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CHAPTER 5
BASELINE

5.1 INTRODUCTION

The DS N°95/01 Title III, First Paragraph, letter f that was published in the Official Journal, December 7th, 2002 defines the Environmental Evaluation System Regulations. According to law, the baseline should describe the current situation of the project's area of influence to allow the environmental impact assessment during and after the project execution phase. Thus, this chapter presents the physical, human and biotic components of the project; the landscape and the risk areas of the area of influence so as to know its current situation before building and operation phase of PHAM (High Maipo Hydroelectric Project)

To collect this data, bibliographic sources, on-site inspections, and public institutions were consulted.

5.2 AREA OF INFLUENCE

Regarding size and extension, it should be pointed out that the study area is directly affected by each environmental component, i.e. the geographical extension that is modified by the construction, exploitation, and maintenance of the project as well as the effects of the natural environment on the project itself.

Area of influence is defined as the geographical and territorial extension of every environmental component that may be directly or indirectly affected by the project. The degree in which a given natural environment may be influenced is different from the spatial distribution of the impacts, i.e. the geographical extension. The configuration of this extension consists of an ecosystem where every environmental component has its place, e.g. hydrology, geomorphology, soil, air quality, noise, flora and fauna, amongst other things. To define *a priori* the extension of the area of influence circumscribes the baseline analysis. It is done according to consultant's experience and the environmental legislation currently in force. The definition of the area of influence will be validated as the environmental impact assessment (EIA) progresses.

There is a direct (AID, area of direct influence) and indirect (AII, area of indirect influence) area of influence. To that effect, the current EIA will proceed as follows:

- **Area of Direct Influence (AID)**
-

It is a well-defined and delimited zone, done by an expert, where the direct effects of the project take place i.e. building works of the project that have an impact on every environmental component. It will have a variable extension.

- **Area of Indirect Influence (AII)**

This area may be indirectly influenced as the project develops, particularly during building works or project's operation. Regarding building works, the area of indirect influence corresponds with some sectors where the contractor performs some additional or provisional works near to the area of direct influence. On the other hand, in relation to project's operation, the area of indirect influence corresponds with some sectors where indirect or residual effects of the project are verified.

The following table shows the direct and indirect areas of influence for each and every environmental component:

Table 5.3.1.1
Area of Direct and Indirect Influence of the Project for each and every Environmental Component

Environment / Environmental Component		Area of Direct Influence	Area of Indirect Influence
NATURAL ENVIRONMENT	Climate and Meteorology	N/A.	N/A
	Air Quality	Workplace and working facilities (Muck disposal, camps, and access roads)	Settlements near to workplaces and working facilities.
	Edaphology	Workplace and working facilities (Muck disposal, camps, and access roads)	Sites near to AID that contractors might use.
	Geomorphology, Geology, and risks	Workplace and working facilities (Muck disposal, camps, and access roads)	Maipo, Yeso, Volcán, and Colorado rivers drainage basins
	Hydrology, Hydrogeology, and Water Quality	Building works that act on drainage systems	Maipo, Yeso, Volcán, and Colorado rivers drainage basins
	Noise and Vibrations	Workplace and working facilities (Muck disposal, camps, and access roads).	Settlements near to project's area
BIOTIC ENVIRONMENT	Flora	Workplace and working facilities (Muck disposal, camps, and access roads)	Sites near to AID that contractors might use.
	Fauna	Workplace and working facilities (Muck disposal, camps, and access roads)	Sites near to AID that contractors might use.
	Limnology	Building works that act on drainage systems	Sites near to AID that contractors might use, Lo Encañado lake included.

Environment / Environmental Component		Area of Direct Influence	Area of Indirect Influence
BUILT ENVIRONMENT AND SOCIAL ENVIRONMENT	Human Settlements	Human settlements such as El Canelo, El Manzano, Los Maitenes, El Alfalfal, San Gabriel, El Romeral, El Volcán, Baños Morales and, Lo Valdés, near to workplace and working facilities.	Town level human settlements
	Archeology, Paleontology, Cultural Heritage	Workplace and working facilities (Muck disposal, camps, and access roads)	Sites near to AID that contractors might use.
	Landscape and Aesthetics	Defined geographical basins from the project's area and in the project's area.	N/A
	Built Environment	The project might impact public-private infrastructure	Settlements near to project's area
	Road System	Roads G-25 (El Volcán), G-345 (Cajón Colorado river), and G-455 (Cajón Yeso river)	Road system in town level human settlements
	Risk Areas	Workplace and working facilities (Muck disposal, camps, and access roads)	Sites near to AID that contractors might use.

5.3 NATURAL ENVIRONMENT

5.3.1 Climate and Meteorology

5.3.1.1 Introduction

The description of this environmental component will generate important information regarding the extent and influence of the project on climatic elements because it has a decisive influence on the geographical space i.e. air pollution dispersion, environmental noise propagation, types of soil and their uses, and the existing vegetation, among other things.

5.3.1.2 Overall Objective

To perform a meteorological and climatic description of the study area so as to provide with a regional climatic description and a local meteorological description with regard to environmental temperatures, relative humidity, rainfall, and winds, among other things.

5.3.1.3 Methodology

First, a regional analysis based on general and universal[1] classification is conducted. It takes into consideration the climate and meteorology particular characteristics. Then, a local analysis is conducted based on agro-climatic districts defined by Santibañez Q. and Uribe M.[2] Finally, the main meteorological variables such as rainfall, temperature, humidity, speed and wind direction, fog, and solar radiation are described according to historical records of some existing stations near to or in the area of the project (San José de Maipo, Las Melosas, Embalse El Yeso, Planta Maitenes, and El Canelo stations) and environmental studies conducted by CONAMA (National Environmental Commission), DGA, and the Chilean Meteorological Service (Dirección Meteorológica de Chile). However, according to the Chilean Meteorological Service there are no operational meteorological stations in San José de Maipo town.

5.3.1.4 Project Area Overall Climatic Description

According to Köppen's classification, the area of the project can be classified as **mild and warm with a prolonged dry season**. Rainfalls are concentrated between May and August (winter) and a dry season of 7 or 8 months. The lowest temperatures vary between 3° and 18° C. In general terms, this climate dominates Chile's central region under 1.500 m.a.s.l. between the steppe and semi-arid climate southern limit from the north (San Felipe) to Talca, the southern border. It includes Maipo river valley and Las Melosas.

[1] Climate Classification of Chile according to Köppen
[2] Agro-climatic map of Chile, V Region and Metropolitan Region, School of Forest and Agricultural Sciences, University of Chile

From Las Melosas to the Argentinian border, Köppen's classification defines a climate zone named **Ice formation in high-altitudes,** with an average temperature below 10°C the warmest month and 5°C the coldest month, with some snow. Therefore, there are mountain glaciers such as San Francisco (4.320 m.a.s.l.), El Morado (5.060 m.a.s.l.), La Paloma (4.960 m.a.s.l.), and El Altar (5.222 m.a.s.l.). San Francisco and El Morado mountain glaciers are located in a natural reserve named "Parque Monumento Natural El Morado" and La Paloma and El Altar, in a natural reserve called "Santuario de la Naturaleza Yerba Loca"[3].

Orography and insolation have a direct impact on the climate of the area as well as vegetation which is closely linked to topoclimatic factors. Besides, the zone's stream flow plays a key role in climate regulation because it is a topoclimatic factor.

5.3.1.5 Agro-climatic Districts

The following agro-climatic districts have been identified in the project's area.

- Lower Temperate Mesothermal Stenothermic Semi-arid Mediterranean (50.2)[4]

It is located in the mountainous region and the Andean valley with an average thermal regime between 26.9° C (summer) and 4.1°C (winter). There is a frost-free period of 206 days with an average of 13 frost occurrences per year. There are 1291 degree days and 1676 hours of cold temperatures. The hydrological regime shows an average rainfall of 656 mm, a water shortage of 897 mm, and a dry season of 7 months.

- Temperate Infra-thermal Stenothermic Mediterranean (50.3)

It is located in the pre-mountain range between the Metropolitan region and the VI region with an average thermal regime between 25.8° C in January and 0.5°C in July. There is a frost-free period of 109 days with an average of 78 frost occurrences per year. There are 979 degree days and 3185 hours of cold temperatures. The hydrological regime shows an average rainfall of 585 mm, a water shortage of 841 mm, and a dry season of 7 months.

- Polar Microthermal Homothermic Sub-humid Mediterranean (50.4)

It is located in the High Mountains with an average thermal regime between 29° C in January and -8°C in July. There is no frost-free period, there are no degree days and there are 8640 hours of cold temperatures. The hydrological regime shows an average rainfall of 1240 mm, a water shortage of 528 mm, and a dry season of 5 months. High altitude determines an extremely cold thermal regime year round. Besides, a high rainfall reduces the number of dry months.

[3] Source: www.sernatur.cl
[4] Text is related to image 3.1, Agro-climatic Districts

- Temperate Infra-thermal Stenothermic Semi-arid Mediterranean (60.5)

It is located in the pre-mountain range with an average thermal regime between 22.9°C in January and 1.2° in July. There is a frost-free period of 103 days with an average of 66 frost occurrences per year. There are 756 degree days and 3355 hours of cold temperatures. The hydrological regime shows an average rainfall of 715 mm, a water shortage of 806 mm, and a dry season of 7 months.

- Temperate Microthermal Stenothermic Semi-arid Mediterranean (74.1)

It is located in the pre-mountain range with an average thermal regime between 19.1° C in January and -2.4°C in July. There is no frost-free period. There are 382 degree days and there are 5616 hours of cold temperatures. The hydrological regime shows an average rainfall of 774 mm, a water shortage of 731 mm, and a dry season of 6 months. High altitude determines a very cold winter with frost and a cool summer year round.

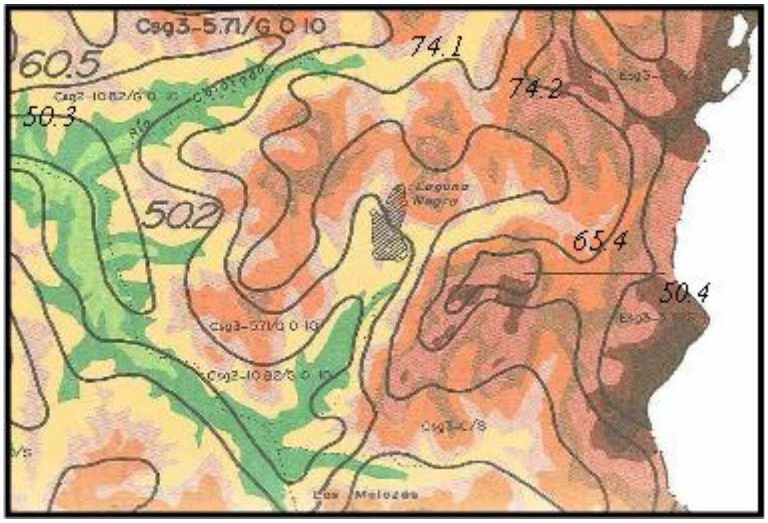
- Temperate Microthermal Stenothermic Sub-humid Mediterranean 74.2

It is located in the High Mountains with an average thermal regime between 12.3° C in January and -5.5°C in July. There is no frost-free period, there are 88 degree days and there are 7581 hours of cold temperatures. The hydrological regime shows an average rainfall of 943 mm, a water shortage of 616 mm, and a dry season of 5 months. High altitude determines a cold thermal regime year round.

- Polar Microthermal Stenothermic Sub-humid Mediterranean (65.4)

It is located in the High Mountains with an average thermal regime between 7.3° C in January and -7.9°C in July. There is no frost-free period, there are 5 degree days and there are 8529 hours of cold temperatures. The hydrological regime shows an average rainfall of 1199 mm, a water shortage of 541 mm, and a dry season of 5 months. High altitude determines an extremely cold thermal regime year round.

Image **5.3.1.1**
Agro-climatic Districts of the Study Area



5.3.1.6 Meteorology

A Rainfalls

Rainfalls totals in the area of the project spread over continuously throughout the year. There is a substantial rainfalls increase during wintertime (May-August) being June the rainiest month and February the driest month, according to data gathered from El Canelo and Planta Maitenes stations.

High atmospheric pressures limit huge air masses flow decreasing rainfalls in summer. See image 5.3.1.1

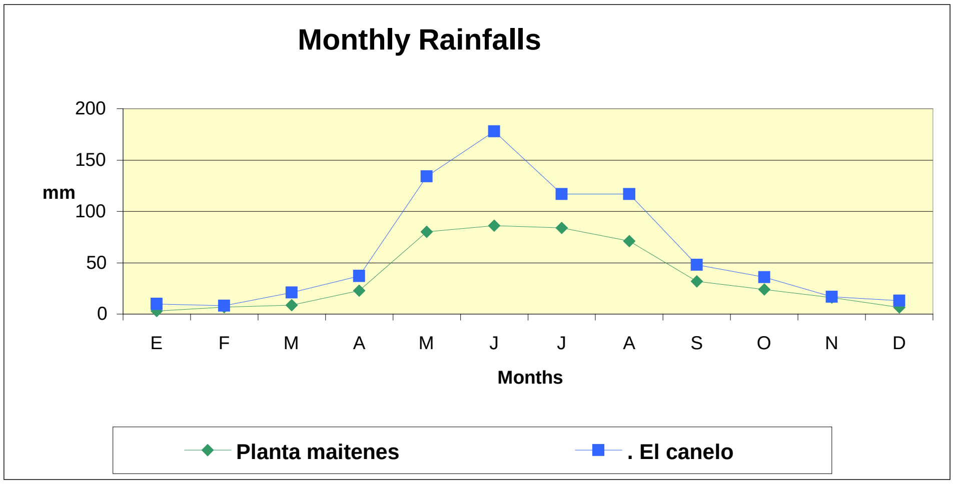
Image 5.3.1.1
Rainfalls Distribution

Monthly Rainfall (mm)												
Months												
Station	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Planta Maitenes	2,9	6,8	8,6	23	80	86	84	71	32	24	16	6,6
El Canelo	9,8	8,2	21	37	134	178	117	117	48	36	17	13

Because of local relief, orographic precipitation is caused when air masses of oceanic origin pushed by wind through central zone are forced up the side of the Andes to collide with cold air masses which results in condensation and precipitation.

Image 5.3.1.2 shows rainfalls distribution per year of the project's area.

Image 5.3.1.2
Rainfalls Distribution

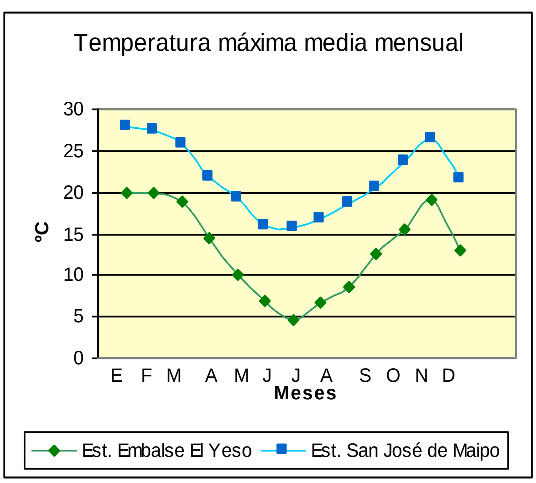


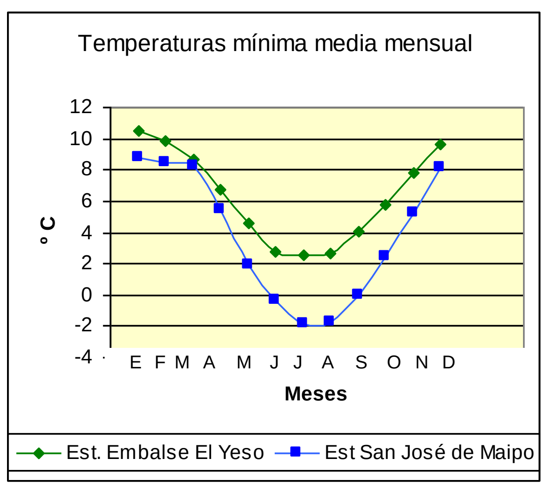
According to the available data, there is an average rainfall of 600 mm per year. Snowfall amounts to 50% of total precipitations, mainly in winter, over the highest peaks.

B Temperature

Generally speaking, higher altitudes mean lower temperatures. San José de Maipo station recorded an average thermal regime between 28°C in January and 2.5°C in July. Embalse El Yeso station recorded an average thermal regime between 19.9°C in January and -1.9°C in July. (See image 5.3.1.3)

Image 5.3.1.3
Isotherms in the Area of Influence
PHAM



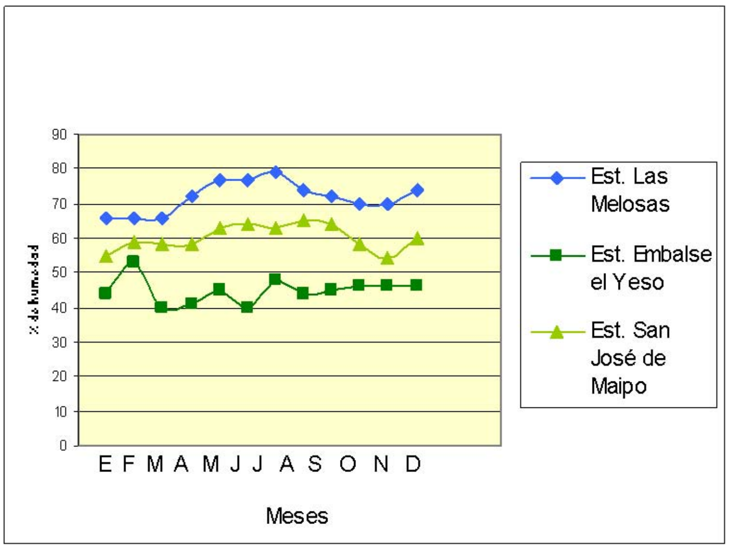


C Humidity

Humidity totals are above 40% year round in the project's area, based on gathered data from three stations. (Embalse El Yeso, San José de Maipo y Las Melosas) Las Melosas station recorded a 78% maximum humidity. Embalse El Yeso station recorded variations of relative humidity, in March and July, between 40% and 48%, respectively.

Topography plays a key role in relative humidity regimes. Sunny hillsides registered lower humidity compared to shady hillsides. In general terms, there is lower relative humidity in summer and higher relative humidity in winter. Average totals are recorded during fall and spring seasons. (See image 5.3.1.4).

Image 5.3.1.4
Monthly Relative Humidity



D. Wind Direction and Wind Speed

In general terms, wind speed increases with height; wind direction flows through the valley. As a result of thermal wind effects in the valley, there is an increase in wind speed. Regarding frequency, there is wind persistency above 2000 meters.

Regarding wind flow, Maipo river basin generates uneven overheating between the valley and the mountain which causes thermal winds between high and low pressure centers that push rising air masses through valleys and ravines. At night, because of earth cooling, there is a cool breeze from the Andes to the valley. It is known as *Terral* in Cajón del Maipo and it consists of descending warm dry winds with a higher average intensity during the night. In addition, there is a night breeze flowing down the valley. *Terral* decreases its intensity in the afternoon because of an ascending wind flow from the valley to the mountains.

There is not so much wind flow at the highest peaks during nine months. There is some wind flow at the end of each season i.e. September, December, and March. Wind speed between 9.2 and 11.1 km/h.

Regarding daily wind flow, there is a high intensity wind flow around 14:00 year round between 9 and 17 knots. There is a wind flow decrease, every afternoon, from April through October but it reactivates moderately from November through March. Prevailing wind direction N from January through March and NE in November and December. Wind average speed 10 km/h. (See image 5.3.1.2).

Image 5.3.1.2
Wind Direction and Wind Speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PWD	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PWDF	57	45	56	59	27	34	41	40	41	4	51	41
WS	11.8	11.3	10.8	9.0	7.3	7.0	7.3	8.8	8.4	9.8	12.8	9.5

Source: San José meteorological station
PWD: Prevailing wind direction
PWDF: Prevailing wind direction frequency
WS: Wind speed

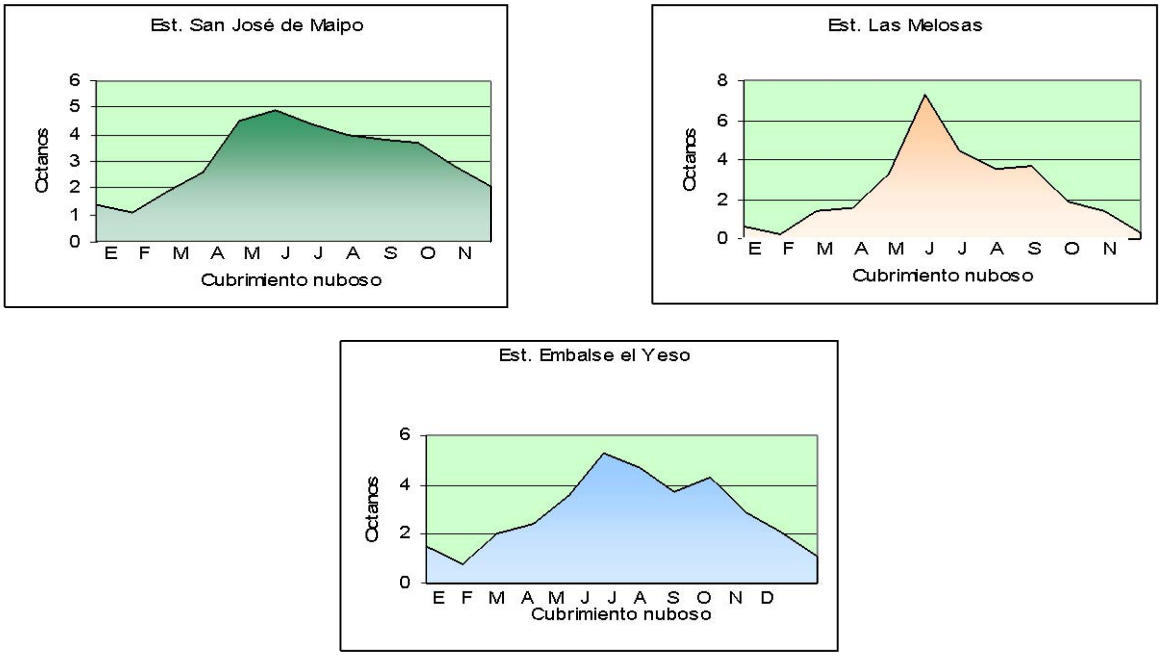
E. Fog and Cloud Cover

According to data gathered from three meteorological stations, (Las Melosas, San José de Maipo and Embalse el Yeso) June is the foggiest month in the study area and February the clearest.

There are variable cloud cover conditions nearby Las Melosas station throughout the year. Thus, January and February are cloudless with an average cloud cover [5] between 0.2 and 0.6. June shows fully cloudy skies with an average cloud cover of 7.3 (See image 5.3.1.5).

[5] Octaves scale from 0 to 8

Image 5.3.1.5
Monthly Cloud Cover



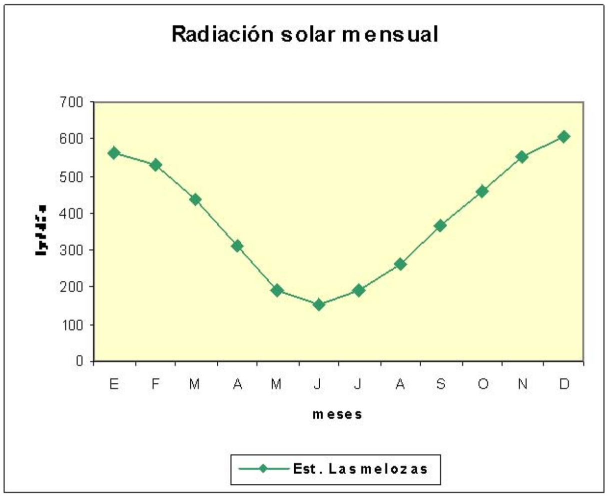
F. Solar Radiation

Solar radiation variations reach approximately 450 Ly/day throughout the year[6]. January and February show the highest radiation levels and June and July the lowest.

Solar radiation is related to hours of sun exposure in a determined area. The project's area shows low insolation levels because of physical and topographic conditions. Embalse El Yeso reaches 8.9 hours of sun exposure in January and 2.9 hours in June. As to solar radiation distribution, see image 5.3.1.6 and table 5.3.1.3

[6] ly/day = cal/day cm^2

Image 5.3.1.6
Monthly Average Solar Radiation (Ly/day)



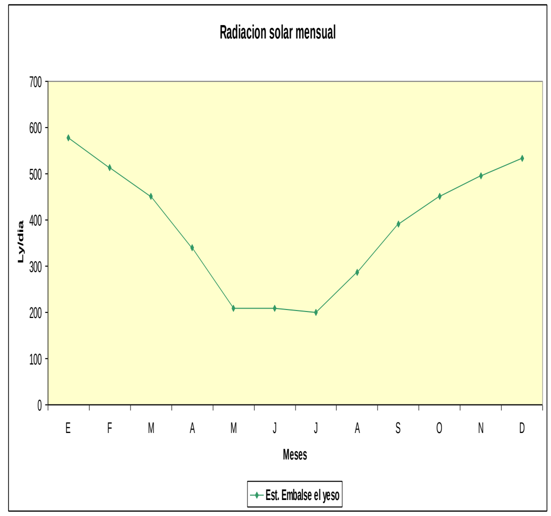


Table 5.3.1.3
Solar Radiation Distribution and Sun Hours per Year

Insolación Media Mensual (Horas/día)												
Estación	Ene	Feb	Mar	Abr	May	Jun	Jul	Ago	Sep	Oct	Nov	Dic
Las Melosas	7,8	7,6	6,5	5,5	4,3	4	4,3	5	5,4	6	7	7,9
Embalse El Yeso	8,9	8,7	7,3	6,3	4,4	2,9	3,4	4	5,1	6,2	7,2	8,4

	Radiación Solar Media Mensual (Ly/día)											
Estaciones	Ene	Feb	Mar	Abr	May	Jun	Jul	Ago	Sep	Oct	Nov	Dic
Las Melosas	564	531	439	314	194	155	193	264	364	459	553	608
Embalse El Yeso	578	514	452	340	210	210	199	287	391	452	495	534

5.3.1.7 Conclusions

Conclusions based on climatic component analysis:

The prevailing wind direction is NE with a high intensity wind flow and a wind speed that fluctuates between 9 and 17 knots. Wind speed increases in proportion to height.
Average annual temperature is 13°C and extreme fluctuations in summer and winter of -5°C and 35°C, respectively. Average rainfall amounts to 600 mm per year.

Average humidity is above 40% during the year. It reaches the highest values in winter and the lowest in summer. It is highly influenced by topographic factors.

Fog concentrates mainly in winter. Summer is cloudless and shows the highest solar radiation values. Nevertheless, the project's area shows low insolation values because of physical and topographic factors.

5.3.2 Air quality

5.3.2.1 Introduction

In this section, it will be described the air quality of San José de Maipo town, specifically, the levels of particulate matter. San José de Maipo town does have a great rural extension and some populated centers which are not relevant in terms of emission sources. However, there are industrial activities such as mining and aggregate extraction which might have an influence in the town's air quality.

