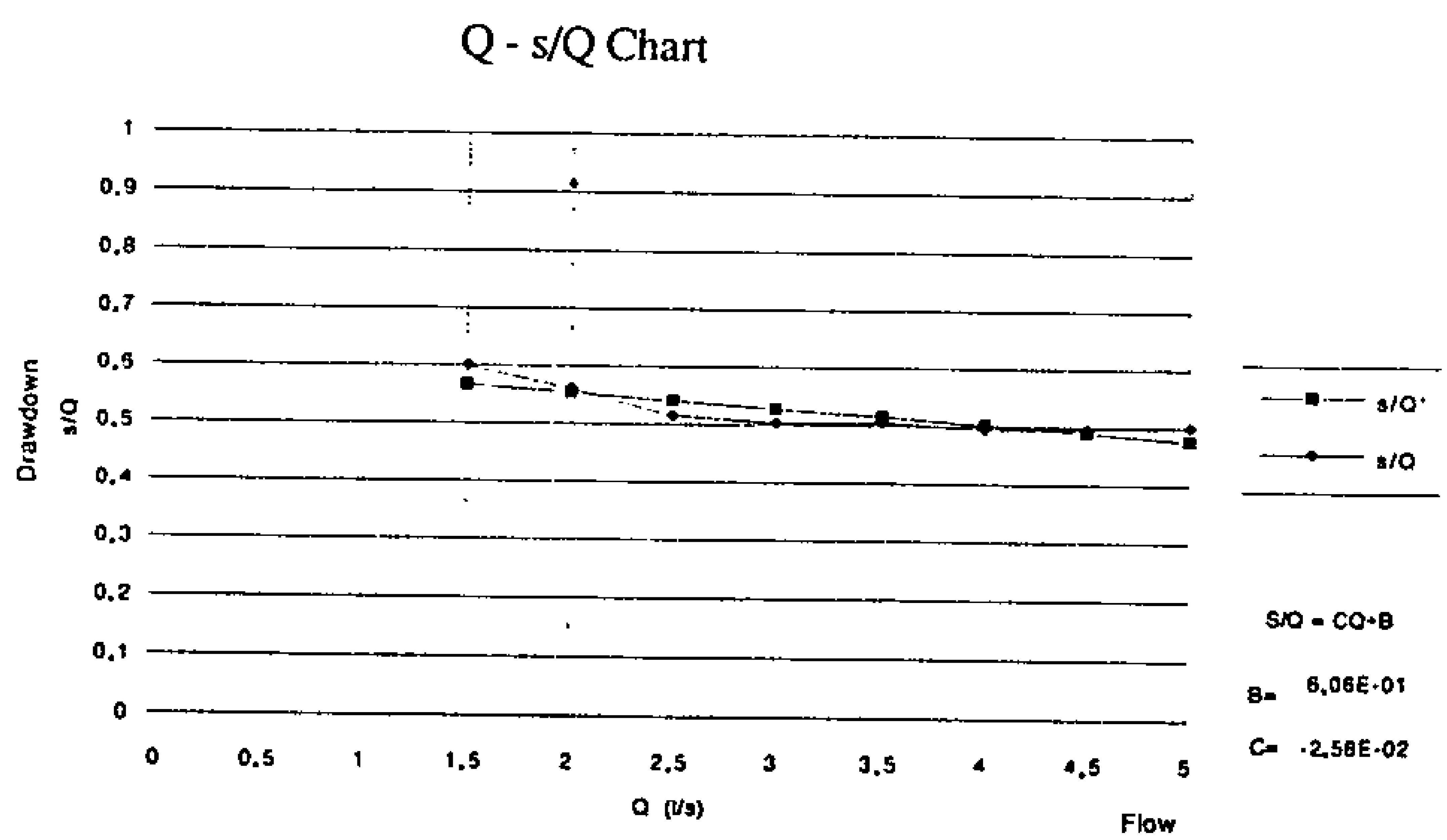


Fig. B-III, 2.3.45 Graphs for Step Drawdown Test (Well No.J-9)

< Gráficos Prueba de Gasto Variable (Pozo Nº J-9) >

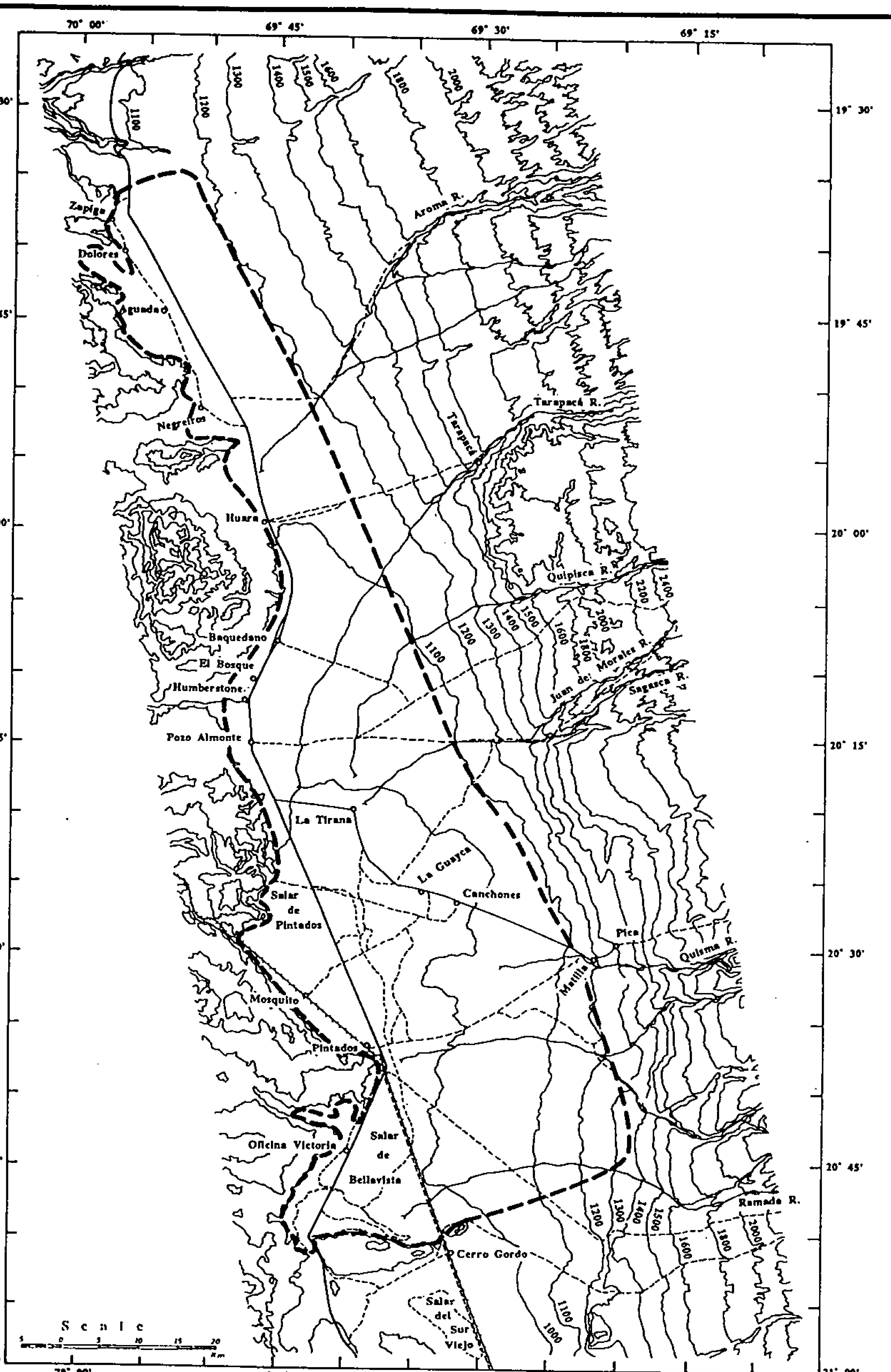


Fig. B-III, 2.4.1 Aquifer Area (Pampa del Tamarugal)
< Area del Aquífero (Pampa del Tamarugal)

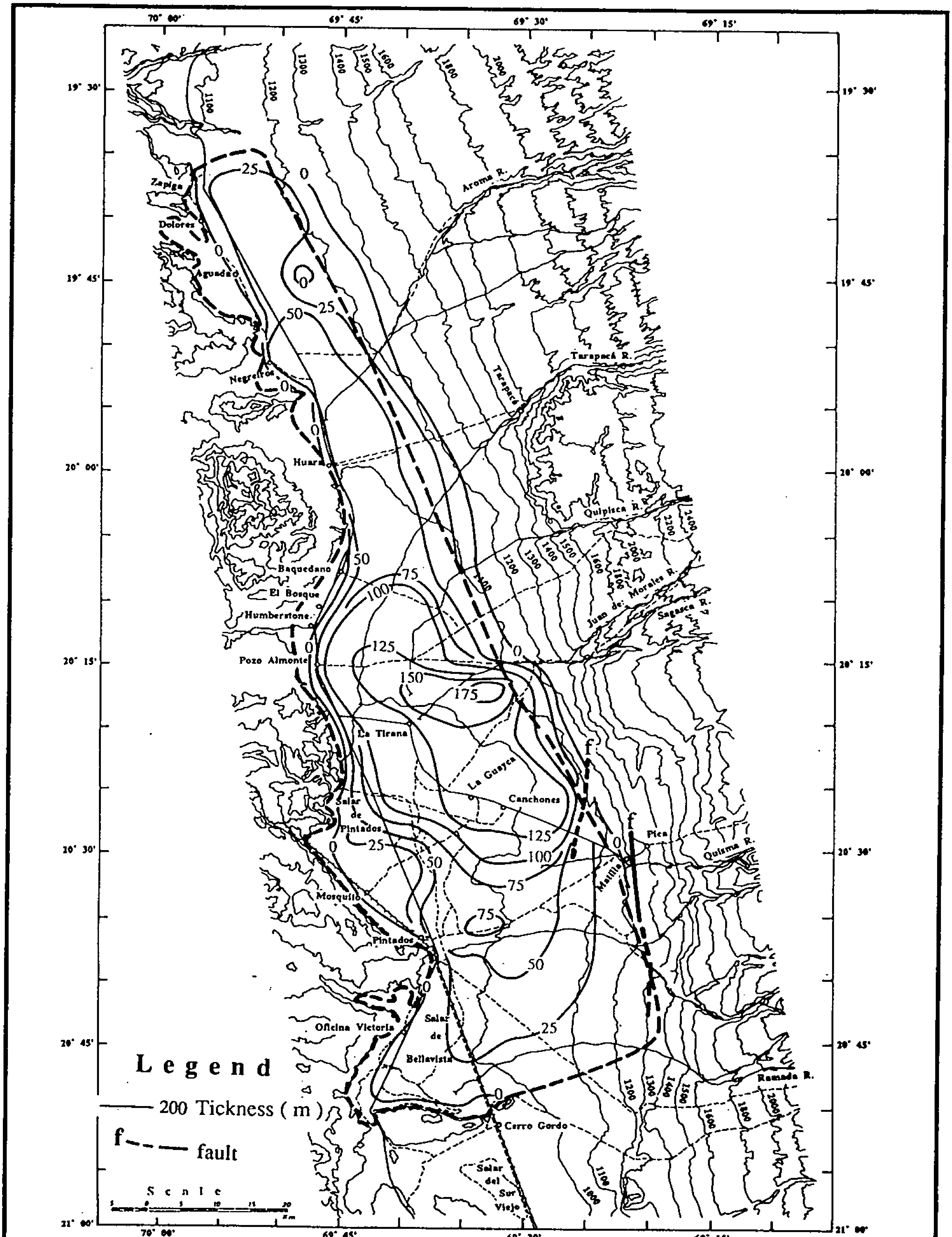


Fig. B-III, 2.4.2 Isopach Map of Aquifer (Pampa del Tamarugal)

< Mapa Isopaca Acuífero (Pampa del Tmarugal) >

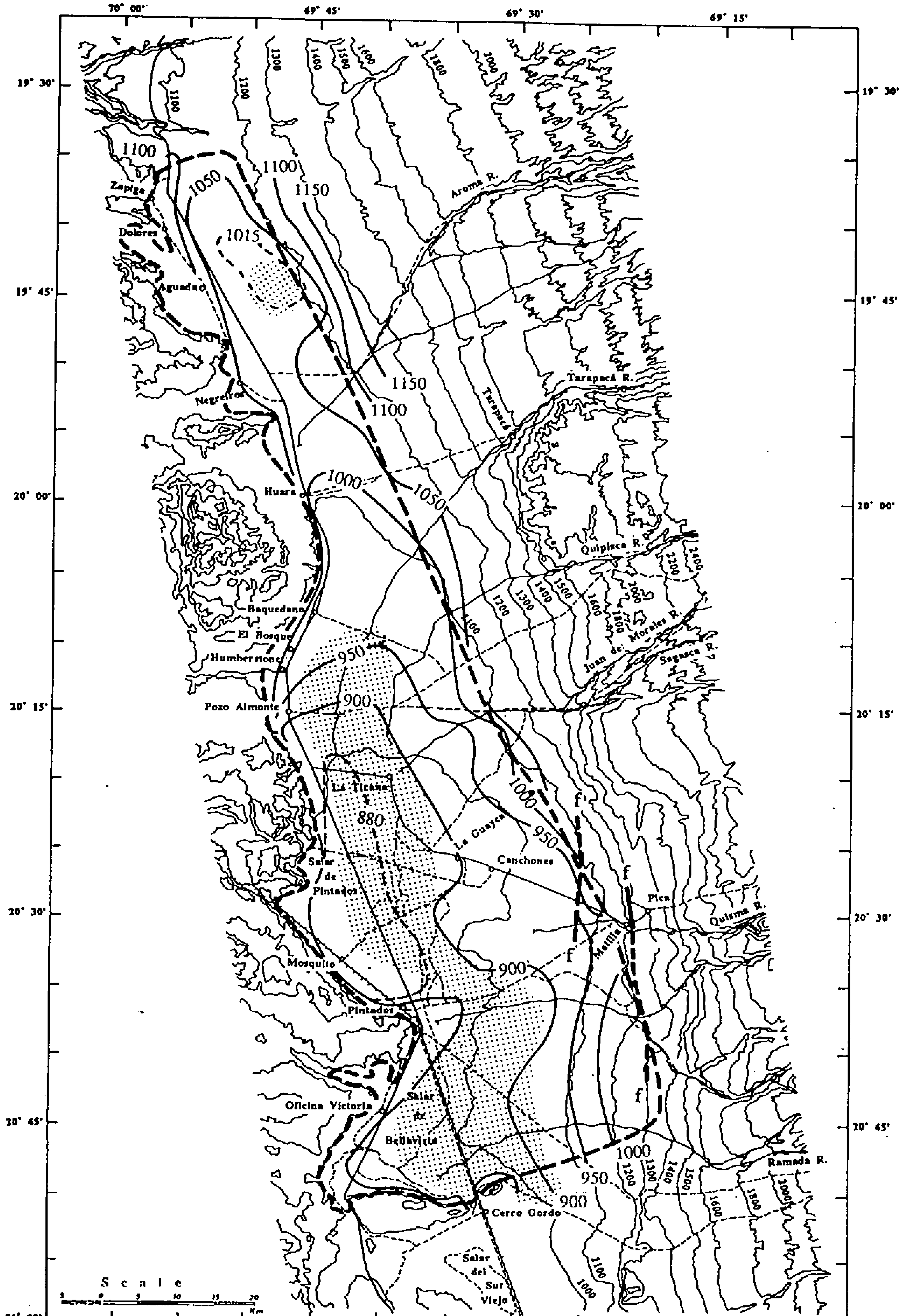


Fig. B-III, 2.4.3 Top of Aquifer (Pampa del Tamarugal)

< Superficie del Acuífero (Pampa del Tamarugal) >

THE STUDY ON THE DEVELOPMENT OF WATER RESOURCES IN NORTHERN CHILE | **JICA**

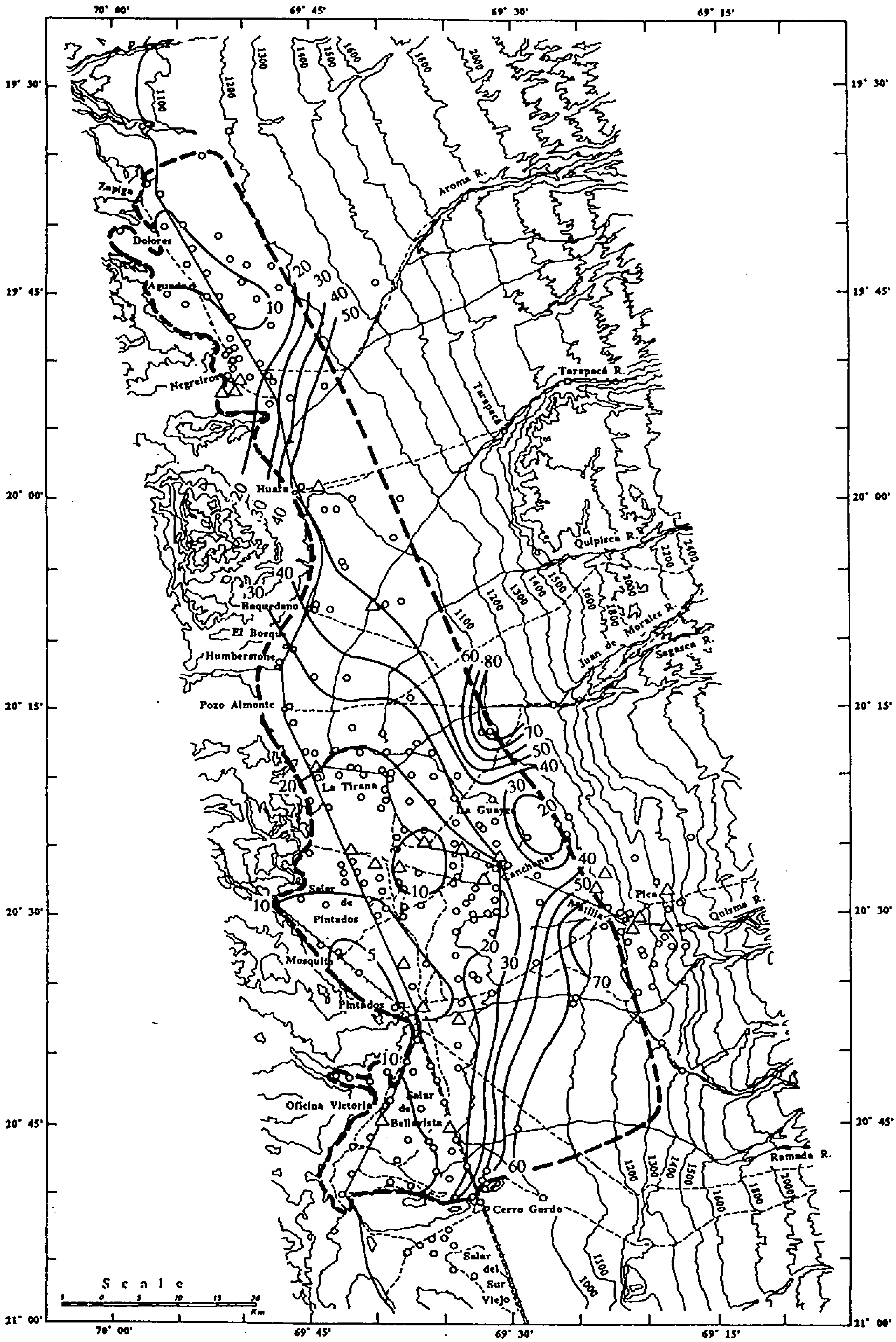


Fig. B-III, 3.2.4 Static Water Level (1960's) (Pampa del Tamarugal)

< Nivel Estático (1960s) (Pampa del Tamarugal) > Unit.: BGL

CHAPTER III GROUNDWATER EXTRACTION

3.1 Existing Groundwater Extraction

Groundwater is used for potable water supply, irrigation, mining and industry in Pampa del Tamarugal. Available pumping data were limited to that of potable water supply by ESSAT in phase I study. Therefore, DGA and the JICA Study Team carried out inteviews survey in the area.

Atotal number of 156 wells are surveyed during the study covering the most wells which are actually extracting groundwater in Pampa except Pica, Matilla and Esmeralda area. The number of wells in actual use is 12 excluding ESSAT wells. The locations of operating wells are shown in Fig. B-II, 3.1.1. The survey results are given following table (see Table B-II, 3.1.1 for more detailed information).

Water Use	Extraction (l/sec)
Domestic	
ESSAT	600.24
Other than ESSAT	60.41
(Sub-Total)	660.65
Mining	35.00
Irrigation	0.35
Total	696.00

note: interviews survey by DGA and the Study Team in Oct. to Nov., 1993

Groundwater production of ESSAT increased by 1,518,500 m^3/year in 1993 compared with the production of 16,355,900 m^3/year (<3) in 1990. The University of Chile estimated groundwater extraction in Pampa to be 716 l/sec in 1980's (<4). However, actual extraction of ESSAT is 599.78 l/sec at Canchones and 0.46 l/sec at Dolores.

Groundwater extraction is also operating at Pica/Matilla area and Sagasca area, although the aquifers are separated from that of Pampa. At Pica area, water use is for irrigation and domestic water supply. Groundwater is extracted 111 l/sec. for irrigation use in Pica and Matilla area.to towns in Pampa such as Pozo Almonte

Extraction for mining use is 35 l/sec. Most of extraction is by a company, ACF Minera, located in the southern part of Salar Bellavista; the rate is 30 l/sec. Other mining use is at Oficina Mapocho, between Huara and Baquedano; the rate is 5 l/sec.

Groundwater for rrigation use is extremely small in Pampa; total rate is 0.35 l/sec.

3.2 Groundwater Level

3.2.1 Static Water Level

Static water level has been periodically measured by DGA on approximately 40 wells every month in the Pampa. In addition to these measurements, the Study Team and DGA conducted a static water level measurement on approximately 160 wells in 1993 (Table B-III, 3.2.1). Following two (2) water table contour maps were constructed on the basis of this results. One is a map of depth to water from the ground level (Fig. B - III, 3.2.1). Other is a map of water level above MSL (Fig. B-III, 3.2.2).

1) Depth of Water Level (below the ground level: BGL)

The depth of water level from the ground level is ahown in Fig. B-III, 3.2.1. Water level is generally shallow in the central to western part of the Pampa, especially in Salar de Pintados and Salar de Bellavista, and increase the depth toward the east, because thick deposits are accumulated as the Fan Deposits in the eastern part of the Pampa. Characterristics of water level by area are described below;

(1) Zapiga, Dolores and Negreiros area

In the Zapiga and Dolores area, the water level is less than 10 BGL and increases the depth to the east reaching to 20m BGL. The Negreiros area shows rather deeper water level, 10 m to 20 m. The water level becomes more deeper to the east; the water level in the end of the fan is estimated to reach to 50 m. The most shallowest level was measured at the well No. ZP-1 (4.7 m) and the deepest one is at the well No. 106 (more than 28 m).

(2) Huara to Pozo Almonte area

Although scarce data are available in the Huara area, the water table is generally the most deepest in the Pampa except Pica area; The water level is deeper than 50 m in the most of Huara area.

The water level decrease the depth toward the Pozo Almonte from Huara; about 50 m in Huara, 40 m at Baquedano, 30 m at Bosque and 20 m in Pozo Almonte. In the Pozo Almonte area, gradual increase of water level is recognized; the water level is about 30 m at the cross point of the roads, to Mamiña and Sascada, about 12 km east from Pozo Almonte.

(3) Salar de Pintados

There was a large salt lake, Salar de Pintados, formed in a depression in this area. Elevation of ground level is slightly lower than surrounding area. The water level continuously becomes shallower from the Pozo Almonte to this area. The most shalllowest area is less than 6 m of the Mosquito area. The area of 10 m depth is widespreading from Pintados to Canchones and Huayca area. There are pumping station of ESSAT in Cnachones where 13 wells are operating. Total yield reaches to approximately 600 l/sec. No remarkable decrease of water table is recognized in the surrounding area of Canchones in spite of these pumping.

The water level abruptly increase toward the Pica, Matilla and Chacarilla area reaching to 90 m.

(4) Salar de Bellavista area

The most shallowest water level of 2m was measured at the well No. 448 located western side of Salar de Bellavista which is disappeared. The area from Panamerican to the railroad, the water level is within 20 m; most water level is less than 15 m. The water level in this area also increase toward the Chacarilla area.

2) Water Level (above the mean sea level: MSL)

Water level distribution is shown in Fig. B-III, 3.2.2. Water level is high in Salar de Zapiga (1,150 m MSL), north of the Pampa and the lowest level appears to in Salar de Bellavista (909 m MSL). It shows a tendency to decline generally from north to south; from Zapiga to Salar de Bellavista through Salar de Pintados. Judging from the distribution of static water level, it is suggested that groundwater flows into the Pampa from eastward, then, slowly moves to southward. The gradient of groundwater is approximately 2/1000 from Zapiga to the southern end of Salar de Bellavista.

No remarkable influence by pumpng at Canchones well field of ESSAT, although a limited area may be influenced by pumping groundwater in Canchones.

There is a significant difference of water level between that of Pampa del Tamarugal Basin and Pica area; the difference is about 60 m. Because of this and the result of geological survey, the groundwater basin is divided into two basins, Pampa del Tamarugal and Pica basins.

Characteristics of water level by area are described as below;

(1) Zapiga, Dolores and Negreiros area

Water level range from 1,150 m to 1,110 m MSL, decreasing from east to west. The water level at Dolores is 1,112 m MSL. There is a ridge like figure of 1,120 m contour line between Dolores and Negreiros. Judging from this, it seems that the groundwater recharged in the east flow down to the west, and diverges its stream to north towarding Dolores and to South.

(2) Huara to Pozo Almonte area

From Huara to northeastwars, the gradient of water table is steep, from 1,050 m to 1,150 m MSL; gradient of groundwater table is 9/1,000. In contrast to this, the gadient of groundwater table becomes gentle from Huara to Baquedano; the gradient is 4/1,000. The water table becomes almost flat toward the south from Baquedano; gradient between Baquedano and Salar de Bellavista is less than 1/1,000. This change of water table gradient is caused by the structure of the aquifer (See, Fig. B-III, 1.2.3).

(3) Pozo Almonte and Salar de Pintados area

The water level is about 1,000 m MSL at Humberstone, 990 m MSL at La Tirana, 980 m MSL at cnachones and 970 m MSL at the southern end of Salar de Bellavista. Contour lines of water table are generally straight and parallel in to the north from Pozo Almonte. However, the contour lines gentelly curve toward the northeast forming a gentle valley like figure. The valley reaches to the southern end of Salar de Bellavista.

The contour lines shows that groundwater flows to Pintados from not only north but also Pica and Chacarilla area.

(4) Oficina Victoria and Salar de Bellavista area

The water level ranges from 970 to 944 m MSL in this area. The lowest level was observed at the southwestern side of the Salar. The contour lines shows that the groundwater flows from northeast to southeast.

(5) Pica area

Although aquifers of the Pampa receive a certain degree of groundwater recharge from the Pica area, aquifers of the Pica area are independent from that of the Pampa as shown in Chapter I, 1.1.

The number of available data is 12 in the Pica area. The highest water level (1,185.1 mASL) is observed at the well No. 404 located apart from Pica, about 10 km south of the town. Thus, this well is exceptional one

Water level ranges from 1,063 to 1,091 m MSL except well No. 404. Depth to water level is different in place to place ranging from 9 to 86 m. Averaged depth is 36 m. Water level in this area is around 100 m higher than that of Salar de Pintados area located to the west of Pica.

3.2.2 Dynamic Level

In the Pampa del Tamarugal area, most well has not been observed the dynamic water level. Only data on the dynamic water level are obtained during the pumping test.

Although the dynamic water level changes corresponding to the yield, draw-down ranges from 1 to 52 m in Pampa del Tamarugal and from 8 to 55 m in Pica area.

Magnitude of draw-down is generally small in Huara area and relatively large value appears in Pozo Almonte area. In Huara area, yield is also small; less than 10 l/s in general. In contrary to this, yield is rather large in Pozo Almonte area; most of well is more than 20 l/s(max. 120 l/s). This difference may be due to the difference of the aquifer tapping the water; depth of well is generally within 50 m in Huara area and most wells are more than 100 m.

Wells in Pica area show large draw-down as mentioned above. No matter how the draw-down is very large, productivity is very small which is less than 10 l/s as a whole. So far as concerned to the results of pumping test (yield, draw-down and specific yield), there is a remarkable difference between the Pampa area and Pica area.

Dynamic level is measured only on the wells of ESSAT in the Canchones well field. As the Pumping for water supply has been continued, it is difficult to measure the static water level of each well. Therefore, the static water level of well No.H (observatory well) is considered as the static water level in the Canchones well field. Draw-down is estimated based on this assumption with the proviso that exact elevation of each well is unknown. Results are shown in Table B-III, 3.2.2.

When pumping is succeeding, water level of each production well is generally decline in a range from about 10 to 25 m against the static water level of the well No. H. This draw-down range is ordinary, compared with that of pumping test results shown in Table B-III, 2.2.1.

3.2.3 Historical Variation

Maps of static water level in 1993 (both BGL and MSL) are shown in Fig. B-III, 3.2.1 and 3.2.2. Furthermore, same kind of contour maps were constructed for the static water level in 1960s (Fig. B-III, 3.2.3 and 3.2.4).

Comparing two (2) maps, Fig. B-III, 3.2.1 and 3.2.3, major difference between both maps is a decrease of the area of 10 m contour line. It appears at areas surrounding the Canchones well field and the Dolores well field.

About 20 wells have long terms of information on static water level. Fig. B-III, 3.2.1 shows the historical variation of static water level in the Pampa del Tamarugal Basin.

Observation of static water level has been made since 1981. Characteristics of the result are as follows;

a) Water level has been gently declined in the rate of extremely small; the rate of draw-down is not more than 2 m between 1982 and 1993 (about 14 to 29 cm/year).

b) No seasonal change is recognized, while small oscillation is sometimes observed.

c) No influence of the production of groundwater around the Canchones well field is recognized so far as concern the available data.

d) Only well No. 122 shows the increase of static water level since 1989 in contrary to the general tendency. This well is located beside the Queb. de Chacarilla which is beyond the border of the western border of the basin. The reason of the increase of water table is unclear.

3.3 Groundwater Quality

Since data of groundwater quality is so scarce that DGA and the Study Team executed groundwater sampling and analyzing in Pampa del Tamarugal. A total number of 50 samples are taken from the existing wells and the JICA Wells in Novenmber, 1993. Results of water quality analysis are shown in Table B-III, 3.3.1.

3.3.1 Water Quality

Groundwater quality is generally characterized by high B and Mn contents, and relatively high TDS , As and Cl contents. The aquifers are generally uniform in the area except Salar de Pintados and Bellavista. Thus, there is no difference in water quality of shallow wells and deep wells. In contrary with this, impermeable clayey beds separate the aquifer of shallow wells and that of deep wells in Salar de Pintados and Bellavista area. Water quality of shallow wells shows high concentration of ions. Such phenomena are appeared in the well No. 113 in Salar de Pintados , and the wells No. 440 and 447 in Salar de Bellavista. Even in the deep wells, TDS is generally high in the Salar area.

Fig. B-III, 3.3.1 to 3.3.5 show the distribution of TDS, Cl, As, B, Fe and Mn contents respectively. Characteristics of major ion's distribution are as follows;

1) TDS

Fig. B-III, 3.3.1 shows the distribution of TDS value. The area of TDS value less than 250 mg/l is divided into two (2) areas; the northern area near Zapiga and Dolores, and the southern wide area with Canchones as a center. The Aroma River reches to Pampa at the eastward from Negreiros. The area of high TDS value is widespread along the stream of the Aroma. TDS value is generally low in the down streams of the Juan de Morales, Sagasca, Quisma, Chacarilla and Ramada.

2) Cl

Cl content is higher than standard of 250 mg/l in the more than half of the total area as shown in Fig. B-III, 3.3.2. The area of high Cl content is distributed along the Aroma, Tarapaca and Quipisca Rivers, and the Salar area.

3) As

The area of high As content (more than 0.05 mg/l) is rather narrow as shown in Fig. B-III, 3.3.2. The western half of the area from Dolores to Salar de Pintados through Negreiros, Huara and Pozo Almonte. These areas correspond to the down stream of the Aroma, the Chacarilla and the Ramada Rivers. Along the other rivers, As content is less than standard.

4) B

Fig. B-III, 3.3.4 shows the distribution of B content. Distribution of high B content (more than 5 mg/l) area is almost similar with that of Cl content. The area of high content is distributed along the Aroma and the Tarapaca Rivers, and Salar area. Entrance to Pampa from the Chacarilla and the Ramada Rivers shows higher content.

5) Mn

Fig. B-III, 3.3.5 shows the distribution of Mn content. Distribution of high content area (more than 0.1 mg/l) is scattered separating five (5) areas. The most widest area is from Humberstone to the south of Dolores. Others are as follows;

a) Area near La Tirana, elongating NE-SW direction
b) Area from Canchones to Pintados
c) Area southern margin of Salar de Bellavista
d) Area between Cerro Gordo and south of Matilla

Distribution of those area seems to have no relation with rivers.

6) Fe

Fig. B-III, 3.3.6 shows the distribution of Fe content. High content areas (more than 0.30 mg/l) are wide spread following area;

a) Total area from Zapiga to Negreiros
b) Western half area from Negreiros to Humberstone
c) Area from La calera and Pica to Pintados and Bellavista

7) Cd

Fig. B-III, 3.3.7 shows the distribution of Cd content. High content area (more than 0.01 mg/l) is widespread in the area from Negreiros to Pozo Almonte along the Aroma and the Tarapaca Rivers. Salar area of Pintados and Bellavista is also high content area.

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<2: Isotopic and Chemical Study of the Water Resources in the Iquique Province, 1985 for IAEA by Magaritz M., Peña H., Grilli A. Orphanopoulos D., O. Suzuki and Aravena R.

