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DIRECTORATE GENERAL OF WATER
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THE REPUBLIC OF CHILE

THE STUDY
ON
THE DEVELOPMENT OF WATER RESOURCES
IN
NORTHERN CHILE

SUPPORTING REPORT E : ENVIRONMENT
SUPPORTING REPORT F : PROJECT ECONOMY AND FINANCE

MARCH 1995

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO

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Chapter I. GENERAL

This project aims to supply municipal water to Arica and Iquique cities by exploiting groundwater in the surrounding areas of the cities.

The potential groundwater acquifers are located in the Lower Lluta Valley, Pampa del Tamarugal and Salar del Huasco. However, groundwater development of these acquifers may draw down the existing water level, causing adverse effects on the natural and social environments in the neighbouring areas.

The following environmental factors were identified, by the initial field reconnaissance, as the major ones which might be affected by the groundwater development.

a) Existing river water uses for irrigation in Lower Lluta Valley
b) Plants, specially Tamarugo forest in Pampa del Tamarugal
c) Existing groundwater uses in Pampa del Tamarugal
d) Ecological and social environments in Salar del Huasco.

The other environmental factors are considered minor.

Existing river water uses for irrigation in Lower Lluta Valley and existing groundwater uses in Pampa del Tamarugal are studied in Supporting Report B and C. Hence, the remaining two (2) major environmental factors are discussed in Chapter III and Chapter IV of this report.

Comprehensive environmental impact assessments on the selected two (2) project; Lower Lluta Groundwater Development for Arica and Groundwater Development in Pampa del Tamarugal for Iquique, are made in Chapter IV and Chapter V respectively.

Chapter II TAMARUGO FOREST IN PAMPA DEL TAMARUGAL

2.1 Tamarugo Forest Area

Natural Tamarugo foPampa del Tamarugal in old days. However, they almost disappeared during the last century since they were cut to use as the fuel of saltpeter mining. (A photograph of Tamarugo is shown in Photo. E,2.1).

Thereafter, planting of Tamarugo trees started with fodder and fuel production purposes in the 1930's. According to the inventory study of the National Forest Corporation of Chile (CONAF), the planted Tamarugo forest consisting of Tamarugo, Algarrobo and mix plantation reached 19,715 ha in 1973. Further, 989 ha were planted during the recent 12 years of 1981 - 1993. Then, the existing total planted Tamarugo forest is 20,704 ha.

On the other hand, a natural Tamarugo forest has grown in a wide area since before 1930. It was estimated to be 3,241 ha by the Institute Forestal in 1981[<1].

The existing Tamarugo area by species and planted year are summarized below.

Species	Planted Year	Area (ha)
Planted Tamarugo		1,005
Tamarugo	Before 1960	16,340
	1966 - 1973	989
	1981 - 1993	
Algarrobo	Before 1960	1,950
Mixed Plantation	Before 1960	420
Subtotal		20,704
Natural Tamarugo	Before 1930	3,241
Total		23,945

The above planted Tamarugo forest all exist in the National Reserved Area of Zapiga and Salar de Pintados / Salar de Bellavista. On the other hand, the natural forests are mainly located in the Pampa Yuri National Reserved Area and its surrounding lands.

For location of the planted tamarugo forest, see Fig. E,2.1 - Fig. E,2.3.

2.2 National Reserved Area

The Tamarugo forest of Pampa del Tamarugal was designated as National Reserved Area in 1984. The total existing reserved area reaches 100,650 ha, distributing over three (3) districts of Zapiga, Salar de Pintados / Salar de Bellavista and Pampa Yuri as follows:

Zapiga	:	17,750 ha
Salar de Pintados / Bellavista	:	77,675 ha
Pampa Yuri	:	5,225 ha
Total	:	100,650 ha

For location of the National Reserved Area, see Fig. E,2.2 and Fig. E,2.3.

The National Reserved Area is managed by CONAF. However, the reserved area is all rented to the local people for cattle breeding.

2.3 Beneficial Effects and Uses

a) Cattle Breeding

A matured tamarugo tree of 14 - 22 year age yields 20 - 70 kg/year on an average. On the other hand, approximately 100 trees are usually planted in one (1) hectare. Then, average annual production of the leaves and fruits of Tamarugo is estimated to be 2,000 - 7,000 kg/ha.

As of 1993, local people of 57 families make their living by rasing 18,000 sheep in the Tamarugo forest.

b) Wood Production

Tamarugo trees are used as a material of chacoal and handicrafts. They are also used for honey collection.

c) Recreational Use

The Tamarugo forest offers such recreational opportunities as camping and hiking to people. Approximately 7,000 people visited the Tamarugo forest in 1993.

d) Opportunities for Research

Tamarugo is one of the limited plant species which might be able to improve the deserts of Chile. The Tamarugo forest in Pampa del Tamarugal offers a valuable experimental field.

2.4 Characteristics and Features

2.4.1 General Features

Tamarugo trees of Pampa del Tamarugal grow on the flat plains of desert with an elevation of approximately +1,000m. The soils of the Tamarugo forest consist of sandy clay, mostly covered by a thick salt layer of 10 - 60 cm.

Usually, Tamarugo forest forms a group of pure species. However, in some few areas, they are mixed with other similar species such as Algarrobo adapted to salty soil and arid climate.

It comes into bloom in November, fruits fall down in February to March and leaves wither in winter.

It can usually grow up 8 to 18 m in height. It has many sharp and long thorns. Its leave is of bipinnated type and 3 cm long. The leave is composed of 15 foliages with 5 mm length each.

2.4.2 Water Absorption Mechanism and Root Length

The mechanism of the water absorption of trees has been studied by many researchers since 1969<2. The results of such previous studies are summarized as below.

a) Tamarugo tree absorbs water through both roots and leaves. In the day time, roots absorb groundwater and leaves evaporate water. At night, leaves absorb water from atmosphere along with groundwater absorption by roots and the absorbed water is stored in roots.

This means that Tamarugo tree consumes less water than the other normal plants.

b) The tree forms a mat of roots in a depth of less than 1.0 m from where tap roots grow downward to extract groundwater.

c) Tamarugo of Pampa del Tamarugal usually grows in the areas where groundwater depth is 5 - 12 m.

d) It is reported that a root of Mesquite (similar species of Tamarugo) has grown downward to 50 m depth in Pampa del Tamarugal. However, it has not been confirmed yet by field survey.

According to the information from CONAF members, tap roots of Tamarugo were found two (2) times in the past during well drilling. In 1987, a tap root of 10 - 15 cm in diameter was found out at a depth of 12 m during well drilling by machine. Judging from the diameter of the tap root, its maximum depth is considered to be 25 - 30 m. Furthermore, in 1993, a tap root of 30 - 40 year age was found out at a depth of 14 m during well excavation by manpower. Considering the diameter of the root, the root is assumed to reach a depth of 25 - 30 m.

2.5 Transpiratory Water Consumption

2.5.1 Evapotranspiration of Tamarugo Forest

Evapotranspiration of Tamarugo tree increases as the tree grows. Evapotranspiration of the Tamarugo trees in Pampa del Tamarugal corresponding to tree age was estimated by Grill, Vidaly and Grain in 1986, as shown in Fig. E,2.4. In this estimation, planting density of the Tamarugo trees was assumed as 50 trees/ha.

Evapotranspiration of the Tamarugo tree reaches the maximum value of about 280 mm/year (=0.089 l/s/ha) when the tree become 50 years old. Even this maximum value is very little compared with the average evapotranspiration of agricultural plants. As an example, the evapotranspiration of the agricultural plants in Azapa Valley is shown below.

Fruit	:	1,236.8 mm/year
Vegetable	:	1,154.7 mm/year
Pasture	:	1,593.1 mm/year

For details of the evapotranspiration of the agricultural plants in Azapa Valley, see Supporting Report C.

2.5.2 Present Total Transpiratory Water Consumption

The Institution of Forest estimated the age distribution of the Tamarugo trees including both planted and natural trees in Salar de Pintados and Salar de Bellavista in 1981. The estimated age distribution as of 1981 was as shown in Table E,2.1.

The age distribution of the Tamarugo trees in the whole Pampa del Tamarugal as of 1993 is estimated by modifying Table E,2.1 as shown in Table E,2.2.

Then, the present total transpiratory water consumption of the Tamarugo trees in the whole Pampa del Tamarugal in 1993 is estimated to be 1,019 l/s by using Table E,2.2 and Fig. E,2.4.

2.5.3 Future Total Transpiratory Water Consumption

The future transpiratory water consumption of the Tamarugo trees in the whole Pampa del Tamarugal is estimated based on the following assumptions:

a) 350 ha of trees will be additionally planted in 1994.

b) During the period of 1995 - 2015, an additional 50 ha will be planted every year. After 2015, the Tamarugo area will not be extended.

c) Life of Tamarugo tree is 75 years

d) Tamarugo tree will be replanted soon after its life expires.

The Tamarugo tree areas in the future are estimated as follows.

Year	Tamarugo Area (ha)
1993	23,945
2005	24,846
2015	25,346
After 2015	25,346

The average annual transpiratory water consumptions in the future are estimated as follows.

Existing (1993)	:	1,019 l/s	≒	1,000 l/s
Future (2015)	:	1,523 l/s	≒	1,500 l/s
Future 50 years (1993-2042)	:	1,566 l/s	≒	1,600 l/s
Future 100 years (1993-2092)	:	1,413 l/s	≒	1,400 l/s

For details, see Table E,2.3.

Reference

<1 : Modelo de Simulación Hidrogeológico de la Pampa del Tamarugal Informe, 1988, DGA, Ingeniería Civil Universidad del Chile.

<2 : Absorción Foliar de Humedad Atmosférica en Tamarugo, *Prosopiis* tamarugo Phil, 1969, Universidad de Chile.

Table E,2.1 Plantations' Ages
<Edades de Plantaciónes>

Plantation Year	Age (years)	Area (ha)
1974 - 1981	7	233.6
1973	8	544.3
1972	9	3242.2
1971	10	2631.1
1970	11	1265.0
1969	12	3011.2
1968	13	1595.4
1967	14	1327.2
1966	15	792.9
1960	21	11.8
1947	34	107.8
1932 - 1937	44 - 49	3380.5
1931 or before	50 or more	3240.8

Source: Instituto Forestal (1981)

Table E,2.2 Distribution of Tamarugo in Pampa del Tamarugal
<Distribución de Tamarugo en Pampa del Tamarugal>

Year	Age (years)	Area (ha)
1993	1	5
1987	7	25
1985	9	300
1984	10	300
1983	11	125
1981	13	234
1973	21	617
1972	22	3,677
1971	23	2,984
1970	24	1,435
1969	25	3,415
1968	26	1,809
1967	27	1,505
1966	28	899
1960	34	12
1947	47	108
1934	60	3,255
1931 or before	63 or more	3,241

Table E,2.3 Transpiratory Water Consumption in the Future

<Consumo de Agua por Transpiración en el Futuro>

Year	Tamarugo Area (ha)	Water Consumption (l/s)
1993	23,945	1,019
2005	24,846	1,701
2015	25,346	1,523
2025	25,346	1,668
2035	25,346	1,830
2045	25,346	1,120
2055	25,346	1,026
2065	25,346	1,120
2075	25,346	1,487
2085	25,346	1,451
2095	25,346	1,450
50 years Average (1993-2042)		1,566 ≒ 1,600
100 years Average (1993-2092)		1,413 ≒ 1,400