5.3.2.2 Methodology

San José de Maipo does not have monitoring stations to measure air quality. Therefore, there are no data available with regard to air quality parameters such as SO_2, NO_2, CO, and particulate matter levels. Given that, the applied methodology focused on identifying emission sources. Besides, studies conducted by CONAMA and other public institutions were consulted as well as on-site inspection to some emission sources.

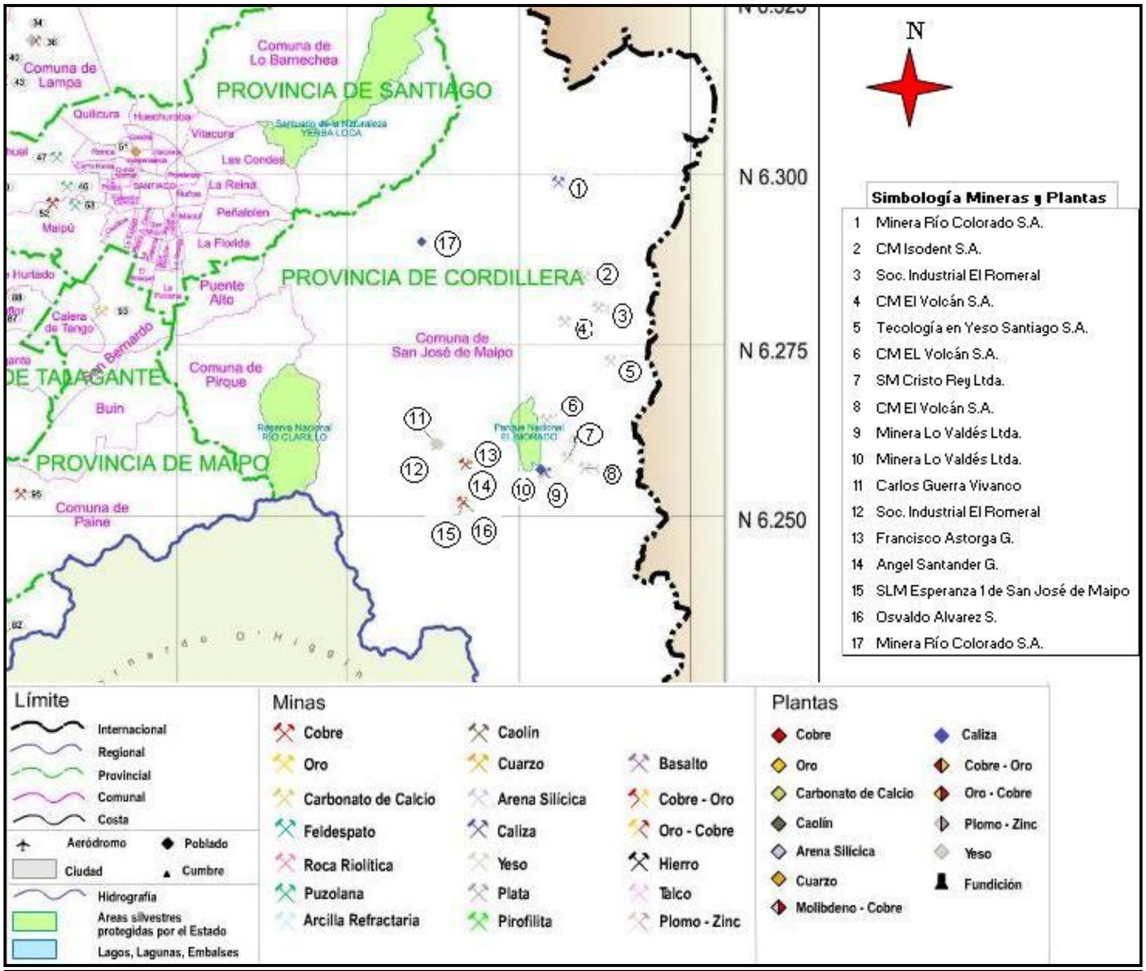
5.3.2.3 Emission Sources

The Andes are Santiago's basin eastern limit with over 3.200 meters above sea level (Cerro Ramón). The coastal mountain range is the western border with 2.000 meters above sea level (Cerros Roble Alto) and it is crossed by Maipo river valley that opens the basin to SE which optimizes ventilation conditions leading to optimum air quality. In addition, there are some few emission sources.

Ventilation conditions are related to wind speed increase because of high altitudes and NE wind direction coincides with valley's orientation. Wind speed increases in summer because of thermal wind effect coming from the Andes.

Regarding sources of dust, there are industrial activities such as mining and aggregate extraction. There is nonmetallic mineral extraction in San José de Maipo town such as gypsum, limestone, and, to a lesser degree, copper. These productive activities are mainly developed in Volcán and Yeso upper river basin. Similarly, in Colorado river sector there is a limestone processing plant owned by Minera Río Colorado. (See image 5.3.2.1 and table 5.3.2.1).

Image 5.3.2.1
Mining activities location in San José de Maipo Town



Source: SERNAGEOMIN, 2007.

Table 5.3.2.1
Mining Companies in San José de Maipo town

	Company name	Mining site	Operation / Process	Mineral	Status
1	Minera Río Colorado S.A.	Mina La Perla	Open pit	Limestone	Active
2	CM Isodent S.A.	Mina Mª Soledad-Pamela	Underground	Gypsum	Active
3	Sociedad Industrial El Romeral	Mina Yeso Romeral	Open pit	Gypsum	Active
4	CM El Volcán S.A.	Mina Paulina	Open pit	Gypsum	Active
5	Tocología en Yeso Santiago S.A.	Mina Portín	Open pit	Gypsum	Active
6	CM EL Volcán S.A.	Mina Ferton	Open pit	Gypsum	Active
7	SM Cristo Rey Ltda.	Mina Dos Ríos	Underground	Gypsum	Active
8	CM El Volcán S.A.	Mina Yeseras	Open pit	Gypsum	Active
9	Minera Lo Valdés Ltda.	Mina Lo Valdés	Underground	Limestone	Inactive
10	Minera Lo Valdés Ltda.	Planta Lo Valdés	Crushing	Limestone	Inactive
11	Carlos Guerra Vivanco	Planta Romeral	Crushing	Gypsum	Active

	Company name	Mining site	Operation / Process	Mineral	Status
12	Sociedad Industrial El Romeral	Planta El Romeral	Crushing	Gypsum	Active
13	Francisco Astorga G.	Mina La Cortada	Underground	Copper	Active
14	Ángel Santander G.	Mina El Álamo	Underground	Copper-Gold	Inactive
15	SLM Esperanza 1 de San José de Maipo	Mina Esperanza	Underground	Copper-Gold	Active
16	Osvaldo Álvarez S.	Mina Carola	Underground	Copper-Gold	Active
17	Minera Río Colorado S.A.	Planta Los Maitenes	Crushing	Limestone	Active

Source: SERNAGEOMIN, 2007.

Regarding mining processes and aggregate extraction, hauling ore in the open air[7] casts out high levels of particulate matter into the atmosphere. It includes loading trucks, stockpiling and loading of marketable and waste products (CONAMA, 2001).

On-site inspection showed the hauling of minerals in HGVs without tarps.

Traffic flow generates particulate matter. In this regard, roads near to the project's area show a higher traffic flow in urban areas (San José de Maipo) and roads G-25, G-455 y G-345 (Tourism). However, traffic flow in no paved roads generate the highest levels of particulate matter in San Gabriel to SE and E (Road G-25 to El Volcán) and the secondary roads leading to road G-25. According to CONAMA (2001), trucks generate at least 10% of particulate matter (PM10) in Santiago. As to other air pollutants, trucks are not a significant source of contaminants[8].

In November 15th, 2007 a traffic flow was monitored so as to estimate emission values in the aforementioned roads. It encompasses all types of vehicles, including light vehicles, buses, single rear wheel, and dual rear wheel trucks. There were 3 measuring points; one in road G-455 and two in road G-25. The first measuring point in road G-25 was located before the junction towards Baños Morales and the second one at the junction towards Baños Morales. See results in annex 5.

[7] Free movement for each element. It is a free fall hauling. (Source: http://conama.cl/rm/568/articles-2572_chapter3.pdf)
[8] According to CONAMA (2001) (PM10), trucks generates a 9.4% of particulate matters: carbon monoxide (CO) 1.8%, nitrogen oxide (NO_x) 16.2%, volatile organic compounds 3%, and sulphur dioxide (SO_2)8,9%.
(Source: www.conama.cl/rm/ppda/663/article-2314.html)

5.3.3 Noise

5.3.3.1 Introduction

To describe sound pressure levels in sensitive areas, 8 measuring points were spread over the area of influence near to future excavating points, muck disposal, canals, discharge point, and buses and trucks traffic.

5.3.3.2 Objectives

- To determine the existence of sensitive receivers inside the defined area of influence for building and operating PHAM.

- To conduct noise level measurements in those areas so as to know current sound pressure levels.

5.3.3.3 Methodology

- Two on-site inspections took place in December 6th and 27th, 2006 and December 6th, 2007. Project engineering determined on-site inspections dates.
- The area of influence was determined on-site. Noise sensitive areas were identified so as to locate measuring points.

- In both diurnal (12:30-14:00) and nocturnal (21:00-22:30) sound pressure levels measurements were conducted (SPLeq, SPLmin, SPLmax) so as to describe the listening environment and its background noise.
- To comply with DS N°146/97 MINSEGPRES background noise measurement methodology, SPLeq measurements were taken every 5 minutes (2dB (A)) the sonometer was located to 1.5 meters on its vertical axis and 3 meters its horizontal axis away from any reflecting surface (walls, windows).

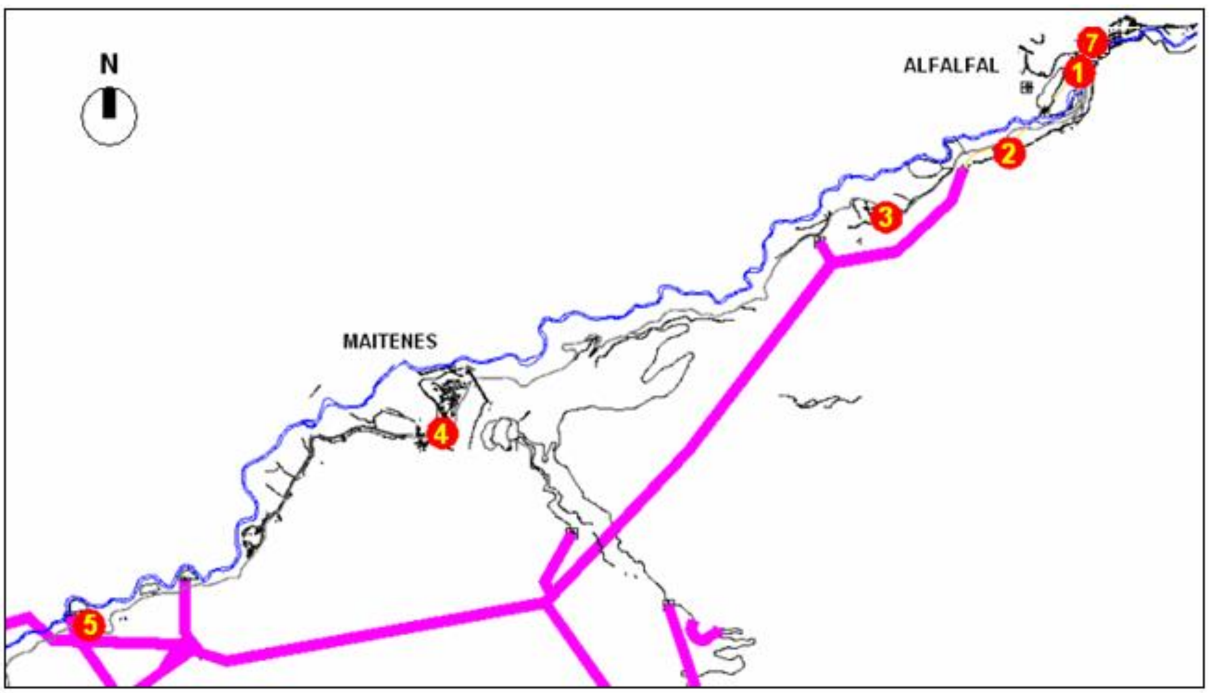
- Testing equipment: NL-22 Rion sonometer (type 2 sonometer, IEC61672-1:2002); NC-73 Rion sound calibrator; Garmin GPS Etrex Venture; Canon PowerShot A75 digital camera. The NL-22 Rion sonometer was calibrated before every measuring test.

Table 5.3.3.1 shows measuring point's location and description. Besides, images 5.3.3.1 to 5.3.3.3 show measuring points location whereas table 5.3.3.1 includes measuring point pictures.

Table 5.3.3.1
Measuring Points Location and Description

Point	Description	Coordinates (UTM)[9]	
		East	North
1	Housing in Alfalfal near to Colorado River.	388.867	6.292.374
2	Ring in Quebrada El Torrejón.	388.196	6.291.602
3	Military premises in Quebrada El Trescientos.	387.018	6.290.987
4	Rural post office Maitenes-Alfalfal, Maitenes.	382.765	6.288.921
5	House in El Sauce.	379.384	6.287.080
6	Future siphon location, El Yeso.	397.732	6.272.271
7	Housing in Alfalfal (football field).	388.828	6.292.360
8	House Nº 7751 Road G-25, Las Lajas.	368.031	6.284.065

Image 5.3.3.1
Measuring Points Location



[9] Datum PSAD 56.

Image 5.3.3.2
Measuring Points Location

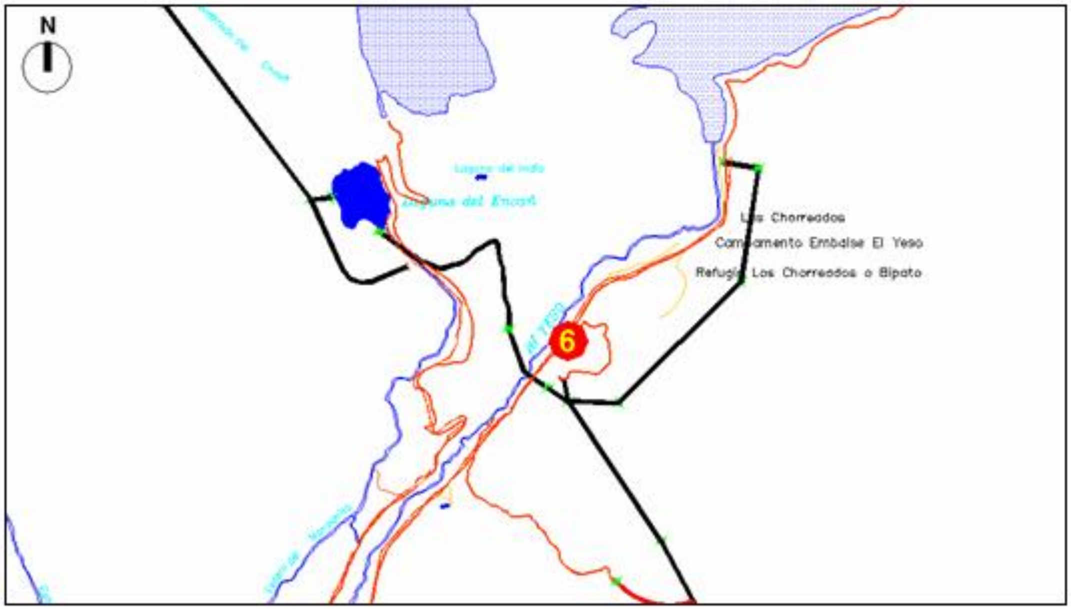


Image 5.3.3.3
Measuring Points Location

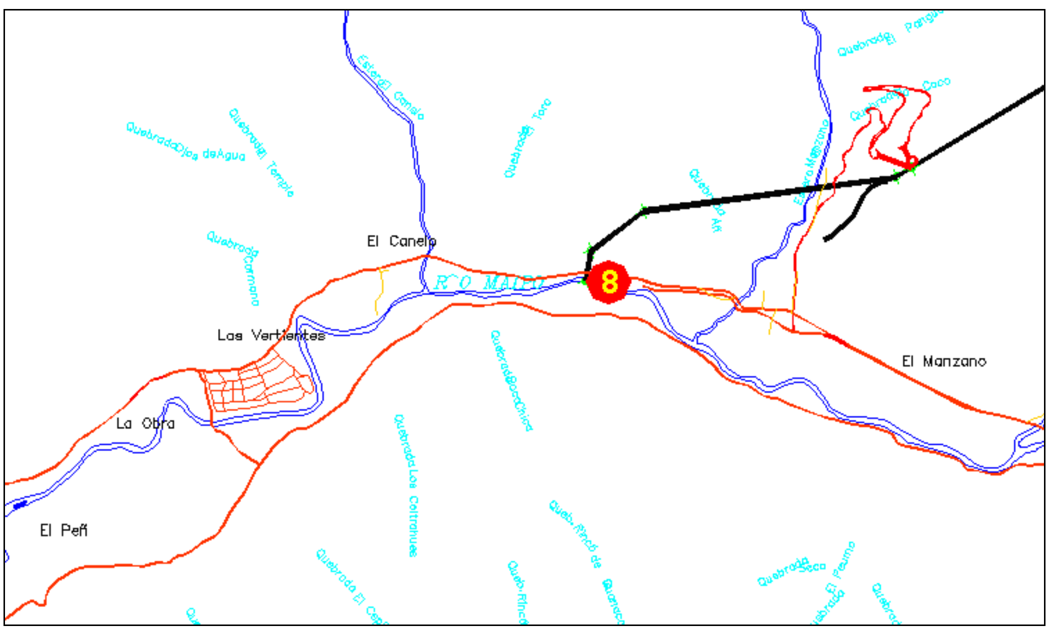
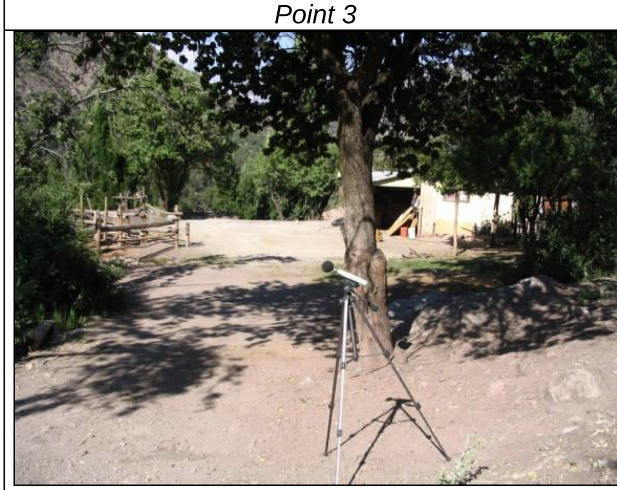
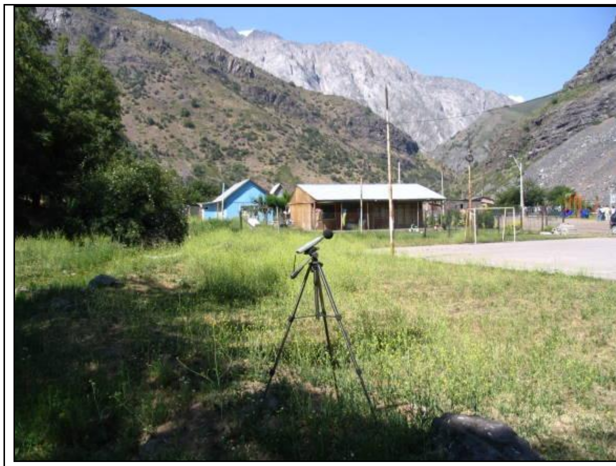


Table 5.3.3.1
Measuring Points Location Pictures

	
Point 1	*Point 2*
	
Point 3	*Point 4*
	
Point 5	*Point 6*



Point 7

Point 8

5.3.3.4 Area of Influence

Receivers located in the area of the project correspond with population centers as well as isolated houses near to muck removal sites, muck disposal sites, siphons, discharge point, and, highways.

Regarding traffic flow during building works, road and sectors within the area of the project are as follows: road G-455 (Puente Alto – El Yeso), road G-25 (Puente Alto – Las Lajas and San Gabriel – El Volcán), and road G-345 (Las Lajas – Alfalfal). On the other hand, sectors that correspond with workplaces and muck disposal are as follows: Alfalfal, Los Maitenes, Las Lajas, El Sauce, El Yeso, Colorado river, Quebrada El Torrejón y Quebrada El Trescientos.

5.3.3.5 Results

A Current Regulations

According to DS N°146 of MINSEGPRES published in the Official Journal in April17th, 1998, Title III, article 4, Corrected Maximum Permissible Sound Pressure Levels are set out according to the area. According to on-site inspections, planning and monitoring instruments applied in the area, and sensitive points, the current receivers location corresponds to a **rural area**.

Subject to the foregoing general rule, DS N°146 of MINSEGPRES, point 5.2.2 establishes:

Rural area is every area outside the urban boundary as set out in the town planning which is affected by territorial planning instruments, town planning regulatory framework, sectional planning, and urban boundaries. Town jurisdictional powers are applicable over such rural area. Rural areas as part of any unplanned town are considered as such regardless of the existence of a territorial planning instrument.

According to DS N°146/97 of MINSEGPRES, Title III, article 5, the sound pressure levels of the project (stationary sources) must not exceed 10dB(A) compare to measured background noise, in the evaluated area. See table 5.3.3.2.

Table 5.3.3.2

Maximum Permissible Levels According to Regulations (D.S N° 146/97, MINSEGPRES)
Approximate values for testing purposes

Point	Background Noise dB(A)	Maximum Permissible Level dB(A)
1	54	64
2	53	63
3	47	57
4	49	59
5	51	61
6	44	54
7	52	62
8	72	82

According to the Metropolitan Master Plan of Santiago (PRMS), a land use homologation certificate has been issued so as to homologate the noise level receiver points according to zoning requirements as set out in DS 146/97, MINSEGPRES, “Regulations regarding disturbing noises coming from stationary sources” issued by San José de Maipo municipality in 03/19/2008. In this EIA, annex 13, is included as an attachment.

B Existing Noise Levels

Sound pressure levels measurements recorded at the measuring points. See tables 5.3.3.3 and 5.3.3.4, and images 5.3.3.4 and 5.3.3.5.

Table 5.3.3.3

Sound Pressure Levels in dB(A)-Slow response Recorded in Daytime

Point	Daytime		
	SPLeq	SPLmin	SPLmax
1	53.6	51.7	58.1
2	52.9	49.6	57.0
3	46.6	43.7	53.5
4	48.5	43.8	58.2
5	51.2	47.5	62.0
6	43.9	39.7	54.2
7	51.7	48.9	58.8
8	71.7	57.4	88.9

Table 5.3.3.4
Sound Pressure Levels in dB(A)-Slow Response Recorded during Nighttime

Point	Nighttime		
	SPLeq	SPLmin	SPLmax
1	54.9	54.4	56.7
2	48.5	47.4	50.2
3	39.3	38.7	40.9
4	40.4	39.7	41.6
5	50.5	49.4	51.9
7	53.0	51.6	57.4

Images 5.3.3.4 y 5.3.3.5 show sound pressure levels summaries recorded during daytime and nighttime. There is a noticeable difference in sound pressure levels measuring points during daytime. The measuring point located near to road G-25 recorded higher sound pressure levels compared to those located in low traffic roads (G-345 and G-455). While point 8 reaches a sound pressure level of 72dB(A), secondary roads measuring points oscillate between 44 and 54 dB(A).

Background noise measurements during nighttime oscillate between 39 and 55 dB(A).

In general terms, point 8 noise emission sources are related to traffic flow, birds, and the Maipo river water flow. As to the remaining points, the noise emission sources are related to Volcán river, Colorado River, Yeso river, birds, wind, tree foliage, community noise (point 1, Alfalfal), and low traffic flow secondary roads (roads G-25, G-345, and G-455).

Image 5.3.3.4
Baseline Noise Summary - Daytime

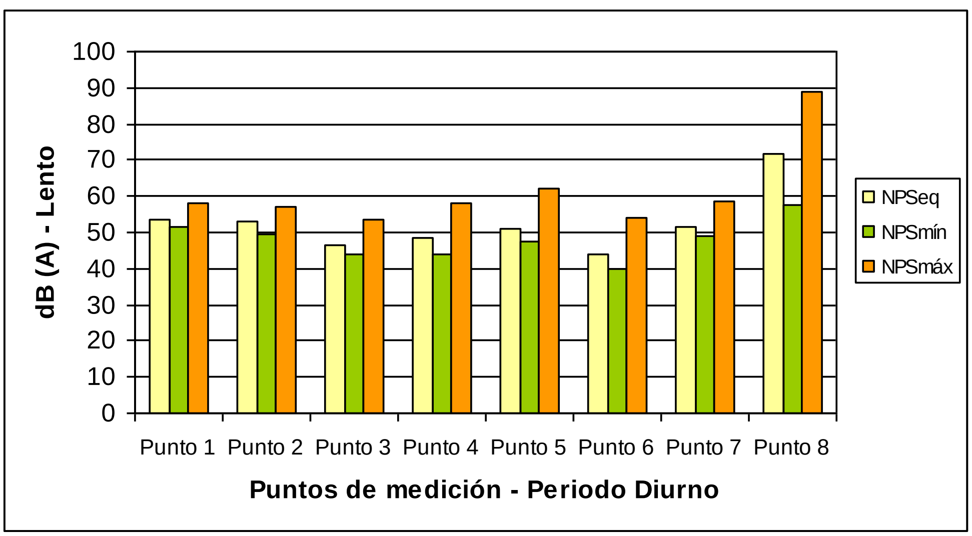
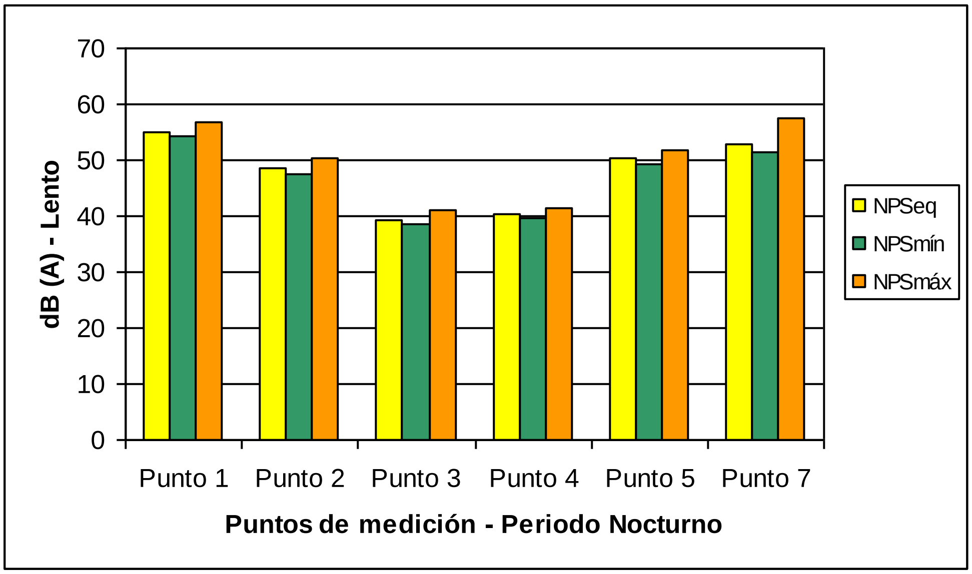


Image 5.3.3.5
Baseline Noise Summary - Nighttime



5.3.3.6 Conclusions

8 measuring points were located in the area of influence of PHAM near to workplaces (muck removal sites, Canals, and main routes (roads G-25, G-345, and G-455).