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Table B-III, 3.1.1 Groundwater Extraction
<Extracción de Agua Subterránea>

(Pampa Area)

Water Use	Well No. (BNA)	Well Name	Extraction Rate (m3/year)	Extraction Rate (l/sec)	Total
Agriculture	381	CONAF	986	0.03	
	412	CONAF	654	0.02	
	363	Luis Quispe	394	0.30	0.35
Domestic	426	Esteban Lucic	1,314	0.04	
	316	David Chiang	263	0.20	
	312	Guillermo Araya	329	0.17	
	128	CORFO	183	0.01	
	-	Dupliza	1,892,160	60.00	
		Pta. Canchones (ESSAT)	18,914,508	599.78	
		Pta. Dolores (ESSAT)	14,622	0.46	660.65
Mining	984 or 985	ACF Minera	157,680	5.00	
		Oficina Mapocho	946,080	30.00	35.00
Total			21,929,173	696.00	696.00

(Other Area: Pica, Matilla, Esmeralda and Cascada)

Water Use	Well No. (BNA)	Well Name	Extraction Rate (m3/year)	Extraction Rate (l/sec)	Total
Agriculture		Pica/Matilla	3,500,496	111.00	111.00
Domestic		Pica/Chintaguay (ESSAT)	1,630,430	51.70	51.70
Mining	221	Cia. Minera La Cascada	432,000	13.70	
	222	Cia. Minera La Cascada	648,000	20.55	34.25
Total			6,210,926	196.95	196.95

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (1)

DGA	11	21		30	10	18	20	25	28	13	31	32	45	57
BNA	171-K	164-7	473-5	104-3	170-1	101-9	179-5	102-7	103-5	173-6	105-1	106-K	191-4	131-0
CORFO	1930-6950	1940-6940	1940-6940	1940-6940	1940-6950	1940-6950	1940-6950	1940-6950	1940-6950	1940-6950	1950-6940	1950-6940	2000-6930	2010-6930
DATE	A-1	A-1	AN-3	C-3	A-3	B-3	B-5	D-1	D-2	A-6	A-2	A-3	C-1	A-1
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11				14.03		8.40	8.16	7.33	9.45		20.54	24.73		
12				14.24		8.15	8.29	7.00	9.30		20.92	25.03		
82/1				13.72		7.95	7.29		9.21		20.78	24.92		
2				14.32		7.24	8.40		9.24		20.67	25.00		
3				13.87		7.28	8.41		9.27		19.98	24.44		
4				13.96		7.97	8.31		9.37		20.01	24.74		
5				13.92		8.00	8.39		9.40		20.05	24.79		
6				14.48		7.98	8.36		9.42		20.75	25.36		
7				14.31		7.99	8.30		9.12		20.78	25.32		
8				14.10		7.81	8.00		9.00		21.00	25.00		
9				13.68		8.31	8.64		9.70		20.11	24.58		
10				14.64		8.24	8.67		9.66		21.12	25.32		
11				14.32		8.08	8.38		9.40		20.93	25.54		
12				11.60		8.26	8.60		9.41		20.92	22.24		
83/1				11.62			8.66		11.64		20.96	24.24		
2														
3				14.07		8.34	8.64		9.71		21.00	24.65		
4				14.10		8.37	8.68		9.77		21.04	24.73		
5				14.72		8.42	8.74		9.84		21.06	25.30		
6				14.65		8.43	8.75		9.84		21.05	25.52		
7				14.62		8.43	8.72		9.85		21.03	25.50		
8				14.15		8.30	8.65		9.65		19.70	25.00		
9				14.20		8.20	8.55		10.00		20.00	24.90		
10				14.35		8.20	8.50		10.80		20.85	24.83		
11				14.57		8.15	8.70		9.85			25.20		
12				14.50		8.35	8.78		9.80		20.89	25.20		
85/1				14.03	6.74	8.04	8.43		9.91		21.41	24.57		20.30
2				14.05	6.78	8.02	8.40		9.89		21.38	24.61		20.26
3				14.00	6.76	8.04	8.40		9.86		21.38	24.58		20.28
4				14.07	6.76	8.02	8.40		9.93		21.38	24.62		20.28
5				14.10	6.81	8.08	8.50		9.97		21.46	24.64		20.31
6				14.15	6.82	8.11	8.54		9.99		21.38	24.59		20.25
7				14.12	6.77	8.09	8.49		9.92		21.43	24.61		20.25
8				14.12	6.79	8.13	8.47		9.95		21.38	24.64		20.27
9				14.11	6.74	8.08	8.46		9.93		21.41	24.62		20.26
10				14.12	6.71	8.03	8.42		9.93		21.38	24.56		20.28
11				14.10	6.71	8.04	8.40		9.91		21.38	24.54		20.25
12				14.08		8.10	8.47		9.97		20.33	24.59		20.31
86/1	6.94			14.15		8.14	8.58				20.25	24.41		20.30
2														
3	7.00			14.09		8.14	8.54				20.31	24.60		20.40
4	6.98			14.13		8.18	8.56				20.34	24.63		20.40
5														
6	6.17			13.55		7.58	7.76				19.56	24.75		20.42
7														
8	6.80			14.08		8.18	8.66				20.39	24.92		20.42
9														
10	7.01			14.12		8.19	8.68				20.37	24.64		20.44
11														
12														
87/1														
2	6.91			14.16		8.24	8.71				20.38	24.64		20.44
3														
4	7.19			14.18		8.31	8.87				20.37	24.64		20.50
5														
6	7.16			14.18		8.33	8.89				20.36	24.63		20.46
7														
8														
9														
10	6.91			14.19		8.37	9.02							20.53
11														
12														
88/1														
2														

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (2)

DGA	11	21		30	10	18	20	25	28	13	31	32	45	57
BNA	171-K	164-7	473-5	104-3	170-1	101-9	179-5	102-7	103-5	173-6	105-1	106-K	191-4	131-0
CORFO	1930-6950	1940-6940	1940-6940	1940-6940	1940-6950	1940-6950	1940-6950	1940-6950	1940-6950	1940-6950	1950-6940	1950-6940	2000-6930	2010-6930
DATE	A-1	A-1	AN-3	C-3	A-3	B-3	B-5	D-1	D-2	A-6	A-2	A-3	C-1	A-1
3	6.95			14.23		8.40								20.54
4	6.98			14.23		8.34								20.54
5														
6	6.96			14.23		8.38								20.53
7														
8	6.70			14.26		8.49								20.57
9														
10	6.94			14.23		8.38								20.58
11														
12														
89/1														
2														
3		15.38	12.06	14.83		8.59				8.08				
4														
5														
6														
7		15.37	12.06			8.60				8.55				
8		15.37	12.06	14.82		8.60				8.55	-			
9														
10		15.37	12.06	14.83		8.60				8.55	-			
11														
12		15.37	12.05			8.60				8.55	-			
90/1														
2				14.86		8.49				8.51				
3														
4														
5				14.86						8.36	-			
6														
7														
8											-			
9														
10														
11				14.87						8.74	-			
12														
91/1		15.41	12.04	14.48						8.72	-			
2		15.43	11.99	14.80						8.74	-			
3		15.41	11.99	14.80						8.74	-			
4		15.46	11.94	14.91						8.92	-			
5		14.28	12.05	14.48						8.80	-			
6														
7		15.41	12.06	14.35						8.73	-			
8		15.40	12.06	14.35						8.72	-			
9		15.37	12.06	14.34						8.96	-			
10		15.40	12.05	14.35						8.96	-			
11		15.38	12.06	14.38						8.18	-			
12		15.38	12.05	14.35						8.21	-			
92/1		15.38	12.05	14.37						8.67	-			
2				14.32										
3		15.43	12.08	14.38										
4		15.40		14.38										
5				14.39										
6		15.53	12.05	14.38										
7														
8				14.36										
9														
10				14.37										
11				14.36										
12				14.36										
93/1				14.38										
2		15.40	12.13	14.37										
3			12.09	14.40										
4														
5														
6			12.09	14.39										
7				14.40						8.85				
8			12.09	14.39						8.87				
9				14.41						9.09				
10			12.13	14.40						9.12				
11														
12														

SOURCE: OBSERVATION RECOEDS BY DGA

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (3)

DGA	59	60	64	77	65	81	56	66	82	72		223	170	174
BNA	204-K	132-9	222-8	230-9	107-8	133-7	234-1	235-K	109-4	129-9	260-0	252-K	263-5	265-1
CORFO	2010-6930	2010-6930	2010-6930	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2020-6910	2020-6910	2020-6920	2020-6920
DATE	C-3	C-4	D-2	D-6	C-2	D-10	D-12	D-13	D-16	D-5	C-13	C-5	A-2	A-4
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11									16.75					
12									21.14					
82/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
83/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
85/1	24.03			10.22			25.96			20.40				
2	24.07			10.20			25.98			20.44				
3	24.06			10.25			25.96			20.40				
4	24.11			10.26			25.97			20.40				
5	24.05			10.18			25.95			20.48				
6	24.10			10.16			25.86			20.46				
7	24.05			10.15			25.90			20.40				
8	24.09			10.20			25.93			20.45				
9	24.07			10.20			25.89			20.43				
10	24.03			10.18			25.91			20.36				
11	24.04			10.18			25.90			20.33				
12	24.00			10.13			25.92			20.49				
86/1	24.02			10.35		14.81	25.81							
2														
3	24.19			10.39		14.80	25.98			20.48				
4	24.20			10.37			26.02			20.55				
5														
6	23.92			10.37			26.11			20.59				
7														
8	24.27			10.41			26.01			20.61				
9														
10	24.27			10.37			26.02			20.66		40.09		
11														
12														
87/1														
2	24.26			10.44			26.04			20.66		39.80		
3														
4	24.32			10.48			26.09			20.68		39.81		
5														
6	24.32			10.55			26.07			20.69				
7														
8														
9														
10	24.36			10.51			26.13			20.70				
11														
12														
88/1														
2														

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (4)

DGA	59	60	64	77	65	81	56	66	82	72		223	170	174
BNA	204-K	132-9	222-8	230-9	107-8	133-7	234-1	235-K	109-4	129-9	260-0	252-K	263-5	265-1
CORFO	2010-6930	2010-6930	2010-6930	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2020-6910	2020-6910	2020-6920	2020-6920
DATE	C-3	C-4	D-2	D-6	C-2	D-10	D-12	D-13	D-16	D-5	C-13	C-5	A-2	A-4
3	24.61			10.56			26.13			20.72				
4	24.38			10.56			26.13			20.54				
5														
6	24.33			10.58			26.12			20.53				
7														
8	24.39			10.56			26.18			20.57				
9														
10	24.38			10.61			26.14		10.04	20.58				
11														
12														
89/1														
2														
3		24.53						20.64		20.93			19.48	16.50
4														
5														
6														
7		24.53						20.56		20.90			19.45	19.50
8		24.53						20.56		20.90			19.45	16.50
9														
10		24.53						20.56		20.90			19.45	16.50
11														
12														
90/1														
2														
3					8.92			20.56					19.16	16.49
4														
5		24.53			8.98			20.56		21.05			19.15	16.40
6														
7														
8		24.62			8.98			20.64		24.80			19.10	16.80
9														
10														
11		24.61			8.96			20.61		24.78			19.13	16.78
12														
91/1		24.61			8.95			20.61					19.11	16.77
2		24.58			9.00			20.66					10.08	16.75
3		24.56						20.68					19.08	16.74
4		24.60						20.68					19.07	16.76
5		24.57			9.06			20.69					19.10	16.86
6														
7		24.68			8.37			20.72					19.20	16.88
8		24.66			8.39			20.71					19.18	16.88
9		24.66			8.37			20.72					19.21	16.89
10		24.65			8.39			20.70					19.20	16.89
11					8.40								19.20	16.89
12					8.42			20.69					19.21	16.89
92/1		24.75			8.45			20.71					19.23	16.90
2		24.73						20.80		21.00			19.08	
3		24.76						20.82		21.31			19.07	17.04
4		24.75						20.83		21.00			19.07	17.02
5		24.81			8.49	14.55		20.81		21.35				
6														
7		24.79			8.47	14.55		20.81		21.32			19.08	17.02
8		24.75			8.46	14.57		20.77		21.32			19.40	17.15
9														
10		24.75			18.47	15.53		20.81		21.07			19.42	17.15
11		24.76			8.50	15.55		20.78		21.33	38.67		19.48	17.22
12		24.73			8.47			20.77		21.30			19.45	17.20
93/1		24.81			8.52	15.58		20.80		21.36	38.72		19.50	17.40
2		24.79			8.55	15.58		20.77		21.35	38.75		19.45	17.40
3		24.83			8.54	15.61		20.83		21.38	38.73		19.43	17.46
4														
5														
6		25.14						20.88					19.40	
7		24.86				15.65				21.39			19.35	
8		24.90				15.65				21.40			19.32	
9		24.91				15.71				21.41			19.28	
10		24.83				15.69				21.36			19.30	
11														
12														

Table B-III, 3.3.1 Variation of Groundwater Level.
<*Variacion del Nivel de Agua Subterranea*> (5)

DGA	212	224	183	185	209-B	197	200	203	226	210			77-B	107
BNA	135-3	267-8	277-5	279-1	280-5	293-7	296-1	299-6	179-3	273-2	148-5	466-2	311-9	316-K
CORFO	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6930	2020-6930	2020-6930	2020-6930
DATE	C-1	C-2	D-11	D-13	D-14	D-27	D-30	D-33	D-6	D-7	A-10	A-13	A-3	A-8
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
82/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
83/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
85/1	29.24													8.50
2	29.24													8.51
3	29.19													8.51
4	29.22													8.50
5	29.18													8.48
6	29.16													8.39
7	29.18													8.45
8	29.21													8.45
9	29.18													8.40
10	29.16													8.40
11	29.15													8.40
12	29.12													8.36
86/1	31.13													8.82
2														
3	31.54													8.71
4	29.38													8.70
5														
6	29.91								39.90					8.70
7														
8	30.65													8.64
9														
10														8.90
11														
12														
87/1														
2														9.11
3														
4														8.98
5														
6	30.62													8.91
7														
8														
9														
10	31.79													8.89
11														
12														
88/1														
2														

Table B-III, 3.3.1 Variation of Groundwater Level.
<*Variacion del Nivel de Agua Subterranea*> (6)

DGA	212	224	183	185	209-B	197	200	203	226	210			77-B	107
BNA	135-3	267-8	277-5	279-1	280-5	293-7	296-1	299-6	179-3	273-2	148-5	466-2	311-9	316-K
CORFO	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6930	2020-6930	2020-6930	2020-6930
DATE	C-1	C-2	D-11	D-13	D-14	D-27	D-30	D-33	D-6	D-7	A-10	A-13	A-3	A-8
3	32.53													8.96
4	32.82													8.97
5														
6	32.38													8.90
7														
8	32.38													8.96
9														
10	33.08													8.99
11														
12														
89/1														
2														
3			24.19	70.02	45.76	49.02	39.17				10.90		10.76	
4														
5														
6														
7			24.19		45.74	49.11	39.17				10.87		10.77	
8			24.19		45.76	49.10	39.17				10.87		10.77	
9														
10			24.31		47.56	49.15	39.32				10.87		10.77	
11														
12			24.30		45.74	49.15	39.34							
90/1														
2													10.80	
3			24.30		45.74	49.15	39.32							
4														
5			24.29		45.77	49.19	39.32				10.75		10.80	
6														
7														
8					45.77	49.14	39.32				10.75		10.90	
9														
10														
11			24.30		45.74	49.14	39.31				10.89		10.90	
12														
91/1			24.30		45.77	40.16					10.85	8.95	10.89	
2			24.35			40.14					10.97	8.94	10.94	
3			24.41			40.14					10.95	8.95	10.90	
4			24.48			40.16	49.56	45.68			11.04	8.94	11.01	
5			24.56			40.06	49.17	45.52			11.00		11.02	
6														
7			24.42			40.15	48.91	45.18			11.02	12.25	10.99	
8			24.40			40.14	48.94	45.58			11.00	12.27	10.99	
9			24.41			40.14	48.89	45.51			11.00	12.23	11.00	
10			24.40			40.14	48.90	45.50			11.00	12.24	11.00	
11											11.02	12.23	11.01	
12			24.40	40.14		40.13	48.70				11.09	12.24	11.07	
92/1			24.45			40.13	48.88	45.54			11.09	12.23	11.12	
2										8.81	11.17	12.59	11.14	
3										8.97	11.14	12.28	11.16	
4			24.44	40.00	49.25	45.46				8.46	11.13	12.30	11.15	
5										8.14			11.21	
6										8.12				
7			24.42			40.00	48.67	45.46			11.13	12.26	11.13	
8										9.44			11.18	
9														
10			24.45			40.00	48.67	45.46		9.43	11.13	11.26		
11										8.21	11.12	12.22	11.17	
12										8.22	11.11	12.21	11.17	
93/1										8.28	11.20	12.70	11.22	
2										8.26	11.18	12.70	11.22	
3			24.52	42.69	42.96	40.09	48.60	45.57		9.30	11.27	12.69	11.33	
4														
5														
6			24.50	41.76	44.94	40.05	48.59	45.63			11.27	11.27	11.36	
7				45.00				45.60					11.36	
8						40.05	48.50	45.55			11.25	12.60	11.38	
9				45.17	60.88	40.19	48.74	45.68			11.21	12.68	11.38	
10			24.50		60.80	40.90	48.66	45.60			11.20	12.66	11.39	
11														
12														

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (7)

DGA	111	140	141	134	148			97	98	121	162	113	123	124
BNA	134-5	323-2	324-0	354-2	365-8	458-1	460-3	367-4	147-7	110-8	112-4	136-1	139-6	376-3
CORFO	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940
DATE	B-5	C-2	C-3	D-17	D-28	D-34	D-36	A-1	B-1	C-1	C-2	D-1	D-10	D-11
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
82/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
83/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
85/1	7.78										7.55	12.08	12.85	7.79
2	7.80										7.52	12.10	12.86	7.79
3	7.79										7.55	12.09	12.81	7.78
4	7.80										7.57	12.12	12.77	7.81
5	7.66										7.60	12.12	12.75	7.87
6	7.64										7.50	12.09	12.81	7.88
7	7.69										7.56	12.09	12.85	7.90
8	7.73										7.57	12.09	12.90	7.85
9	7.74										7.55	12.05	12.87	7.82
10	7.71										7.55	12.04	12.86	7.81
11	7.70										7.58	12.10	12.86	7.85
12	7.65										7.54	12.04	12.86	7.78
86/1	8.31													
2														
3	8.31										7.71	12.24	13.32	7.98
4	8.35										7.75	12.23	13.35	8.00
5														
6	7.75										7.76	12.06	12.81	7.85
7														
8	8.07										7.78	12.14	13.31	8.04
9														
10	8.27										7.77	12.20	13.10	8.01
11														
12														
87/1														
2	8.47										7.81	12.19	13.44	8.09
3														
4											7.83		13.47	8.20
5														
6											7.88	12.34	13.42	8.27
7														
8														
9														
10											7.93	12.55	13.25	8.34
11														
12														
88/1														
2														

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (8)

DGA	111	140	141	134	148			97	98	121	162	113	123	124
BNA	134-5	323-2	324-0	354-2	365-8	458-1	460-3	367-4	147-7	110-8	112-4	136-1	139-6	376-3
CORFO	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940
DATE	B-5	C-2	C-3	D-17	D-28	D-34	D-36	A-1	B-1	C-1	C-2	D-1	D-10	D-11
3											7.95	12.64		8.48
4											7.98	12.64	13.41	8.46
5														
6											7.93	12.67	13.42	8.48
7														
8											7.99	12.66	13.42	
9														
10	12.65										8.99	12.65	13.42	
11														
12														
89/1														
2														
3		7.97				9.70	22.78				7.90			
4														
5														
6														
7						9.90	22.77				8.15			
8						9.90	22.78				8.16			
9														
10						9.90	22.78				8.16			
11														
12			2.38				22.78							
90/1														
2						9.90	22.77							
3														
4														
5						9.92	22.75							
6														
7														
8						9.90	22.77							
9														
10														
11						10.02	22.77							
12														
91/1						10.00								
2						10.10								
3											8.20			
4						10.10					8.20			
5						10.31					8.23			
6														
7						10.68	24.44				8.25			
8						10.64	24.41				8.25			
9						10.23					8.24			
10						10.25					8.25			
11														
12						10.24					8.25			
92/1						10.24					8.30			
2														
3		8.31												
4		8.31				10.20								
5		8.35			18.80									
6														
7		8.35			18.80	10.20								
8		8.33			18.80	10.79								
9														
10		8.35			18.77	10.20								
11		8.34		32.11	19.30	10.46								
12		8.30				10.44								
93/1		8.40		32.46	18.76	10.27								
2		8.42		32.44	18.76	10.25								
3		8.45		32.11	19.50	10.77								
4														
5														
6		8.49			19.51	10.75								
7		8.49			19.28	10.77					8.56			
8		8.49		31.50	19.30	10.76					8.55			
9		8.49		32.16	20.78	10.81					8.57			
10		8.49		32.10	20.78	10.83					9.30			
11														
12														

Table B-III, 3.3.1 Variation of Groundwater Level.
<*Variacion del Nivel de Agua Subterranea*> (9)

DGA	137		163	122	315	320	301	302				323	238	237
BNA	140-K	137-K	383-6	138-8	114-0	143-4	142-6	117-5	469-7	470-0	471-9	404-2	113-2	411-5
CORFO	2020-6940	2020-6940	2020-6940	2020-6940	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6930	2030-6930
DATE	D-15	D-20	D-19	D-9	A-2	A-2	B-1	B-2	BN-9	BN-10	BN-11	D-1	A-1	A-9
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11						54.73								
12	13.20													
82/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
83/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
85/1	12.11				70.08	55.01							4.65	
2	12.12				70.10	55.04							4.65	
3	12.10				70.14	55.00							4.65	
4	12.11				70.16	55.04							4.70	
5	12.05				70.08	54.98							4.56	
6	12.10				70.04	55.00							4.59	
7	12.05				70.08	55.04							4.65	
8	12.07				70.11	55.04							4.65	
9	12.05				70.11	55.00							4.62	
10	12.05				70.12	54.98							4.63	
11	12.10				70.13	54.98							4.66	
12	12.05				70.09	54.94							4.59	
86/1					69.10	54.24								
2														
3	12.22				70.24	55.22							4.75	
4	12.26				70.28	55.35							4.78	
5														
6	12.32				70.33	55.37							4.80	
7														
8	12.30				70.57	55.43							4.81	
9														
10					70.30	55.44	13.65						4.91	
11														
12														
87/1														
2	12.38				70.34	55.45	13.41						4.91	
3														
4	12.43				70.41	55.50							4.97	
5														
6	12.42				70.40	55.52							4.99	
7														
8														
9														
10	12.29				70.48	55.57							5.03	
11														
12														
88/1														
2														

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (10)

DGA	137		163	122	315	320	301	302				323	238	237
BNA	140-K	137-K	383-6	138-8	114-0	143-4	142-6	117-5	469-7	470-0	471-9	404-2	113-2	411-5
CORFO	2020-6940	2020-6940	2020-6940	2020-6940	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6930	2030-6930
DATE	D-15	D-20	D-19	D-9	A-2	A-2	B-1	B-2	BN-9	BN-10	BN-11	D-1	A-1	A-9
3					70.49	55.58								
4					69.79	55.65							5.01	
5													5.02	
6					70.48	55.57								
7													5.01	
8					70.32	55.67								
9													5.18	
10					70.55	50.46								
11													4.38	
12														
89/1														
2														
3	12.56				71.18	55.91			21.22	28.35	20.01			
4														
5														
6														
7	12.46		5.73		71.18	55.95			21.85	28.42	20.01			
8	12.46				71.18	55.95			21.84	28.42	21.01			
9														
10	12.36		5.73		71.18	55.86				28.39	20.01			5.70
11														
12					71.18	55.86			21.84	28.45				
90/1														
2														
3	12.35		5.72											5.39
4														
5									22.27	28.35	18.81			
6														
7														
8	12.50		5.85		71.26			56.30						5.56
9														
10														
11	12.47		6.65		71.24			56.25	22.89	29.75				5.53
12														
91/1	12.50		5.80		71.26			56.25	22.86	29.75				5.50
2	12.49				71.25			56.21	22.88					5.53
3									22.89					
4	12.48				71.25			56.20	22.91					5.55
5	12.63				71.18			56.26	22.26		20.00			5.56
6														
7	12.58				70.84			55.81	21.76	30.80	20.85			5.64
8	12.61				70.83			55.80	21.70	30.81	20.88			5.64
9	12.60				70.94			55.85	21.73	30.78				5.64
10	12.60				70.09			55.83	21.70	30.76	20.86			5.63
11	12.45				70.90			55.85	32.36	31.44	20.30			5.66
12	12.62				70.90			55.91	39.46		21.00			5.71
92/1	12.67				70.88			55.89	23.52		21.10			5.73
2					70.80	55.95					20.36			
3					70.98	56.05					20.64			5.78
4					70.94	56.00				30.60				5.78
5					70.92	56.09			21.10	30.94	20.88			5.79
6														
7					70.90	56.05								5.78
8	12.52				70.95	55.97			22.14	30.83	19.43			5.79
9														
10	12.52				70.93	55.97			22.61	31.03	20.27			5.79
11	12.50				71.00	56.00			22.33	31.38	19.80			5.80
12	12.50				71.00	55.98			22.50	31.40	19.80			5.79
93/1					71.03	52.06				31.03	19.98			5.83
2					71.05	52.05				31.00	19.98			5.83
3					71.07	56.05			21.30	31.00	19.60	19.90		5.86
4														
5														
6					71.09				21.37	31.43	20.22			5.91
7					71.07	56.12					20.51			5.91
8					71.07	56.12					20.50	19.90		5.89
9					71.11	56.14						19.90		
10					71.13	56.12						19.90		5.91
11														
12														

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (11)

DGA	230	254	256	257	265	249	259	253	260	263	264		235	247
BNA	412-3	118-3	141-8	144-2	151-5	120-5	119-1	121-3	426-3	150-7	427-1	116-7	430-1	145-0
CORFO	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6940	2030-6940
DATE	A-10	C-1	C-3	C-4	C-6	C-7	D-1	D-2	D-5	D-6	D-7	D-9	B-2	B-3
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11		4.44	7.25			3.14	16.15	28.46	9.24	4.03			4.50	
12			7.08			3.65	16.40			4.02				
82/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
83/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
85/1		3.90	7.11	7.69		3.70	16.21	28.78	10.40				4.70	2.33
2		3.90	7.13	7.65		3.73	16.19	28.75	10.40				4.74	2.31
3		3.85	7.15	7.67		3.75	16.15	28.76	10.41				4.73	2.26
4		3.86	7.20	7.69		3.78	16.18	28.78	10.44				4.76	2.30
5		3.81	7.02	7.64		3.59	16.14	28.81	10.48				4.78	2.26
6		3.77	7.04	7.58		3.63	16.13	28.77	10.46				4.70	2.26
7		3.84	7.12	7.65		3.70	16.15	28.75	10.44				4.78	2.31
8		3.86	7.17	7.70		3.75	16.19	28.77	10.46				4.75	2.35
9		3.85	7.12	7.68		3.70	16.17	28.75	10.45				4.74	2.31
10		3.86	7.13	7.70		3.70	16.15	28.75	10.42				4.73	2.32
11		3.85	7.12	7.73		3.70	16.11	28.78	10.41				4.73	2.31
12		3.81	7.16	7.73		3.70	16.11	28.75	10.38				4.69	2.26
86/1				8.37			16.26		10.30	17.57				
2														
3		4.01	7.51	7.90		3.84	16.25	29.04	11.65	17.63			4.92	2.51
4		3.98	7.51	7.90		3.85		29.06	10.50	17.68			4.97	2.55
5														
6		4.04	7.50	7.92		3.90	16.27	29.08	11.04	17.67			4.98	2.56
7														
8		4.06	7.37	7.94		3.95	16.31	29.10	11.82	17.68			4.99	2.56
9														
10		4.05	7.37	7.95		4.00	16.45	29.14	10.80	17.85			4.98	2.55
11														
12														
87/1														
2		4.09	7.39	8.00		4.08	16.31	29.18	11.39	17.65			5.04	2.57
3														
4		4.14	7.40			4.11	16.33	29.28	10.53	17.89			5.07	2.66
5														
6		4.13	7.42	8.04		4.18	16.38	29.33	11.63	17.88			5.05	2.66
7														
8														
9														
10		4.25	7.47	8.04		4.28	16.43	29.29	10.40	17.89			5.17	2.73
11														
12														
88/1														
2														

Table B-III, 3.3.1 Variation of Groundwater Level.
<*Variacion del Nivel de Agua Subterranea*> (12)

DGA	230	254	256	257	265	249	259	253	260	263	264		235	247
BNA	412-3	118-3	141-8	144-2	151-5	120-5	119-1	121-3	426-3	150-7	427-1	116-7	430-1	145-0
CORFO	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6940	2030-6940
DATE	A-10	C-1	C-3	C-4	C-6	C-7	D-1	D-2	D-5	D-6	D-7	D-9	B-2	B-3
3		4.26	7.50	8.02		4.34	16.44	29.35	10.49	17.92			5.16	2.75
4		4.28	7.48	8.02		5.18	16.37	29.37	10.59	17.80			5.15	2.75
5														
6		4.26	7.49	8.04		4.33	16.43	29.35	10.48	17.89			5.17	2.73
7														
8		4.32	7.66	8.05		4.56	16.35	29.44	10.53	17.91			5.40	2.83
9														
10		4.20	7.50	8.09		4.38	16.36	29.41	10.55				5.18	2.83
11														
12														
89/1														
2														
3	10.90	4.29	7.73			4.59	16.52	29.64			0.75		5.61	
4														
5														
6														
7	10.96	4.42	7.98			4.59	16.55	29.71			0.75		5.85	
8	10.96	4.42	7.98			4.59	16.55	29.71			0.75		5.85	
9														
10	10.94	4.41	7.98				16.55	29.68			0.75		5.85	
11														
12			7.98				16.55	29.68			0.75			
90/1														
2			7.88					29.68						
3	10.94	4.52											5.89	
4														
5		4.61											6.04	
6														
7														
8	10.90	4.59	7.91					29.64					6.00	
9														
10														
11	11.02	4.55	7.94					29.61					6.00	
12														
91/1	11.00	4.55	7.92					29.59				18.05	6.00	
2	11.00	4.61	7.93					29.56					6.04	
3														
4	11.05	4.57	7.94					28.81				18.10	6.05	
5	11.03	4.67	7.95					29.64				18.04	6.09	
6														
7	10.97	4.67	8.05					29.67				18.07	5.60	
8	10.99	4.69	8.05					29.70				18.04	5.57	
9	11.02	4.68	8.04					29.66				18.10	5.57	
10	11.00	4.69	8.04					29.68				10.07	5.59	
11	11.02	4.73	8.06					29.71				18.13	5.57	
12	11.09	4.74	8.09					29.73				18.10	5.67	
92/1	11.11	4.74	8.11					29.77				18.15	5.66	
2			8.34					29.75				18.09		
3	11.10	4.76	8.11					29.82				18.13	5.62	
4	11.08	4.76						29.80				18.15	5.62	
5		4.76	8.11					29.81					5.66	
6														
7		4.74	8.16					29.75				18.13	5.65	
8		4.78	8.13					29.80				18.10	5.64	
9														
10		4.76	8.11					27.78				18.18	5.65	
11		4.81	8.14									18.17	5.73	
12		4.81	8.11									18.15	5.72	
93/1		4.83	8.17									18.20	5.75	
2		4.83	8.16									18.20	5.72	
3		4.83	8.19									18.22	5.74	
4														
5														
6	11.10	4.89	8.22									18.24	5.76	
7		4.87	8.23									18.20	5.81	
8	11.10	4.89	8.23									18.21	5.82	
9		4.88	8.22									18.22	5.81	
10		4.88	8.22									18.22	5.83	
11														
12														

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (13)

DGA	236	326	267	269	271	275	276	280	283	287	281	286	284	
BNA	146-9	122-1	125-6	126-4	434-4	436-0	157-4	128-0	152-3	440-9	444-1	127-2	449-2	461-1
CORFO	2030-6940	2040-6910	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6940	2040-6940
DATE	B-4	A-1	A-1	A-3	A-4	A-6	A-7	C-1	C-2	C-4	D-3	D-5	D-2	D-2
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11											17.19	19.02	0.70	
12														
82/1												19.49		
2														
3												19.04		
4												19.39		
5												19.39		
6														
7														
8														
9												19.12		
10														
11														
12														
83/1														
2														
3												18.94		
4														
5														
6														
7														
8														
9														
10														
11														
12														
85/1	1.27		9.92				15.60		1.83		17.98	19.39	0.70	
2	1.25		9.90				15.62		1.81		17.96	19.29	0.71	
3	1.25		9.90				15.63		1.83		17.99	19.33	0.68	
4	1.26		9.93				15.65		1.84		17.98	19.34	0.68	
5	1.23		9.88				15.57		1.80		17.95	19.39	0.74	
6	1.20		9.82				15.71		1.80		18.06	19.34	0.70	
7	1.26		9.89				15.66		1.85		18.03	19.38	0.73	
8	1.23		9.92				15.60		1.85		18.02	19.35	0.70	
9	1.23		9.90				15.55		1.76		17.99	19.36	0.72	
10	1.22		9.91				15.55		1.81		17.99	19.34	0.70	
11	1.25		9.86				15.52		1.80		17.95	19.34	0.68	
12	1.26		9.81				15.56		1.84		18.40	19.39	0.70	
86/1														
2														
3	1.26		9.95				15.63		1.85		18.10	19.36	0.70	
4	1.41		9.95				15.63		1.84		18.10	19.36	0.74	
5														
6	1.45		9.99				15.63		1.87		18.11	19.35	0.50	
7														
8	1.44		10.00				15.64		1.88		18.11	19.34	0.50	
9														
10	1.47		10.01				15.63		1.91		18.10	19.41	0.45	
11														
12														
87/1														
2	1.48		10.00				15.63		1.92		18.10	19.38	0.45	
3														
4	1.59		10.00				15.65		1.94		18.10	19.39	0.51	
5														
6	1.60		10.01				15.65		1.94		18.14	19.40	0.49	
7														
8														
9														
10	1.62		10.03				15.65		1.95		18.14	19.39	0.50	
11														
12														
88/1														
2														

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (14)

DGA	236	326	267	269	271	275	276	280	283	287	281	286	284	
BNA	146-9	122-1	125-6	126-4	434-4	436-0	157-4	128-0	152-3	440-9	444-1	127-2	449-2	461-1
CORFO	2030-6940	2040-6910	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6940	2040-6940
DATE	B-4	A-1	A-1	A-3	A-4	A-6	A-7	C-1	C-2	C-4	D-3	D-5	D-2	D-2
3	1.68		10.03	39.29			15.66		1.96		18.14	19.40		
4	1.66		10.10	39.26			15.65				18.12	19.08		
5														
6	1.66		10.03	39.30			15.66		1.95		18.11	19.39		
7														
8	1.74		10.03	39.29			15.69		1.95		18.16	19.41		
9														
10	1.68		0.54	17.90			15.69		1.89		18.15	19.39		
11														
12														
89/1														
2														
3		89.30			10.84	10.65	15.82	7.66		1.97	18.27	19.57		10.73
4														
5														
6														
7		89.26			10.86	10.64	15.73	7.31		1.57	18.27	19.57		10.33
8		89.26			10.86	10.64	15.73	7.30		1.97	18.27	19.57		10.33
9														
10		89.24			10.86	10.64	15.73	7.30		1.97	18.26	19.55		10.33
11														
12		89.20				10.65	15.73	7.31		1.97	18.25	19.57		
90/1														
2						10.67	15.55	7.30		1.96	18.25	19.43	0.88	
3		88.90			10.84									10.31
4														
5		88.70												10.30
6														
7														
8		88.70			10.83	10.67	15.75	7.55		2.04	18.24	19.51	0.77	11.08
9														
10														
11		88.68			10.83	10.65	15.70	7.53		2.02	18.23	19.50	0.77	11.10
12														
91/1		88.70				10.84	15.70	7.50			18.23	19.50	0.77	11.08
2		88.68				10.88	15.73	7.49			18.22	19.52	0.77	11.05
3							15.75	7.44			18.20	19.51	0.76	
4		87.55				10.86	15.77	7.44			18.19	19.57	0.76	
5		87.71				10.89	15.73	8.32			18.18	19.50	0.76	
6														
7		87.86			10.91		15.75	7.97			18.20	19.51	0.79	11.52
8		87.86			10.90	10.69	15.73	7.97			18.18	19.50	0.79	11.51
9		88.87			10.93	10.69	15.80	8.03			18.22	19.57	0.78	11.51
10		87.85			10.92	11.24	15.78	8.00			18.19	19.55	0.78	11.53
11		87.60			10.92	11.25	15.78	8.02			18.22	19.54	0.79	
12		87.30			10.92		15.79	8.11			18.20	19.56	0.79	11.50
92/1		87.46			10.95	11.28	15.78	8.15			18.22	19.55	0.80	11.52
2		87.20			10.91	10.71	15.76	8.44			18.21	19.54	0.82	
3					10.93	10.73	15.76	8.43			18.23	19.53	0.81	11.51
4		87.40			10.94	10.74	15.75	8.40			18.19	19.50	0.80	11.50
5					10.93	10.73	15.70	8.24			18.21	19.53	0.83	
6														
7		86.75			10.93	10.70	15.70	8.24			18.19	19.52	0.80	11.45
8		86.55			10.91	10.70	15.73	8.30			18.19	19.51	0.81	
9														
10		86.55			10.94	10.72	15.73	8.29			18.19	19.51	0.80	11.48
11					10.02	10.71	15.75	8.56			18.20	19.51	0.80	11.51
12					10.90	10.71	15.73	8.55			18.20	19.50	0.80	11.50
93/1					10.93	10.72	15.75	8.62			18.20	19.51	0.81	
2		86.55			10.90	10.70	15.75	8.60			18.19	19.53	0.80	
3		86.33			11.34	10.73	15.76	9.27			18.20	19.52	0.83	
4														
5														
6		86.79			10.98	10.75	15.77	8.76			18.19	19.55		
7					10.95	10.75	15.76	8.53			18.21	19.53		
8		86.13			10.97	10.74	15.78	8.50			18.22	19.53		
9		85.93			10.96	10.75	15.76	8.61			18.21	19.54		
10		85.90			10.96	10.75	15.78	8.59			18.22	19.54		
11														
12														

