2) Case 2

It is remarkable that an impact to the groundwater by an agricultural development plan (CAPPTA Project) in the northern part of the study area and mining development plan in the south-western part of the area is very great. It is anxious about reduction of forest area, since they are located in Tamarugo forest and their drawdown of groundwater is great Though effected area around the project site would be enlarge slightly in this case than Case 1, there's no extreme change among these cases.

Case 2-2 is the most serious case that maximum drawdown would be assumed 40m in the northern part of the study area and 55m in the south-western part of the area after 100 years from present.

4.5 Change of Water Quality in Future

Proposed new groundwater development area, La Tirana, is located near th area of existing well field. Groundwater storage in this area is estimated to be 10.7×10^9 m^3. On the one hand, total exploitation of groundwater in Canchones and La Tirana well fields are estimated to be 530×10^6 m^3. It is 5.0 % of the total storage in the well field area. Therefore, water quality of groundwater in the both well field will not cause a change for the worse within the Project period.

Table B-III, 4.1 Maximum Drawdown of Groundwater between Present and Future
<Descenso Máximo de Agua Subterránea entre el Presente y Futuro>

(Unit: m)

Case	Area	2015 Target Year	2043 50 Years After	2093 100 Years After
	Northern	2	5	10
Case 1-1	Project Site	**8**	**20**	**25**
	Southern	2	5	10
	Northern	4	10	10
Case 1-2	Project Site	**8**	**20**	**30**
	Southern	2	5	10
	Northern	10	30	40
Case 2-1	Project Site	**8**	**20**	**30**
	Southern	8	30	30
	Northern	10	30	40
Case 2-2	Project Site	**10**	**20**	**30**
	Southern	15	40	55

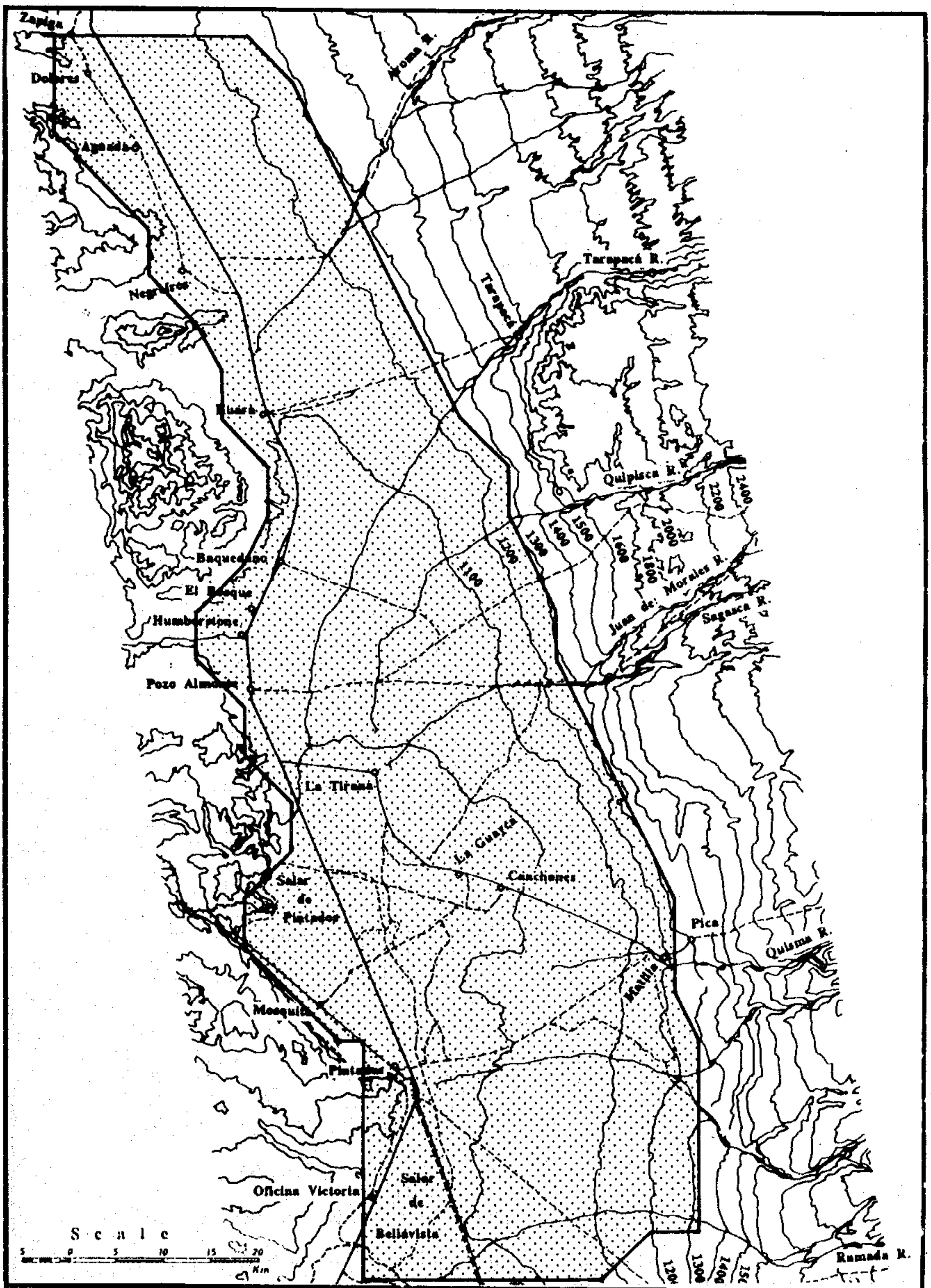


Fig. B-III, 4.1 Groundwater Simulation Area in Pampa del Tamarugal
<Area de Simulacion del Nivel Freatico en Pampa del Tamarugal>

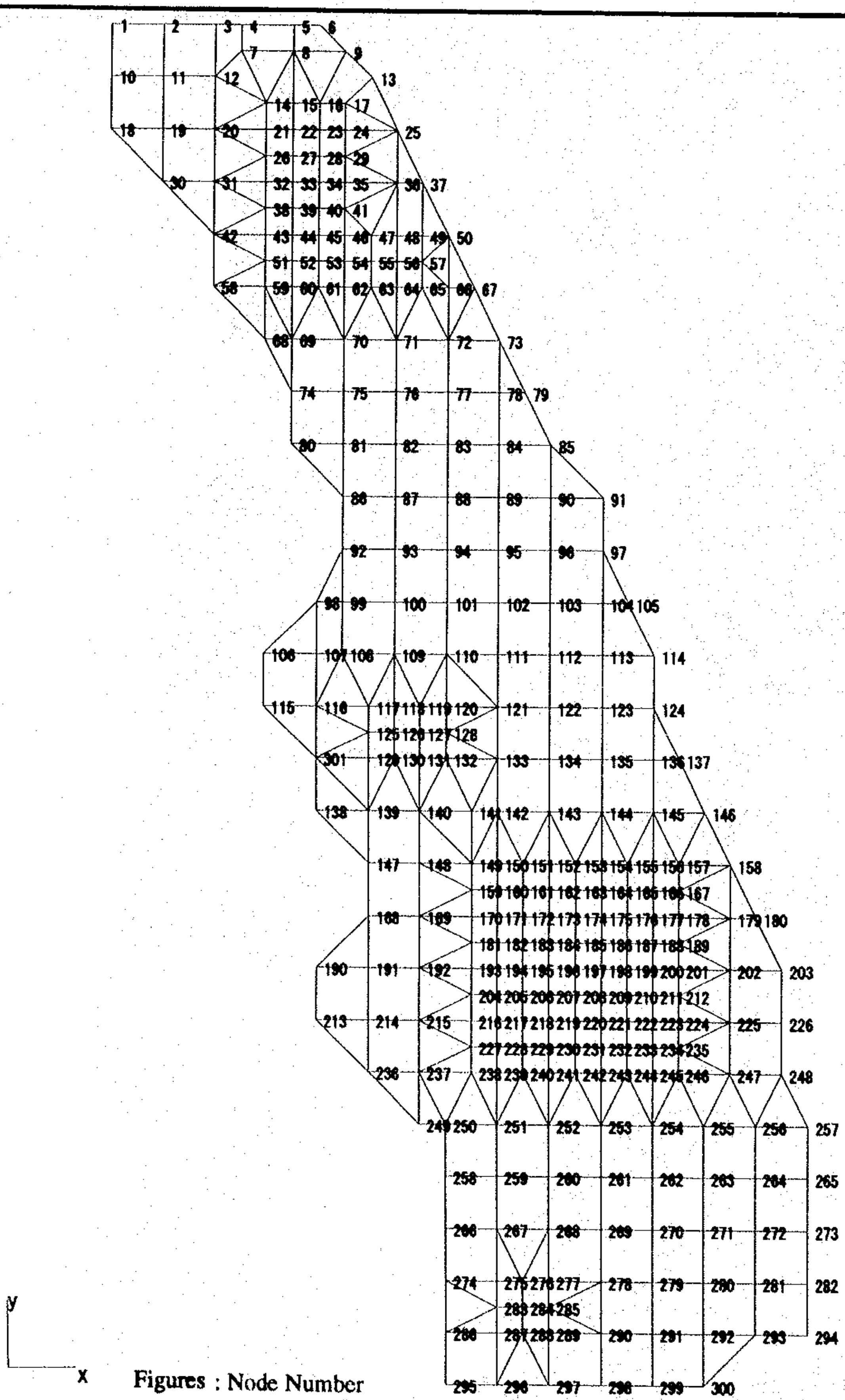


Fig. B-III, 4.2 Calculation Network for Groundwater Simulation
<Red de Calculo para la Simulacion del Nivel Freatico>

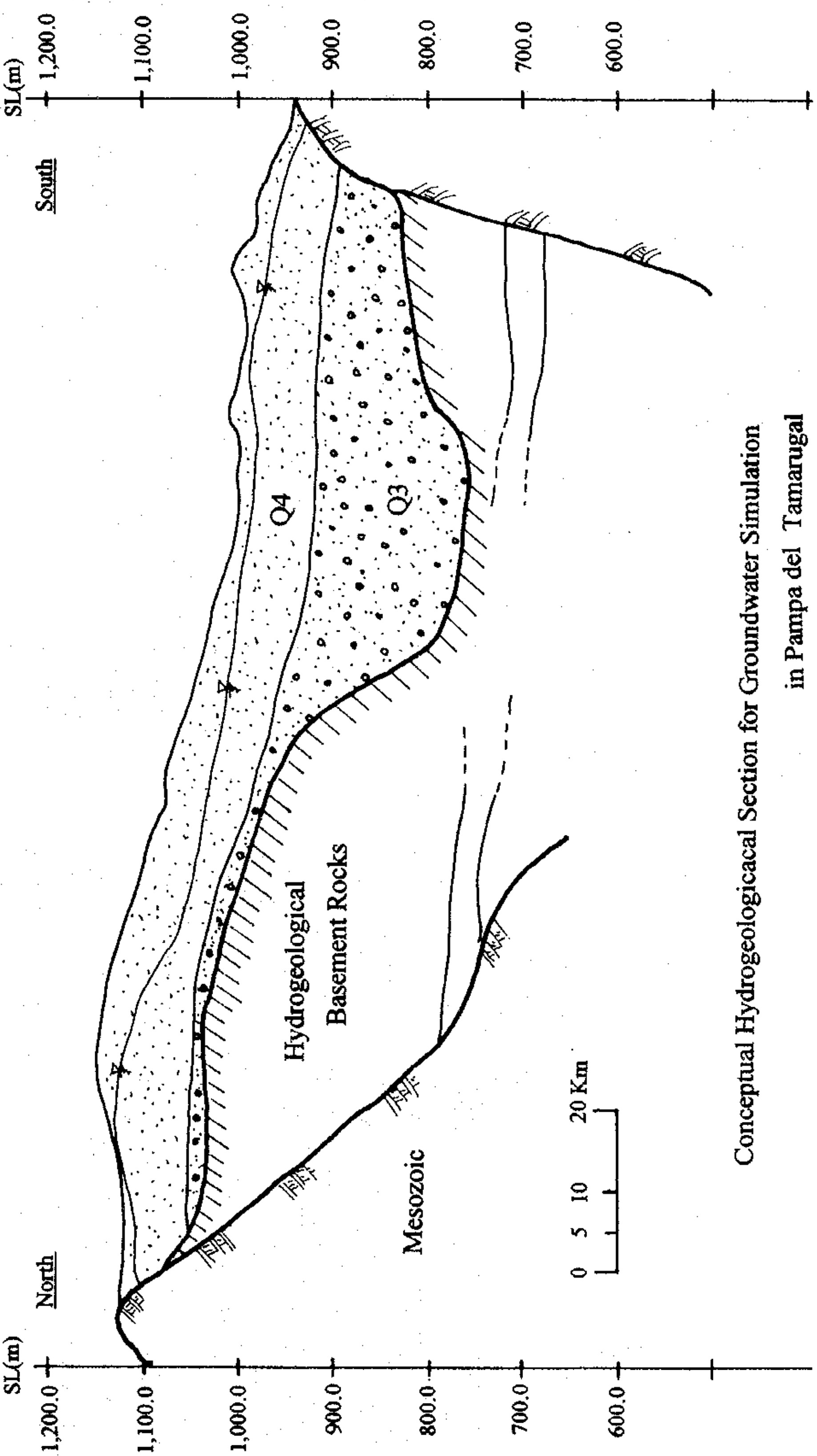


Fig. B-III, 4.3 Conceptual Hydrogeological Section for Groundwater Simulation
<Corte Transuersal Hidrogeologico de la Simulacion del Nivel Freatico>