Areas near to the main road reach noise levels of 72dB(A) whereas the remaining measuring points do not exceed 54dB(A) during daytime and 55dB(A) during nighttime. In general terms, noise levels are related to birds, water flows, tree foliage, community noise, and traffic flow.

According to DS N°146/97 of MINSEGPRES, the sound pressure levels of the project during building works and operation of the project must not exceed 10dB(A) compare to current noise levels measured in two on-site inspections.

5.3.4 Soils

San José de Maipo town shows poor soil quality, because of topographic and geomorphological factors. According to a study from the Research Institute of Natural Resources (IREN) (Pérez, W.; Tamayo, A.; 1996) non-arable land (dry land) predominates.

Non-arable lands (dry land) can be classified as follows:

- ***Class VI soils*** have severe limitations that cannot be corrected such as steep slopes, erosion hazards, and climate that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food cover. They may serve for some kinds of crops, such as tree crops, provided favorable rainfall patterns.
- ***Class VII soils*** have very severe limitations that make them unsuited to cultivation and also, restrict their use largely to grazing, woodland, or wildlife. The limitations are such that these soils are not suited for any of the common crops.
- ***Class VIII soils*** and land forms have limitations such as topography, steep slopes, and erosion that preclude their use for commercial plant production.

Arable lands (dry land) as follows:

- ***Class III soils*** are related to the cultivation of cereals in rotation, nature grassland, artificial grassland, and farms. Class III soils include rolling hills located in La Obra and San José de Maipo with a gentle steepness of 4% to 15%. ***Class IV soils*** have very severe limitations that restrict the choice of plants and or require very careful management. Several limitations such as steep slopes, drainage, and stoniness are a permanent feature of the land. Class IV soils include rolling hills with a steepness of 10% to 15%.

With regard to soils, in the area of direct influence (AID) of the project there are poor quality soils (Class VI, Class VII) that have limitations such as topography, steep slopes, and erosion.

5.3.5 Water Resources

5.3.5.1 Hydrological Description

A. Introduction

In this section there is a description of basins and tributaries of Volcán River, Yeso River, and Colorado River as well as Lo Encañado Lake as part of the Maipo River Andean Water Resources System. It will be focused on describing the current most relevant aspects related to environmental assessment, water flow regime, and the use of water resources.

Regarding environmental studies, different sources have been consulted, namely, CONAMA, the Chilean Meteorological Service, National Water Board (DGA), Aguas Andinas, and the 2005 report "Water Resources Analysis", from Gener. The latter determines average water level of every stream included in the project, based on DGA National Water Bank (BNA) data, among other studies.

B. Maipo River Upper Sub-drainage Basin

i) General Description

The project is developed in its entirety in the Maipo river upper basin (See image 5.3.5.1). This is Maipo river source area, where the river begins from an extensive volcanic matter plain located at the west foot of Maipo volcano. It is the confluence of three streams coming from springs. It is called Nacimientos, at an elevation of 3125 meters. The upper course flows to SSE-NNW 62 kilometers with an average gradient of 2.9% up to the confluence with Volcán River (Muñoz, C.; Orellana, J.; 1997).

Its headwaters begin in the highest peaks of the Andes. See table 5.3.5.1.

Table 5.3.5.1

Maipo River Source Stream Mountaintops

Mountaintop	Altitude
Nevado del Juncal	6.111 m
Nevado del Plomo	6.050 m
Cerro Tupungato	6.570 m
Nevado de los Piuquenes	6.190 m
Cerro Marmolejo	6.108 m
El Volcán San José	5.856 m
El Volcán Maipú	5.264 m
El Pico del Barroso	5.160 m

Source: Muñoz, C. y J. Orellana, 1997.

Alvarado and Cruza de Piedra tributaries feed into Maipo River at this elevation. Downstream flow together Negro river, El Barroso river, and El Blanco river, all glacier-fed rivers.

Moreover, melt water streams into Maipo River being Claro River, which begins at Codegua watershed, the largest tributary.

Downstream the river bed widen out between alluvial and fluvio-glacial terraces colloquially known by locals as 'Llanos' (grazing land) in Chile's central zone.. Moreover, in its upper course, Maipo River reaches high water turbidity levels because of badlands (gypsum-rich soils).

Three upper headwaters tributaries such as Volcán, Yeso, and Colorado feed into Maipo River. They are particularly important in developing PHAM. (See image 5.3.5.1).

The hydrological regime of Alto Maipo is nival type i.e. 74% of a hydrological year superficial runoff takes place in the snow melt season, from October to March. In both Yeso and Colorado rivers there is an altered hydrological regime. The former because of El Yeso reservoir and the latter because of Los Maitenes and El Alfalfal hydroelectric power stations.

Image 5.3.5.1
Maipo River Basin – Sub-drainage basins First Section –

ii) Average Monthly Water Levels

Data gathered from two fluviometric stations located at Maipo river upper basin as follows:

- *Maipo Station in San Alfonso*

It is located at 1108 m.a.s.l. with a drainage area of 2850 km^2 . It is located downstream of the confluence of Volcán river and Yeso river. This station recorded some important floods in the snow melt season between November and March. They reached the highest levels in January (wet years) and the lowest in December (dry years). Nevertheless, in those wet years there was a flood in June because of a considerable rainfall increase. (See table 5.3.5.2).

Table 5.3.5.2

Maipo River Average Annual and Monthly Water Levels (m3/s) Natural Flow Regime
San Alfonso Station

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Qma
144,80	99,20	80,38	45,46	41,12	39,04	37,64	37,04	43,23	62,39	111,72	162,40	**77,80**

Source: Water Resources Analysis, Gener 2005

- *Maipo Station in El Manzano*

It is located at 850 m.a.s.l. with a drainage area of 4968 km^2 (see image 5.3.5.1). Melt water streams into it between November and March, reaching the highest levels in January. See table 5.3.5.3. (2005).

Table 5.3.5.3

Maipo River Average Annual and Monthly Water Levels m3/s
El Manzano Station

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Qma
200	141	99	69	60	57	59	59	68	96	156	207	**106**

Source: DGA, año 2005

C. Volcán river basin system

Volcán river basin is composed of a homonymous main river bed that begins in San José volcano mountaintop (5856 m.a.s.l.) Colina stream, which begins in the westernmost hillside of San José volcano, and Marmolejo hill (6100 m.a.s.l.) feed into Volcán River. It has an area of approximately 530 km^2 to its outlet into Maipo river. (see image 5.3.5.1).

The relevant zone for PHAM includes sub-drainage basins of Colina stream, namely, Cajón del Morado, Quebrada Las Placas, el Estero Colina stream, and Cajón La Engorda.

The hydrological regime of Volcán river is nival-glacial type, covering up to 36 Km^2 of Marmolejo and Loma Larga glaciers, as well as other snowdrift glaciers formed on San José volcano. See table 5.3.5.4, for average water levels in natural flow regime in every sub-drainage basins and catchment areas included in PHAM. Image 5.3.5.2 shows sub-drainage catchment basins in the upper Volcán river.

Table 5.3.5.4
Average Annual and Monthly Water Level m3/s Natural Flow Regime
Volcán River Sub-drainage basins

Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Qma
La Engorda	2,58	1,93	1,13	0,73	0,40	0,36	0,34	0,33	0,36	0,51	1,01	1,81	**0,96**
Colina	7,54	5,79	3,33	2,10	1,06	0,88	0,84	0,82	0,88	1,24	2,88	5,35	**2,73**
Las Placas	1,08	0,83	0,48	0,30	0,15	0,12	0,12	0,11	0,12	0,17	0,41	0,77	**0,39**
El Morado	4,52	3,37	1,97	1,28	0,71	0,64	0,61	0,59	0,64	0,90	1,77	3,17	**1,68**

Source: Water Resources Analysis, Gener 2005.

Table 5.3.5.4 shows highest water levels between November and March because of rising temperatures. As previously mentioned, sub-drainage basins water levels decrease in winter.

On the other hand, downstream Volcán river shows other streams that feed into its water system such as Morales, Las Amarillas, Chacales, El Yesillo, El Salto, Colorada, and El Cobra as well as Cajón de Ruhillas and Cajón Lo Valdés (see image 5.3.5.2), as indicated by the average monthly water levels in Queltehues fluviometric station, located 1.5 km to the east of the confluence with Maipo river (see image 5.3.5.1), which recorded a Volcán river's average annual water level of 16m^3/s.

Table 5.3.5.5
Average Annual and Monthly Water Level m3/s Natural Flow Regime
Queltehues Station

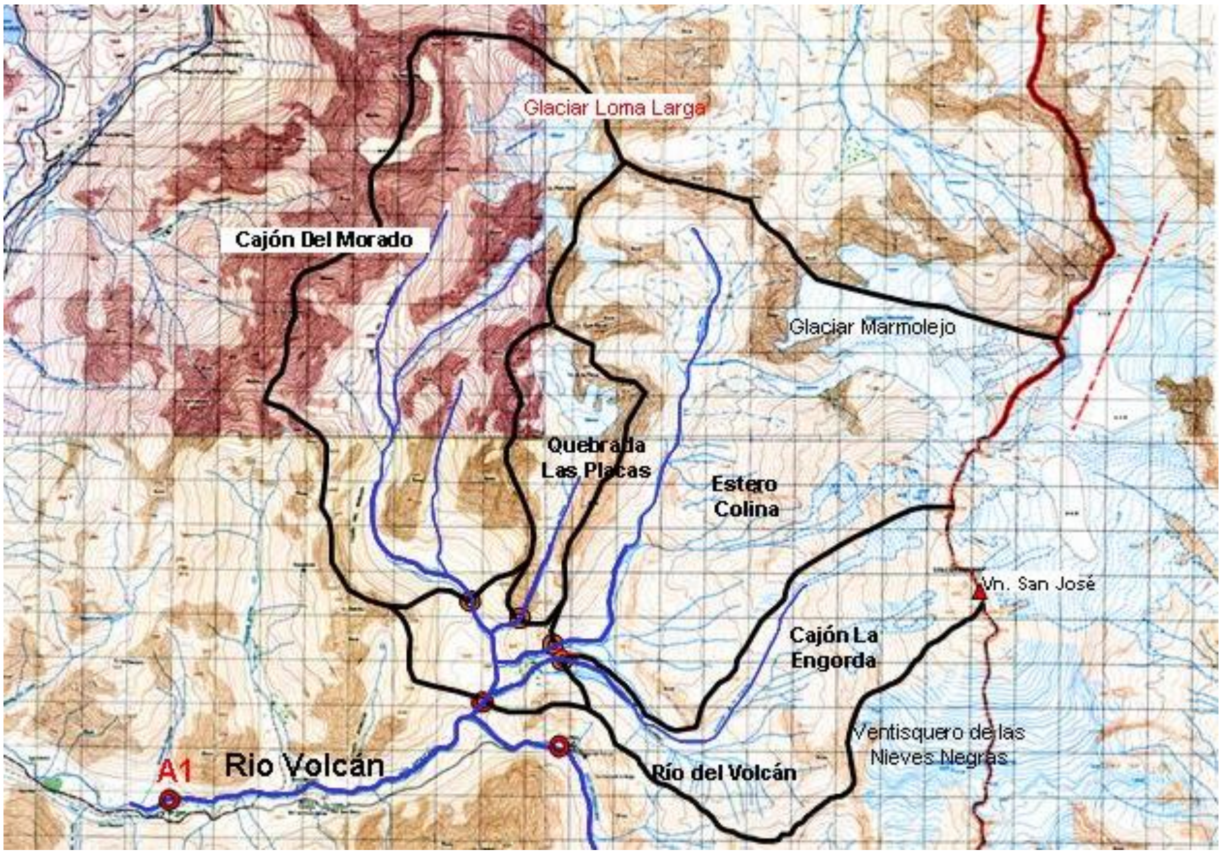
River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Qma
El Volcán	31,11	22,86	16,99	11,24	8,83	8,44	7,98	7,74	8,79	11,79	20,65	31,28	**15,64**

Source: Water Resources Analysis, Gener 2005.

According to the study "Analysis and Classification of Streams and Water Bodies, Maipo river basin" conducted by DGA and data submitted by GENER, the current requirements and uses of this basin are related to deep valley irrigation, hydroelectric power generation, namely, El Volcán hydroelectric power station, whose catchment area is located in A1,image 5.3.5.2., and mining water requirements.

Image 5.3.5.1

Catchment Area Details, Volcán System



Source: Water Resources Analysis, Gener 2005.

D. Yeso river system

This basin of 637Km^2 is composed of the homonymous main river and streams coming from mountaintops. Yeso river begins at Portillo de los Piuquenes, in the confluence of Yeguas Muertas river and Plomo river. Melt water feeds into Plomo river, which comes from SE, Marmolejo's hillside.

Relevant water bodies in the basin are Negra lake, Lo Encañado lake, and El Yeso reservoir. They came into existence as a result of a prehistoric landslide, in El Mesón Alto where 4,3 Km^2 of rock material shifted position. In turn, Yeso river runoff was temporarily interrupted as well as tributaries coming from NW (Del Encañado and Negra lake streams). Later, some lakes were formed (Negra, Lo Encañado, and Yeso) through mudflow.

A description of relevant water bodies in the basin as follows:

i) Lo Encañado Lake

Lo Encañado Lake is an integral part of Yeso river system. The basin that feeds into the lake has a surface area of approximately 38 km^2, southward-oriented, being Negra lake basin its Eastern limit and Colorado basin its northwest limit (see image 5.3.5.3). Highest mountaintops reach approximately 4700 m.a.s.l. and a height above sea level of 2480 m.a.s.l., with an average of 3100 m.a.s.l. There are no glaciers and the hydrological regime is nival. The highest runoff levels are reached in November being somewhat lower in December. The average annual water level natural flow regime is 0.76m3/s.

Table 5.3.5.6
Average Annual and Monthly Water Level m3/s Natural Flow Regime
Tributary Basin to Lo Encañado Lake

Tributary	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Qma
Basin	1,13	0,62	0,42	0,39	0,42	0,39	0,33	0,33	0,42	0,98	1,76	1,88	**0,76**

Source: Water Resources Analysis, Gener 2005.

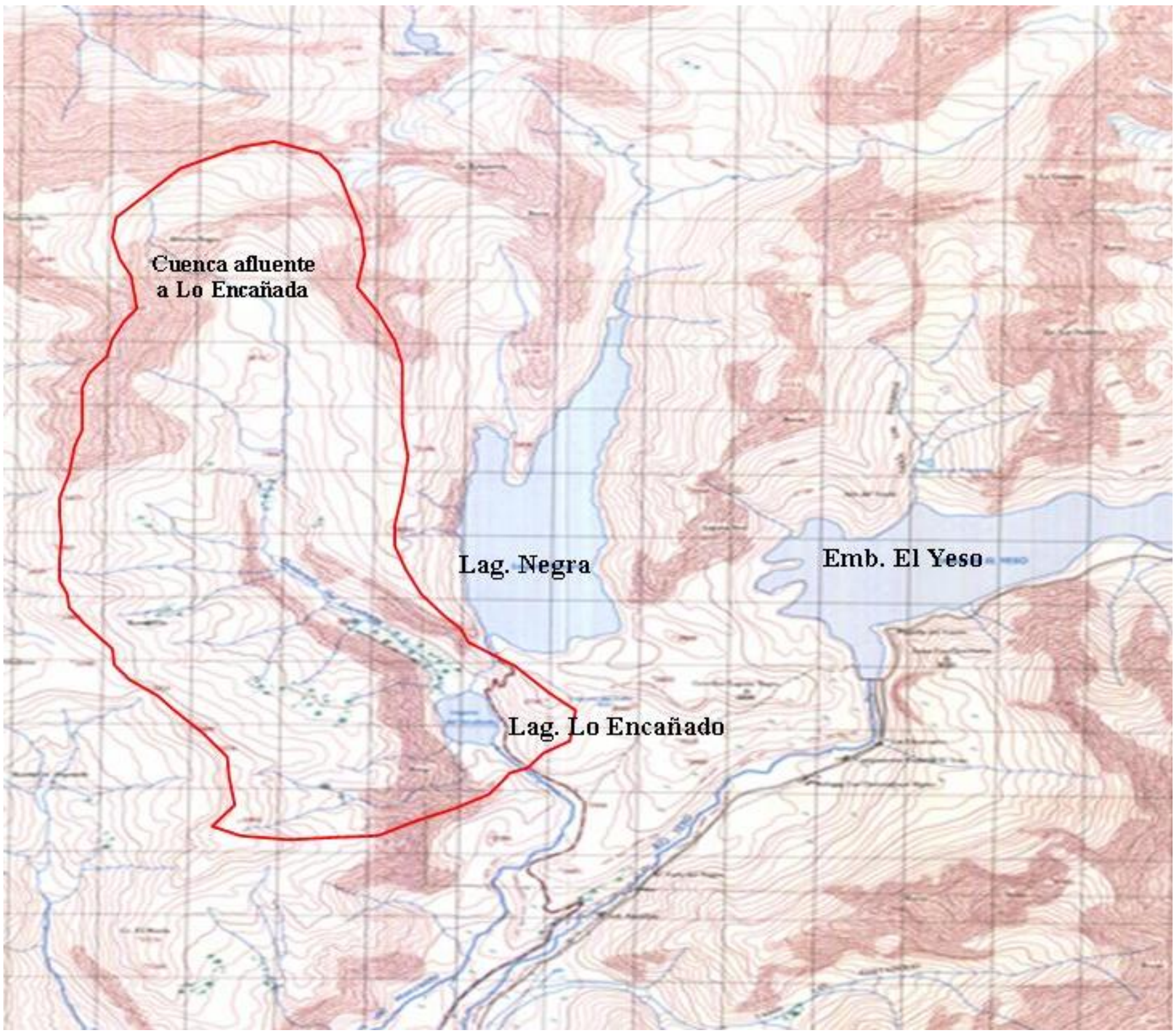
Besides, Negra lake, located to the west of Lo Encañado lake at an elevation of above 2200 m.a.s.l., infiltrates it which increases water levels. Negra lake hydrological regime is markedly nival type, getting melt water from mountaintops located in the northern area. It has an approximately volume of 600m^3 .

Lo Encañado lake has an average volume of 50m^3 , regularly checked by Agua Andinas. It is controlled through El Manzanito stream discharge of water overflow. (see image 5.3.5.3). Later, in Romaza catchment area, the water overflow is canalized towards Aguas Andinas water purification plant, in accordance with pure tap water supply standards. (see image 5.6.1.1).

Negra lake and Lo Encañado lake systems currently constitute drinking water reserves under Aguas Andinas management.

Picture 5.3.5.1 Water Resource: Lo Encañado Lake, under Aguas Andinas management.

Image 5.3.5.2
Tributary basin to Lo Encañado Lake



Source: Water Resources Analysis, Gener 2005

ii) El Yeso Reservoir

El Yeso Reservoir corresponds to a drinking water supply under Aguas Andinas management. A Yeso river system tributary basin feeds into it. See image 5.3.5.4.

The hydrological regime that feeds into this reservoir is nival-glacial type, covering up to 20.4 Km^2 of El Yeso , Bello, Del Pirámide, and, to some extent, Marmolejo glaciers. As a result, a tributary basin water level increase to El Yeso reservoir between November and March takes place but it decreases during winter with an annual average water level of 8.4m^3/s. See table 5.3.5.7.

Table 5.3.5.7
Average Annual and Monthly Water Level m3/s Natural Flow Regime
Tributary Basin to El Yeso Reservoir

Tributary	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Qma
Basin	17.92	13.88	9.22	6.35	4.89	4.14	3.81	3.35	3.87	5.84	10.32	17.20	**8.4**

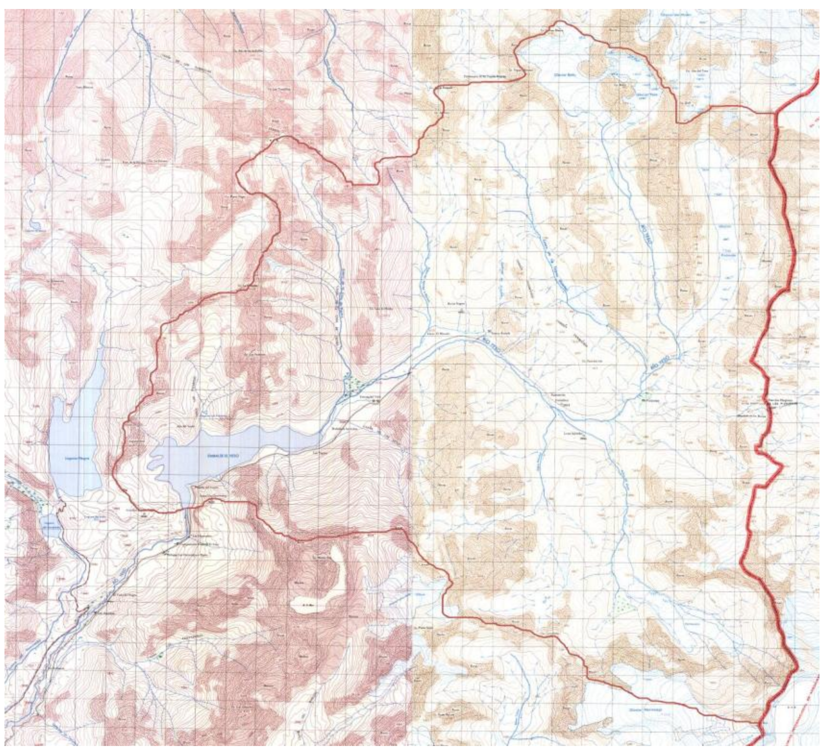
Source: Water Resources Analysis, Gener 2005.

In recent years, the storage volume level has varied from 175m³ in 1999 to 245m³ in 2001. The current average storage volume level is 250m³ , which is regularly checked and controlled by Aguas Andinas to comply with drinking water requirements of the Metropolitan Region. It is controlled through water overflow discharge to Yeso river.

There are some additional streams that feed into El Yeso river downstream reservoir's discharge water system such as Cortaderas, Las Arenales, Los Chacayes, Las Lunes, El Rodeo de los Bueyes, and San Nicolás stream.

El Yeso Reservoir is a drinking water reserve and it is used sporadically in sport fishing. In turn, Yeso river is used both in sport and in leisure fishing. It is also a source of irrigation water[10].

Image 5.3.5.3
Tributary basin to Lo Encañado Lake



Source: Water Resources Analysis, Gener 2005

[10] "Analysis and Classification of Streams and Water Bodies, Maipo river basin", DGA

E. Tributary basin Colorado River System

Colorado river begins in the mountaintops of Tupungato volcano (6570 m.a.s.l.). Olivares river is its main tributary which begins both in the homonymous glacier (Alfa, beta, and gamma components) and in El Plomo hill (6050 m.a.s.l.). After the confluence of both rivers, Colorado river feeds into Maipo at an elevation of 890 m.a.s.l. Colorado river basin and Yeso river basin are the most relevant tributaries to Maipo river in the Andes.

Olivares river joins the Colorado river for its right bank in the middle (see Figure 5.3.5.5). It begins in a large ice field called “Ventisqueros de Olivares y Juncal Sur” . Azufre river, which begins at the foot of the Tupungato volcano and Museo volcano, also feeds into Colorado river.

The Olivares river course and the upper Colorado River course, before its confluence with Olivares river, have steep slopes (approximately 9%) and sparse vegetation. There are frequent landslides, boulders and mudslides on the slopes. The geological composition, the basin’s erosion, and a high sediment transport capacity of rivers, induced a high concentration of suspended sediment and bedload transport in water flows. Figure 5.3.5.5 shows the outline of Colorado River water system.

Colorado river sub-drainage basin sections as follows:

i) Olivares river sub-drainage basin

This micro-basin is located above 2000 m.a.s.l. in its middle and upper section. The first section narrows down above 2500 m.a.s.l., and this is where tributary streams such as Picarte, El Plomo, Cordillera Ferroso, Esmeralda, and Las Pircas are located. Cumbres de Olivares glacier, Juncal sur and Nevados del Plomo feed into them. The most important water source in the second section is La Jarilla. Compare to the preceding sections, the basin becomes flatter near to the confluence with Colorado river. Olivares river water flow shows water levels in natural flow regime that fluctuates between 25,11 m^3/s in January to 3,37 m^3/s in July. The average annual water level is 10 m^3/s.

Table 5.3.5.8

Average Annual and Monthly Water Level m3/s Natural Flow Regime of Olivares River before the confluence with Colorado River

Olivares river	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Qma
	25,11	21,35	12,64	6,09	4,06	3,50	3,37	3,59	4,38	6,57	10,65	19,24	**10,06**

Source: Water Resources Analysis, Gener 2005.

ii) Colorado river basin before the confluence with Olivares river

In this section, Colorado river hydrological regime is markedly nival type i.e. melt water only feeds into it. The river narrows down up to Chacayal stream sector, above 2000 m.a.s.l.

At this elevation, the Aguas Blancas, El Azufre, El Museo, Parraguirre, Chacayal, de las Vacas, and La Paloma streams feed into the basin. Colorado river water flow shows water levels that fluctuates between 36,92 m^3/s in January to 9,05 m^3/s in August. The average annual water level is 17,62 m^3/s.

Table 5.3.5.9
Average Annual and Monthly Water Level m3/s Natural Flow Regime of Olivares River before the confluence with Colorado River

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Qma
36,92	26,87	19,10	13,64	10,64	9,58	9,05	8,82	9,16	12,53	20,85	33,76	**17,62**

Source: Water Resources Analysis, Gener 2005.

iii) Colorado river basin before the confluence with Maipo river

In this section, this flatter basin is approximately at an elevation of 1000 m.a.s.l.

At this elevation, water sources such as Olivares river, Cabeza de León, Temblor, and Aucayes streams have already fed into the basin as well as the streams that are located in the upper section of Colorado river.