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (15)

DGA	296	298	292	294	299	290
BNA	153-1	451-4	453-0	155-8	160-4	124-8
CORFO	2050-6930	2050-6930	2050-6930	2050-6930	2050-6930	2050-6940
DATE	A-1	A-2	B-3	B-4	D-1	B-1
81/1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						2.31
12						
82/1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
83/1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
85/1	18.90		36.78	26.85		2.35
2	18.85		36.76	26.80		2.30
3	18.88		36.77	26.81		2.29
4	18.86		36.80	26.84		2.30
5	18.88		36.76	26.88		2.27
6	18.88		36.70	26.88		2.38
7	18.93		36.75	26.80		2.42
8	18.90		36.80	26.85		2.35
9	9.85		36.78	26.80		2.31
10	18.89		36.75	26.83		2.35
11	18.85		36.72	26.80		2.40
12	18.90		36.78	26.77		2.44
86/1						
2						
3	18.95		36.80	26.80		2.33
4	19.00		36.80	26.89		2.34
5						
6	19.01		36.83	26.89		2.34
7						
8	19.19		36.86	26.88		2.34
9						
10	19.00		36.80	26.90		2.32
11						
12						
87/1						
2	19.10		36.85	26.89		2.33
3						
4			36.34	26.89		2.38
5						
6			36.84	26.90		2.39
7						
8						
9						
10			36.87	26.91		2.39
11						
12						
88/1						
2						

Table B-III, 3.3.1 Variation of Groundwater Level.
<Variacion del Nivel de Agua Subterranea> (16)

DGA	296	298	292	294	299	290
BNA	153-1	451-4	453-0	155-8	160-4	124-8
CORFO	2050-6930	2050-6930	2050-6930	2050-6930	2050-6930	2050-6940
DATE	A-1	A-2	B-3	B-4	D-1	B-1
3			36.85	26.94		2.38
4			36.84	26.91		2.40
5						
6			36.81	26.93		2.38
7						
8			37.38	26.96		2.43
9						
10			36.84	26.97		2.40
11						
12						
89/1						
2						
3				27.21	13.28	2.39
4						
5						
6						
7				27.03	13.28	2.38
8				27.02	13.28	2.39
9						
10				27.02	13.28	2.39
11						
12				27.03	13.28	
90/1						
2				27.03	13.30	2.47
3						
4						
5						
6						
7						
8				26.78	13.28	2.46
9						
10						
11				26.83	13.27	2.47
12						
91/1				26.86	13.29	2.45
2				26.90	13.35	2.48
3				26.98	13.32	2.46
4				27.03	13.29	2.47
5				27.01	13.32	2.32
6						
7				26.99	13.33	2.68
8				26.99	13.32	2.68
9				27.02	13.34	2.49
10				27.04	13.34	2.53
11				27.00	13.33	2.54
12				27.00	13.32	2.54
92/1				26.98	13.36	2.49
2		12.35		26.97	13.35	2.50
3		12.37		26.96	13.31	2.51
4		12.37		26.94	13.31	2.47
5		12.47		27.01	13.36	2.51
6						
7		12.45		26.99	13.31	2.50
8		12.43		26.94	13.33	2.50
9						
10		12.32		26.93	13.31	2.50
11		12.34		26.92	13.33	2.51
12		12.35		26.88	13.31	2.49
93/1		12.34		26.93	13.33	2.50
2		12.35		26.95	13.33	2.52
3		12.33		26.94	13.34	2.51
4						
5						
6		12.37		26.96	13.32	2.49
7		12.36		26.94	13.36	2.52
8		12.35		26.96	13.39	2.52
9		12.36		26.94	13.37	2.54
10		12.30		26.94	13.35	2.54
11						
12						

Table B-II,3.3.1 Groundwater Quality (Pampa del Tamarugal) (Nov. 1993)

<Calidad de Agua Subterránea (Pampa del Tamarugal) (Nov. 1993)>

	B.N.A CODE	DGA CODE	NAME	TEMP. (C)	pH	TDS	Cond. mmho/cm	Turb.	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	SO4 mg/l	Cl mg/l	CO3 mg/l	HCO3 mg/l	HEALTH SIGNIFICANCE NO3 mg/l	As mg/l	F mg/l	Cd mg/l	Cr mg/l	Pb mg/l	B mg/l	Fe mg/l	Mn mg/l	Zn mg/l	Cu mg/l	Al mg/l)
			(STANDARD)		6.0-8.5	1000		5					400.0	250			10.0	0.050	1.50	0.005	0.050	0.05	1.00	0.30	0.100	5.00	1.000	0.20
ZAPIGA	173	13	PTA. AP. DOLORES 6	20.0	8.34	844.7	1100	166	13.8	4.6	190.1	28.2	62.0	253.1		81.2	3.1	0.005		0.005		0.01	5.60	0.47	0.007		0.007	
	178	19	SALAR DE ZAPIGA	25.5	8.87	1187	1600	129	109.0	6.8	158.2	37.5	309.8	274.7	4.2	63.5	12.4	1.383		0.028		0.33	4.76	36.80	4.310		0.222	
	165	23	SALAR DE ZAPIGA	25.0	9.07	1187	1600	266	95.8	10.4	174.8	32.1	116.2	308.1		105.6	13.4	0.027		0.009		0.05	0.46	7.84	0.312		0.086	
	104	30	SALAR DE ZAPIGA	24.2	10.45	1940	2700	990	209.8	0.2	460.0	64.9	283.4	822.8	21.0	15.3	3.6	0.071		0.017		0.08	11.62	6.86	0.173		0.050	
	931		JOSEFINA 1	23.2	8.25	1803	2500	120	134.7	32.6	473.8	57.5	307.4	785.2		66.5	21.1	0.158		0.014		0.04	39.87	18.20	0.250		0.015	
	947		POZO POCHA 1	23.6	8.73	2077	2900	171	64.9	36.8	450.8	60.6	312.2	547.3		82.4	50.5	0.007		0.014		0.04	13.31	35.50	0.620		0.021	
HUARA		45-B-D	POZO DUPLISA	24.5	7.74	1529	2100	143	166.5	26.4	207.0	28.9	509.1	247.4		114.7	8.2	0.029		0.011		0.05	5.28	0.05	0.007		0.011	
	196	46	BAQUEDANO No. 3	25.2	8.46	2488	3500	193	79.9	29.3	535.9	54.3	12.5	939.8		153.2	6.0	0.015		0.015		0.03	6.67	4.05	0.402		0.024	
	226	50	HUMBERSTONE 2	26.0	7.30	2077	2900	161	230.5	8.8	448.5	50.1	525.9	594.5		156.8	9.4	0.088		0.018		0.06	10.78	3.54	0.027		0.020	
HUARA	955		NORIA Nº95	18.3	7.59	2968	4200	146	244.1	19.7	710.7	55.1	658.0	863.6		227.6	3.5	0.731		0.022		0.07	5.94	0.08	0.008		0.028	
			SONDAJE DE HUARA	29.0	7.98	3105	4400	221	468.9	31.6	434.7	39.1	1450.5	451.3		61.0	6.5	0.028		0.018		0.10	9.52	4.86	0.250		0.130	
	-	-	POZO PORVENIR A	26.2	8.12	1119	1500	116	148.3	18.8	187.7	28.2	451.5	254.9		63.5	4.1	0.005		0.009		0.03	7.55	0.76	0.248		0.011	
	202	53	PORVENIR	22.6	7.68	981.6	1300	277	136.3	20.4	187.7	22.7	403.5	207.0		117.2	9.2	0.057		0.008		0.03	4.26	2.53	0.032		0.007	
	240	81A	SARA TIRANA	23.8	8.56	2831	4000	107	155.5	34.8	892.4	84.5	17.3	1696.6		62.9	7.3	0.005		0.023		0.06	10.15	4.77	0.265		0.020	
	311	77B	LA TIRANA 104 A	24.4	8.98	1187	1600	186	23.0	3.6	257.6	41.1	104.7	348.1		85.4	2.7	0.005		0.007		0.01	5.80	0.17	0.005		0.005	
	316	107	BOSQUE JUNOY 15	19.2	7.58	1119	1500	144	152.3	23.2	138.5	30.5	331.4	211.3		102.5	3.9	0.034		0.006		0.03	2.70	0.05	0.004		0.007	
	381	149	BOSQUE JUNOY	23.9	7.40	3310	4700	178	367.0	66.3	455.4	63.3	494.7	1152.8		89.1	4.4	0.200		0.023		0.08	6.67	0.60	0.036		0.020	
	354	134	P. CANCHONES H	26.3	7.70	1529	2100	158	146.7	6.8	262.2	19.2	619.6	158.1		76.3	10.1	0.035		0.012		0.03	1.73	0.07	0.900		0.009	
	323	140	PTA. AP. HISPANIA	26.6	7.65	1803	2500	196	214.4	34.7	188.6	37.5	451.5	391.7		116.6	11.1	0.021		0.009		0.05	10.78	14.80	1.050		0.018	
	113	238	PINTADOS RADIO	25.2	9.65	21937	31900	166	620.0	130.0	5612.0	450.0	2862.6	9363.8		157.4	4.1	1.131		0.201		0.31	4.55	0.72	0.330		0.130	
	146	236	MOSQUITOS 1	23.2	9.20	1529	2100	183	62.5	11.1	414.0	44.2	155.6	676.4		50.6	3.9	0.021		0.012		0.03	12.25	1.66	0.017		0.009	
	144	257	SALAR PINTADOS 3	25.4	4.11	1803	2500	335	24.6	3.0	351.9	32.8	17.3	628.5			28.5	0.005		0.007		0.06	3.52	51.70	3.950		0.087	
	421	251	SALAR PINTADOS 1	25.7	9.35	981.6	1300	434	3.0	0.2	233.5	13.7	8.6	212.7	13.2	247.7	9.1	0.020		0.008		0.02	0.80	6.53	0.030		0.012	
	415	231	SALAR PINTADOS 2	28.6	8.75	570.7	700	408	9.4	1.5	119.6	12.5	12.5	86.5		215.4	7.2	0.005		0.006		0.19	0.48	17.50	0.185		0.027	
	222	64	Q.J. MORALES	29.4	7.62	1256	1700	147	179.4	9.2	100.3	21.5	353.0	141.8		87.3	10.1	0.006		0.007		0.03	1.25	0.02	0.006		0.007	
PINTADOS	143	320	PINTADOS PICA 2	?	9.66	838.5	1091											0.028										
	114	315	PINTADOS PICA 3	31.0	8.07	639.2	800	112	27.5	3.0	161.0	17.6	157.5	96.4		173.3	4.4	0.018		0.007		0.09	0.85	0.91	0.043		0.045	
	447	272	SALAR BELLAVISTA	23.8	11.35	16801	24400	182	1025.0	5.0	3772.0	509.9	1037.4	7423.9		91.5	4.8	0.028		0.141		0.28	14.46	0.25	0.061		0.092	
	440	287	SALAR BELLAVISTA	24.8	9.24	45494	66300	212	576.9	304.0	18998.0	1910.0	13160.2	21121.1	144.6	87.9	8.3	13.815		0.530		0.71	118.32	3.02	0.680		0.345	
	157	276	SALAR BELLAVISTA	20.5	8.70	683	864	168	11.0	2.1	158.2	16.0	135.4	79.8	4.8	167.8	6.1	1.214		0.006		0.06	2.25	1.17	0.032		0.031	
	442	278	OF. VICTORIA - 2	20.6	7.80	707.7	900	173	28.7	6.2	175.7	15.6	153.7	128.7		216.7	2.8	0.230		0.006		0.05	1.99	0.17	0.015		0.006	
	444	281	SALAR BELLAVISTA	26.2	8.85	707.7	900	268	13.7	3.0	207.0	15.2	148.9	167.7	1.8	140.3	14.3	0.388		0.006		0.05	2.00	3.40	0.039		0.025	
	453	292	CHALLACOLLO 2	27.0	8.38	1050	1400	182	60.1	8.4	287.5	28.2	210.4	310.2		169.7	5.6	0.471		0.008		0.07	2.52	1.31	0.036		0.017	
	122	226	CHACARILLA	30.2	9.52	981.6	1300	370	2.2	0.2	308.2	15.2	249.8	137.2	9.6	209.9	11.4	0.611		0.007		0.05	10.36	42.80	0.215		0.030	
	402	324	CHACARILLA 1	31.2	12.30	9679	14000	227	2.8	0.2	2033.2	141.9	581.2	822.4	1186.6		5.7	0.770		0.050		0.18	2.24	5.50	0.095		0.073	
	-	-	POZO SAN GENARO - ENAP	25.8	7.95	639.2	800	152	53.3	6.0	90.6	70.2	165.2	61.7		111.7	4.0	0.039		0.003		0.01	0.31	0.23	0.116		0.006	
			JICA J-3		7.05	595.4	736		33.1	4.4	99.4	16.1	108.1	98.9		80.5	1.36	0.087		0.002	0.02	0.01	2.38	0.04	0.050	0.90	0.004	0.1
			JICA J-4		7.47	3310	4700		208.0	43.0	738.8	74.0	450.0	1124.5		236.1	0.515	0.754		0.016	0.02	0.04	26.82	0.04	0.120	1.20	0.014	0.1
			JICA J-5		7.19	3132	4440		337.0	59.5	501.4	60.0	500.0	1095.1		130.6	1.916	0.054		0.015	0.02	0.05	25.14	0.22	0.009	1.47	0.014	0.1
			JICA J-6		7.74	670.7	846		22.8	2.4	137.1	23.0	199.8	50.7		111.7	1.042	0.077		0.005	0.01	0.01	1.15	0.16	0.018	1.11	0.006	0.1
			JICA J-7		7.84	2255	3160		102.0	43.5	303.6	49.0	300.2	748.7		120.8	1.418	0.058		0.011	0.01	0.04	7.30	0.06	0.004	1.54	0.009	0.1
			JICA J-8		8.09	653.6	821		6.5	0.4	159.2	22.0	105.2	88.6		167.2	0.645	0.292		0.005	0.02	0.01	1.76	0.11	0.380	0.60	0.008	0.1
			JICA J-9		7.07	4228	6040		351.5	60.5	851.0	63.5	800.2	1469		124.5	1.345	0.217		0.023	0.02	0.70	9.41	8.70	0.055	1.50	0.023	0.1
			JICA J-C		7.43	2611	3680		331.5	31.5	409.4	45.5	699.8	719.6		78.1	0.705	0.039		0.013	0.02	0.05	6.67	0.13	0.840	0.57	0.013	0.1
			JICA J-D		7.71	3022	4280		310.0	57.5	501.4	59.0	450.0	1052.5		130.6	1.44	0.005		0.014	0.02	0.05	23.24	3.90	0.018	1.17	0.019	0.1
			JICA J-E		7.28	3029	4290		354.0	58.0	437.0	60.0	699.8	855.4		130.6	2.45	0.038		0.013	0.02	0.06	24.50	0.04	0.030	1.11	0.012	0.1
			JICA J-F		7.56	1584	2180		73.0	24.0	322.0	36.5	199.8	487.1		147.1	0.918	0.197		0.005	0.01	0.03	3.51	0.11	1.400	1.20	0.007	0.1
PICA	252	223	POZO CONCOVA	32.6	8.35	365.3	400	201	18.4	0.2	46.5	1.6	33.1	25.9		97.6	5.6	0.005		0.004		20.01	0.02	0.92	0.015		0.007	
	263	170	LA CALERA Nº3	29.8	8.05	1940	2700	148	81.8	7.7	408.3	15.6	614.8	220.5		70.2	43.5	0.027		0.010		0.02	13.94	0.63	0.034		0.009	
	270	213	ESMERALDA 7	32.2	8.82	981.6	1300	165	19.8	0.5	175.7	5.1	261.8	75.9		54.9	7.0	0.059		0.007		0.01	1.57	1.56	0.025		0.006	

SAMPLED AND ANALYZED BY DGA AND JICA STUDY TEAM IN NOVEMBER 1993
TDS IS CALCULATED FROM CONDUCTIVITY BY USING EQUATION MENTIONED IN CHAPTER 3, B-I (SEE FIG. B-I, 3.3.2).

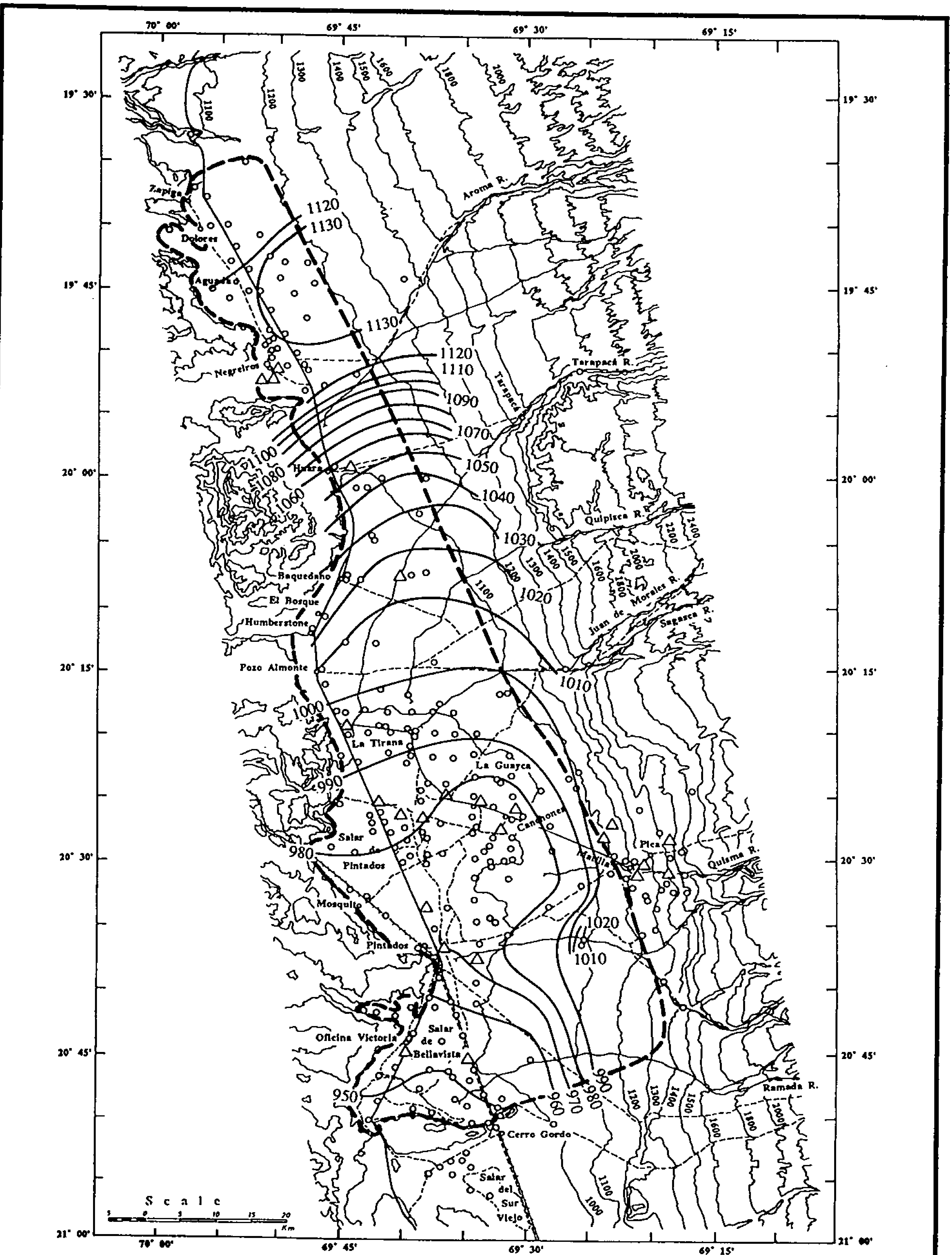

Fig. B-III, 3.2.1 Static Water Level (1993)

<Nivel Estático (1993) >

Unit. : m MSL

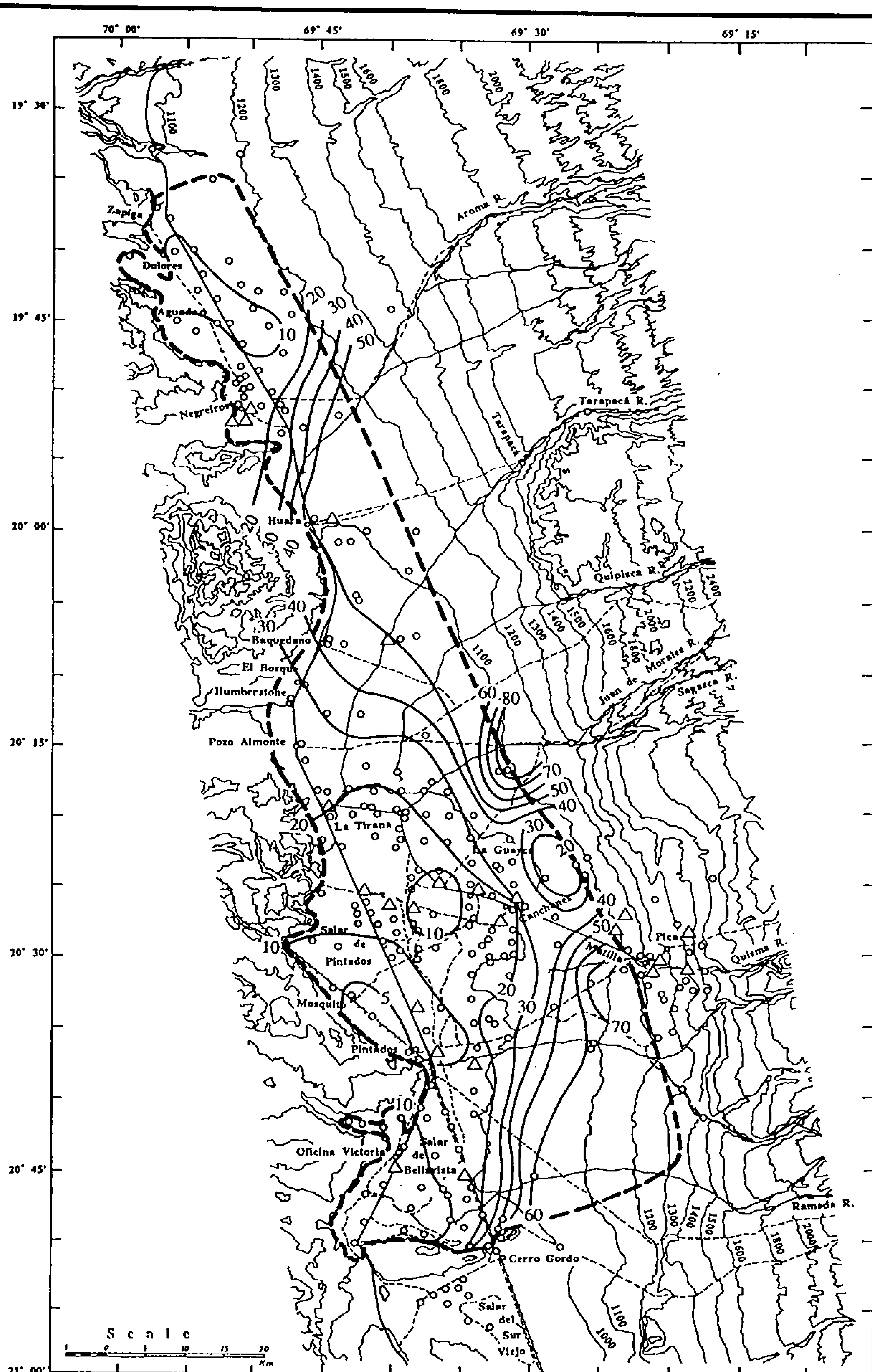

Fig. B-III, 3.2.2 Static Water Level (1993)

<Nivel Estático (1993)>

Unit. : m BGL

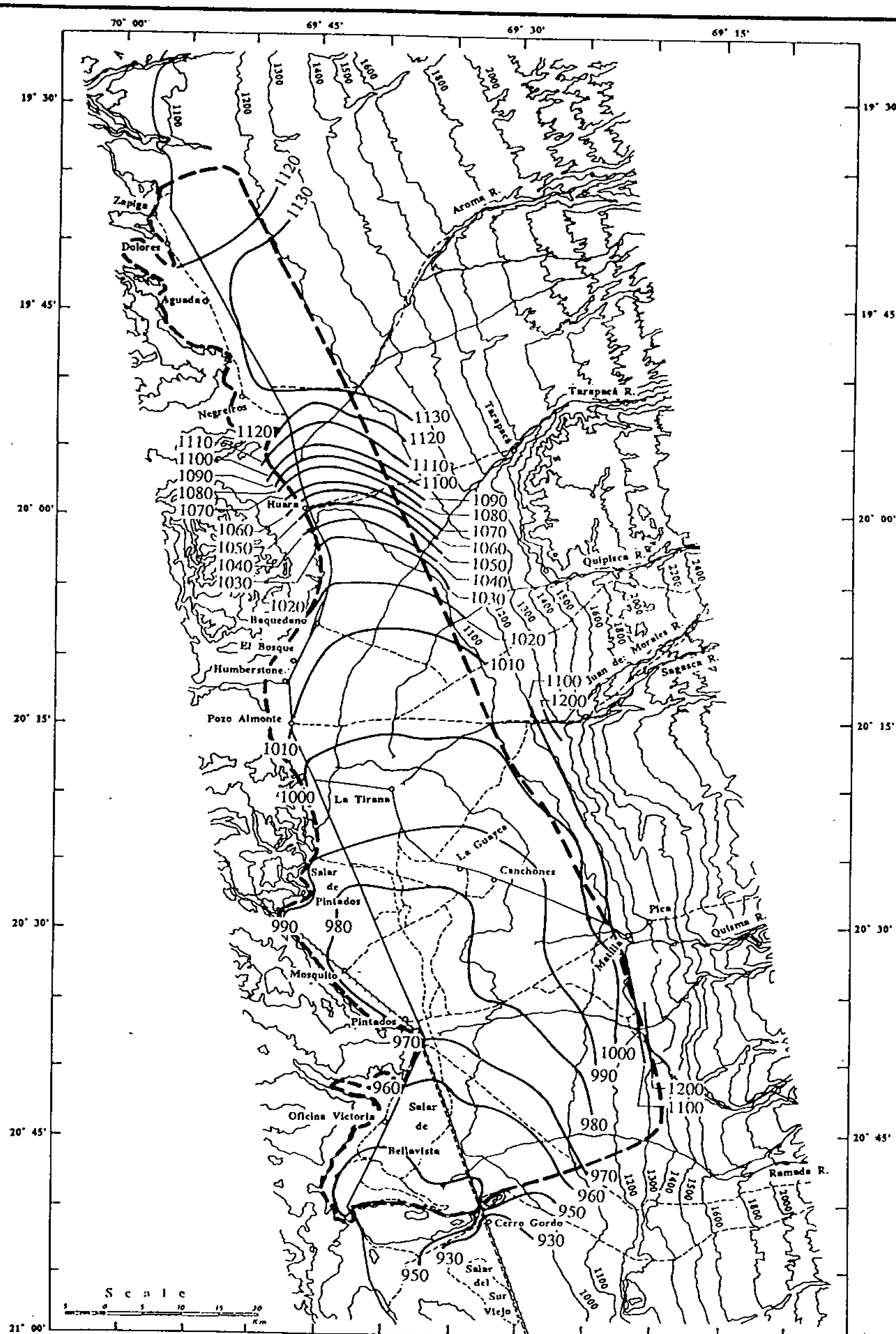

Fig. B-III, 3.2.3 Static Water Level (1960's) (Pampa del Tamarugal)

< Nivel Estático (1960s) (Pampa del Tamarugal) > Unit.: MSL

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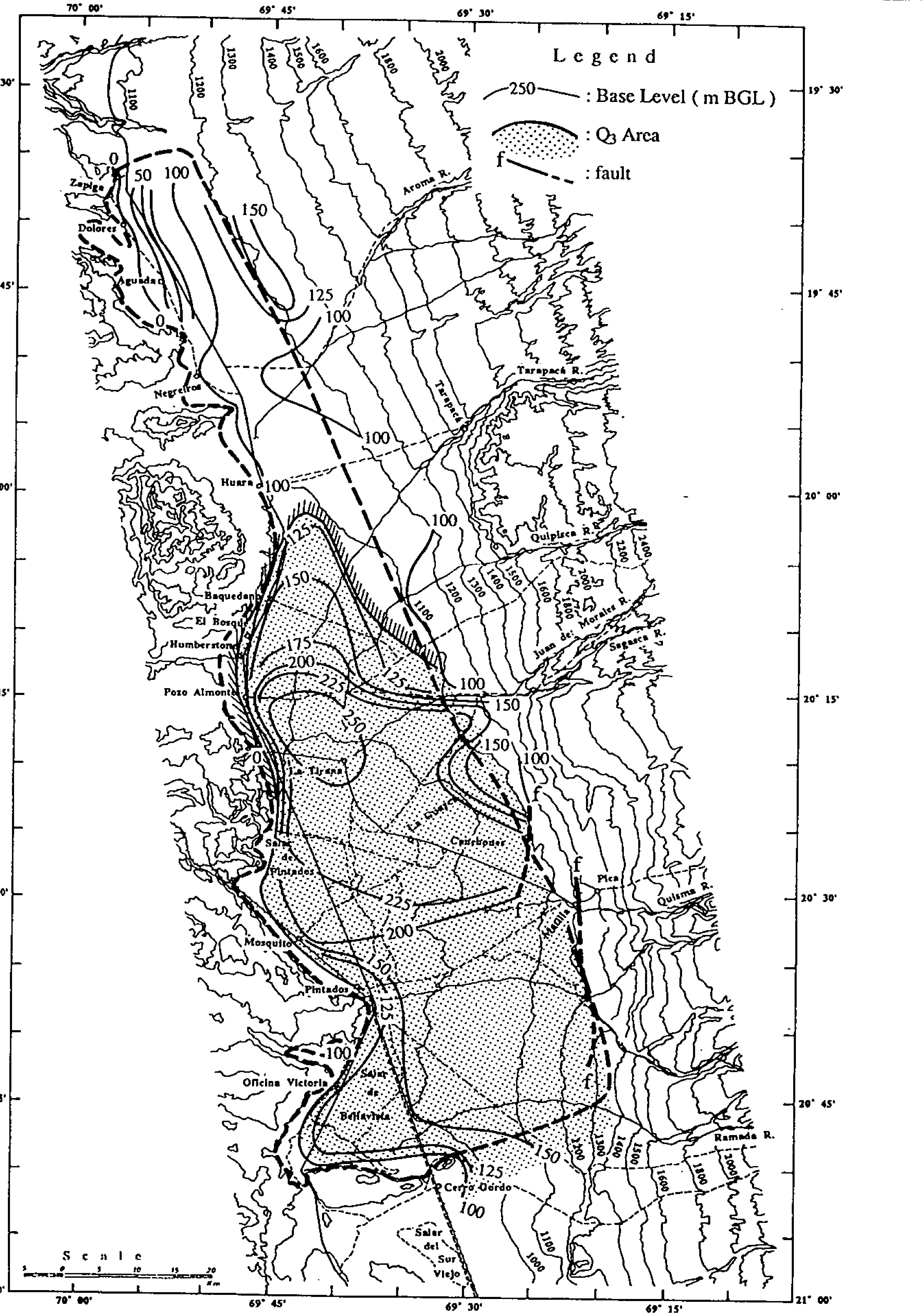

Fig. B-III, 2.4.4 Base of Aquifer (Pampa del Tamarugal)

< Fondo del Acuífero (Pampa del Tamarugal) >

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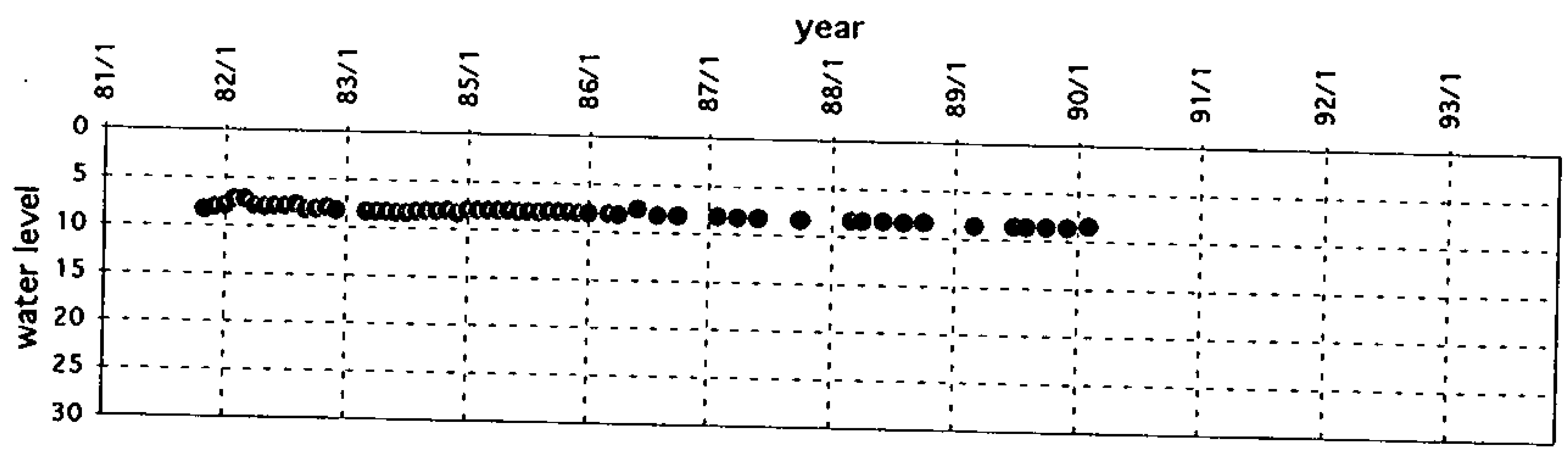
(ZAPIGA)

101-9 (1940-6950 B-3)



104-3 (1940-6950 C-3)