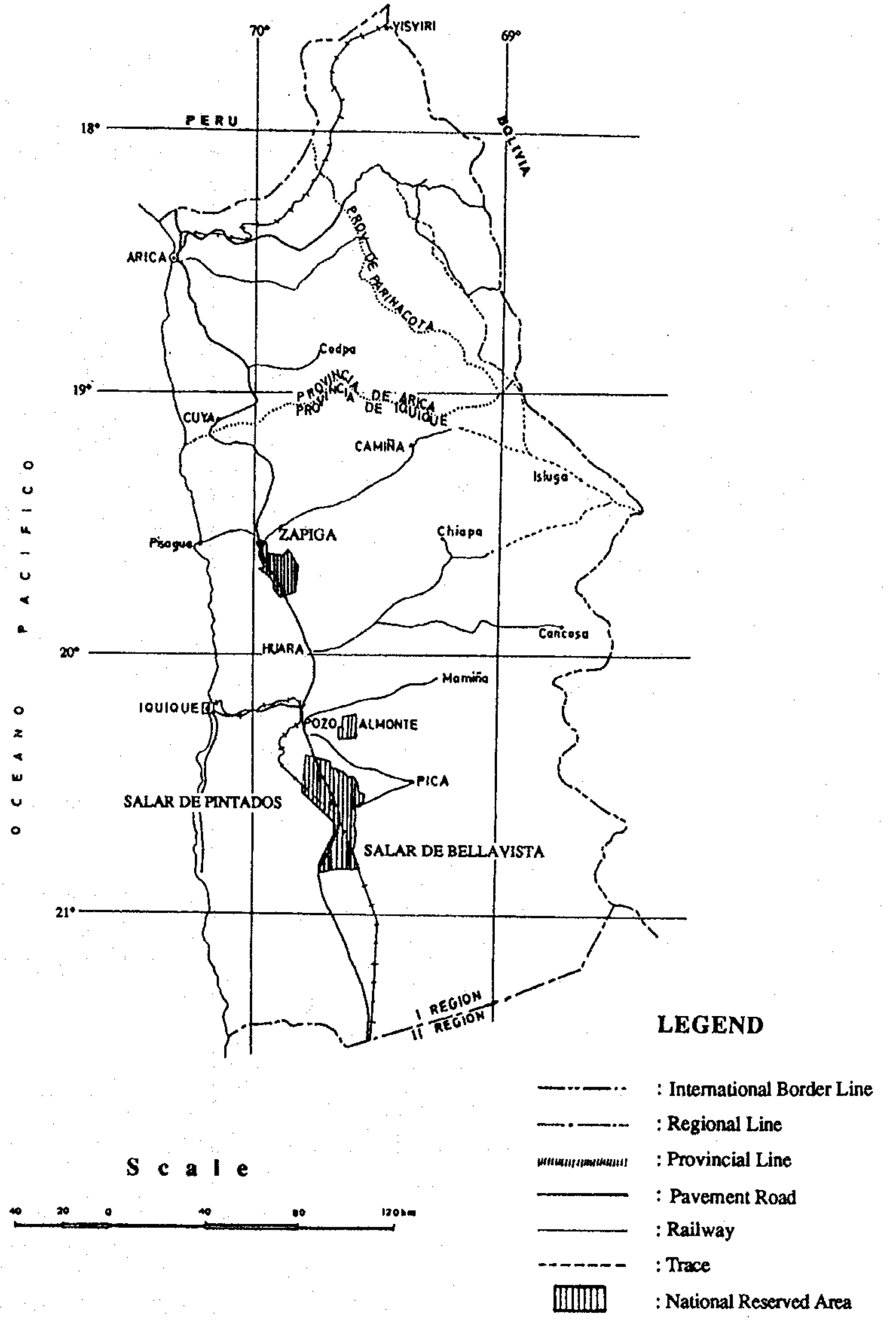

Fig.E.2.1 National Reserved Area of Pampa del Tamarugal

<Area de la Reserva Nacional Pampa del Tamarugal>

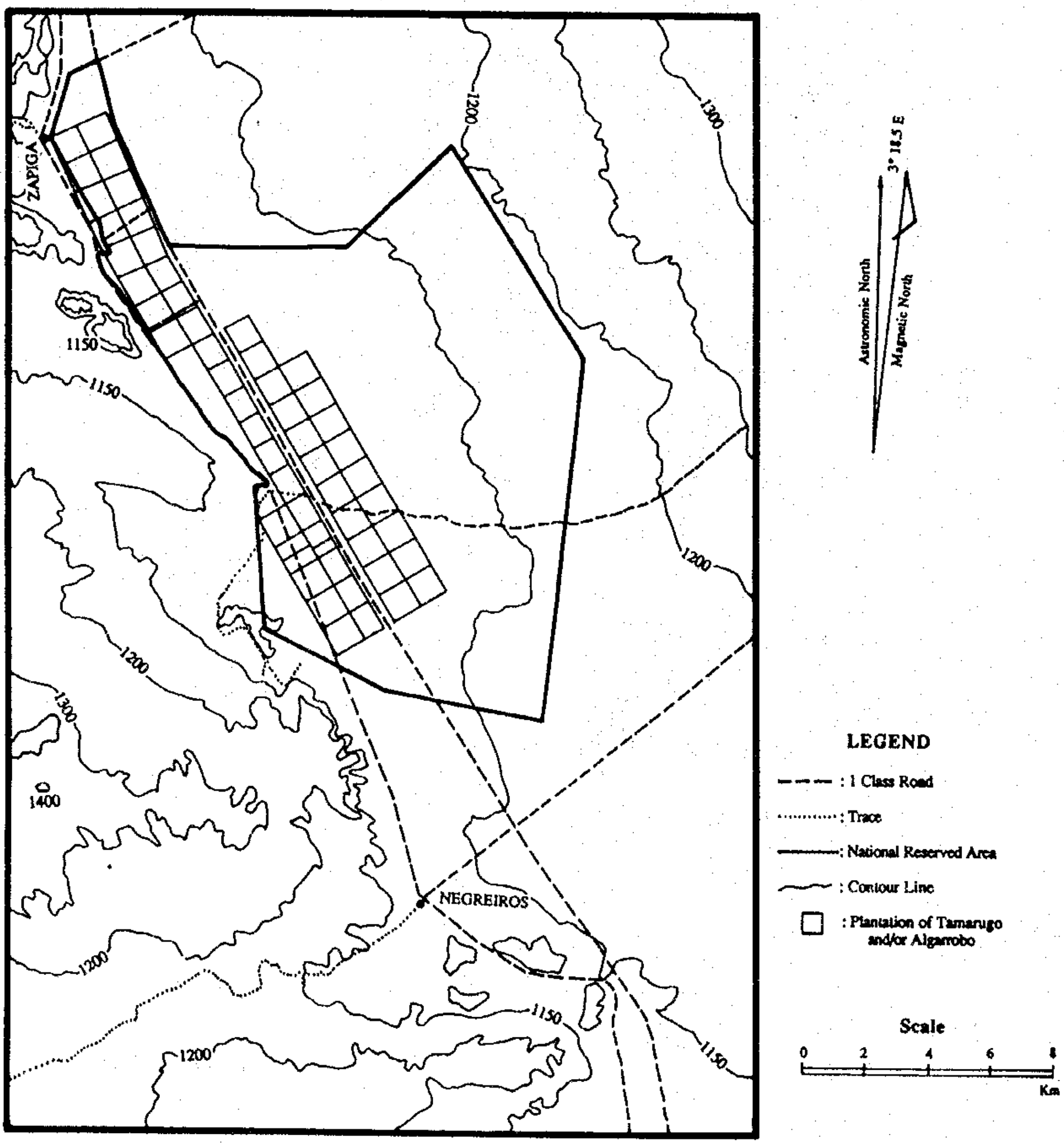

Fig. E,2.2 National Reserved Area of Zapiga

< Area de la Reserva Nacional, Zapiga >

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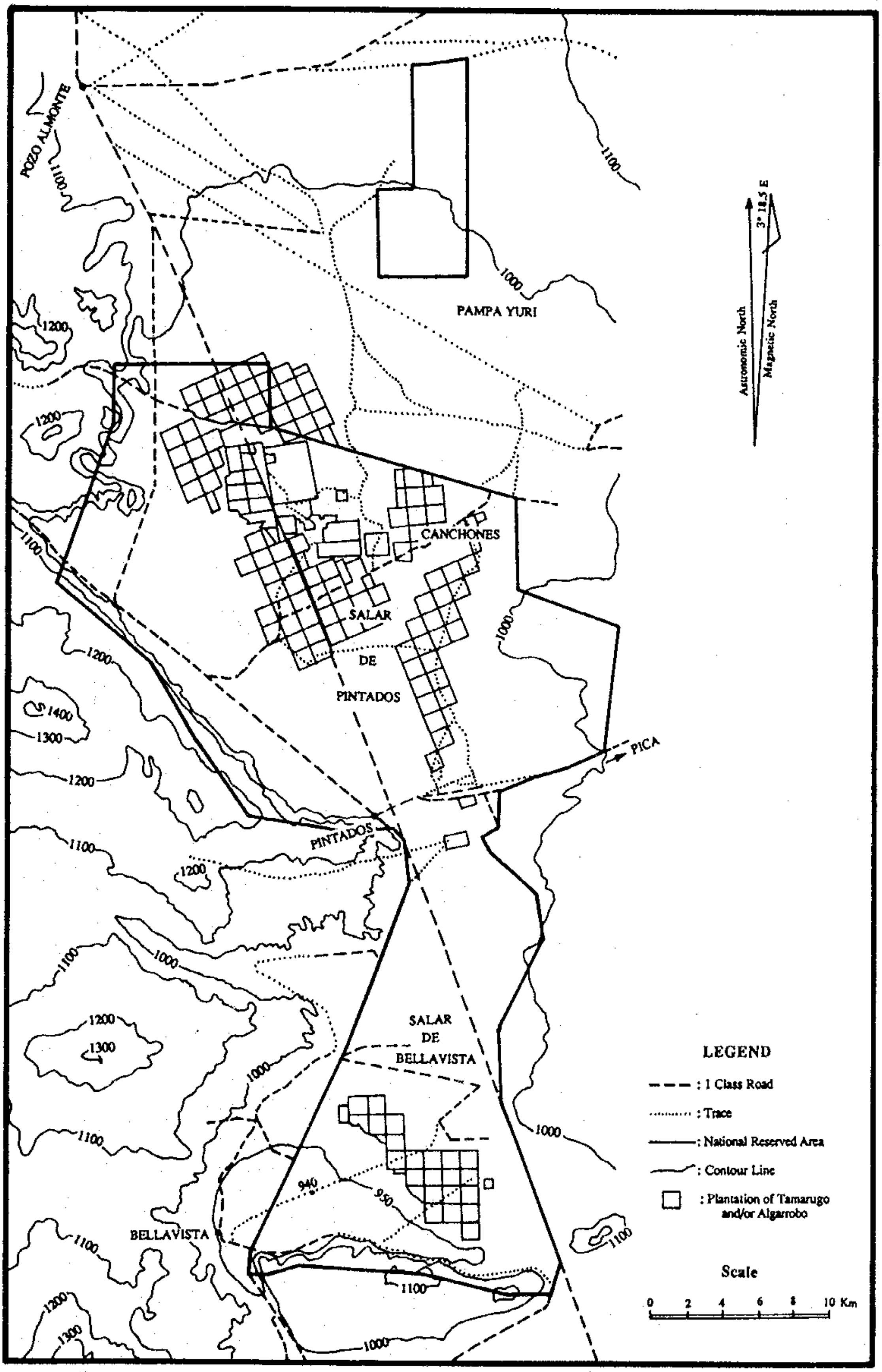


Fig.E.2.3 National Reserved Area of Salar de Pintados and Salar de Bellavista

< Area de la Reserva Nacional Salar de Pintados y Salar de Bellavista >

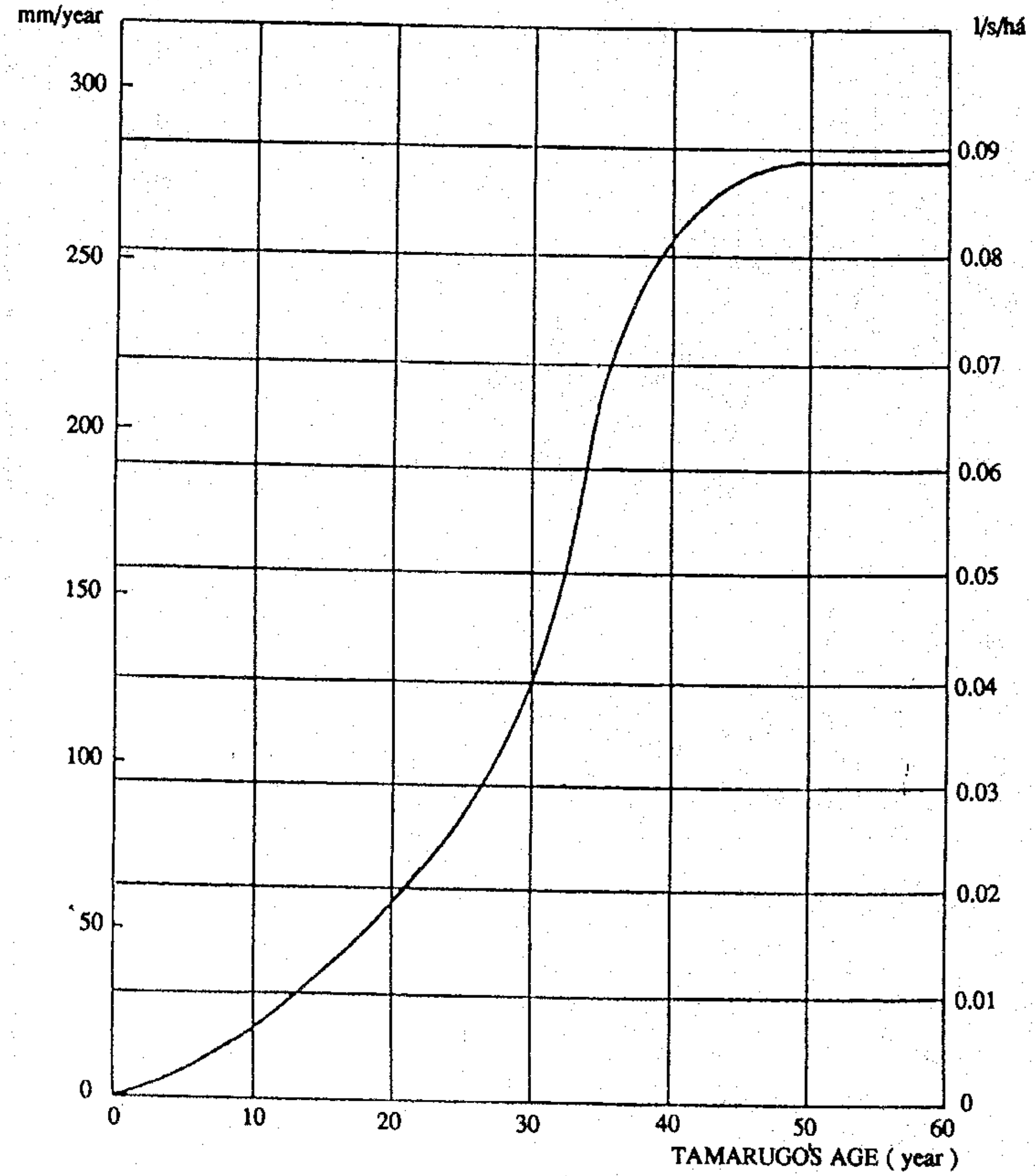


Fig. E,2.4 Transpiration by Tamarugo Plantations in Pampa del Tamarugal (Grill, Vidaly and Garin (1986))

< *Transpiración de las Plantaciones de Tamarugo en Pampa del Tamarugal* >

Photo E, 2.1 Tamarugo (Taken in Febmaty 1994)

< Tamarugo (Tomada en Febrero de 1994) >

Chapter III ENVIRONMENTAL ASSESSMENT OF SALAR DEL HUASCO

3.1 Topographical Condition

3.1.1 Location

Salar del Huasco basin located in the Andes Highland in Iquique Province, has a total basin area of 1,712 km^2. The basin is closed and no surface water runs off from the basin. The precipitation in this area is about 100 - 200 mm/year. Salar del Huasco is situated at an altitude of about 3,800 m.

3.1.2 Water Surface Area

Water surface area of Salar del Huasco, shown in Fig. E,3.1, was about 2 km^2 (approximate maximum dimensions: width = 5km and length = 8.0km) on February 1994.

3.1.3 Water Depth

As shown in Fig. E,3.2, the water depth was 16 cm in the maximum; 4 cm in average on February 1994.

3.2 Water Quality

3.2.1 Introduction

The following major water quality parameters of the lake were sampled and analyzed in order to know the relationship between the water quality and species of plankton, which are food for flamingos.

Temperature, pH, DO, Conductivity, NaCl, Turbidity, Na, K, Li, Ca, Mg, CO_3, SO_4, HCO_3, Cl, P, B, As, TDS, Dissolved Solids, Suspended Solids, Total Hardness.

The field investigation was conducted in November, December 1993 and January 1994.

The water sampling points are shown in Fig. E,3.3. This study was performed in cooperation with the UNAP (Universidad Arturo Prat).

3.2.2 Results of Water Quality Analysis

1) Springs (H0 and H3)

There are two springs (H0 and H3) located around the westside of the Salar. The results of the water analysis are shown in Tables E,3.1 and E,3.2.

The values in milliequivalent per liter of the major elements of Ca, Mg, Na, K, CO_3, HCO_3, SO_4 and Cl are shown in Tables E,3.3 and E,3.4. The results indicate that the dominant cation is sodium and the dominant anion is bicarbonate; calcium and sulphates are abundant, as observed in Collins' diagram of Fig. E,3.4. They are classified as Sodium Bicarbonated Water. The water quality is compatively good. The water quality concentration is within the allowable limits of drinking water except turbidity. The phosphate concentration is in a low level, which will not cause an excessive growth of algaes.

2) Ponds

(1) Fresh Water Pond (H1)

The pond H1 is located to the northwestern border of the Salar.

The results of the water quality analysis of this pond are shown in Table E,3.5. As observed in Collins' diagram, the sodium cation is more than 60% (See Table E,3.6 and Fig. E,3.5); bicarbonate and sulphate anions show similar values as the spring water. They are classified as Sodium Bicarbonated Sulphated Water. The water quality is compartviely good. The water quality is within the allowable limits of drinking water except turbidity.

(2) Lightly-Saline Pond (H6); Huasco Lipez

The pond H6 is located in the southeast of the Salar and is enclosed by a zone of extensive "bofedal". In the surrounding area of this pond, domestic camelidae cattle are raised. It must be noted that no saline crust is identified in the surroundings of this pond. The results of the water analysis are given in Table E,3.7. The calculated values in milliequivalent per liter is shown in Table E,3.8. The dominant anion is sulphate, over 72%, and the dominant cation is sodium, over 50%.

According to Collins' diagram (See Fig. E,3.5), the water is classified as Sodium Sulphated Water. The water quality is comparatively good. The water quality is within the allowable limits of drinking water except turbidity and sulphate.

(3) Laguna Huasco (H2 and H4)

Laguna Huasco is the biggest pond of the Salar and occupies a vast area in the west and southwest part. Results of the water analysis are shown in Tables E,3.9 and E,3.10.

Water at H2 is much contaminated in all the observed water quality parameters. Chloride is in the range of 10,774 mg/l and 16,323 mg/l. Boron is 110 mg/l ~ 145 mg/l. Arsenic is 12 mg/l ~ 18 mg/l.

Water at H4 is also much contaminated in all the observed parameters. Chloride ranges from 23,079 mg/l to 69,768 mg/l. Boron is 203 mg/l ~ 515 mg/l. Arsenic is 36 mg/l ~ 66 mg/l.

Water at H2 is less contaminated than water at H4. This may be due to the dilution effects of the spring water. Tables E,3.11 and E,3.12 show the calculated values in milliequivalent per liter. Fig. E,3.6 shows Collins' diagrams for H2 and H4. The dominant cation is sodium, over 70%. The dominant anion is chloride, over 51%. The water is classified as Chlorided Sulphated Sodium or Sulphated Chlorided Sodium.

(4) Brine Pond (H5)

The pond H5 is located at the southwest of the Salar. The water is highly saline in taste and shallow in depth. No recharge of surface water was observed in it.

The results of water quality analysis are given in Table E,3.13. Table E,3.14 shows the calculated values in milliequivalent per liter. Fig. E,3.7 shows Collins' diagrams. The dominant cation is sodium, over 75%. The dominant anions are chloride and sulphate. They share more than 48% and 49% respectively. The water is classified as Chlorided Sulphated Sodium Water, similar to Laguna Huasco. Water at H5 is much contaminated in all the observed water quality parameters. Chloride is in the range of 32,390 mg/l ~ 102,508 mg/l. Boron is 395 mg/l ~ 773 mg/l. Arsenic is 60 mg/l ~ 128 mg/l.

3.3 Ecology

3.3.1 Fishes, Amphibous and Mollusks

1) Fishes

Two fish species were found in the spring; they are:

a) *Trichomycterus* aff. *rivulatus* Valenciennes (Fam. Trichomyctaridae, Siluriformes).

b) *Orestias* aff. *agassizi* Valenciennes (Fam. Cyprinodontidae, Atheriniformes)

These are not rare (uncommon) species.

2) Amphibious

Three amphibious species were found in the fresh water.

a) *Telmatobius* aff. *Peruvianus*:

This has been detected also previously in Pampa Lagunilla and Rio Collacagua, to the north of Salar del Huasco. This is not a rare species.

b) *Pleuroidema marmorata*:

This species is typical one in the central and southern parts of Perú and northeast of Argentina. In Chile, it has only been found at Lago Chungará, Putre, Portezuelo de Putre, Parinacota and Chungara. At present this species extends over 150 km in north-south direction in northern Chile. This shows the zoogeographic importance of Laguna Huasco.

c) *Bufo spinulosus:*

This is not a rare species.

3) Mollusks

Three mollusk species are found in the fresh water. One is bivalve and the others are snails. These are not rare species.

a) *Pisidium* sp.:

This bivalve (Pelecypoda) is living in the subaquatic vegetation of the fresh water spring in the west part of the Salar.

b) *Tropicorbis* sp.:

This snail is living together with *pisidium* sp..

c) Indeterminatae sp.:

This species is different from *Tropicorbis* sp. (probably *Littoridina*); and is limited in the "bofedal" and the effluents of Huasco Lipez spring.

3.3.2 Plankton

Plankton is one of the major foods of flamingos. The existing fitoplankton and zooplankton in the three ponds; Laguna Huasco, Huasco Lipez and Cerro Huasco, of Salar del Huasco were surveyed. Samples were taken from the column of water and bottom sediment. The results of the survey are shown below.

1) Laguna Huasco

The analysis of the specific composition of fitoplankton in Laguna Huasco identified 15 species of Bacillariophyceae (diatoms) and four species of Cyanophyceae (See Table E,3.15) of which two species of diatoms; *Surirella* sp.1 and *Navicula* sp. (See Photo. E,3.1) are dominant. The zooplankton is represented by four species of Artropoda and one of Nematoda (See Table E,3.16) of which two species of Artropoda; Copepoda Calanoidea and Copepoda Ciclopoidea are dominant.

2) Pond of Huasco Lipez

The specific composition of fitoplankton in this pond is 15 species in total (See Table E,3.17): 11 Bacillariophyceae and four Cyanophyceae. The species of *Surirella* sp.1 and *Fragillaria* sp. are noted for their abundance. The zooplankton are represented by four species of Artropoda and one of Nematode (See Table E,3.18). The species of Artropoda: Copepoda Calanoidea and Ciclopoidea are abundant, same as in Laguna Huasco.

3) Pond of Cerro Huasco

The specific composition of fitoplankton was confirmed as eight species of Bacillariophyceae and four species of Cyanophyceae (See Table E,3.19). The species of *Diploneis* sp. of Bacillariphyceae are noted for their abundance. Zooplankton is represented by three species of Artropoda and one of Nematode of which Copepoda Calanoidea of Artropoda is dominant (See Table E,3.20).

The composition of the fitoplankton in the ponds of Salar del Huasco are characterized by a dominance of two species of Bacillariophyceae: *Surirella* sp.1 and *Navicula* sp.1. The composition of the zooplankton is represented mainly by two species of Artropoda: Copepoda Calanoidea and Copepoda Ciclopoidea.