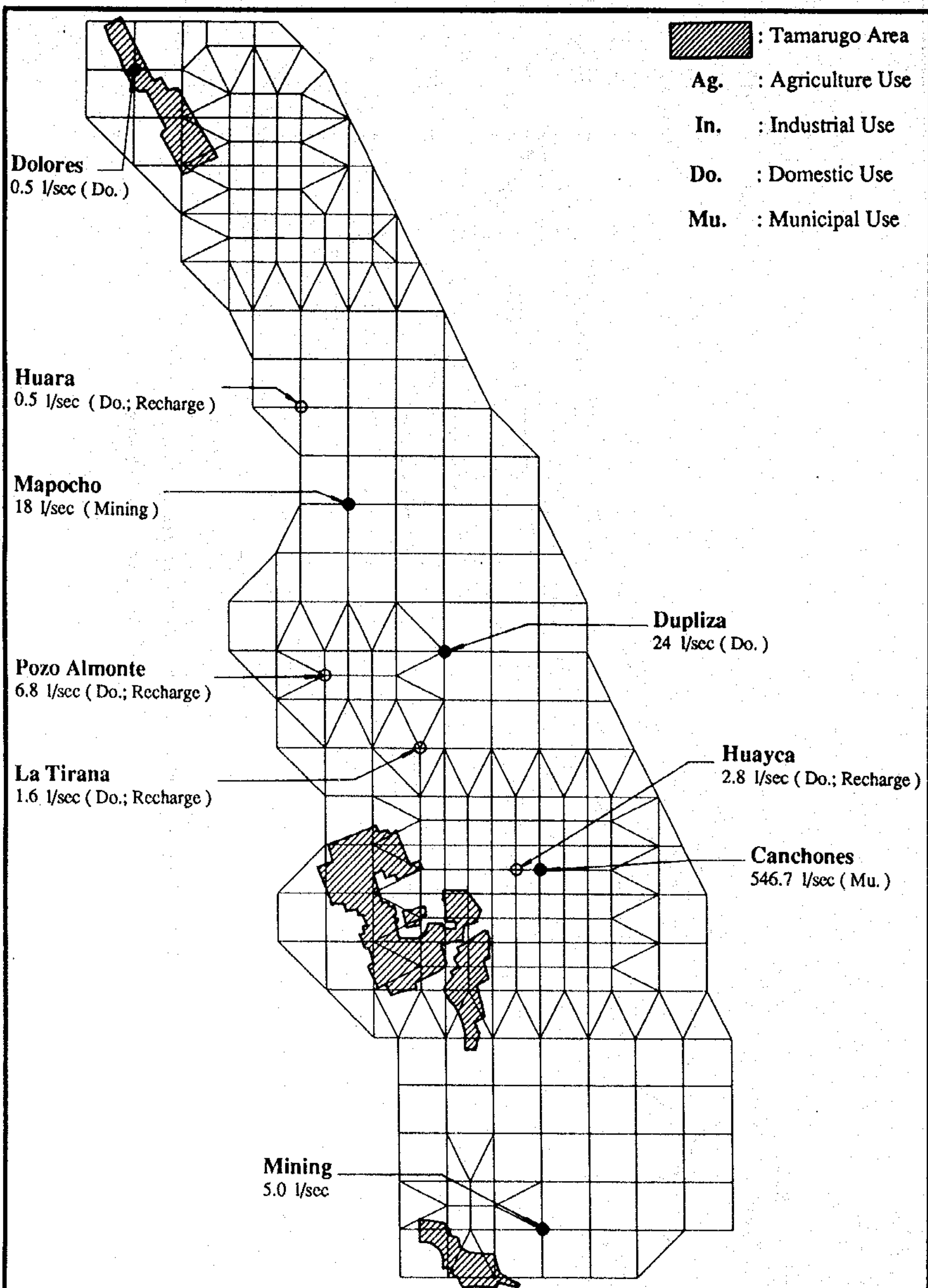


Fig. B-III, 4.4 Discharge Condition in 1993
<Condicion de Descarga en 1993>

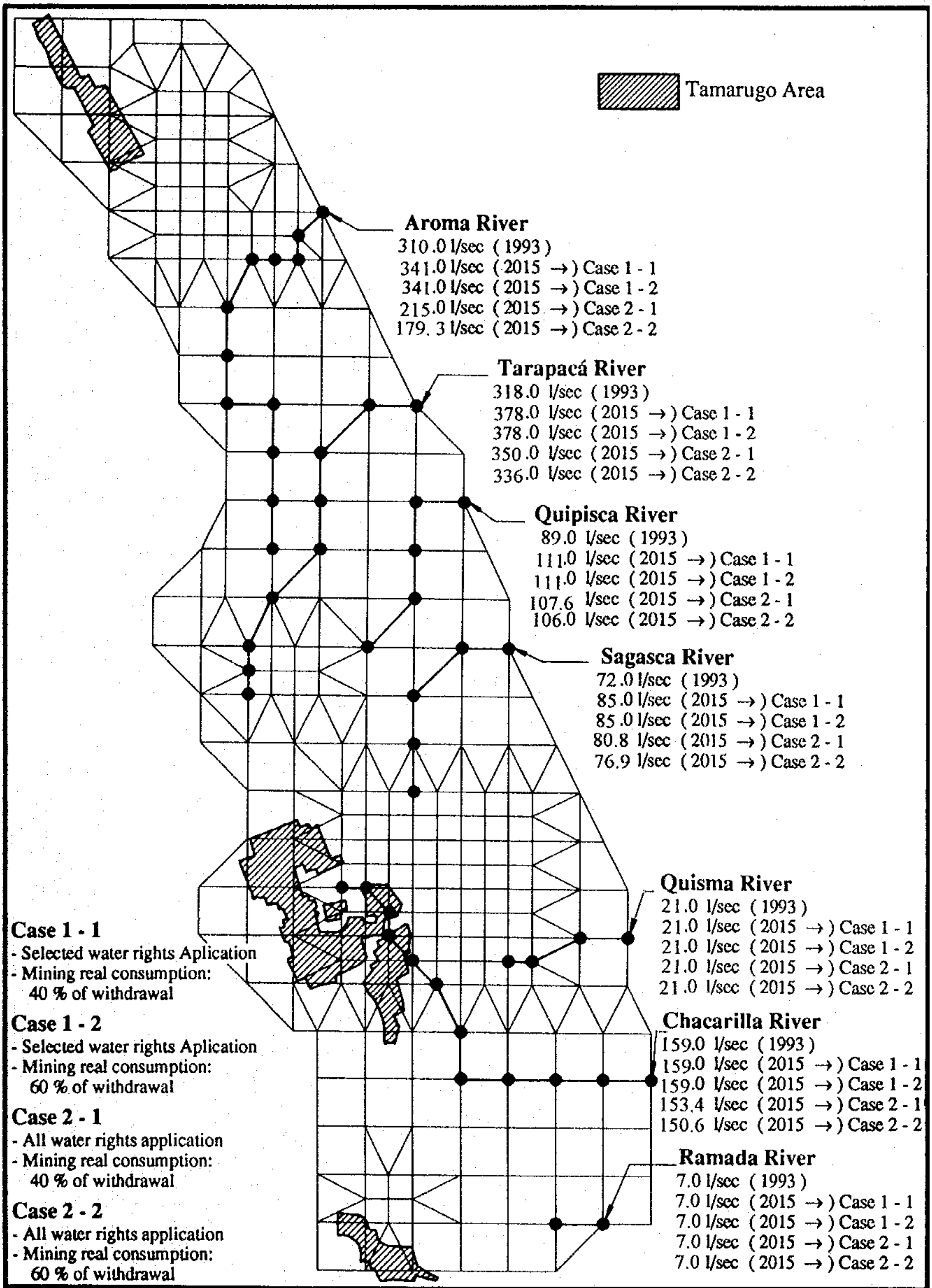


Fig. B-III, 4.5 Modeled River Water Inflow

< Modelo de Afluencia de Agua de Río >

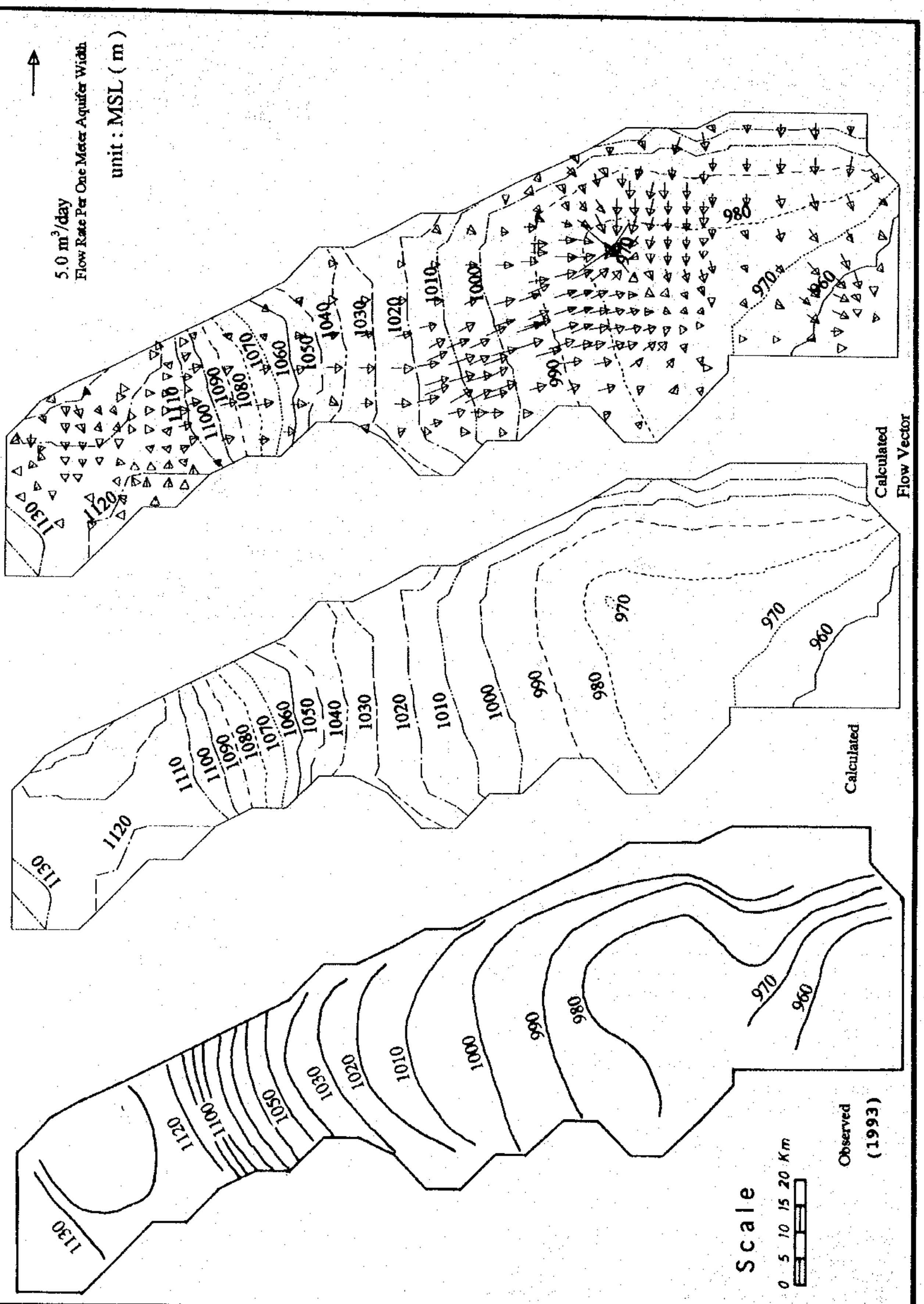


Fig. B-III, 4.6 Comparison Between Observed and Calculated Groundwater Level
<Comparacion Entre Mueles Freaticos Observados y Calculados>

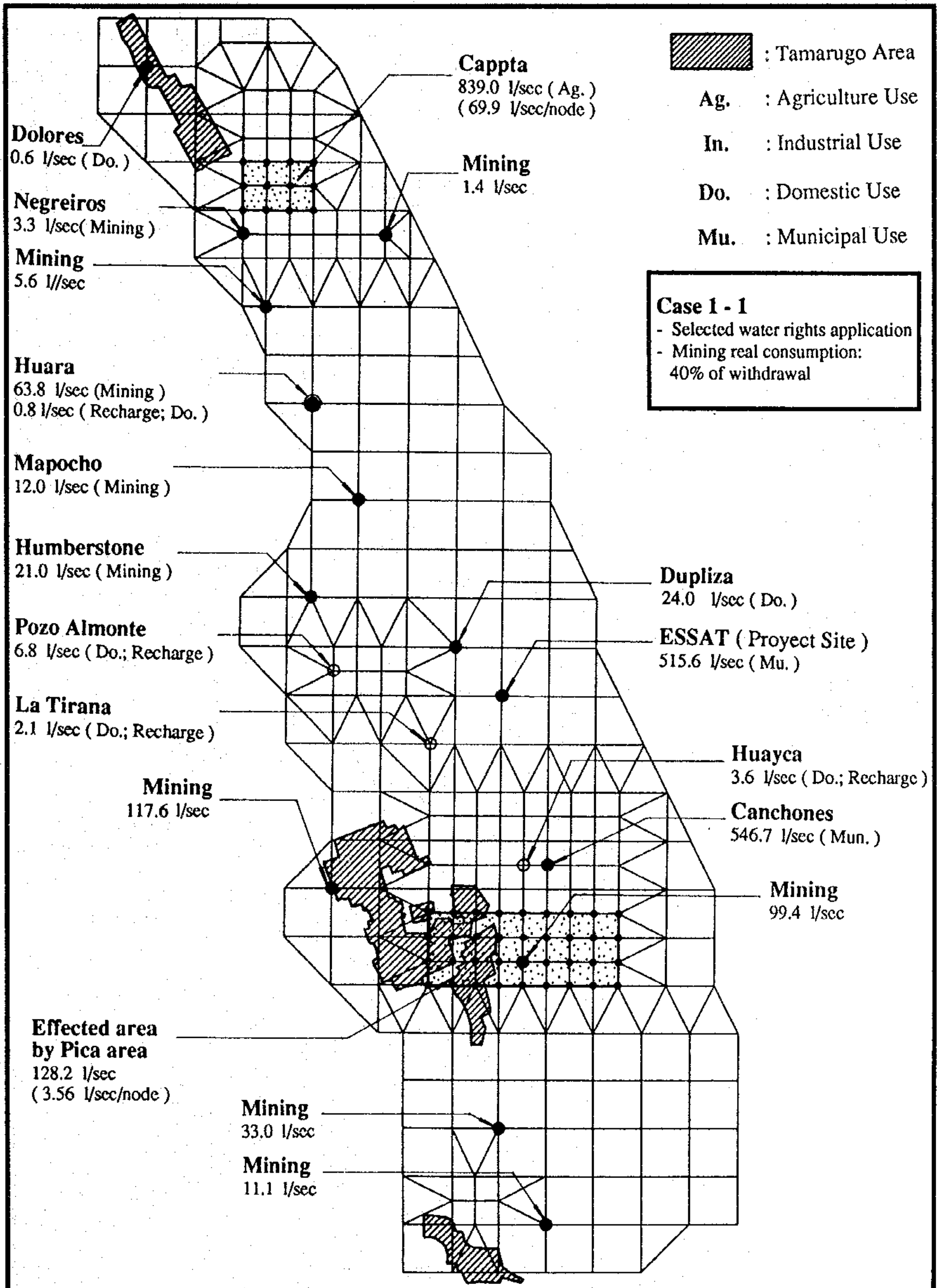


Fig. B-III, **4.7** Discharge and Recharge Condition in 2015 Case 1 - 1

<Condicion de Descarga y Recarga en el Año 2015 Caso 1-1>

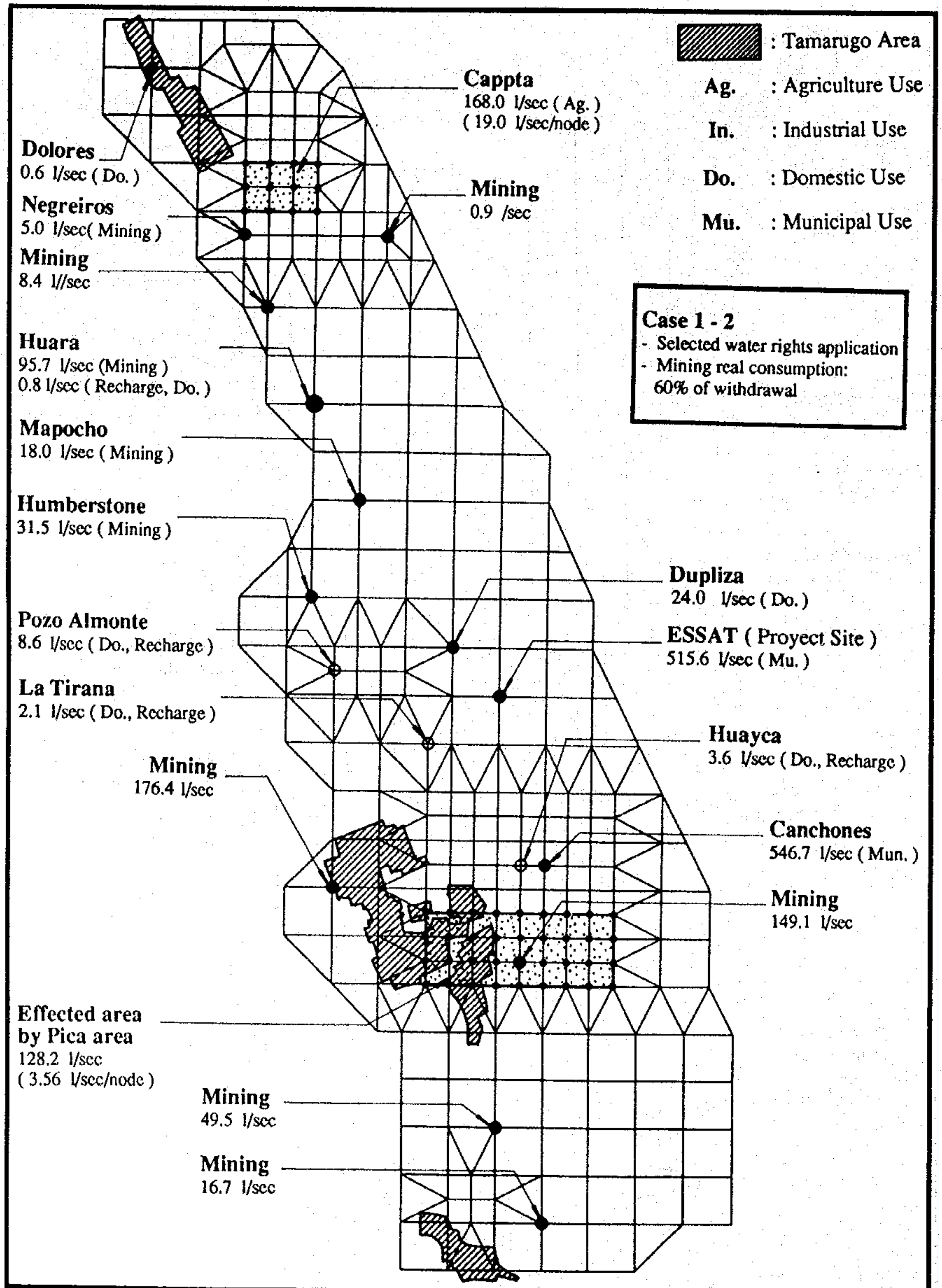


Fig. B-III, 4.8 Discharge and Recharge Condition in 2015 Case 1 - 2

<Condicion de Descarga y Recarga en el Año 2015 Caso 1-2>

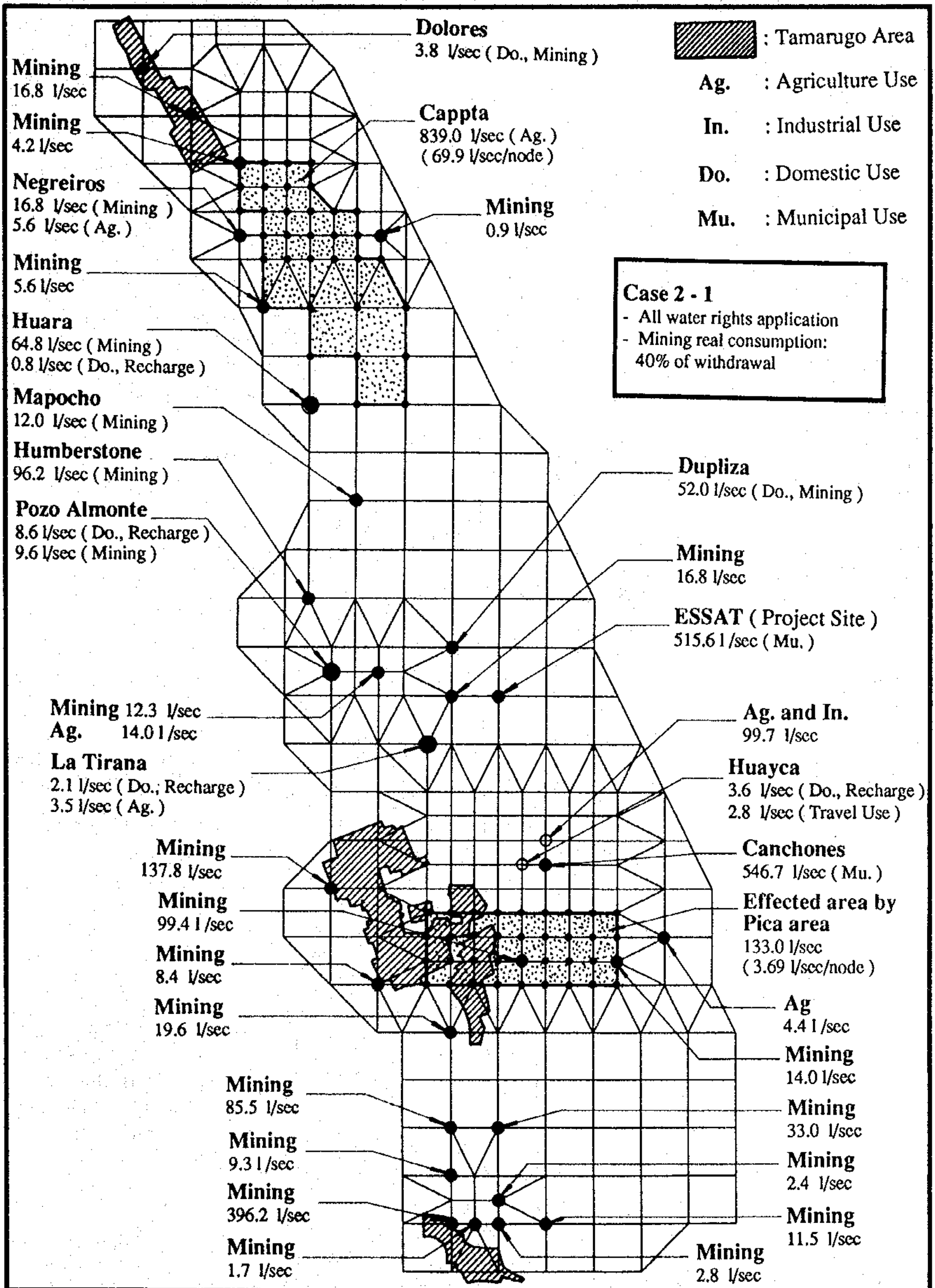
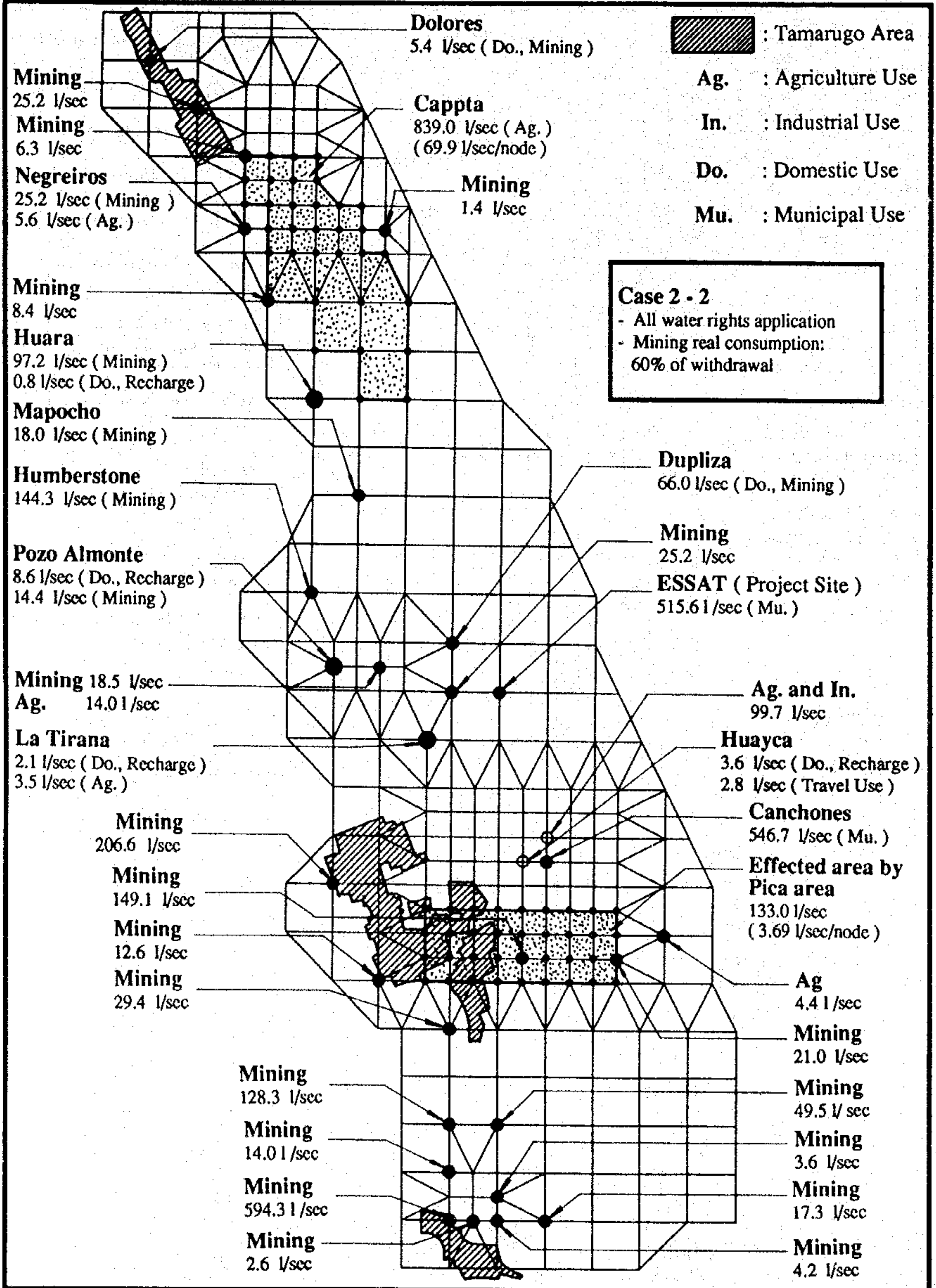