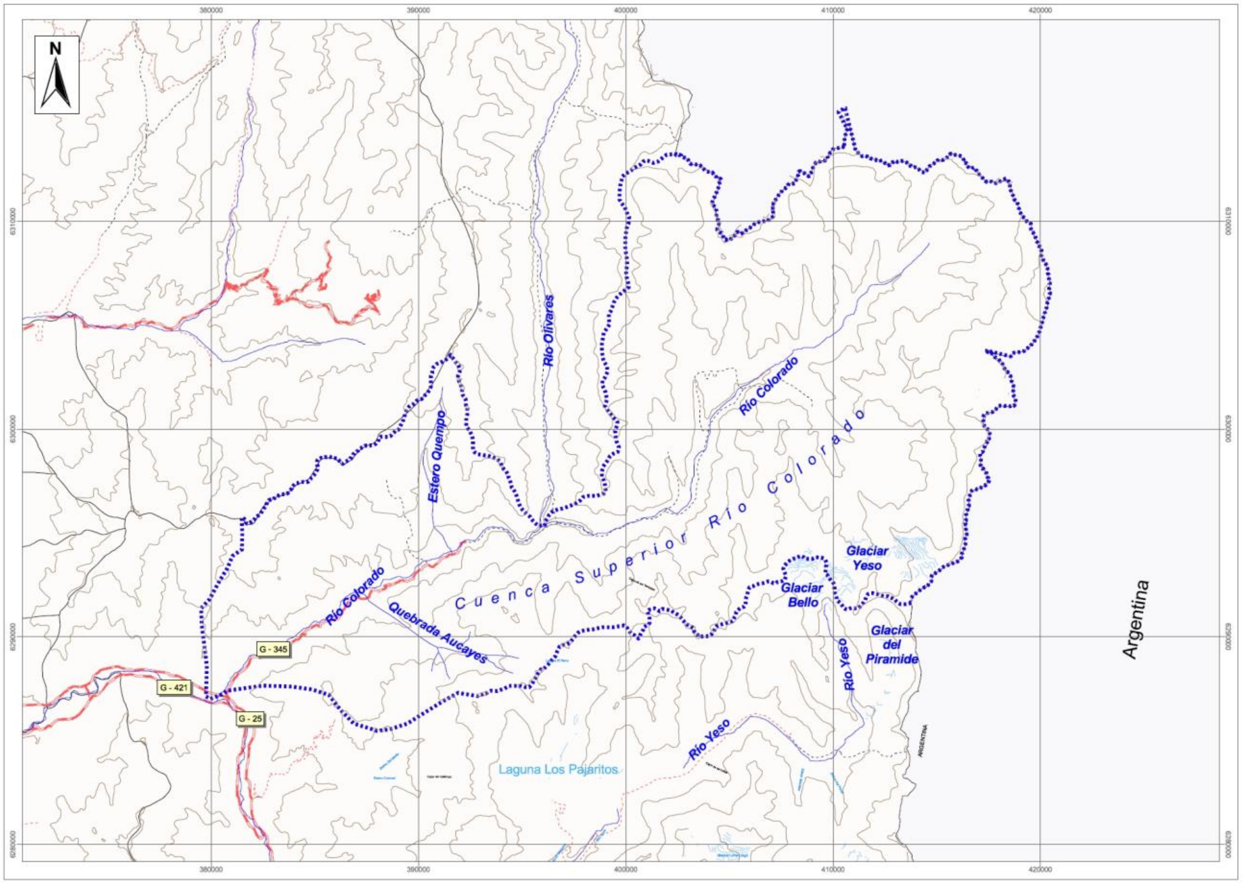
The water flow shows water levels that fluctuates between 64,17 m^3/s in January to 16,87 m^3/s. The average annual water level is 32,75 m^3/s, being Colorado river one the main tributaries of Maipo river basin.

Table 5.3.5.10
Average Annual and Monthly Water Level m3/s Natural Flow Regime of Colorado River before the confluence with Maipo River

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Qma
64,17	51,41	34,79	21,85	18,76	18,05	16,87	18,52	19,96	27,15	42,03	60,85	32,75

Source: Water Resources Analysis, Gener 2005.

Image 5.3.5.5
Tributary basin to Colorado River



F. Conclusions

In general terms, the hydrological system is composed of Yeso, Colorado, and Volcán rivers and its hydrological regime is nival type i.e. the hydrological year superficial runoff takes place mainly in the snow melt season, from October to March. In both Yeso and Colorado rivers there is an altered hydrological regime because of electric power generation infrastructure located in Yeso and Colorado rivers as well as El Yeso reservoir.

5.3.5.2 Water quality

In July 2004, the study “Analysis and Classification of Streams and Water Bodies, according to quality objectives, Maipo river basin” was conducted by DGA to describe water quality in the study area. To specify exactly what is required in order to develop the project, three on-site inspections were conducted to gather data from relevant water courses.

The first on-site inspection took place in April 2005. The upper tributaries of Volcán river basin were analyzed, being the most relevant in terms of both the environmental assessment and the objectives and conditions of PHAM. The second on-site inspection took place in November 2006, analyzing the aforementioned upper tributaries as well as Lo Encañado lake and its corresponding discharge (El Manzanito stream), Volcán river, Yeso river, Colorado river, and Maipo river. To determine water quality, samples were taken in all sectors according to sampling points locations indicated in images 5.3.5.5. A, B, and C.

A third on-site inspection took place in December 2007 to complement data regarding heavy metals in superficial runoffs. Results are shown in annex 31, in accordance with maximum permissible levels regulations. All heavy metals concentration samples did not exceed Nch 1333 regulation.

Lo Encañado lake and Manzanito, Quempo, and Cortaderas streams will not be affected by the Project. They were included in the analysis since they are within the indirect area of influence of PHAM.

Image **5.3.5.6-A**
Water Quality Sampling Points

Image **5.3.5.6-B**
Water Quality Sampling Points

Image 5.3.5.6-C
Water Quality Sampling Points

A Methodology

Owing to its lymnological importance, water samples were taken to analyze physical and chemical parameters in order to categorize water resources in every sampling area and to describe the habitat for aquatic biota (section 5.4.3).

- **Temperature (°C):** In situ measurements were taken using mercury thermometers with 0.1°C accuracy.

- **Specific conductivity (25 °C, µS/cm):** Water conductivity was measured in situ using a Jenway water conductivity meter with µS/cm 0.01 accuracy. (APHA, AWWA & WEF 1995).

- **Hydrogen ion concentration(pH):** Hydrogen ion concentration was measured in situ using an Extech calculator of 0.01ph. (APHA, AWWA & WEF 1995).

- **Dissolved oxygen (mg/l):** Water samples to analyze oxygen were taken in situ and then carried to laboratory. The Winkler test was used to determine the concentration of dissolved oxygen in water samples. (APHA, AWWA & WEF 1995).

- **Total suspended solids (mg/l):** Total suspended solids were analyzed using the standard gravimetric method, APHA, AWWA & WEF (1995).

- **Total dissolved solids (mg/l):** Total dissolved solids were measured through vaporization at a temperature of 103°, using gravimetrics. (APHA, AWWA & WEF 1995).

- **Alkalinity (mM):** Total alkalinity and phenolphtaleine alkalinity were analyzed in water samples according to the methodology described in APHA, AWWA & WEF (1995).

- **Orthophosphate (µg/l):** Orthophosphate ion concentration (P-PO4) was measured according to molybdenum complex method. (APHA, AWWA & WEF 1995).

- **Nitrite (µg/l):** Nitrite ion concentration was measured in accordance with sulphanilamide-etilendiamine method. (APHA, AWWA & WEF 1995).

- **Nitrate (µg/l):** Nitrate ion concentration (N-NO3) was measured in accordance with citrate method (APHA, AWWA & WEF 1995).

- **Ammonium (µg/l):** Ammonium ion concentration (N-NH4) was measured in accordance with Indophenol blue method. (APHA, AWWA & WEF 1995).

- **Total phosphorus (µg/l):** Total phosphorus concentration was measured in accordance with the methodology described in APHA, AWWA & WEF (1995).

- **Total Organic Nitrogen (µg/l):** Total organic concentration was measured in accordance with the methodology described in APHA, AWWA & WEF (1995).

- **Sulphate (mg/l):** Sulphate concentration (SO4-2) was determined using flame spectrophotometry in accordance with the methodology described in APHA, AWWA & WEF (1995).

- **Biochemical oxygen demand (mg/l):** Biochemical oxygen demand was measured in water samples in accordance with APHA, AWWA & WEF (1995).

- **Chlorohyll (µg/l):** Chlorophyll concentration is an autotrophic biomass estimator. The concentration of photosynthetic Cl pigment was determined filtering 1L volume through fiberglass filters(0,45 µm) kept approximately at a temperature of 0° C after 90% pigment extraction in acetone in the laboratory. Absorbance measurements in chlorophyll concentration were carried out using a Shimadzu spectrophotometer in accordance with Lorenzen's methodology (1967). Sampling was carried out in two areas of Lo Encañado lake.

- **Runoff speed (m/s):** Runoff speed was estimated using a Mini Meter 1205 current meter with 0.001 m/s accuracy. Average speed estimation was obtained after three speed measurements.

- **Substrate type:** It was quantified in accordance with Bain *et al* methodology, which was developed to analyze the aquatic biota and their habitat. See table 5.3.5.11 for a particle size description of the river's substrate.

Table 5.3.5.11
River Substrate Classification regarding Particle Size
(Bain *et al* 1985)

Substrate type	Size(mm)	Code
Flat bedrock	-	1
Sand, Silt	< 2	1
Gravel	2-16	2
Pebbles	17-64	3
Stones	65-256	4
Large stones	> 256	5
Irregular bedrock	-	6

B. General background

In Yeso river basin there is a large area below 0°C isotherm that generates rock weathering and the subsequent ion leaching, which in turn generates salt solutions. Besides, there are iron sulphur rocks and sedimentation of solids in both the lake and the reservoir. Gypsum exploitation results in sulphates and waste water from mining processes. On the other hand, this basin is composed of colluvial and rocky washout material in slopes with sparse vegetation. As a result, loose sediments feed into water courses.

As to Olivares river basin and Colorado river basin, they show runoffs with clay sediments (aluminum and silicates) with a basic ph, which in turn generate aluminum complex in solution. Low temperatures present favorable conditions for weathering and sparse vegetation in slopes. Sediments are accumulated in slopes.

Volcán river basin shows a lithology that generates metal leaching and ph decrease.

Besides, there are thermal waters with high levels of inorganics and metals in solution. On the other hand, limestone mining generates dissolved solids and waste waters associated with mines.

A general description of water quality parameters for Volcán, Yeso, and Colorado water courses [11] as follows:

- **Electrical conductivity (uS/cm):** Yeso river shows low electrical conductivity throughout the year while Colorado river shows high electrical conductivity. The coldest months recorded the highest levels of conductivity.

- **Dissolved Oxygen (mg/l):** Colorado river basin shows the highest concentrations of dissolved oxygen while Volcán river basin the lowest. Seasonal distribution of concentrations varies according to basin. Yeso river basin recorded the lowest concentrations in summer while Volcán river basin recorded the lowest concentrations in winter and spring.

- **pH:** pH levels in all three water courses fluctuate between 7.7 and 8.3 units. These pH levels indicate a basic and neutral water condition, which is often the case in Andean aquatic systems. However, Yeso river recorded levels over 10 in spring because of limestone deposits with high pH levels in the study area.

- **SAR (sodium adsorption ratio):** Yeso river basin shows the lowest SAR concentration levels, being homogeneous throughout the year. Volcán river, however, shows the highest SAR concentration levels year round, particularly in winter and spring.

- **Chloride (mg/l):** Volcán river shows the highest chloride concentration levels, almost exceeding in 100% in both Yeso river and Colorado river. Yeso river shows the lowest chloride concentration levels.

- **Copper:** Colorado river presents the highest concentrations of copper in summer while Volcán river presents the lowest concentrations which are homogeneous throughout the year.

- **Iron:** Colorado river iron concentrations are the highest in the Maipo river basin reaching such levels in summer. Yeso river, however, recorded the lowest iron concentrations in winter.

[11] Data gathered from the study “Water quality in Maipo river basin”.

C. Fieldwork results

i) On-site inspection, April 2005

- Volcán river upper sector

Sampling points as follows:

Table 5.3.5.12
Sampling points Location

Nº	Sampling Points	UTM Coordinates	
		East	North
1	La Engorda stream	408.028	6.259.724
2	Stream 1; between La Engorda stream and Colina stream (50 m from La Engorda stream)	408.160	6.260.094
3	Colina stream	408.164	6.260.099
4	Stream 2, in the confluence between La Engorda and Colina streams	407.301	6.259.788

Physical and Chemical Parameters

- **pH:** pH levels in the study area fluctuate between 6.9 and 8.6 units. These pH levels indicate a basic and neutral water condition, which is often the case in Andean aquatic systems. Besides, they represent a natural substrate condition because of limestone deposits with high pH levels in the study area.

- **Specific conductivity:** Specific conductivity levels in the study area fluctuate between 325 and 920 µS/cm, being typical of a fresh water area with a high ion concentration. La Engorda stream showed significant higher levels of specific conductivity tan Colina stream (Table 5.3.5.13). Limestone mining would generate a high availability of ions in the study area.

- **Dissolved oxygen:** Dissolved oxygen levels in the study area fluctuate between 7.5 and 8.1 mg/l indicating high oxygen availability for aquatic biota.

- **Total alkalinity and phenolphtaleine alkalinity:** No Phenolphtaleine alkalinity levels were present in the monitoring stations indicating undetectable levels of CO_3 concentration and average levels of basicity in water. On the other hand, total alkalinity quantification shows HCO_3 ions indicating a buffer zone in the system. (Table 5.3.5.13).

- **Total phosphorus and orthophosphate:** Total phosphorus concentration fluctuated between 17.0 and 49.2 µg/l (Table 5.3.5.13). Orthophosphate concentration fluctuated between 12.8 and 47.8 µg/l. Inorganic fraction represents the main form of phosphorus in water bodies. Phosphorus levels show high availability of this nutrient in the study area and mesotrophic waters. The study area is composed of grasslands where cattle generate high availability of phosphorus nutrients.

- **Total organic nitrogen:** Organic nitrogen concentration varied significantly between Colina and La Engorda streams. Colina stream reached low concentration levels while La Engorda stream recorded a concentration level of 365,3 µg/l which accounts for downstream nitrogen concentration in the confluence of both streams.(Table 5.3.5.13).The study area is composed of grasslands where cattle generate high availability of nitrogenous nutrients.
- **Inorganic nitrogen:** In contrast with organic nitrogen, the inorganic nitrogen fraction reached low quantification levels, particularly those related to nitrite and nitrate concentration levels with the exception of stream 2 located downstream the confluence of all streams. (Table 5.3.5.13). The inorganic nitrogen fraction was represented by ammonium ions in three monitoring stations indicating ammonium as the main source of inorganic nitrogen in this area.(Table 5.3.5.13).

- **Biochemical oxygen demand (BOD_5):** BOD_5 levels reached low levels that varied between 0.25 and 1.99 mg/l. La Engorda stream showed a BOD_5 level significantly higher than the value recorded in Colina stream. (Table 5.3.5.13).

- **Total dissolved solids:** High levels of total dissolved solids were recorded with a fluctuation of 289.5 and 1024 mg/l. La Engorda stream showed total dissolved solids concentration levels significantly higher than the values recorded in Colina stream. (Table 5.3.5.13).

- **Total suspended solids:** Total suspended solids concentration varied between 0.03 and 17.4mg/l. La Engorda stream showed total suspended solids concentration levels significantly higher than the values recorded in Colina stream. (Table 5.3.5.13).

- **Sulphate:** The study area showed a high sulphate concentration level with a fluctuation of 22.2 and 131.2 mg/l. La Engorda stream showed higher sulphate concentration levels than Colina stream. (Table 5.3.5.13).

Table 5.3.5.13
Chemical Quality Parameters, Volcán River Sub-drainage Basin (April, 2005)

Parameter	Unit	Colina	Engorda	Stream S1	Stream S2
Temperature	°C	8,7	11,4	14,0	9,3
Specific conductivity	µSims/cm	325	624	920	606
Dissolved oxygen	mg/l	7,54	7,94	7,54	8,13
pH	unit	8,4	8,6	8,3	6,9
Total suspended solids	mg/l	2,5	17,4	0,03	3,7
Total dissolved solids	mg/l	289,5	778,5	1024,5	548,0
Total alkalinity	mM	1,10	1,27	1,57	1,70
Phenolphtaleine alkalinity	mM	0	0	0	0
Nitrite	µg/l	U	U	U	U
Nitrate	µg/l	U	D	D	35,5
Ammonium	µg/l	24,0	15,4	20,4	21,9
Orthophosphate	µg/l	41,5	12,8	14,0	47,8
Total nitrogen	µg/l	D	365,3	D	275,7
Total phosphorus	µg/l	43,2	32,0	17,0	49,2
Sulphate	mg/l	22,2	90,2	131,2	55,4
BOD_5	mg/l	0,80	1,99	0,25	0,39

D = Detected

U = Undetected
S1 = Stream located between La Engorda and Colina streams
S2 = Stream located in the confluence of La Engorda y Colina streams

Picture 5.3.5.2. Confluence between La Engorda-Colina streams.

ii) On-site inspection, 2006

- Volcán river upper sector

Sampling points as follows:

Table 5.3.5.14
Sampling points location

Stations	Sector	Sampling points	UTM Coordinates	
			East	North
1	Volcán river upper basin	La Engorda stream (catchment area)	407.401	6.259.712
2		Colina stream (catchment area)	407.091	6.260.730
3		El Morado stream (catchment area)	406.193	6.259.012
4		Volcán river[12]	403.274	6.257.048

[12] No catchment area.

In general terms, fluvial courses of the catchment area such as La Engorda, Colina, and El Morado that are in Volcán river upper sector showed high availability of dissolved oxygen (> 8.2 mg/l), high runoff speed (0.66 – 0.96 m/s), high load of sediment transport, and a substrate that is composed of pebbles and stones in La Engorda and Colina streams (Bain et al, 1985), rocks and large stones in El Morado stream, and pebbles and gravel in Volcán river. The substrate showed underdeveloped ephilitic flora with the exception of La Engorda stream and Volcán river where a number of benthic microalgae were detected. There were no macrophytes in the river bank areas and the water courses. According to physical characteristics, the streams of the catchment area that are in Volcán river upper sector are classified as Rithron type systems in accordance with Illies & Botosaneanu (1963). No fish were detected in the study area.

Table 5.3.5.15
Physical Parameters. Volcán River Upper Sector

Water bodies	**Temperature (ºC)**	**Runoff speed(m/s)**	**Substrate type (Bain)**	**Water course type (Sthraler 1954)**
La Engorda stream	12,1	0,66 ± 0,04	Pebbles-stones	Rithron
Colina stream	7,0	0,84 ± 0,05	Pebbles-stones	Rithron
El Morado stream	7,9	0,69 ± 0,05	Rocks-large stones	Rithron
Volcán river	7,5	0,96 ± 0,09	Gravel-pebbles	Rithron

Ion concentration and Basicity

- **pH:** pH levels in El Volcán catchment area varied between 7.4 and 8.7 units. These levels indicate a basic condition, a high buffering capacity, and acidity regulation which are often the case in lotic systems with low anthropogenic disturbance. (Table 5.3.5.16). pH levels in the catchment area of Volcán river upper sector are within the law (5.5 – 9.0 units; Chilean official regulation, 1.333, Official letter 78, INN-Chile, 1987). The natural resource is suitable for irrigation and aquatic life.

- **Total alkalinity and phenolphtaleine alkalinity**: There are no phenolphtaleine alkalinity levels in all water bodies in the catchment area of Volcán river upper sector, which indicates undetectable levels of carbonate ions and average levels of basicity in water because of bicarbonate ions (110 and 200 mgHCO_3^-/l), which in turn would generate buffering capacity in these water bodies. (Table 5.3.5.16). Alkalinity levels in the catchment area of Volcán river upper sector were higher than the minimum required value (20.0 mg/l). (Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987).The natural resource is suitable for irrigation and aquatic life.

- **Specific conductivity and total dissolved solids:** Specific conductivity levels in the catchment area of Volcán river upper sector varied between 640 and 1290 uSims/cm (Table 5.3.5.16). These high levels are frequent in the snow melt season in the Andes due to high ion transport and sediment transport. Total dissolved solids concentration levels also were high (530 – 1212 mg/l). Specific conductivity levels detected in the catchment area of Volcán river upper sector were higher than the maximum permissible level (750 uSims/cm; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987). Thus, water resources in the area of influence of the project are not suitable for irrigation and aquatic life. Furthermore, total dissolved solids concentration was higher than the maximum permissible level (500 mg/l), which indicates that the natural resource is not suitable for irrigation and aquatic life. Sample collections took place in spring. (Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987).

- **Total suspended solids:** High levels of total suspended solids were detected in the catchment area of Volcán river upper sector because of seasonal superficial runoff in the basin. Total suspended solids concentration in water courses varied between 19.1 and 154.3 mg/l (Table 5.3.5.16). It is very likely that these levels decrease significantly in summer.

Nutrient concentration and Trophic condition

- **Orthophosphate and total phosphorus** The orthophosphate concentration detected in the catchment area of Volcán river upper sector varied between 12.5 and 37.3 ug/l (Table 5.3.5.16), which indicates a low concentration of dissolved inorganic phosphorus in water courses. Total phosphorus levels (organic and inorganic) were higher than orthophosphate levels (39.9 – 218.3 ug/l), which indicate that the main source of phosphorus is the organic fraction, mainly in La Engorda stream. In accordance with the phosphorus concentration, water courses are classified as mesotrophic according to Ryding & Rast (1989).Thus, there is some natural capacity to generate eutrophication because of an alleged phosphorus limitation in these water courses. It should be noted that total phosphorus levels characterize Colina stream as meso-eutrophic. Due to low anthropogenic disturbance detected in the streams within the catchment area, it is likely that phosphorus in these water bodies comes from natural sources connected to the lithology of the basin.

- **Inorganic nitrogenous forms and total organic nitrogen:** The inorganic nitrogen fraction was mainly represented by nitrate ions, which would indicate that they are the main source of inorganic nitrogen in the water bodies of the area (Table 5.3.5.16). The organic nitrogen fraction reached quantification levels, which varied between 65.5 and 105.5 ug/l (Table 5.3.5.16). Organic nitrogen concentration levels in the water courses within the catchment area of Volcán river upper sector reached quantification levels (323.5 – 376.8 ug/l, Table 5.3.5.16), with the exception of El Morado Stream. These results are indicative of organic fraction predominance over inorganic fraction in these water courses. It is very likely that a high runoff speed in the sampling area of El Morado stream is preventing in situ generation of organic particles such as benthic microalgae. Because of total nitrogen concentration, the water courses within the catchment area of Volcán river upper sector are classified as oligotrophic according to Ryding & Rast (1989). Thus, there is a low capacity to generate eutrophication.

Oxic condition

- Dissolved oxygen concentration in the catchment area of Volcán river upper sector varied between 8.2 and 8.9mg/l (Table 5.3.5.16), indicating a high availability of dissolved oxygen in the water which indicates favorable conditions for aquatic biota. Concentration levels detected in the area were higher than the minimum required value (5.0 mg/l; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987), which indicates that the natural resource is suitable for irrigation and aquatic life. Because of the high availability of dissolved oxygen, BOD_5 levels were low. They varied between 0.39 and 0.78mg/l (Table 5.3.5.16). These levels are frequent in fluvial systems with low anthropogenic disturbance.

Macroelements Concentration

- **Sulphate:** There was a high sulphate concentration in fluvial courses in the catchment area of Volcán river upper sector varied between 76.5 and 142.0 mg/l (Table 5.3.5.16). In spite of the natural high sulphate levels present in these fluvial courses, the values were lower than the maximum permissible levels. (250 mg/l; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987). Thus, the natural resource is suitable for irrigation.

Table 5.3.5.16

Water Quality: Physical and Chemical Parameters. Volcán River upper sector

Parameter	Unit	La Engorda stream	Colina stream	El Morado stream	Volcán river
Temperature	ºC	12,1	7,0	7,9	7,5
pH	unit	7,4	8,4	8,7	7,7
Specific conductivity	uSims/cm	640	1.290	730	1.125
Dissolved oxygen	mg/l	8,2	8,9	8,7	8,5
Nitrite ($N-NO_2$)	ug/l	1,56	0	0	0
Nitrate ($N-NO_3$)	ug/l	83,0	65,5	70,4	105,5
Ammonium ($N-NH_4$)	ug/l	43,3	46,9	0	0
Total organic nitrogen (N-Ntotal)	ug/l	450,1	323,5	0	376,8
Orthophosphate ($P-PO_4$)	ug/l	15,0	12,5	37,3	15,0
Total phosphorus (P-Ptotal)	ug/l	218,3	99,5	39,9	55,0
Total dissolved solids	mg/l	530	1.212	610	933
Total suspended solids	mg/l	154,3	119,8	19,1	63,0
Phenolphtaleine alkalinity	mg/l	0	0	0	0
Total alkalinity	mg/l	110	110	150	200
Sulphate	mg/l	76,5	142,0	82,5	110,0
Biochemical oxygen demand(BOD_5)	mg/l	0,67	0,57	0,39	0,78

* Minimum detectable value through analytical techniques

- Yeso river sector

Sampling points location in both Yeso river and Cortaderas stream. See table 5.3.5.17.

Table 5.3.5.17
Sampling Points Location

Nº	Sampling area	Sampling Point	UTM Coordinates	
			East	North
6	Yeso river sector	Yeso river	396.534	6.270.780
7		Cortaderas stream	394.994	6.268.252

The section of Yeso river in the area of influence presented a temperature of 12.5°C, high availability of dissolved oxygen (8.7 mg/l), high runoff speed (0.93 ± 0.16 m/s), and a low load of sediment transport . The substrate was highly heterogeneous (5 - 40 cm) and it is composed of sand, gravel, pebbles, and stones. The substrate presented highly developed ephilitic flora. There were no macrophytes in the river bank areas and the water courses. The section of Cortaderas stream in the area of influence presented a temperature of 15°C, high availability of dissolved oxygen (7.7 mg/l), high runoff speed (0.89 m/s), and a low load of sediment transport. The substrate was heterogeneous (20 - 40 cm) and it is composed of pebbles and stones. There was no ephilitic flora and macrophytes.

According to physical characteristics, the sections of both Yeso river and Cortaderas stream are classified as Rithron type systems in accordance with Illies & Botosaneanu (1963). Low levels of suspended particles represent favorable conditions for ichthyic fauna. (Campos, 1985). In consequence, fish were detected in the study area of Yeso river.

Ion concentration and Basicity

- **pH:** pH value in this section of Yeso river was 8.4 units and in Cortaderas stream was 8.7 units. Those values are directly influenced by the project. (Table 5.3.5.18). This level indicates a basic condition, a high buffering capacity, and acidity regulation which are often the case in lotic systems with low anthropogenic disturbance. pH levels in both Yeso river and Cortaderas stream are within the law (5.5 – 9.0 units; Chilean official regulation, 1.333, Official letter 78, INN-Chile, 1987), which indicate that both systems present suitable physical and chemical conditions for irrigation and aquatic life.

- **Total alkalinity and phenolphtaleine alkalinity**: There are no phenolphtaleine alkalinity levels in both Yeso river and Cortaderas stream which indicates undetectable levels of carbonate ions and average levels of basicity in water because of bicarbonate ions (105 mgHCO_3^-/l y 100 mgHCO_3^-/l, respectively) , which in turn would generate buffering capacity in these water bodies. (Table 5.3.5.18). Alkalinity levels were higher than the minimum required value (20.0 mg/l). (Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987).The natural resource is suitable for irrigation and aquatic life in both systems.