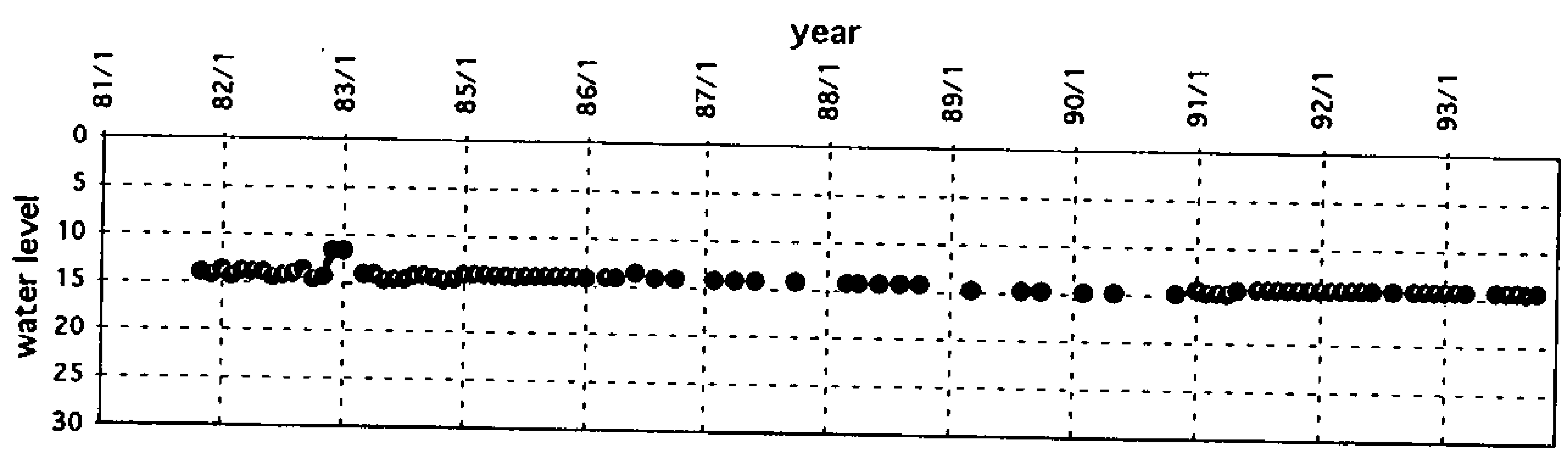


Fig. B-III, 3.2.5 (1) Variation of Groundwater Table in Pampa del Tamarugal

< Variación de Nivel Estatico en Pampa del Tamarugal >

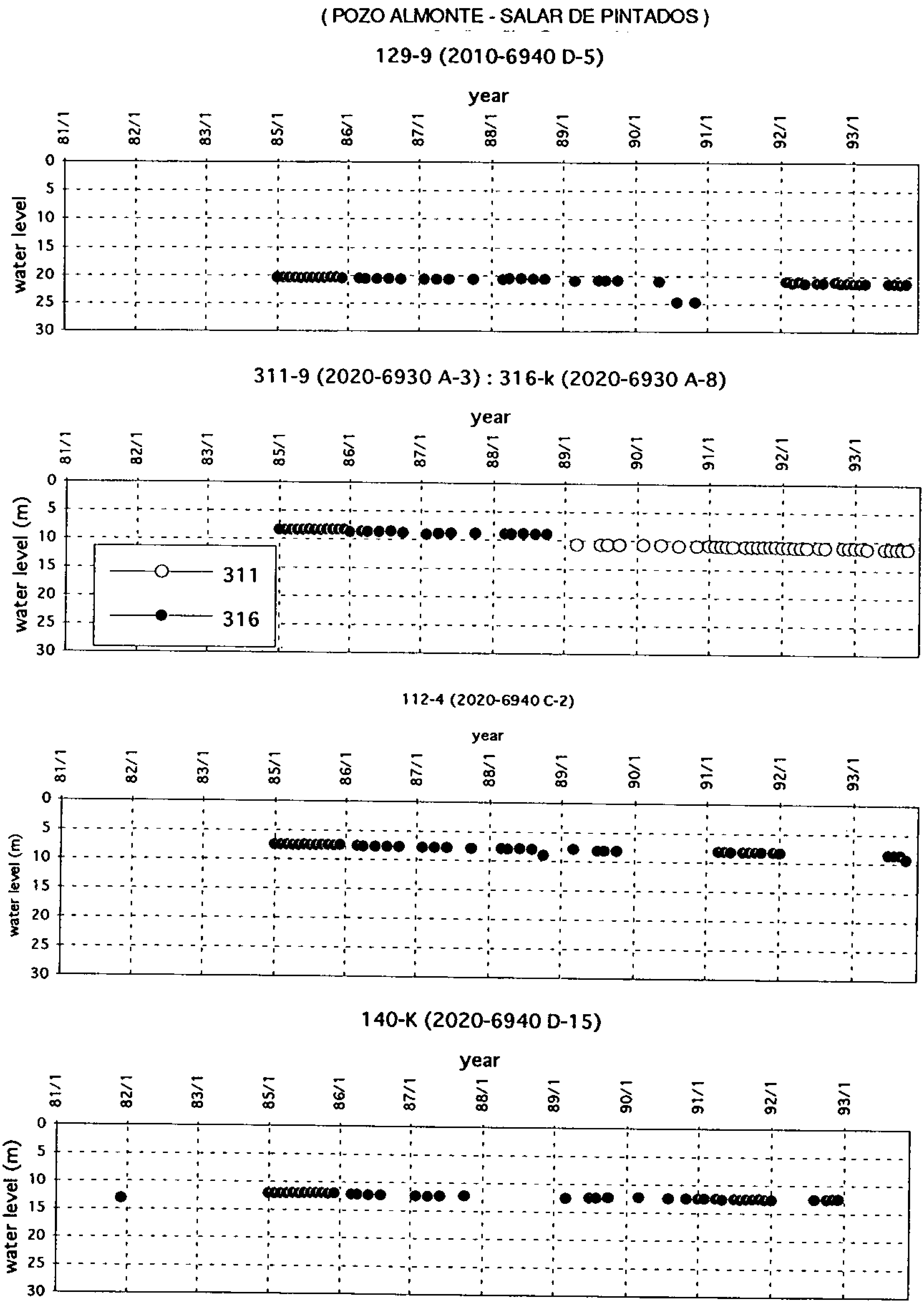
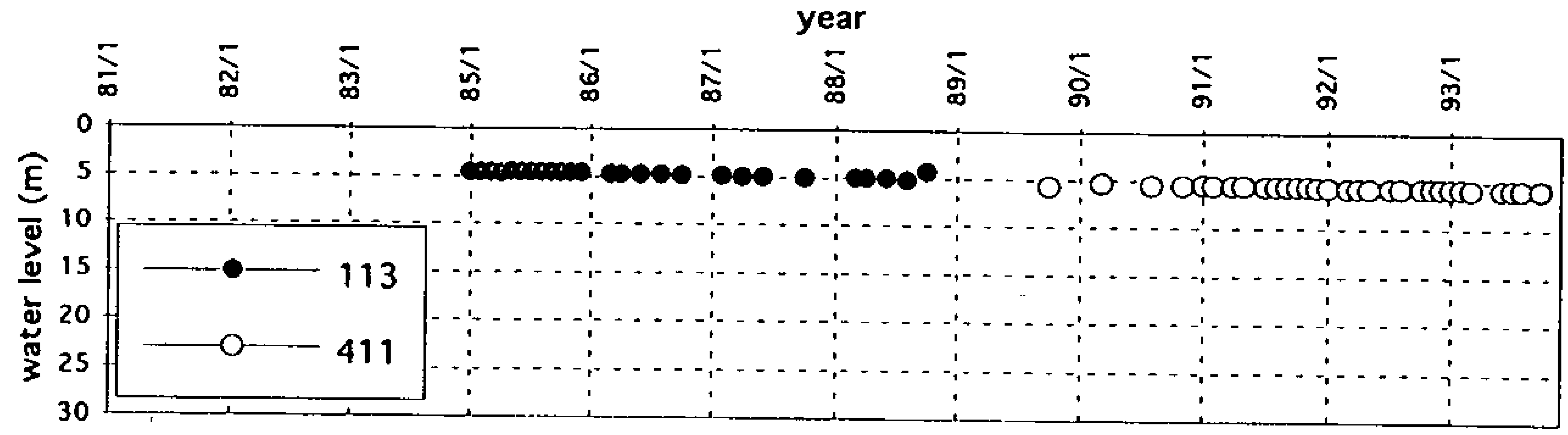


Fig. B-III, 3.2.5 (2) Variation of Groundwater Table in Pampa del Tamarugal

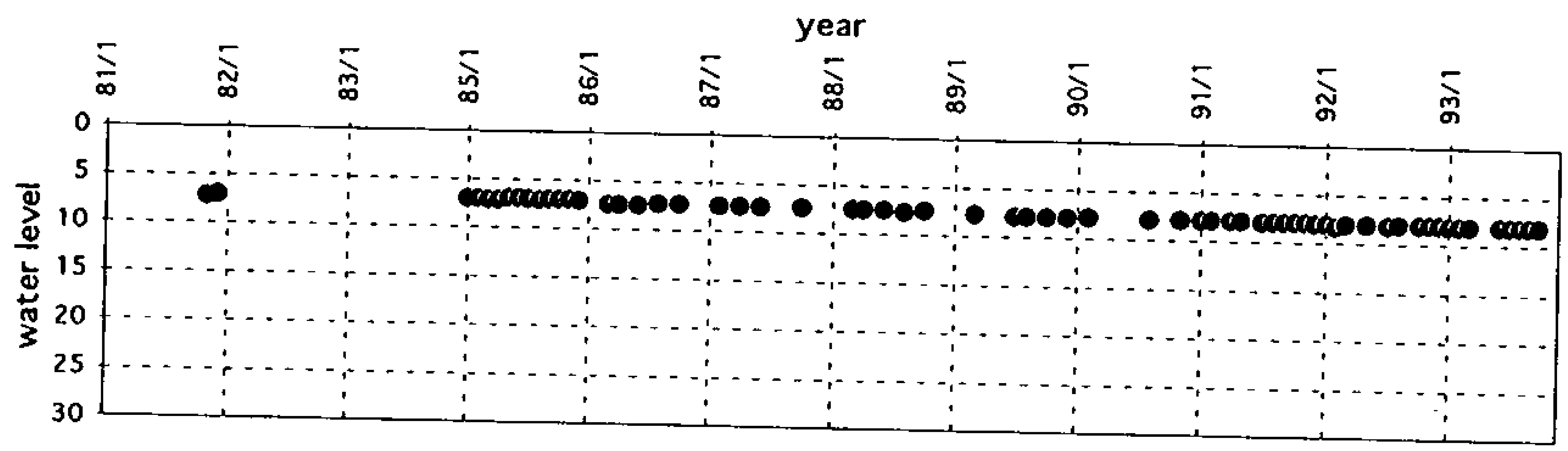
< Variación de Nivel Estatico en Pampa del Tamarugal >

(POZO ALMONTE - SALAR DE PINTADOS)

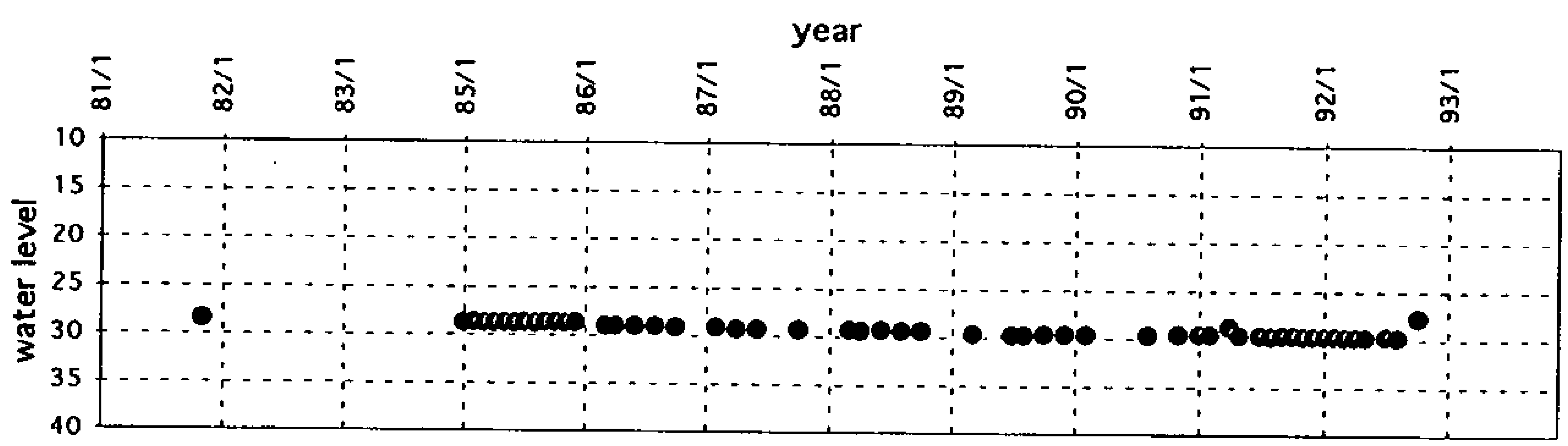
113-2 (2030-6930 A-1) : 411-5 (2030-6930 A-9)



141-8 (2030-6930 C-3)



121-3 (2030-6930 D-2)



430-1 (2030-6940 B-2)

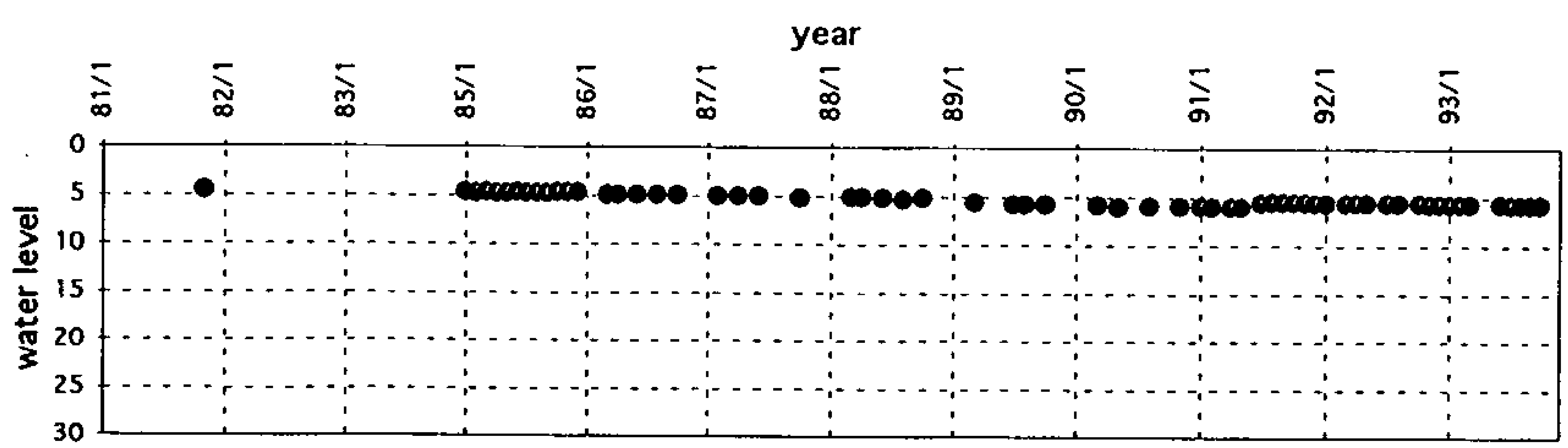
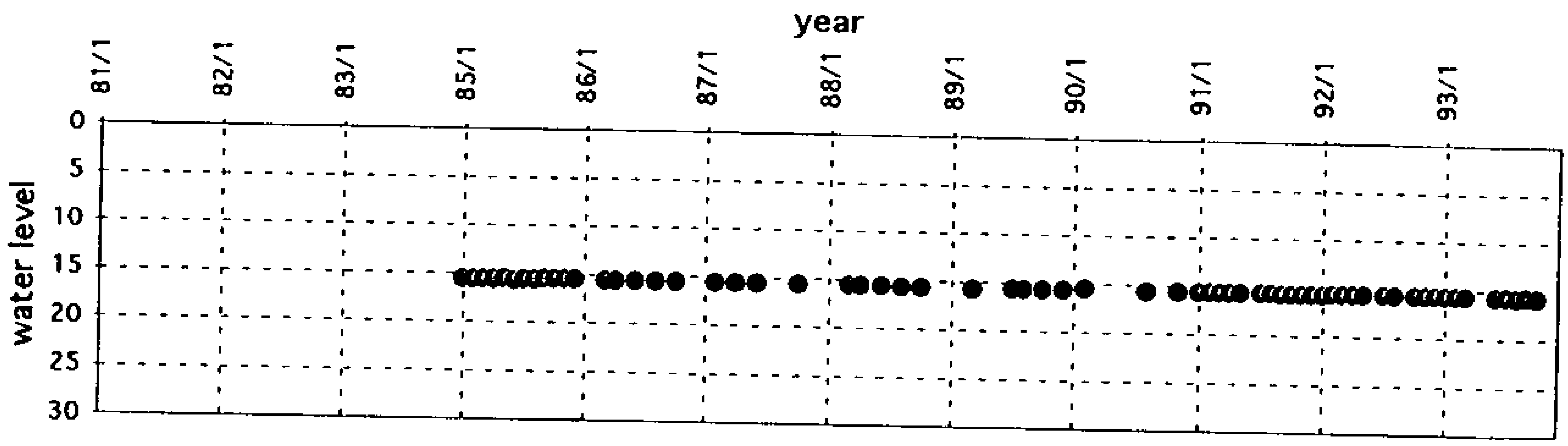


Fig. B-III, 3.2.5 (3) Variation of Groundwater Table in Pampa del Tamarugal

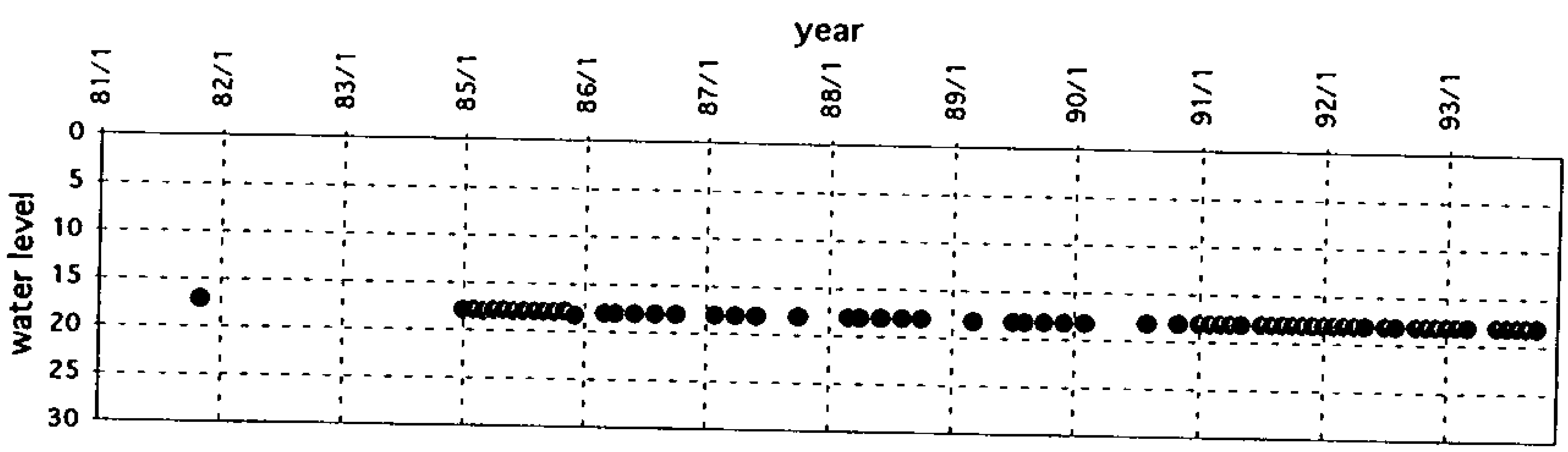
< Variación de Nivel Estatico en Pampa del Tamarugal >

(OFICINA VICTORIA - SALAR DE BELLAVISTA)

157-4 (2040-6930 A-7)



444-1 (2040-6930 D-3)



127-2(2040-6930 D-5)

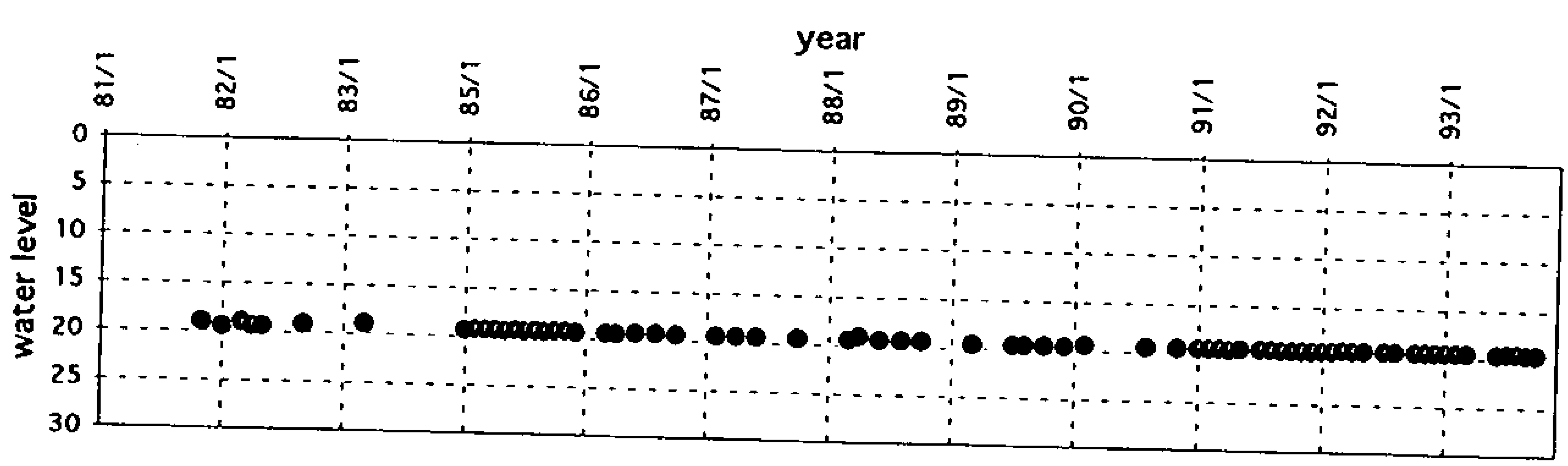
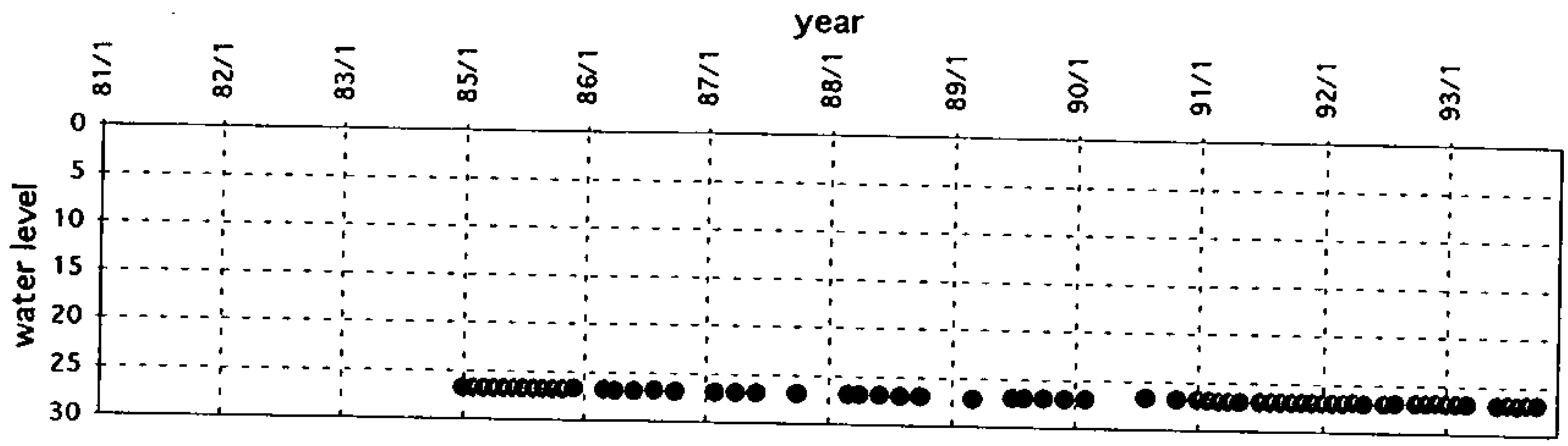


Fig. B-III, 3.2.5 (4) Variation of Groundwater Table in Pampa del Tamarugal

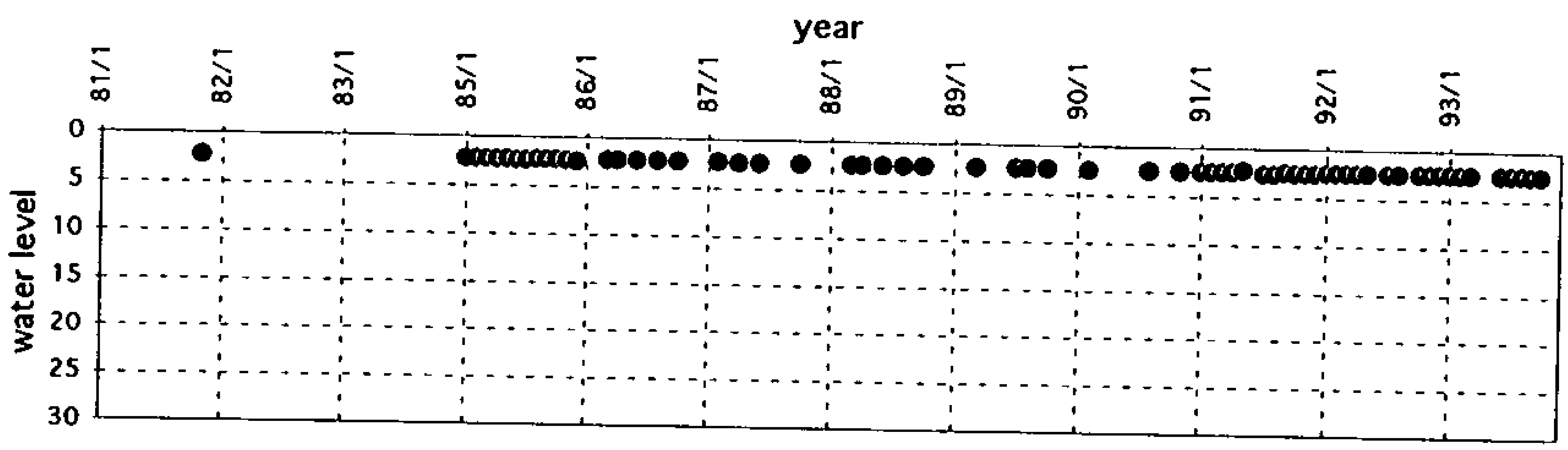
< Variación de Nivel Estatico en Pampa del Tamarugal >

(OFICINA VICTORIA - SALAR DE BELLAVISTA)

155-8 (2050-6930 B-4)



124-8 (2050-6940 B-1)



122-1 (2040 6930 A-1)

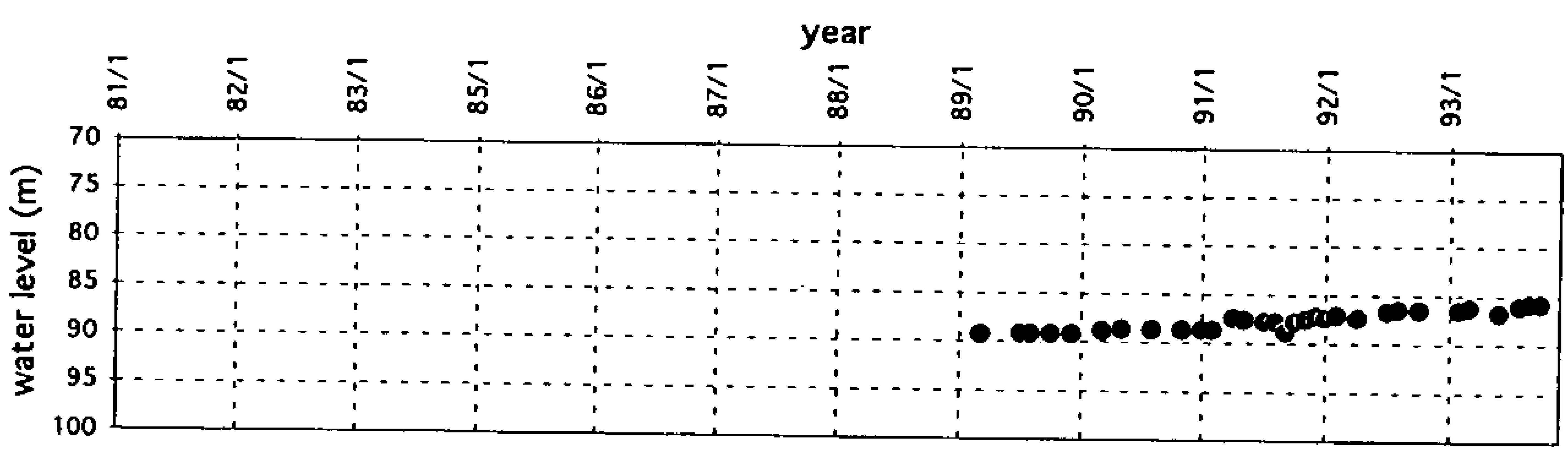
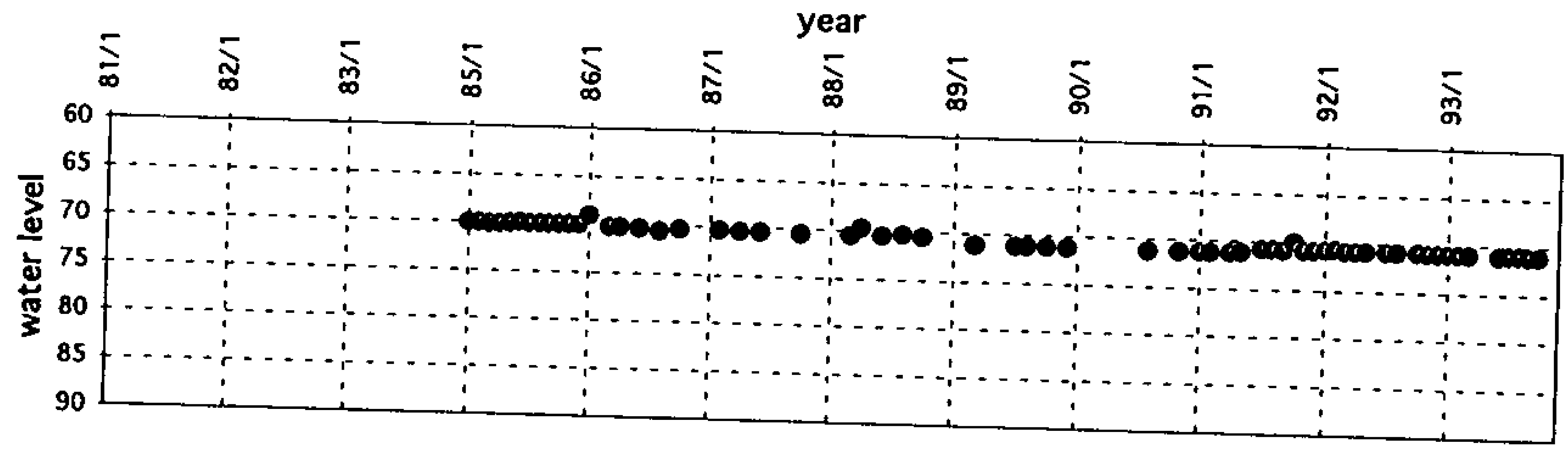


Fig. B-III, 3.2.5 (5) Variation of Groundwater Table in Pampa del Tamarugal

< Variación de Nivel Estatico en Pampa del Tamarugal >

(PICA)

114-0 (2030-6920 A-2)



118-3 (2030-6930 C-1)

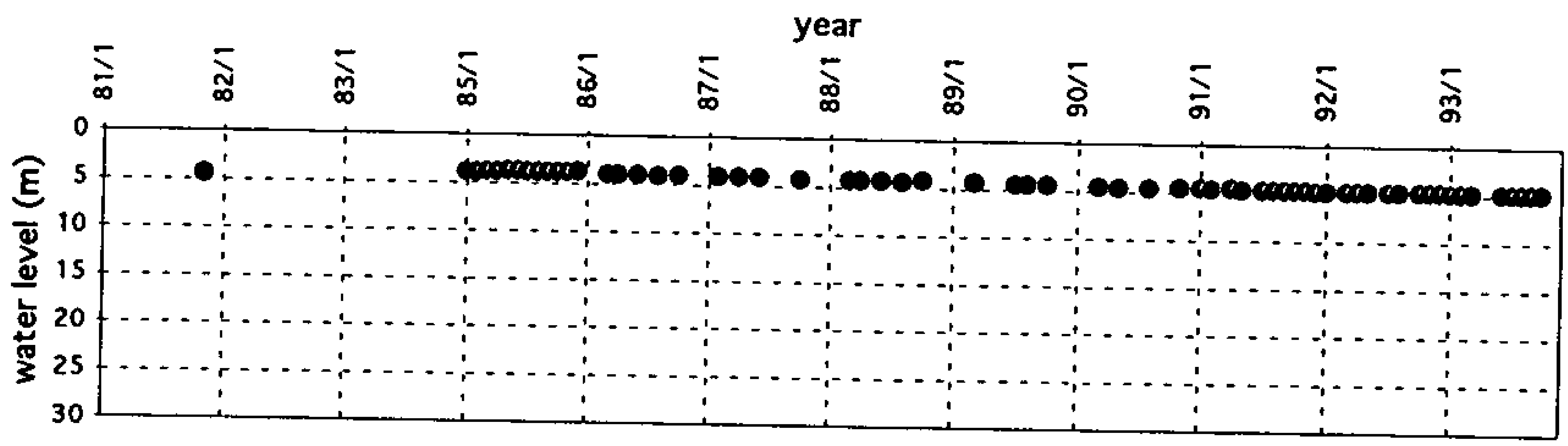


Fig. B-III, 3.2.5 (6) Variation of Groundwater Table in Pampa del Tamarugal

< Variación de Nivel Estatico en Pampa del Tamarugal >

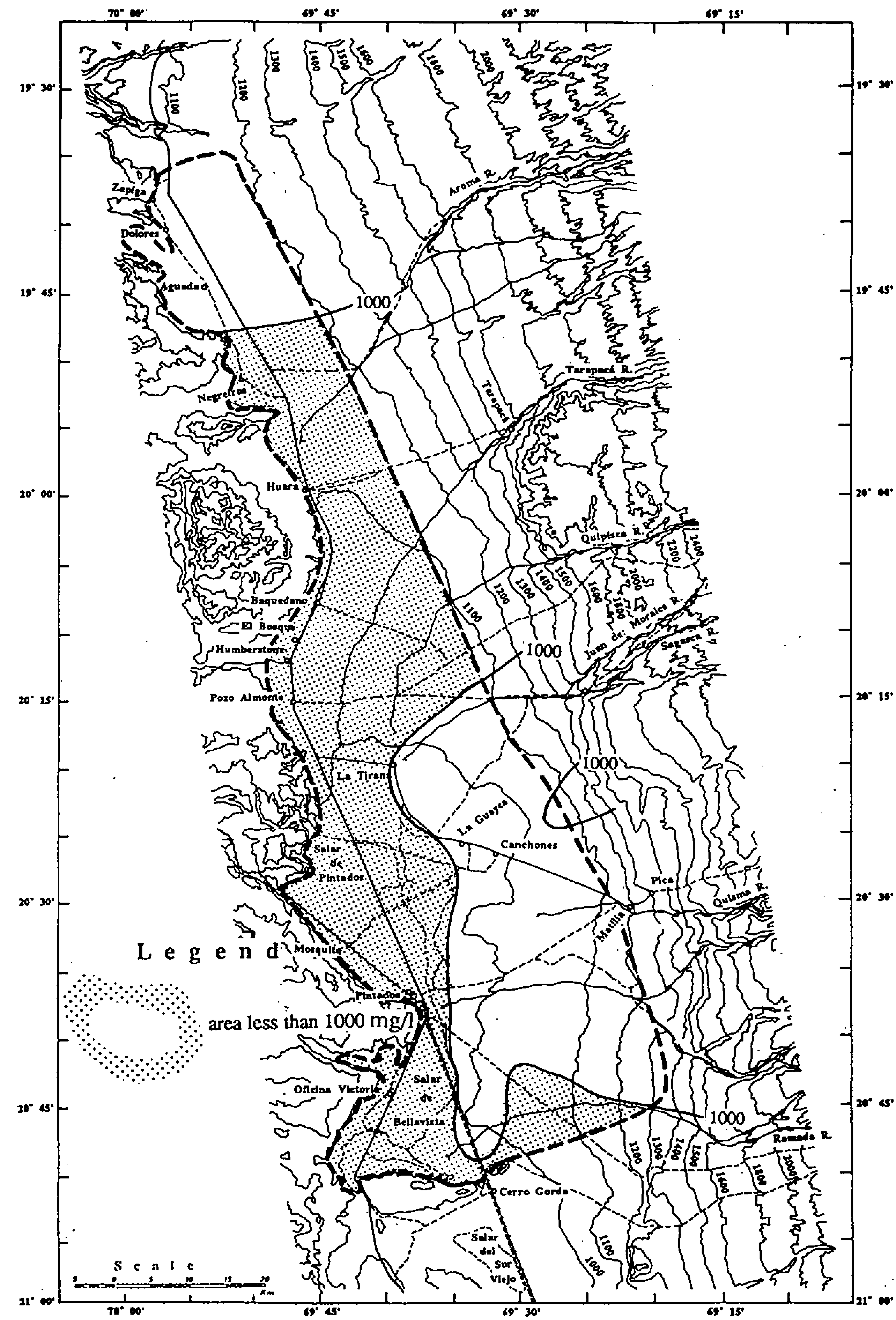


Fig. B-III, 3.3.1 Distribution of TDS (Pampa del Tamarugal)