Fig. B-III, **4.9** Discharge and Recharge Condition in 2015 Case 2 - 1

<Condicion de Descarga y Recarga en el Año 2015 Caso 2-1>



FigB-III, 4.10 Discharge and Recharge Condition in 2015 Case 2 - 2

<Condicion de Descarga y Recarga en el Año 2015 Caso 2-2>

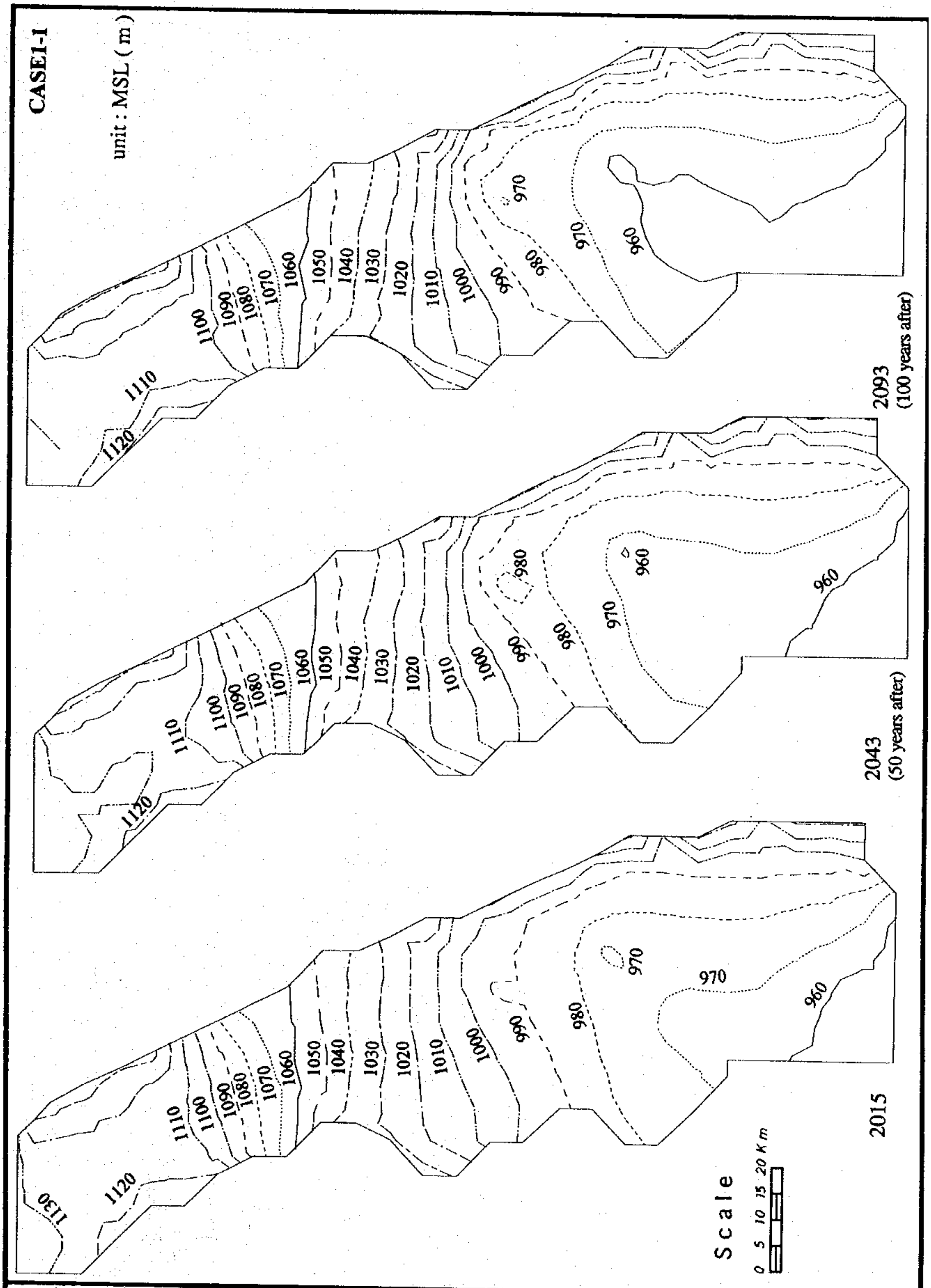


Fig. B-III, 4.11 Simulated Groundwater Level in Future — Case 1 - 1

< Simulación Futura del Nivel de Agua Subterránea > — *Caso 1 - 1*

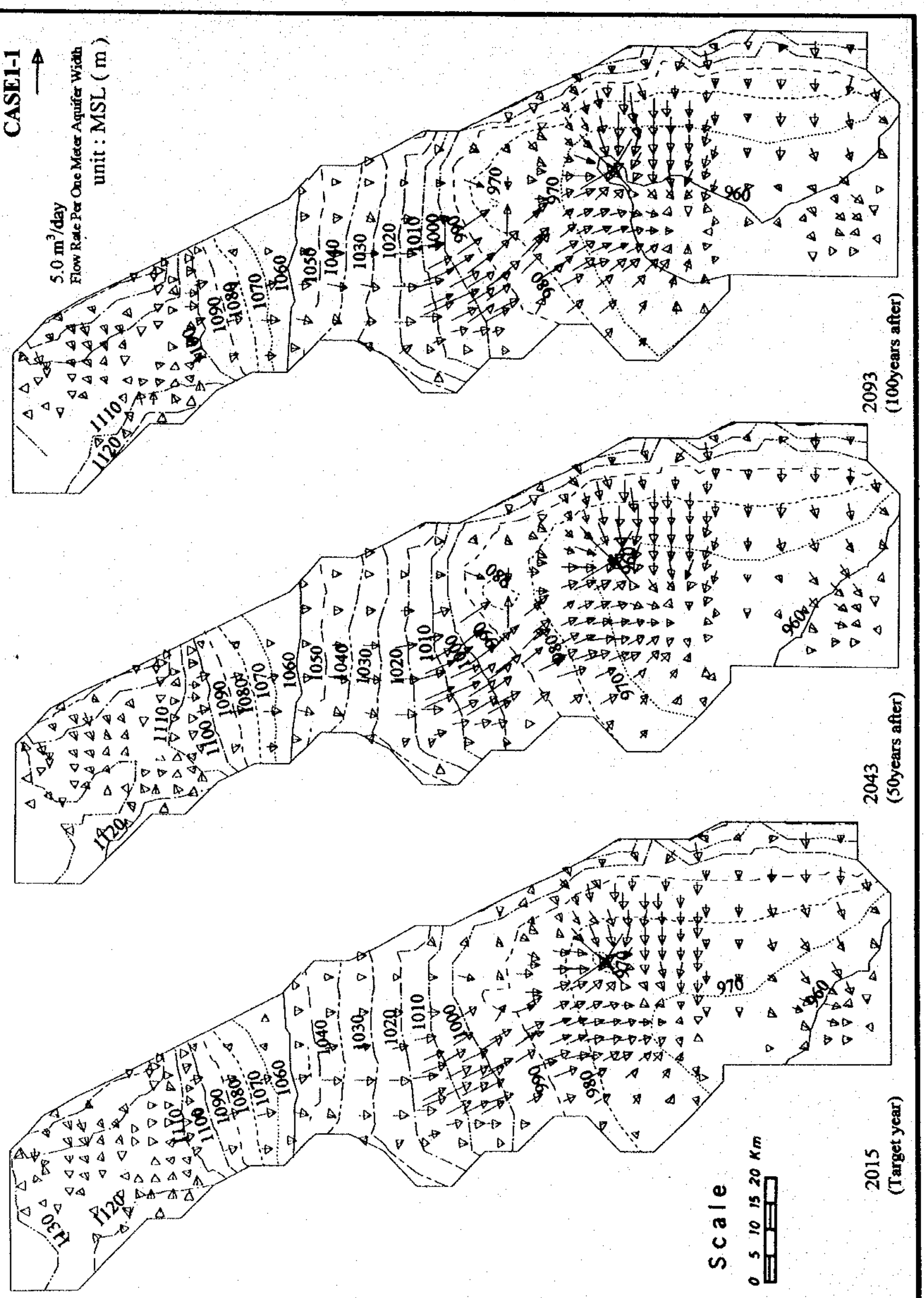


Fig. B-III, 4.12 Simulated Groundwater Level and Flow Vector in Future Case 1 - 1

< Simulación Futura del Nivel de Agua Subterránea y Vectores de Flujo > Caso 1 - 1

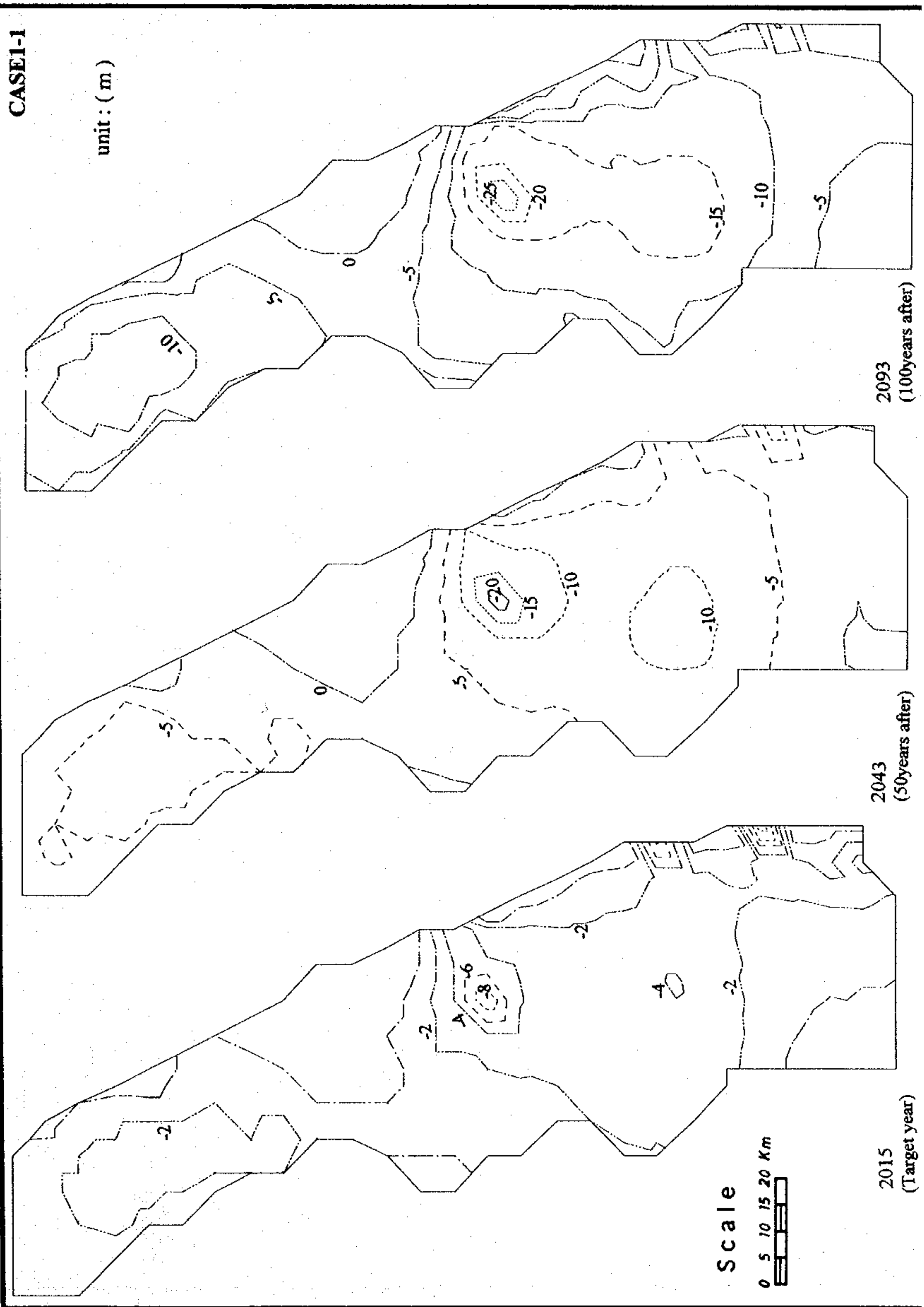


Fig. B-III, 4.13 Drawdown of Groundwater Level Between Present (1993) and Future (2015; 2043 & 2093) Case 1 - 1

< Descensos Simulados entre el Presente (1993) y el Futuro (2015; 2043 y 2093) > Caso 1 - 1

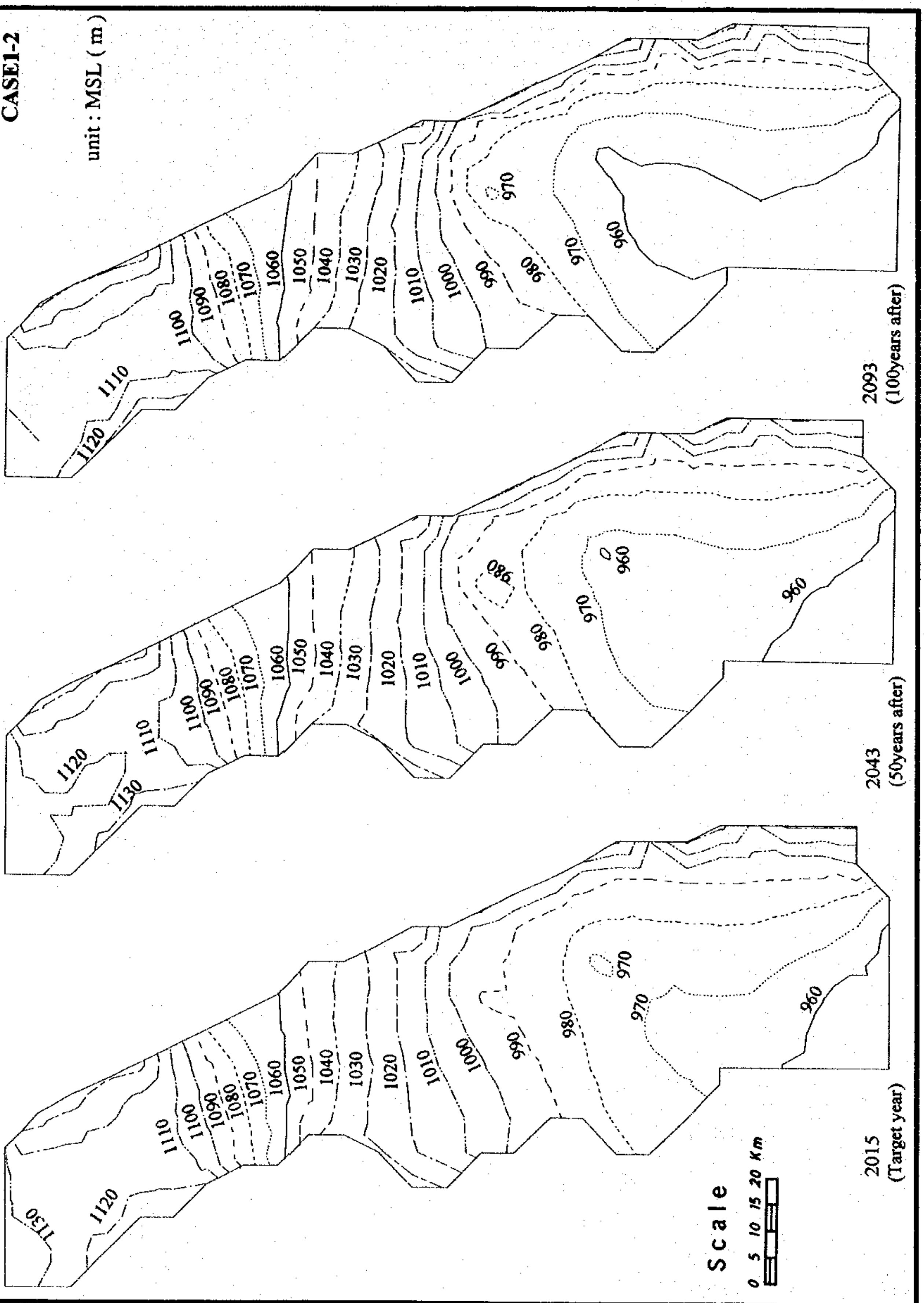


Fig. B-III, 4.14 Simulated Groundwater Level in Future — Case 1 - 2

< Simulación Futura del Nivel de Agua Subterránea > — *Caso 1 - 2*

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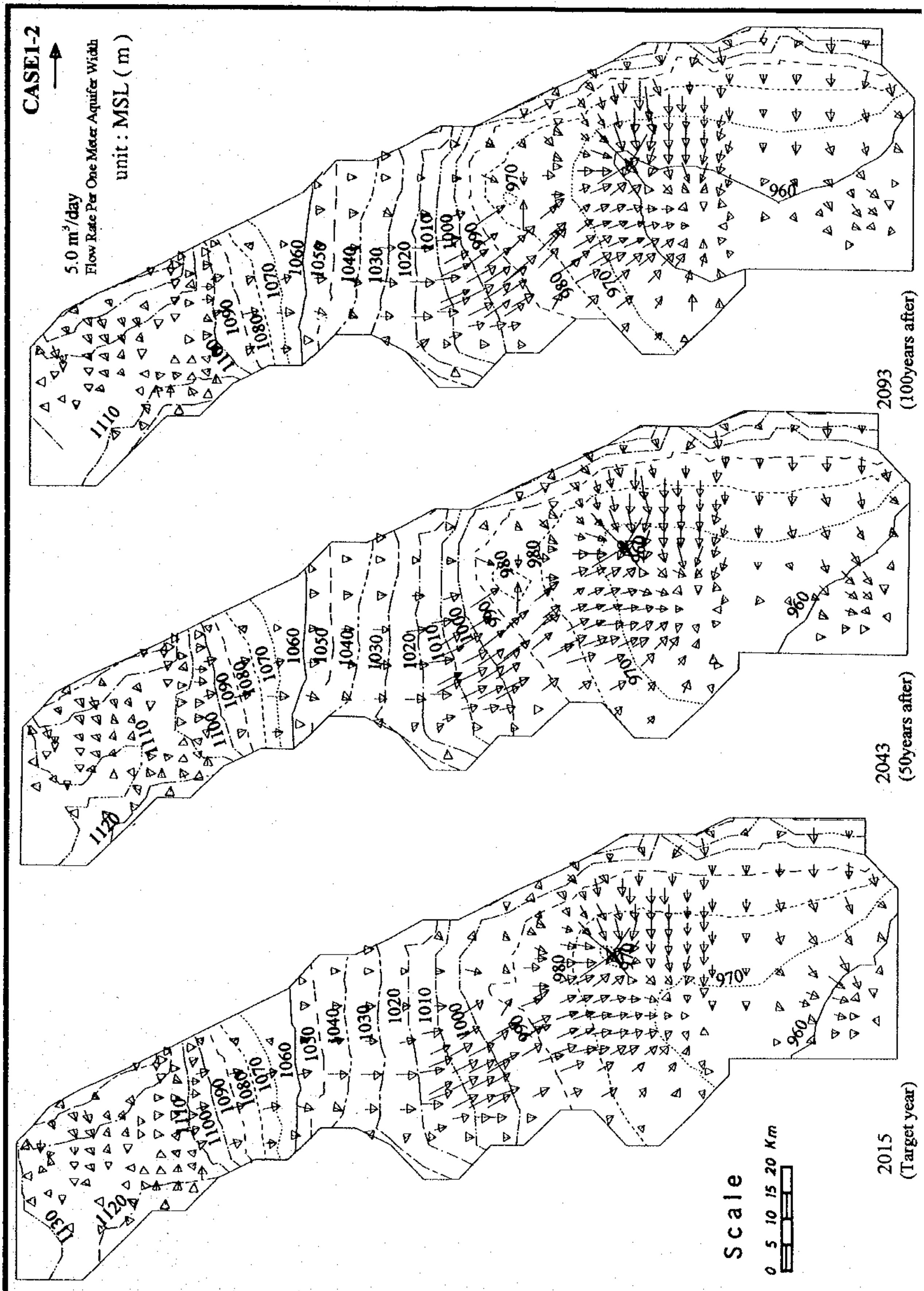

Fig. B-III, 4.15 Simulated Groundwater Level and Flow Vector in Future Case 1 - 2

< Simulación Futura del Nivel de Agua Subterránea y Vectores de Flujo > Caso 1 - 2

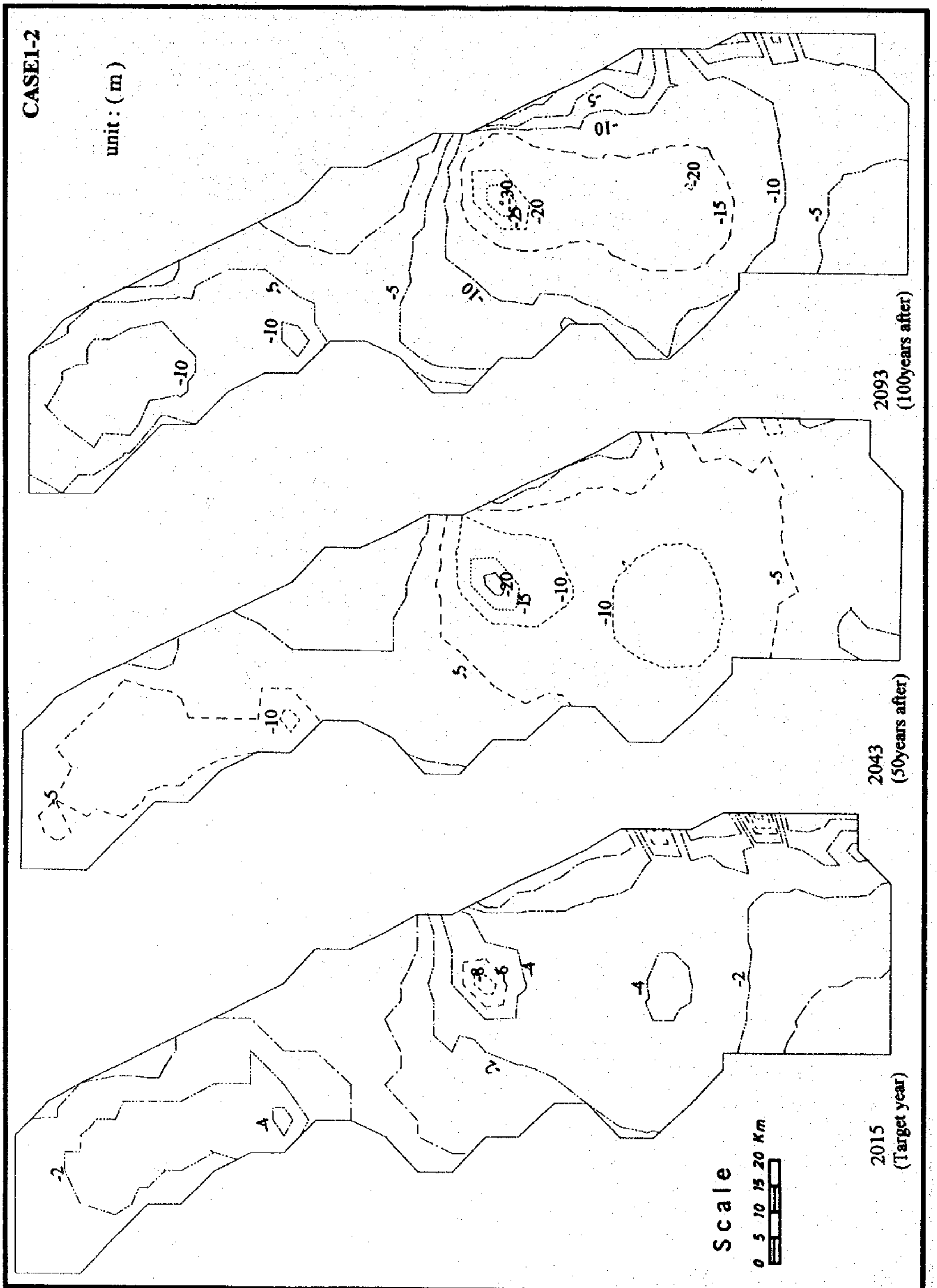

Fig. B-III, 4.16 Drawdown of Groundwater Level Between Present (1993) and Future (2015; 2043 & 2093) Case 1 - 2

< Descensos Simulados entre el Presente (1993) y el Futuro (2015; 2043 y 2093) > Caso 1 - 2