- **Specific conductivity and total dissolved solids:** Specific conductivity levels in the section influenced by the project in both Yeso river and Cortaderas stream were 910 and 102 uSims/cm, respectively (Table 5.3.5.18). These levels are frequent in the snow melt season in the Andes since high runoff speed generates higher suspended ions concentration that is carried by water courses (Table 5.3.5.18). Total dissolved solids concentration levels were higher in Yeso river (834 mg/l) but in Cortaderas stream were lower (158 mg/l). Specific conductivity levels detected in Yeso river were higher than the maximum permissible level while in Cortaderas stream were lower (Specific conductivity=750 uSims/cm; total dissolved solids=500 mg/l) Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987). Thus, Yeso river water resources in the area of influence of the project are not suitable for irrigation and aquatic life but Cortaderas stream water resources are suitable for irrigation and aquatic life.
- **Total suspended solids:** In contrast with dissolved fraction (ions in transport) low levels of total suspended solids or suspended particles were detected in both sections of Yeso river (5.3 mg/l) and in Cortaderas stream (1.68 mg/l) (Table 5.3.5. 18). This result is concordant with a high level of transparency in the water column. It is very likely that these levels decrease significantly in summer.

Nutrient concentration and Trophic condition

- **Orthophosphate and total phosphorus:** The orthophosphate concentration detected in both Yeso river and Cortaderas stream respective sections (Table 5.3.5.18) indicates a low concentration of dissolved inorganic phosphorus in water courses. Total phosphorus levels (organic and inorganic) were quantified in Yeso river, which indicate that the main source of phosphorus in these water systems is the organic fraction. Total phosphorus levels were not detected in Cortaderas stream. In accordance with the phosphorus concentration, the respective sections in these water courses are classified as oligotrophic according to Ryding & Rast (1989).Thus, there is a low capacity to generate eutrophication because of an alleged phosphorus limitation in these water courses. It should be noted that total phosphorus levels reveal almost no profitable farming in the study area.

- **Inorganic nitrogenous forms and total organic nitrogen:** No inorganic nitrogen fraction was found in both Yeso river and Cortaderas stream, which indicates that the main source of nitrogen in both sections of the study area is the organic fraction (Table 5.3.5.18). The organic nitrogen fraction reached quantification levels, reaching 313.1ug/l in Yeso river (Table 5.3.5.18) and 263.3 ug/l in Cortaderas stream (Table 5.3.5.17). In accordance with the total organic nitrogen concentration, the respective sections in both Yeso river and Cortaderas stream are classified as oligotrophic according to Ryding & Rast (1989).Thus, there is a low capacity to generate eutrophication. It should be noted that total phosphorus levels reveal almost no profitable farming in the study area.

Oxic Condition

- Dissolved oxygen concentration in Yeso river reached 8.7mg/l while in Cortaderas stream reached 7.7mg/l (Table 5.3.5.18). These values show a high availability of dissolved oxygen in the water which indicates favorable conditions for aquatic biota. Oxygen concentration levels detected in both sectors were higher than the minimum required value (5.0 mg/l; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987), which indicate that the natural resource is suitable for irrigation and aquatic life. Because of the high availability of dissolved oxygen, BOD_5 levels were low in both Yeso river and Cortaderas stream (0.58 and 1.08mg/l, respectively; Table 5.3.5.18). These levels are frequent in fluvial systems with low anthropogenic disturbance.

Macroelements Concentration

- **Sulphate:** There was a high sulphate concentration in Yeso river section (105.5 mg/l) while in Cortaderas stream section was low (7.56 mg/l) (Table 5.3.5.18). The values in both sections were lower than the maximum permissible levels. (250 mg/l; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987). Thus, the natural resource is suitable for irrigation.

Table 5.3.5.18
Physical and Chemical Parameters of Yeso River and Estero Cortaderas tributaries
Yeso River Sector

Parameter	Unit	Yeso river	Cortaderas stream
Temperature	ºC	12,5	15,0
pH	unit	8,4	8,7
Specific conductivity	uSims/cm	910	102
Dissolved oxygen	mg/l	8,7	7,7
Nitrite (N-NO_2)	ug/l	0,0	D
Nitrate (N-NO_3)	ug/l	0,0	U
Ammonium (N-NH_4)	ug/l	0,0	D
Total nitrogen (N-Ntotal)	ug/l	313,1	263,3
Orthophosphate (P-PO_4)	ug/l	0,0	D
Total phosphorus (P-Ptotal)	ug/l	12,8	D
Total dissolved solids	mg/l	834	158
Total suspended solids	mg/l	5,3	1,68
Phenolphtaleine alkalinity	mg/l	0,0	0,0
Total alkalinity	mg/l	105	100
Sulphate	mg/l	105,5	7,56
Biochemical oxygen demand	mg/l	0,58	1,08

* Minimum detectable value through analytical techniques

- Lo Encañado lake sector

Sampling points location as follows:

Table 5.3.5.19
Sampling points location

Nº	Sampling Area	Sampling Point	UTM Coordinates	
			East	North
6	Lo Encañado lake	SW of Lo Encañado lake	395.471	6.273.716
7		SE of Lo Encañado lake, current water outlet area	394.800	6.273.990
8		El Manzanito stream, downstream the water outlet area	396.187	6.272.939

Lo Encañado lake represents a high altitude lentic system. Negra lake water outlet feeds into it as the main source of water resources. See sampling points location (Table 5.3.5.19). Sampling points showed a temperature that varied between 12.5°C and 12.9°C, high availability of dissolved oxygen (> 8.4 mg/l), and low transparency in the water column. There were no macrophytes in the river bank areas with the exception of *Miriophyllum* sp. The study area in the water outlet area towards El Manzanito stream showed a temperature of 11.8°C, and a high runoff speed of 0,84 ± 0,05 m/s. The substrate was heterogeneous (20 - 60 cm) and it is composed of rocks and large stones. (Bain *et al*, 1985). Water quality in the study area downstream the water outlet area of the lake does not present significant variations with regard to lake's water quality. Temperature levels, high availability of dissolved oxygen, and low levels of suspended particles represent favorable conditions for aquatic biota, specifically, introduced ichthyic fauna. (Campos, 1985).

Ion Concentration and Basicity

- **pH:** pH level in the study area of Lo Encañado lake and its water outlet varied between 8.3 and 8.5 units(Table 5.3.5.20). These levels indicate a basic condition, a high buffering capacity, and acidity regulation which are often the case in lotic systems with low anthropogenic disturbance. pH levels detected in both the study area of Lo Encañado lake and in its water outlet towards El Manzanito stream are within the law (5.5 – 9.0 units; Chilean official regulation, 1.333, Official letter 78, INN-Chile, 1987), which indicate that both systems present suitable conditions for irrigation and aquatic life.

- **Total alkalinity and phenolphtaleine alkalinity**: There are no phenolphtaleine alkalinity levels in all sampling points within the lake and El Manzanito water outlet, which indicates undetectable levels of carbonate ions and average levels of basicity in water because of bicarbonate ions (50 and 60 mgHCO_3^-/l), which in turn would generate buffering capacity in these water bodies. (Table 5.3.5.20). Alkalinity levels in the catchment area of Volcán river upper sector were higher than the minimum required value (20.0 mg/l). (Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987).The natural resource is suitable for irrigation and aquatic life.

- **Specific conductivity and total dissolved solids:** Specific conductivity levels in Lo Encañado lake and its water outlet did not show significant variations (128 y 133 uSims/cm; Table 5.3.5.20). These low levels are frequent in lentic systems in the Andes with low trophic condition. Total dissolved solids concentration levels were low (76.0 – 80.5 mg/l). Specific conductivity levels detected in the discharge area in Lo Encañado lake and downstream the water outlet towards El Manzanito stream were lower than the required value (750 uSims/cm; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987). Thus, the natural resource in this section is suitable for irrigation and aquatic life. Similarly, total dissolved solids concentration was lower than the required level (500 mg/l), which indicates that the natural resource, despite low water quality levels, is suitable for irrigation and aquatic life. (Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987).
- **Total suspended solids:** There were low levels of total suspended solids in both Lo Encañado lake and in the water outlet area of the lake during sample collection. They varied between 5.1 and 6.4 mg/l (Table 5.3.5. 20). It is very likely that these levels decrease significantly in summer.

Nutrient Concentration and Trophic condition

- **Orthophosphate and Total phosphorus:** No orthophosphate levels were detected in the water outlet of Lo Encañado lake (lower than the minimum detectable value through analytical techniques, Table 5.3.5.20), which indicates a low concentration of dissolved inorganic phosphorus. Total phosphorus levels (organic and inorganic) were quantified and they varied between 20.8 and 30.6ug/l., which indicate that the main source of phosphorus in these water systems is the organic fraction. Similar results showed downstream in the water outlet of Lo Encañado lake towards El Manzanito stream. In accordance with the phosphorus concentration, Lo Encañado lake and its water outlet are classified as mesotrophic according to Ryding & Rast (1989).Thus, there is some capacity to generate eutrophication because of an alleged phosphorus limitation in these water courses. Because of low anthropogenic disturbance in the study area, it is likely that the predominant organic phosphorus comes from natural sources that are connected to the internal autotrophic production of the system, which is transferred to El Manzanito stream 900 meters downstream the lake.
- **Inorganic nitrogenous forms and total organic nitrogen:** No inorganic nitrogen fraction was found in both Lo Encañado lake and its water outlet (Table 5.3.5.20). The organic nitrogen concentration reached quantification levels (340 – 458.3ug/l, table 5.3.5.20). These results are indicative of organic fraction predominance over inorganic fraction. In accordance with the total organic nitrogen concentration, both Lo Encañado lake and its water outlet present an oligomesotrophic condition according to Ryding & Rast (1989).Thus, there is some capacity to generate eutrophication.

- **Chlorophyll a.** Chlorophyll a concentration varied between 2.3 and 3.3ug/l (Table 5.3.5.20). According to these results, Lo Encañado lake presented an oligotrophic condition (Ryding & Rast, 1989). Thus, there is a low capacity to generate eutrophication.

Oxic Condition

- Dissolved oxygen concentration in the water outlet area and SW of Lo Encañado lake varied between 8.4 and 8.5mg/l (Table 5.3.5.20). In addition, El Manzanito stream presented a high availability of dissolved oxygen. These values show a high availability of dissolved oxygen in the water which indicates favorable conditions for aquatic biota. Oxygen concentration levels detected in both sectors were higher than the minimum required value (5.0 mg/l; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987), which indicate that the natural resource is suitable for irrigation and aquatic life. Because of the high availability of dissolved oxygen, BOD_5 levels were low; they varied between 0.96 and 1.47mg/l.(Table 5.3.5.20).

Macroelements Concentration

- **Sulphate:** There was a comparatively low sulphate concentration in relation to other sectors in the area of influence of the project. The concentration varied between 6.9 and 7.2mg/l (Table 5.3.5.20). The values were lower than the maximum permissible levels. (250 mg/l; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987). Thus, the natural resource is suitable for irrigation.

Table 5.3.5.20

Water Quality: Physical and Chemical Parameters Sampling areas: Lo Encañado lake and el Manzanito Stream

Parameter	Unit	Lo Encañado lake		El stream
		SE of the lake (current water outlet)	SW of the lake	
Temperature	ºC	12,5	12,9	11,8
pH	Unit	8,3	8,5	8,4
Specific conductivity	uSims/cm	129	133	128
Dissolved oxygen	mg/l	8,5	8,4	8,3
Nitrite (N-NO_2)	ug/l	0,0	0,0	0,0
Nitrate (N-NO_3)	ug/l	0,0	0,0	0,0
Ammonium (N-NH_4)	ug/l	0,0	0,0	0,0
Total nitrogen (N-Ntotal)	ug/l	340,0	458,3	415,1
Orthophosphate (P-PO_4)	ug/l	0,0	0,0	0,0
Total phosphorus (P-Ptotal)	ug/l	20,8	30,6	25,6
Total dissolved solids	mg/l	76,0	77,0	80,5
Total suspended solids	mg/l	5,1	5,4	6,4
Phenolphtaleine alkalinity	mg/l	0,0	0,0	0,0
Total alkalinity	mg/l	50,0	60,0	55,0
Sulphate	mg/l	7,2	7,2	6,9
Chlorophyll a	ug/l	2,26	3,27	-
Biochemical oxygen demand	mg/l	1,45	1,47	0,96

* Minimum detectable value through analytical techniques

- Colorado river sector

Sampling points location as follows:

Table 5.3.5.21
Sampling points Location

Nº	Sampling area	Sampling point	UTM Coordinates	
			East	North
9	Colorado river basin	Colorado river ((in the future location of the regulating reservoir).	388.704	6.291.940
X		Quempo stream	387.804	6.292.262
10		Aucayes stream (catchment area)	382.743	6.288.874
11		Colorado river (Las Lajas tunnel intersection)	380.744	6.287.505

The section of Colorado river in the area of influence presented a high availability of dissolved oxygen (8.2 – 8.4 mg/l), high runoff speed (0.70 - 0.72 m/s), and a high load of sediment transport. The substrate, in the future location of the regulating reservoir, is mainly composed of large stones, larger than 50cm. In both Aucayes stream and in the Colorado river aqueduct intersection there was a substrate composed of rocks and large stones. There was no ephilitic flora in the substrate. There were no macrophytes in the river bank areas and the water courses. The substrate in Quempo stream showed a predominance of rocks and large stones, an underdeveloped ephilitic flora, and a low presence of macrophytes.

According to physical characteristics, this section of Colorado river is classified as Rithron type systems in accordance with Illies & Botosaneanu (1963). High levels of suspended particles represent unfavorable conditions for ichthyic fauna. (Campos, 1985). On the other hand, in both Aucayes and Quempo streams showed small water courses and a low load of suspended particles. In addition, a high availability of dissolved oxygen generates favorable conditions for aquatic biota. Nevertheless, there was a low presence of fish in both this section of the river and Aucayes stream. There were no results in Colorado river and Quempo stream.

Table 5.3.5.22
Physical Parameters Colorado River and tributaries

Water body	Temperature (ºC)	Runoff speed(m/s)	Substrate type (Bain et al. 1985)	Water course type (Sthraler 1954)
Colorado river in the future location of the regulating reservoir	11,4	0,72 ± 0,01	Large stones (+)	Rithron
Quempo stream	13,0	0,60± 0,01	Rocks and large stones	Rithron
Aucayes stream	14,0	0,49 ± 0,02	Rocks and large stones	Rithron
Colorado river at the aqueduct intersection	17,0	0,70 ± 0,08	Rocks and large stones	Rithron

Ion concentration and Basicity

- **pH:** pH level of Colorado river in the study area directly influenced by the project varied between 8.3 and 8.4 units(Table 5.3.5.23). These levels indicate a basic condition, a high buffering capacity, and acidity regulation. pH levels detected in Colorado river are within the law (5.5 – 9.0 units; Chilean official regulation, 1.333, Official letter 78, INN-Chile, 1987), which indicate that the study area present suitable conditions for irrigation and aquatic life. pH levels detected in both Aucayes and in Quempo streams reached 8.2 and 8.4 units respectively (Table 5.3.5.23), which indicate similar basicity characteristics in relation to Colorado river.

- **Total alkalinity and phenolphthaleine alkalinity**: There are no phenolphthaleine alkalinity levels in the study area of Colorado river, which indicates undetectable levels of carbonate ions and average levels of basicity in water because of bicarbonate ions (110 and 120 mgHCO_3^-/l), which in turn would generate buffering capacity in these water bodies. (Table 5.3.5.23). Alkalinity levels were higher than the minimum required value (20.0 mg/l). (Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987).The natural resource is suitable for irrigation and aquatic life. Alkalinity levels in both Aucayes and in Quempo streams reached 50 and 55mg/l respectively, because of bicarbonate ions in both fluvial courses.

- **Specific conductivity and total dissolved solids:** Specific conductivity levels in the section influenced by the project in Colorado river varied between 730 and 755uSims/cm (Table 5.3.5.23). These levels are frequent in the snow melt season in the Andes because of a high ions concentration and a high load of sediment transport. High total dissolved solids concentration levels were detected (556-652mg/l). Specific conductivity levels detected in Colorado river are similar to the maximum permissible level (Specific conductivity=750 uSims/cm; total dissolved solids=500 mg/l) Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987). Thus, Colorado river water resources in the area of influence of the project are not suitable for irrigation and aquatic life but in both Aucayes and in Quempo streams there were low specific conductivity levels (83 and 48uS/cm respectively) and low total dissolved solids levels (78 and 94mg/l respectively). Those values are significantly lower than the maximum permissible levels; thus, water resources are suitable for irrigation and aquatic life.

- **Total suspended solids:** There were average levels of total suspended solids in the section influenced by the project in Colorado river during sample collection. They varied between 160 and 491mg/l (Table 5.3.5. 23). It is very likely that these levels decrease significantly in summer. On the other hand, total suspended solids concentration levels in both Aucayes and Quempo streams were low (8.0 and 16.5 mg/l respectively). Thus, those values are significantly lower than the levels in Colorado river.

Nutrient concentration and Trophic condition

- **Orthophosphate and Total phosphorus:** Low orthophosphate levels were detected in the section influenced by the project in Colorado river (11.3 – 15.0 ug/l; Table 5.3.5.23). Total phosphorus levels (organic and inorganic) were quantified and they varied between 175.0 and 535.9ug/l. in Colorado river, which indicate that the main source of phosphorus in this water system is the organic fraction. In accordance with the phosphorus concentration, this section of Colorado river is classified as eutrophic, according to Ryding & Rast (1989).Thus, there is a natural capacity to generate eutrophication because of an alleged phosphorus limitation in this water course. This value indicates a high anthropogenic disturbance in the study area. Orthophosphate levels in both Aucayes and in Quempo streams are similar to Colorado's river. Organic phosphorus concentration levels in Aucayes stream were lower than Colorado's river (23.9ug/l) while Quempo stream showed higher levels (50.8ug/l). A mesotrophic condition would be present in both Aucayes and Quempo streams.

- **Inorganic nitrogenous forms and total organic nitrogen:** Due to nitrate ions, low inorganic nitrogen concentrations were found in the section influenced by the project in Colorado river. The values varied between 93.0 – 98.1ug/l (Table 5.3.5.23).The total organic nitrogen concentration reached quantification levels (416.9 – 746.3ug/l; table 5.3.5.23). These high values are indicative of organic fraction predominance over inorganic fraction. In accordance with the total organic nitrogen concentration, this section of Colorado river that might be influenced by the project presents an oligomesotrophic condition according to Ryding & Rast (1989).Thus, there is some capacity to generate eutrophication. This value indicates a high anthropogenic disturbance in the study area. Aucayes stream also presented inorganic and organic nitrogen levels similar to Colorado river. As to Quempo stream, there were no detectable levels of nitrite and nitrate and low levels of total organic nitrogen (245.0 ug/l). Thus, in accordance with the organic nitrogen concentration Aucayes stream presented an oligomesotrophic condition while Quempo stream an oligotrophic condition.

Oxic Condition

- Dissolved oxygen concentration in Colorado river varied between 9.3 and 9.7mg/l (Table 5.3.5.23). These values show a high availability of dissolved oxygen in the water which indicates favorable conditions for aquatic biota. Oxygen concentration levels detected in this sector were higher than the minimum required value (5.0 mg/l; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987), which indicate that the natural resource is suitable for irrigation and aquatic life. Because of the high availability of dissolved oxygen, BOD_5 levels were low; they varied between 1.16 and 1.17mg/l.(Table 5.3.5.23). However, in the area of influence, these values were comparatively higher than other areas less affected by the project. As to Aucayes and Quempo streams, they presented high concentration levels of dissolved oxygen (9.1 and 8.5mg/l respectively) and comparatively low BOD_5 levels (0.77 y 1.36 mg/l respectively).

Macroelements Concentration

- **Sulphate:** There was a high sulphate concentration in the area of Colorado river that might be affected by the project. The concentration varied between 70.7 and 79.6mg/l (Table 5.3.5.23). The values were lower than the maximum permissible levels. (250 mg/l; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987). Thus, the natural resource is suitable for irrigation. On the other hand, sulphate levels in both Aucayes and in Quempo streams were significantly lower (2.2 and 2.9mg/l), indicating lithological differences between these sub-drainage basins in relation to Colorado river main basin.

Table 5.3.5.23
Physical and Chemical Parameters Colorado River Sector

Parameter	Unit	Colorado river upstream future siphon	Quempo stream	Aucayes stream	Colorado river future siphon
Temperature	ºC	11,4	13,0	14,0	17,0
pH	Unit	8,4	8,4	8,2	8,3
Specific conductivity	uSims/cm	755	48	83	730
Dissolved oxygen	mg/l	9,3	8,5	9,1	9,7
Nitrite (N-NO_2)	ug/l	0,0	D	0,0	0,0
Nitrate (N-NO_3)	ug/l	98,1	D	58,2	93,0
Ammonium (N-NH_4)	ug/l	0,0	U	0,0	0,0
Total nitrogen (N–Ntotal)	ug/l	416,9	245,0	305,7	746,3
Orthophosphate (P-PO_4)	ug/l	15,0	10,0	17,5	11,3
Total phosphorus (P-Ptotal)	ug/l	175,0	50,8	23,9	535,9
Total dissolved solids	mg/l	652	94,0	78	556
Total suspended solids	mg/l	160	16,5	8,0	491
Phenolphtaleine alkalinity	mg/l	0,0	0,0	0,0	0,0
Total alkalinity	mg/l	110	55	50	120
Sulphate	mg/l	79,6	2,9	2,2	70,7
Biochemical oxygen demand	mg/l	1,16	1,36	0,77	1,17

* Minimum detectable value through analytical techniques.

- Maipo river

Sampling point in Maipo river was located at the discharge area of the tunnel, between coordinates 6283512N – 365369E. This section of Maipo river is classified as Rithron type system in accordance with Illies & Botosaneanu (1963). The water course showed a runoff speed of 1.23 ± 0.08 m/s, water oxygen saturation levels of > 12.0 mg/l and high turbidity levels. The substrate is mainly composed of large stones, between 10 and 40 cm. There was ephilitic flora in the river banks. There were no macrophytes in the river bank areas and the water courses. High turbidity levels represents unfavorable conditions for aquatic biota, specifically, native ichthyic fauna (Campos, 1985). No fish were detected in the study area.

Ion Concentration and Basicity

- **pH:** pH value in this section of Maipo river was 8.4 units (Table 5.3.5.24). These levels indicate a basic condition, a high buffering capacity, and acidity regulation. pH levels detected in Maipo river are within the law (5.5 – 9.0 units; Chilean official regulation, 1.333, Official letter 78, INN-Chile, 1987), which indicate that the study area presents suitable conditions for irrigation and aquatic life.

- **Total alkalinity and phenolphthaleine alkalinity**: There are no phenolphthaleine alkalinity levels in the study area of Maipo river affected by the project, which indicates undetectable levels of carbonate ions and average levels of basicity in water because of bicarbonate ions (90 mgHCO_3^-/l), which in turn would generate buffering capacity in this water body. (Table 5.3.5.23). Alkalinity levels were higher than the minimum required value (20.0 mg/l). (Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987).Thus, the natural resource is suitable for irrigation and aquatic life.
- **Specific conductivity and total dissolved solids:** Specific conductivity level in the section influenced by the project in Maipo river was 905uSims/cm (Table 5.3.5.24). This level is frequent in the snow melt season in the Andes because of a high ions concentration and a high load of sediment transport. High total dissolved solids concentration levels were detected. Specific conductivity levels detected in Maipo river are higher than the maximum permissible level (Specific conductivity=750 uSims/cm; total dissolved solids=500 mg/l) Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987). Thus, Maipo river water resource in the area of influence of the project is not suitable for irrigation and aquatic life.

- **Total suspended solids:** There were average levels of total suspended solids in the section influenced by the project in Maipo river during sample collection. (144mg/l; Table 5.3.5. 24). It is very likely that these levels decrease significantly in summer.

Nutrient Concentration and Trophic Condition

- **Orthophosphate and Total phosphorus:** A low orthophosphate level was detected in the section influenced by the project in Maipo river (12.5ug/l; Table 5.3.5.24), which indicates minimum levels of dissolved inorganic phosphorus. As a matter of fact, there was a high total organic phosphorus concentration, which indicates that the main source of phosphorus in this water system is the organic fraction. In accordance with the phosphorus concentration, this section of Maipo river is classified as eutrophic, according to Ryding & Rast (1989).Thus, there is a natural capacity to generate eutrophication because of an alleged phosphorus limitation in this water course. This value indicates a high anthropogenic disturbance in the study area.

- **Inorganic nitrogenous forms and total organic nitrogen:** Nitrate was the main source of inorganic nitrogen in the study area 100.5ug/l; Table 5.3.5.24).The total organic nitrogen fraction was high (333.3ug/l; table 5.3.5.24). This high value indicates organic fraction predominance over inorganic fraction. In accordance with the total organic nitrogen concentration, this section of Maipo river presents an oligomesotrophic condition according to Ryding & Rast (1989).Thus, there is a low capacity to generate eutrophication.

Oxic Condition

- Dissolved oxygen concentration in Maipo river was 9.5mg/l (Table 5.3.5.24). This value shows a high availability of dissolved oxygen in the water which indicates favorable conditions for aquatic biota. Oxygen concentration levels detected in this sector were higher than the minimum required value (5.0 mg/l; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987), which indicate that the natural resource is suitable for irrigation and aquatic life. Because of the high availability of dissolved oxygen, BOD_5 levels were low. (0.77mg/l; Table 5.3.5.24).

Macroelements Concentration

- **Sulphate:** There was a high sulphate concentration in the area of Maipo river (59.3mg/l; Table 5.3.5.24). This value was lower than the maximum permissible level. (250 mg/l; Chilean Official regulation 1.333, Official letter 78, INN-Chile, 1987). Thus, the natural resource is suitable for irrigation.

Table 5.3.5.24

Physical and Chemical Parameters Maipo River Discharge Sector

Parameter	Unit	Maipo River
Temperature	ºC	12,5
pH	unit	8,4
Specific conductivity	uSims/cm	905
Dissolved oxygen	mg/l	9,5
Nitrite (N-NO_2)	ug/l	2,2
Nitrate (N-NO_3)	ug/l	100,5
Ammonium (N-NH_4)	ug/l	0,0
Total nitrogen (N–Ntotal)	ug/l	333,3
Orthophosphate (P-PO_4)	ug/l	12,5
Total phosphorus (P-Ptotal)	ug/l	195,8
Total dissolved solids	mg/l	631
Total suspended solids	mg/l	144
Phenolphtaleine alkalinity	mg/l	0,0
Total alkalinity	mg/l	90
Sulphate	mg/l	59,3
Biochemical oxygen demand	mg/l	0,77

* Minimum detectable value through analytical techniques.