<Distribución de TDS (Pampa del Tamarugal)>

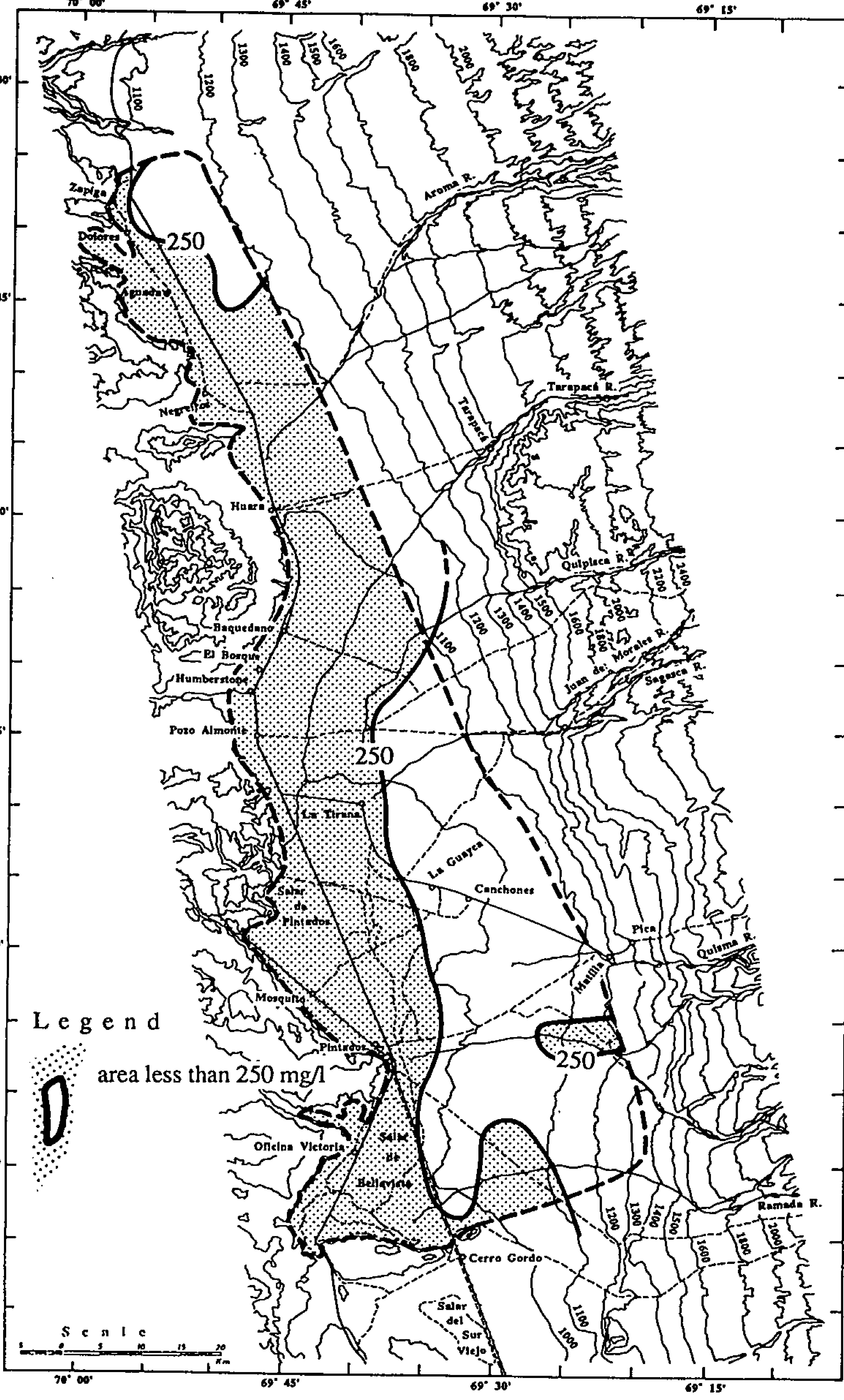


Fig. B-III, 3.3.2 Distribution of Cl (Pampa del Tamarugal)

< Distribución de Cl (Pampa del Tamarugal) >

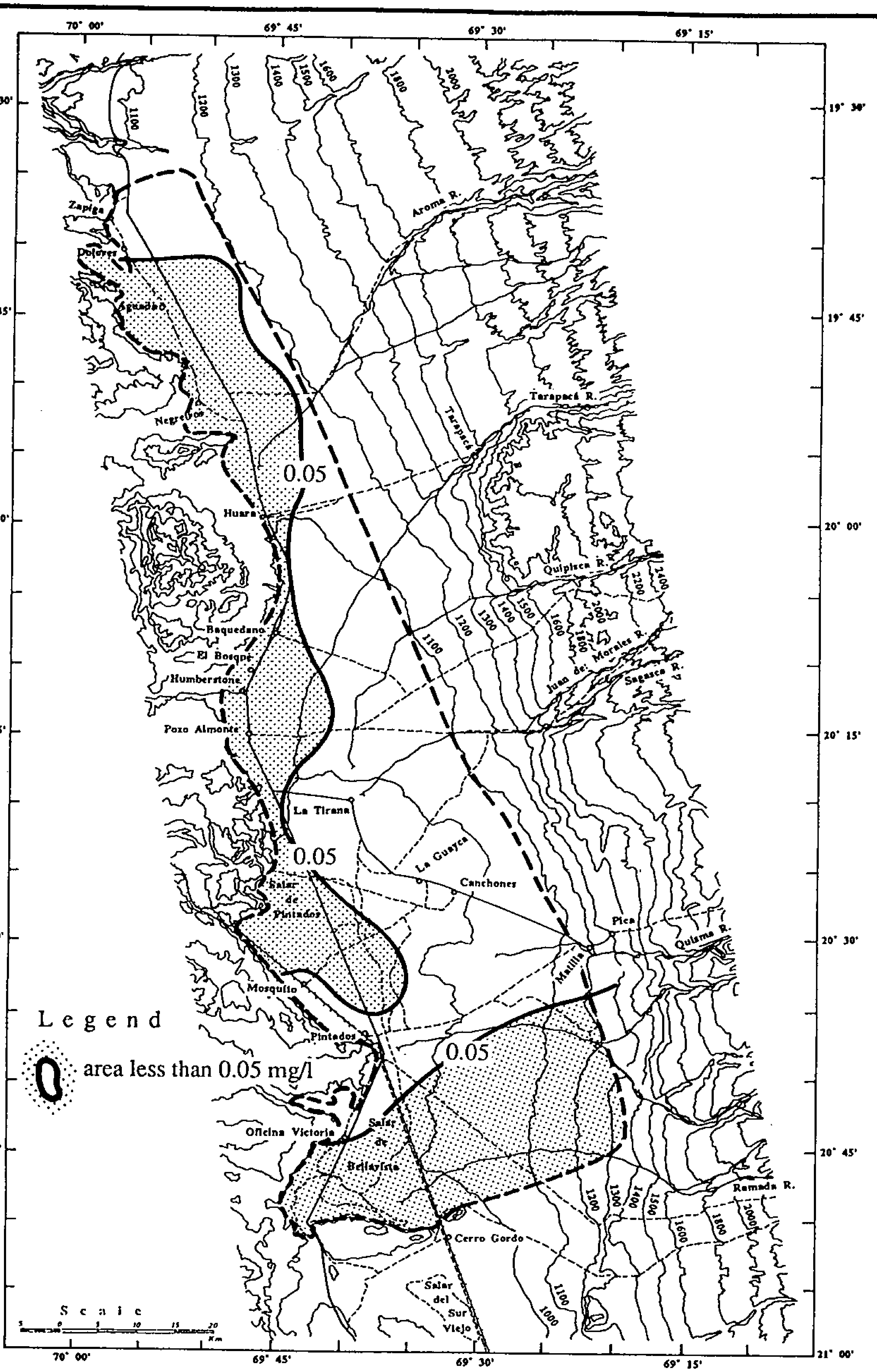


Fig. B-III, 3.3.3 Distribution of As (Pampa del Tamarugal)

< Distribución de As (Pampa del Tamarugal) >

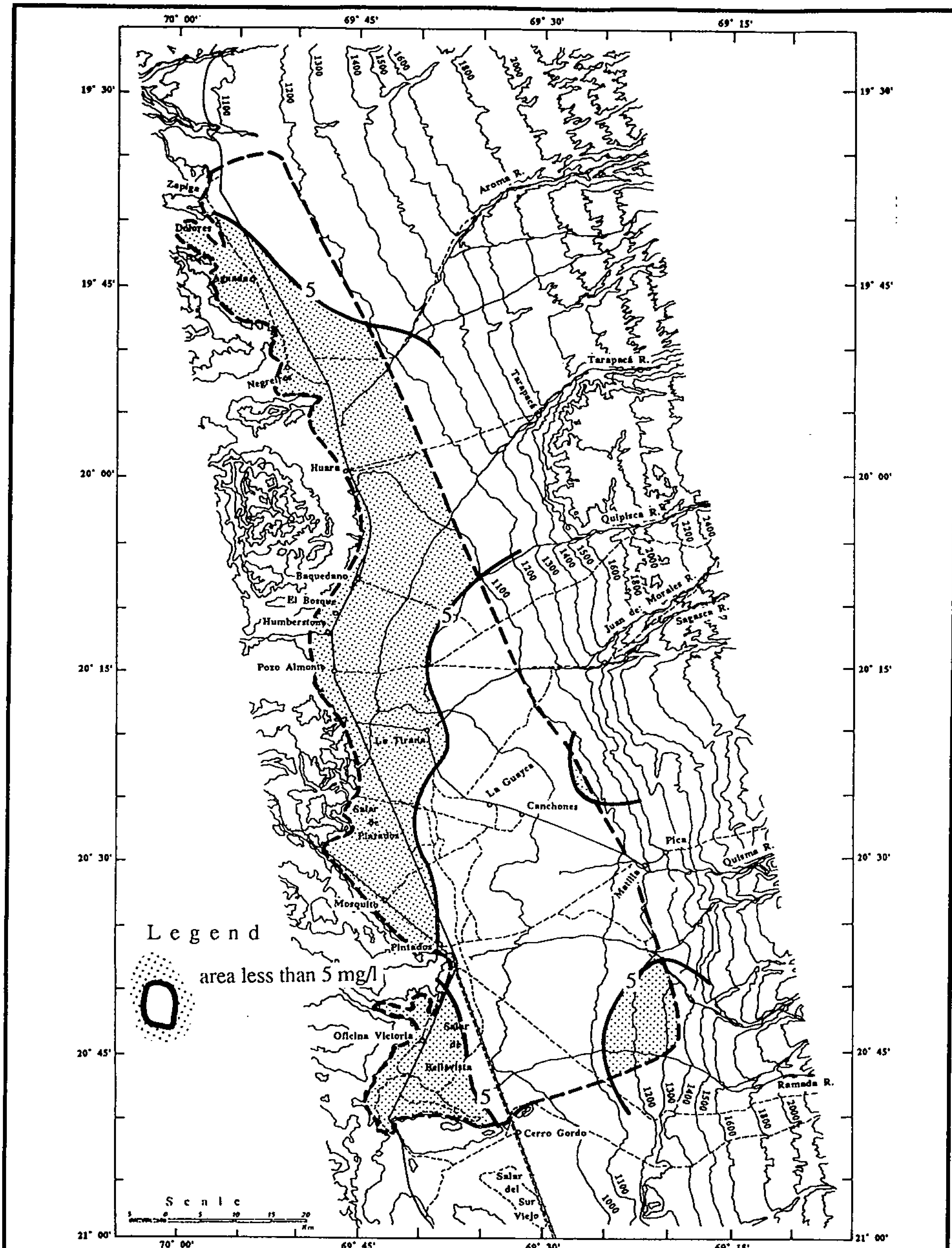


Fig. B-III, 3.3.4 Distribution of B (Pampa del Tamarugal)

< Distribución de B (Pampa del Tamarugal) >

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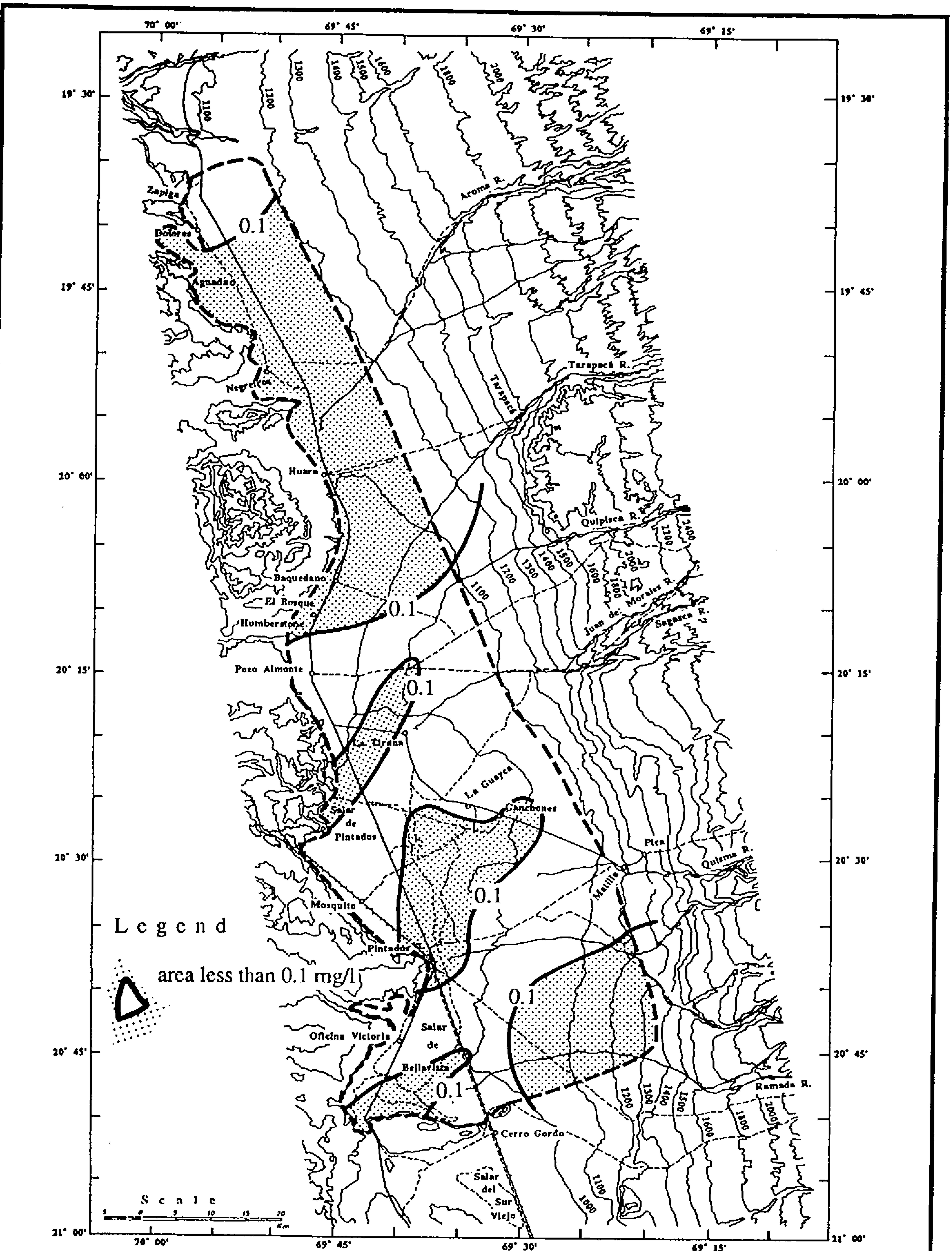


Fig. B-III, 3.3.5 Distribution of Mn (Pampa del Tamarugal)

< Distribución de Mn (Pampa del Tamarugal) >

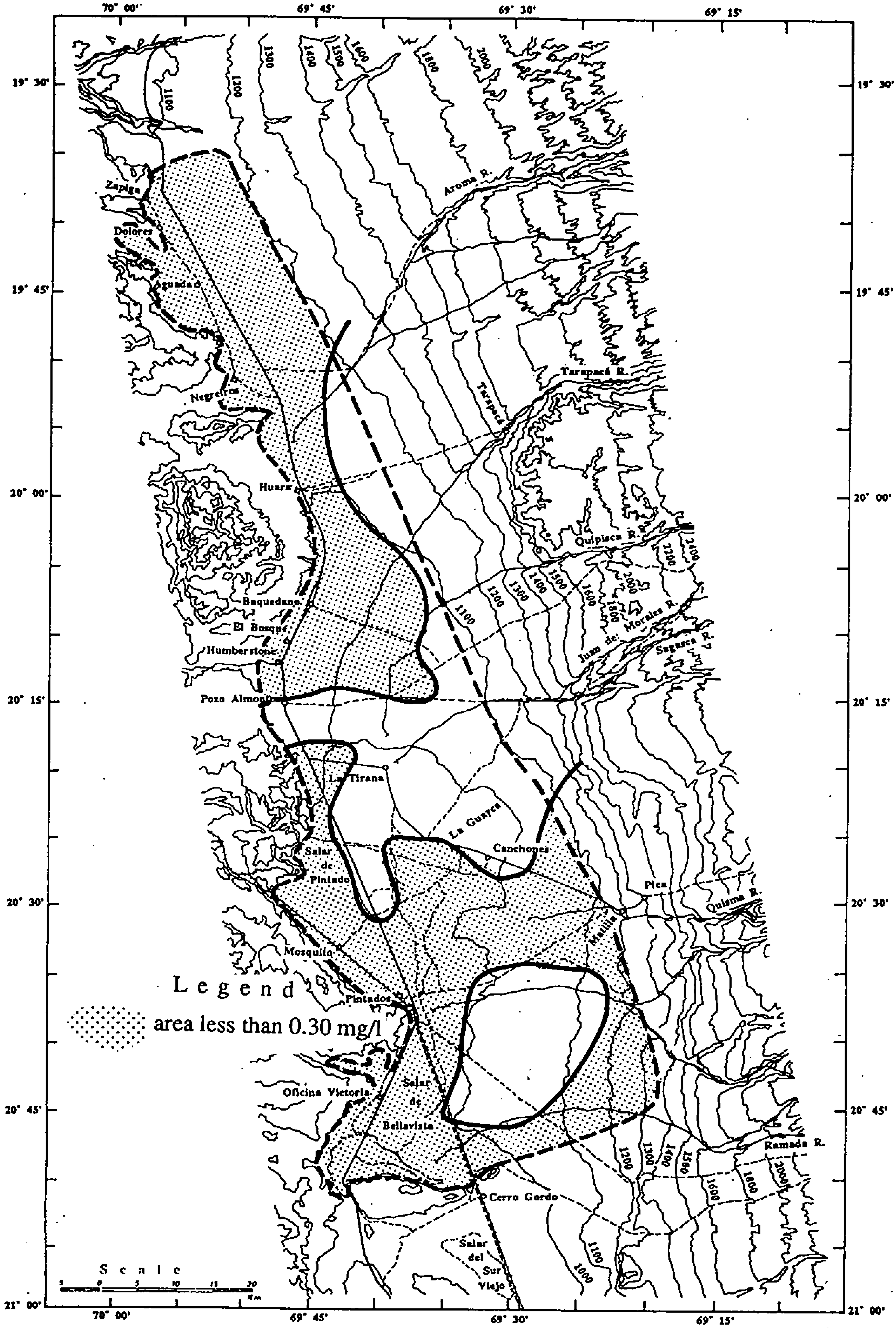


Fig. B-III, 3.3.6 Distribution of Fe (Pampa del Tamarugal)

<Distribución de Fe (Pampa del Tamarugal)>

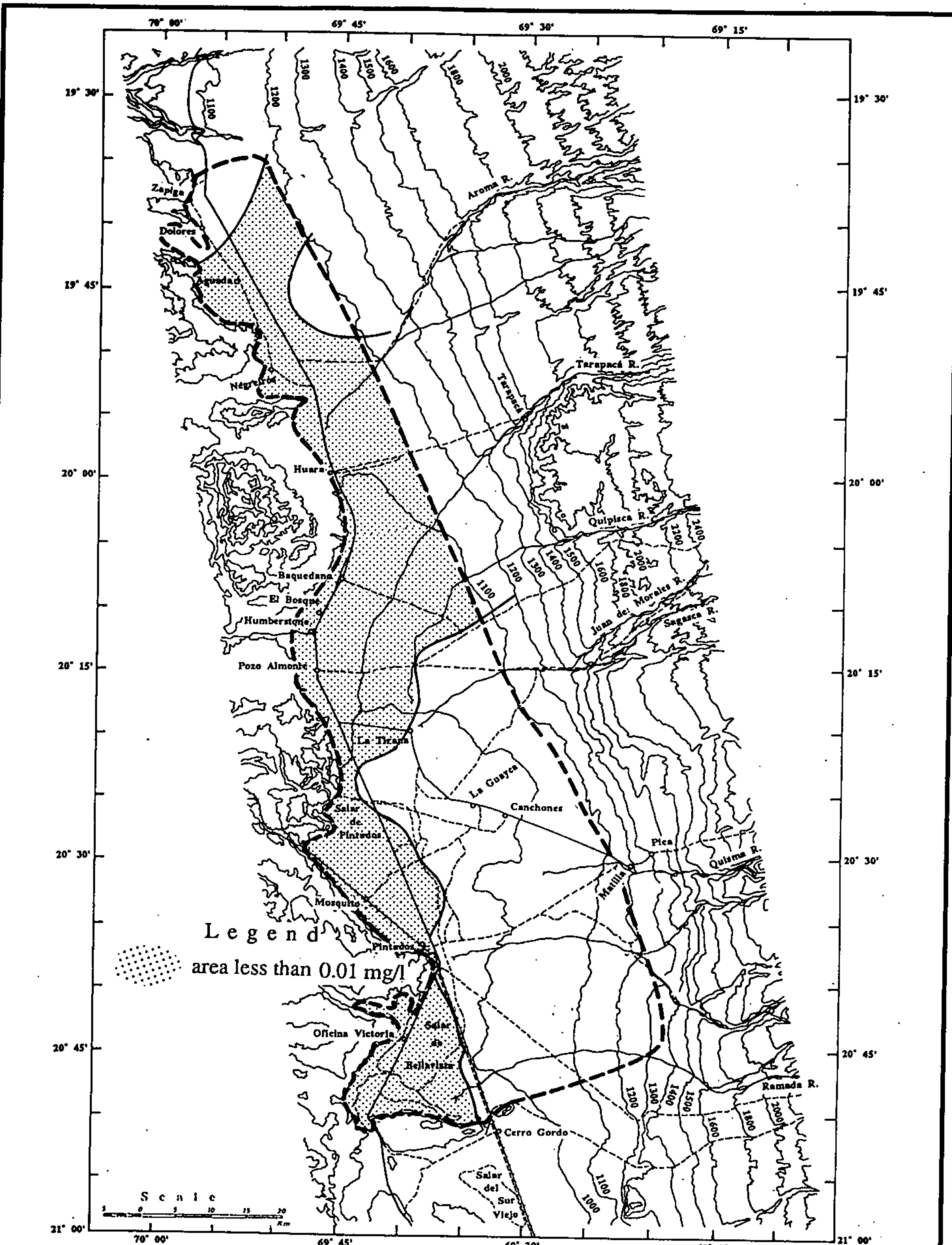
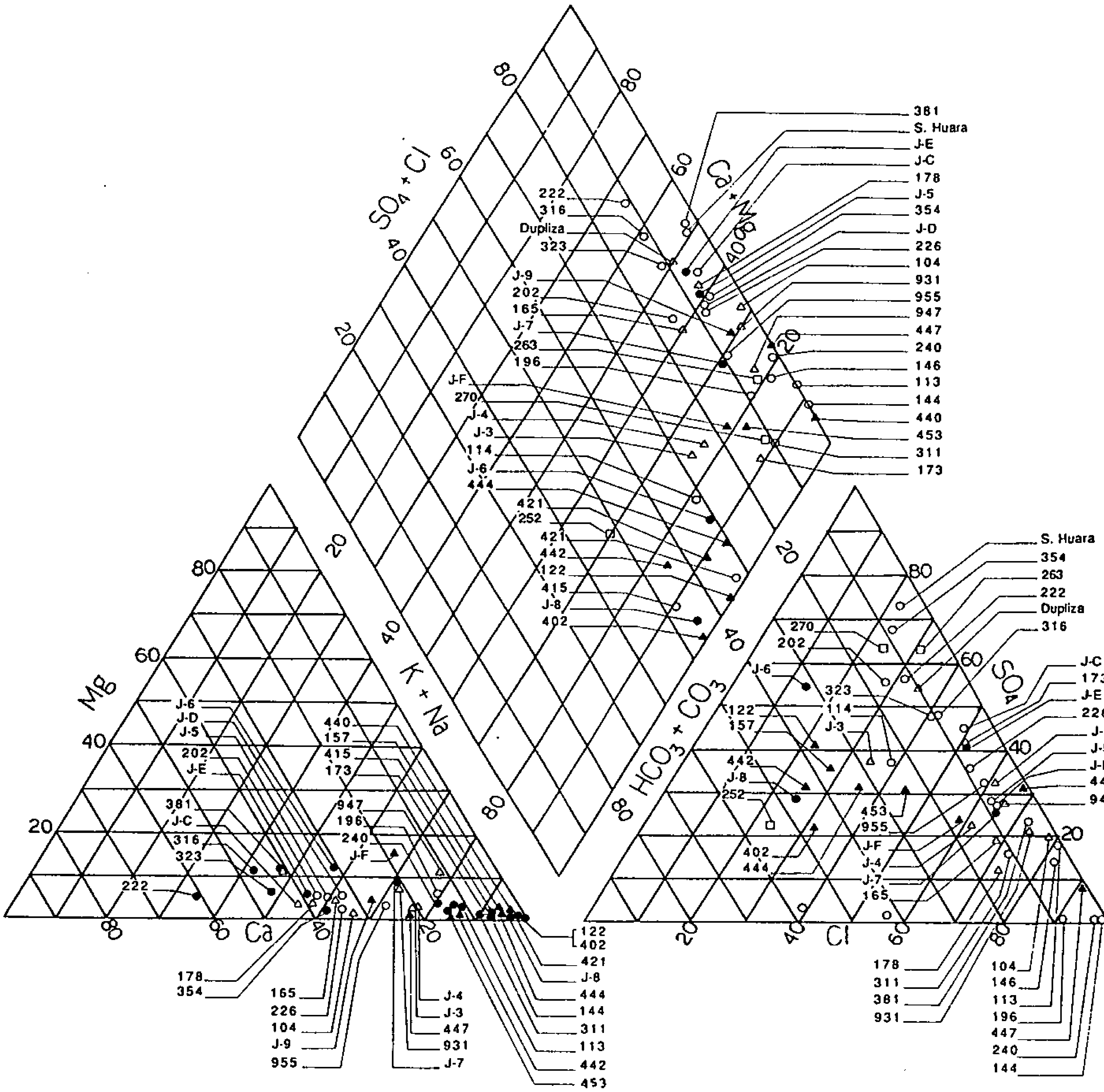


Fig. B-III, 3.3.7 Distribution of Cd (Pampa del Tamarugal)

<Distribución de Cd (Pampa del Tamarugal)>



L E G E N D

△ ZONE 1: Dolores- Zapiga- Huara

○ ZONE 2: Huara- Baquedano- Pozo Almonte

● ZONE 3: Pozo Almonte- Canchones- Pintados

▲ ZONE 4: Bellavista

□ ZONE 5: Pica- Matilla- Calera

Fig. B-III, 3.3.8 Tri-linear Diagram of Major Ions (Pampa del Tamarugal)

< Diagrama Tri-Lineal de Iones Mayores (Pampa del Tamarugal)>

Chapter 1 TOPOGRAPHY AND GEOLOGY

1.1 Topography

Salar del Huasco Basin occupies the parts of Altiplano, as shown in Fig. B-I, 1.1.1, and is situated at the altitude between 3,800 and 4,200 m. Drainage systems of the basin shown in Fig. B-III, 1.1.1 shows that the basin is closed and no river flow out from the basin.

Fig. B-IV, 1.1.1 gives the topographic figure of Salar del Huasco, which is interpreted from aerial photographs taken during 1966 and 1967;

Area of wet land	: 27 km^2
Area of water surface	: 2 km^2
Total area of salt lake	: 29 km^2

Depth of the salt lake was measured during phase 2 study. It revealed that salt lake is generally very shallow and do not exceed 20 cm of depth (see, Supporting Report D).

1.2 Geology

1.2.1 Methodology of Geological Analysis

On the details of the methodology, refer to the part of San Jose River Basin (B-I, 1.1).

1) Interpretation of LANDSAT Images

As for Salar del Huasco Basin, one (1) scene of image, path 002-row 074 is used for the interpretation.

2) Interpretation of Aerial Photographs

31 sheets of black and white aerial photographs taken in 1977 and 1979 were used for the interpretation.

1.2.2. General Geological Features of the Basin

Geology in the Salar del Huasco Basin was summarized based on the interpretation of LANDSAT Images and existing reports (<1 to 4); A geological map, a geological profile and geological cross sections are shown in Fig. B-IV, 1.2.1, 1.2.2 and 1.2.3 respectively. Stratigraphic classification is shown below;

Geologic Age	Formation	Lithology	Units
Quaternary	Recent Deposits	unconsolidated alluvial, eolian and fan deposits	Qal, Qe, Qf
	Pastillos Ignimbrite	lapilli tuff with intercalation of claystone, siltstone and diatomite	Qip
	Collacagua Formation	lake deposits consisting of gravel, mud and volcanic breccia	Qc
	Volcanic Rocks	andesite and dacite (lava flow and lava dome)	Qv
Tertiary		andesitic and dacitic lavas sand pyroclastics. intensely to moderately eroded.	TPv, TMv
	Huasco Ignimbrite	totally or partially welded tuff, rhyolitic and dacitic ignimbrite, grayish and pinkish color	Tsh

1) General Geology of the Basin

(1) Huasco Ignimbrite (Upper Tertiary) (Tsh)

It consists of totally or partially welded rhyolitic and dacitic ignimbrite of grayish and pinkish in color. It seems to be more than 100 m in thickness. Member 4 of Altos de Pica Formation in Pica is correlated to this Huasco ignimbrite (<4). Joints and fissures are well developed in both Altos de Pica Formation and Huasco Ignimbrite. It is observable on the image and aerial photographs that this ignimbrite is intensely fractured.

(2) Volcanic Rocks (TMv, TPv, Qv)

The Volcanic Rocks are composed of andesitic and dacitic lava flow and pyroclastics. These are derived from different stage of volcanic activities; Late Miocene (TMv), Pliocene (TPv) and Early Pleistocene (Qv). TMv is strongly eroded as a whole. While TPv is eroded near the crater, the rocks form a volcanic cones. The volcanoes formed by Qv have been weakly eroded and the shape of crater is still clear.

TMv is cut by fault of N-S direction at the western end of distribution area. the Huasco Basin is located on the west of the fault, therefore, there is a high possibility that TNv is underlain by the Huasco Ignimbrite. Furthermore, there is a possibility that the volcanic breccia (Qcl) of lower part of the Collacagua Formation is correlate with TMv.

(3) Collacagua Formation (Qc)

The drilling results of H-1, J-G and J-10 revealed the details of this formation (<1 and 2.2, Chapter II). The formation is 100 m to 200 m in thickness and is divided into three (3) units based on its lithology; Upper, Middle and Lower. It is lake deposits sedimented in the Huasco Basin. It seems that the Collacagua Formation is correlative with Tt and TPt described by <2 judging from the lithology and stratigraphic relation with other formations. Although <2 described the Collacagua Formation as a Tertiary deposits, the Study Team considered the formation as a Quaternary deposits based on <3.

(i) Lower Unit (Qcl)

The lithology is volcanic breccia in the H-1, changing to gravel, sand and mud in boreholes J-G and J-10. It is more compact compared with other units.

(ii) Middle Unit (Qcm)

The lithology is gravel, sand and mud in the borehole H-1, and gravel in boreholes J-G and J-10.

(iii) Upper Unit (Qcu)

Gravel, sand and mud appear in the borehole H-1 and are overlain by salt crust. It is mainly composed of gravel in boreholes J-G and J-10.

The Upper Unit and Middle Unit are composed mainly of gravel to the north of the Salar. In contrast to this, the sediments consist of gravel and mud in the Salar.

(3) Quaternary Volcanic Rocks (Qv)

It consists mainly of andesite and dacite which form strato volcanoes and lava domes distributed in the eastern side of the Salar. Dacite is compact in the lava dome.

(4) Pastillos Ignimbrite (Qip)

It is divided into two (2) units; Upper and Lower. The Lower Unit is scarcely welded volcanic ash and mud flow deposits abundant in lapilli and pumice. The Upper Unit is composed of dacitic tuff with intercalation of siltstone and diatomite. The Pastillos Ignimbrite is thought to be correlative with the Collacagua Formation (<3). However, the Study Team divided the Pastillos Ignimbrite from the Collacagua Formation, judging from the difference of the lithology of the both; the former consists of acidic pyroclastic rocks and the latter consists of alluvial deposits. It seems that the former is underlain by the latter.

(5) Recent Deposits (Qf, Qe, Qal)

The Recent deposits are divided into three (3) units; Fan deposits, Eolian deposits and Alluvial Deposits.

The Alluvial Deposits are unconsolidated and composed mainly of gravel and sand, deposited in the valleys. The Fan Deposits appear in the fan distributed in the northeastern-ward of the Salar and are composed of reworked fine to coarse volcanic ash with clastics of dacite.

2) General Geological Structure of the Basin

As mentioned in the part of Pampa del Tamarugal, many fractures with NE-SW direction are found on the welded tuff in the area from Collacagua to Altos de Pica. On the aerial photographs, these are mostly normal faults dipping NW or SE. Western side of the Salar del Huasco is bounded by the fault which is extended to the north and meets with the Collacagua River at the northern end. Since the Collacagua River changes to under flow at that place, most of water of the Collacagua River is thought to flow into the faults.

1.2.3 Hydrogeology in Salar del Huasco

As mentioned in 1.1 of this Chapter, the Salar del Huasco Basin is a hydrologically closed basin; Only the Collacagua River flows into the basin from the north. However, surface water of the river completely infiltrate into the under ground recharging the Collacagua Formation. The Collacagua Formation is the most prospective aquifer in the Salar del Huasco Basin. Several springs occur at the western margin of the salt lake yielding fresh water. No rivers flow out from the basin. The change of water level of the Salt Lake is not so much. This feature suggests that the inflow rate of the Collacagua River balances with the trans-evaporation rate from the surface of the Salt Lake and the outflow through the joints and fissures of the rocks (water balance is mentioned in Chapter III).

Geology of the Salar del Huasco Basin is classified into following five (5) units;

Recent Deposits (Qf, Qe, Qal)
Pastillos Formation (Qip)
Quaternary Volcanic Rocks (Qv)
Collacagua Formation (Qc)
Huasco Ignimbrite (Tsh)

Among these, the Collacagua Formation is the prospective aquifers of the basin. Hydrogeological descriptions of each unit are given below;

(1) Recent Deposits (Qf, Qe, Qal)

The Recent Deposits are thin unconsolidated sediments and have low permeability as a whole because the deposits are abundant in clay, silt and fine-grained volcanic ash. However, the deposits consist mainly of fluvial deposits which are poor in fine-grained materials in the area along the Collacagua River. Therefore, this deposits are not considered to be a aquifer in the basin.

(2) Pastillos Formation (Qip)

Although the Upper Unit is weakly welded and abundant in pumice, it is considered to be low permeable.

The Lower Unit is of low permeability because it consists of mud flow deposits and intercalated with many clay and silt layers.