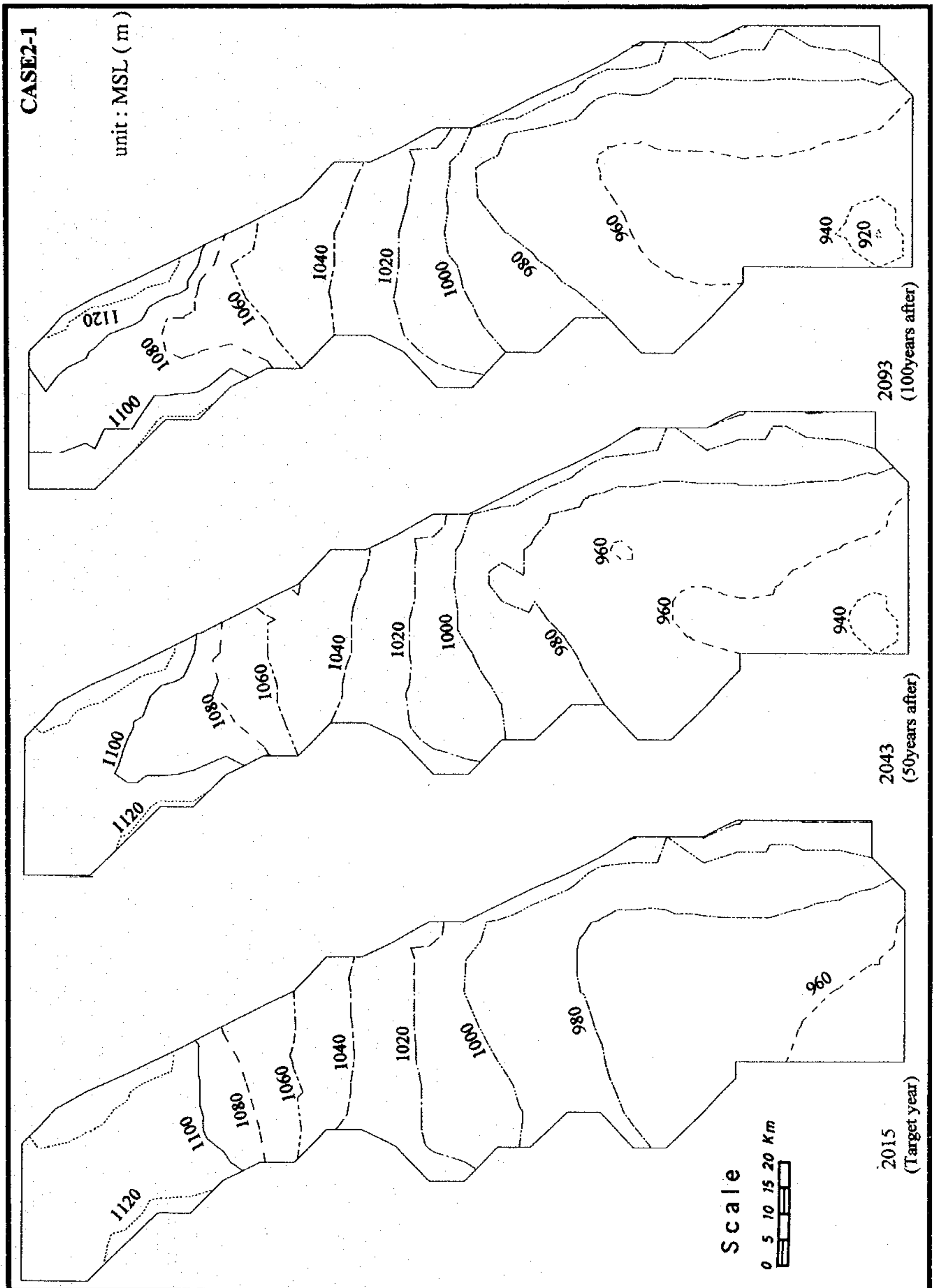

Fig. B-III, 4.17 Simulated Groundwater Level in Future — Case 2 - 1

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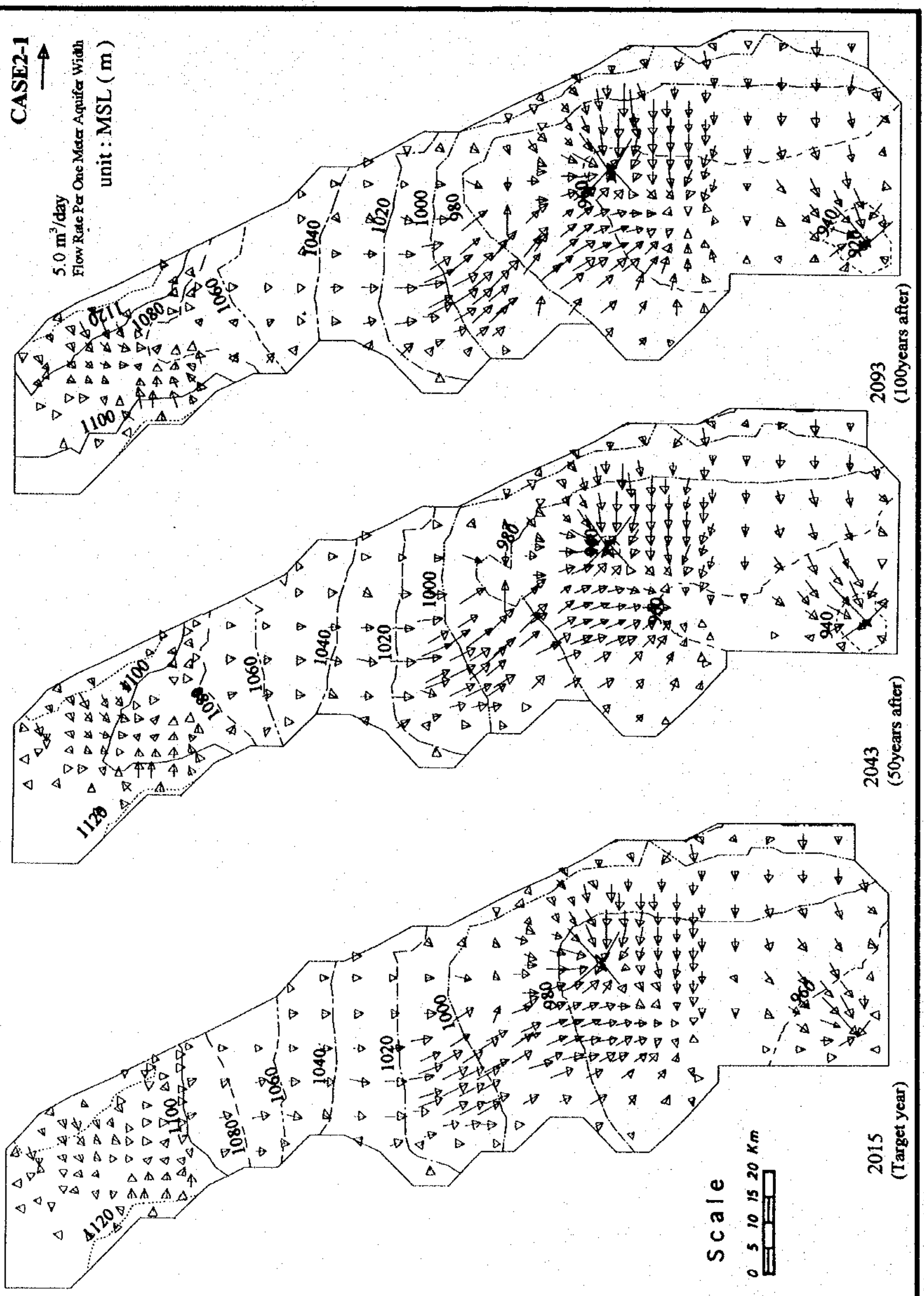

Fig. B-III, 4.18 Simulated Groundwater Level and Flow Vector in Future Case 2 - 1

< Simulación Futura del Nivel de Agua Subterránea y Vectores de Flujo > Caso 2- 1

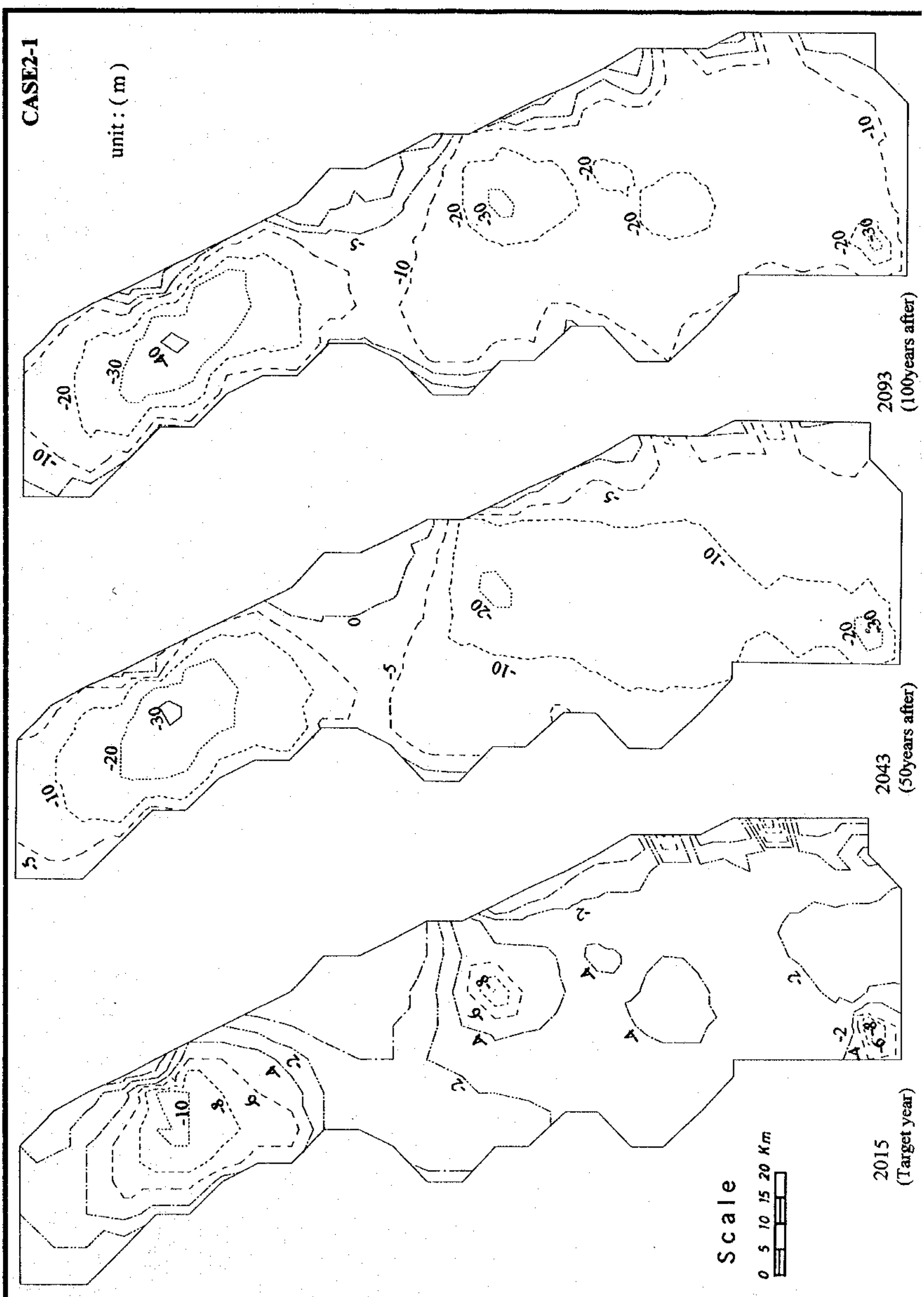

Fig. B-III, 4.19 Drawdown of Groundwater Level Between Present (1993) and Future (2015; 2043 & 2093) Case 2 - 1

< Descensos Simulados entre el Presente (1993) y el Futuro (2015; 2043 y 2093) > Caso 2 - 1

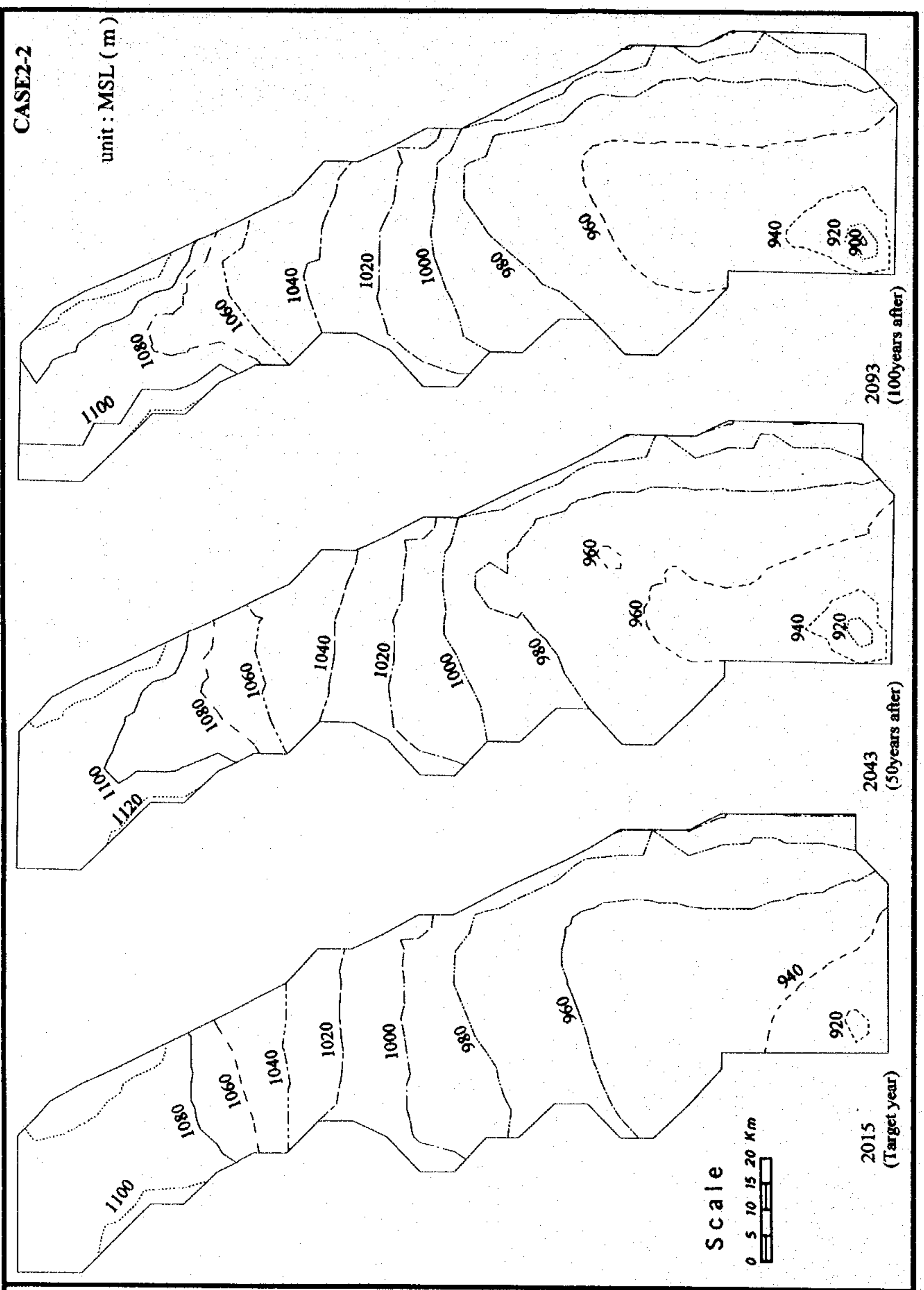

Fig. B-III, 4.20 Simulated Groundwater Level in Future — Case 2 - 2

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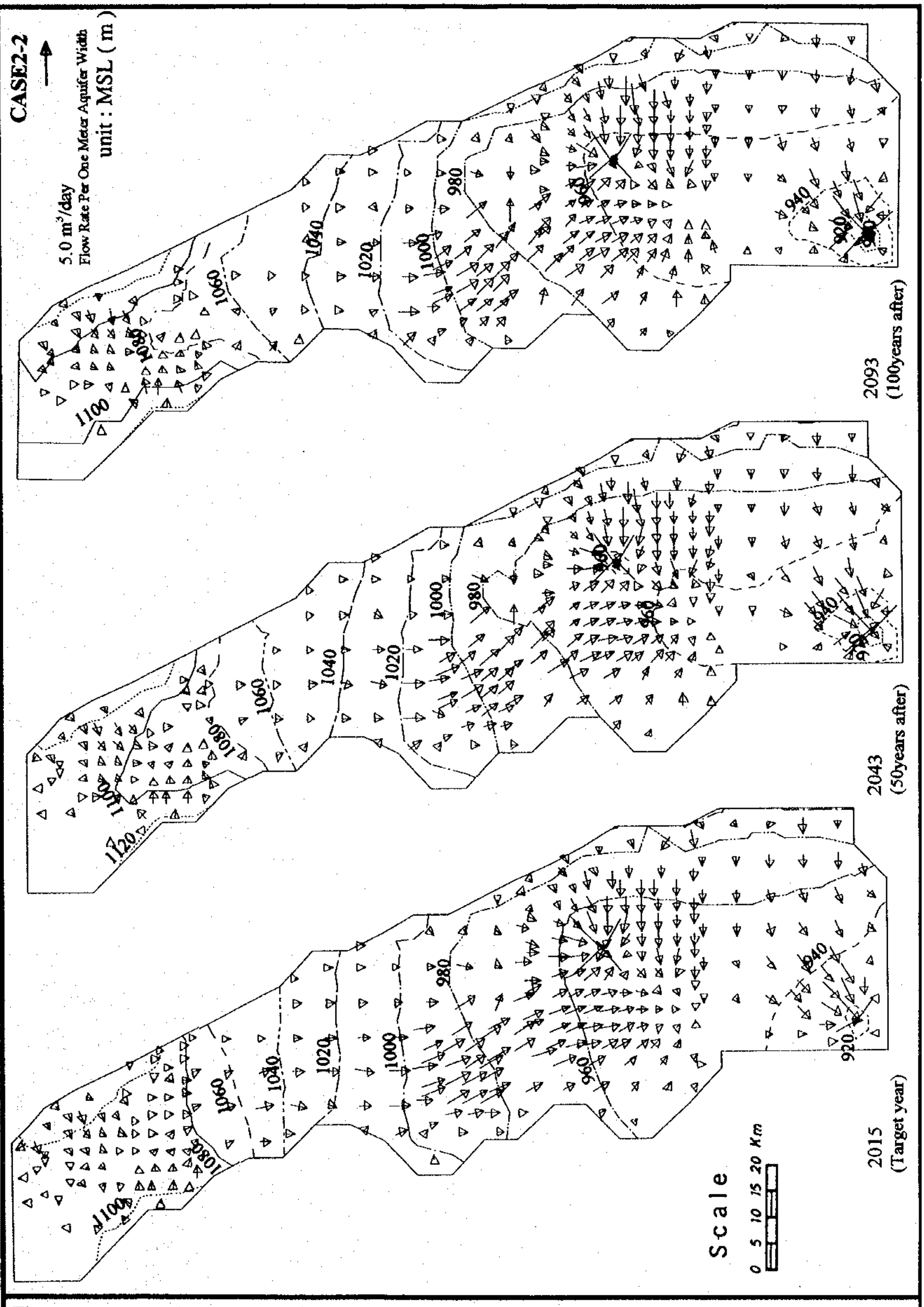

Fig. B-III, 4.21 Simulated Groundwater Level and Flow Vector in Future — Case 2 - 2

< Simulación Futura del Nivel de Agua Subterránea y Vectores de Flujo > Caso 2 - 2

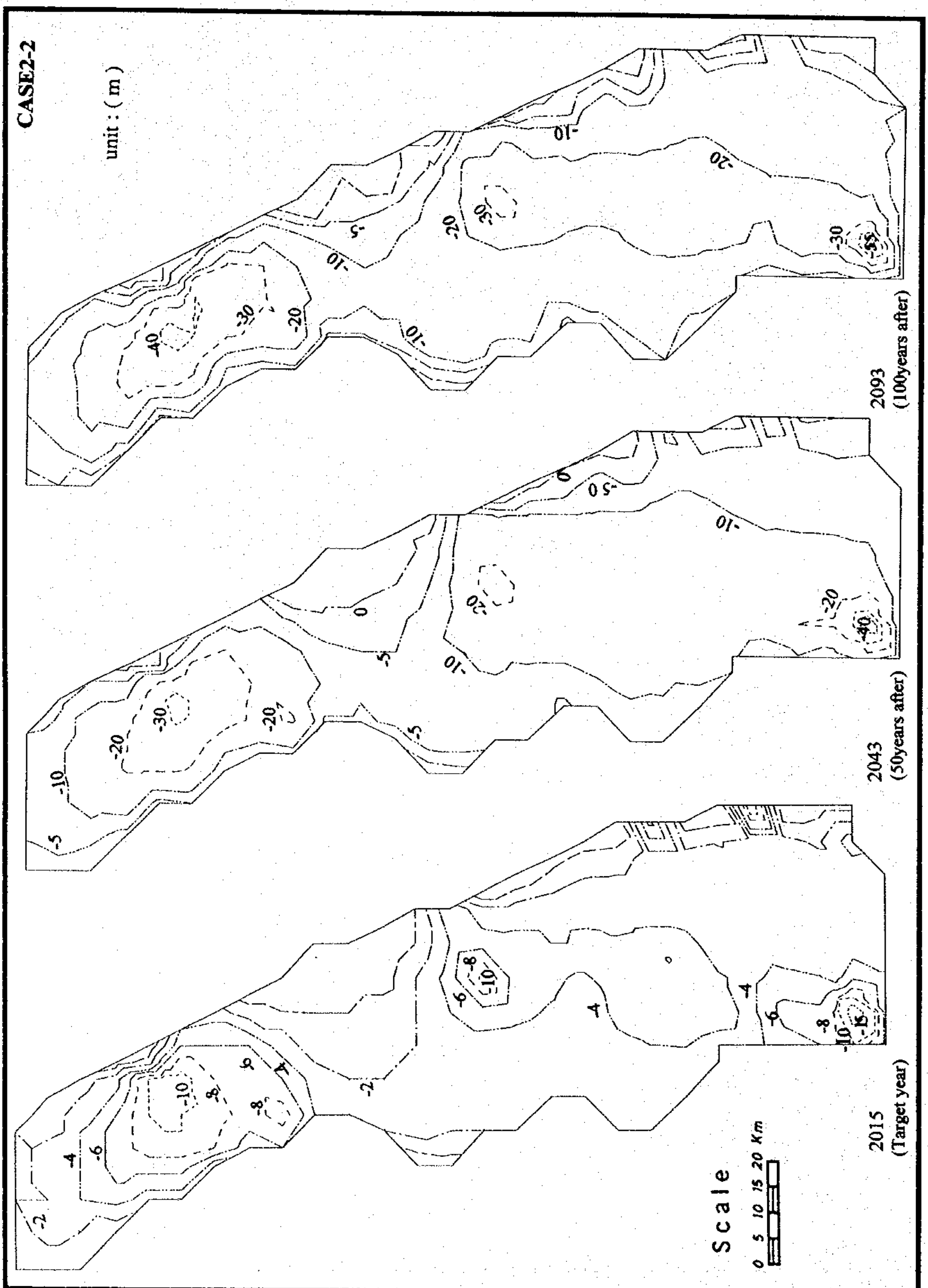

Fig. B-III, 4.22 Drawdown of Groundwater Level Between Present (1993) and Future (2015; 2043 & 2093) Case 2 - 2

< Descensos Simulados entre el Presente (1993) y el Futuro (2015; 2043 y 2093) > Caso 2 - 2

Chapter V. GROUNDWATER MONITORING PLAN

Declination of water level in Pampa del Tamarugal is 7 cm/year in average. If groundwater development project starts to services, the rate of declination will be accelerated in acertain degree. Although no significant drawdown is caused by the project as mentioned in Chapter IV of this Report, it is important to continue the observation of wells on both water level and water quality.