D. Conclusions

Maipo river and Colorado river water systems showed a higher suspended particles transport (115.7 – 343.2 g/m^{2}s) as well as La Engorda and Colina streams (102 and 101 g/m^{2}s respectively) during sample collection (spring). On the other hand, there was a significantly low suspended particles transport in El Yeso River (4.9 g/m^2.s) and Aucayes, Cortaderas, Quempo, and Manzanito streams. (2.9 - 6.9 g/m^{2}s) (Table 5.3.5.24). These values indicate highly unfavorable conditions for aquatic biota during seasonal superficial runoff in these basins with a nivo-pluvial regime. Nevertheless, there are water courses such as Aucayes, Cortaderas, Quempo, and El Manzanito streams and Yeso River that present comparatively favorable conditions for aquatic biota.
Based on fieldwork and bibliographic data, the study area presents variable conditions of anthropogenic disturbance. Systems such as Maipo, Colorado, and Yeso River as well as Aucayes stream present high levels of anthropogenic disturbance. On the other hand, Volcán River and Colina, La Engorda, and El Morado streams show low levels of anthropogenic disturbance due to distant human settlements and low agricultural activities in the basin.(DGA, 1994).

Despite the suspended particle load, the water quality presents highly favorable conditions for aquatic biota in all water courses within the study area. All sampling points showed detectable levels of dissolved oxygen, pH, alkalinity, and specific conductivity that comply with environmental regulations regarding irrigation and aquatic life. BOD_5 levels in the study area were low, which indicate that the study area presents suitable conditions for aquatic life. Nevertheless, there are some differences in water quality that lead to differential analysis of water courses. The streams located in the upper basin of rivers such as El Volcán, Yeso, Colorado, and Maipo showed the highest sulphate concentration levels in the study area (59.3 – 142.0mg/l). Those values differ considerably from the levels detected SE of Lo Encañado Lake and Aucayes, Quempo, and Cortaderas streams indicating a favorable condition and good water quality, which is variable among the systems within the study area. However, all sulphate concentration levels were lower than the maximum permissible levels for aquatic life (250 mg/l, N-Ch 1.333, Of 57).

As to heavy metals in surface waters, the analysis showed that all samples presented lower heavy metals concentration values than the maximum permissible levels (N-Ch 1333).

Table 5.3.5.25
Water Quality and Physical Condition of Streams Beds of the Area of Influence PHAM: Comparative Analysis

PARAMETRO	Área de captación en el sector alto del río El Volcán				Área de captación en el río Yeso		Áreas de descarga y bocatoma en la laguna Lo Encañado			Área del trazado del acueducto en el río Colorado y tributarios				Área de descarga en el río Maipo
Sistema	Estero La Engorda	Estero Colina	Estero El Morado	Río El Volcán	Rio Yeso	Estero Cortaderas	Sector de descarga	Sector de bocatoma	Estero El Manzanito	Río Colorado en tranque de contrapunta	Estero Quempo	Estero Aucayes	Río Colorado en zona de cruce de acueducto	Río Maipo en zona de descarga
Tipo predominante de cauce	Rithron	Rithron	Rithron	Rithron	Rithron	Rithron	-	-	Rithron	Rithron	Rithron	Rithron	Rithron	Rithron
Tamaño de sustrato (cm)	10 – 30	10 – 30	40 – 80	3 – 10	5 – 40	20-40	-	-	20 – 60	50 -100	30-60	10 – 40	30 – 60	10 – 40
Velocidad (m/s)	0,66 ± 0,04	0,84 ± 0,05	0,69 ± 0,05	0,96 ± 0,09	0,93 ± 0,16	0,89	-	-	0,84 ± 0,05	0,72 ± 0,01	0,60± 0,01	0,49 ± 0,02	0,70 ± 0,08	1,23 ± 0,08
pH	Neutro	Básico	Básico	Neut-Bas	Básico	Básico	Básico	Básico	Básico	Básico	Básico	Básico	Básico	Básico
	7,4	8,4	8,7	7,7	8,4	8,7	8,3	8,5	8,4	8,4	8,4	8,2	8,3	8,4
Conductividad específica (uS/cm)	Alta	Alta	Alta	Alta	Alta	Baja	Baja	Baja	Baja	Alta	baja	Baja	Alta	Alta
	640	1.290	730	1.125	910	102	129	133	128	755	48	83	730	905
Desarrollo de algas epilíticas	Alto	Bajo	Bajo	Alto	Alto	Bajo	-	-	Bajo	Bajo	Medio	Bajo	Bajo	Alto
Sólidos totales suspendidos (mg/l)	154,3	119,8	19,1	63,0	5,3	1,7	5,1	5,4	6,4	160,0	16,5	8,0	491,0	144,0
Transporte de sedimento (g m^{-2} s^{-1})	102	100,8	13,2	60,2	4,9	2,9	-	-	5,4	115,7	6,9	3,9	343,2	177,6
Concentración de oxígeno disuelto (mg/l)	Alta	Alta	Alto	Alta	Alta	Alta	Alta	Alta	Alta	Alta	Alta	Alta	Alta	Alta
	8,2	8,9	8,7	8,5	8,7	7,7	8,5	8,4	8,3	9,3	8,5	9,1	9,7	9,5
Condición trófica en base a P	Meso-eutrófico	Mesotrofía	Mesotrofía	Mesotrofía	Oligotrofía	Oligotrofía	Mesotrofía	Mesotrofía	Mesotrofía	Oligotrofía	Mesotrofía	Mesotrofía	Oligo-mesotrofía	Oligotrofía
Condición trófica en base a N	Oligotrofía	Oligotrofía	Oligotrofía	Oligotrofía	Oligotrofía	Oligotrofía	Oligo-mesotrofía	Oligo-mesotrofía	Oligo-mesotrofía	Oligotrofía	Oligotrofía	Oligo-mesotrofía	Oligo-mesotrofía	Oligotrofía
Condición trófica en base a Cl*a*	-	-	-	-	-	-	Oligotrofía	Oligotrofía	-	-	-	-	-	-
Concentración de SO_4 (mg/l)	76,5	142,0	82,5	110,0	105,5	7,56	7,2	7,2	6,9	79,6	2,9	2,2	70,7	59,3
DBO_5 (mg/l)	0,67	0,57	0,39	0,78	0,58	1,08	1,45	1,47	0,96	1,16	1,36	0,77	1,17	0,77

5.3.5.3 Hydrogeology

A. Underground Waters

Maipo river upper basin does not show an extensive development of sedimentary deposits. They are limited to some small valleys such as the confluence of Colorado River with Maipo River. The soil is mainly composed of large stones, gravel, and clay matrix with a flow of 2.000 m^3/d near to fluvial course. Hence, there is a close relation between water courses and the phreatic layer in which superficial water courses variations cause a swift response in both the phreatic layer and in the underground runoff water courses. As a consequence, the exploitation of underground waters amounts to 436 l/s, with a four years dry season included.

As to hydrogeology, the study area is located in the Central-South sub-province, between 33° and 42°S. There are some aquifers connected to the development of the physiographic unit of the intermediate depression area. Water sources that flow into the underground phreatic layers are surface water courses, melt water, and pluvial infiltration. The phreatic layers are not limited to water courses; they occupy vast portions of unconsolidated quaternary filling in the depression. This heterogeneous filling is composed of fluvial sediment transport and towards the south, fluvioglacial sediment transport from the Andes. The groundwater runoff runs in parallel to superficial runoff from the Andes to the sea. Runoffs flow unconfined, semi-confined, and confined due to impermeable clay deposits and volcanic deposits.

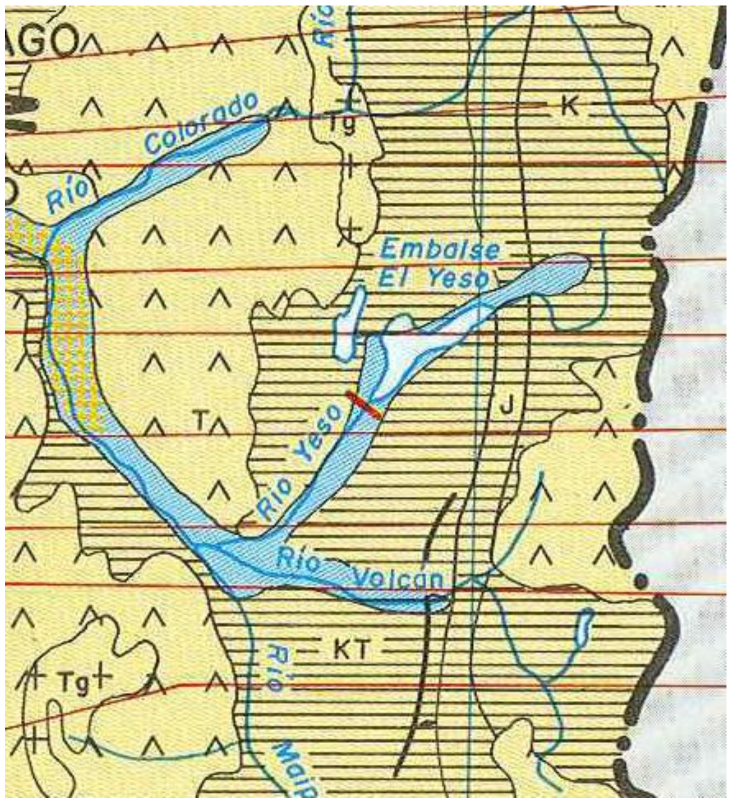
The Andes present in the first section of Maipo river basin granitic rocks, because of riverbed excavation. Granitic rocks form hydrogeological barriers that prevent groundwater from flowing into the basin. Mapocho River and Colina and Angostura streams feed into the basin through excavated beds in impermeable volcanic rocks. As a result, superficial water feeding flows into the basin from Colina stream, Mapocho River, upper Maipo River, and Angostura stream. Then, it infiltrates the filling.

In general terms, the study area shows a low presence of underground waters. The soil permeability is very low or non-existent because of rocky soil predominance (Image 5.3.5.6). The study area shows different rock types such as volcanic/sedimentary, breccia, ignimbrites with some intercalations of claystone, sandstone, and conglomerate rocks. These rocks are considered the aquifer foundation. Hence, they form the parent rock as well as the border area of groundwater runoff and they are not considered a water bearing layer in the underground.

However, there are some areas with alluvial deposits that present high hydrogeological potential as aquifers, namely, superficial and recent deposits. Additionally, there are glacial deposits in the area. In general terms, moraines are not good aquifers because of low permeability characteristics but they may be connected to flood plains, which indicate the presence of spring waters. The colluvial deposits present high permeability levels but the steep slopes that characterize alluvial fans, and the storage and low water holding capacity prevent them from being considered as potential aquifers. The valleys in which Colorado, Yeso, and Volcán rivers are located present primary permeability and high availability. The occurrence of underground waters is connected to unconsolidated fillings, fluvial, glacial, alluvial, lacustrine, and eolic sediments. In general, the phreatic layers are unconfined and semi-confined while permeability is variable.

On the other hand, because of volcanic activity there are thermal water deposits. There are a number of thermal waters in the study area connected to recent volcanic activity in both Tupungato and in San José volcanoes. The main sources of thermal waters are as follows: Baños Colina (Colina river), Baños Morales (Volcán river), Baños Tupungato y Salinilla (Colorado River), Baños azules (Museo river), and Vertientes Piuquenes (Yeso river).

Image 5.3.5.6
Hydrogeological Map



Extremely low hydrogeological importance with volcanic rock permeability

High productivity well > 10m3/h/m

Extremely low hydrogeological importance with sedimentary rock permeability

High hydrogeological importance with porous formation permeability

5.3.6 Geology and Geomorphology

5.3.6.1 Introduction

This section presents data regarding geological and geomorphological conditions and characteristics in the area of influence of the project. These environmental components are included in the same section because of their high level of interdependence.

First, this section presents general data regarding the location of the project. Then, it presents a detailed description of the geological and geomorphological characteristics of specific areas in which the project will be developed.

5.3.6.2 Methodology

Based on fieldwork and some other sources, bibliographic data was collected. It was conducted a diligent analysis of Ricardo Thiele's Santiago geological chart, at a scale of 1:250.000, and its description. In addition, the geological layout of Moreno *et al* at a scale of 1:50.000 was consulted (1991). Previous environmental impact assessment studies were also consulted such as the geomorphological study (Instituto Geográfico Militar), San José de Maipo town development plan (PLADECO), and the Basic and definitive geological studies, milestone 3 report, 2007, for Gener[13].

To complement geological layout data, a validation process was made so as to verify lithological, structural, and stratigraphic specialized research that was conducted in preliminary visits to the location of the project. In addition, satellite images from *Google Earth* and aerial photographs of the area were analyzed at a scale of 1:20.000 and 1:100.000. Furthermore, a detailed analysis of the geological and lithological characteristics of the surface i.e. contacts, spatial configuration, and relevant structural characteristics (Fault lines, fracture zone, layers, and rock mass)

5.3.6.3 Results

A. General Background

In general terms, the project is developed in the Andes, Central Region, between 33° and 34°S, to the east of Santiago. There are in the area 4 units of macroforms in relief, north-south oriented. Being west-east oriented, the 4 units are as follows: the Coastal mountain range, the intermediate depression (Santiago basin), and the Andes (Main and frontal section of the mountain range).

The formation of Santiago basin has been highly influenced by ongoing processes in the geomorphological sub-region in which the project is located, in the northern sector of the Andes.

The main sector of the Andes can be divided in two main tectonic strips: 1) The west strip that represents the westernmost Chilean flank flows into the intermediate depression (filled with quaternary sediments) through the steep San Ramón fault (Rauld, R. 2002) This strip is

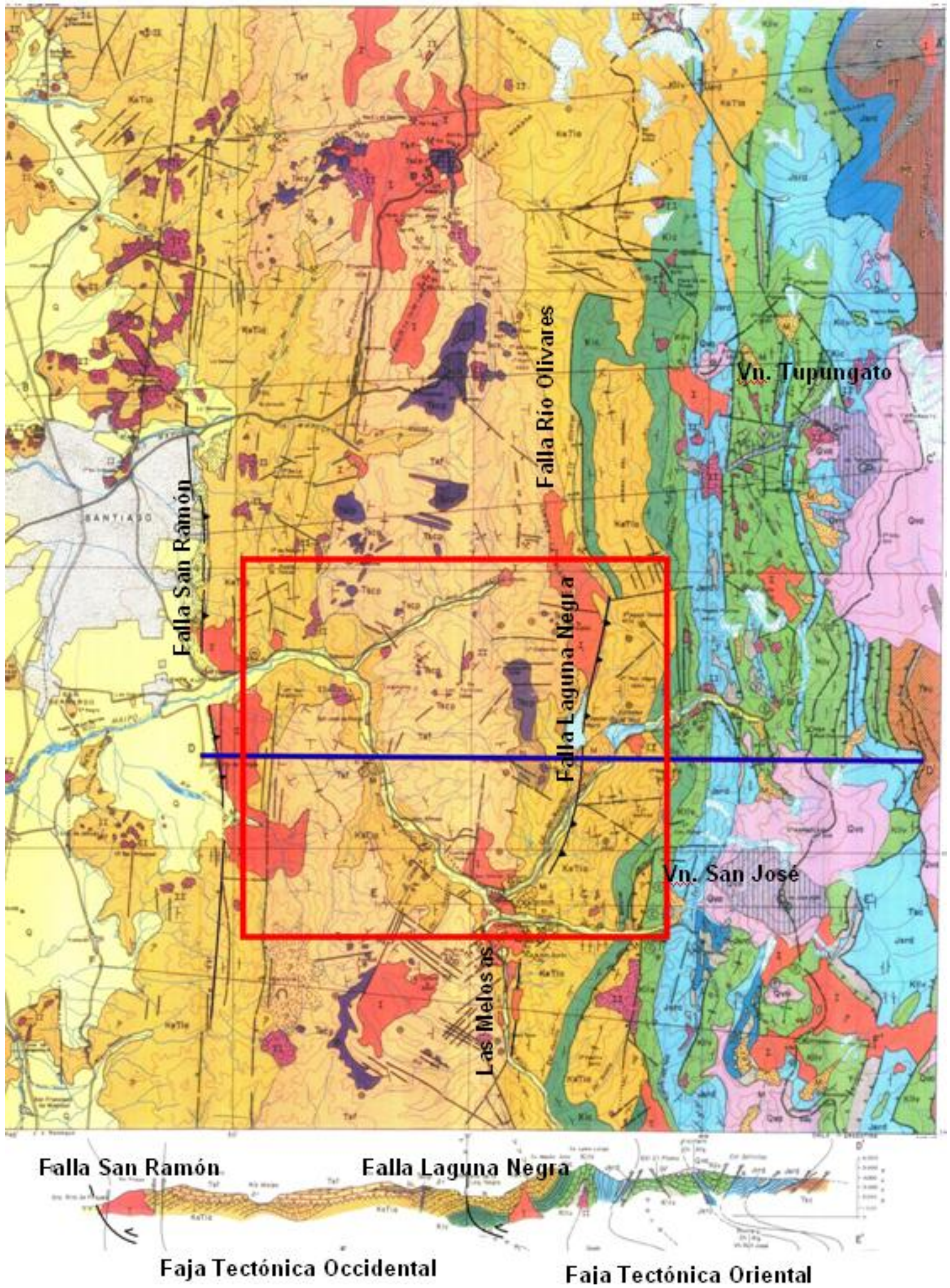
[13] Study conducted by Cade Idepe, Poch Ingeniería, and Norconsult consultants.

composed of volcanic rocks and weak and deformed clastic-cenozoic volcanic rocks. 2) The east strip that represents the easternmost Chilean flank and the whole Argentinian flank. This strip is composed of volcanic rocks, sedimentary rocks of marine origin, and very deformed continental mesozoic-cenozoic rocks. This tectonic strip shows a “folded” system, east oriented, in which active volcanoes are located, following the watershed line. (Thiele, R. 1980) (Image 5.3.6.1).

The area of influence of PHAM covers only in part the west and the east strip. The boundary between these tectonic strips corresponds with the east flank of Negra Lake and Yeso river valley. It is connected to La Paloma-Negra lake fault, north-south oriented, which spreads under mass-wasting deposits of Mesón Alto (Image 5.3.6.1).

Image 5.3.6.1.

Central Zone of Main Mountain Range: Geological Profile between 33°S and 34°S (Thiele, 1980)



* Red Box: The location of PHAM.

* Blue line: Regional geological profile

The northern area of the Andes extends across Cerro Juncal from the north to the headwaters of both Cachapoal and Tinguiririca rivers to the south. Towards the south of the source of Aconcagua river, the magnitude of the Andean massif is related to the lack of portezuelos; There are some at high altitudes such as Navarro (4.160 m.a.s.l.) and de las Pircas (4.287 m.a.s.l.). Towards the south of the source of Colorado River, which is the northern tributary of Maipo River, exists Tupungato portezuelo (4.761 m.a.s.l.) that is located between Las Polleras hill (5.993 m.a.s.l.), from the north, and Tupungato volcano (6.570 m.a.s.l.) to the south. From Tupungato volcano southwards the borderline indicates a straight line of 110 km that reaches from the south Paso del Maipo (3.429 m.a.s.l.)

Southward Tupungato it is located Tupungatito (5.682 m.a.s.l.) and in the same line Nevado Piuquenes (6.019 m.a.s.l.), Pirámide hill (5.520 m.a.s.l.), Marmolejo hill (6.108 m.a.s.l.), San José volcano (5.586 m.a.s.l.), Manchado hill (5.845 m.a.s.l.), Nevado Arhuelles (4.850 m.a.s.l.), and Maipo volcano (5.264 m.a.s.l.) This mountaintop system feeds into Maipo river upper basin and its tributaries and it is of key importance to deliver energy and water supply to Santiago metropolitan area.

The orographic mountain range together with the Andean massif brings into alignment mountaintops north-south oriented. The first one, as previously mentioned, it is located in the frontier between Chile and Argentina. The second orographic alignment is located westward the first orographic alignment following the location of Plomo hill southward Parva hill (4.670 m.a.s.l.), Gruca hill (4.124 m.a.s.l.), and Quempos mountain chain, northward El Alfalfal. Towards the north, Negra lake is surrounded by Pico Negro hill (4.520 m.a.s.l.) and between Yeso and Volcán rivers the watershed line is determined by Morado hill (4.150 m.a.s.l.). The third alignment is located in the westernmost side of the Andes in Santiago. The most important mountaintops NE are Colocalán hill (2.450 m.a.s.l.), Piuquenes (3.337 m.a.s.l.), Vizcachas (2.887 m.a.s.l.), and Manquehue (1.650 m.a.s.l.). To the east, over Santiago, San Ramón hill (3.244 m.a.s.l.); SW of San José de Maipo, Alto de la Yareta hill (2.400 m.a.s.l.); and Cristales hill (2.847 m.a.s.l.) located at about 25 km of Paine. Finally, eastward in front of Angostura de Paine, Pabellones hill (2.497 m.a.s.l.). This mountaintop system forms the westernmost side of the Andes being the natural reserve of crionival waters that are the main source of irrigation for the central plain during summer.

B. Geological and Geomorphological description of the Area of the Project

The effects of glacial erosion caused the current relief characteristics in which abrupt hillsides and deep glacial valleys may be observed. A number of the tributary slopes of the main rivers are hanging valleys at about one hundred meters above the main valleys. The access to some valleys is difficult but in a number of areas there are wide and extensive valleys with a gentle declivity.

It should be noted that important volcanic processes have had an influence on Maipo river upper basin. In addition, the area has been affected by plastic and glacial runoff. Slopes and ravines have also contributed to modeling it because of falling perpendicular to the main river axis. The geomorphological dialectic has manifested itself with full energy between linear runoff and the violent rising of lateral cones perpendicular to the main river axis modifying and interrupting the regular geomorphological sequence. (Börgel, 1966, in Muñoz and Orellana, 1996).

The balance of hillsides in Maipo river has oriented the evolution of materials coming from the main axis, which presents a failed sequence of accumulation and erosion. It should be noted that except some terraces—some cones in Maipo river valley—there are no forms in the upper course that had not ended abruptly its evolution due to cataclysmic processes caused by lateral contributions. Towards the Maipo upper river basin there is a constant unbalance because of active gravitational feeding of cornices and periglacial solifluction phenomena that lubricate and transport material of mechanic disaggregation. (Börgel, 1966 in Muñoz and Orellana, 1996).

Volcanic ashes cones have fossilized both alluvial and colluvial deposits. Later erosion and periglacial solifluction phenomena allowed for some eolic effusions, caused by local volcanic activity, flow into Maipo river. The same volcanic activity destroyed moraines that should have been located in the high valleys of this fluvial system. (Börgel, 1966 in Muñoz and Orellana, 1996).

There was a partial development of a normal geomorphological cycle in Maipo river upper basin because of volcanic activity that not only destroyed the formations generated by moraines but also altered the sediment transport in these glacio-volcanic masses overflowed with coarse material. Moraines lacked suspended sediments because of glaciers could not move to valley floors; the plateau topography in the High Andes allowed for 'Calote' i.e. sabre-shaped ice concentration, which accounts for the ice sheet dynamics in the area. Then, the volcanic activity forced mass flow into narrow valleys overflowing them and creating new baseline levels and water blockage for tributary rivers and tributary valleys. As a consequence, lateral contributions from Yeso river and Colorado river obstructed the normal geomorphological cycle of Maipo river. (Börgel, 1966 in Muñoz and Orellana, 1996).

A brief description of the rock sequence and the unconsolidated deposits in the area of the project as follows:

Stratified Rocks

There are outcrops of stratified rock sequences of volcanic, sedimentary, continental, and marine rocks intruded by veins, reefs, laccoliths, dikes, and stocks. The sequences in the study area correspond to stratified sections dating from Jurassic Superior to Upper Tertiary based on the regional geological description of Thiele (1980). They have been divided in 7 lithostratigraphic units that outcrop in strips from north to south (generally, from east to west).

- **Colina river unit (Jsrc)**

It outcrops in the eastern border of the territory, near to the Argentinian border. It is mainly composed of sequences of limestones, claystones, and sandstones interrupted by large volumes of gypsum, also known as "Yeso Principal" (Primary gypsum). The sequence reaches a thickness of 700m The structural disposition of the sequence is from north to south and it presents a highly deformed, fault-folded, interwoven structure vergence east.

- **Damas river unit (Jsrd)**

This formation corresponds to a powerful continental sequence of conglomerates and conglomeratic breaches (thick, medium) intruded by sandstones, limonites, and andesitic lava. The base of this unit is east-oriented under Colina's river unit location. The top of the unit is west-oriented where Lo Valdés unit underlies. (Thiele, 1980). In accordance with these stratigraphic relations, it dates back to Jurassic Superior. It has been estimated a thickness of 3.000m.

- **Lo Valdés unit (Kilv)**

This sequence outcrops to the east of Damas river unit and it is composed of limestones, claystones, calcilutites, calcareous limestone, conglomerates, and breccia. In the lower section of this sequence there is an intercalation of thick to medium levels of andesitic volcanic rocks and thin layers of lenticular interstratified gypsum. (Moreno et al. 1991). The base as well as the top of this unit is concordant with both Damas river and Colimapu units (Thiele, 1980). The fossil record dates from Jurassic Superior to Cretaceous Inferior. It has been estimated a thickness of 1.350m. (Biró, 1964, Tavera, 1968; Hallam et al. 1986).

- **Colimapu unit (Kic)**

This outcrop corresponds to both volcanic and continental sedimentary sequences. The latter is composed of sandstones, claystones, and red sandstone conglomerates with intercalations of andesitic lava, tuff, and limestone with secondary gypsum, in laterally discontinuous layers. This unit is over Lo Valdés unit and under Abanico unit (Thiele, 1980). This unit dates from Cretaceous Inferior to Superior. It has been estimated a thickness of 2.000m. (Thiele, 1980).

- **Abanico unit (Kstia)**

Abanico unit concentrates the largest part of the stratified sequences of volcanic rocks and clastic-volcanic rocks outcrops. It is composed of basic and intermediate lava, acid pyroclastic rocks (ash tuffs, lapilli, and conglomerates), and continental sedimentary intercalations (fluvial, alluvial, and lacustrine). This unit dates from Eocene Superior-Miocene (tertiary). It has been estimated a thickness of 3.000m despite the fact of a number of vein-reef and andesitic laccoliths intrusions (Thiele, 1980).

Abanico unit regional disposition consists of two strips, north-south oriented. There are east and west strips connected to the east tectonic strip and the west tectonic strip respectively (Image 5.3.6.1.) These strips are presented partially separated because of Farellones unit (F) higher geographical location.

- **Farellones unit (Tsf).**

Farellones unit corresponds to a succession of lava, tuffs, and ignimbrites rocks with non-extrusive volcanic breccia intercalations (over the west strip of Abanico unit) and cut by numerous dikes E-W resembling a sub-volcanic body. It should be noted that near to Piuquencillo hill and the headwater basin of Lo Encañado valley either there is no stratification or it is exceptionally thick (decametric). The outcrops of this sequence form the mountaintop of the aforementioned mountain range and they extend across Bronce hill, northwards the headwater of Aucayes ravine. (Image 5.3.6.1). The unit dates back to Miocene. It has been estimated a thickness of 2.500m.

- **Colorado-La Parva unit (Tscp).**

Rhyolite porphyry, lava flows, tuffs, and breccia rocks that are composed of trachyte-andesite-dacite-rhyolite. The upper part of this unit is the current surface erosion. Based on stratigraphy and radiometric dating the unit dates back to Pliocene.