(3) Volcanic Rocks (TMv, TPv, Qv)

Although the rocks itself is compact, it is moderately permeable because joints and fissures are well developed in the rocks. In case of strato volcano, high permeable pyroclastics are intercalated with lavas. There is less possibility that the Quaternary Volcanic Rocks form aquifers judging from the distribution.

(4) Collacagua Formation (Qc)

The formation is formed by coarse-grained alluvial deposits of highly permeable. Therefore, it is considered that the Collacagua formation is the most prospective aquifer in the basin. However, the lower part is less permeable compared with the middle and upper units, because it occasionally contains pyroclastics and is compacted as a whole.

The static water level of groundwater in this formation is 10 mBGL at the well No. J-G and 30 mBGL at No. J-10. The gradient of static water level between the wells is approximately 3/1000, since the distance between the wells is 7 km.

(5) Huasco Ignimbrite (Tsh)

Joints and fissures are well developed in the rocks so far as observed in the outcrops. Therefore, it is considered to be permeable in a certain degree. However, it seems to be difficult to meet groundwater properly by drilling. To give a instance of the water well drilling in the welded tuff, " The history of well drilling in the Pica area shows that only one (1) good well has been obtained in approximately 40 attempt"(<4). This fact shows that it is difficult to develop the groundwater in the welded tuff (including ignimbrite). However, there is a possibility that a part of the groundwater in the basin flows out to Pampa del Tamarugal basin through the joints, fissures and faults (<5).

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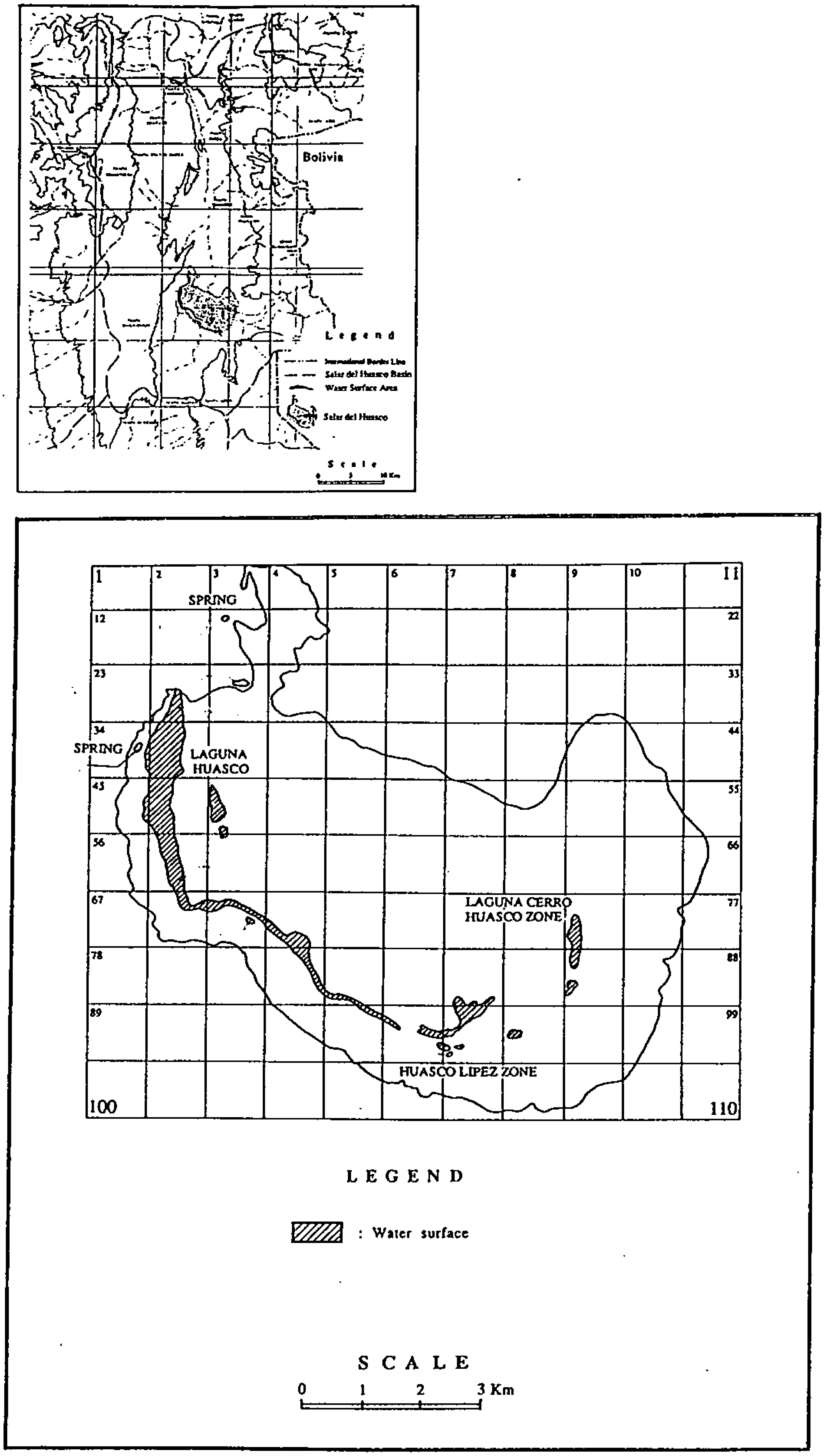

Fig. B-IV, 1.1.1 Topographic Figure (Salar de Huasco)

<Figura topografica (Salar de Huasco)>

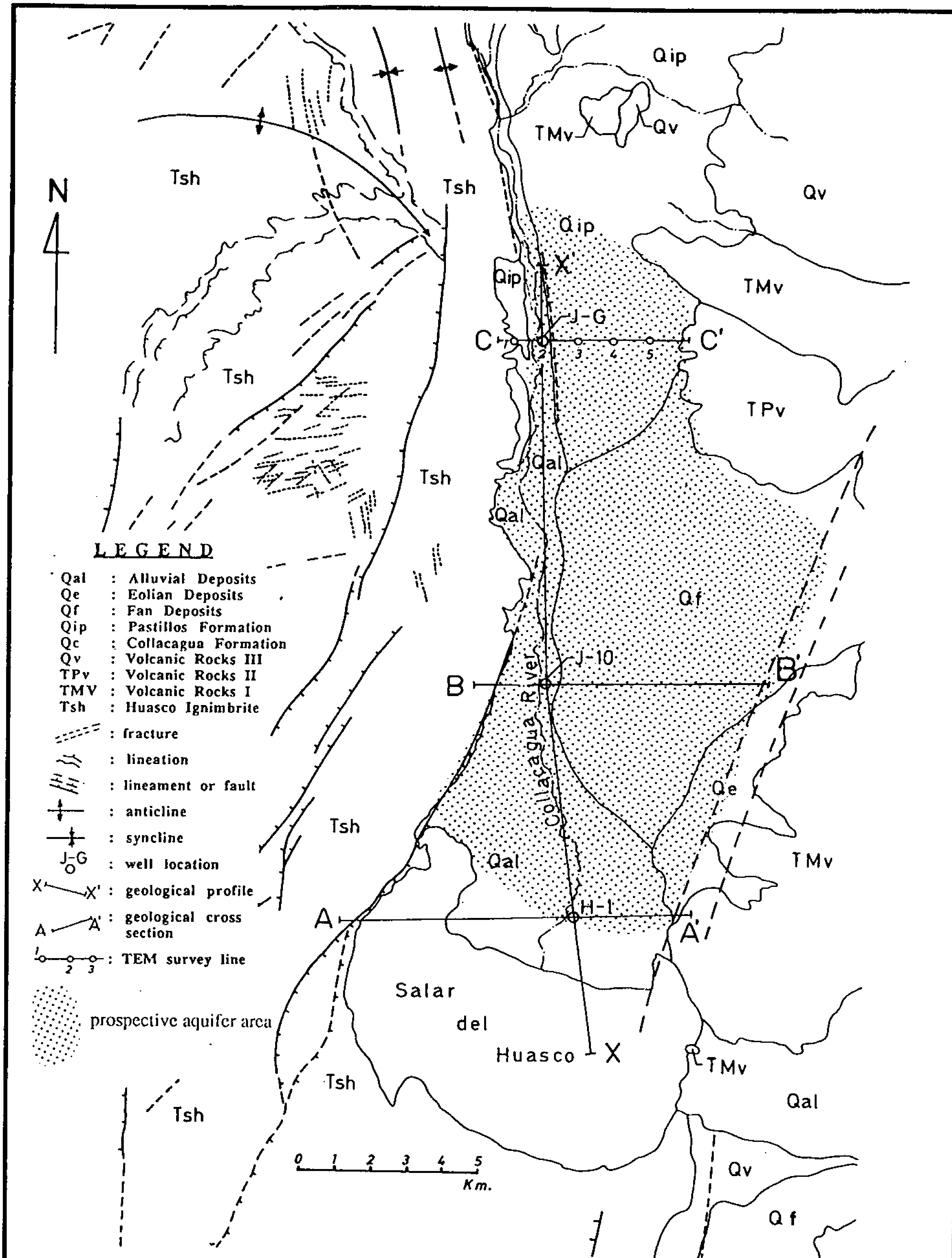

Fig. B-IV, 1.2.1 Geological Map (Salar del Huasco)

< Mapa Geológico (Salar del Huasco) >

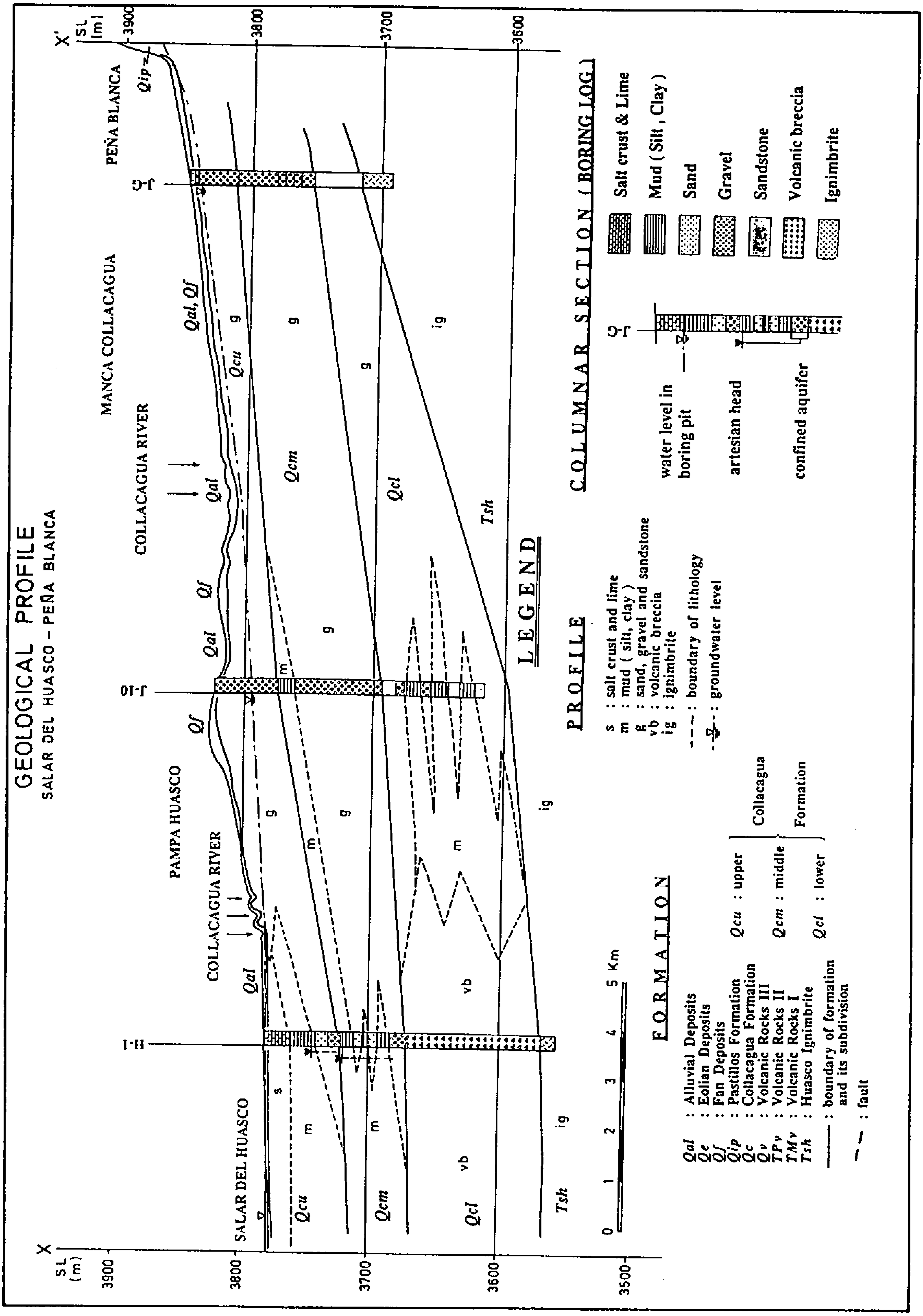

Fig. B-IV, 1.2.2 Geological Profile

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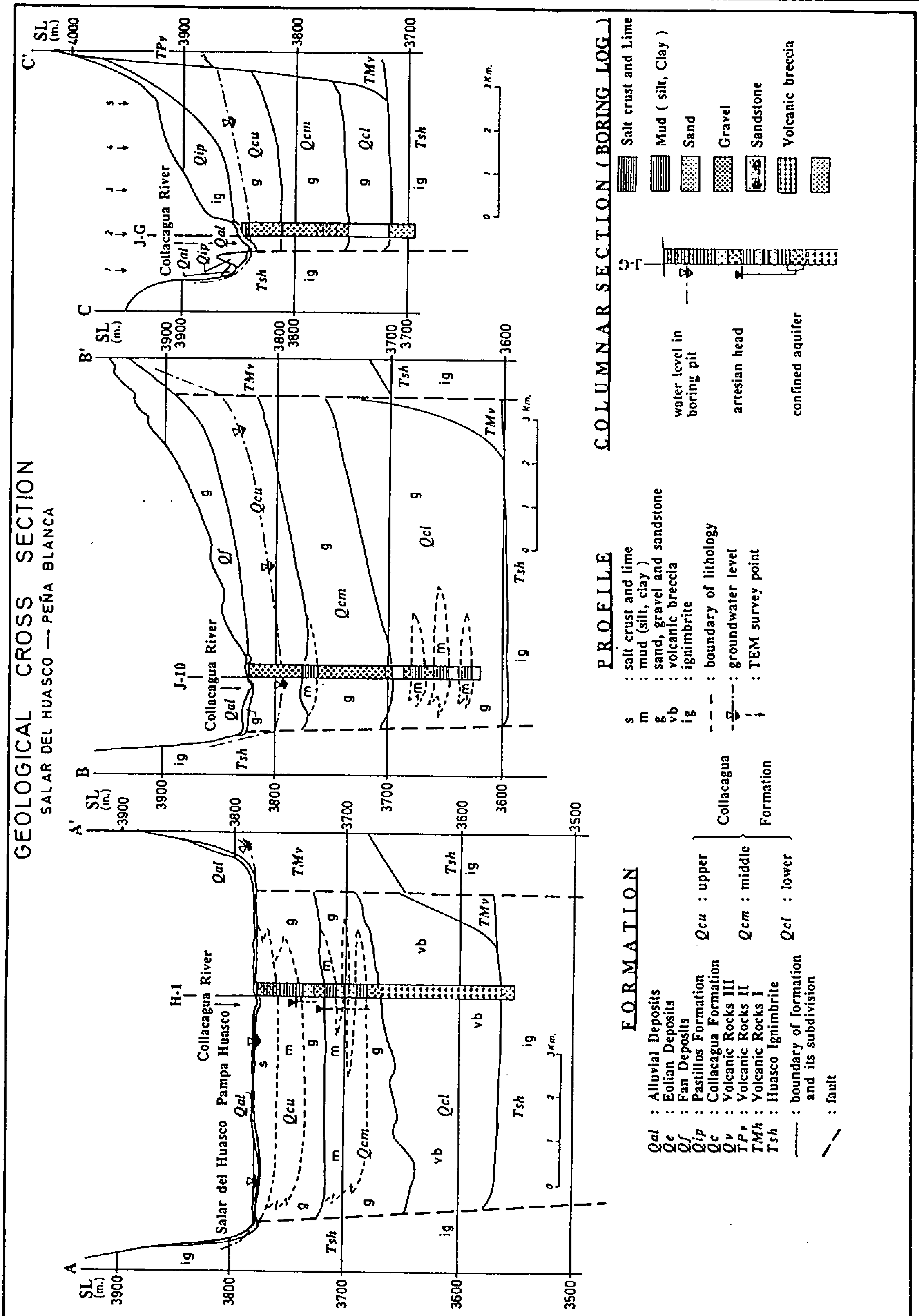

Fig. B-IV 1.2.3 Geological Cross Section

< Sección de Cruce Geológico >

Chapter II AQUIFER OF HUASCO BASIN

2.1 Existing Data

Although two (2) bore hole was drilled in the Salar del Huasco Basin, only one (1) datum is available. Pumping test was not done. The stratigraphic column is cited in the Data Book.

There are springs along the western side of the Salar. Water quality analysis were executed on the water from these springs as well as the river water of the Collacagua (<1).

2.2 Supplementary Geological Survey

The following geological surveys were executed by the JICA Study Team, to supplement the existing geological data. The surveys location is shown in Fig. B-IV, 2.2.1.

a) Electromagnetic Survey	5 survey points (1 lines)
b) Boring Survey	
(a) Drilling	
Test well drilling	1 well
Observation well drilling	1 well
(b) Pumping Test	2 wells
c) Water Quality Analysis	2 wells (JICA wells)
d) C-14 analysis	1 well (JICA well)

2.2.1 Electromagnetic (TEM) Survey

1) Survey Area

Transient Electro Magnetic (TEM) survey is conducted at north of Salar del Huasco (Fig. B-IV, 2.2.1). One (1) TEM line was set perpendicular to the main axis of Collacagua River. A total of 5 stations were set at interval of 1000m each as shown below.

Quantity of TEM Work

	Profile	Stations	Station Interval
	SH-1	5	1000 m
Total		5	

2) Methodology of Study

For the details of the methodology, see B-II, section 2.3.1 of chapter II.

3) Survey Results.

A apparent resistivity curve at station No.2 is shown in Fig. B-IV, 2.2.2. A geological profile is made by the apparent resistivity curve of each station. Geoelectrical profile along Line SH-1 is shown in Fig. B-IV, 2.3.2. The resistivity structure along the profile is classified as 6 layers. The geophysical characteristics of each layer are summarized as follows.

a) The first layer shows a resistivity value of higher than 350 ohm-m. This resistivity represents a relatively dry layer composed sand and gravel. On the other hand, at only station No. 5, the resistivity of the layer is relatively low (100 ohm-m) due to wet land condition of river side.

b) The second layer shows a resistivity range of 55 to 90 ohm-m. The layer is distributed in the all stations except No.5. It is considered as expected aquifer.

c) The third layer shows a resistivity value of 190 ohm-m. This layer exists only at station No. 2. Due to high value of the resistivity, the layer is considered as impermeable bed.

d) The forth layer shows a resistivity range of 11 to 12 ohm-m. The layer is expected as aquifer. However, its rather lower resistivity than second layer would be indicate that the layer is contaminated. The layer is distributed in station No.1 and No.2.

e) The fifth layer shows a resistivity range of 14 to 42 ohm-m. The layer is distributed in the all stations. However, the depth to the boundary of sixth layer is not clear. The layer is also considered as aquifer with less contamination by the same reason of forth layer.

f) The sixth layer shows a resistivity range of 3 to 7 ohm-m. This layer is considered as aquifer with much concentration of dissolved solids. Because resistivity value is extremely low.

4) Interpretation with Boring Log

Geoelectric profiles, described in above section are analyzed by boring log including lithology observed and geophysical logging data. Fig B-IV, 2.2.3 shows analyzed resistivity profile interpreted by inverted geoelectrical sections and boring logs. Position of screen is also indicated. These figure consisting of Analyzed Layered Model showing analyzed resistivety profile with boring log and Resistivety Inversion showing isoresistivity in the same profile. Interpretation for each analyzed resistivity profile are summarized as follows.

Following table shows summary of interpreted relation between lithological formation and resistivity range.

Layer	Depth (m.bgl)	Resistivity Range(ohm-m)	Lithology	Interpretation
1 st	0 - 108	55 - 90	gravel, clayey to sandy gravel	Expected Aquifer
2 nd	>108	190	clayey sandstone rhyolite	Impermeable Layer

2.2.2 Boring Test

1) Location and Depth of Each Well

One (1) Test Wells of J-G and one (1) Observation Wells of J-10 are placed on the line of the TEM survey (see, Fig.B-IV, 2.2.1). Location, drilling depth and casing size of each wells are summarized as follows.

Well No.	Location	Latitude	Longitude	Elevation (m.msl)	Casing (inch)	Depth (m.bgl)
J-G	Salar del Huasco	20º 06' 29.5"	68º 49' 00.4'	3,850	8-5/8"	157
J-10	Salar del Huasco	20º 11' 38.0"	68º 49' 52.9'	3,825	5-1/2"	207

2) Methodology of Well Construction

For the details of the methodology, see B-II, section 2.3.2 of Chapter II.

3) Result of Boring Test

All the data including lithological observation, well logging and drilling rate are compiled together with casing design in same formatted sheet as shown as Fig. B - IV, 2.2.4 for Test Well and Fig. B-IV, 2.2.5 for Observation Well with scale of 1:1000.

(1) Well No. J-G (see Fig.B-IV, 2.2.4)

i) Lithology

The well was drilled up to 157m depth. In the whole sequence, two (2) formations, Quaternary Collacagua Formation (upper, middle and lower) and Tertiary Huasco Ignimbrite were observed. Based on the result of geophysical logging and lithology observed, following three (3) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Formation	Period
1 st	0 - 30	Surface Deposit	sand and gravel	Collacagua	Quaternary
2 nd	30 - 108	Aquifer	clayey to sandy gravel	Collacagua	Quaternary
3 rd	108 - 157	Impermeable Layer	clayey sandstone Rhyolite	Collacagua Huasco Ignimbrite	Quaternary Tertiary

ii) Well Logging

Relative basement line (boundary of permeable lithology and mud) of the SP is estimated as - 57.5 mv based on the lithology observed and gamma ray. Gamma ray indicates 30 to 70 cps at surface 50m and 60 to 100 cps at blow 50m. This range is well coincident with lithological observation as clean gravel at surface 38m and clayey gravel at below 38m. The range of resistivity also coincident with TEM's resistivity, especially 30 to 100 ohm-m of the depth from 30 to 108m. Slow increase rate of water temperature curve from surface to 110m depth (17° to 18°) endorse the grandwater flow.

iii) Determination of Casing Design

In order to determine position of screen pipe installation, following interpretation were made by both of lithological and well logging data. Decided casing design is shown in Fig, B-IV, 2.2.4.

a) 1 st layer (Surface Deposit)

The layer consists of coarse sand at surface and fine gravel at lower. It is estimated as high permeability and indication of SP and gamma ray also well endorsed. However, the layer is interpreted as dry because of very high value of resistivity. Blank casing pipes were installed in this layer.

b) 2 nd layer (Aquifer)

The layer is considered that permeability is rather lower than 1 st layer because of clayey matrix. The range of SP and gamma ray also indicates higher value which is estimated as low permeability. However, the range of resistivity (30 to 90 ohm-m) shows approximately same value of the TEM's resistivity (55 to 90 ohm-m). This range was classified as most promising aquifer within the sequence by the TEM analysis. Therefore, the layer is expected as aquifer.

The screen pipes were installed at the depth from 30.81 to 54.84m and 60.82 to 102.91m of this layer.

c) 3 rd layer (Impermeable bed)

Due to higher range of gamma ray and high value of resistivity (more than 100 ohm-m), the layer is considered as dry or impermeable. The temperature curve also shows stable line than upper layer. Blank casing pipes were installed in this layer.

(2) Well No. J-10 (see Fig. B-IV, 2.2.5)

i) Lithology

Upper, Middle and lower Collacagua Formation of Quaternary were observed in the whole sequence. The total drilling depth is 207m. Based on the result of geophysical logging and lithological observation, following four (4) major layers are classified.

Layer	Depth (m)	Classification	Lithology	Formation	Period
1 st	0 -49	Surface Aquifer	clayey gravel	U. Collacagua	Quaternary
2 nd	49 - 63	Impermeable layer	silty clay	M. Collacagua	Quaternary
3 rd	63 - 147	Shallow Aquifer	clayey gravel	M. Collacagua	Quaternary
4 th	147 - 207	Deep aquifer	mudstone, clayey gravel, sandstone	L. Collacagua	Quaternary

ii) Well Logging

On the gamma ray, tree (3) deferent range is observed; 30 to 70 cps at surface to 55m depth, 50 to 100 cps at depth from 55 to 160m and 20 to 200 cps at depth from 160 to bottom. Clay intercalation is observed well at depth of 167m and 192m by the high value of gamma ray. Based on the lithology and gamma ray. relative basement line of the Spontaneous Potential is estimated as -9.2. In consideration of SP and gamma ray curve, higher permeability at surface to 150m is estimated. The resistivity range is high value at surface 40m and middle part (90 to 140m depth). The temperature range is from 14° C to 18 °C and it is gradually increased from surface to bottom

iii) Determination of Casing Design.

Casing design is decided as shown in Fig. B-IV, 2.2.5, based on the following interpretation for each layer.

a) 1 st layer (Surface Aquifer)

Highest permeability among four (4) layer is expected by the SP and gamma ray. based on the lithological observation, clayey, but well sorted fine gravel is confirmed in this layer. The layer is expected as aquifer except upper layer which is indicated too high resistivity value (more than 500 ohm-m).

Short interval of 39.02 to 51.03m at lower layer is selected for screen installation.

b) 2 nd Layer (Impermeable Layer)

The layer is single and thin bed (14m thickness) of sandy to silty clay. The layer is classified as impermeable layer.

c) 3 rd Layer (Shallow Aquifer)

The layer is consists of mainly clayey gravel of Middle Collacagua Formation. Based on the resistivity range and gamma ray. the layer is expected as promising aquifer.

The screen pipes were installed the depth from 86.53 to 146.51m of this layer.

d) 4 th Layer (Deep Aquifer)

The layer is alternation with sandy clay and clayey gravel of Lower Collacagua Formation. The aquifer is found out at the layer of clayey gravel by the resistivity range.

Two (2) positions were selected as screen installation the depth from 161.81 to 167.81m and 172.83 to 184.79m.

2.2.3 Pumping Test

1) Methodology of Pumping Test

For the details of the methodology, see B-II, section 2.2.2 of Chapter II.

2) Result of Pumping Test

(1) Aquifer Constants

In order to evaluate of capacity and characteristics of the aquifer, the Aquifer Constants were estimated by the data of constant discharge test and recovery test. Two (2) methods, Theis and Jacob, were applied for estimation of the Transmissibility, Storage Coefficient and Permeability.

i) Well No. J-G

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	5.86 m
	Discharge Rate (Q)	25 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	39.76 m
	Drawdown (Sw)	33.90 m
	Specific Yield	63.72 m3/d/m
Recovery Test	Duration of Test	1440 min.
	Water Level (s')	6.39 m
	Recovery (S-s')	33.37 m
	Water Level Variation (s'-SWL)	0.53 m

Analysis was made by graphs which is shown in Fig. B-IV, 2.2.6 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analyzed Method	Kind of Test	Transmissibility (m3/d/m)	Transmissibility (m3/s/m)	Storage Coefficient
Theis	C/T	82.94	9.60E-04	1.30E-04
	R/T	228.96	2.65E-03	
Jacob	C/T	102.82	1.19E-03	1.98E-06
	R/T	210.82	2.44E-03	
Average		156.39	1.81E-03	6.60E-05

C/T : Constant Discharge Test
R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	1.45E-03	cm/sec	66.12
	R/T	4.01E-03	cm/sec	66.12
Jacob	C/T	1.80E-03	cm/sec	66.12
	R/T	3.69E-03	cm/sec	66.12
Average		2.74E-03	cm/sec	

C/T : Constant Discharge Test
R/T : Recovery Test

ii) Well No. J-10

Outline of the data obtained by each test is summarized as follows.

Constant Discharge Test	Static Water Level (SWL)	26.56 m
	Discharge Rate (Q)	5 l
	Duration of Pumping Time (t)	1440 min.
	Dynamic Water Level (S)	30.64 m
	Drawdown (Sw)	4.08 m
	Specific Yield	105.88 m3/d/m
Recovery Test	Duration of Test	1770 min.
	Water Level (s')	26.61 m
	Recovery (S-s')	4.03 m
	Water Level Variation (s'-SWL)	0.05 m

Analysis was made by graphs which is shown in Fig. B-IV, 2.2.7 for Theis and Jacob method, using the data obtained by constant discharge test and recovery test. Estimated aquifer constants are summarized as follows.

a) Transmissibility and Storage Coefficient

Analyzed Method	Kind of Test	Transmissibility		Storage Coefficient
		(m3/d/m)	(m3/s/m)	
Theis	C/T	181.44	2.10E-03	1.01E-05
	R/T	208.22	2.41E-03	
Jacob	C/T	175.39	2.03E-03	1.22E-05
	R/T	200.45	2.32E-03	
Average		191.38	2.21E-03	1.12E-05

C/T : Constant Discharge Test
R/T : Recovery Test

b) Permeability

Analyzed Method	Kind of Test	Permeability		Thickness of Aquifer (m)
Theis	C/T	2.33E-03	cm/sec	89.95
	R/T	2.68E-03	cm/sec	89.95
Jacob	C/T	2.26E-03	cm/sec	89.95
	R/T	2.58E-03	cm/sec	89.95
Average		2.46E-03	cm/sec	

C/T : Constant Discharge Test
R/T : Recovery Test

(2) Critical Discharge and Safe Yield

The step drawdown test was conducted to examine the performance of well which represented as critical discharge and safe yield. In the test, the well is pumped as several successively higher pumping rate and the same for each rate, steps and its drawdown is recorded.

The details of critical discharge and safe yield, including method of analysis are descried in part B-II, Lluta River Basin.

Critical discharge and safe yield examined by step drawdown test for each wells are described as following section.

i) Well No. J-G

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-IV, 2.2.8.

Step N0.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	7.00	16.22	10.36
2	120	10.00	19.50	13.64
3	120	13.00	23.34	17.48
4	120	16.00	28.39	22.53
5	120	19.00	31.14	25.28
6	120	22.00	36.44	30.58
7	120	25.00	40.22	34.36
6'	120	22.00	36.64	30.78
5'	120	19.00	31.18	25.32
4'	120	16.00	27.30	21.44
3'	120	13.00	22.80	16.94
2'	120	10.00	18.64	12.78
1'	120	7.00	14.98	9.12

1, 2 : Steps for discharge increased
1', 2' : Steps for discharge decreased

As shown in Q-Sw chart of B-IV, 2.2.8, a incline both of increased and decreased rate indicates almost 45 degrees. No changing point for high incline is observed in this chart. Thus critical discharge is estimated as more than 25 l/s of 7th step. It is more than pump capacity.

b) Safe Yield

Well efficient and area of influence are observed from following table.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
10.00	97.75	60.00	87.85
15.00	96.66	65.00	86.97
20.00	95.59	70.00	86.10
25.00	94.55	75.00	85.26
30.00	93.53	80.00	84.43
35.00	92.53	85.00	83.61
40.00	91.56	90.00	82.82
45.00	90.60	95.00	82.03
50.00	89.66	100.00	81.26
55.00	88.75	105.00	80.51

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	6.7 l/s	10 l/s	75 l/S
1			56	114	599
6			137	280	1,468
12			193	395	2,077
18			237	484	2,543
24	1		274	559	2,937
240	10		865	1,769	9,287
720	30		1,499	3,063	16,086
8760	365	1	5,228	10,685	56,108
17520	730	2	7,393	15,110	79,348
26280	1095	3	9,055	18,506	97,181
43800	1825	5	11,690	23,891	125,460
87600	3650	10	16,532	33,788	177,428

High discharge rate of 70 l./s is obtained at 85% well efficiency. However, in order to meet a criteria of less than 250m on area of influence, 6.7 l/s is a maximum rate. Thus, 6,7 l/s is estimated as safe yield.

i) Well No. J-10

a) Critical Discharge

As the result of step drawdown test, discharge rate and its drawdown for each steps are summarized as following table, and Sw (drawdown) - Q (discharge rate) chart is shown in Fig B-IV, 2.2.9.

Step N0.	Time Interval (min)	Discharge Rate Q (l/s)	Water Level (m.bgl)	Draw Down Sw (m)
1	120	3.50	29.20	2.64
2	120	3.75	29.53	2.97
3	120	4.00	29.87	3.31
4	120	4.25	30.14	3.58
5	120	4.50	30.35	3.79
6	120	4.75	30.57	4.01
7	120	5.00	30.80	4.24
6'	120	4.75	30.43	3.87
5'	120	4.50	30.25	3.69
4'	120	4.25	29.94	3.38
3'	120	4.00	29.85	3.29
2'	120	3.75	29.66	3.10
1'	120	3.50	29.50	2.94

1, 2 : Steps for discharge increased
1', 2' : Steps for discharge decreased

Almost 45 degrees of incline is observed by Q-Sw chart both of increased and decreased rate. Moreover, no high drawdown is indicated. Thus, critical discharge is estimated as more than 5 l/s of the 7th step.

b) Safe Yield

Well efficiency and area of influence are obtained from following table.

Well Efficiency

Discharge Rate (l/s)	Well Efficiency (%)	Discharge Rate (l/s)	Well Efficiency (%)
1.00	90.99	3.50	74.27
1.25	88.99	3.75	72.93
1.50	87.07	4.00	71.64
1.75	85.24	4.25	70.39
2.00	83.48	4.50	69.19
2.25	81.79	4.75	68.02
2.50	80.17	5.00	66.90
2.75	78.61	5.25	65.81
3.00	77.11	5.50	64.75
3.25	75.66	5.75	63.73

Area of Influence

Pumping Duration			Area of Influence (m)		
Hour	Date	Year	1.75 l/s	5.6 l/s	50 l/S
1			1	56	2,396
6			1	137	5,868
12			2	194	8,299
18			2	237	10,164
24	1		3	274	11,737
240	10		8	866	37,115
720	30		14	1,500	64,285
8760	365	1	50	5,233	224,231
17520	730	2	71	7,400	317,111
26280	1095	3	86	9,063	388,380
43800	1825	5	112	11,700	501,396
87600	3650	10	158	16,547	709,081

Considering criteria of more than 85% well efficiency and less than 250m area of influence, 1.75 l/s is estimated as safe yield.

2.3 Configuration of Aquifer

Few hydrogeological study has been executed in the Salar del Huasco Basin before this Study. However, it is believed that the principle aquifers are appeared in the basin-fill alluvial deposits and the underlying Altos de Pica formation and the basin is hydrologically in a dynamic equilibrium (<2, <3and <4).

The basin is topographically closed by mountains and it has an ovoid shape depression elongated to the north and south as shown in Fig. B-III, 1.1.1. Thus, the figure of the aquifers are governed by this topographical condition. The width of the basin is about 10 km in the south of the basin and extension to the north is about 25 km judging from the topography. .

A series of study by the Study Team revealed that the prospective aquifers appear in the Collacagua Formation and the distribution of aquifers are restricted by the faults in the east and west, by Quaternary to Tertiary Volcanic Rocks in the north and south. The figure of the aquifers in the basin is shown in Fig. B-IV, 1.2.1, 1.2.2 and 1.2.3.

The aquifers extends from the Salar to approximately 6 km north of Peña Blanca. The distance is about 30 km. However, the Salar area is not suitable for aquifer, because it seems that clayey sediments increase in the Salar and groundwater quality is bad. Therefore, the Salar area is excepted from the aquifer area. Accordingly, the prospective aquifer area is about 126 km^2; 20 km in length and 4.5 to 7km in width. The thickness of aquifer is 130 to 210 m, averaging 170 m.