Proposed wells to be monitored are mentioned below. It is important to continue observation at the same wells and never to change monitoring wells. Items of water quality analysis are same as that of the Azapa Valley.

Total number of 12 wells are selected for the observation as follows. For location, refer to Fig. B-II, 2.1.

Well No.	Well Name	Interval of Observation	
		Water Level	Water Quality
104	Salar Zapiga	every 2 months	once a year
173	PTA AP Colores 6		
178	Salar de Zapiga		
132	EL Carmelo 2		
221	O.J. Morales 1		
129	PTA. Sara 3A		
256	Loreto 3		
263	La Calera 3		
264	La Calera 2		
265	Esmeralda 6		
270	Esmeralda 7		
277 or 293	Esmeralda 11 or 28		
316	Bosoue Junoy 15		
354	P. Canchones H		
363	Salar Pintados		
112	Salar Pintados		
114	Pintados Pica 3		
117	Matilla 5		
402	Chacarilla 1		
113	Pintados Radio		
415	Salar Pintad 2		
426 or 150	Estacion Pinta 4 or 1		
430	Salar Pintados		
146	Mosquitos 1		
434	Salar Belavista		
157	Salar Belavista		
128	Salar Bellavista		
440	Salar Bellavista		
127	Salar Bellavista		
447	Salar Bellavista		
J-C	Huara	continuously	once a year
J-D	Baquedano		
J-E	La Tirana		
J-F	Ramada		
J-3	Aguada		
J-4	Negreiros		
J-5	Pozo Almonte		
J-6	Canchones		
J-7	Conaf		
J-8	Pintados		
J-9	Oficina Victoria		

B-IV SALAR DEL HUASCO BASIN

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Chapter I. TOPOGRAPHY AND GEOLOGY

1.1 Topography

The Salar del Huasco Basin occupies the parts of Altiplano, as shown in Fig. B-I, 1.1, and is situated at the altitude between 3,800 and 4,200 m. Drainage systems of the basin are shown in Fig. B-III, 1.1 shows that the basin is closed and no river flows out from the basin.

Fig. B-IV, 1.1 gives the topographic figure of Salar del Huasco, which is interpreted from aerial photographs taken during 1966 and 1967. The figure of Salar del Huasco is as follows.

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 E).

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 the Salar del Huasco Basin, one (1) scene of image, path 002-row 074 was 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 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, 1.3 and 1.4 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 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 stages 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 thedistribution 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, the volcanic breccia (Qcl) of the lower part of the Collacagua Formation could be correlated 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; the Upper, the Middle and the 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 the stratigraphic relation with other formations. Although <2 described the Collacagua Formation as Tertiary deposits, the Study Team considered the formation as Quaternary deposits based on <3.

(i) Lower Unit (Qcl)

The lithology is volcanic breccia in the well H-1, changing to gravel, sand and mud in wells No. 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 well No. H-1, and gravel in well No. J-G and J-10.

(iii) Upper Unit (Qcu)

Gravel, sand and mud appear in the well No. H-1 and are overlain by the salt crust. It is mainly composed of gravel in well No. J-G and J-10.

The Upper Unit and the 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; The Upper and the Lower. The Lower Unit consists of 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 northeast 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. The western side of Salar del Huasco is bounded by the fault which is extended to the north and meets the Collacagua River at the northern end.

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 infiltrates 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 most prospective aquifer 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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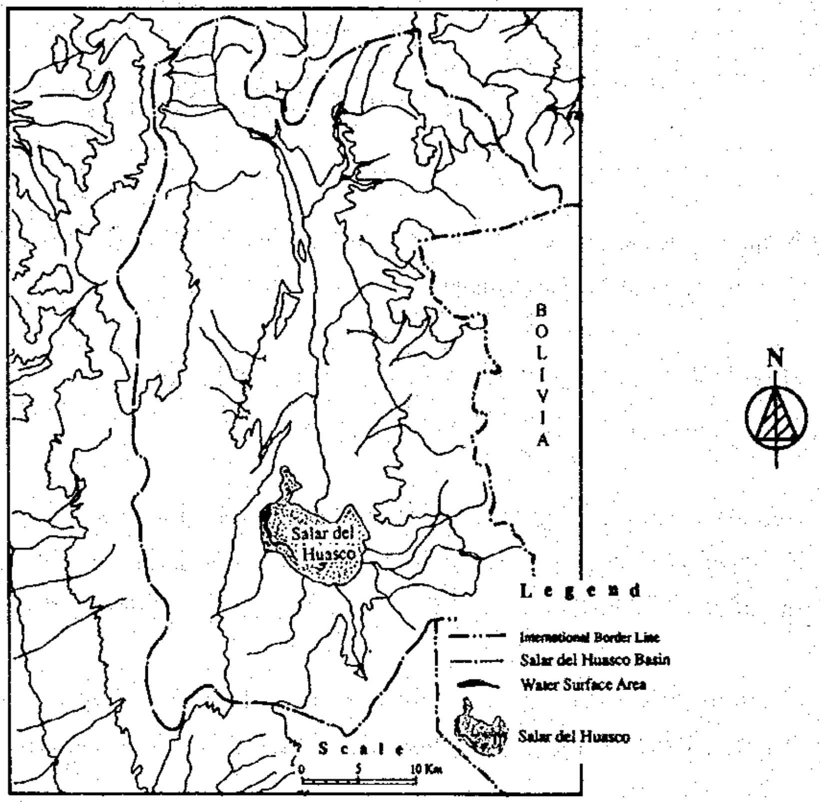

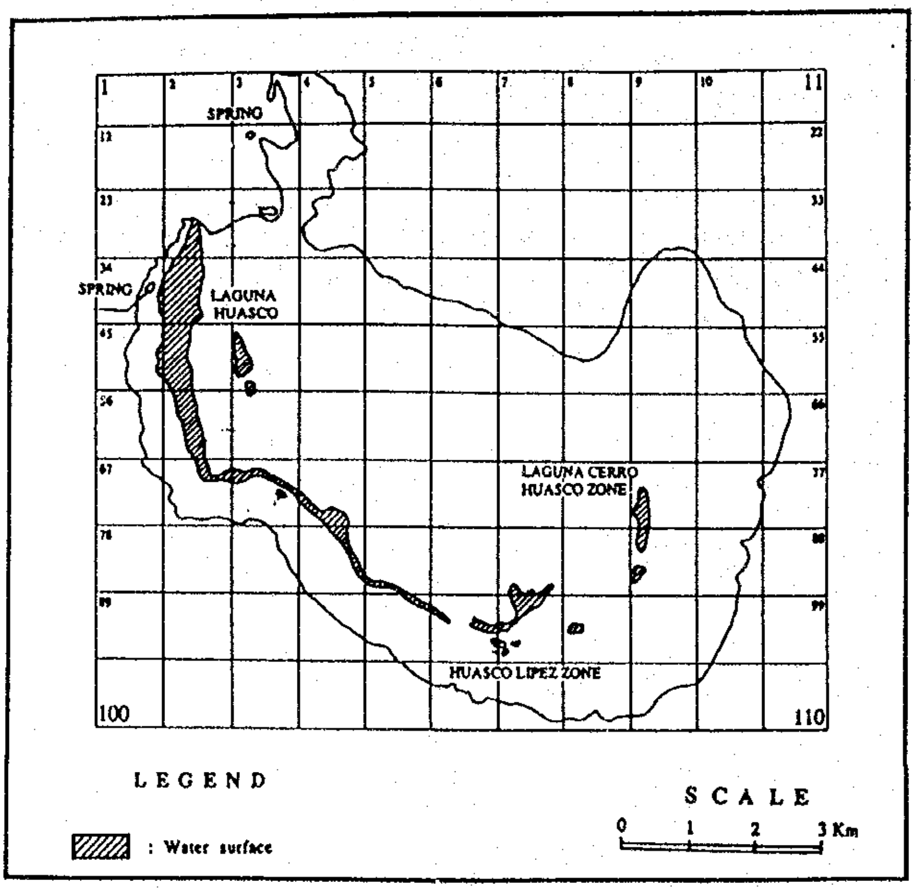

Fig. B-IV, 1.1 Topographic Figure (Salar del Huasco)

< *Figura Topográfica (Salar del Huasco)*>

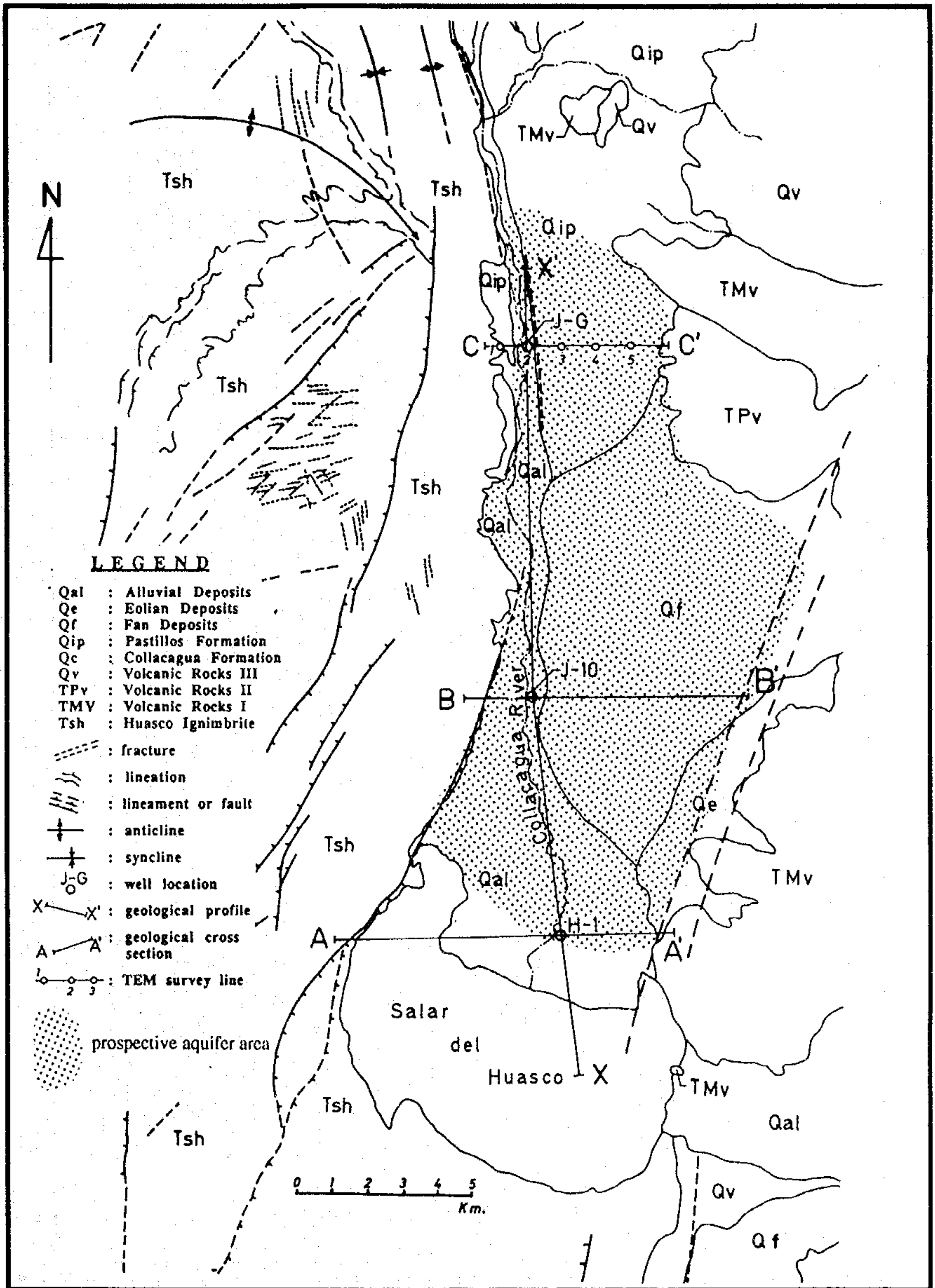

Fig. B-IV, 1.2 Geological Map (Salar del Huasco)

< Mapa Geológico (Salar del Huasco) >

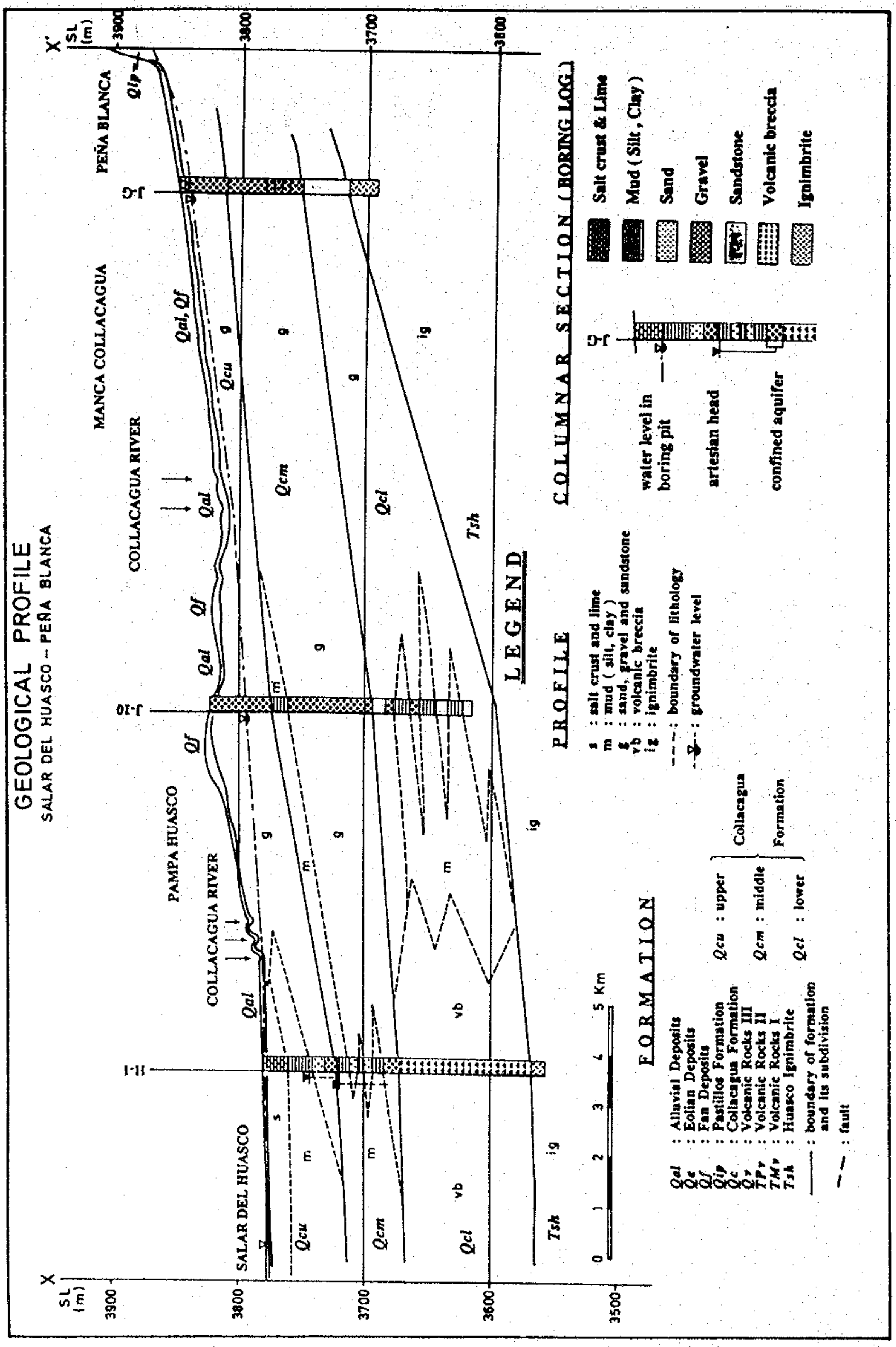

Fig. B-IV, 1.3. Geological Profile (Salar del Huasco)

<Perfil Geológico (Salar del Huasco)>

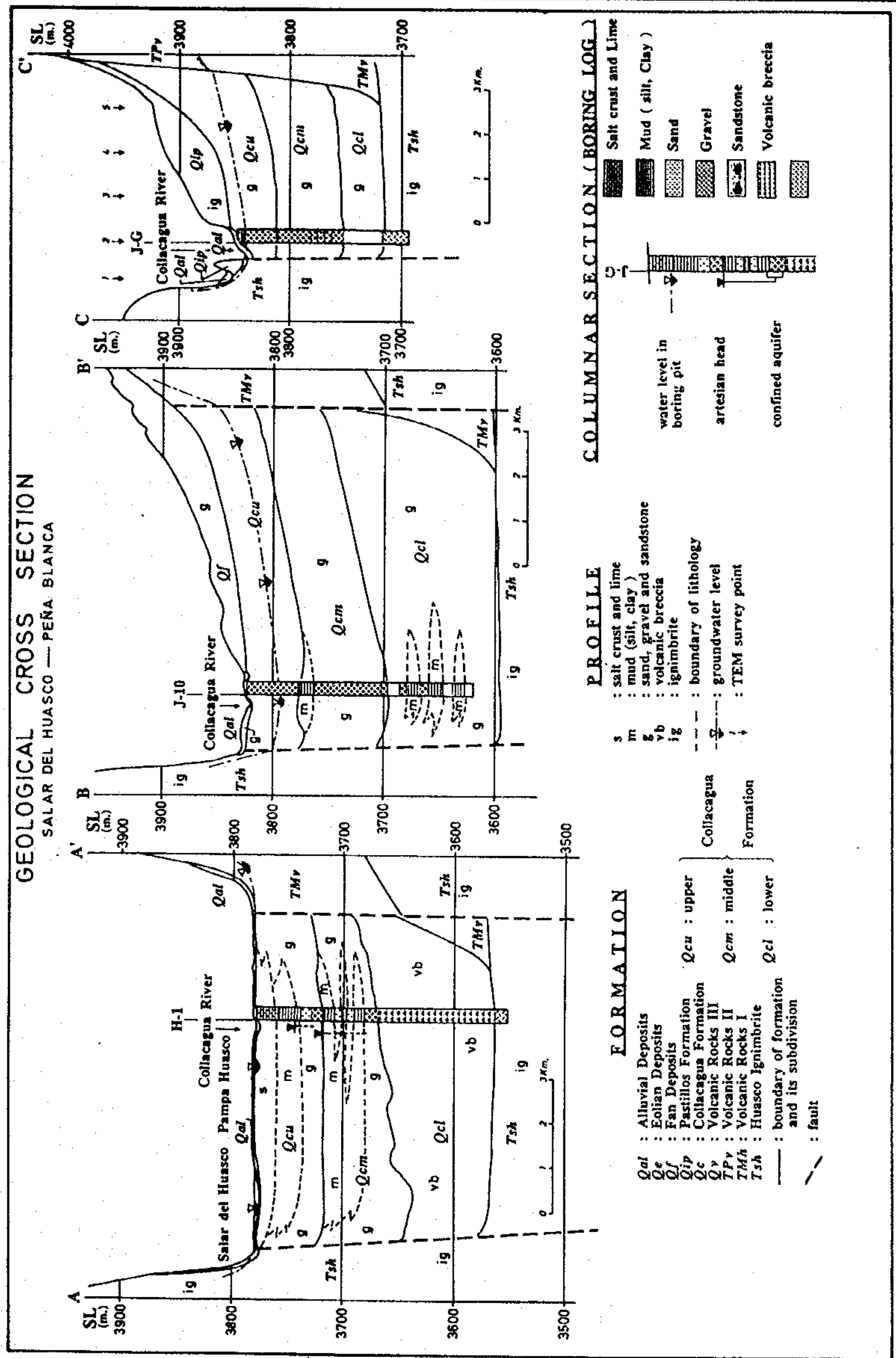

Fig. B-IV 1.4 Geological Cross Section

< Sección de Cruce Geológico >

Chapter II. AQUIFER OF HUASCO BASIN

2.1 Existing Data

Although two (2) bore holes were 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 on 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 survey locations are shown in Fig. B-IV, 2.1.

a) Electromagnetic Survey	5 survey points (1 line)
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, 2.1). 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.