Intrusive Rocks

There are two units of intrusive rocks dating back to Miocene. They have been classed together according to structural and petrographic characteristics. These units are as follows:

- Plutonic Granitoid Rocks

They correspond to granodiorites and monzogranites. There are a number of diorites and gabbroic rocks The main plutonic bodies present in the study area are the stock of La Obra in the confluence of Maipo river with the central depression; La Gloria, to the east of Alfalfal and San Gabriel pluton in the confluence of Volcán-Yeso-Maipo rivers (Moreno et al. 1991).

Small plutonic bodies that are composed of microgranodiorites and porphyritic diorites facies are evenly distributed in the study area. From west to east, El Canelo, El Manzano, El Durazno, and Mesón Alto intrusives, to the east of Las Placas hill (Moreno et al. 1991). These bodies date back to Miocene.

- Hypabyssal Porphyritic Rocks

In this unit, all the small intrusive bodies have been classed together; domes, laccoliths, reef mantles, dikes, and irregular bodies go across Farellones unit, whose lithology corresponds to microgranodiorites, porphyritic diorites, dacitic, and andesitic rocks. There are some specific basic facies such as the basaltic dome outcrop in the confluence of El Plomo stream with Yeso river. These small intrusive bodies date back to Pliocene. (Moreno et al. 1991).

Structures

The main structural characteristic in the region represents varying degrees of deformation of the east area compare to the west area.

- East Sector

Most of the units or formations outcrop in this sector. They are highly deformed because of folds and faults. The majority of the structures are N to NE oriented. To the easternmost sector there is a tectonic unit vergence east, which is controlled by a number of faults, anticlines and synclines N to NW, that have an impact on Mesozoic rocks (Thiele, 1980).

The formations that outcrop to the east of San Francisco-Mesón Alto ridge present a vertical-reverse disposition of the strata, north-south oriented, between Volcán and Yeso rivers. (Moreno et al. 1991).

In Yeso river valley’s flank, between Cortaderas valley and Volcán river valley, there are anticline and syncline of La Colorada hill affecting Abanico unit. This is the ultimate westward expression of the extreme deformation that characterizes the east sector (Moreno et al. 1991).

- West Sector

In this sector the rock units are folded to a lesser degree than the east sector. There are both concentric anticlines and synclines with twisted axes and with a kilometric wavelength ratio. In some cases, a decametric wavelength ratio. To the west, in San Ramón hill ridge there are deformed strata with closed folds and flanks that present 85° reefs. The latter deformation extends across El Canelo area to the south. There is also an anticlinal fold.

Unconsolidated Deposits

Unconsolidated deposits correspond to fluvial, alluvial, glacial, lacustrine, gravitational, and mass-wasting. It should be noted that the deposits located to the west of Yeso river valley were classified as moraines.

- **Fluvial and Alluvial deposits**

They correspond to blocks, gravel, sand, silt, and clay. The petrography of clastic materials is related to the aforementioned lithological units. In general terms, at 1.500 meters above sea level fluvial deposits grade to glaciofluvial deposits. (Thiele, 1980).

- **Glacier Deposits**

They correspond to marginal moraines and detritus accumulations coming from rock glaciers present in most of the headwaters streams above 2.500 m.a.s.l., in cirque glaciers and niches in the mountaintops (Thiele, 1980).

- **Lacustrine Deposits**

They correspond to thin laminates of silt and clay accumulated in lakes formed behind frontal moraines and mass-wasting deposits in the valleys of Colina, Volcán, Maipo, Yeso, and Colorado rivers. (Thiele, 1980).

- **Gravitational Deposits and Mass-Wasting**

They are virtually present in the entire area. The most important ones come from creeping soil and slopes caused by detritic accumulation; the former, at the base of gentle slopes, and the latter, at the base of rough slopes. Regarding mass-wasting, Mesón Alto stands out as the most important; whose deposits impound Negra lake. There are also the landslides of Alfalfal in Colorado river valley downstream Alfalfal power plant, the landslides of Morales ravine in Volcán river valley (Lo Valdés), and Damas river unit in El Morado area (Thiele, 1980).

C. Specific Geological and Geomorphological Description of the Area of the Project

The geology of the area in which the project is developed presents four geological maps at a scale of 1:25.000. They extend across a strip of 2km in width along tunnel layout. The geological maps are attached in annex (layout 020-GE-PLA-001 to 004). The geomorphology of the area is presented at the end of this chapter as follows: From image 5.3.6.2 to image 5.3.6.5.

West Sector

In the confluence of Colorado river and Maipo river and El Manzano stream there are stratified rocks outcrops classified in 2 units, from oldest to youngest, according to geologic time: 1) Las Lajas Unit, and 2) Intracaldera El Manzano Unit.

In Colorado river area between El Alfalfal and in both Aucayes and El Sauce ravines the stratified rocks of Abanico unit have been classified in 4 sub-units, from oldest to youngest, according to geologic time: 1) A Unit (inferior series), 2) B Unit (mid-inferior series), 3) C Unit (mid-superior series), and 4) D Unit(superior series).

The unconsolidated deposits are composed of mass-wasting usually distributed in the upper contact of both A and B units, colluvial deposits located in rough hillsides, and alluvial and fluvial deposits, some of them terraced, located at the bottom of ravines and in both Colorado and Maipo rivers.

- **Stratified Rocks**

- Las Lajas Unit; West Abanico Unit

This unit outcrops in Las Lajas sector, in the northern bank of Maipo river at 900 m.a.s.l. and in the west hillside of El Manzano ravine at 1.900 m.a.s.l. Las Lajas Unit is composed of massif strata with decimetric to metric thickness of andesitic lava.

- Intracaldera El Manzano Unit; Abanico / Farellones Formations

This unit outcrops in the northern bank of Maipo river between the west hillside of El Manzano ravine and the eastern bank of Colorado river at about 900 m.a.s.l. in the southern area, near to Maipo river, and 1.950 m.a.s.l. in the northern border of the outcrops. The fieldwork in the west bank of Colorado river near to the confluence of Maipo river indicated a mixed gradational contact in which ignimbrites underlie pyroclastic breccias. According to these characteristics, Intracaldera El Manzano unit would be composed of an upper sub-unit called Ignimbrites El Manzano Unit.
In the northern sector, the contact of Intracaldera El Manzano with volcaniclastic breccias of Abanico formation B Unit corresponds to an abrupt contact by fault with a number of dikes E-W and NW oriented that would define the border collapse of the caldera. The contact of this unit with Abanico formation is less clear in the east, west, and south borders. Nevertheless, the observations conducted in the eastern border suggested a contact conditioned by paleotopography, probably related to the caldera. In this sector, decimetric to metric strata of tuffs and pyroclastic breccias are wedged into 45°W reefs against a wall formed by volcaniclastic breccias strata of B Unit, whose reefs are low, approximately 20°E.

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Image 5.3.6.1 Series of tuffs strata and pyroclastic breccias of Intracaldera El Manzano Unit (El Manzano breccias) being wedged against a hillside formed by volcaniclastic breccias of B Unit. SSE oriented.


Image 5.3.6.2. Detail of the lithology of pyroclastic breccias drawing attention to the ash matrix with whitish young clastic rocks and lithic volcanic fragments, some of them with a cooling (halo) effect.


Image 5.3.6.3 **Left**: Northern contact of Intracaldera El Manzano Unit (El Manzano breccias) with volcaniclastic breccias of B Unit (eastward). **Right**: Detail of the previous image describing the contact area between the preceding units with intrusive dikes in subvertical disposition.


Image 5.3.6.4. Outcrops of pyroclastic breccias of Intracaldera El Manzano Unit (El Manzano breccias) with intrusive dikes in subvertical disposition near to the contact with volcaniclastic breccias of B Unit.

The ignimbrites sub-units El Manzano and El Manzano breccias are composed of massif strata of ignimbrites and pyroclastic breccias with ash matrix and young clastic up to 50cm in diameter in the Ignimbrite El Manzano sub-unit and up to 80cm in diameter in El Manzano breccias. In addition, ash tuffs and lapilli.

In the west hillside of Colorado river near the confluence of Maipo river there are some outcrops in the strata of the Ignimbrites El Manzano sub-unit. They are WNW oriented with 25 °S reef mantles. There are noticeable signs of stratification and flow texture in the pryroclastic breccias strata in the upper area of the outcrops of El Manzano breccias sub-unit. They are NW oriented with 15°S reef mantles.

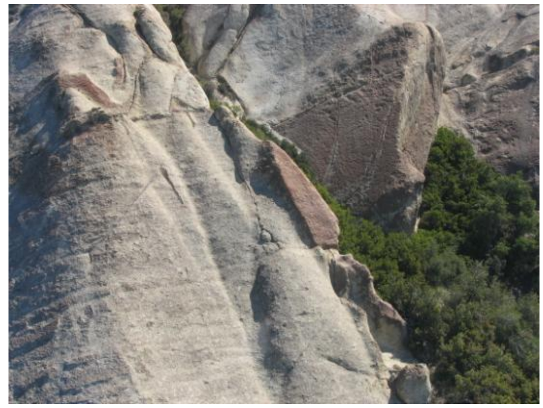



Image 5.3.6.5. Pyroclastic breccia strata and tuffs of Intracaldera El Manzano Unit with a predominant structure lying in parallel to layout stratification. NW oriented.

- A Unit (inferior series); West Abanico Formation

This unit outcrops in both hillsides of Colorado river valley along the road between El Alfalfal and El Sauce ravine at altitudes between 1.000 m.a.s.l. and 1.500 m.a.s.l. It is over the mixed gradational contact due to B unit's breccias (mid-inferior series). Its base is unknown. The outcrops of this unit correspond to centimetric to decimetric strata of tuffs and volcaniclastic sandstones. They are mid to thick of low selection and low textural maturity with intercalations of strata and volcaniclastic lenticular breccias with metric to decametric thickness (<30%). They increase their frequency near the top of the unit. There is a low amount of metric to decimetric strata thickness of andesitic lava and pyroclastic breccias.


Image 5.3.6.6. **Left**: Contact between A Unit and B Unit in the southern hillside of Colorado river between Aucayes ravine and El Sauce ravine. The contact is located in the mid-superior area of the image. **Right**: Intercalations of breccias, tuffs, and sandstones in the upper area of A Unit in the mixed gradational contact with volcaniclastic breccias of B Unit. The image corresponds to the northern hillside of Aucayes ravine in the water intake channel of Los Maitenes power plant.


Image 5.3.6.7. **Left**: The outcrops of tuffs and sandstones strata of A Unit in the southern hillside of Colorado river between Aucayes ravine and El Sauce ravine. **Right**: Tuffs and sandstones strata of A unit. Volcaniclastic breccias over them. (Upper left part of the image).

Image 5.3.6.8. **Left**: The outcrops of tuffs and sandstones of A unit in the northern hillside of Aucayes ravine along Los Maitenes power plant channel. **Right**: Intercalations of volcaniclastic lenticular breccias between tuffs and sandstones of A unit in El Sauce ravine, ground level, to El Alfalfal.

- B Unit (mid-inferior series); West Abanico Formation

It outcrops in the mid area of Aucayes Ravine as well as the upper sectors of both hillsides of Colorado river valley, El Sauce ravine, to the north of El Manzano. It is over, with mixed gradational contact, the tuffs and sandstones of A unit and underlies the volcanic breccias and andesitic lava of C Unit. Its basal contact at about 1.500-1.600m in the SE hillside of Colorado river between Aucayes ravine and El Sauce ravine. Morphologically, the outcrops of this unit condition a more abrupt relief as regards the underlying unit.

In the Lagunillas area, in the southern hillside of Colorado river there are series of strata of tuffs, sandstones, and volcaniclastic breccias similar to the ones described in A Unit. It is defined as Lagunillas sub-unit. The equivalent of this sub-unit in the northern hillside of Colorado river outcrops in Bandurrias hill.

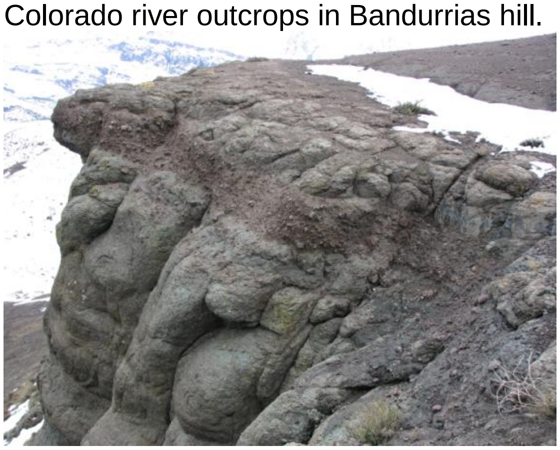


Image 5.3.6.9. **Left**: Outcrops of volcaniclastic breccias strata of B unit. **Right**: Detail of the typical lithology of volcaniclastic breccias of B unit, highlighting its low selection and low textural maturity. The outcrop is located between Aucayes ravine and El Sauce ravine.


Image 5.3.6.10. Outcrops of metric to decametric volcaniclastic breccias strata in the northern hillside of Aucayes ravine (left image), and the southern hillside of the same ravine (right image)

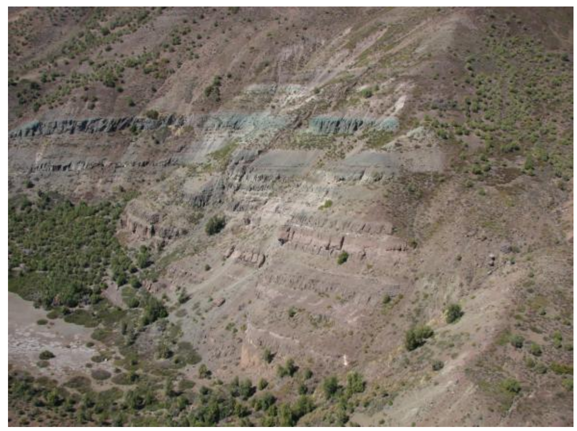



Image 5.3.6.11. Outcrops of volcaniclastic breccias of B unit in the southern hillside of Aucayes ravine. Outcrops of breccia strata of B unit in which la Ventana Alfalfal 2 (VA-2) is to be located (right photo).

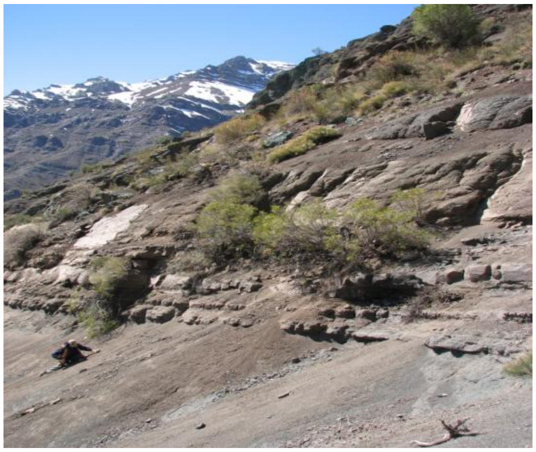



Image 5.3.6.12. Outcrops of breccias and thick volcaniclastic sandstones in the area of VA-2 in the southern hillside of Aucayes ravine (B unit). There is a green volcaniclastic breccia with matrix and chlorinated young clasts of a thickness of approximately 10m. (photo, right). Over this unit there are decimetric breccias strata and thick sandstones where La Ventana was to be located (B unit).


Image 5.3.6.13. Detail of the green volcaniclastic breccia with angular lithic clasts and chlorinated young clasts (left) and a thick sandstone of low selection angular clasts (B unit).


Image 5.3.6.14. Outcrop of breccia strata and volcaniclastic sandstones with young clasts in the southern hillside of Aucayes ravine (B unit).

- C Unit (mid-superior series); Abanico West Formation

This unit outcrops in the upper-mid sector of Aucayes ravine. It is over the volcaniclastic breccias of B unit and underlies D unit. Its basal contact is located between 2.100 m.a.s.l. to 2.300 m.a.s.l. southwards and northwards of Aucayes ravine as well as in the Lagunillas area. The observation of this unit has been difficult because of the access being covered with snow. Hence, it has been studied the lower section and the morphology of the upper section. Morphologically, the outcrops of this unit are important rock cliffs that characterize the upper-mid sector of Aucayes ravine.

The study of a transparent cut of a pyroclastic breccia of this unit near the contact with the stock of Las Tórtolas hill showed the presence of interstitial chlorite, epidote in the matrix, and some crystals of biotite highly altered by chlorite and fine limonite as well as a slight and moderate impregnation of young fragments and matrix of chlorite, limonites, and fine crystals of leucoxene.

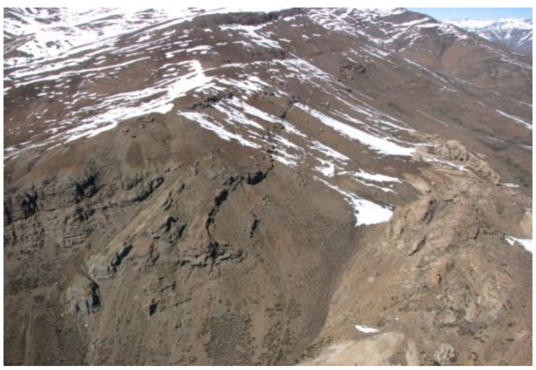


Image 5.3.6.15. **Left**: SSW view of the lower area of the strata of C unit in the northern hillside of Aucayes ravine. Morphologically, stand out the dikes that cut the stratified series of this unit near the contact with the stock of Las Tórtolas hill, in the lower-right side of the photo **Right**: Metric strata of andesitic lava of C unit near the contact with the stock of Las Tórtolas hill.

Image 5.3.6.16. **Left**: Outcrops of andesitic lava strata of C unit near the contact with the stock of Las Tórtolas hill. **Right**: Detail of the lithology of the outcrops of andesitic lava.

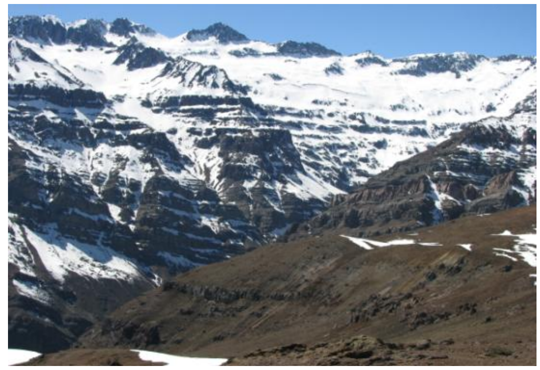


Image 5.3.6.17. Outcrops of volcanic breccias of C unit in the northern hillside (left) and the southern hillside (right) of Aucayes ravine.

- D Unit (superior series); Abanico West Formation

This unit outcrops in the upper sector, in both hillsides of Aucayes ravine, and in the Echaurren mountain chain. Fieldwork has been prevented due to snow covering in the area. Moreno et al. (1991) present a description of the rocks in D unit as follows: volcaniclastic sandstones strata, greenish-grey and brown tuffs of lapilli of decimetric strata. There are over them a sequence of lutites, sandstones, and conglomerates of lacustrine origin.

- E Unit: Echaurren mountain chain strata; Farellones Formation

In the upper part of Aucayes ravine and the Echaurren-Piuquencillo mountain chain outcrop brecciated andesitic lava and volcanic breccia with clasts of 5 to 15cm in diameter; 50cm or more on rare occasions. There are also larger fragments, up to 5 meters or more, of grey, green, and purple porphyritic andesites (Moreno et al. 1991). In the area near to Piuquencillo and in the headwaters cirque of Lo Encañado valley there is no stratification; it is a solid and very thick structure of agglomerates and volcanic breccias that resembles a sub-volcanic body.
An outstanding trait that characterizes the volcanic massif previously described in the Echaurren mountain chain it is the great amount of intrusive dikes (decimetric to metric), vertical, and east-west oriented. These intrusive structures extend across the mountain chain and beyond the limits of the massif affecting the rocks of D Unit West Abanico.

- Intrusive rocks

The stock of Las Tórtolas hill corresponds to an intrusive microgranodiorite body with strong banding and dominant structures of NE disposition that coincides with the general disposition of the stock and N-S with a strong mantle (75°-85°). To the west, overlapping a joint system that defines columnar structures.

Regarding the reefs, the stratified volcanic rock sequences stand out in the area. As to dikes, they are NW and NE oriented; some of them are E-W to NW oriented. They limit the northern contact of Intracaldera El Manzano Unit.

There are also wide, parallel, and vertical dikes, E-W oriented, cutting the rocks that characterize the volcanic massif of Echaurren mountain chain (E Unit).

Image 5.3.6.18. **Left**: Aerial view to NW of the stock of Las Tórtolas hill with NE disposition. **Right**: Detail of the columnar structures in the northern wall of the intrusive body.

- ***Structures***

A considerable extent of the area of influence presents both anticline and syncline gentle folds with lower mantles (<30º).

The dominant structure along Colorado river is an anticline gente fold whose axis follows the course of the river. In effect, throughout Colorado river, from El Alfalfal to El Sauce ravine, the strata of A unit present a sub-horizontal disposition, NW oriented in the southern hillside and NE oriented in the northern hillside with 10° mantles.

Upstream Colorado river, between Aucayes and El Sauce ravines, in the southern hillside of the valley B unit strata present a NE disposition and decreasing mantles. In the northern hillside of Colorado river, in front of El Sauce ravine, the strata present a NE disposition. Northwards El Manzano the strata present gentle folds with a sub-horizontal disposition with gentle mantles to the south. There is also in this area an abrupt contact between Intracaldera El Manzano unit and B unit, probably because of a high-angle fault and a southwards mantle.

In the Aucayes ravine area the strata of C unit present a NNW to NNE disposition with lower mantles (10°) to the east. In the upper area of Aucayes ravine the basal contact of this unit with the overlying unit, D unit, present a N-S to NW-SE disposition with lower mantles to N and NE.

Throughout the area there are faults, fractures, and lineaments standing out the fault-normal components with a NE disposition. They cut the stratified units in the Aucayes ravine area. Conspicuous elements in the landscape previously mentioned are the fracture systems, E-W oriented, that go across Echaurren mountain chain.

Between Aucayes and El Alfalfal ravines (Southern hillside of Colorado river) the strata of A and B units are affected by high-angle faults (70-80°) present in Aucayes ravine, NE-SW oriented, as lineaments in the topography.

- ***Unconsolidated deposits***

Colluvial deposits and mass-wasting predominate in the study area. To a lesser degree, fluvial, alluvial, and in some specific sectors, lacustrine deposits.

- Colluvial deposits and dejection cones

This unit is composed of diamictic deposits, matrix-supported, of heterogeneous granulometry that include blocks and fine lime-clay matrix In general terms, there are angular clasts similar in composition to the rocks of the area. These deposits are located in the hillsides with slopes of 20° to 25°, poorly stratified, in which predominate massive deposits. Thickness is variable, reaching tens of meters in the lower hillside areas.

- Terraced recent fluvial deposits

Recent fluvial deposits of this unit consist of sandy gravel and sand present in the waterway of rivers, streams, and ravines of the study area. They form plain and flood plains located at approximately 1 to 2 meters above the current level of rivers, streams, and ravines of the area. These deposits form terraces located in both banks of the main rivers present in the study area at approximately 5 to 10m of the current course.

- Alluvial deposits

They are deposits of thick granulometry, matrix-supported with some blocks and large stones. The most important ones are located in El Manzanito and Yeso river. In general terms, they form flat terraced levels as well as alluvial fans in the outlets and tributary water flows. They correspond to deposits of detritus flow, mudflow, and flooding.

- Lacustrine deposits

These deposits are mappable to the north of Lo Encañado lake and in Colorado river, upstream Maitenes slope. The unit is composed of fine granulometry, mainly lime-clay with intercalations of turfs, calcareous deposits, travertines, and salt deposits. Thickness varies between 1 to 15m.

- Landslide block deposits

This unit is composed of massive blocks of rock that preserve the internal structures and the main characteristics of the fundamental rock unit. The magnitude of this block is variable, from tens of meters to hundreds of meters. These kind of deposits are mainly located in El Alfalfal sector and Lo Encañado ravine surroundings.

- Landslide detritus deposits and rocks

These deposits extend across the entire area and are mostly related to landslide rocks and landslide detritus in steep hillsides. They are formed by angular clastic material of varying size including blocks and mega-blocks inserted in a matrix which is mainly composed of a mixture of sand, silt, and clay. These deposits are internally massive and present almost no stratification.

East Sector

The upper Volcán river area, and El Morado, Las Placas, Colina, and La Engorda streams correspond to an area of confluence of 3 sub-drainage basins, tributaries of Volcán river: El Morado stream basin, Las Placas stream, and Colina-La Engorda system. The most relevant mountaintops in the area are San José volcano (5.856 m.a.s.l.) to the east, and Marmolejo hill (6.108 m.a.s.l.), to the northeast. There is a glacier in Marmolejo hill mountaintop.

Image 5.3.6.19: SW view to the confluence of Colina stream (left) with El Morado-Las Placas (right)

In the lower course of La Engorda, Colina, Las Placas and El Morado streams there is a series of materials generated in massive mass-wasting processes that correspond to landslides and debris flows that are represented by soils of heterogeneous granulometric composition in which predominate mega-blocks of rocks of approximately 20m, of variable compactness. (Image 5.3.6.19).

Mass-wasting is related to rock instability in Damas river unit that outcrops nearby the mountain chain. In effect, this unit is composed of sandstones, conglomerates, sedimentary breccias, and continental lutites, with sub-vertical stratification. They present some discontinuity, moving them into a sloping position away the hill, as it were. They form wedges that tend to detach (“swelling”) because of the probable presence of anhydrite in the rocks of both units, the increase of hydrostatic pressure and/or seismic phenomena during the Holocene (last 10.000 years).

Structure and erosional tendencies of the stream system: Morphogenesis predominates over pedogenesis (predominance of erosive activity) There are free-face/rocky slopes and talus slopes that present important stabilization processes (slopes facing east in the confluence of El Morado-Las Placas) and some of them present a considerable gravitational activity (Colina-La Engorda stream valley). (**Images** 5.3.6.20 and 5.3.6.21). There are no signs of erosion to indicate superficial instability in the cones. As a matter of fact, the slopes are covered with a number of herbs and bushes.

The slopes are 1/1. The borders of the valley present in the slopes facing west bulky material of 1m in diameter, on the slope, in a temporary balance status (Image 5.3.6.22) that can be broken because of seismic movements and the weight of the snow during winter. In general terms, the slope facing east of El Morado-Las Placas stream valley shows these accumulations.

Image 5.3.6.20: SW view. In the foreground, it can be observed a stable slope covered with sparse vegetation. The characteristic morphology of the free-face/rocky slope and talus slope presents an important stabilization process.

Image 5.3.6.21: S view. Colina-La Engorda stream valley. In the foreground, Colina stream. In the background, there is a system of cones forming a slope. The bottom of the valley is full of fluvial deposits of thick granulometry. The water courses correspond to Andean torrents.