2.4 Hydrogeological Characteristics of Aquifer

Geology of the Salar del Huasco Basin is divided into three formations; the Alluvial Deposits, the Collacagua Formation and the Huasco Ignimbrite. The Alluvial Deposits is of hydrogeologically no value because it is very thin and overlies as the top of the sediments. The Collacagua Formation is composed mainly of sand and gravel so that it is considered a prospective aquifer in the area. JICA Well No. J-G and existing well No. H-1 penetrated into the Huasco Ignimbrite as shown in Fig. B-IV, 1.2.2. The Huasco Ignimbrite is covered by the Collacagua Formation which consists of three (3) units (lower, middle and upper) as mentioned in 1.2.2 of Chapter I. The Lower Collacagua Formation is composed of mainly sand in J-G. It increses its thickness toward the well J-10, however, it is intercalated with mud layers. Finally, it changes its lithology to volcanic breccia in the well No. H-1. The middle and upper part of the Collacagua Formation is composed mainly of gravel. It is intercalated with mud, and salt crust and lime. Therefore, the Collacagua Formation is permeable in the well No. J-G and J-10.

Aquifer constants are shown in following table.

Well No.	Specific Yield (l/sec/m)	Transmissibility (m^3/day/m)	Storage Coefficient	Permeability (cm/sec)
J-G	0.74	156	6.60×10^{-5}	2.74×10^{-3}
J-10	1.23	191	1.12×10^{-5}	2.46×10^{-3}
Average	0.99	174	3.86×10^{-5}	2.60×10^{-3}

Both wells show moderate specific yield and transmissibility. Permeability is rather small as that of sand and gravel beds.

In addition to this, Huasco Ignimbrite is also considered to store the groundwater because many fractures are developed in this rocks as mentioned in 1.2.2. However, the groundwater stored in this rocks is a type of fissure water, therefore, it is difficult to estimate the groundwater storage of this rocks.

Groundwater level is generally shallow; 27m in the well J-G and 5m in well J-10.

2.5 Estimation of Groundwater Storage

Groundwater storage of Salar del Huasco Basin is shown in Table B-IV, 2.5.1 and Fig. B-I, 2.5.1. These present the estimated groundwater storage in the area from Salar to Peña Blanca where DGA's observatory station is located.. Total volume of groundwater storage is estimated as follow;

$$S_{\text{Total Storage}} = \mathbf{465 \times 10^6 m^3}.$$

The estimation was made based on the one (1) geological profile and three (3) geological sections dividing the area into two (2) zones as shown in following table;

Zone	Geological section	Area
1	sect. A-A to B-B'	Salar to J-10
2	sect. B-B' to C-C'	J-10 to J-G (Peña Blanca)

Conditions applied in the estimation are as follows;

a) Climate condition will be constant during the estimated period.
b) The extent of the estimation is limited to the area from Salar to Peña Blanca, because no stratigraphic column of well is available toward the upper reaches from Peña Balanca.
c) Effective porosity of aquifer is assumed to be 30 % as a whole, considering the materials which compose the aquifer.

2.6 Groundwater Quality

Groundwater quality analysis was executed on the JICA Wells and two (2) springs which occurred at the margin of the Salar.by DGA and the Study Team. Results of the analysis are shown in Table B-IV, 2.6.1.

a) Most of ion contents are less than standard for dorinking water; TDS, Mg, Na, SO4, Cl, Cd, Cr, Pb, Cu and Al.
b) As content is higher than standard at the both JICA Wells and one of the spring (H - 0).
c) B content is higher than standard at the well No. J-G and spring H-3.
d) Fe contents is much higher than standard (4.30 to 18.00 mg/l) at the JICA Wells. However, these contents could be influenced by rizer pipe in pumping test because new pipes are used at the test.

Fig. B-IV, 2.6.1 shows the composition of major ions together with spring water, salt lake water, and the surface water of the Collacagua River.

a) Groundwater of well J-G , spring water of H-3 and surface water of the River are plotted in the area among carbonate alkali type, noncabonate alkali type and carbonate hardness type. This type of water is rather normal as a water in the volcanic zone.
b) Groundwater of the well J-10 is plotted in the area of noncarbonate hardness type. It means that the water of the well J-10 consists mainly of chemical compounds of Ca/Mg and SO4/Cl.

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Table B-IV, 2.5.1 Estimation of Groundwater Storage

<Estimación de Reservas de Agua Subterráneas>

DEPTH (m BSWL)	ZONE 1 (SALAR-SECT.A) (m3)		ZONE2 (SECT. A-B) (m3)		TOTAL (SALAR-SECT. B)	
		SUM		SUM		SUM
10	7,825,313	7,825,313	18,049,406	18,049,406	25,874,719	25,874,719
20	7,809,559	15,634,871	17,992,408	36,041,815	25,801,967	51,676,686
30	7,800,404	23,435,275	17,954,409	53,996,224	25,754,813	77,431,499
40	7,791,607	31,226,882	17,892,662	71,888,885	25,684,268	103,115,767
50	7,788,057	39,014,939	17,835,663	89,724,549	25,623,720	128,739,488
60	7,956,760	46,971,699	18,049,406	107,773,955	26,006,166	154,745,654
70	7,938,742	54,910,440	17,954,409	125,728,364	25,893,151	180,638,805
80	7,747,257	62,657,697	17,612,421	143,340,785	25,359,678	205,998,482
90	7,731,493	70,389,190	17,541,173	160,881,958	25,272,666	231,271,148
100	7,714,515	78,103,705	17,455,676	178,337,634	25,170,191	256,441,339
110	7,701,485	85,805,190	17,360,679	195,698,313	25,062,164	281,503,503
120	7,652,754	93,457,944	16,743,199	212,441,512	24,395,953	305,899,456
130	7,603,412	101,061,355	15,175,751	227,617,263	22,779,162	328,678,618
140	7,554,885	108,616,240	12,682,083	240,299,346	20,236,968	348,915,586
150	7,490,758	116,106,998	11,162,133	251,461,478	18,652,890	367,568,476
160	7,410,938	123,517,935	11,043,387	262,504,865	18,454,324	386,022,800
170	7,315,313	130,833,248	10,900,892	273,405,757	18,216,204	404,239,004
180	7,203,750	138,036,998	10,734,647	284,140,403	17,938,397	422,177,401
190	6,932,813	144,969,810	10,330,910	294,471,314	17,263,723	439,441,124
200	5,641,875	150,611,685	8,407,223	302,878,537	14,049,098	453,490,222
210	3,362,813	153,974,498	5,011,085	307,889,622	8,373,898	461,864,120
220	1,083,750	155,058,248	1,614,947	309,504,569	2,698,697	464,562,817
230	0	155,058,248	0	309,504,569	0	464,562,817
	155,058,248		309,504,569		464,562,817	

NOTE: "BSWL" means below the static water level in 1993.

Table B-IV, 2.6.1 Groundwater Quality

<Calidad de Agua Subterránea>

														HEALTH SIGNIFICANCE											
TYPE	NAME	DATE	TEMP.	pH	TDS	Ca	Mg	Na	K	SO4	Cl	CO3	HCO3	NO3	As	F	Cd	Cr	Pb	B	Fe	Mn	Zn	Cu	Al
			(C)			mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
(STANDARD)				6.0-8.5	1000		125	200		400	250			10.00	0.050	1.50	0.005	0.050	0.050		0.30	0.10	5.000	1.000	0.20
JICA WELL	J-G	Dec-94		7.5	747	37.5	28.4	159.2	17.2	95.0	83.7	0	326		0.055		0.002	0.010	0.030	2.59	4.30	0.61	0.480	0.011	0.10
	J-10	Dec-94		6.1	623	82.2	10.9	68.1	35.0	325.0	49.6	0	52		0.460		0.005	0.020	0.040	0.39	18.00	1.40	6.710		
SPRING	H-0	Dec-93	16.1	8.1	388	47.6	13.0	78.6	7.5	98.7	32.6	0	110		0.060					1.00					
		Jan-94	15.0	8.0	384	47.0	9.8	81.2	7.7	95.9	32.9	0	110		0.060					1.00					
		Average	15.6	8.04	386	47.3	11.4	79.9	7.6	97.3	32.8	0	110		0.06					1					
	H-3	Nov-93	15.5	8.3	466	41.5	5.9	76.6	6.4	88.3	40.0	0	207		0.030					1.20					
		Dec-93	20.3	7.9	453	40.5	5.8	76.0	6.7	82.7	36.4	0	205		0.030					0.90					
		Jan-94	17.0	8.8	456	41.3	5.8	75.9	7.1	85.9	36.6	0	204		0.030					1.10					
		Average	17.6	8.3	458	41.1	5.8	76.2	6.7	85.6	37.7	0	205		0.03					1.07					

Note: Sampled and Analyzed by DGA and the JICA Study Team.
Spring waters are analyzed by the Arturo Prat University.

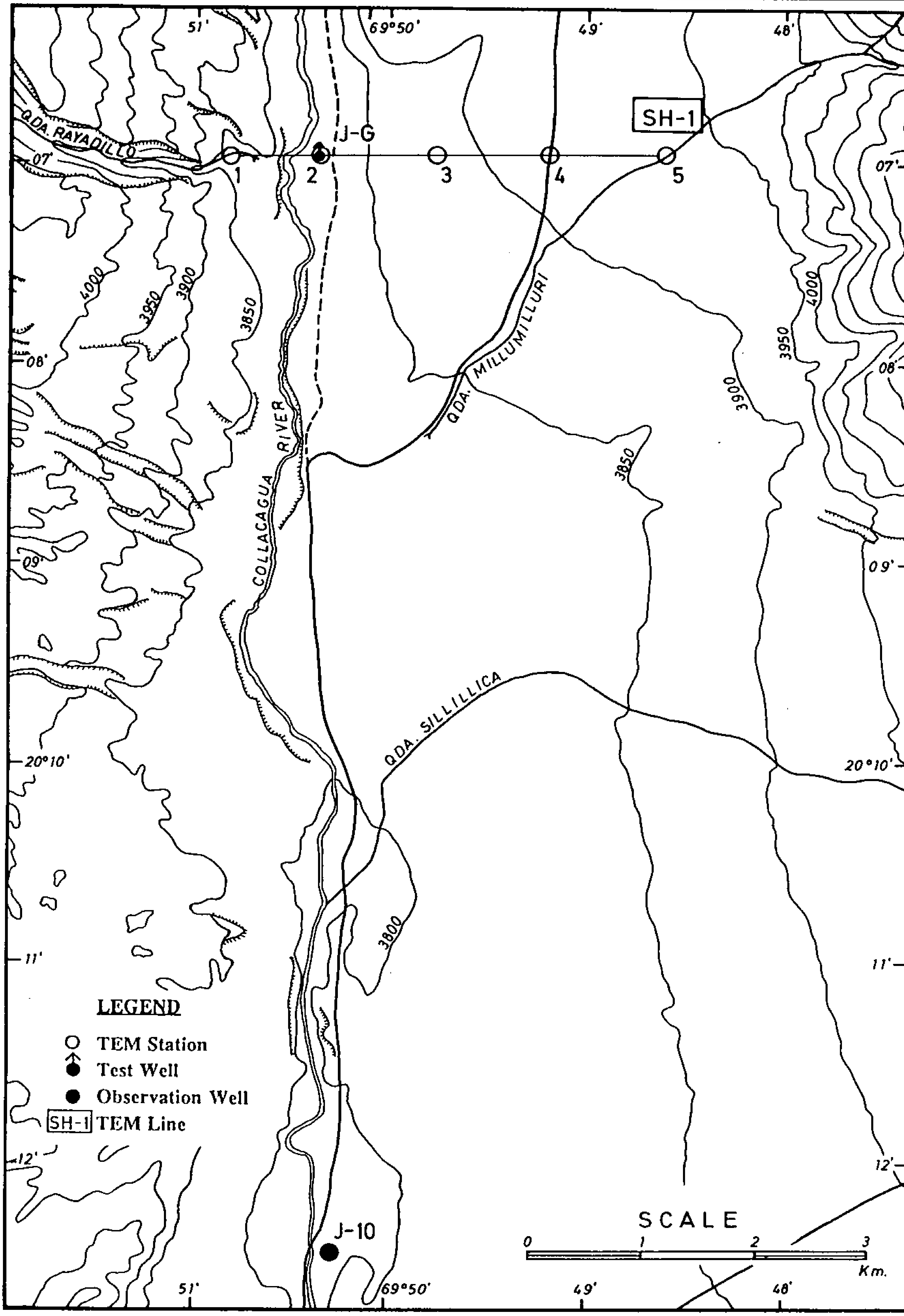


Fig. B-IV,2.2.1 Location of TEM Station and Test/Observation Well in Salar del Huasco Area

<Ubicación de las Estaciones TEM y pozos de Prueba y Observación en el area del Salar del Huasco >

SH-1 Nº 2 (JICA Well J-G)

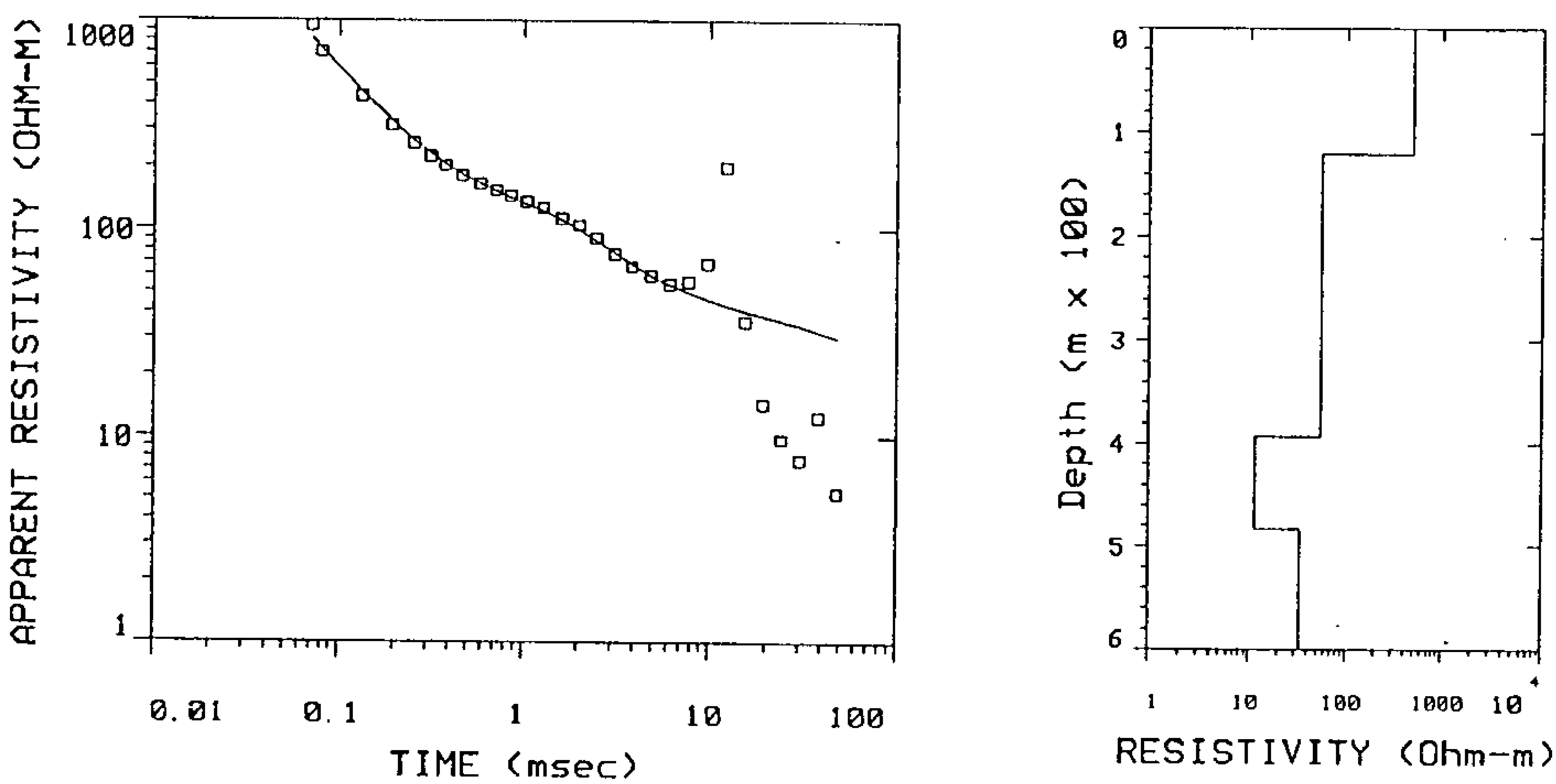
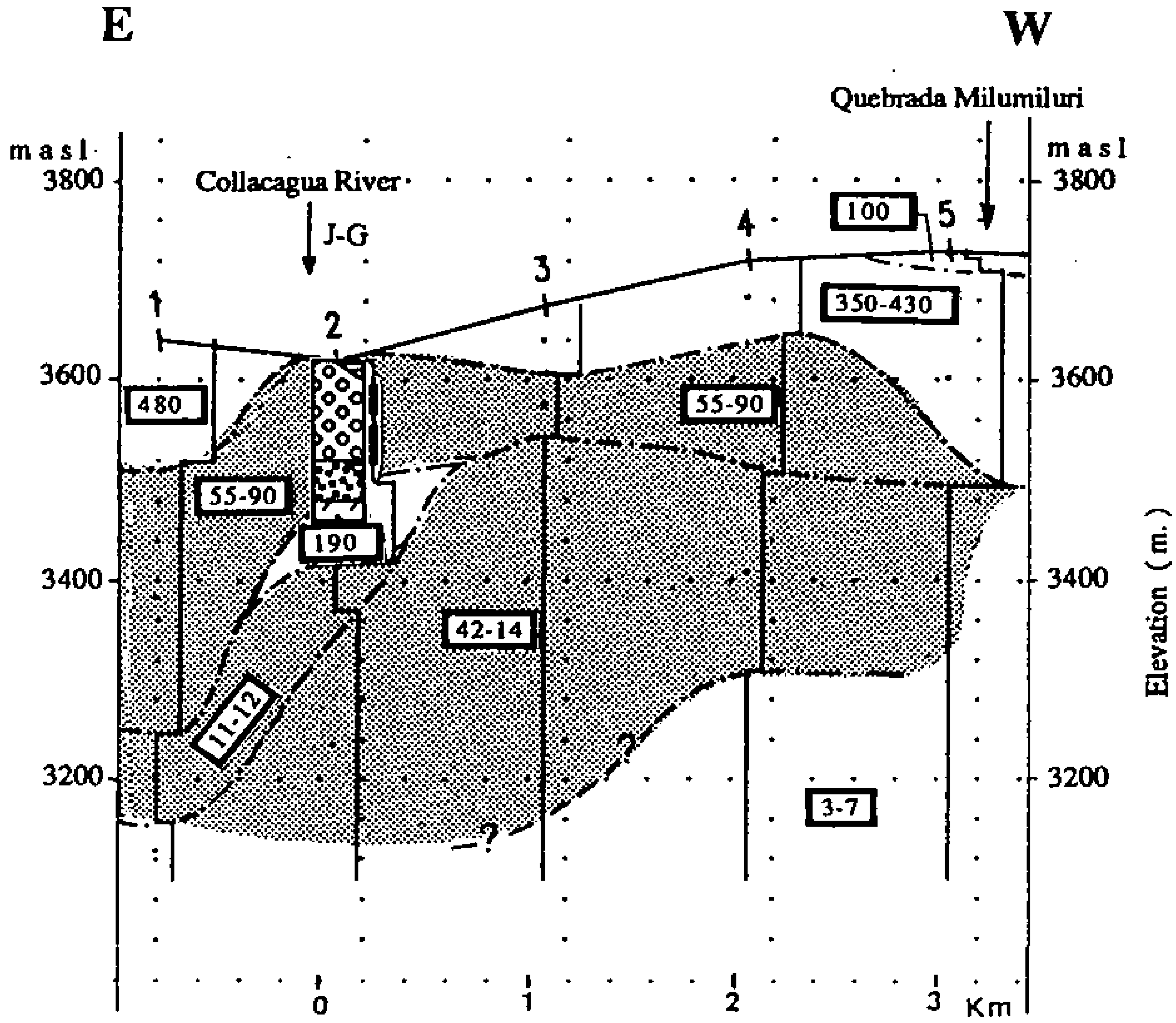
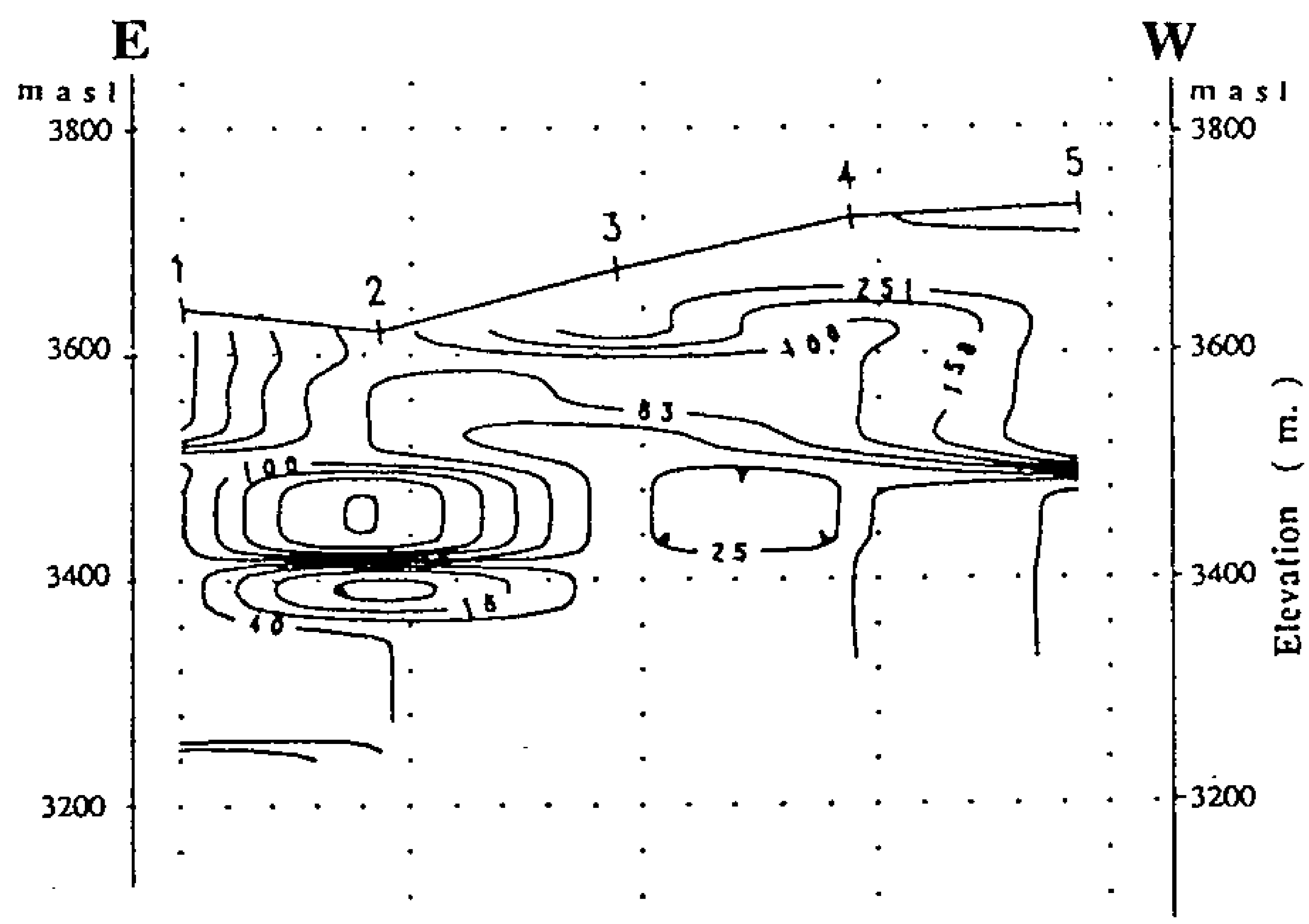


Fig. B-IV,2.2.2 Measured Aparent Resistivity Curves and Inverted Geoelectrical Section in Salar del Huasco Area

< Curvas de Resistividad Aparente Medidas y Secciones Geoeléctricas Invertidas en el Area del Salar del Huasco >

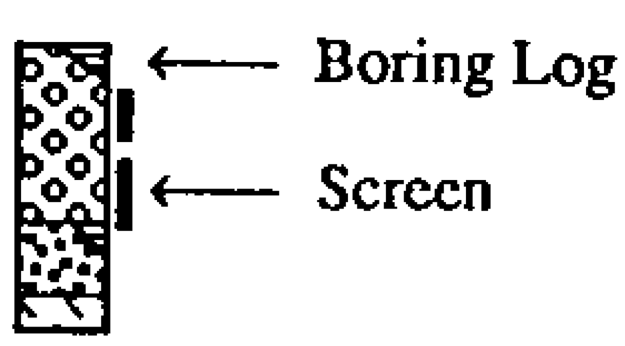


ANALYZED LAYERED MODEL



RESISTIVITY INVERSION

L E G E N D



1, 2, 3 : TEM Station Nº
55 - 90 : Resistivity Range Analyzed
—·—·— : Boundary of Resistivity Layers
m a s l : Meter above sea level
: Expected aquifer
J-G : Well Constructed by JICA
: Lateral Discontinuity

Fig. B-IV,2.2.3 Analized Resistivity Profile of SH-1 in Salar del Huasco Area

< Perfil de Resistividad Analizado del SH-1 en el Area del Salar del Huasco >

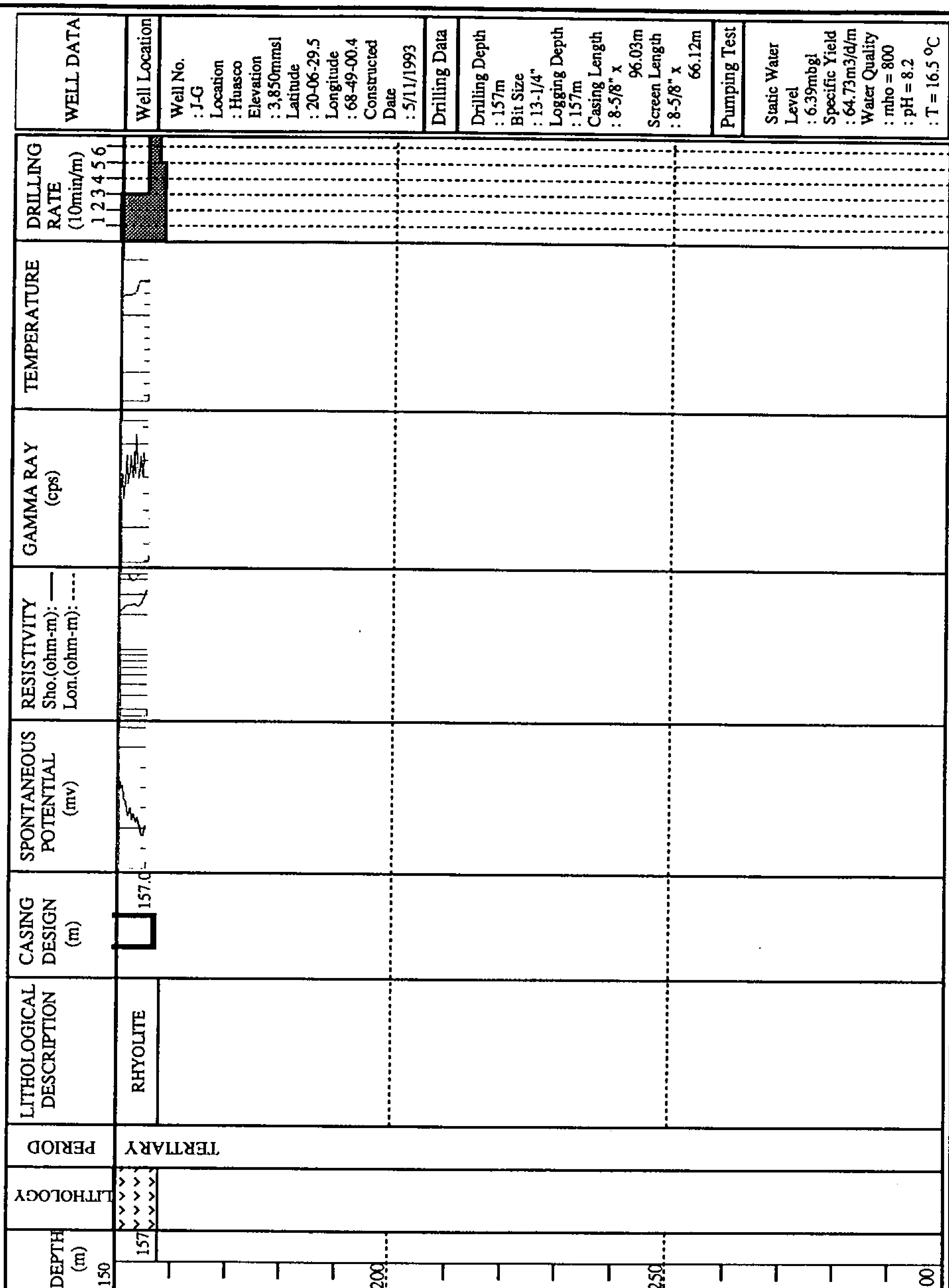


Fig. B-IV, 2.2.4 Well Data for J-G (Sheet No. 1)

< Información del Pozo J-G (Hoja Nº 1) >

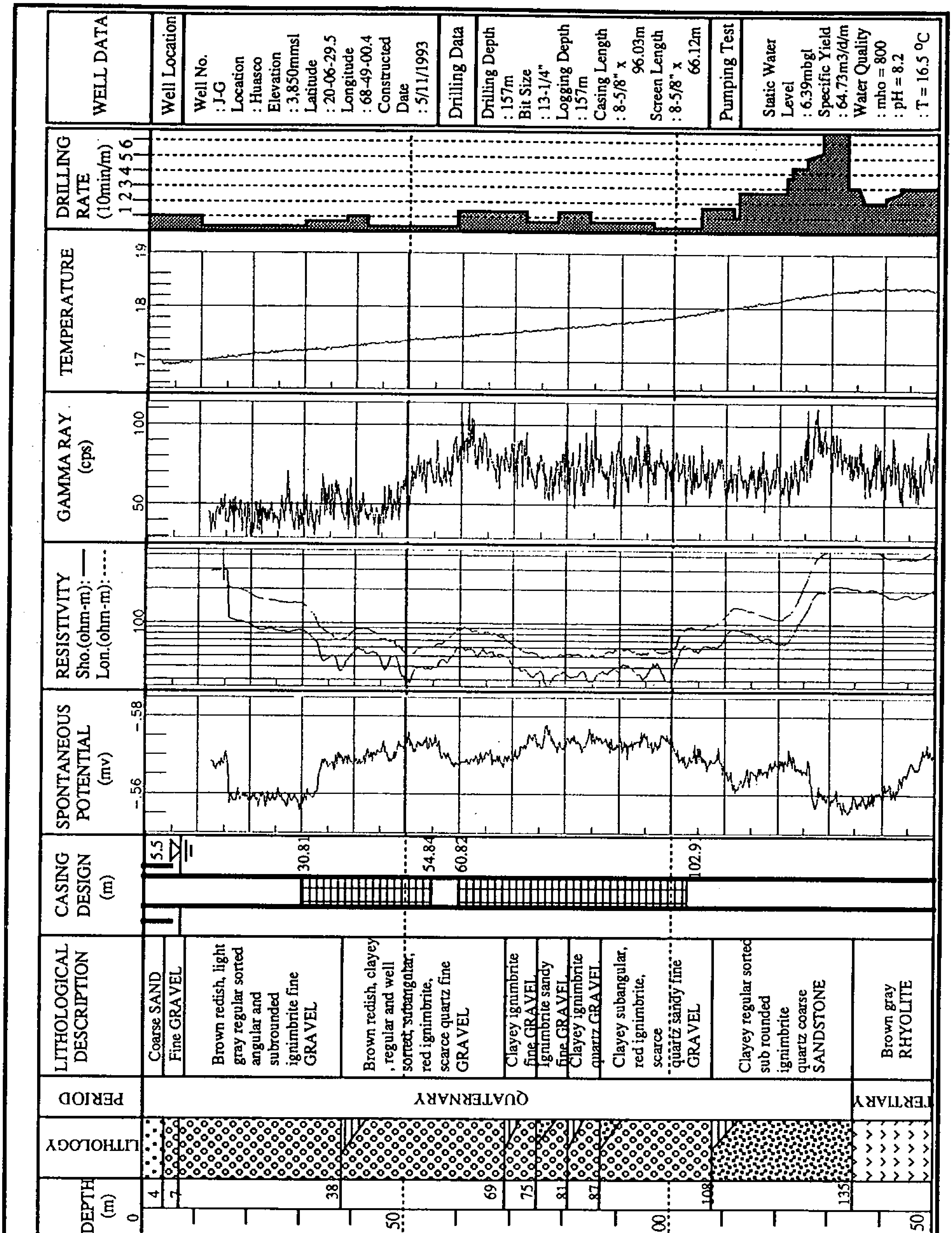


Fig. B-IV, 2.2.4 Well Data for J-G (Sheet No. 2)

< Información del Pozo J-G (Hoja Nº 2) >

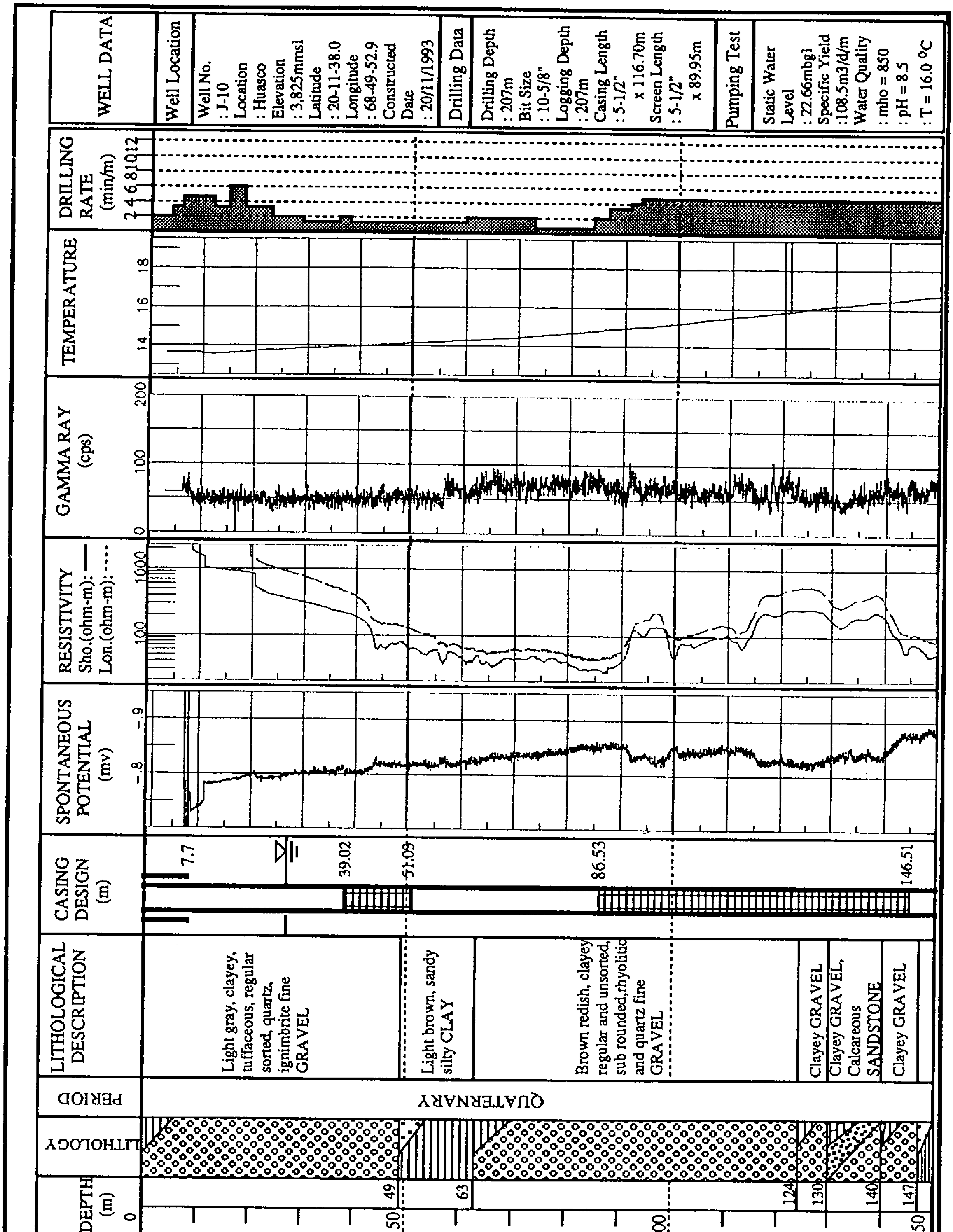


Fig. B-IV, 2.2.5 Well Data for J-10 (Sheet No. 1)