An apparent resistivity curve at the station No.2 is shown in Fig. B-IV, 2.2. A geological profile is made by the apparent resistivity curve of each station. A geoelectrical profile along the Line SH-1 is shown in Fig. B-IV, 2.3. The resistivity structure along the profile is classified as six (6) layers. The geophysical characteristics of each layer is summarized as follows.

a) The first layer shows a resistivity value, higher than 350 ohm-m. This resistivity represents a dry layer composed of 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 the wet condition beside the river.

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

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

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

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

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

4) Interpretation with Boring Log

Geoelectric profiles, described in the above section, are analyzed based on the boring log including observed lithology and geophysical logging data. Fig B-IV, 2.3 shows analyzed resistivity profile interpreted by using inverted geoelectrical sections and boring logs. Interpretation for each resistivity profile is 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 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, 2.1). 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-G	Salar del Huasco	20° 06' 29.5"	68° 49' 00.4'	3,850	8-5/8"	157
J-10	Salar del Huasco	20° 11' 38.0"	68° 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

The results of the boring test are shown in Table B-IV, 2.1. The well data for each well, including lithological column, casing design, well logging and drilling rate are shown in Fig. B-IV, 2.4 for test well and in Fig. B-IV, 2.5 for observation well with scale of 1:1000.

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

(J-G)

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

Spontaneous potential (SP) indicates a range of -55.5 to -58 mv. From the lithological point of view, a relative basement line (relative 0 line) which is the boundary between permeable formation (gravel sand) and impermeable formation (mud) is estimated as - 57.5 mv. Gamma ray indicates 30 to 70 cps at 50m from surface and 60 to 100 cps at below 50m. This range is in well coincidence with lithological observation of clean gravel at 38m from surface and clayey gravel at below 38m. The range of resistivity is also in coincidence with TEM's resistivity, especially 30 to 100 ohm-m at depth from 30 to 108m. A slow increase rate of water temperature curve from surface to 110m depth (17° to 18°C) indicates groundwater flow.

iii) Determination of Casing Design

In order to determine the position of screen pipe, the following interpretation were made by lithological and well logging data. Decided casing design is shown in Fig, B-IV, 2.4.

a) 1 st layer (Surface Deposit)

The layer consists of coarse sand at surface and fine gravel at lower part. It is estimated as highly permeable, based on the SP and gamma ray values. 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 to have permeability lower than 1st layer because of clayey matrix. The range of SP and gamma ray also indicates higher value which can be interpreted as low permeability. However, the range of resistivity (30 - 90 ohm-m) shows approximately same value with the TEM result (55 - 90 ohm-m). This range was classified as most promising aquifer by the TEM analysis. Therefore, the layer is expected as aquifer.

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

c) 3 rd layer (Impermeable bed)

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

(2) Well No. J-10 (see, Fig. B-IV, 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 results of geophysical logging and lithological observation, following four (4) major layers are classified.

(J-10)

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, three (3) different ranges are observed; 30 to 70 cps from 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 at depths of 167m and 192m by the high value of gamma ray. Based on the lithology and gamma ray, a relative basement line of the SP is estimated as -9,2mv. In consideration of SP and gamma ray curves, higher permeability can be expected from surface to 150m. The resistivity value is high at 40m from surface and at middle part (90 to 140m depth). The water temperature gradually increases from surface to bottom.

iii) Determination of Casing Design.

Casing design is decided as shown in Fig. B-IV, 2.5, based on the following interpretation for each layer.

a) 1 st layer (Surface Aquifer)

The layer is considered to has the highest permeability among four (4) layers 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 has extremely high resistivity value (more than 500 ohm-m).

A 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 compared of single 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 at depth from 86.53 to 146.51m of this layer.

d) 4 th Layer (Deep Aquifer)

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

Two (2) positions were selected for screen pipes at the depths 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 2.2.3 of Chapter II.

2) Result of Pumping Test

(1) Aquifer Constants

Aquifer constants are analyzed by using the graphs shown in Fig. B-IV, 2.6 to 2.7. The results of this analysis are summarized in Table B-IV, 2.2 and 2.3. The tables include pumping data and aquifer constants calculated by two (2) methods mentioned above. The aquifer constants for two (2) wells are summarized as follows;

Well No.	Transmissibility (m^3/day/m)	Permeability (cm/sec)
J-G	156.39	2.74×10^{-3}
J-10	191.38	2.46×10^{-3}

A similar value of the aquifer constants in all item is obtained at both wells. A range of 156 to 191 m^3/day/m of transmissibility indicates that the aquifer has moderate groundwater potential. Considering the proportion of the each lithology, it is presumed that a range of 2.4×10^{-3} to 2.7×10^{-3} cm/s represents the permeability of clayey gravel.

iii) Well Capacity

Well capacity is evaluated by the amount of critical discharge and safe yield. The Q-Sw chart for to examine the critical discharge and Q-s/Q Chart for to obtain the well efficiency and area of influence are shown in Fig. B-IV, 2.8 to 2.9. The capacities for two (2) wells are summarized as follows;

Well No.	Critical Discharge (l/s)	Safe Yield (l/s)
J-G	more than 25.00	6.70
J-10	more than 5.00	1.75

Critical discharge is estimated as more than 25 l/s at J-G and more than 5 l/s at J-10. It is confirmed that the amount of critical discharge is larger than maximum pumping rate capacity. Safe yield is estimated as 6.7 l/s at Test Well and 1.75 l/s at Observation Well.

2.2.4 C-14 Analysis

One (1) sample was taken fron the JICA Well No. J-G.

The result of the analysis is as shown below;

Well No.	Tritium (TU)	C-14 (pmc)	Age (Y.BP)*	Average Age**
J-G	<0.8	7.8	8,690-9,800	9,245

Y.BP : years before present

* : Estimated age by Modified Pearson Model

Tritium contents is close to 0, therfore, the groundwater age is older than at least 40 years. C-14 data shows an old age, 9,245 Y.BP. C-14 age is rather old.

It is suggested that velocity of the groundwater in the Salar del Huasco Basin is very small.

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 appear in the basin-fill alluvial deposits and the underlying Altos de Pica formation and the basin is hydrologically in a dynamic equilibrium (<2, <3 and <4).

The basin is topographically closed by mountains and it has an ovoid shaped depression elongated to the north and south as shown in Fig. B-III, 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 figures of the aquifers in the basin is shown in Fig. B-IV, 1.2, 1.3 and 1.4.

The aquifers extend 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 excluded from the aquifer area. Accordingly, the prospective aquifer area is about 126 km^2; 20 km in length and 4.5 to 7 km 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 as 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, 1.3. 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 increases 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	Transmissibility	Permeability
	(l/sec/m)	(m^3/day/m)	(cm/sec)
J-G	0.74	156	2.74×10^{-3}
J-10	1.23	191	2.46×10^{-3}
Average	0.99	174	2.60×10^{-3}

Both wells show moderate specific yield and transmissibility. Permeability is rather small compared to 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, 2.4 and Fig. B-IV, 2.10. 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 remain 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 Blanca.
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 by DGA and the Study Team on the JICA Wells and two (2) springs which occurred at the margin of the Salar. Results of the analysis are shown in Table B-IV, 2.5.
From the table, it is interpreted that:

a) Most of ion contents are less than standard for drinking water. The parameters are 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 riser pipe in pumping test because new pipes are used at the test.

Fig. B-IV, 2.11 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 non carbonate hardness type. It means that the water of the well J-10 consists mainly of chemical compounds of Ca/Mg and SO_4/Cl.

2.7 Evaluation of Groundwater Development Potential

2.7.1 Existing Water Balance

The Salar del Huasco Basin is hydrologically closed; only the Collacagua River flows into the Salar collecting surface water from its tributaries and no surface water flows out from the Basin. The surface water of the Collacagua River entirely infiltrates into the underground before reaching the Salar. Water of the Salar evaporates from its surface. Some portion of groundwater seems to flow out through fissures toward the Pampa. Water in the Basin is balanced with those factors.

Surface water of the Collacagua River is calculated in Supporting Report C. It is 809 l/sec. Evaporation rate in the Salar del Huasco Basin was measured by DGA during 1981-1982 (<6). The rate was 1935mm/year by evaporation pan. Considering that the evaporation rate by pan is generally larger than that of actual evaporation, an approximately 75 % of evaporation rate by pan is adopted for the evaporation rate from the water surface. However, data on the evaporation rate from the wet land are not available. Then, the evaporation rates of Pampa del Tamarugal (<6) are applied to estimate the total volume of evaporation. Depth to water level in the wet land is very small because the water depth of the Salar is 16 cm in maximum. The evaporation rate from the wet land is considered to be more larger than the rate mentioned in <6. Therefore, the size of water area is regarde to be 6 km^2, although actual size of the wet land is 2 km^2 for calibration. Taking all these factors into consideration, evaporation from the salt lake is calculated in the following table.

Area			Evaporation Rate		Total Evaporation			
Water Area	6	km^2	1.5	m/year	9,000,000	m^3/year	285.39	l/sec
Wet Land	25	km^2	0.365	m/year	9,125,000	m^3/year	289.35	l/sec
Total Area	31	km^2		m/year	18,125,000	m^3/year	574.74	l/sec

Water level of the salt lake is almost constant, therefore, change of the storage volume of the Basin is considered to be zero (0).

Water balance of the Salar del Huasco Basin is given following formula;

$$\Delta Q = R_R - (R_F + E_S)$$

where,

ΔQ : variation of groundwater volume (0 l/sec)

R_R : recharge from the rivers (809 l/sec, see Supporting Report A)

R_F : outflow through fissures (l/sec)

E_S : evaporation from Salars (575 l/sec)

Then,

$$R_F = R_R - E_S = 809 - 575 = 234 \text{ (l/sec)}$$

This result shows a possibility that 234 (l/sec) of groundwater flows out to Pampa through the fissures recharging the groundwater in Pampa del Tamarugal.

2.7.2 Groundwater Development Potential

Aquifers in Salar del Huasco Basin are recharged by surface water of the Collacagua River and discharge water by evaporation through salt lake, and by flowing out through fissures to Pampa, as mentioned in 2.7.1. Groundwater storage in the Basin is estimated to be 465 x 10^6 m^3 in 2.5 of this Report. In consideration of groundwater development potential, this storage groundwater is not an object of development.

It is impossible to clarify the location and/or range of fissures through which groundwater flows out to Pampa del Tamarugal Basin. Exploitable groundwater is limited to the water which flows into the salt lake. 809 l/sec of surface water infiltrates into aquifers, however, 234 l/sec of groundwater flows out through fissures. Therefore, a volume of exploitable groundwater is,

809 - 234 = <u>575 (l/sec)</u>

Groundwater development potential is considered to be 575 l/sec. If groundwater is developed in the Salar del Huasco Basin, it will be unavoidable that the salt lake is dried up to balance with the decrease of recharge from groundwater.

An interpretation on radius of influence was made to decide the spacing of production wells. Aquifer constants are given by the pumping tests mentioned in 2.2 of this Chapter. Formula for determination of the radius of influence is mentioned in Chapter III of B-II. Conditions of production well construction are planned as follows;

Diameter of well : 17-1/2" (444.5 mm)

Diameter of casing : 12" (318.5 mm)

Production rate : 40 l/sec
Allowable drawdown : 40 m
Drilling depth : 150 - 200 m

Following table gives details of radius of influence.

	R (m)	Q (m3/sec)	T (m3/sec/m)	S	t (sec)	time
J-G	76	0.04	1.81E-03	0.3	43200	0.5 day
	94	0.04	1.81E-03	0.3	64800	0.75 day
	108	0.04	1.81E-03	0.3	86400	1 day
	419	0.04	1.81E-03	0.3	1E+06	10 day
	592	0.04	1.81E-03	0.3	3E+06	1 month
	1451	0.04	1.81E-03	0.3	2E+07	6 months
	2066	0.04	1.81E-03	0.3	3E+07	1 year
J-10	83	0.04	2.21E-03	0.3	43200	0.5 day
	102	0.04	2.21E-03	0.3	64800	0.75 day
	118	0.04	2.21E-03	0.3	86400	1 day
	456	0.04	2.21E-03	0.3	1E+06	10 day
	645	0.04	2.21E-03	0.3	3E+06	1 month
	1580	0.04	2.21E-03	0.3	2E+07	6 months
	2250	0.04	2.21E-03	0.3	3E+07	1 year

Radius of influence is 110 to 120 m (220 to 240 m in diameter)when pumping period is one (1) day. It increases up to 420 to 460 m (840 to 920 m in diameter) when 10 days continuous pumping operation is executed. Considering these results, spacing of production wells are decided to be 1000 m.

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Table B-IV, 2.1 Result of Boring Test of Salar del Huasco Area

< Resultado de Prueba de Sondaje en el Area del Salar del Huasco>

Well No.	Bore hole Depth (m)	Casing Pipe		Screen Pipe		Geological Conditions of Aquifer			Geophysical Data	
		Size (inches)	Total Length (m)	Position (m)	Total Length (m)	Lithology	Formation	Period	Well Logging Resistivity (ohm-m)	TEM Resistivity (ohm-m)
J-G	157	8-5/8"	96.03	30.81 -54.84	66.12	gravel clayey gravel	Collacagua (Qcm)	Quaternary	30 - 90	55 -90
				60.82 -102.91		clayey gravel sandy gravel			25 -90	55 -90
J-10	207	5-1/2"	116.70	39.02 -51.03	89.95	gravel	Collacagua (Qcu)	Quaternary	70 -300	-
				86.53 -146.51		clayey gravel	Collacagua (Qcm)		40 - 500	-
				161.81 -167.81		clayey gravel	Collacagua (Qcl)		25 -80	-
				172.83 -184.79		sandy mudstone clayey sandstone			40 - 80	-

Table B-IV, 2.2 Result of Pumping Test (Salar del Huasco)

<Resultado de Prueba de Bombeo (Salar del Huasco) >

Well No.	Pumping Data (by Constant Test)				
	Static Water Level (m)	Pumping Rate (l/s)	Dynamic Water Level (m)	Drawdown (m)	Specific Yield (l/s/m)
J-G	5.86	25.00	39.76	33.90	0.74
J-10	26.56	5.00	30.64	4.08	1.23

Table B-IV, 2.3 Aquifer Constants (Salar del Hasco)
<Coeficientos de Acúiferos (Salar del Hasco)>

Well No.	Aqufer Constant		Test Method				Average
			Theis		Jacob		
			Constant	Recovery	Constant	Recovery	
J-G	ransmissibili	(m3/s/m)	9.60E-04	2.65E-03	1.19E-03	2.44E-03	9.08E-04
	Storage Coefficient		1.50E-09		2.29E-11		7.64E-10
	Permeability	(m3/s/m)	1.97E-13	5.43E-13	2.44E-13	5.00E-13	1.86E-13
J-10	Transmissibi	(m3/s/m)	2.10E-03	2.41E-03	2.03E-03	2.32E-03	1.09E-03
	Storage Coefficient		1.17E-10		1.41E-10		1.29E-10
	Permeability	(m3/s/m)	1.45E-07	3.53E-08	4.16E-13	4.10E-08	1.02E-08
Average	Transmissibi	(m3/s/m)	1.53E-03	2.53E-03	1.61E-03	2.38E-03	9.98E-04
	Storage Coefficient		8.11E-10		8.21E-11		4.46E-10
	Permeability	(m3/s/m)	7.23E-08	1.77E-08	3.30E-13	2.05E-08	5.12E-09

Table B-IV, 2.4 Estimation of Groundwater Storage

<Estimación de Reservas de Agua Subterránea >

DEPTH (m BSWL)	ZONE 1 (SALAR-SECT.A)		ZONE2 (SECT. A-B)		TOTAL (SALAR-SECT. B)	
	(m3)		(m3)			
		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, 2.5 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		250	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.

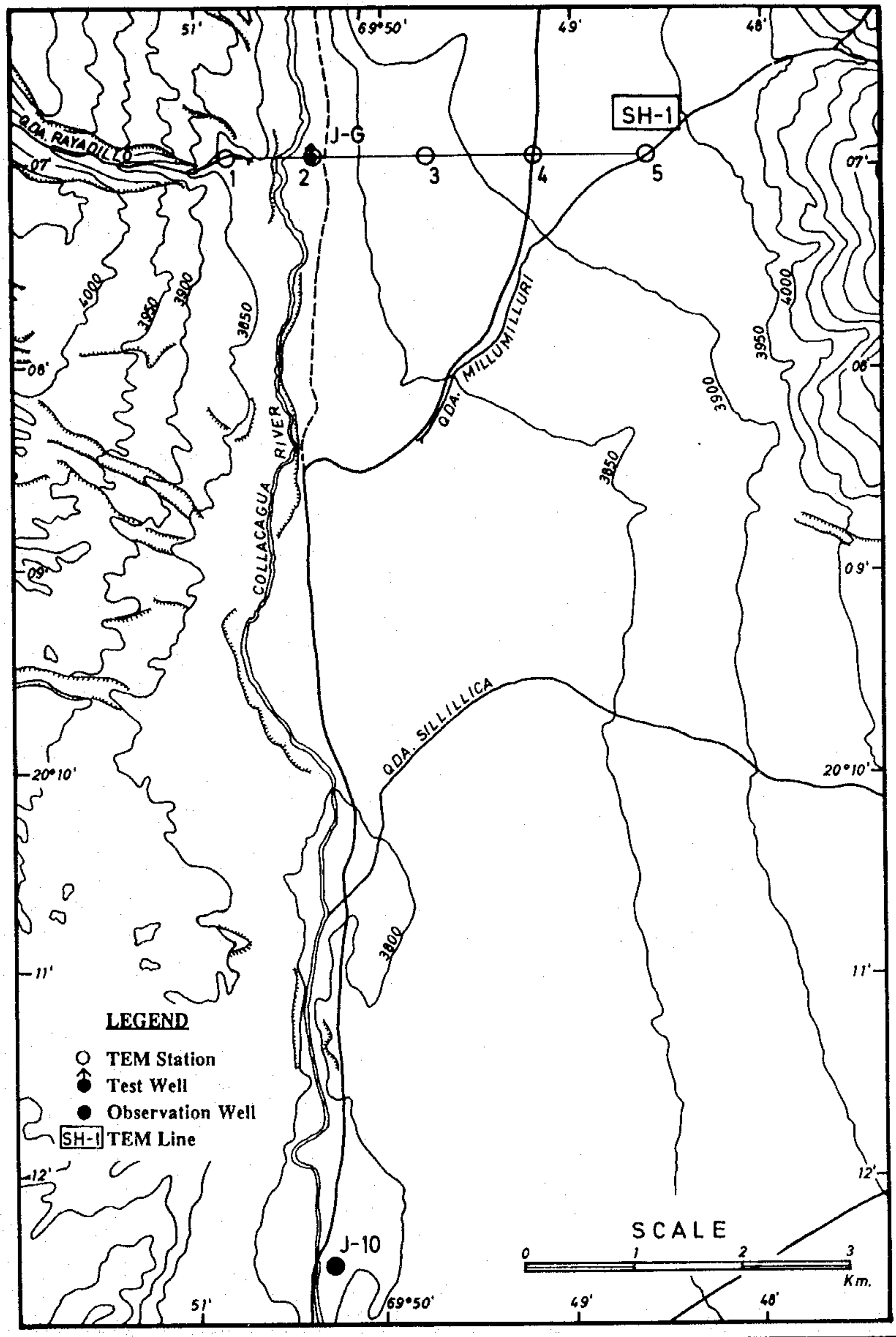


Fig. B-IV, 2.1 Location of TEM Station and Test/Observation Well in Salar del Huasco Area

<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)