A higher concentration of fitoplankton / zooplankton and a greater diversity of species are identified in Laguna Huasco. A lesser diversity is confirmed in Cerro Huasco, different from other ponds in biological components.

The water of Salar del Huasco is mixed by wind because of its shallow depth. The existing organic matters in the bottom are mixed with water, resulting in homogenization of fitoplankton and zooplankton in both stratum.

3.3.3 Plants

1) Around the Salar

(1) Formation of "Pajonales"

This formation is located around the Salar and dominant in the hills. This formation is dominated by tall gramineous genuses: *Festuca, Parastrephia* and *Stipa.*

(2) Formation of "Tolares"

This formation is characterized by a high cover of vegetation and an abundance for shrubs and subshrubs which are well known as "tolas" and "tolillas". The dominant genuses are *Baccharis, Fabians* and *Parastrephia.*

(3) Formation of "Bofedales"

This formations exists around the Salar, with marshy soil. This is a food for mammals during the dry periods. This formation is composed of *Oxychloe andina, Festuca* sp., *Lycium* sp., *Werneria* sp., *Azolla* sp. and *Deyeuxia* sp. "Bofedales" are preserved by the special law "Modifica Artículos 58 y 63 del Código de Aguas" since the year 1992.

2) Aquatic Plants

The following aquatic plants are identified in the surrounding area of fresh water.

Family	Species
Salvinacea	*Azolla* sp.
Zemnacea	*Zemna* sp.
Haloragacea	*Ruppia* sp.
Charophyceae	*Chra* sp.

3.3.4 Others

1) Bird

The number of birds in Salar del Huasco was surveyed during November 14th - 18th, December 14th - 17th 1993 and January 11th - 14th 1994. The identified bird species are listed in Table E,3.21. It should be noted that among the above, species given below are designated by CONAF as the endangered or vulnerable species to be conserved.

a) Endangered Species

Pterocnemia pennatas (d'Orbigny) (Fam. Rheidae, Lesser Rhea) (see Photo E,3.2.).

b) Vulnerable Species

Tinamotis pentlandii Vigors (Fam. Tinamidae, Puna Tinamou)
Phoenicopterus chilensis Molina (Fam. Phoenicopteridae, Chilean Flamingo)
Phoenicopterus andinus (Philippi) (Fam. Phoenicopteridae, Andean Flamingo)
Phoenicopterus jamesi (Sclater) (Fam. Phoenicopteridae, Puna Flamingo)
Chloephaga melanoptera (Eyton) (Fam. Anatidae, Andean Goose)
(See Photo E,3.3)
Fulica gigantea Eydoux & Souleyet (Fam. Rallidae, Gaiant Coot)

2) Reptiles

Liolaemus sp. (Fam. Iguanidae) is identified in the "Tolar" near the Laguna Huasco.

3.4 Flamingo

3.4.1 Population

Three species of flamingo were identified during November 1993 - January 1994. The maximum population during the period of survey was counted at 3,344 on December 16th 1993 (See Table E,3.22). The species and maximum counted population are shown below.

Species	Population
Phoenicopterus chilensis Chilean Flamingo	544
Phoenicopterus andinus Andean Flamingo	1,267
Phoenicopterus jamesi Puna Flamingo	1,533
Total	3,344

These are designated by CONAF as the vulnerable species and further authorized by CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) as the endangered one.

3.4.2 Population Share in Northern Chile

1) *Phoenicopterus chilensis* (Chilean Flamingo)

The population of *Phoenicopterus chilensis* in the world were reported as 330,000 in 1993, all of which are living in South America. According to the survey of Corporation National Forest - U.S.A. in 1985 - 1987, number of this species was counted in the Northern Chile as below:

Season and Year		Population
Winter	1985	3,451
Summer	1986	15,464
Winter	1986	2,797
Summer	1987	6,450

The species migrates among mountainous area in Chile, Peru, Bolivia and Argentina, and the east coast of South America. The population in Salar del Huasco shares 3.5% (544/15,464=0.035) of that in the Northern Chile.

2) *Phoenicopterus andinus* (Andean Flamingo)

The population of *Phoenicopterus andinus* in the world were reported as 130,000 in 1993, all of which are living in Andes. According to the above U.S.A. survey, number of this species in the northern Chile was counted as below:

Season and Year		Population
Winter	1985	4,216
Summer	1986	40,747
Winter	1986	11,109
Summer	1987	37,245

The species migrates among mountainous area in Chile, Perú, Bolivia and Argentina. The population of Salar del Huasco shares 3.1% (1,267/40,747=0.031) of that in the Northern Chile.

3) *Phoenicopterus jamesi* (Puna Flamingo)

The population of *Phoenicopterus jamesi* in the world were reported as 15,000 in 1973, all of which are living in Andes. According to the above U.S.A. survey, the number of this species was counted as shown below.

Season and Year		Population
Winter	1985	5,760
Summer	1986	17,268
Winter	1986	10,503
Summer	1987	12,802

The species migrates among mountainous area in Chile, Peru, Bolivia and Argentina. The population of Salar del Huasco shares 8.9% (1,530/10,268=0.089) of that in Northern Chile.

3.4.3 Nesting Habit

As shown in Tables E,3.23 and E,3.24, chickens, nests and eggs of *Phoenicopterus jamesi* were found on December 1993 and January 1994 in Salar del Huasco (See Photo E,3.4). This fact is important because Salar del Huasco provides one of the nesting areas of the rare species; *Phoenicopterus jamesi*, population of which in the world was reported as 15,000 in 1973.

3.5 Land Use, Social and Cultural Aspects

According to CONAD (National Corporation of Indigenous Right), a part of the northwest area ("bofedal", spring and lagoon of fresh water) of Salar del Huasco, is considered as private property. All the other areas of Salar del Huasco are owned by Bienes Nacionales de Chile. However, four aymara families (16 persons) are living in this area at present.

The "bofedales" of the Laguna Huasco is also used sometimes as feeding area for the Auchenid livestock of surrounding communities outside Salar del Huasco. For example, the shepherds of Colchane visit Salar del Huasco every 3 - 10 years, together with 1,000 - 1,500 animals.

Table E,3.1 Water Quality (Huasco 0)

<Calidad del Agua (Huasco 0)>

Item		Nov. 93	Dec. 93	Jan.94
Temperature	(° C)	17.0	16.1	15.0
pH	(U)	8.06	8.05	8.03
Dissolved Oxygen (DO)	(mg/l)	3.6	3.8	3.1
Conductivity (EC)	(mS/cm)	0.5	0.5	0.5
NaCl	(%)	0.02	0.02	-
Turbidity	(mg/l)	69	173	-
Sodium (Na)	(mg/l)	-	78.6	81.2
Potacium (K)	(mg/l)	-	7.5	7.7
Litium (Li)	(mg/l)	-	4.8	1.8
Calcium (Ca)	(mg/l)	-	47.6	47.0
Magnesium (Mg)	(mg/l)	-	13.0	9.8
Carbonates (CO_3)	(mg/l)	-	0.0	0.0
Sulphates (SO_4)	(mg/l)	-	98.66	95.9
Bicarbonates (HCO_3)	(mg/l)	-	109.7	109.8
Chloride (Cl)	(mg/l)	-	32.6	32.9
Phosphate (P)	(μg-at/l)	-	2.10	2.0
Boron (B)	(mg/l)	-	1.0	
Arsenic (As)	(mg/l)	-	0.06	
Total Solids (TDS)	(mg/l)	-	440	397
Dissolved Solids	(mg/l)	-	440	393
Suspended Solids (SS)	(mg/l)	-	0	3.4
Total Hardness	(mg/l)	-	171.4	157.3

Table E,3.2 Water Quality (Huasco 3)

<Calidad del Agua (Huasco 3)>

Item		Nov. 93	Dec. 93	Jan. 94
Temperature	(° C)	15.5	20.3	17.0
pH	(U)	8.34	7.88	8.77
Dissolved Oxygen (DO)	(mg/l)	3.4	5.2	4.8
Conductivity	(mS/cm)	0.5	0.5	0.5
NaCl	(%)	0.02	0.02	-
Turbidity	(mg/l)	70	18	-
Sodium (Na)	(mg/l)	76.6	76.0	75.9
Potacium (K)	(mg/l)	6.4	6.7	7.1
Litium (Li)	(mg/l)	1.5	1.5	1.5
Calcium (Ca)	(mg/l)	41.5	40.5	41.3
Magnesium (Mg)	(mg/l)	5.9	5.8	5.8
Carbonates (CO_3)	(mg/l)	0.0	0.0	0.0
Sulphates (SO_4)	(mg/l)	88.3	82.7	85.9
Bicarbonates (HCO_3)	(mg/l)	207.4	204.8	203.8
Chloride (Cl)	(mg/l)	40.0	36.4	36.6
Phosphate (P)	(μg-at/l)	1.4	1.5	1.4
Boron (B)	(mg/l)	1.2	0.9	
Arsenic (As)	(mg/l)	< 0.03	< 0.03	
Total Solids (TDS)	(mg/l)	421	390	400
Dissolved Solids	(mg/l)	393	380	398
Suspended Solids	(mg/l)	28	10	2
Total Hardness	(mg/l)	139.5	140.1	150

Table E,3.3 Parameters in Milliequivalent/l (Huasco 0)

<Parámetros en Equivalente de Miligramol/l (Huasco 0)>

Item		Nov.93	Dec. 93	Jan.94
Calcium (Ca)	(meq/l)	-	2.4	2.4
Magnesium(Mg)	(meq/l)	-	1.1	0.8
Sodium (Na)	(meq/l)	-	3.4	3.5
Potacium(K)	(meq/l)	-	0.2	0.2
Carbonate (CO_3)	(meq/l)	-	0.0	0.0
Bicarbonate (HCO_3)	(meq/l)	-	3.5	3.6
Sulphate (SO_4)	(meq/l)	-	2.1	2.0
Chloride (Cl)	(meq/l)	-	0.9	0.9
Cations Total	(meq/l)	-	7.1	6.9
Anions Total	(meq/l)	-	6.6	6.5

Table E,3.4 Parameters in Milliequivalent/l (Huasco 3)

<Parámetros en Equivalente de Miligramo/l (Huasco 3)>

Item	Nov. 93	Dec. 93	Jan. 94
Calcium (Ca)	2.1	2.0	2.1
Magnesium (Mg)	0.5	0.5	0.5
Sodium (Na)	3.3	3.3	3.3
Potacium (K)	0.2	0.2	0.2
Carbonate (CO_3)	0.0	0.0	0.0
Bicarbonate (HCO_3)	3.4	3.4	3.3
Sulphate (SO_4)	1.8	1.7	1.8
Chloride (Cl)	1.0	1.0	1.0
Cations Total	6.1	6.0	6.1
Anions Total	6.3	6.1	6.1

Table E,3.5 Water Quality (Huasco 1)

<Calidad de Agua (Huasco 1)>

Item		Nov. 93	Dec. 93	Jan. 94
Temperature	(°C)	20.0	19.6	18.0
pH	(U)	9.36	9.07	9.10
Dissolved Oxygen (DO)	(mg/l)	2.7	4.3	3.8
Conductivity (EC)	(mS/cm)	0.3	0.6	0.4
NaCl	(%)	0.01	0.02	-
Turbidity	(mg/l)	89	212	-
Sodium (Na)	(mg/l)	96.5	91.1	97.0
Potacium(K)	(mg/l)	9.2	8.8	9.9
Lithium (Li)	(mg/l)	1.8	1.8	2.1
Calcium (Ca)	(mg/l)	27.4	33.0	26.9
Magnesium (Mg)	(mg/l)	11.3	10.6	12.4
Carbonates (CO_3)	(mg/l)	23.4	21.0	28.0
Sulphates (SO_4)	(mg/l)	97.14	98.66	98.66
Bicarbonates (HCO_3)	(mg/l)	137.6	148.4	128.1
Chloride (Cl)	(mg/l)	44.3	41.9	45.3
Phosphate (P)	(μg-at/l)	1.5	1.30	0.9
Boron (B)	(mg/l)	1.1	1.0	
Arsenic (As)	(mg/l)	0.04	0.04	
Total Solids (TDS)	(mg/l)	473	480	465
Dissolved Solids	(mg/l)	413	460	433
Suspended Solids (SS)	(mg/l)	60	20	31.7
Total Hardness	(mg/l)	114.5	125.3	118.1

Table E,3.6 Parameters in Milliequivalent/l (Huasco 1)

<Parámetros en Equivalente de Miligramo/l (Huasco 1)>

Item		Nov.93	Dec.93	Jan.94
Calcium (Ca)	(meq/l)	1.4	1.6	1.3
Magnesium (Mg)	(meq/l)	1.0	0.8	1.0
Sodium (Na)	(meq/l)	4.2	4.0	4.2
Potacium (K)	(meq/l)	0.2	0.2	0.3
Carbonate (CO_3)	(meq/l)	0.8	0.7	0.9
Bicarbonate (HCO_3)	(meq/l)	2.2	2.4	2.1
Sulphate (SO_4)	(meq/l)	2.0	2.1	2.1
Chloride (Cl)	(meq/l)	1.2	1.2	1.3
Cations Total	(meq/l)	6.8	6.6	6.8
Anions Total	(meq/l)	6.2	6.4	6.4

Table E,3.7 Water Quality (Huasco 6)

<Calidad de Agua (Huasco 6)>

Item		Nov. 93	Dec. 93	Jan. 94
Temperature	(°C)	14.0	14.0	10.0
pH	(U)	8.66	7.93	8.40
Dissolved Oxygen (DO)	(mg/l)	2.1	3.6	3.4
Conductivity (EC)	(mS/cm)	2.0	1.2	1.8
NaCl	(%)	0.1	0.8	-
Turbidity	(mg/l)	95	203	-
Sodium (Na)	(mg/l)	335	363	437
Potacium(K)	(mg/l)	113	116	95
Lithium (Li)	(mg/l)	9.1	9.3	9.6
Calcium (Ca)	(mg/l)	150	178	209
Magnesium (Mg)	(mg/l)	31.1	30.2	36.9
Carbonates (CO_3)	(mg/l)	12.6	0.0	0.0
Sulphates (SO_4)	(mg/l)	962	1040	1269
Bicarbonates (HCO_3)	(mg/l)	138	215.4	209.8
Chloride (Cl)	(mg/l)	167.7	184.7	235.8
Phosphate (P)	(μg-at/l)	12.3	17.4	19.1
Boron (B)	(mg/l)	5.0	5.4	
Arsenic (As)	(mg/l)	2.0	2.0	
Total Solids (TDS)	(mg/l)	1953	2190	2480
Dissolved Solids	(mg/l)	1872	2140	2327
Suspended Solids (SS)	(mg/l)	81	50	153
Total Hardness	(mg/l)	502.8	572.5	673

Table E,3.8 Parameters in Milliequivalent/l (Huasco 6)

<Parámetros en Equivalente de Miligramo/l (Huasco 6)>

Item		Nov. 93	Dec. 93	Jan. 94
Calcium (Ca)	(meq/l)	7.5	8.9	10.4
Magnesium (Mg)	(meq/l)	2.5	2.5	3.0
Sodium (Na)	(meq/l)	14.6	15.8	19.0
Potacium (K)	(meq/l)	2.9	3.0	2.4
Carbonate (CO	(meq/l)	0.4	0.0	0.0
Bicarbonate (HCO	(meq/l)	2.3	3.5	3.4
Sulphate (SO_4	(meq/l)	20.0	21.7	26.4
Chloride (Cl)	(meq/l)	4.7	5.2	6.6
Cations Total	(meq/l)	27.5	30.2	34.8
Anions Total	(meq/l)	27.5	30.4	36.4

Table E,3.9 Water Quality (Huasco 2)

<Calidad de Agua (Huasco 6)>

Item		Nov. 93	Dec. 93	Jan. 94
Temperature	(°C)	19.0	23.7	28.0
pH	(U)	8.74	8.60	8.30
Dissolved Oxygen (DO)	(mg/l)	2.0	3.2	3.0
Conductivity (EC)	(mS/cm)	509.0	39.6	>
NaCl	(%)	3.21	2.39	-
Turbidity	(mg/l)	19	230	-
Sodium (Na)	(mg/l)	17250	11500	27081
Potacium (K)	(mg/l)	2558	1835	1429
Lithium (Li)	(mg/l)	245	234	408
Calcium (Ca)	(mg/l)	392.8	196.4	198.4
Magnesium (Mg)	(mg/l)	477.6	303.8	329.3
Carbonates (CO_3)	(mg/l)	110.0	138.4	168.0
Sulphates (SO_4)	(mg/l)	18541	12253	35965
Bicarbonates (HCO_3)	(mg/l)	575.8	245.2	216.0
Chloride (Cl)	(mg/l)	16323	10774	15925
Phosphate (P)	(μg-at/l)	230	212.5	243.4
Boron (B)	(mg/l)	145	110	
Arsenic (As)	(mg/l)	18	12	
Total Solids (TDS)	(mg/l)	52547	34290	66683
Dissolved Solids	(mg/l)	51143	34250	65348
Suspended Solids (SS)	(mg/l)	1404	40	1335
Total Hardness	(mg/l)	2948	1739	1852

>: Very High

Table E,3.10 Water Quality (Huasco 4)