< Información del Pozo J-10 (Hoja Nº 1) >

THE STUDY ON THE DEVELOPMENT OF WATER RESOURCES IN NORTHERN CHILE | **JICA**

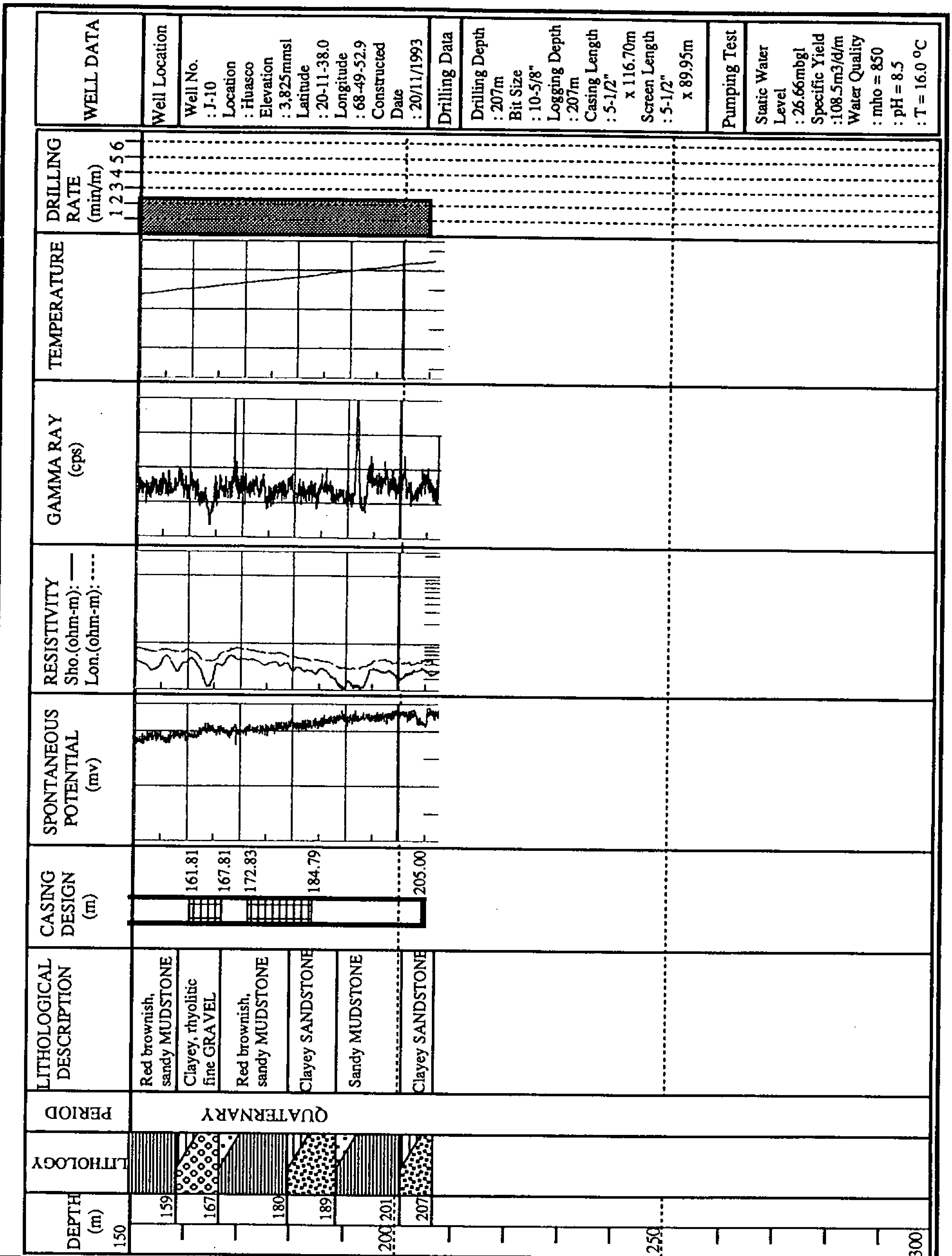


Fig. B-IV, 2.2.5 Well Data for J-10 (Sheet No. 2)

< Información del Pozo J-10 (Hoja Nº 2) >

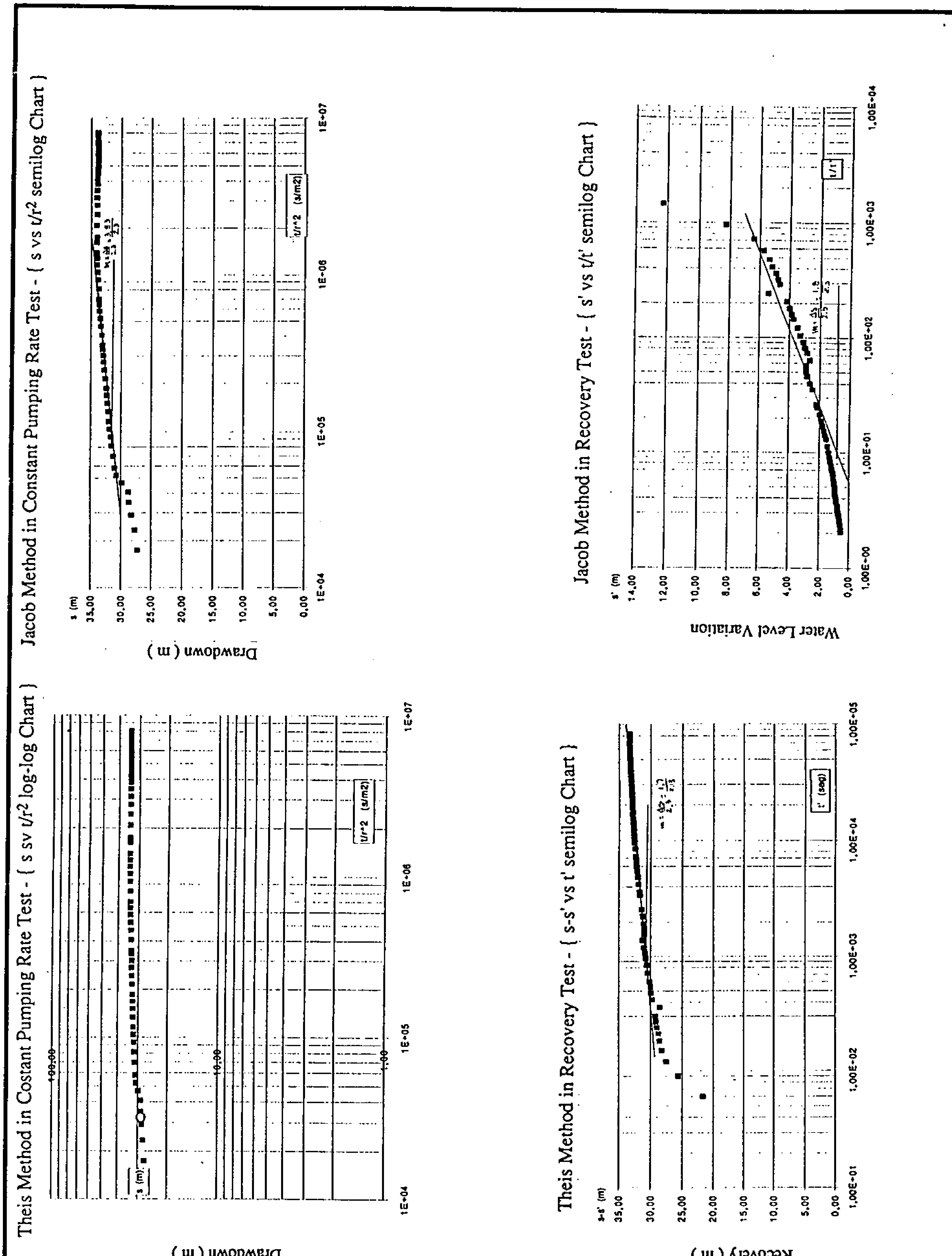


Fig. B-IV, 2.2.6 Graphs for Theis and Jacob Method Analysis (Well No.J-G)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº J-G) >

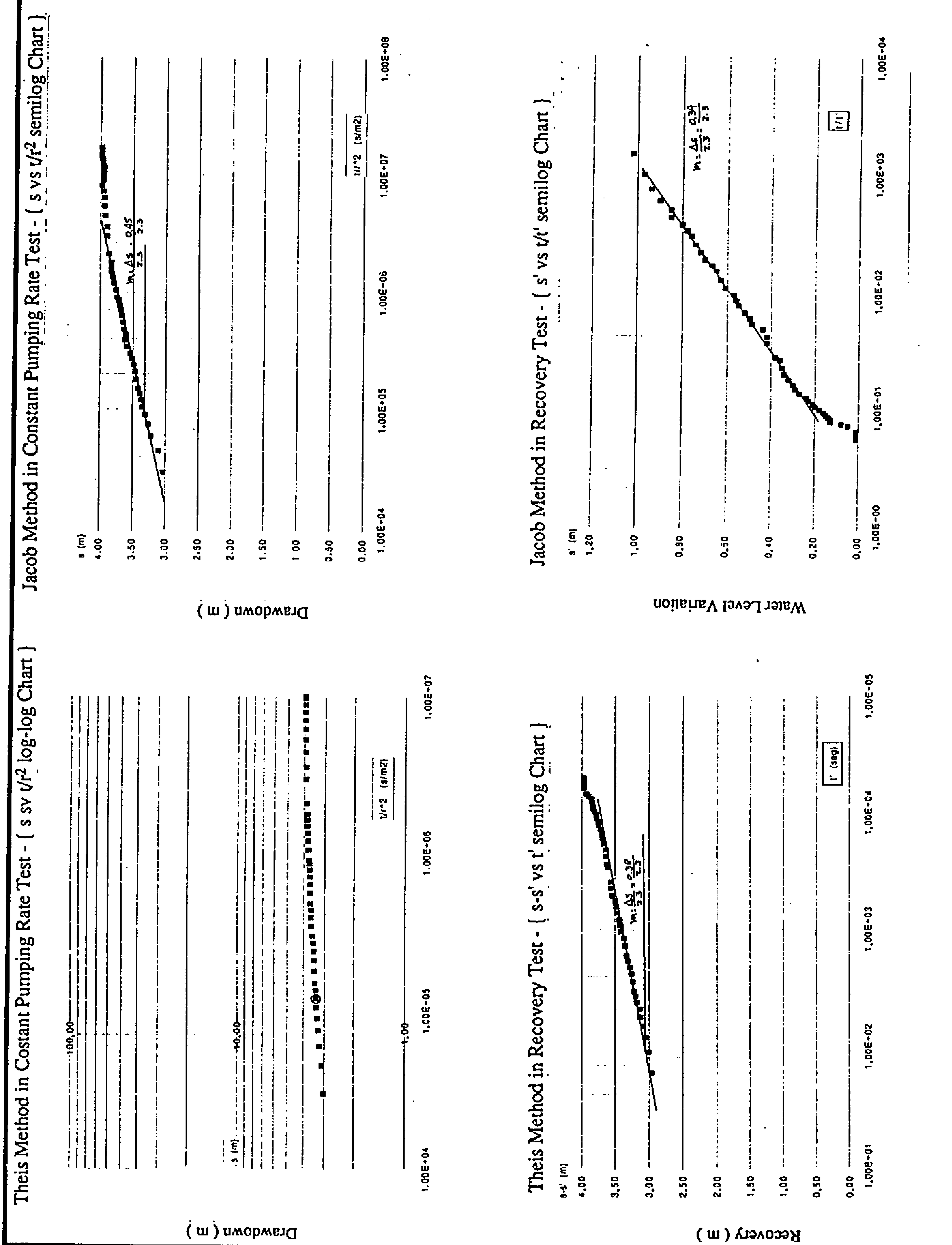
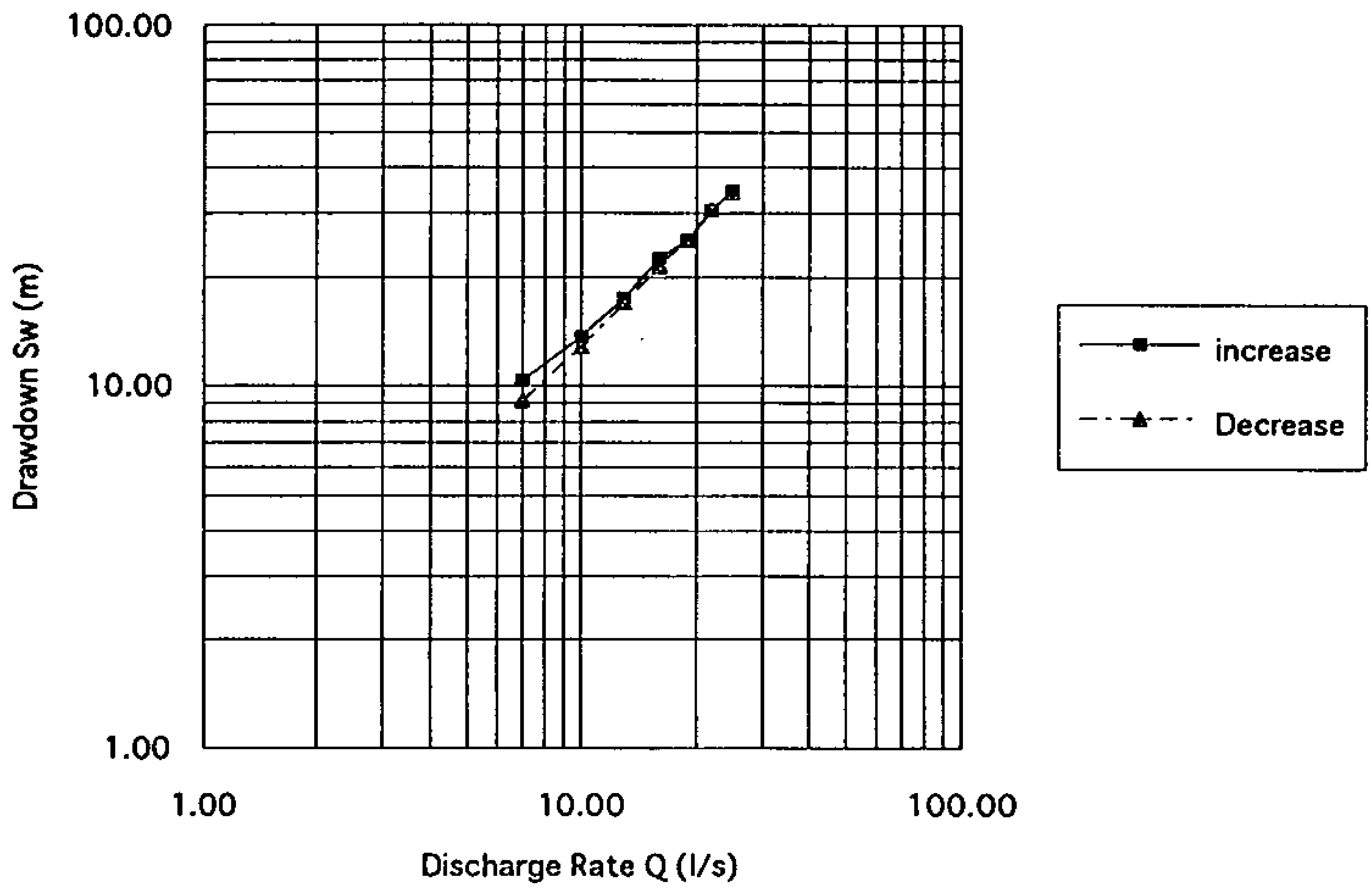


Fig. B-IV, 2.2.7 Graphs for Theis and Jacob Method Analysis (Well No.J-10)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº.J-10) >

Q - Sw Chart



Q - s/Q Chart

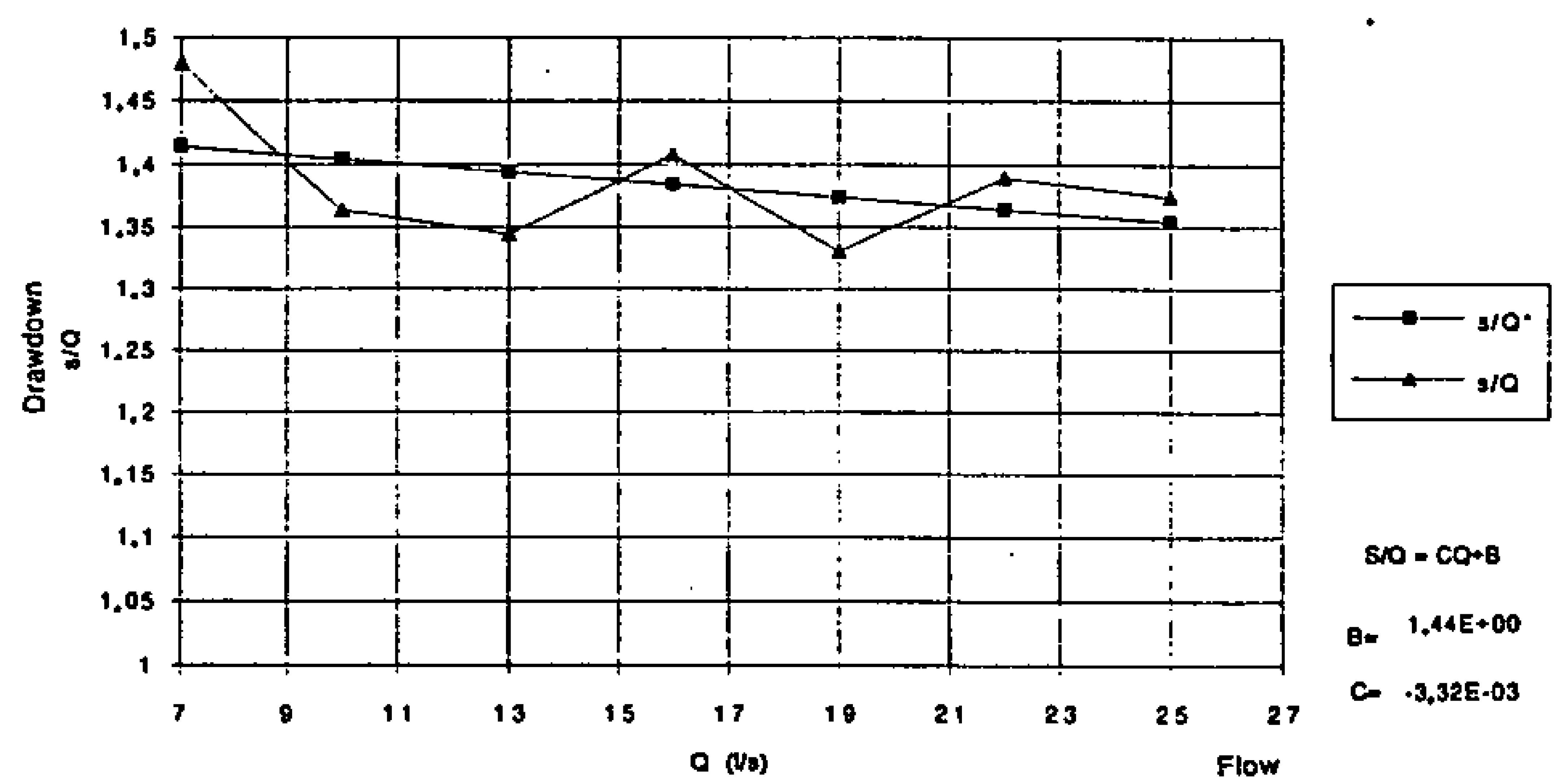
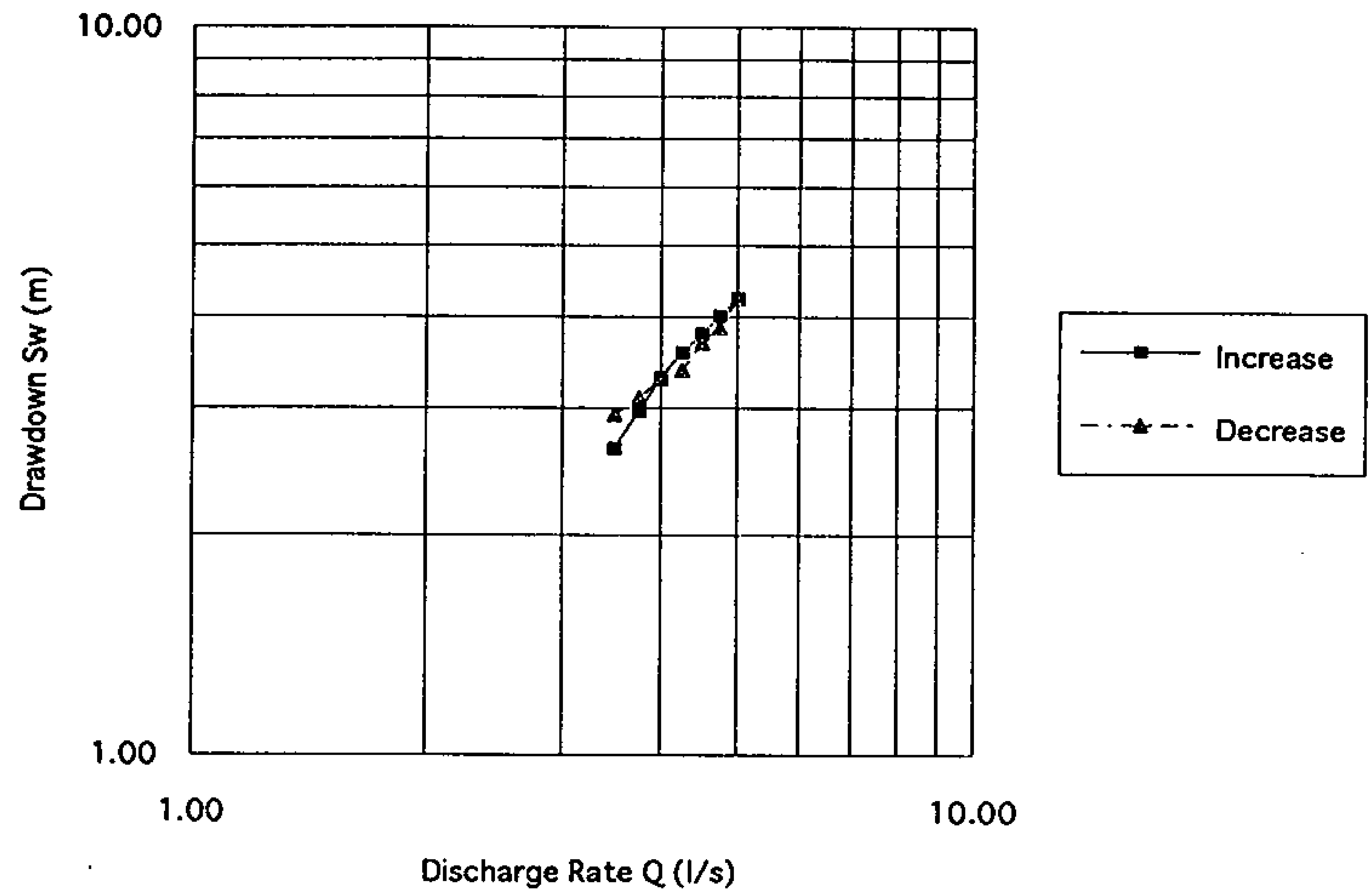


Fig. B-IV, 2.2.8 Graphs for Step Drawdown Test (Well No.J-G)

< Gráficos Prueba de Gasto Variable (Pozo Nº.J-G) >

Q - Sw Chart



Q - s/Q Chart

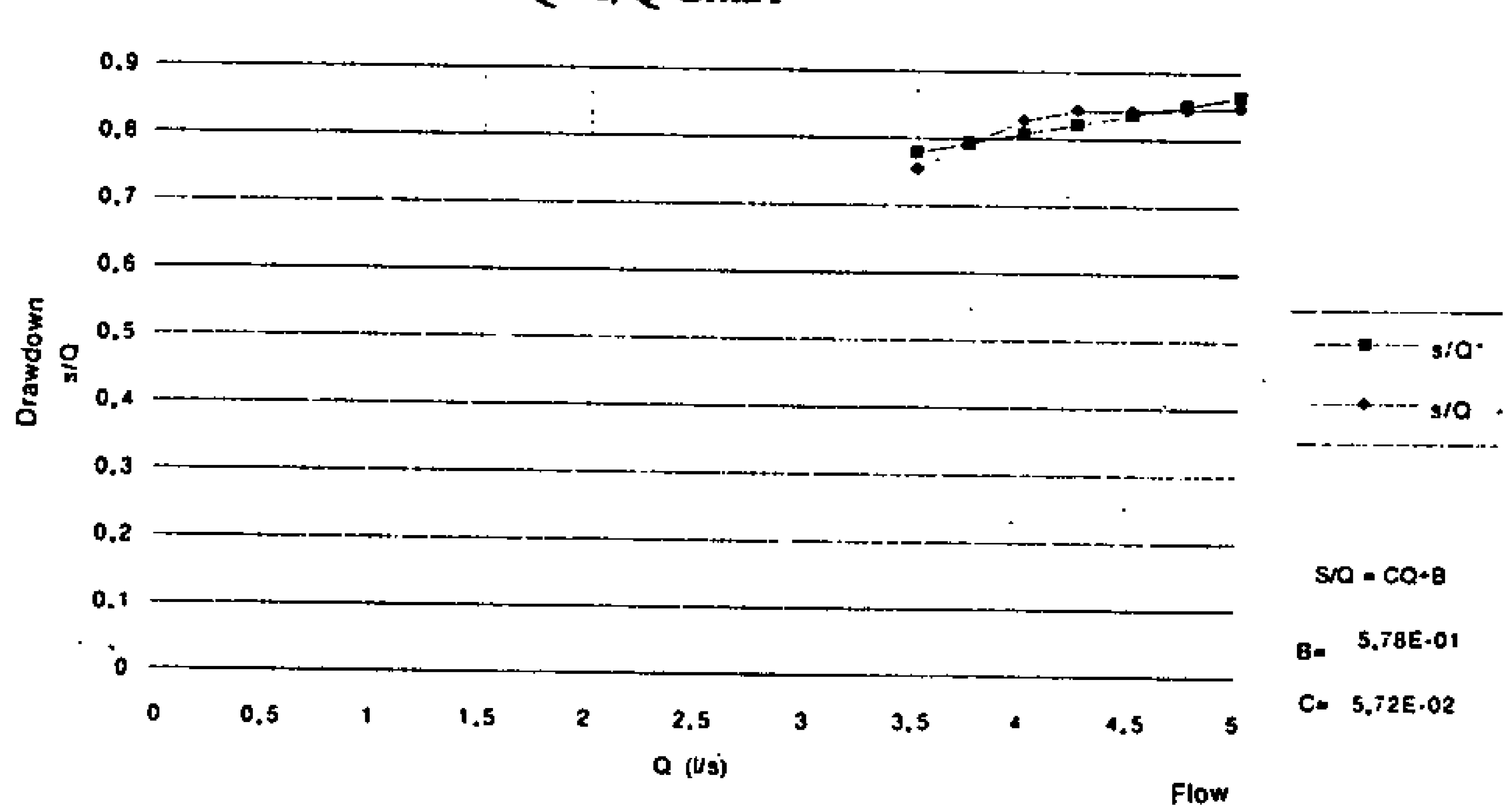


Fig. B-IV, 2.2.9 Graphs for Step Drawdown Test (Well No.J-10)

< Gráficos Prueba de Gasto Variable (Pozo Nº J-10) >

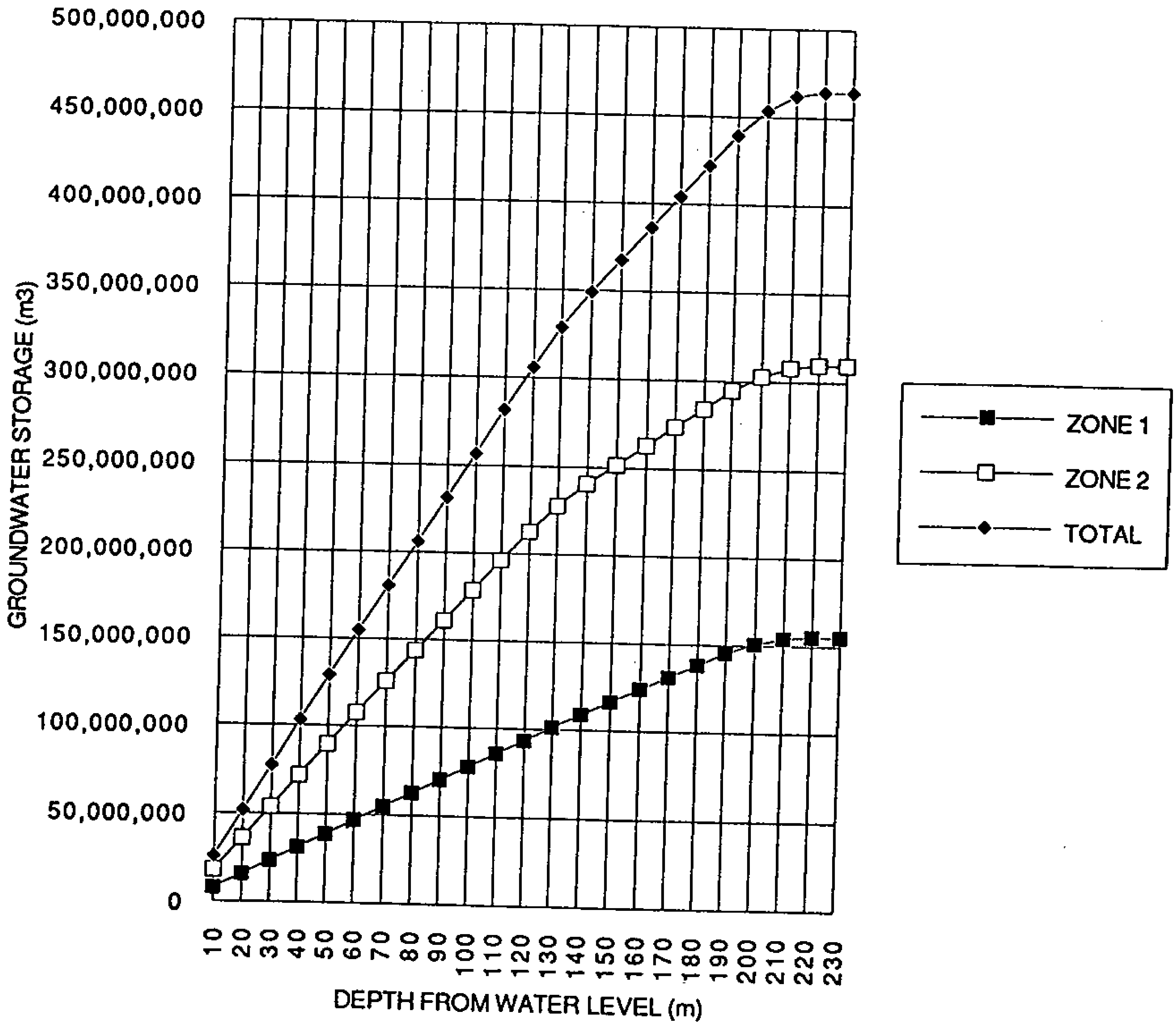


Fig. B-IV 2.5.1 Groundwater Storage

<Reservas de Agua Subterránea>

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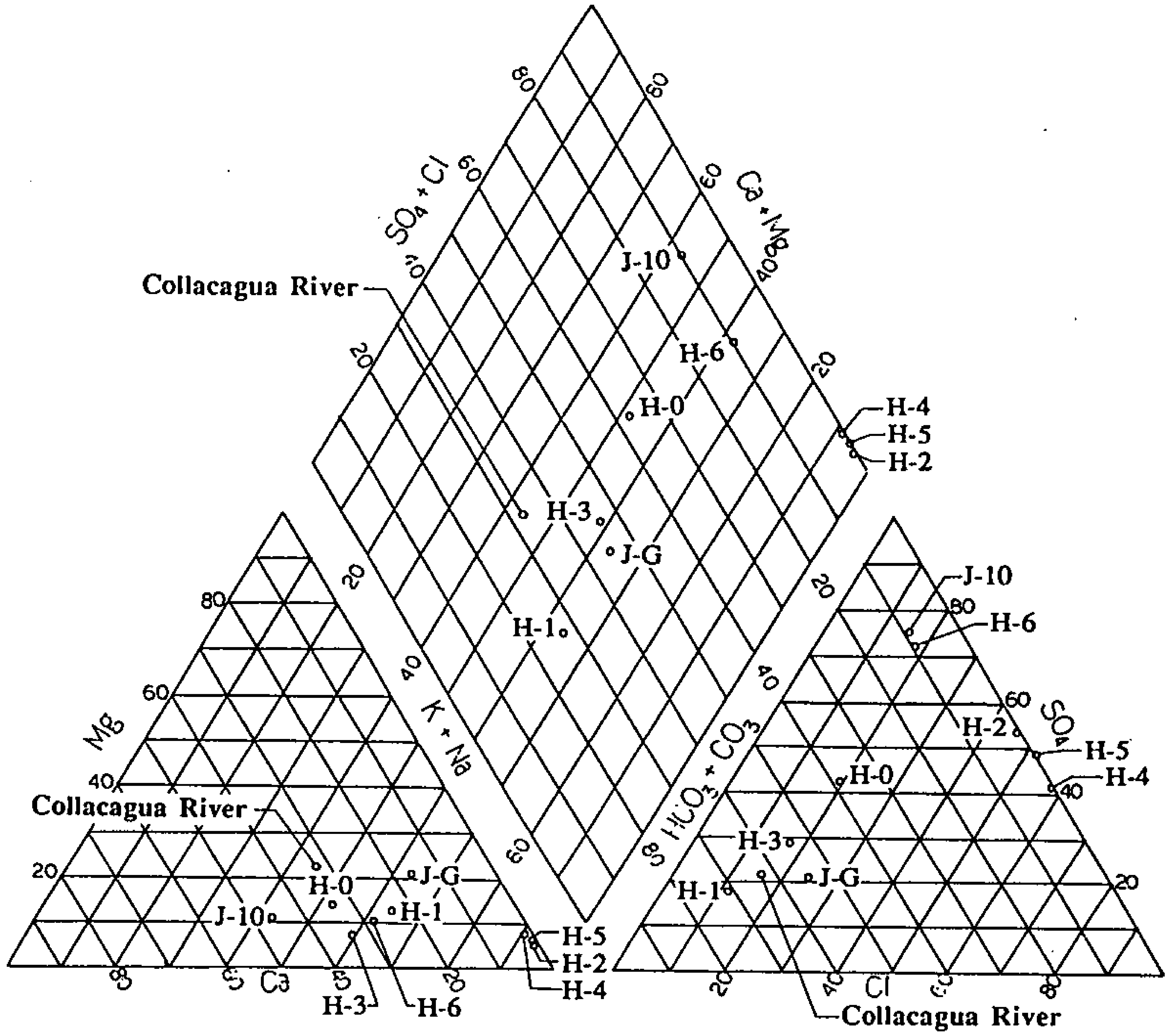

Fig. B-IV, 2.6.1 Trilinear Diagram of Maayor Ions

< Diagrama Trilinear de Iones Principales >