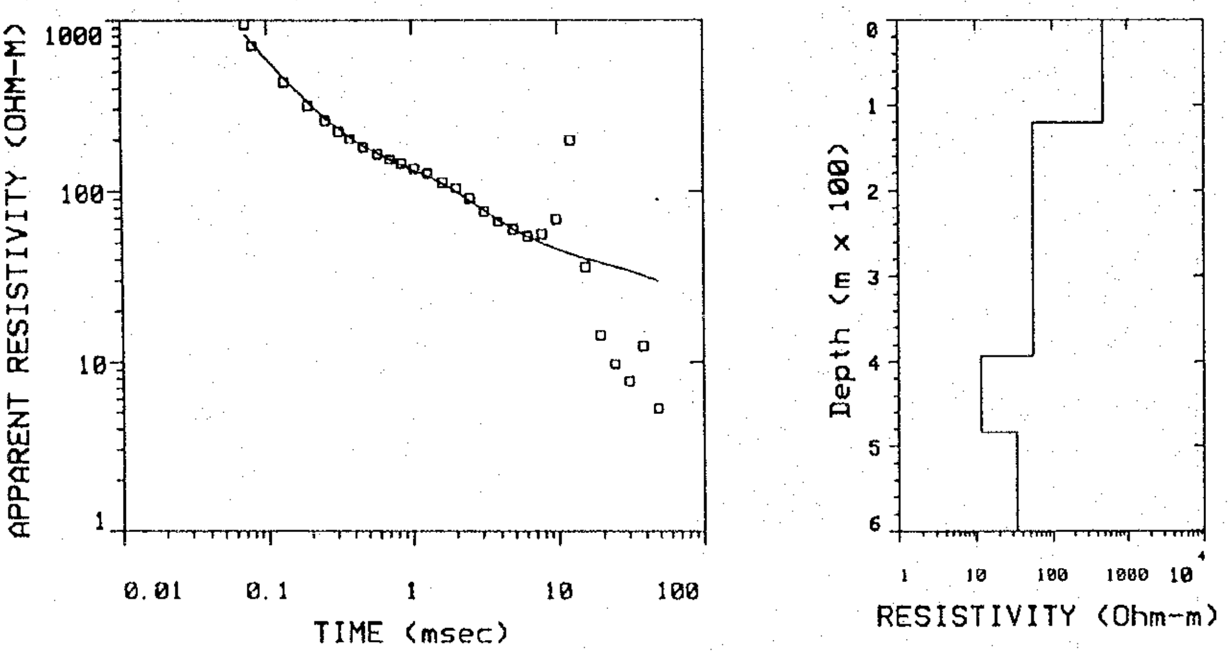
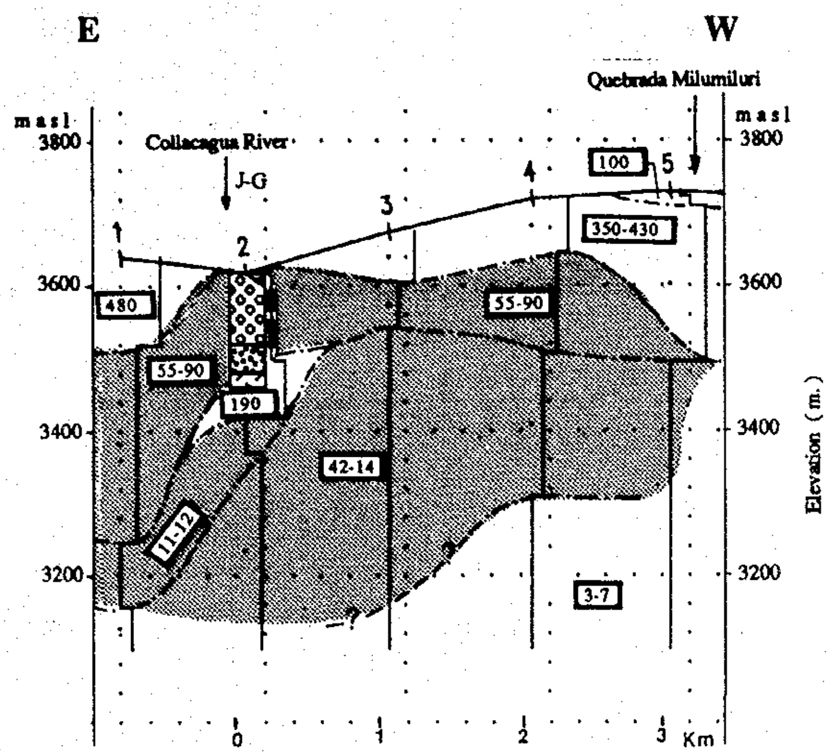
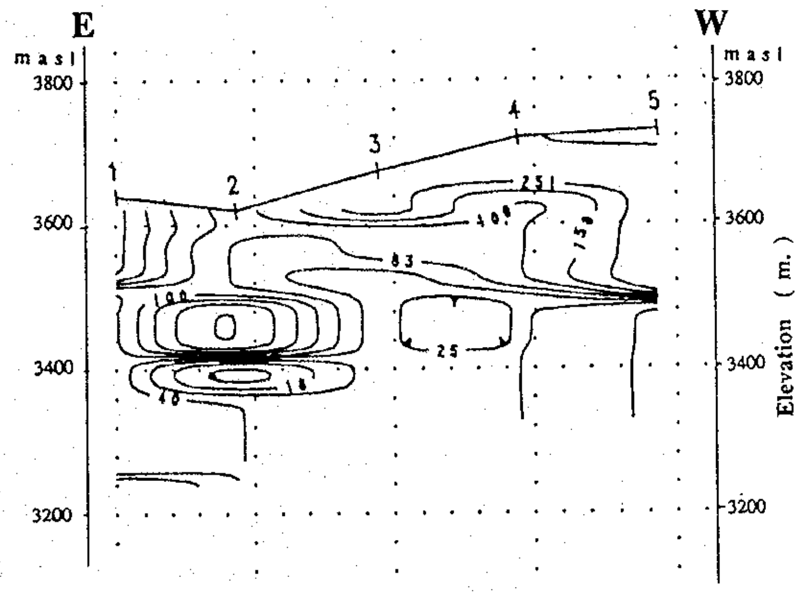


Fig. B-IV,2.2 Measured Aparent Resistivity Curves and Inverted Geoelectrical Section in Salar del Huasco Area

< *Curvas de Resistividad Aparente Medidas y Secciones Geoeléctricas Invertidas en el Area del Salar del Huasco* >



ANALYZED LAYERED MODEL



RESISTIVITY INVERSION

LEGEND

Boring Log
Screen

1, 2, 3	**: TEM Station Nº**
55 - 90	**: Resistivity Range Analyzed**
—·—·—	**: Boundary of Resistivity Layers**
m a s l	**: Meter above sea level**
(shaded)	**: Expected aquifer**
J-G	**: Well Constructed by JICA**
≷	**: Lateral Discontinuity**

Fig. B-IV,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 >

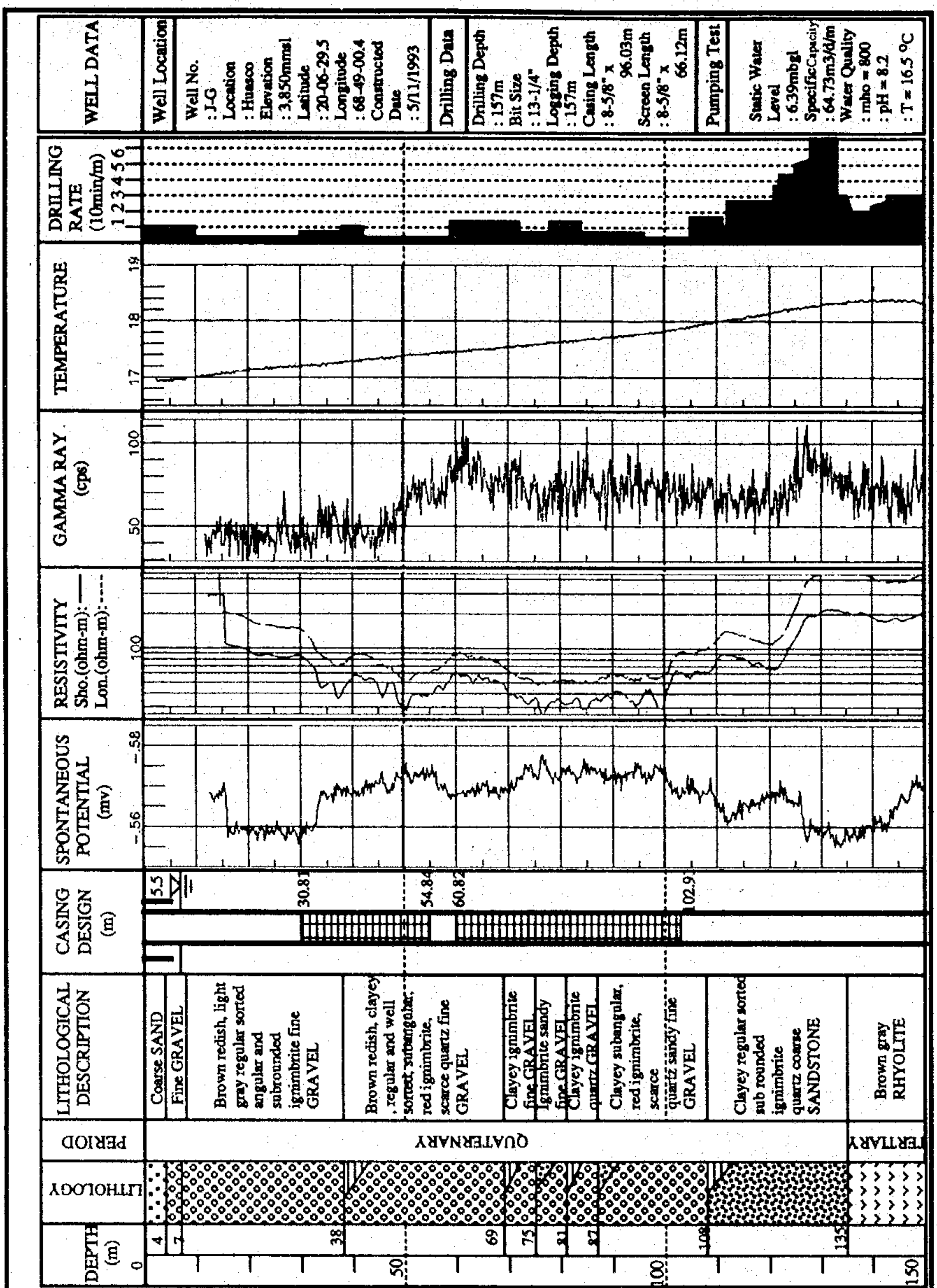


Fig. B-IV, 2.4 Well Data for J-G (Sheet No. 1)

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

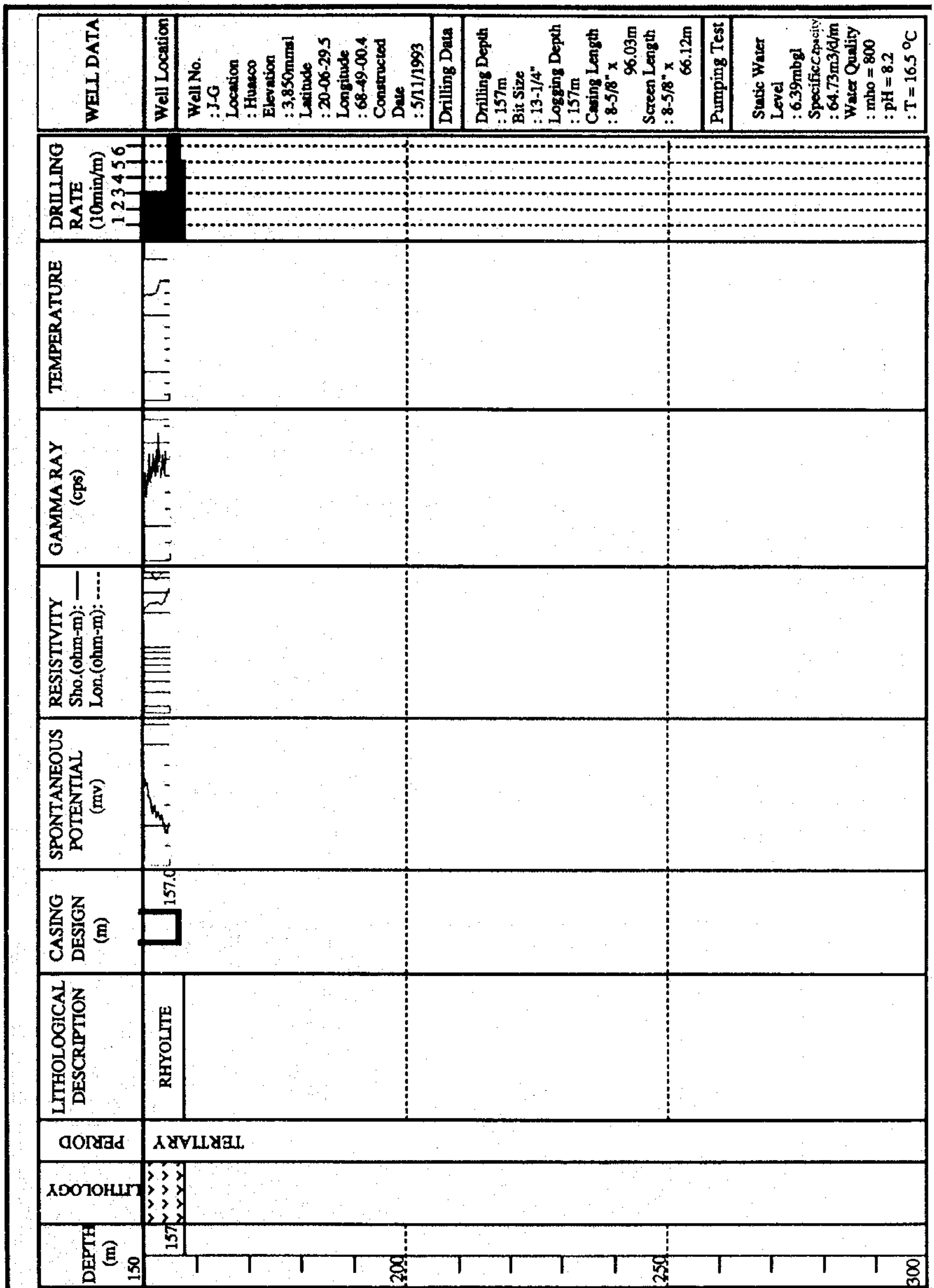


Fig. B-IV, 2.4 Well Data for J-G (Sheet No.2)

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

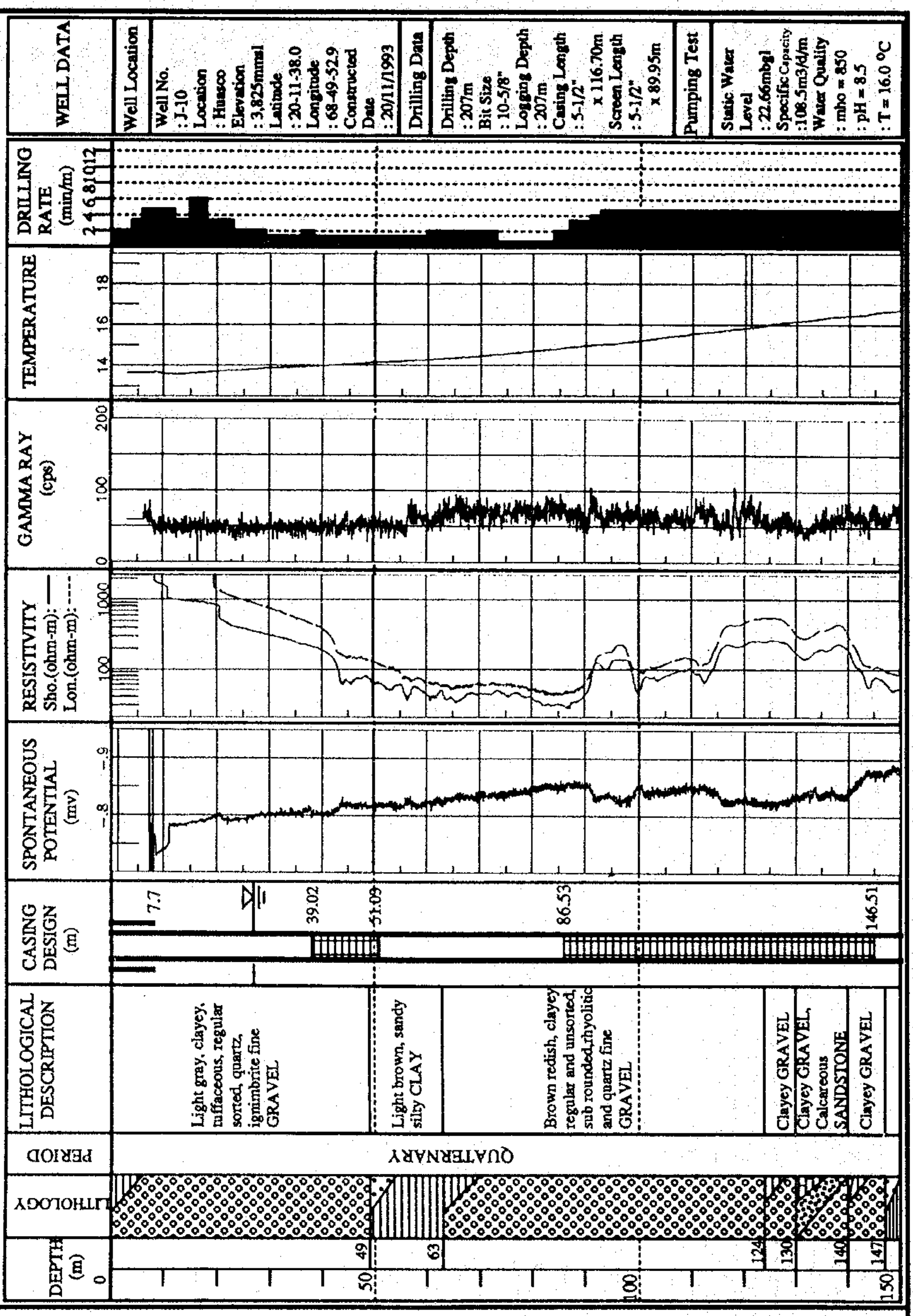


Fig. B-IV, 2.5 Well Data for J-10 (Sheet No. 1)

< Información del Pozo J-10 (Hoja Nº 1) >

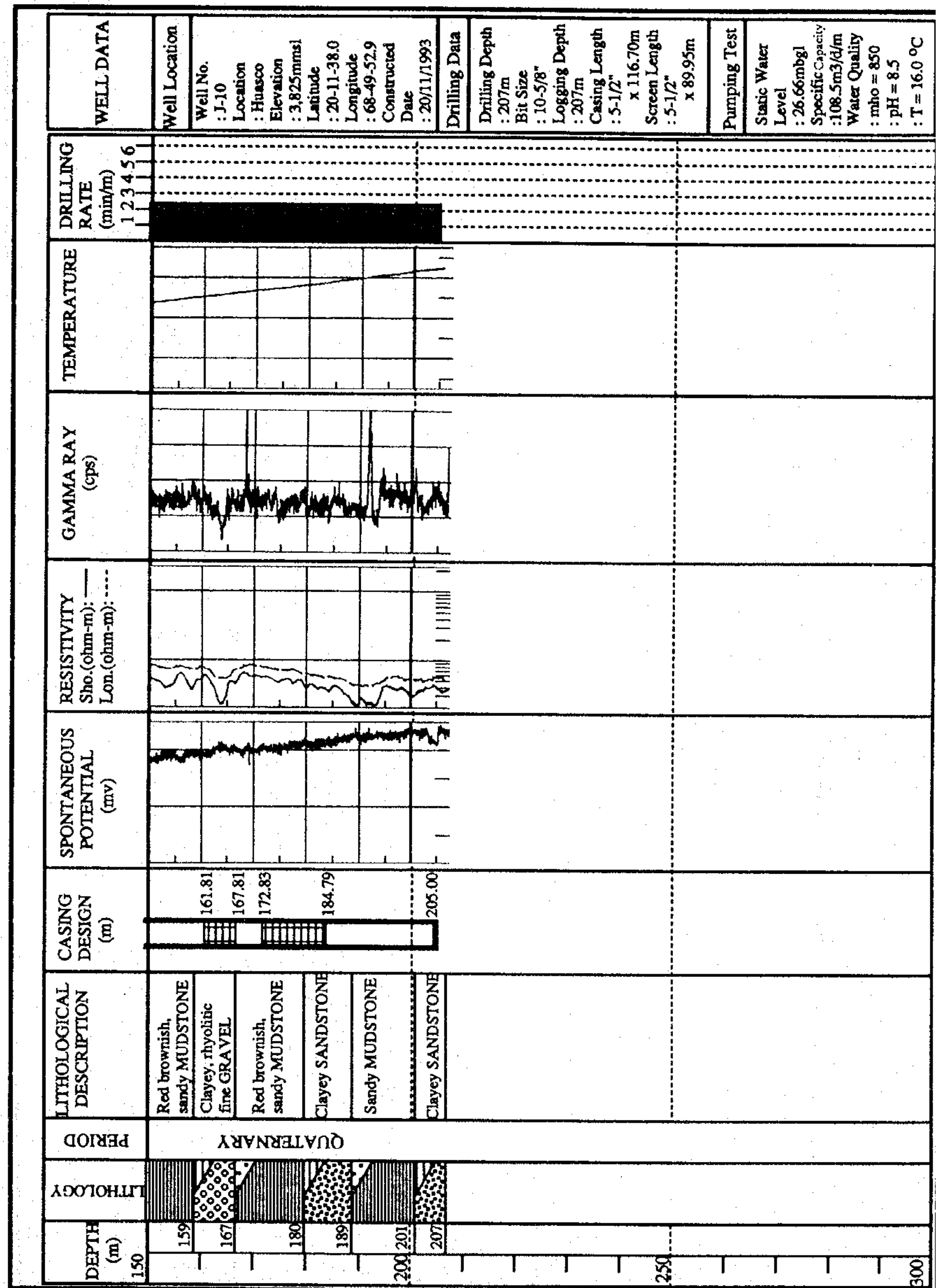


Fig. B-IV, 2.5. Well Data for J-10 (Sheet No. 2)