<Calidad de Agua (Huasco 4)>

Item		Nov. 93	Dec. 93	Jan. 94
Temperature	(°C)	20.0	24.2	19.0
pH	(U)	8.64	8.22	7.92
Dissolved Oxygen (DO)	(mg/l)	2.0	1.6	1.5
Conductivity (EC)	(mS/cm)	>	>	>
NaCl	(%)	>	>	-
Turbidity	(mg/l)	133	217	-
Sodium (Na)	(mg/l)	25471	68103	52210
Potacium (K)	(mg/l)	5565	13103	14414
Lithium (Li)	(mg/l)	898	1633	2449
Calcium (Ca)	(mg/l)	587	465	1275
Magnesium (Mg)	(mg/l)	695	1994	4726
Carbonates (CO_3)	(mg/l)	154.6	672.8	1056.0
Sulphates (SO_4)	(mg/l)	34590	58962	45204
Bicarbonates (HCO_3)	(mg/l)	637.4	637.4	358.6
Chloride (Cl)	(mg/l)	23079	69768	53973
Phosphate (P)	(μg-at/l)	226.3	361.6	321.4
Boron (B)	(mg/l)	203.0	515.0	
Arsenic (As)	(mg/l)	36	66	
Total Solids (TDS)	(mg/l)	96312	203420	176910
Dissolved Solids	(mg/l)	91698	180250	175273
Suspended Solids (SS)	(mg/l)	4614	23170	1637
Total Hardness	(mg/l)	4329	9373	11330

N. D. : Not Determined

> : Very High

Table E,3.11 Parameter in Milliequivallent/l (Huasco 2)

<Parámetros en Equivalente de Miligramo/1 (Huasco 2)>

Item		Nov. 93	Dec. 93	Jan. 94
Calcium (Ca)	(meq/l)	19.6	9.8	9.9
Magnesium (Mg)	(meq/l)	39.1	24.9	27.0
Sodium (Na)	(meq/l)	750.0	500.0	1,177.0
Potacium(K)	(meq/l)	65.4	46.9	36.5
Carbonate (CO_3)	(meq/l)	3.7	4.6	5.6
Bicarbonate (HCO_3)	(meq/l)	9.4	4.0	3.5
Sulphate (SO_4)	(meq/l)	386.2	255.3	749.0
Chloride (Cl)	(meq/l)	459.8	303.5	448.6
Cations Total	(meq/l)	874.1	581.6	1,250.4
Anions Total	(meq/l)	859.4	567.4	1,206.7

Table E,3.12 Parameters in Milliequivalent/l (Huasco 4)

<Parámetros en Equivalente de Miligramo/1 (Huasco 4)>

Item		Nov. 93	Dec. 93	Jan. 94
Calcium (Ca)	(meq/l)	29.4	23.2	31.9
Magnesium (Mg)	(meq/l)	56.9	163.4	193.8
Sodium (Na)	(meq/l)	1,327.0	2,961.0	2,270.0
Potacium (K)	(meq/)	142.3	335.1	368.6
Carbonate (CO_3)	(meq/l)	5.1	22.4	35.2
Bicarbonate (HCO_3)	(meq/l)	10.4	10.4	5.8
Sulphate (SO_4)	(meq/l)	720.6	1,228.3	941.8
Chloride (Cl)	(meq/l)	650.0	1,965.3	1,520.0
Cations Total	(meq/l)	1,555.6	3,482.7	2,864.3
Anions Total	(meq/l)	1,386.1	3,226.4	2,502.8

Table E,3.13 Water Quality (Huasco 5)

<Calidad de Agua (Huasco 5)>

Item		Nov. 93	Dec. 93	Jan. 94
Temperature	(°C)	27.5	32.5	-
pH	(U)	8.34	8.38	-
Dissolved Oxygen (DO)	(mg/l)	1.4	1.9	-
Conductivity (EC)	(mS/cm)	>	>	-
NaCl	(%)	>	>	-
Turbidity	(mg/l)	158	105	-
Sodium (Na)	(mg/l)	113022	31119	-
Potacium (K)	(mg/l)	17198	11958	-
Lithium (Li)	(mg/l)	2960	1878	-
Calcium (Ca)	(mg/l)	689.4	645.3	-
Magnesium (Mg)	(mg/l)	2908	1382	-
Carbonates (CO_3)	(mg/l)	0.0	N.D.	-
Sulphates (SO_4)	(mg/l)	130858	40697	-
Bicarbonates (HCO_3)	(mg/l)	N.D.	N.D.	-
Chloride (Cl)	(mg/l)	102508	32390	-
Phosphate (P)	(µg-at/l)	2.5	4.7	-
Boron (B)	(mg/l)	773.0	395.0	-
Arsenic (As)	(mg/l)	128.0	60.0	-
Total Solids (TDS)	(mg/l)	297128	119480	-
Dissolved Solids	(mg/l)	287485	112070	-
Suspended Solids (SS)	(mg/l)	9643	7410	-
Total Hardness	(mg/l)	13697	7301	-

N.D. : Not Determined

\> : Very High

Table E,3.14 Parameters in Milliequivalent/l (Huasco 5)

<Parámetros en Equivalente de Miligramol/l (Huasco 5)>

Item		Nov. 93	Dec. 93	Jan. 94
Calcium (Ca)	(meq/l)	34.0	32.0	-
Magnesium (Mg)	(meq/l)	238.0	113.0	-
Sodium (Na)	(meq/l)	4,988.0	1,353.0	-
Potacium (K)	(meq/l)	440.0	306.0	-
Carbonate (CO_3)	(meq/l)	-	-	-
Bicarbonate (HCO_3)	(meq/l)	-	-	-
Sulphate (SO_4)	(meq/l)	2,726.0	912.0	-
Chloride (Cl)	(meq/l)	2,888.0	848.0	-
Cations Total	(meq/l)	5,700.0	1,804.0	-
Anions Total	(meq/l)	5,614.0	1,760.0	-

Table E,3.15 Fitoplankton in the Laguna Huasco

<Fitoplancton en la Laguna Huasco>

(Unit: Num./l)

Square	35		46	
Month	Nov. 1993	Dec.1993	Nov. 1993	Dec. 1993
BACILLARIOPHYCEAE				
Surirella sp.1	1,533.333	1,713,333	3,200.000	2,383,333
Navicula sp.1	1,033.333	20,000	200.000	233,333
Amphora sp.	300.000	-	66.667	83,333
Surirella sp. 2	-	86,667	-	183,333
Nitzschia sp.1	266.667	6,667	-	66,667
Diploneis sp.	66.667	20,000	233.333	50,000
Navicula sp.2	66.667	-	-	-
Fragillaria sp.	166.667	6,667	100,000	266,667
Navicula sp. 3	133.333	-	33,333	-
Pinnularia sp. 1	-	3,333	-	66,667
Surirella sp. 3	-	-	-	150,000
Ophepora sp.	-	-	-	16,667
Nitzchia sp.2	-	-	-	16,667
Navicula sp.4	33.333	-	-	16,667
Coconeis sp.	-	-	33.333	-
CYANOPHYCEAE				
Anabaena sp. 1	66,667	-	-	-
Oscillatoria sp.1	-	10,000		16,667
Oscillatoria sp. 2	-	10,000		-
Oscillatoria sp. 3	-	-		33,333

Table E,3.16 Zooplankton in the Laguna Huasco

<Zoolancton en la Laguna Huasco>

(Unit: Num./l)

Square	35		46	
Month	Nov. 1993	Dec. 1993	Nov. 1993	Dec. 1993
ARTROPODA				
Copepodos Calanoideos	22.00	4.00	18.00	-
Copepodos Ciclopoideos	189.00	2.40	8.00	2.00
Ostracodo	2.00	0.60	-	-
Insect larva (3)	-			2.00
NEMATODA				
Sp. Indeterminata	10.00			

Table E,3.17 Fitoplankton in Huasco Lipez
<Fitoplancton en Huasco Lipez>

(Unit: Num./l)

Month	Nov. 1993	Dec. 1993
BACILARIOPHYCEAE		
Diploneis sp.	33,333	23,333
Fragillaria sp.	150,000	766,667
Navicula sp.1	116,667	50,000
Navicula sp.3	100,000	-
Surirella sp.1	916,667	506,667
Navicula sp.4	-	10,000
Amphora sp.	200,000	23,333
Pleurosigma sp.	-	13,333
Nitzschia sp.1	83,333	6,667
Surirella sp.2	100,000	50,000
Navicula sp.6	-	16,667
Pinnularia sp.	-	26,667
CYANOPHYCEAE		
Anabaena sp.3	-	6,667
Anabaena sp.1	16,667	-
Oscillatoria sp.1	66,667	10,000
Oscillatoria sp.3	33,333	80,000

Table E,3.18 Zooplankton in Huasco Lipez
<Zooplancton en Huasco Lipez>

(Unit: Num./l)

Month	Nov. 1993	Dec. 1993
ARTROPODA		
Copepoda Calanoidea	17.00	2.40
Copepoda Ciclopoidea	3.30	2.00
Insect larvae (2)		0.40
Ostracoda		0.60
NEMATODA		
Sp. Indeterminatae	3.30	0.40

Table E,3.19 Fitoplankton in the pond of Cerro Huasco

<Fitoplancton en el Estanque de Cerro Huasco>

(Unit: Num./l)

Month	Nov. 1993	Dec. 1993
BACILLARIOPHYCEAE		
Diploneis sp.	2,300,000	1,200.000
Navicula sp.1	83,333	6,667
Navicula sp.3	66,667	-
Surirella sp.1	400,000	506.667
Opephora sp.	16,667	-
Nitzschia sp.1	16,667	3,333
Navicula sp.4	-	13,333
Navicula sp.5	-	13,333
CYANOPHYCEAE		
Anabaena sp.1	916,667	363,333
Anabaena sp.2	16,667	-
Oscillatoria sp.1	50,000	13,333

Table E,3.20 Zooplankton in the Pond of Cerro Huasco

<Zooplancton en el Estanque de Cerro Huasco>

(Unit: Num./l)

Month	Nov. 1993	Dec. 1993
ARTROPODA		
Copepodos Calanoideos	15.00	14.00
Artemia sp.	2.00	3.60
Larvas de Insecto (3)	-	0.20
Ostracodo	10.00	-
NEMATODA		
Sp. Indeterminada	6.00	0.20

Table E,3.21 Bird Species in Salar del Huasco and Conservation Status

<Especies de Aves en Salar del Huascoy Condición de Conservación>

Fam. TINAMIDAE			
Tinamotis pentlandii Vigors	Puna Tinamou	V	v
Fam RHEIDAE			
Pterocnemia pennata (d'Orbigny)	Lesser Rhea	E	e
Fam. PODICIPEDIDAE			
Podiceps occipitalis (Garnot)	Silvery Grebe	X	x
Fam. PHOENICOPTERIDAE			
Phoenicopterus chilensis Molina	Chilean Flamingo	V	v
Phoenicoparrus andinus (Philippi)	Andean Flamingo	V	v
Phoenicoparrus jamesi (Sclater)	Puna Flamingo	V	v
Fam. ARDEIDAE			
Nycticorax nicticorax (Linné)	Black-crowned Night Heron	X	x
Fam. ANATIDAE			
Chloephaga melanoptera (Eyton)	Andean Goose	O	v
Lophonetta specularioides (King)	Crested Duck	X	x
Anas flavirostris Veillot	Chilean Teal	X	x
Anas georgica Gmelin	Brown Pintail	X	x
Ana puna Tschudi	Puna Teal	X	x
Fam. FALCONIDAE			
Phalcoboenus megalopterus (Meyen)	Mountain Caracara	X	x
Fam. RALLIDAE			
Fulica gigantea Eydoux & Souleyet	Giant Coot	V	v
Fam. CHARADRIIDAE			
Vanellus resplendens (Tschudi)	Andean lapwing	X	x
Charadrius alticola (B. & S.)	Puna Plover	X	x
Fam. RECURVIROSTRIDAE			
Recurvirostra andina (Phil. & Landb.)	Andean Avocet	X	x

.... continuation

Fam. SCOLAPACIDAE			
Tringa flavipes (Gmelin)	Lesser Yellowlegs	X	x
Calidris bairdi (Coues)	Baird's Sandpiper	X	x
Gallinago andina (Taczanowski)	Puna Snipe	X	x
Phalaropus tricolor (Veillot)	Wilson's Phalarope	X	x
Fam. THINOCORIDAE			
Thinocorus rumicivorous Eschscholtz	Least Seedsnipe	X	x
Fam. LARIDAE			
Larus serranus Tschudi	Andean Gull	X	x
Fam. FURNARIIDAE			
Geositta cunicularia (Veillot)	Common Miner	X	x
Geositta punensis Dabbene	Puna Miner	X	x
Cinclodes fuscus (Veillot)	Bar-winged Cinclodes	X	x
Upucerthiaruficauda (Meyen)	Earthcreeper	X	x
Tripophaga dorbigny (Reichenbach)	Canastero	X	x
Fam. TYRANNIDAE			
Agriornis albicauda (Phil. & Landb.)	White-tailed Shrike-Tyrant	X	x
Muscisaxicola rufivertex d'Orb. & Lafr.	Rufous-naped Ground-Tyrant	X	x
Muscisaxicola juninensis Taczanowski	Puna Groud-Tyrant	X	x
Muscisaxicola flavinucha Lafresnaye	Creamy-naped Tyrant	X	x
Lessonia rufa (Gmelin)	Rufous-backed Negrito	X	x
Fam. HIRUNDINIDAE			
Hirundo rustica Linné	Barn Swallow	X	x
Fam. COLUMBIDAE			
Metriopelia aymara (Knip & Prevost)	Andean pigeon	X	x
Fam. MOTACILLIDAE			
Anthus correndera Veillot	Correndera Pipit	X	x
Fam. EMBERIZIDAE			
Sicalis uropygialis (Laf. & d'Orb.)	Bright-rumped Yellow-Finch	X	x
Fam. FRINGILLIDAE			
Phrygilus erythronotus (Phil. & Landb.)	White-throated Finch	X	x
Phrygilus unicolor (lafres. & d'Orb.)	Plumbeus Sierra-Finch	X	x
Carduelis atratus Lafres. & d'Orb.	Black Siskin	X	x

Remark - 1: Conservation Status in based of CONAF

Status	I. Region	Chile
Endangered	E	e
Vulnerable	V	v
Out of danger	O	o
Not defined	X	x

Table E,3.22 Number of Flamingos

<Número de Flamencos>

SPECIE	Nov. 93	Dec. 93	Jan. 94
Phoenicopterus chilensis Chilean flamingo	145	544	181
Phoenicoparrus andinus Andean flamingo	951	1,267	579
Phoenicoparrus jamesi Puna flamingo	-	1,533	1,449

Table E,3.23 Nesting Flamingos (December 1993)

<Flamencos Anidando (Diciembre 1993)>

Species	Nests	Eggs	Chickens
Phoenicopterus chilensis Chilean flamingo	-	-	-
Phoenicoparrus andinus Big parina	-	-	-
Phoenicoparrus jamesi Small parina	287 Nos.	290 Nos.	-

Table E,3.24 Nesting Flamingos (January 1994)

<Flamencos Anidando (Enero 1994)>

Species	Nests	Eggs	Chickens
Phoenicopterus chilensis Chilean flamingo	-	-	-
Phoenicoparrus andinus Big parina	-	-	-
Phoenicoparrus jamesi Small parina	451 Nos.	350 Nos.	165 Nos.

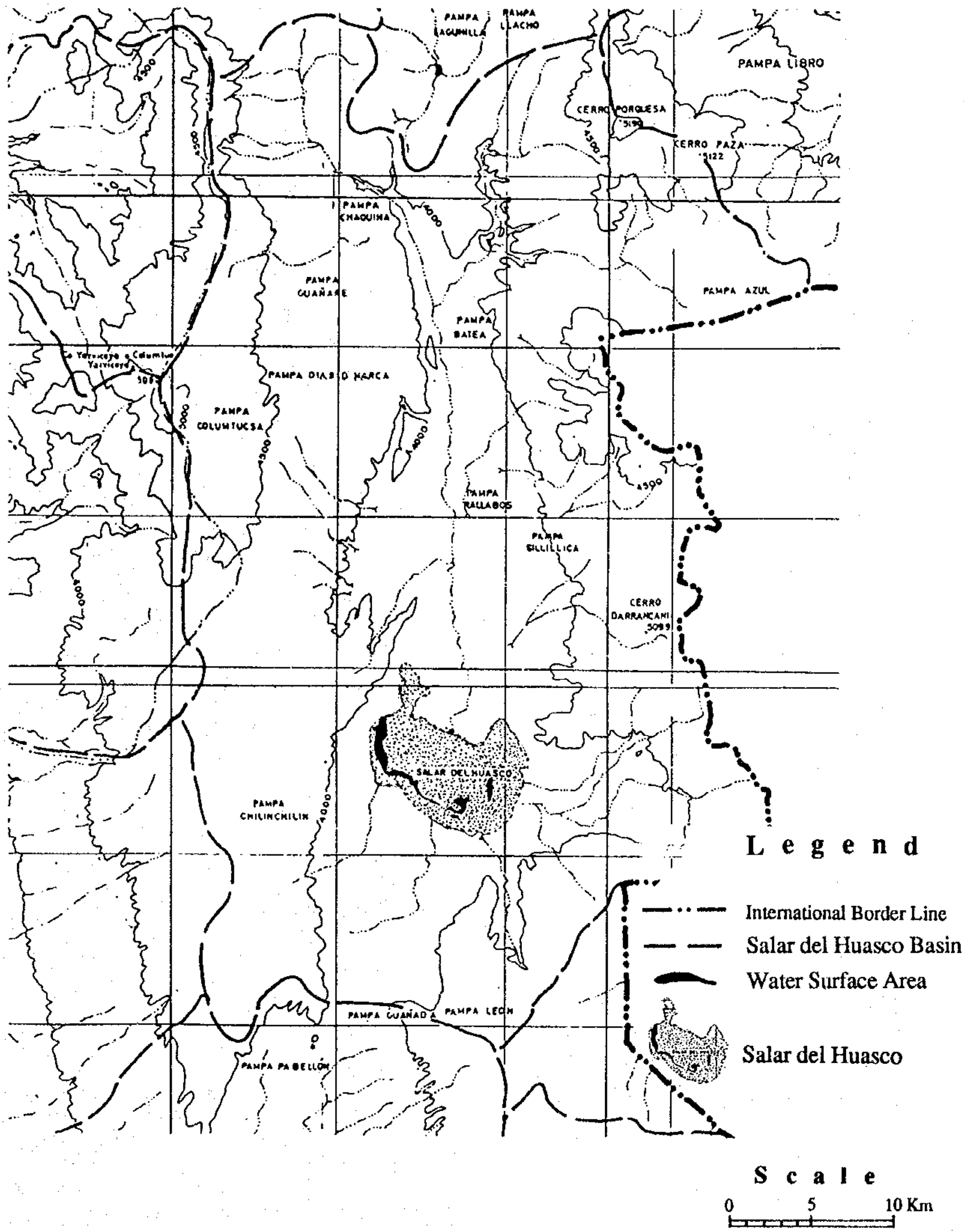


Fig. E.3.1 Salar del Huasco Basin and Water Surface Area

< Cuenca del Salar del Huasco y Area de la Superficie de Agua >

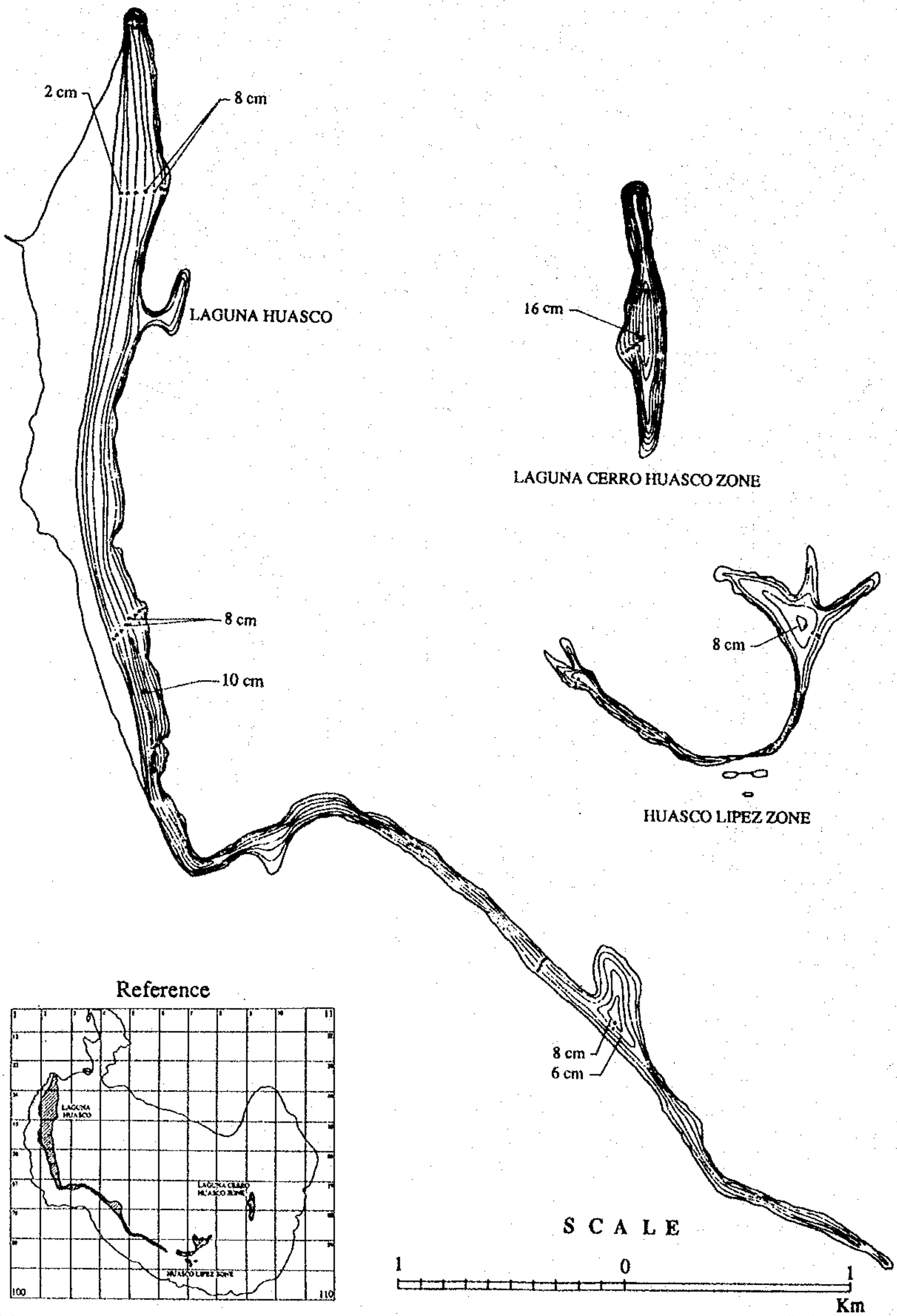


Fig. E,3.2 Isobath of the Salar del Huasco

< Isóbatas del Salar del Huasco >

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

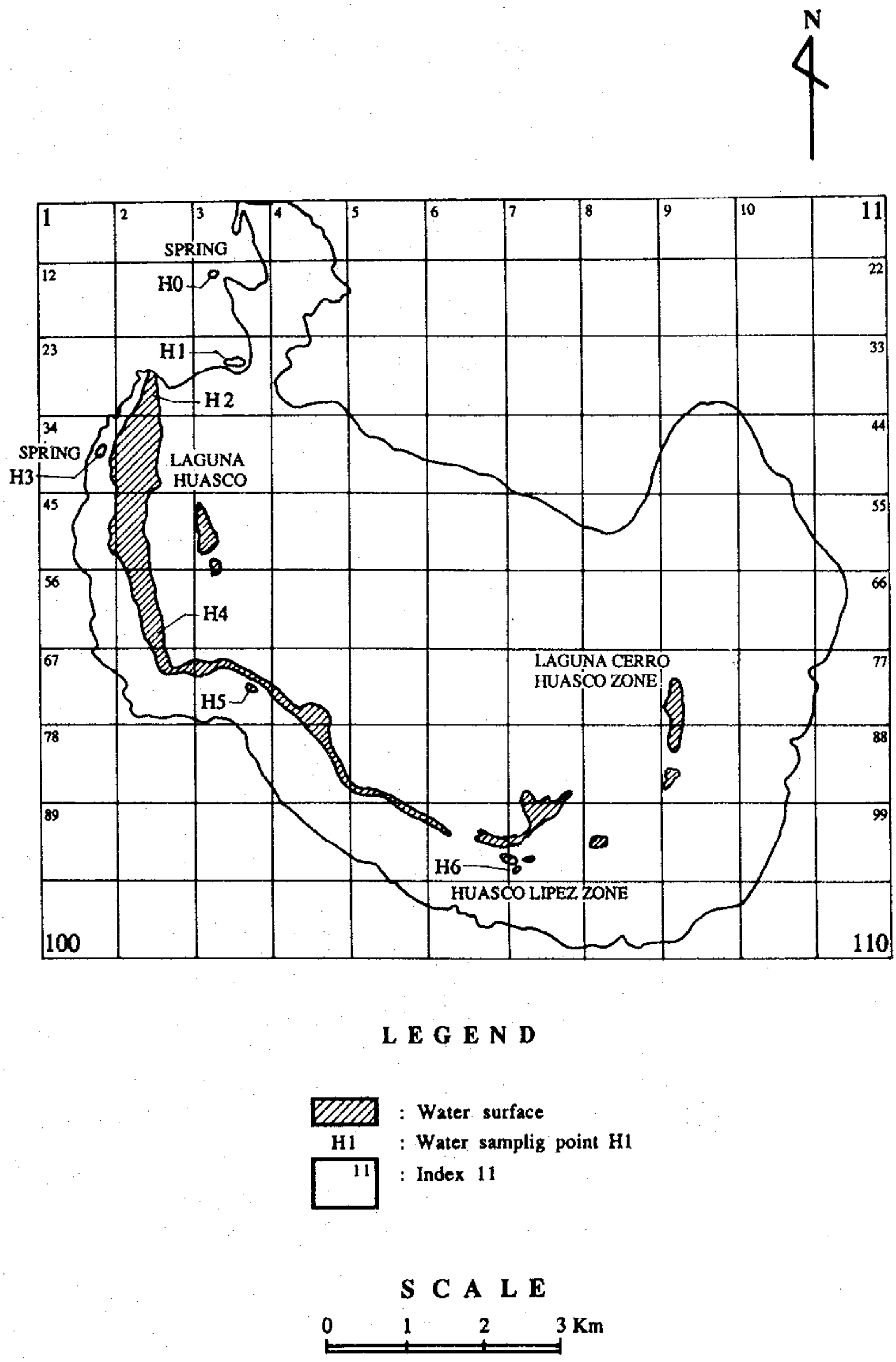
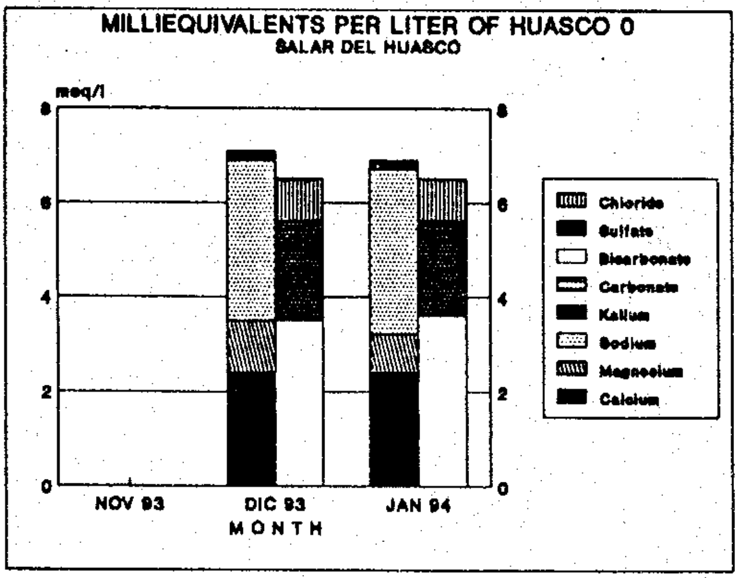


Fig. E.3.3 Water Sampling Points of the Salar del Huasco

< Muestreo de agua del Salar del Huasco >

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



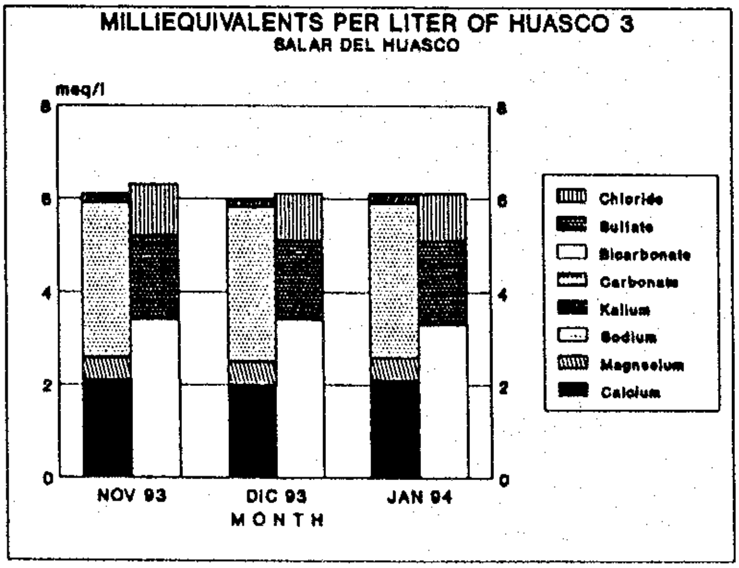
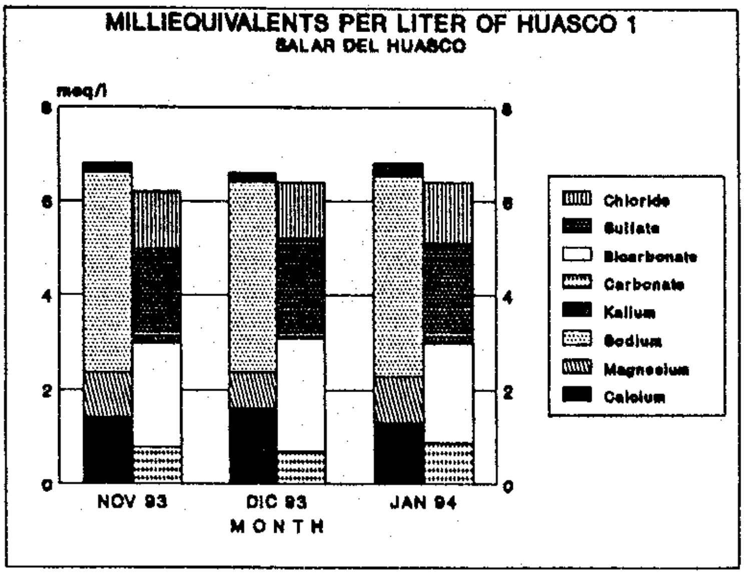


Fig. E, 3.4 Collins Diagram (H0 and H3)

< Diagrama Colins (H0 y H3) >



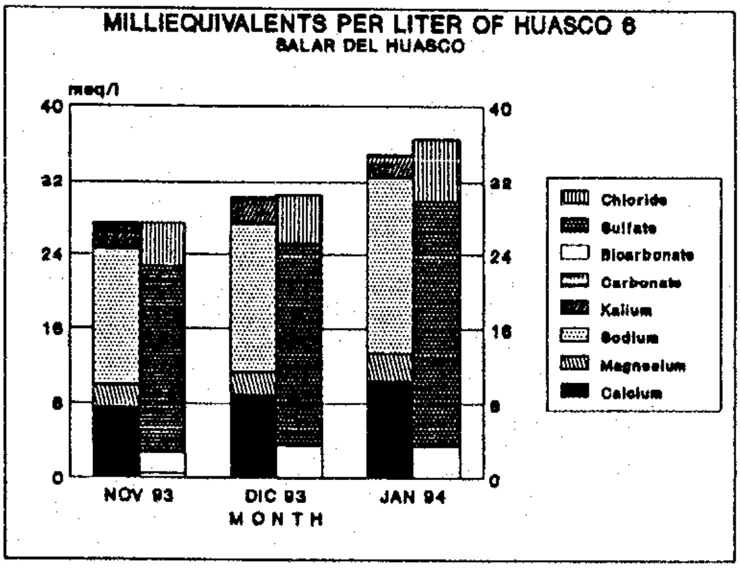
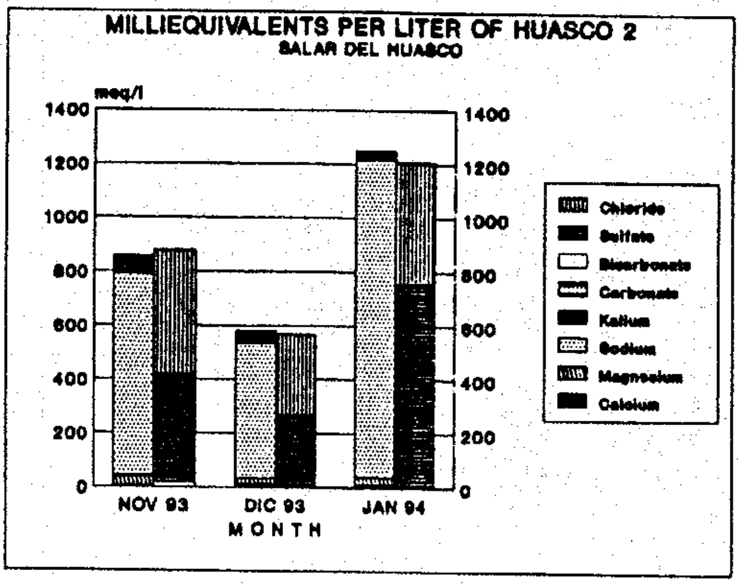


Fig. E, 3.5 Collins Diagram (H1 and H6)

< Diagrama Collins (H1 y H6) >



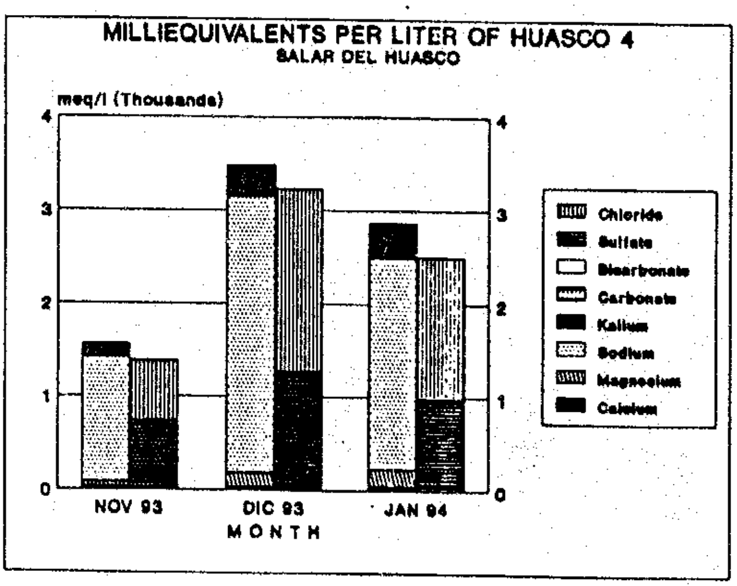


Fig. E, 3.6 Collins Diagram (H2 and H4)

< Diagrama Collins (H2 y H4) >

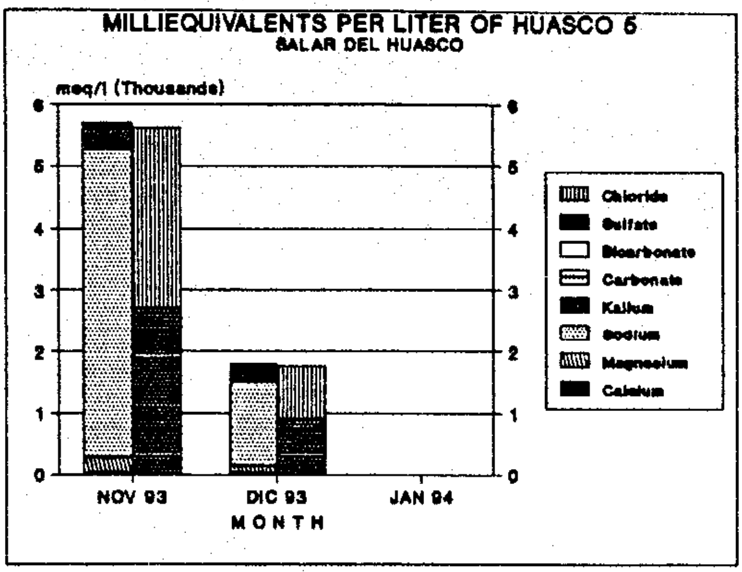


Fig. E, 3.7 Collins Diagram (H5)

< Diagrama Collins (H5) >

Microphotography of *Surirella* sp 1.