< Información del Pozo J-10 (Hoja Nº 2) >

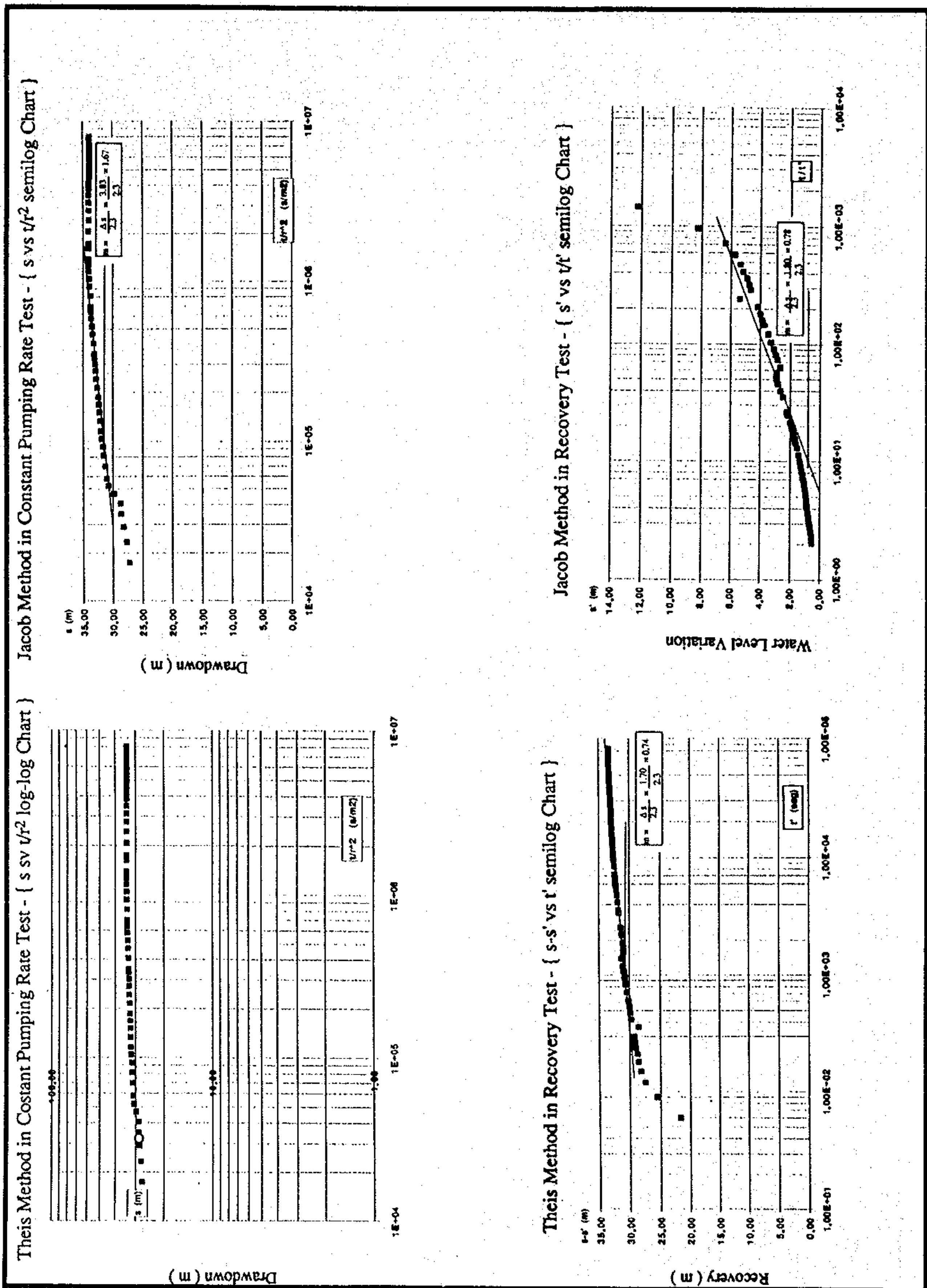


Fig. B-IV, 2.6 Graphs for Theis and Jacob Method Analysis (Well No.J-G)

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

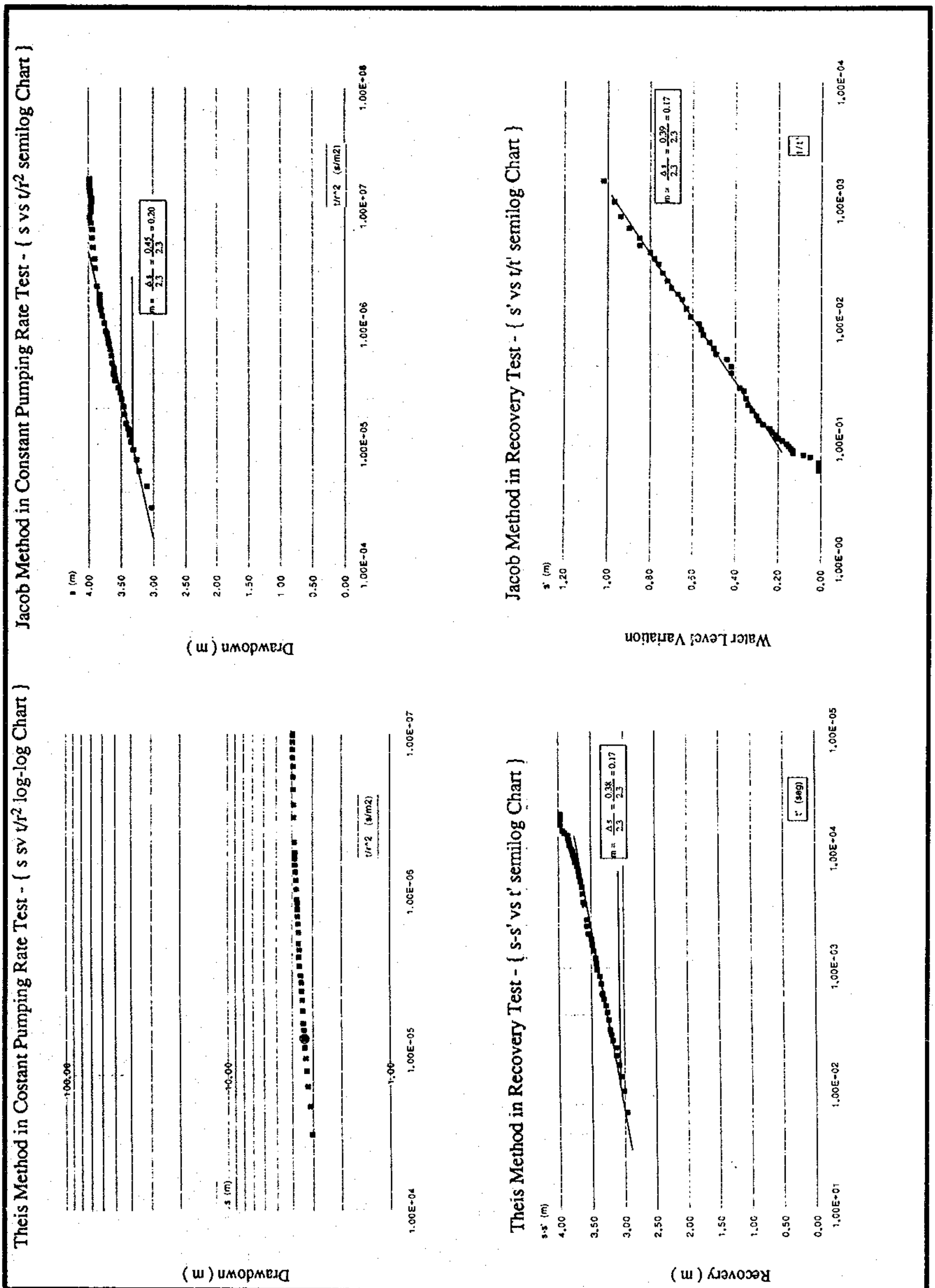
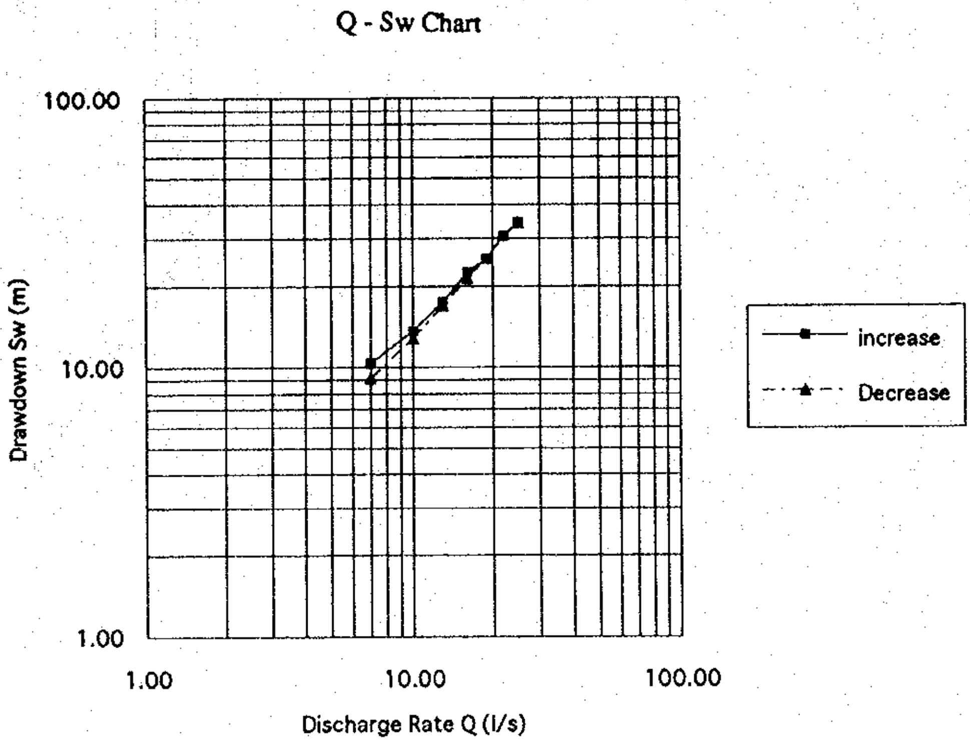


Fig. B-IV, 2.7 Graphs for Theis and Jacob Method Analysis (Well No.J-10)

< Gráficos para los Métodos de Análisis Theis y Jacob (Pozo Nº J-10) >



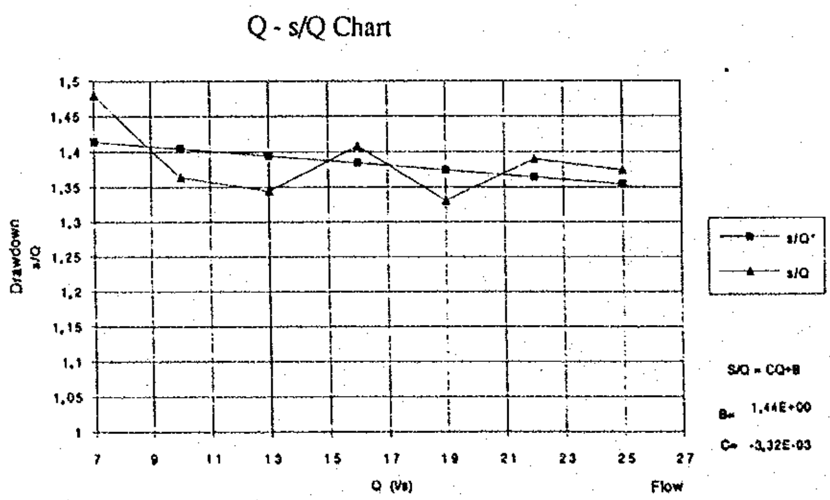
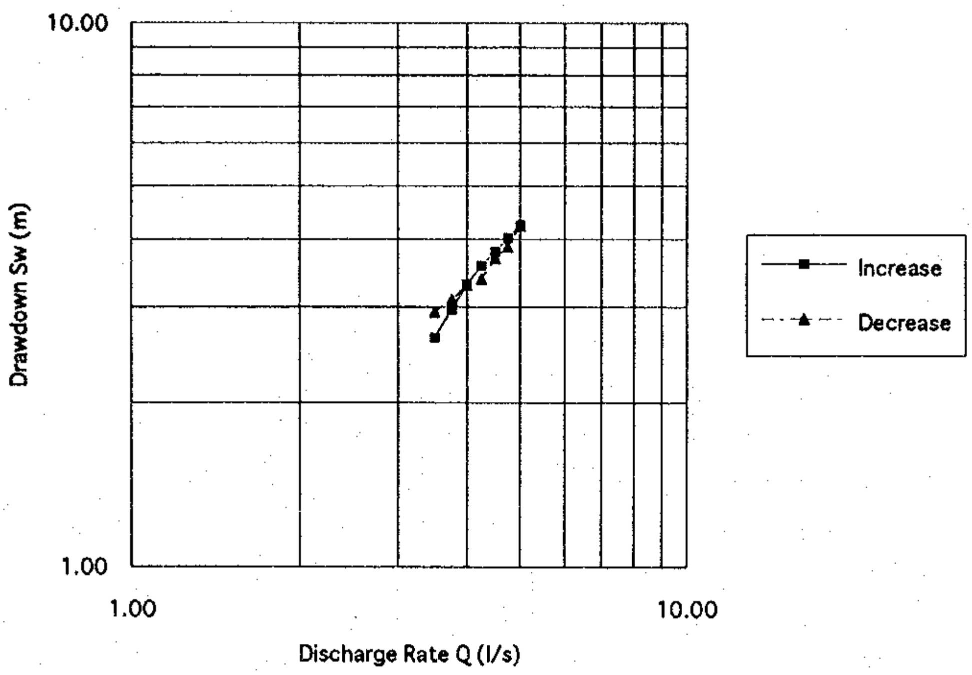


Fig. B-IV, 2.8 Graphs for Step Drawdown Test (Well No.J-G)

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

Q - Sw Chart].



Q - s/Q Chart

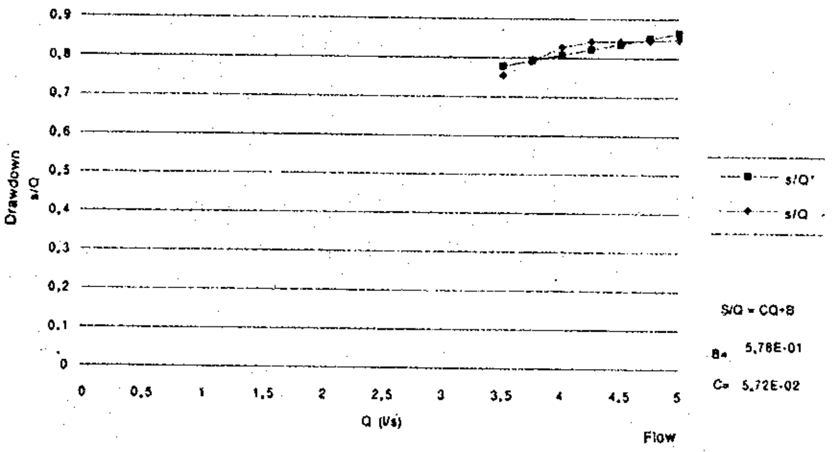


Fig. B-IV, 2.9 Graphs for Step Drawdown Test (Well No.J-10)

< Gráficos Prueba de Gasto Variable (Pozo Nº J-10) >

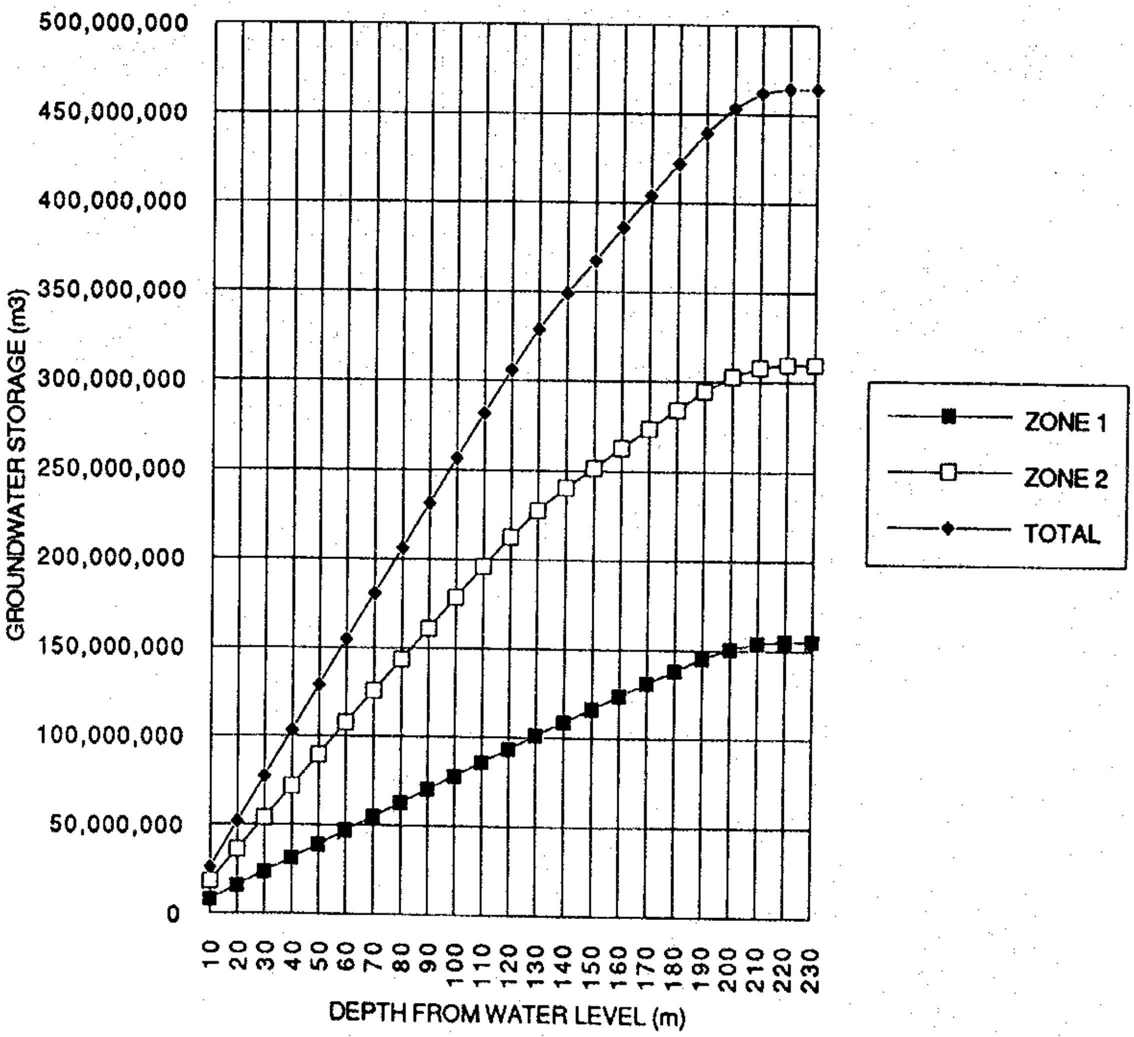


Fig. B-IV 2.10 Groundwater Storage

<Reservas de Agua Subterránea>

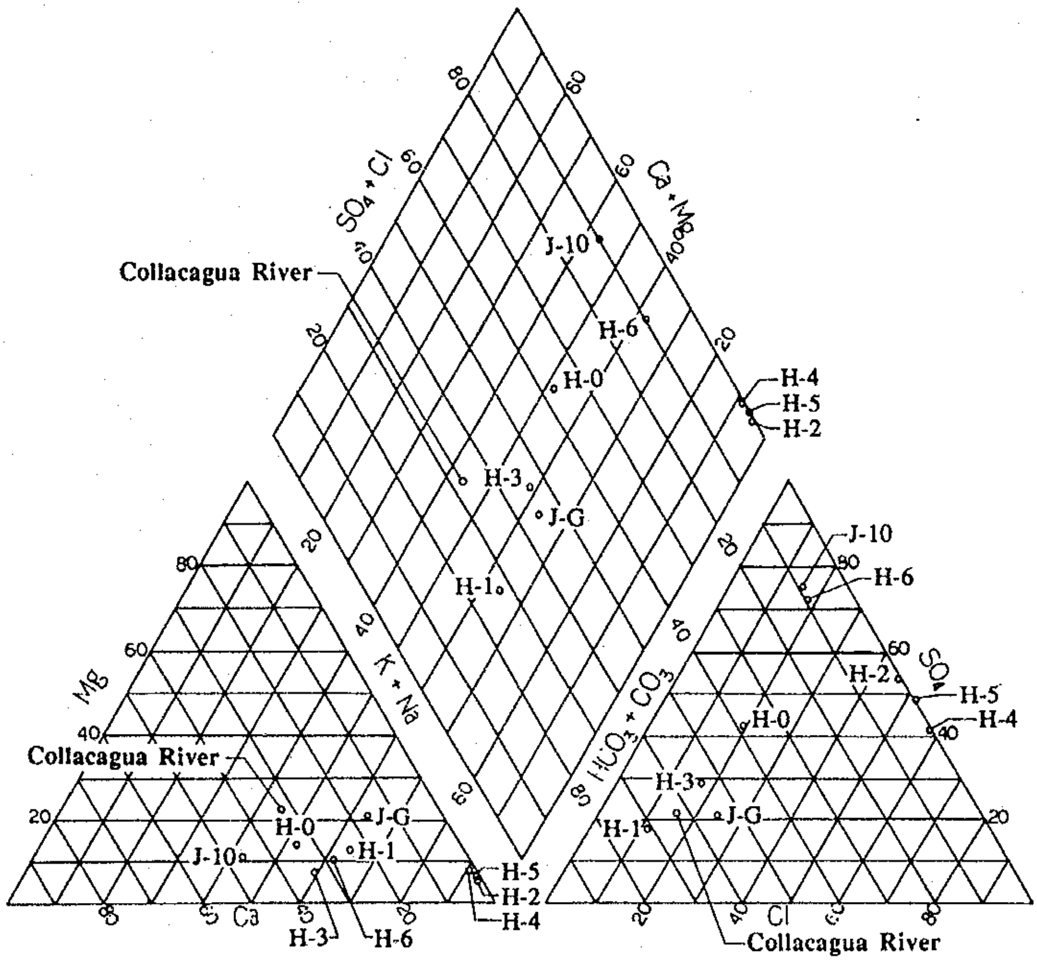


Fig. B-IV, 2.11 Trilinear Diagram of Maayor Ions

< Diagrama Trilinear de Iones Principales >