Microphotography of *Navicula* sp.

Photo E, 3.1 Plankton (*Surirella* sp.1 and *Navicula* sp.)
<Plancton (Surirella sp1 y Navicula sp.)>

Photo E, 3.2 *Pterocnemia Pennata* (Lesser Rhea)
< *Pterocnemia Pennata (Rhea Menor)* >

Photo.E, 3.3 *Chloephaga Melanoptera* (Andean Goose)
< *Chloephaga Melanoptera (Ganso Andino)* >

Photo.E, 3.4 Nests and Eggs of *Phoenicoparrus Jamesi* (Puna Flamingo)
< Nidos y Huevos de Phoenicoparrus Jamesi (Flamenco de la Puna) >

Chapter IV PREDICTION AND ASSESSMENT OF ENVIRONMENTAL IMPACT IN LOWER LLUTA VALLEY

4.1 Prediction of Environmental Impacts

The Project contribute the improvement the environment of the domestic water supply and is indispensable for the future development of Arica city. However, some negative impacts may be also expected to some extent. The impacts in the pre-construction, construction and operation stages are listed in Table E, 4.1

The anticipated negative impacts in the three (3) stages are described in detail as follows.

4.1.1 Pre-construction Stage

Prior to construction of water supply system, following lands need to be acquired.

(1) Intakes

26 wells are to be newly constructed along the Panamerican Highway to Bolivia (Route 11). A land of 25 m^2 (= 5 m x 5 m) needs for each site. Well sites are located between the railway to Bolivia and the Highway to Bolivia. The first well is located at the site, 4,800 m from the Panamerican Highway and others are situated toward Rosario with a spacing of 500 m.

All the wells are constructed in the public land.

(2) Water treatment plant/distribution tank sites (Lluta Treatment Plant)

Water treatment plant and two (2) distribution tanks are to be constructed in the area between Chuilona and Sascapa, approximately 5 km from Panamerican Highway. A land of 37,500 m^2 (= 150 m x 250 m) is required for the site.

(3) Transmission pipeline/Waste Water Pipeline

Transmission pipeline is to be laid in the underground between the Highway and the railroad to Bolivia connecting the wells to the water treatment plant. Land necessary for the pipeline is 25,000 m^2 (= 2 m x 12,500 m).

Concentrated water (waste water) would be discharged from the water treatment plant (RO system). This waste water will be directly led to the sea through the pipeline from the Lluta Water Treatment Plant. Most part of pipeline is to be constructed under the existing roads. Length of the pipeline is about 17 km.

4.1.2 Construction Stage

The possible negative impacts which may occur during the construction stage are summarized as follows, however, they will be all temporary and short term ones, and would disappear with the completion of construction activities.

- Nuisance by vibration and noise during well construction works, installation of pipeline, preparation work of water treatment site and installation of pipelines.
- Dust caused by earth works during installation of pipeline and treatment plant.
- Traffic disturbance caused by installation works of pipelines and water treatment plant, and transportation for soil dumping and of construction materials.
- Road damages caused by installation works and transportation of construction materials.
- Lowering of groundwater table.
- There may be aesthetic nuisance due to construction works.

4.1.3 Operation Stage

Effects to be examined during operation stage are summarized as follows.

- Influence to existing wells caused by production of groundwater, especially dry up of wells.
- Sea water intrusion to aquifers caused by production of groundwater, especially in Villa Frontera area.
- Impact to environment caused by drain of concentrated water from the water treatment plant.

4.2 Evaluation and Mitigation of Impact

4.2.1 Pre-construction Stage

(1) Well Field

All the well sites belong to the public sector because wells are constructed between the railway and the road as mentioned in 4.1.1.

The land area required for each well site is rather small (25 m^2) and is required no resettlement. Hence no significant impact is anticipated concerning this land acquisition.

(2) Water treatment plant/distribution tank sites (Lluta Treatment Plant)

The land area required for the Lluta Treatment Plant is 37,500 m^2. Though the land belongs to the private sector, it is a vacant land requiring no settlement. Hence no significant impact is anticipated concerning this land acquisition.

(3) Transmission Pipeline/Waste Water Pipeline

The land for the construction of transmission pipeline all belongs to the public sector because the land is between the Route 11 and the railway to Bolivia. No land use is confirmed on the land. It is entirely vacant one.

Hence no significant impact is anticipated concerning this land acquisition.

The waste water pipeline is laid under the existing roads, therefore, no land acquisition is necessary.

4.2.2 Construction Stage

The anticipated negative impacts are short term ones. They could be minimized by proper construction planning and schedule as follows.

1) Vibration and noise nuisance

(1) Evaluation

Nuisance by vibration and noise may be caused during construction works of wells, preparation works of water treatment plant and installation of pipelines. However, the areas are scarcely inhabited and there is no densely built-up area. Therefore, nuisance by vibration and noise could be few even if such nuisance occurred.

(2) Mitigation

Drilling work of wells is planned to be carried out during day and night. Rotary drilling method much reduces the period of construction compared with the percussion method. Rotary method requires three (3) to five (5) days for completion of drilling work. In contrary to this, it is necessary approximately one (1) month to complete by percussion method. Thus, even if nuisance by vibration and noise is caused by drilling work, it could be minimized by applying proper drilling method.

In principle reparation of land and installation of pipelines are planned to execute in daytime only. Therefore, that may not cause serious nuisance of noise and vibration.

2) Dust nuisance

(1) Evaluation

Dust nuisance to some extent is inevitable during construction. However, it is not so serious because houses are scattered in the area.

(2) Mitigation

Cleaning and water spraying of roads in and/or around the construction sites will be employed to minimize dust nuisance. The soil loads on the vehicles will be covered with sheets to mitigate dust spreading if any.

3) Traffic disturbance

(1) Evaluation

The anticipated traffic disturbance is both due to excavation of pipelines and transpiration of construction materials.

The production wells are constructed between the Route 11 and railway to Bolivia. The transmission, distribution and waste water pipelines are also installed same place. The production wells are combined to the transmission pipeline by pipeline at each well site (intake). These pipelines from wells to transmission pipeline do not cross the road. The transmission pipeline crosses the Route 11 at the Lluta Treatment Plant site. The waste water pipeline crosses the Route 11 at the same place and the Panamerican Highway at the entrance to Villa Frontera.

According to Dirección de Vialida, Primera Region, MOP, the volume of traffic of the Route 11 is approximately 300 to 400 motor lorries/day and lesser motor cars. Therefore, the impact by the installation of those pipelines are considered to be small.

Only waster water pipeline crosses the Panamerican Highway at the entrance to Villa Frontera. The traffic volume of the Highway is approximately 600 vehicles/day in total (Dirección de Vialida). The waste water pipeline is constructed under the existing road between the Highway and the coast via Villa Frontera. Traffic in the Villa Frontera area is few. Accordingly, impact caused by the installation of those pipelines are considered to be small.

The impact due to the transportation of materials is expected to be not significant.

(2) Mitigation

Though traffic disturbance is evaluated to be small, still it could be minimized by the following management and scheduling measures.

Installation of pipelines and transportation of materials will be scheduled to avoid peak hours of daily traffic with proper work plan.

Even if the installation work is planned to be executed in daytime, it is easy to provide a suitable by-pass at the working place.

4) Road damages

(1) Evaluation

The road damages anticipated are evaluated to be minimal by adopting the following mitigatory measures.

(2) Mitigation

Overloading by project vehicles shall not be allowed to minimize road damages. Road damages by project vehicles, if caused, will be immediately repaired.

Road surface damaged by installation of pipelines will be restored to the initial condition immediately after completion of the installation of pipelines.

5) Lowering of groundwater table

(1) Evaluation

No pipeline is installed under the groundwater table. Drilling of wells generally does not influence the groundwater table. Therefore, lowering of groundwater table is not anticipated.

(2) Mitigation

No mitigation method is proposed because no impact to the groundwater table is caused by the installation of pipeline and drilling of wells.

4.2.3 Operation Stage

Lowering of groundwater table, sea water intrusion to the aquifers and contamination caused by drained waste water are the anticipated potential long term impact by the project.

1) Lowering of groundwater table

(1) Evaluation

(i) Influence to existing wells

There are a few wells near the well field, and two (2) deep wells and about 10 dug wells in Villa Frontera.

Proposed 26 wells basically intend to extract a volume of groundwater which is possibly recharged every year (sustainable), not to consume the stored volume of groundwater. Influence radius by pumping is estimated within 200 m. Two (2) deep wells are more than 4,000 m away from the well field. Approximately 10 dug wells are operating in the Villa Frontera area, which are still further away from the two (2) deep wells to the well field. Thus, no influence to existing two (2) deep wells could be caused by operation of production wells.

(ii) Influence to existing surface water extraction

In the Lluta Valley, the surface water is extracted for irrigation use as mentioned in Supporting Report C. The aquifers of the Lluta Valley are recharged by the surface water. Therefore, groundwater extraction in the Lower Lluta Valley may accerelate the infiltration of surface water into the groundwater due to the lowering of groundwater table. It may fringe the existing surface water extraction (refer, Supporting Report B, B-II). Thus, a mitigation measure should be considered.

(2) Mitigation

(i) Influence to existing wells

No mitigatory measure is proposed for the influence of existing wells, because no impact is anticipated. However, monitoring the groundwater level is proposed to observe the variation of groundwater level. Detailed monitoring schedule is mentioned in Supporting Report B-II.

(ii) Influence to existing surface water extraction

A new irrigation system is proposed to cope with the influence to the surface water extraction as mentioned in supporting Report B, B-II. The new irrigation system aims to distributes irrigation water to the sector III, IV and V. It consists of one (1) headworks, irrigation canal, collection channel and returning channel. The existing intakes are integrated to one (1) headworks in the upstream of Poconchile. The extracted water will be distributed to these sectors by new irrigation canal. Further, the collection channels collect the surplus water (drain water) to return to the irrigation canal for recycling use. This proposed new irrigation system satisfies all the existing water rights including the legally authorized and customary ones. For more detail, see Supporting Report B, B-II.

2) Sea water intrusion to the aquifer

(1) Evaluation

As mentioned above, production wells are planned to extract a recharged volume of groundwater, therefore, no sea water intrusion to the aquifers in the Villa Frontera area is basically considered. Even if caused, the extent of sea water intrusion is estimated small and all the dug wells are excavated above the sea level. It means that no sea water can reach to the those dug wells since extraction rate of wells is negligibly small.

(2) Mitigation

Wells located near the well field may be affected by the lowering of groundwater table due to operation of wells. If it ever caused, any problem to existing wells then the extraction abstraction will be reduced so that the existing wells are not affected.

3) Contamination by concentrated water

(1) Evaluation

A total volume of 47,740 m^3 (daily maximum) of raw water is treated in the Lluta Water Treatment Plant and approximately 12,300 m^3 of waste water (concentrated water: 11,970 m^3 and backwashed water: 320 m^3) is drained every day. Contents of major ions in waste water are shown below;

Ion	mg/l	Ion	mg/l	Ion	mg/l
(TDS)	13,030	SO_4	3,422	Fe	5.3
Ca	1,203	Cl	3,751	Mn	2.8
Mg	361	HCO_3	381	As	0.105
Na	2,093	CO_3	0	B	74.3
K	241			SiO_2	107.4

Waste water is lead to the coast by the pipeline and drained directly to the sea near the Villa Frontera area. There is a beach resort in the Chinchorro, to the south from the outlet of waste water pipeline. However, this waste water is carried away towards the north and is immediately diluted with sea water. Therefore, no significant effect is caused to the environment of the vicinity.

(2) Mitigation

No mitigation measure is proposed since no significant negative impact is anticipated by drain of waste water.

Table E, 4.1 Matrix of Important Environment Impact Assessment
<Matriz sobre la Evaluación del Importante Impacto Ambiental>

Assessment Factor	Project Stage	Impact Examination	Impact Assessment
(a) Population affected	1) Pre-construction stage	No resettlement of population with respect to land acquisition for well construction, water treatment plant and pipelines is involved.	Less important
	2) Construction stage	The daily average population affected is few.	Less important
	3) Operation stage	The impact is less important, in consideration to scarce habitation in the surrounding area of well sites and water treatment site. No impact is caused by groundwater lowering. Waste water drain causes no significant effect to the environment.	Less important
(b) Area of impact distribution	1) Pre-construction stage	Although the required land of about 4 ha for construction of water treatment plant belongs to the private sector, it is not so difficult to acquisite. Other required lands for 26 well sites and pipeline routes belong to the public sectors. All those lands require no resettlement.	Less important
	2) Construction stage	All the institutions are constructed in the scarcely habitation area. In contrary to this, the area of benefit is the whole Arica city. The ratio of affected area to benefited area is quite small.	Less important
	3) Operation stage	No impact is anticipated.	Less important
(c) Duration of impact	1) Pre-construction stage	No impact is anticipated.	Less important
	2) Construction stage	Construction period is planned two (2) years. This is a very short period in comparison to the long-term benefit of the project beyond its implementation.	Less important
	3) Operation stage	The duration of potential impact is long-term. However, it is not significant.	Less important

Assessment Factor	Project Stage	Impact Examination	Impact Assessment
(d) Intensity of impact	1) Pre-construction stage	No impact is anticipated.	Less important
	2) Construction stage	(i) Vibration and noise nuisance Construction work is carried out only in the scarcely inhabited area. The impact is considered as less important.	Less important
		(ii) Dust Nuisance Dust nuisance can be minimized easily by adopting accepted procedures like water spraying and covering of soil transportation vehicles.	Less important
		(iii) Traffic disturbance Traffic volume of both Panamerican Highway and the Route 11 is small even if additional surplus transportation trucks is included.	Less important
		(iv) Road damages In consideration to the available mitigatory measures of road damages and the amenability of quick repair of road damages, the impact is considered as less important.	Less important
		(v) Groundwater lowering No impact is anticipated.	Less important

Assessment Factor	Project Stage	Impact Examination	Impact Assessment
(d) Intensity of impact (continued)	3) Operation stage	(i) Lowering of groundwater table Arrangement of wells are planned considering the radius of influence. Lowering of water level in Villa Fronterea area is considered to be small. Groundwater extraction will cause the lowering of groundwater table, resulting in accerelation of the river water infiltration into the underground. It may infringe the existing river water extraction of the for irrigation use. However, no significant impact is anticipated after adoption of the compensation works.	Less important
		(ii) Sea water intrusion to aquifers Groundwater extraction is planned to be within the recharge volume to the aquifers. Basically no significant impact is anticipated.	Less important
		(iii) Contamination by concentrated water Concentrated water is directly lead to the sea by pipeline and it is rapidly diluted by the sea water. No significant impact is anticipated.	Less important
(f) Cumulativeness of impact	1) Pre-construction stage	No significant impact is anticipated.	Less important
	2) Construction stage	In consideration to the very temporary nature of the construction activities, the cumulativeness of impact is assessed to be nil (0).	Less important
	3) Operation stage	There is no accumulative effect concerned to the operation of water treatment plant and well operation.	Less important

Chapter V PREDICTION OF ENVIRONMENT IMPACT IN PAMPA DEL TAMARUGAL BASIN

5.1 Pre-construction Stage

The Project contributes to the improvement of potable water supply environment to Iquique city and is indispensable for the future development of the city. However, some negative impacts may be also expected to some extent. The impacts in the pre-construction, construction and operation stages are listed in Table E, 5.1.

The anticipated negative impacts in the three (3) stages are described in detail as follows.

5.1.1 Pre-construction Stage

Prior to construction of water supply system, following lands need to be acquired.

1) Well field (La Tirana Well Field: Pampa North)

16 wells are to be newly constructed (eight (8) wells in the first stage and remaining wells in the second stage) in the proposed La Tirana Well Field (Pampa North). A land of 2,560,000 m^2 (= 1,600 m x 1,600 m) is needed for the well field.

Well field is located approximately 4.5 km away to the southwards from the road between Pozo Almonte and Sagasca. An access road is necessary to construct from the road to Sagasca and of which length is approximately 5,800 m (Ref. Supporting Report D). A land necessary for the access road is 58,000 m^2 (=5,800 m x 10 m).

2) Transmission pipeline

Transmission pipeline is laid in the underground between the La Tirana Well Field and Cavancha Distribution Tank along the existing roads. Land necessary for the pipeline is 135,200 m^2 (= 2 m x 67,600 m).

3) Transmission and pressure-break tank sites

One (1) transmission tank is to be constructed at the Santa Laura site. Land necessary for this site is 3,000 m^2 (=50 m x 60 m). In addition to this, three (3) more pressure-break tanks will be constructed on the route to Alto Hospicio; La Isla Tank, El Toro 1 Tank and El Toro 2 Tank. Lands necessary for these tanks are 2,000 m^2 (=40 m x 50 m).

5.1.2 Construction Stage

The possible negative impacts which may occur during the construction stage are summarized as follows, however, they will be all temporary and short term ones, and would disappear with the completion of construction activities.

- Nuisance by vibration and noise during well construction works, installation of pipeline and preparation work of water tank sites .
- Dust caused by earth works during installation of pipeline and preparation work of water tank sites.
- Traffic disturbance caused by installation works of pipelines and construction of water tanks, and transportation for soil dumping and of construction materials.
- Road damages caused by installation works and transportation of construction materials.
- There may be aesthetic nuisance due to construction works.

5.1.3 Operation Stage

Effects to be examined during operation stage are summarized as follows.

- Influence to existing wells caused by production of groundwater, especially dry up of wells.
- Influence to the Tamarugo Forests due to the groundwater level lowering caused by production of groundwater.

5.2 Evaluation and Mitigation of Impact

5.2.1 Pre-construction Stage

(1) Well field

The well field is located in the dessert and no land use is confirmed. Most land in the area belongs to the public sector, however, a part of access road may belong to the private sector.

Each land areas required for the well field and access road are rather small (approximately 2,600,000 m^2). Although a part of lands belongs to the private sector, they are small part of the private lands requiring no resettlement. Hence no significant impact is anticipated concerning this land acquisition.

However, co-ordination among the concerned governmental agencies is necessary to expedite the land acquisition procedure.

(2) Transmission pipeline

Most lands for the installation of transmission pipeline belongs to the public sector because the pipeline is laid along the existing road. Only in the Pozo Almonte area, the pipeline will pass through the densely built-up area. However, it is possible to avoid the most densely built-up area by properly selecting the route.

Hence no significant impact is anticipated concerning this land acquisition.

(3) Water treatment plant

The land areas required for the tanks are rather small (3,500 m^2 for transmission tank and 2,000 m^2 x 3 sites for pressure-break tanks). They are located in the dessert area and are vacant lands requiring no settlement. Hence no significant impact is anticipated concerning this land acquisition.

5.2.2 Construction Stage

The anticipated negative impacts are short term ones. They could be minimized by proper construction planning and schedule as follows.

1) Vibration and noise nuisance

(1) Evaluation

Nuisance by vibration and noise may be caused during construction works of wells, preparation works of water tanks sites and installation of pipelines. The nearest town to the well field is La Tirana and it is approximately 20 km of distance. There is no inhabitants in/around the vicinity of the well field.

Transmission pipeline is installed in the dessert area except the Pozo Almonte and Alto Hospicio areas. Vibration and noise nuisance are inevitable to a certain extent in these areas. However, it is possible to minimize the nuisances by following mitigation measures.

(2) Mitigation

In principle preparation of land and installation of pipelines are planned to be executed in daytime only. Therefore, that may not cause serious nuisance of noise and vibration.

2) Dust nuisance

(1) Evaluation

Dust nuisance to some extent is inevitable during construction. However, it is not so serious because houses are scattered in the area except Pozo Almonte and Alto Hospicio areas.

Following mitigation measures are planned to be adopted in Pozo Almonte and Alto Hospicio areas.

(2) Mitigation

Cleaning and water spraying of roads in and/or around the construction sites will be employed to minimize dust nuisance. The soil loads on the vehicles will be covered with sheets to mitigate dust spreading, if necessary.

3) Traffic disturbance

(1) Evaluation

The anticipated traffic disturbance is both due to excavation of pipelines and transportation of construction materials.

The transmission pipelines is installed along the existing roads; the road to Sagasca from well field to Pozo Almonte, Panamerican Highway between Pozo Almonte and Humberstone, and the Route 1 from Humberstone to Iquique (old road near Alto Hospicio). The pipeline crosses the Panamerican Highway at Humberstone, several times Route 1 and once the railway line between Alto Hospicio and Cavancha.

According to Dirección de Vialidad, Primera Region, MOP, the average volumes of traffic of each road are as follows.

Humberstone-Iquique (Route 1)	: 1,988 vehicles/day
Humberstone-Pozo Almonte (Panamericana)	: 1,626 vehicles/day
Humberstone-Huara (Panamericana)	: 1,130 vehicles/day

Trains from/to Iquique pass the railway several times a week.

Therefore, the impact due to the installation of those pipelines are considered to be not so significant.

(2) Mitigation

Though traffic disturbance is evaluated to be small, it could be minimized by the following management and scheduling measures.

Installation of pipelines and transportation of materials will be scheduled to avoid peak hours of daily traffic with proper work plan.

Even if the installation work is planned in daytime, it is easy to provide a suitable by-pass at the working places.

4) Road damages

(1) Evaluation

The road damages anticipated are evaluated to be minimal by adopting the following mitigation measures.

(2) Mitigation

Overloading by project vehicles shall not be allowed to minimize road damages. Road damages by project vehicles, if caused, will be immediately repaired.

Road surface damaged by installation of pipelines will be restored to the initial condition immediately after completion of the installation of pipelines.

5) Lowering of groundwater table

(1) Evaluation

No pipeline is installed under the groundwater table. Drilling of wells generally does not influence the groundwater table. Therefore, lowering of groundwater table will not be caused.

(2) Mitigation

No mitigation method is proposed because no impact to the groundwater table is caused by the installation of pipeline and drilling of wells.

5.2.3 Operation Stage

Lowering of groundwater table is the anticipated potential long term impact by the project. Under these circumstances, influence to the existing wells and Tamarugo Forests are major potential impacts to be considered.

1) Influence to the existing wells

(1) Evaluation

There are totally 458 well in Pampa del Tamarugal Basin. According to the field interview by DGA and the Study Team, only 12 wells other than ESSAT wells are actually operating (Supporting Report B-III). Depth and static water level of those wells are as follows;

Water Use	No. (BNA)	Name	Depth (m)	S.W.L (mBGL)	Extraction Rate (l/sec)
Irrigation	381	CONAF	12	9.2	0.03
	412	CONAF	8	5.4	0.02
	363	Luis Quispe	10	6.7	0.30
Domestic	426	Esteban Lucic	395	12.0	0.04
	316	David Chiang	12	9.6	0.20
	312	Guillermo Araya	13 (?)	13	0.17
	128	CORFO	12	8.7	0.01
	-	Dupliza (3 wells)	90-114	52.0	60.00
	**	Canchones	54-110	14.0*	599.78
	**	Dolores	32-49	8.9	0.46
	131	La Tirana 1	199	21.7	
Mining	985	ACF Minera	162	23.3	5.00
	951	Oficina Mapocho	251	55.0	30.00

* : S.W.L of JICA Well No. 6 (Canchones)

** : Well field of ESSAT

Lowering of the groundwater level in Pampa del Tamarugal is predicted by the groundwater simulation by the Study Team. The results are shown in Supporting Report B-III.

Six (6) wells, out of 12 wells, are so shallow (less than 13 m) that the wells will be dried up as a result of the groundwater production in La Tirana Well Field.

Although the production rates of six (6) wells are rather small (less than 0.3 l/sec), following mitigation or substitutional measure should be considered.

(2) Mitigation

As mentioned above, drying up of the wells is inevitable so far as the groundwater development is executed in the La Tirana Well Field. Therefore, new wells should be constructed to compensate for the dried wells. Prediction of water level by case is shown in Table E, 5.2. If all the water right application is approved (case 2-2 of simulation), wells to be drilled are as follows;

Existing Well			New Well to be drilled	
BNA	Well Name	Depth (m)	Depth (m)	by the year
381	CONAF	12	35	1999
412	CONAF	8	35	1999
363	Luis Quispe	10	40	1999
316	Davis Chiang	12	40	1999
312	Guillermo Araya	13	40	1999
128	CORFO	12	75	1999

Note: Depth of new wells is estimated based on the water level of Case 2-2 in 2093.

Construction cost of these wells are as follows;

Item			Quantity		Unit Price (US$)	Cost (US$)
1	Mobilization to the Site		1	times	25,000	25,000
2	Installation		6	sites	3,000	18,000
3	Drilling (including Drilling Mud)		265	m	250	66,250
4	Well Logging		265	m	1 lot	28,725
5	Installation of Casing & Screen)				-	-
	(1)	Casing Pipe 5-1/2"	79.5	m	50	3,975
	(2)	Screen Pipe 5-1/2"	185.5	m	150	27,825
	(3)	Installation of Screen/Casing Pipes	265	m	15	3,975
	(4)	Gravel Packing	90	m^3	550	49,500
6	Development (15 hours)		6	wells	3,500	21,000
7	Pumping Test		6	wells	15,000	90,000
8	Transfer between the Sites		5	times	2,500	12,500
9	Installation of water pump		6	wells	20,000	6,000
10	Demobilization from the Site		1	time	25,000	25,000
TOTAL						377,750

2) Influence to Tamarugo Forests

National reserved areas are designated in Pampa del Tamarugal and several Tamarugo Forests exist in the areas as mentioned in Chapter 2 of this report. Locations of the forests are shown in Fig. E, 2.2 and 2.3.

Roots of Tamarugo is assumed to reach a depth of 25 - 30 m. If groundwater level becomes lower than this depth, the forests may receive some influence. Groundwater simulation (Case 2-2) is the worst case; water demand is maximum. The results show that lowering of water level in 2093 (100 years after) is less than 20 m in the most areas and approximately 25 m in maximum. Therefore, impact to Tamarugo Forest due to groundwater lowering is not so significant.

Also, it is said that a root of Mosquite (similar species of Tamarugo) has grown to 50 m depth in Pampa del Tamarugal, although it has not been confirmed yet by field survey. If this is true, no significant impact is recognized to Tamarugo Forests.

(2) Mitigation

It is estimated that influence of groundwater lowering to Tamarugo Forests is not so significant. Although, mechanism of water absorption of trees has been studied by many researchers since 1962, it has not been confirmed that "How deep roots of Tamarugo trees can grow."

Considering these circumstances, it is proposed to continue the observation of groundwater level in Pampa del Tamarugal Basin. Detailed groundwater monitoring system is mentioned in Supporting Report B.

Table E, 5.1 Matrix of Important Environment Impact Assessment
<Matriz sobre la Evaluación del Importante Impacto Ambiental>

Assessment Factor	Project Stage	Impact Examination	Impact Assessment
(a) Population affected	1) Pre-construction stage	No resettlement of population with respect to land acquisition for well construction, water treatment plant and pipelines is involved.	Less important
	2) Construction stage	The daily average population affected is few.	Less important
	3) Operation stage	Six (6) existing wells will be affected. Considering the small extraction rates of these wells and water use, population affected is quite small. While the population of Iquique city will be more than 270,000 in 2015. The rate of affected population to benefitted population is very small and new well construction is proposed as a substitutional measure. Then, the impact is considered to be small.	Less important
(b) Area of impact distribution	1) Pre-construction stage	The required land for well field is about 2.3 ha. The land belongs to the public sector and no resettlement is involved. Other required lands for water tank sites and pipeline route belong to the public sectors and it is vacant lands requiring no settlement.	Less important
	2) Construction stage	All the institutions are constructed in the scarcely habitated area except Pozo Almonte area where pipeline passes through. Its length is approximately 1 km. In contrary to this, the area of benefit is the whole Iquique city. The ratio of affected area to benefited area is quite small.	Less important
	3) Operation stage	Lowering of groundwater level will affect to six (6) existing wells. However, it can be minimized by adopting substitutional measures (construction of new wells). Influence to Tamarugo Forests is considered to be not so significant. No other impact is anticipated.	Less important but monitoring of groundwater table is required.

Assessment Factor	Project Stage	Impact Examination	Impact Assessment
(c) Duration of impact	1) Pre-construction stage	No impact is anticipated.	Less important
	2) Construction stage	Construction period is planned two (2) years. This is a very short period in comparison to the long-term benefit of the project beyond its implementation.	Less important
	3) Operation stage	The duration of impact is long-term. However, when substitutional measure is executed, the impact is not significant.	Less important
(d) Intensity of impact	1) Pre-construction stage	No impact is anticipated.	Less important
	2) Construction stage	(i) Vibration and noise nuisance Construction work is carried out only in the scarcely inhabited area except Pozo Almonte area. The impact is considered as less important.	Less important
		(ii) Dust Nuisance Dust nuisance can be minimized easily by adopting accepted procedures like water spraying and covering of soil transportation vehicles.	Less important
		(iii) Traffic disturbance Traffic volume of both Panamerican Highway and the Route 11 is small even if additional surplus transportation trucks is included.	Less important
		(iv) Road damages In consideration to the available mitigatory measures of road damages and the amenability of quick repair of road damages, the impact is considered as less important.	Less important

Assessment Factor	Project Stage	Impact Examination	Impact Assessment
(d) Intensity of impact (continued)		(v) Groundwater lowering No significant impact is anticipated after adoption of substitutional measure.	Less important
	3) Operation stage	(i) Lowering of groundwater table No significant impact is anticipated after adoption of substitutional measure.	
		(ii) Influence to Tamarugo forests No significant impact is anticipated.	
(e) Cumulativeness of impact	1) Pre-construction stage	No significant impact is anticipated.	
	2) Construction stage	In consideration to the very temporary nature of the construction activities, the cumulativeness of impact is assessed to be nil (0).	
	3) Operation stage	There is no accumulative effect concerned to the operation of well field after adopting the substitutional measure.	

Table E, 5.2 Prediction of Groundwater Lowering

<Predicción de la Depresión del Agua Suterránea>

Well No. (BNA)	Name	Depth (m)	S.W.L (m)	Case 1-1			Case 1-2			Case 2-1			Case 2-2		
				2015	2043	2093	2015	2043	2093	2015	2043	2093	2015	2043	2093
381	CONAF	12	9.2	12.2	17.2	22.2	12.2	18.2	22.2	12.2	20.2	23.2	12.7	21.2	24.2
412	CONAF	8	5.4	9.1	18.4	21.4	9.4	18.4	21.4	9.9	18.4	24.4	11.9	18.4	26.4
363	Luis Quispe	10	6.7	10.7	19.7	23.7	11.2	18.7	23.7	11.2	19.7	31.7	11.2	19.7	31.7
316	David Chiang	12	9.6	12.6	12.6	19.1	12.6	19.6	26.6	13.1	24.6	27.6	13.6	24.6	30.6
312	Guillermo Araya	13	13.0	16.0	21.0	26.0	16.0	21.0	27.0	16.5	25.0	29.0	16.5	26.0	30.0
128	CORFO	12	8.7	9.7	9.7	10.2	9.7	9.7	10.7	16.7	33.7	38.7	23.7	48.7	63.7
-	Dupliza (3 wells)	90	52.0	55.0	58.0	62.0	55.0	59.0	64.0	55.0	62.0	70.0	57.5	62.0	70.0
	Canchones	110	9.6	12.6	17.6	23.6	12.6	18.6	24.6	13.1	21.6	27.6	13.6	21.6	30.6
	Dolores	32	8.9	10.4	12.9	16.9	10.4	12.9	18.9	11.9	16.9	21.9	11.9	16.9	23.9
131	La Tirana	199	21.7	24.7	29.7	35.7	24.7	29.7	35.7	25.2	33.7	39.7	27.7	35.7	40.7
985	ACF Minera	162	23.3	24.8	25.3	26.3	24.8	26.3	27.3	24.3	30.3	31.3	26.8	31.3	32.3
951	Oficina Mapocho	251	55.0	55.0	55.0	58.0	56.0	57.0	59.0	56.5	58.0	63.0	56.5	61.0	67.0

Unit : mBGL

THE STUDY
ON
THE DEVELOPMENT OF WATER RESOURCES
IN
NORTHERN CHILE

SUPPORTING REPORT F : PROJECT ECONOMY AND FINANCI

MARCH 1995

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO

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<u>SOCIO-ECONOMIC ANNEX</u>

Chapter I NATIONAL AND REGIONAL ECONOMIC CONDITIONS

1.1 Brief Description of National Economic Conditions

1.1.1 General

The Chilean economy has been growing very fast at a rate of 27.3% for the period 1990 - 1993. This growth can be explained by growth of investment in fixed assets (46.7%) and exports (44.8%) Living conditions measured by growth of consumption expenditures (private and public) improved by 27% during the four years period. More than half a million new jobs were created during the same period; the unemployment rate fell down to 4.4%. Inflation was under control with an average rate of 12.2% at the end of 1993, The level of International Net Monetary Reserves grew three times compared to the level of 1989. The Chilean peso was devaluated 11.5% compared with its 1992 average level (from 362.58 pesos/dollar to 404.17 pesos/dollar)
Main economic indicators are shown below.

Gross Domestic Product Growth Rate	27.3 %
Fixed Capital Investment Growth Rate	46.7 %
Exports Growth Rate	44.8 %
Total Consumption Growth Rate	27.0 %
New Jobs	570,300
International Reserves Level	10,200 million dollars
Annual Inflation Rate	12.2 %
Unemployment Level Rate	4.4 %
Coefficient of Investment in Fixed Assets	27.5
Average Annual Devaluation Rate	11.5%

Source: INE

1.1.2 Global Supply and Demand

In 1993 GDP and total imports increased 5.7% and 11% respectively. Global supply and demand are shown in Table F, 1.1.

Due to this increase global supply of goods and services increased 7.2% compared with the 1992 level.

Taking into account the results above mentioned, it can be said that GDP has been growing at an accumulative annual average rate of 6.2%. If it is assumed that the population has been growing at a steady rate, the per capita GDP has grown 4.6%

compared with 1992 and almost 20% if compared with the 1989 level.

Chile's GDP growth rate of 5.7% is remarkable if it is compared with the rates achieved by other countries within the Latin America and Caribbean region (average rate: 1.3%) and the 7 main industrialized countries (average rate: 1.1%)

Exports grew 3.5% which is a moderate rate if compared with other years. This means that a strong domestic demand was the main stimulant factor behind the growth of the economy. Domestic demand grew at a rate of 8.5% compared with the level of 1992. Of total availability of goods and services, 74% was sold domestically in order to satisfy consumption and investment needs.

In terms of growth of global supply, from 512.3 thousand million pesos (1986 pesos), 67.2 thousand million pesos were exports and 445.1 thousand million pesos were used for the domestic market. From the 445.1 thousand million pesos, 208.2 thousand million pesos were spent in increasing the production capability and 236.9 thousand million pesos were used for consumption purposes. In other words, from the increase in goods availability, around 41% of it was used to improve the production capability incorporating modern technologies.

Domestic demand grew 14.6% and 11.1% during the first and second quarters of 1993 respectively. This growth brought about a strong increase in import of services and goods of 19.1% and 14.2% for the same quarters. The increase was represented mainly by increased imports of capital goods required by the investment process. From the third quarter, domestic demand began to desaccelerate reaching a growth of 6.6%. This desacceleration affected the GDP and volume of imports. GDP growth rate for the first quarter of 1993 was 8% while for the third it was around 5%. Volume of imports registered a growth rate of 19% for the first quarter while for the third quarter it was 10%.

The growth in domestic demand for the first two quarters can be explained by the growth in the construction sector and imports of capital assets.

Domestic supply related to development of investment projects reacted in an adequate way. Specially the construction sector, which was the most active during 1993 as well as the industrial branches producing inputs required for the construction works. On the other hand, the availability of foreign exchange made it possible to increase imports in order to satisfy that sector of the domestic demand which was not covered by the GDP.

1.2 Regional Socio-economic Indicators

1.2.1 Demographic Data

Region I covers the Provinces of Arica, Iquique and Parinacota. Its territorial surface is 58,698.1 km^2 which represents 7.8% of the continental area. At present it has a population of 341,112 habitants which is 2.58% of total national population; its population is divided in 95% and 5% for urban and rural population respectively. Regional population density is 5.8 hab/km^2, being 34 hab/km^2 and 53 hab/km^2 for the Arica and Iquique communities respectively. Rural density is 0.4 hab/km^2.

Demographic information for the three provinces and ten communities of Region I is shown in Table F, 1.2.

The regional and country average population growth rates are shown below for different time periods:

unit: %

Period	60-70	70-82	82-92
Region	3.80	3.76	2.99
Country	1.99	2.03	1.79

Source: INE

1.2.2 Regional Production

The regional economy has a remarkable mono-producer characteristic; it means that the main contributor to the Regional Gross Domestic Product is the manufacturing sector which is centered on the fishery sector. With the introduction of the Free Zone (ZOFRI) from 1975 generated a strong impact on the commercial and services sectors. However it was not strong enough to make it possible the diversification of the regional economy.

Contribution of main productive sectors to total regional production is as follows:

a)	Fishery processing industry	35.6%
b)	Services	21.4%
c)	Commerce	14.0%
d)	Extractive fishery	10.8%
e)	Agriculture	2.3%
f)	Mining	1.5%

1.2.3 Regional Public Investment

Regional public investment per habitant for the last seven years is shown in the following Table:

(unit: million 1992 pesos)

Year	Amount	Population	Investment/Habitant ($)
1985	5,564	293,447	18,961
1986	7,815	299,815	26,066
1987	8,442	306,321	27,559
1988	12,718	312,968	40,637
1989	10,159	319,759	31,771
1990	13,198	326,698	40,398
1991	15,871	333,698	47,548
1992	22,348	341,112	65,515

Source: SERPLAC

In average public investment percapita is around $37,189 being 1992 the year with the highest investment amount and 1985 the lowest. During the recent years it can be seen that investment was been growing steadily.

1.2.4 Labor

According to data from INE, Region I's total labor force is around 140,150 persons from which 135,450 persons are actually employed. Employed labor force is mostly composed by men (92,290 persons or 65.85% of total labor force). Unemployment rate for the latest data (first quarter of 1993) was 4.78%.

The service, commerce, and industry sectors occupy around 67% of total regional labor force.

Another important parameter to consider is the historical unemployment trend of recent years in order to visualize the regional trend and national average. The Table F, 1.4 shows the rate of unemployment at regional and country level.

It can be seen that the regional average has been always inferior to the national average. It can be seen that Arica shows unemployment rates above the ones from Iquique, except in the year 1989.

1.2.5 Poverty

Poverty is understood as that level of income which is too low to satisfy basic needs of the members of a household. Extreme poverty means that level of income which is so low that even if whole income is used for food, it would not be enough to satisfy the nutritional needs of the household members.

The following Table gives data on poverty and extreme poverty levels in Region I.

	Urban Sector (Persons)	(%)	Rural Sector (Persons)	(%)	Total Region (Persons)	(%)
Extreme Poverty	26,446	8.1	1,239	5.9	27,685	8.0
Poverty	75,324	23.2	4,525	21.7	79,849	23.1
Total Poverty	101,770	31.3	5,764	27.6	107,534	31.1

Source: MIDEPLAN-Casen 1990

However, it must be said that Region I has the lowest level proportion of poverty within the country.

1.3 Main Sectorial Indicators

1.3.1 Fishery

Fishery industry is the main economic activity in Region I. The following Table shows the fishery-related production.

(Unit: ton)

Year	Fishmeal	Oil	Canning	Frozen	Total
1985	707,716	111,730	10,231	1,904	831,581
1986	745,887	123,943	12,392	2,662	884,884
1987	449,027	60,772	12,413	2,348	524,560
1988	448,135	24,261	14,867	2,092	489,355
1989	560,037	96,316	20,510	2,908	679,771
1990	309,697	38,379	12,428	5,693	366,197
1991	331,986	46,196	3,454	4,690	386,326
1992	344,295	24,354	9,628	6,853	385,130

Source : INE/MINVU/ESSAT

Exports of the fishery-related production is shown below..

(Unit : Thousand Dollars)

Year	Fishmeal	Oil	Canned	Frozen	Total
1985	185,481	31,517	3,065	1,913	221,976
1986	206,284	17,689	8,907	2,196	234,078
1987	198,800	13,849	8,324	1,287	224,240
1988	184,415	16,824	9,278	1,684	212,181
1989	225,310	18,648	16,554	1,809	282,321
1990	118,173	7,401	10,083	1,840	138,497
1991	138,432	11,387	4,583	2,914	157,296
1992	168,008	8,114	5,311	2,078	183,509

Source : INE/MINVU/ESSAT

1.3.2 Mining

The mining sector represents one of the sectors with the highest development potential in the region.

The following Table shows production in tons of non-metallic and metallic minerals in the region for 1991.

	(unit: ton)
NON-METALLIC	
Sodium Chloride	1,674,483
Sodium Sulfate	921
Iodine	1,214
Kieselghur	11,668
Boric Acid	17,328
METALLIC	
Gold	2,921 (kg)
Silver	23,699 (kg)
Cooper	17,832

Source: SERPLAC

1.3.3 Agriculture

Agriculture is not a very important contributor to total regional production (it contributes with only 2.3%) However, it can this fact can be explained by the physical conditions of Region I which are not so optimal for agricultural production. However, agricultural sector contributes to the region under the form of agricultural exports.

Data concerning production and exports can be seen in following tables respectively.

Year	Olive (Ton)	Tomatoes (Ton)	Corn (1,000 units)
1985	3,993.0	18,810.0	22,136.0
1986	6,194.0	16,555.0	22,360.0
1987	3,706.0	21,360.0	24,500.0
1988	1,575.0	35,630.0	26,250.0
1989	5,759.0	35,840.0	26,250.0
1990	4,185.0	39,100.0	26,100.0
1991	6,020.0	50,254.0	27,000.0
1992	960.0	54,943.0	32,400.0

Source : Ministry of Agriculture

(unit: ton)

Year	Olive	Oregano
1985	96	78.0
1986	191	70.0
1987	167	83.0
1988	130	89.0
1989	242	138.0
1990	352	194.0
1991	390	178.0
1992	306	27.3

Source: Ministry of Agriculture

1.3.4 ZOFRI (Free Zone)

The Free Zone of Iquique greatly contributed to the growth of international trade in the region. Sales in 1992 were 1,620.8 Million Dollars, representing an increase of 13% compared with 1991. Total operational commercial movement for 1992 was 3,220.4 Million Dollars. From total sales made in 1992, 334.7 Millions correspond to those made in the region, 411.8 Millions to the rest of the country, and 874.3 correspond to sales outside the country.

Following table shows Commercial Movement in the Free Zone.

(unit: Million Dollars)

Year	Purchases	Sales	Total
1990	937.9	1,051.6	1,989.5
1991	1,436.2	1,434.0	2,870.2
1992	1,599.6	1,620.8	3,220.4

Source: ZOFRISA

Following table shows the employment generated by ZOFRI.

Sectorial Employment			Total Employment by ZOFRI		
Commerce Services	Industry Iquique	Industry Arica	Arica	Iquique	Total
5,240	1,607	2,936	2,935	6,847	9,782

Source: ZOFRISA

On the other hand ZOFRI allocates part of its revenues (15%) to the communities of Iquique province. In 1992, this percentage represented 521 Million Pesos which allows for an increasing the communal financial resources as well as an contribution to the Regional Development Fund (Fondo de Desarrollo Regional, FNDR) of 223 Million Pesos. For 1993, this contribution amounted to 266 Million Pesos.

1.3.5 Housing Sector

Data concerning number of houses, private and public, and coverage of water supply and sewerage services is shown below.

	Housing			Coverage	
Year	Public	Private	Total	Water Supply	Sewerage
1985	1,372	250	1,622	96%	80%
1986	1,286	241	1,527	98%	86%
1987	694	320	1,014	98%	86%
1988	1,340	313	1,653	98%	86%
1989	1,603	586	2,189	98%	86%
1990	1,649	573	2,222	98%	86%
1991	1,872	877	2,749	98%	86%
1992	2,035	2,035	363	98%	93%

Source : INE/MINVU/ESSAT

1.3.6 Energy Sector

The following Table shows information concerning electricity consumption in the provinces of Arica and Iquique.

(Unit: kW)

Year	Arica	Iquique	Region
1985	81,122	117,411	198,533
1986	80,003	124,580	204,583
1987	79,913	122,540	202,453
1988	81,202	126,034	207,236
1989	94,071	127,707	221,778
1990	93,893	125,471	219,364
1991	101,215	125,066	226,281
1992	112,827	139,379	252,206

Source : EMELAR/ELIOSA

Table F, 1.1 Global Supply and Demand (Thousand million of 1986 Pesos)
<Oferta Global y Demanda (Mil Millones de Pesos, 1986>

						Annual Change Rates			
	1989	1990	1991	1992	1993	1990	1991	1992	1993
Gross Domestic Product	4308.3	4436.0	4705.1	5188.7	5484.5	3.0	6.1	10.3	5.7
Imports	1482.9	1512.6	1607.6	1968.6	2185.1	2.0	6.3	22.5	11.0
Global Supply	5791.2	5948.6	6312.7	7157.3	7669.6	2.7	6.1	13.4	7.2
Exports	1372.8	1494.2	1643.9	1920.3	1987.5	8.8	10.0	16.8	3.5
Domestic Demand	4418.4	4454.4	4668.8	5237.0	5682.1	0.8	4.8	12.2	8.5
Total Investment	1135.3	1097.6	1074.5	1303.1	1511.4	-3.3	-2.1	21.3	16.0
Fixed Assest Investment	1029.0	1092.0	1051.0	1301.4	1509.6	6.1	-3.8	23.8	16.0
Stock Variations	106.3	5.6	23.5	1.7	1.8				
Total Consumption	3283.1	3356.8	3594.3	3933.9	4170.7	2.2	7.1	9.4	6.0
Households Consumption	2838.7	2918.2	3137.8	3453.5	3671.1	2.8	7.5	10.1	6.3
Government Consumption	444.4	438.6	456.5	480.4	499.6	-1.3	4.1	5.2	4.0
Global Demand	5791.2	5948.6	6312.7	7157.3	7669.6	2.7	6.1	13.4	7.2

Source : 1989 - 1992 Central Bank
1993 INE

Table F, 1.2 Population, Surface and Density by Province and Communities
<Población, Superficie y Demandaapor Provincia y Comunidades>

Province/Community	Population		Surface	
	(habitant)	(%)	(km^2)	(%)
Prov. Arica	170,064	49.9	8,726.1	14.9
Arica	169,217	49.6	5,010.6	8.5
Camarones	847	0.3	3,715.5	6.3
Prov. Parinacota	3,805	1.1	8,172.5	13.9
Putre	2,797	0.8	6,061.4	10.2
General Lagos	1,008	0.3	2,111.1	3.6
Prov. Iquique	167,243	49.0	41,799.5	71.2
Iquique	152,529	44.7	2,876.1	4.9
Pozo Almonte	7,266	2.1	13,775.0	23.5
Pica	2,514	0.7	8,668.2	14.8
Huara	1,964	0.6	10,416.1	17.7
Camina	1,420	0.4	2,138.6	3.6
Colchane	1,550	0.5	3,925.5	6.7
Total Region	341,112	100.0	58,698.1	100.0

Source: INE - Census 1992

Table F, 1.3 Distribution of Labour Force
<Distrobución de la Mano de Obra>

unit: thousand persons

Activity	Arica	Iquique	Rest of Communities	Region
Agriculture/Fishery	3.7	2.3	7.0	13.0
Mining	0.4	1.0	0.7	2.1
Manufacturing	10.2	7.6	0.0	17.8
Energy, Water, Gas	0.2	0.4	0.1	0.7
Construction	3.0	5.7	0.3	9.0
Commerce	16.6	18.9	1.1	36.6
Transport	6.5	8.2	0.4	15.1
Financial Services	2.0	2.5	0.1	4.6
Other Services	17.1	16.6	0.8	34.5
TOTAL	59.7	63.2	10.5	133.4

Source: INE

Table F, 1.4 Unemployment Rate
<Tasa de Desempleo>

unit: %

Year	Arica	Iquique	Region	Country
1985	14.8	11.2	12.3	13.4
1986	12.5	12.0	11.3	10.6
1987	9.4	5.9	7.1	10.3
1988	7.9	6.5	6.6	9.0
1989	4.5	4.9	4.4	6.7
1990	6.3	4.7	5.2	6.7
1991	6.0	4.4	5.1	7.4
1992	6.7	1.6	3.9	5.3

Source: INE

Chapter II REGIONAL DEVELOPMENT PLAN

2.1 Regional Development Strategy (Region I)

2.1.2 Development Potentiality

1) Privileged geographical situation in the sub-continent

Region I has a good geographical position to make it possible to carry out regional integration plans, commercial as well as cultural and economic plans with neighbor countries.

This potentiality is complemented by good port facilities as the region has two ports with enough capability to attend future demands; at present, only 50% of its capabilities are used. The Arica port has a capacity of 1,300.00 ton/year and the Iquique port has a capacity of 1,500 ton/year.

2) Enough marine resources

The region has a rich marine fauna. Its exploitation is centered in the near-coast fishing; this area is under-exploited as deep-sea fishing has a high potentiality to be exploited. In spite of this fact, the region is the leading fishing region in the country. As mentioned before, the fishing sector represents the biggest contributor to the regional gross domestic product.

3) Mining Resources

There is a strong potential in the non-metallic mining. This fact is corroborated by many mining exploitations, private and public, around the region. Main non-metallic potentiality can be found on the following products: rock salt, sodium sulfate, iodine, sulfate, sodium chloride, boric acid, and bentonite.

From the point of view of metallic mining, the exploitations of Quebrada Blanca and Cerro Colorado for copper, Collahuasi for gold, silver, copper, and Choquelimpie for gold and silver offer good perspectives for development of the regional mining sector.

4) Tourism Resources

The potentiality of the region from this point of view resides in the fact that the climate is not affected by drastic changes in comparison to the rest of the country.

In the highlands and plains of the region, attractive oasis and natural attractions make it possible to attract tourists at the domestic and international level.

5) Agricultural Resources

Climatic conditions make it possible to cultivate sub-tropical fruits, livestock belonging to the dromedary family. Sub-tropical fruits include mangoes, maracuyas, guayabas, and bananas. Corn is also another important agricultural product with high potential.

6) Industrial-Commercial Free Zone

Region I was benefited by the creation of the Free Zone given by the Legislative Decree 1055 of 1975. The purpose was to create a development pole for the region and facilitate economic integration with neighboring countries. ZOFRI has become a truly development center for the region creating jobs and allowing a full utilization of the ports and airports of the region. It is also a main contributor to the public finances and to the regional gross domestic product.

2.1.2 Main Regional Problem

The main regional problem is the scarcity of water resources. This in turn affects the agricultural, mining, industrial, tourism, and urban sectors.

The problem can be viewed from the point of view of the demand and supply of the water resources.

From the supply side, due to the desert characteristics of the region together with climatic problems (an almost total lack of rainfall) water resources are scarce making living conditions very hard in some areas. This scarcity generates the need for an exhaustive management of the water resources due to the high cost it represents.

On the other hand, this scarcity generates a strong competition among the different sectors of users.

The problem mainly affects the urban consumption of Arica city, limiting its multi-sectorial development.

Other problems are:

1) High exploitation cost of new water resources due to the location far away from urban centers (Arica and Iquique)

2) Existence of shared water sources with other neighboring countries. Water rights are a not well defined problem.

3) Legal restrictions for explotaiton of available water resources.

4) Inefficiency in the use of resources and lack of adequate technology for saving of water use.

2.1.3 Main Development Projects

According to the Regional Development Strategy of the Region I Intendency formulated for the period 1990-1995, development of water resources will be based on a "Program for Integral Development of Water Resources". This program has the following main activities:

1) Analysis and quantification of water resources in the Region

It is necessary to keep locating and evaluating the alternative water sources; it is believed that water resources are being under-utilized at present. Following this assumption, it is expected to study the potentialities of Salar del Huasco as well as the possibility to exploit the water resources which are being shared with neighboring countries.

2) Integral improvement of water supply for Arica city

Arica city faces serious water supply problems. The regional government has set a goal to increase water availability from 130 lts/sec (June 30, 1994) to 170 lts/sec (October 30, 1994)

Other projects included in the Program are as follows:

- Improvement of wells drilling (6 drillings in Pago de Gomez, San Miguel de Apaza, and the city)
- Improvement of the water station of Estadio Cerro La Cruz
- Improvement of the conduction system of El Chuno
- Construction of drillings at the Saucache sector
- Program for decreasing water losses within the distribution network
- Evaluation of new water sources
- Review of present legislation concerning use of potential water sources (Azapa, Chungara, and international waters)