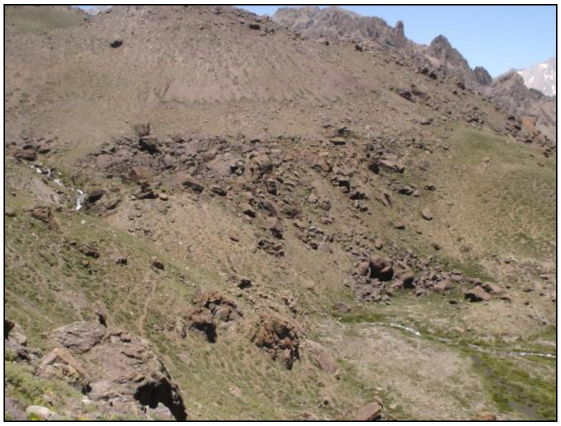


Image 5.3.6.22. SE view. In the foreground, it can be observed Las Placas stream and series of bulky and rocky materials located on the slope in a temporary balance status. The materials come from mass-wasting, specifically, landslides.

Fluvial forms: La Engorda, Colina, Morado, and Las Placas streams present a nival regime. The water level rises sharply during the snow melt season being fed into by the snow from the mountaintops of San José volcano and Marmolejo glacier.

The water courses are typical Andean torrents. The water courses present stony beds filled with materials of different granulometry, thick sandstone, gravel, and predominant blocks. In general, they show a negative dissection balance.

The water courses are erratic, poorly defined and not encased. They present high variations in depth, varying between 2m to 1m in the area of the project.

D. Specific Geological analysis in the area of direct influence of the project

Geological profiles at a scale of 1: 25.000 of the tunnels layout are included as attachments (layouts 020-GE-PLA-005 a 007, Annex 46).

El Volcán Tunnel Sector

From the access of El Morado ravine, this section of 700m crosses the rock formations of Damas river unit (600m of conglomerates, sandstones, and lutites) and Lo Valdés unit (limestones with black lutites intercalations).

Later, the section (approximately 1.900m in length) corresponds to Lo Valdés unit (limestones with black lutites intercalations) and Colimapu unit (red sandstones and andesitic volcanic rocks).

In a section of approximately 3.400m in length, it crosses the rock formations of both Colimapu and Abanico units.

In a section of 4.400m in length, all rocks are within Abanico unit (andesitic volcanic rocks).

The last section, facing Yeso river valley, of 3.600m in length corresponds to rocks of Abanico unit.

Alfalfal Tunnel sector

The first section between 0 and 1km (West flank of Lo Encañado lake) was correlated with C Unit of West Abanico Unit defined in the upper south flank of Aucayes ravine.

Between 1 and 12.2km the layout goes across the rock mass, with a roof of 1000m, and it is composed of rocks of E Unit correlated with Echaurren mountain chain and D Unit of West Abanico Unit.

In the section southwards Aucayes ravine, between 15.1km and the connection with Las Lajas tunnel in 17.9km, outcrops B Unit of West Abanico unit whose strata present gentle mantles between 10° and 25° east.

Las Lajas Tunnel sector

The layout in the southern slope extends across A Unit of West Abanico Unit. B Unit outcrops only in the uppermost topographically area of both flanks of Aucayes ravine.

The layout in the northern slope extends across A Unit from the river axis to 11.2km (A Unit is covered in this sector by mass-wasting deposit). From this point to 14.8km the layout crosses the rocks present in B Unit of Abanico. They progressively modify its apparent mantle in a sub-horizontal position. The section between 14.8 and 20.7km extends across Intracaldera El Manzano Unit whose apparent mantles configure a wide syncline. Last section, from 20.7 to 22.3km, extends across Las Lajas Unit sequence of West Abanico whose strata configure a tight anticline.

5.3.6.4 Conclusions

According to fieldwork analysis conducted in different areas of the project, there are, in geomorphological terms, two morphogenetic fields that correspond to high-and-mid mountain areas. The first morphogenetic field presents predominance of erosional processes in the slopes and sediment transport. Areas such as Upper Volcán river, Yeso river, and Lo Encañado lake are within this field. The second morphogenetic field corresponds to a more stable environment in which predominate pedogenetic processes in the slopes. These are areas with a perennial vegetation cover; thus, there is a higher soil biological activity.

Nearby La Engorda, Colina, Las Placas, and Morado streams (Volcán river tributaries) there is massive mass-wasting phenomena, specifically, landslides and detritus flow. The mass-wasting phenomena are associated with rock instability of Damas river unit that outcrops nearby mountain chains, with favorable lithology and structural conditions to generate wedging in unstable rocks. Eastwards, to the left side of Colina stream valley and the right side La Engorda stream valley outcrop volcanic deposits associated with eruptions of San José volcano.

On the other hand, between Rudillas hill and San Francisco hill there is volcanic and sedimentary rock development of Damas river unit, Lo Valdés unit, and Colimapu unit. In general terms, these rocks present a sub-vertical stratification, partially folded, and affected by extensional fracturing of the rock with longitudinal joints and variable uniaxial compressive strength. To the north, East Abanico unit is composed of tuffs and volcanic breccias with intercalations of lava, volcaniclastic rocks, and some other intrusive bodies. These folded and faulted rock sequences affected by extensional fracturing do not present high degrees of geological and geotechnical heterogeneity in the rocks. In the intersection of Cortaderas cajón, the slopes are covered with colluvial deposits and mass-wasting deposits. In this area, some rocks of East Abanico unit are affected by hydrothermal alteration.

Northwards El Yeso reservoir, it can be observed the fault rupture plane of the mega-landslide of Mesón Alto hill whose soil deposits formed Yeso, Negra, and Lo Encañado lakes. There were landslides composed of large rocky blocks inserted in a chaotic mass of soil of heterogeneous granulometry.

Yeso river valley downstream El Yeso reservoir and Lo Encañado area present thick deposits related to the mega-landslide coming from the western slope of Mesón Alto hill, which is SE located of El Yeso reservoir, removing large volumes of soil and rocks tens of kilometers downstream. The dam caused terraced deposits that border the current water course of Yeso river. Natural dam-break caused “avenidal” deposits that border the current water course of Yeso river and Manzanito stream downstream Lo Encañado lake. The intense erosion generated by Yeso river in landslides deposits, specifically, in the mountain chain that border the right flank of the river has generated soil landslides.

Between El Yeso reservoir and Los Maitenes-El Alfalfal area, West Abanico unit, there are volcarenites and tuffs of lapilli intruded by small granitic bodies and dikes. Rocks are mainly massive with sub-horizontal stratification. They correspond to andesitic lava, breccias, and volcanic agglomerates crossed by dikes and reefs. Colorado river area, between Los Maitenes and El Alfalfal, present mass-wasting deposits and rocks of West Abanico unit.

They correspond to massive rocks such as breccias, volcanic agglomerates, and brecciated lava with horizontal to sub-horizontal stratification as well as small intrusive bodies.

To the southwest, there is a massive ignimbrite tuff, less fractured (Volcanic Intracaldera El Manzano). In addition, there is both andesitic lava and brecciated lava development with sub-vertical stratification of West Abanico unit. They are extremely hard, and present extreme superficial fractures. The area presents, nearby Las Lajas, debris slope (talus slope) and various levels of terraced fluvial deposits of Maipo river.

Insert Figure 5.3.6.2

Insert Figure 5.3.6.3

Insert Figure 5.3.6.4

Insert Figure 5.3.6.5

5.4 BIOTIC ENVIRONMENT

5.4.1 Flora and Vegetation

5.4.1.1 Analysis of Secondary Information on Flora and Vegetation in the Study Area

A FLORA

The richness and the significant degree of endemism of the flora of Mediterranean environments have been widely documented (Mooney, 1988; Arroyo *et al.* 1995; Cowling *et al.* 1996). In the central part of Central Chile, the interest is even greater because of the isolated conditions in which the flora and vegetation developed (Villagrán & Hinojosa, 1997). Given the extension of the Alto Maipo Project, in terms of altitude, there is an important variation in the number of species. The trend is for the richness of species to diminish with altitude; similarly, the flora's large number of endemic species also becomes smaller with altitude.

There is information for central Chile that shows that its flora includes 2500 species, 50% of which are endemic Chilean species and 23% of them, endemic to central Chile. The higher percentages of endemic species and the degree of threat of central Chile's ecosystems, which support the greatest human occupation in the country (Cunill, 1970; Aschmann & Bahre, 1977; Fuentes & Hajek, 1979; Espinoza & Hajek 1988), have led the area to be declared a biodiversity "hot spot" worldwide (Cowling *et al* 1996; Arroyo & Cavieres, 1997; Arroyo *et al*. 1999; Myers *et al.* 2000).

The "Andean-*Mediterranean*" flora extends in Chile between 32° and 38°S (Villagrán *et al*. 1983; Rivas Martínez, 1999). The sector that shows greatest aridity goes between the Andes Mountains of Illapel and Rancagua. Schmithüsen (1959) indicates that the presence on the hillsides (zonal vegetation) of *Gaultheria pumila* is the indicator of the northern limit of the humid Mediterranean Andes. The richness and composition of the Andean flora in the Metropolitan Region was studied at the beginning of the 20th Century by Reiche (1934) and Grandjot & Grandjot (1936). In papers published in recent decades, Teillier *et al*. (1994) point out that the flora of El Morado Natural Monument is made up, at least, by some 273 species, approximately 45 of which are locally endemic, in other words, species whose distribution limits do not go beyond 33° S to the north or 35° S to the south.

Cavieres *et al*. (1999), on the other hand, indicates the existence of some 103 species in the Andean Canyon of the Molina River (33° S), in the Mapocho River basin, between an altitude of 2100 and 3700 m.a.s.l. Arroyo *et al*. (2000) recorded about 475 species in the Yerba Loca Sanctuary; however, the data include species that grow at an altitude ranging from 1450 m (non-Andean vegetation), to the vegetation's upper limit; Kong (1997), only for the Andean Sector (over an elevation of 2000 m.a.s.l.) found 176 species. Muñoz *et al*. (2000), finally reports approximately 357 species for an altitude transect in the Maipo River Canyon, Metropolitan Region; but at a gradient that includes samples below 1800 m.a.s.l.

i) Vascular Flora in the Maipo River Canyon.

The vascular flora of the Maipo River Canyon, located between 1900 and 3800 m.a.s.l. (Faúndez, 1999; Muñoz *et al*.. 2000) is made up of, at least, 202 species. Among the species classified in conservation categories are *Laretia acaulis*, **vulnerable** nationwide and *Kageneckia angustifolia*, **vulnerable** regionally. From the point of view of the geographic origin, 95% (191) of the species are native, whereas 5% (11) are feral and allochthonous. The distribution of the species according to plant life forms, shows that hemicryptophytes (perennial, rizomatose or cespitose herbs), account for 57.4%; camephites (low micropyle shrubs) 20.3%; and therophytes, annual herbs, 8.9%. If we compare the life form with the geographic origin of the species, we find a similar situation to that of the total for the native species. For the allochthonous species, the predominant life form is hemicryptophyte with 9 species, followed by therophyte and nano-phanerophyte with one; no camephite was found.

ii) Vascular Flora in the Yeso River Canyon

The results for the vascular flora are shown, taking literature data as reference (Muñoz *et al*. 2000) and based on an excursion carried out by the author to the Salinillas Stream Canyon (Andalué, 2001). The vascular flora is made up of, at least, 158 species. Among the species in a conservation category is the *Alstroemeria umbellata*, **rare** in the entire country and *Laretia acaulis*, **vulnerable** nationwide. From a geographic origin point of view, 95% (150) of the species are native, whereas 5% (8) are feral and allochthonous.

The distribution of the species in life forms shows that hemicryptophytes (perennial, rizomatose or cespitose herbs) account for 56.3%; camephites (low mycropyle shrubs) 20.3 %; and therophytes, annual herbs, 9.5%.

If we compare the life form with the geographic origin of the species, we find a similar situation to the total for the native species, whereas for the allochthonous species, the predominant life form is hemicryptophyte (75%) and therophyte (25%), and no nano-phanerophyte or camephite were found.

iii) Flora in the La Engorda Stream Basin Sector

There are no specific flora studies available for this zone. It is likely that at equivalent altitudes it may have somewhat similar flora than the one existing in the El Morado Natural Monument (Teillier *et al*, 1994; Teillier, 2003).

iv) Vascular Flora in the Colorado River Canyon

There is no local information available for the flora.

B VEGETATION

The vegetation in the Project area is shown in a very general way at the level of the Maipo River Basin, as a gradient of communities chiefly determined by variations in elevation, also showing differences that may be attributed to the hillside's exposure. The vegetation is laid out on floors, where the different communities develop in the form of a territorial complex.

i) Sclerophyllous Forest and Shrub Vegetation

According to Pisano (in Fuenzalida 1965), the vegetation corresponds to Chile's Mesomorphic Zone; the formation existing in the basal area of the Maipo Canyon (600-1300 m.a.s.l.) is the Sub-Andean Thorny Scrubland. A scrubland with numerous thorny plants where the principal bushes are *Colletia histryx*, *Proustia cuneifolia*, *Retanilla trinervia*, *Trevoa quinquenervia*, *Porlieria chilensis*, *Colliguaja odorifera*, and trees like *Lithrea caustica*, *Quillaja saponaria* and *Cryptocarya alba*.

According to Gajardo (1994), the Maipo River Canyon's basal floor corresponds to the phytoecologic region's vegetation of the Sclerophyllous Forest and Shrub Vegetation. Regarding the sub-regions, the area corresponds to the Sclerophyllous Forest. The characteristic vegetation communities of Mediterranean Chile are highly endemic to the area, with the exception of the *Acacia caven* thorny trees, a community that indicates the degradation of the native forest (Oberdorfer 1960). According to the author, the region extends along Chile's central region, whose salient climatic characteristic is the presence of a "Mediterranean climate;" in other words, the presence of cold, rainy winters and warm, dry summers.

The vegetal landscapes in the region are complex because of their position in terms of altitude, as it is a region with significant climatic variation (see: Di Castri & Hayek, 1982), and also because it is the zone with the greatest vegetation alteration rate in the country. In the region there is predomination of trees with hard leaves, low shrubs with certain characteristics of xerophytic species (deciduous leaves in the dry season, thorns), succulent plants (cactaceae, bromeliaceae), which together confer a mosaic character to the landscape. In the sub-region of the sclerophyllous forest, trees and high shrubs predominate often with the appearance of "scrub" or arborescent scrubland, which represents a state of natural regeneration of the associations that have been the object of human impact (tree felling, fires). It has a rich flora composition with species of the laurisilva type (trees and shrubs) and an herb stratum with native and allochthonous species.

With regard to formations, for the study area—particularly the lower part of the Maipo and Colorado River canyons—Gajardo (1994) proposes the presence of the Sclerophyllous Forest of the Andes Foothills. The distribution pattern of the communities that make it up is related to the altitude and exposure. The chief type of vegetation is the Sclerophyllous Forest, many times limited to arborescent scrubland because of the impact of tree felling and fires. The associations more widely distributed are *Quillaja saponaria-Lithrea caustica*, *Quillaja saponaria-Colliguaja odorifera*, *Cryptocarya alba-Quillaja saponaria*, *Cryptocarya alba-Lithrea caustica*, *Puya coerulea-Colliguaja odorifera, Puya berteroniana-Adesmia confusa* and *Acacia caven-Lithrea caustica*. As altitude increases, the formation is replaced by associations belonging to the Mountain Sclerophyllous Forest, where in the zone there are associations of *Colletia hystrix-Baccharis rhomboidalis* and *Colliguaja integerrima*.

Finally, Luebert & Pliscoff (2006) propose that the study area is in the region of the Sclerophyllous Forest formation, where we find the following sequence of vegetation floors:

Floor of the Andean Mediterranean Sclerophyllous Forest of *Quillaja saponaria* and *Lithrea caustica*: in the Maipo Canyon it is present on the basal part (approximately 700 m.a.s.l.) up to 1700 m.a.s.l. The dominant species, in addition to those named above are *Kageneckia oblonga* and *Cryptocarya alba* in the wetter sectors (hillsides exposed to south). The shrubby stratum is very heterogeneous, with species like *Satureja gilliesi, Colliguaja odorifera and bicolor Teucrium;* in the herbaceous stratum we frequently find *Alstroemeria ligtu simsii* subspecies*, Solenomelus pedunculatus* and *Pasithea coerulea*. On the floor of the hillsides exposed to the north we can find a community of succulents including *Echinopsis chilensis* and *Puya berteroniana*. Due to the intensity of forest exploitation of that floor, they are frequently in succession phases where shrub associations predominate, the dominant ones being *Baccharis linearis* and *Muehlenbeckia hastulata*, repeated and severe disruptions give origin to an association of *Acacia caven* or annual prairies, with strong presence of feral, allochthonous species. Theoretically it is stated that in their development these associations should originate a forest formation similar to the initially existing one.

Floor of the Andean Mediterranean Sclerophyllous Forest of *Kageneckia angustifolia* and *Guindilia trinervis*: it is present in the area at an altitude of between 1400 and 2200 m.a.s.l. corresponding to a very open forest with an herbaceous cover consisting of *Echinopsis chilensis* and *Puya berteroniana*. In wet sectors (ravines) it comes into contact with the association of *Maytenus boaria* and *Escallonia myrtoidea*. In altered places it is replaced by communities of shrubs with *Colliguaja integerrima-Tetraglochin alatum*.

ii) Andean and Sub-Andean Vegetation

In general terms, zoning of vegetation in elevated floors of the Andean foothills of the Maipo River has been studied by a number of authors and if we synthesize the proposals, this is as follows: between 1500 and 2000 m.a.s.l., floor of the Sub-Andean Scrubland; between 2000 and 2600 m.a.s.l., floor of the Andean Scrubland; between 2700 and 3300 m.a.s.l., floor of the High-Andean Steppe and above 3300 m.a.s.l., High-Andean Desert (Table 5.4.1.1). Regarding vegetation coverage in the altitude gradient, Cavieres *et al* (1999) and Muñoz *et al* (2000) indicate that it diminishes as elevation increases; however, this reduction depends on the region. The same authors point out that there are differences in the delimitation of the altitude range of the floors, and that it is very unlikely to distinguish limits applicable to the entire Santiago mountain range, as there are local variations in the floors. Notwithstanding, the study mentioned above suggests the existence of constant distribution patterns of species, according to altitude, which suggests an influence of climatic factors at a regional level.

Table 5.4.1.1
Vegetation Floors of the Santiago Mountain Range from 1800 to 2500 m.a.s.l. Described by Different Authors

MEIGEN (1893)	VILLAGRAN *et al*. (1982,1983)	HOFFMANN & HOFFMANN (1982); HOFFMANN (1992)	TEILLIER *et al*. (1994)	MUÑOZ *et al*. (2000)
Mountain Floor: 1000 - 2000 m.a.s.l. High scrubland consisting of: *Quillaja saponaria, Lithrea caustica* and *Kageneckia oblonga*; sclerophyllous shrub like *Colliguaja odorifera, C.integerrima, Retanilla trinervia* and *Bacharis linearis.*	**Andean foothill Floor:** 1800 – 2100 m.a.s.l. Scrubland made up of *Kageneckia angustifolia.*	Between 1000 and 1500 m.a.s.l. we find trees like *Quillaja saponaria*, *Maytenus boaria,* and in wetter places, *Escallonia illinita* shrub. Over 1900 m.a.s.l., more than half of the species are camephites.	**Sub-Andean Arborescent Scrubland** (Oberdorfer, 1960; Gajardo, 1987): 1800 – 2000 m.a.s.l. The principal species are *K. angustifolia, C.integerrima, Guindilla trinervis, Schinus montanus* and *Ribes polyanthes.* On the riverbanks we find *Discaria trinervis, M. boaria* and *Buddleja globosa.*	**Sub-Andean Scrubland:** 1500 -2000 m.a.s.l. Arborescent scrubland dominated by *K.angustifolia, G. trinervis, C.integerrima*, and significant specimens of shrubs like *Haplopappus illinitus, Bacharis rhomboidalis* spp.*truncata* and *S. montanus.* In ravines and water upwelling we find thickets of *E.myrtoidea*
Sub-Andean Floor: 2000 – 2800 m.a.s.l. Low and/or thorny shrubs like *Tetraglochin, Chuquiraga, Berberis and Ephedra*; perennial herbs like *Acaena splendens* and trees like *K. angustifolia* and *Escallonia myrtoidea*	**Andean Scrubland:** 2100 – 3000 m.a.s.l. *Chuquiraga oppositifolia* shrub	**Sub-Andean Floor:** 2100 -2700 m.a.s.l. 2200 m: Arboreous limit represented by *Kageneckia angustifolia.* Between 2200 and 2800 m.a.s.l.: only camephites.	**Andean Scrubland** (Gajardo, 1987): 2000 – 2600 m.a.s.l. Made up principally of shrubs like: *Adesmia gracilis, Tetraglochin alatum, Mutisia sinuata, M.subulata* fma. *rosmarinifolia, Mulinum spinosum* and *Senecio eruciformis.*	**Andean Scrubland** 2000 – 2700 m.a.s.l. Low scrubland with predomination of *Chuquiraga oppositifolia*, *Ephedra chilensis, T.alatum* and *M. spinosum*.

Pisano (in Fuenzalida 1965), considers that vegetation in Central Chile's Andean zone belongs to the Mesomorphic Zone, indicating that the formation of the elevated areas corresponds to the Andean Xeromorphic Formation, a type of vegetation formed by small shrubs, turfs of grass and plants forming cushions. He also indicates that the limits of the formation in Chile are the Coquimbo and Curicó mountain ranges. The principal shrubs he mentions are: *Fabiana imbricata, Nardophyllum lanatum (N. revolutum), Chuquiraga oppositifolia, Ephedra chilensis (E. andina), Anarthrophyllum cumingii* and *Junellia spathulata*, among others; the predominant grass turfs are *Stipa chrysophylla, Hordeum chilense* and several *Festuca* species.

Gajardo (1994), in turn, proposes that Central Chile's Andean vegetation must be included in that of the High-Andean Steppe Region, Sub-Region of the Mediterranean Andes, with the formation of the High-Andean Steppe of the Santiago Mountain Range; the associations proposed, determined by elevation and humidity gradients, are: *Mulinum spinosum-Chuquiraga oppositifolia, Azorella madreporica-Laretia acaulis; Chuquiraga oppositifolia-Guindilia trinervis*. The Sub-Andean vegetation includes the associations of the Andean Sclerophyllous Scrubland like the open forest of *Kageneckia angustifolia-Guindilia trinervis* and *Tetraglochin alatum-Colliguaja integérrima* shrubs. For this type of formation, among the species in a conservation category, he underlines the presence of *Kageneckia angustifolia, Puya berteroniana*, the *Austrocactus spiniflorus* cacti and several *Neoporteri*a, the *Pellaea ternifolia* fern and the *Solaria miersioides* bulbous (Benoit, 1994; Baeza *et al*, 1998; Belmonte *et al*1998 and Ravenna *et al* 1998).

Muñoz *et al* (2000) describe the existence of vegetation zoning according to altitude, which at the Maipo River's latitude is expressed in the existence of vegetation floors from the bottom upwards are as follows:

The Sub-Andean Scrubland Floor, extending from 1500 to 2000 m.a.s.l. with predomination of the *Kageneckia angustifolia* tree and *Guindilia trinervis* and *Colliguaja integerrima* shrubs. The Andean Scrubland starts over 2000 m.a.s.l. with predominance of minor shrubs 50 cm high, where the dominant species are *Chuquiraga oppositifolia, Ephedra chilensis, Tetraglochin alatum* and *Mulinum spinosum*. Vegetation coverage ranges between 20 and 40% and its longitudinal distribution is between 31° and 35° S. The upper limit of this floor is at about 2700 m.a.s.l. Over that elevation we find vegetation corresponding to the High-Andean Steppe where the predominant plants are minor shrubs 20 cm high—frequently found in plaques or cushions—, grasses and perennial herbs. Vegetation coverage is approximately 25%. The most frequent species are *Poa holciformis, Hordeum comosum, Adesmia aegiceras* and *Laretia acaulis*.

Over 3300 m.a.s.l. the steppe gives way to the High-Andean Desert, where the predominant species are small shrubs forming cushions and perennial herbs. The prevalent species are *Menonvillea spathulata, Azorella spp, Oxalis spp. Nassauvia spp*, among others. The same authors point out the presence of wet prairies, a type of azonal vegetation that develops in areas with upwelling of water or on the margins of streams and in ravines. In these areas, the most widespread species are *Carex, Patosia*, and *Eleocharis*, among others.

For the Andean area, Luebert & Pliscoff (2006) describe a sequence of floors that go from high-altitude low scrubland to high-altitude grassland:

- Andean Mediterranean Low Scrubland consisting of *Chuquiraga oppositifolia* and *Nardophyllum lanatum*. Low shrubs predominate on this floor where besides those named we can find others like *Mulinum spinosum*, *Tetraglochin alatum*, *Ephedra chilensis* and *Viviania marifolia*. Vegetation coverage ranges between 20 and 40%. We frequently can find herbs like *Tropaeolum polyphyllum* and *Argylia adscendens*. We also find wet prairies as intrazonal units consisting of *Patosia clandestina* and forests in the ravines with *Escallonia myrtoidea* and *Maytenus boaria*. The floor extends on the Andes Mountains from the south of Region IV to Region VI, between 2000 and 2600 m.a.s.l.

- Andean Mediterranean Low Scrubland with *Berberis empetrifolia* and *Laretia acaulis*: corresponding to scrubland with low shrubs and ligneous or herbaceous plants forming cushions. The most frequent herbs are *Poa holciformis, Bromus setifolius* and *Hordeum comosum*. In the wet prairies we find dense prairies with predominance of *Patosia clandestina* and other juncaceae, grasses and cyperaceae. It is distributed in the Andes Mountains between Region IV and Region VII. To its north (south of Region IV to the Metropolitan Region) it ranges between 2600 and 3300 m.a.s.l.

- Andean Mediterranean Grassland with *Nastanthus spathulatus* and *Menonvillea spathulata*: In this floor the zonal association corresponds to an altitude desert where we find herbs forming rosettes intermingled with grasses. The most frequent species, besides those named above, are *Nassauvia lagascae, Nassauvia pinnigera* and *Nassauvia pyramidalis*, among others; among the most frequent grasses we have *Trisetum preslei* and *Hordeum comosum.* It is distributed in the Andes Mountains over 3000 m.a.s.l. up to the upper vegetation limit, between the south of Region IV and Region VI.

iii) Conservation of the Flora and Vegetation of the Sclerophyllous Forest and Scrubland

One of the most important aspects in the efforts to preserve the flora's diversity is its presence in SNASPE protected areas. In that respect, in central Chile there are two principal sclerophyllous vegetation protected areas, the La Campana Natural Park and the Río Clarillo Reserve (Region V). The High-Andean Vegetation of Mediterranean Chile is chiefly protected in the Yerba Loca Sanctuary (Metropolitan Region), the Río Blanco Reserve (Region V), and the El Morado Natural Monument (Metropolitan Region).

However, in relation to the sclerophyllous forest, Arroyo *et al* (1997), indicate that 4.1% of its distribution area is protected. This is particularly worrying because the region with Mediterranean climate of central Chile concentrates the highest percentage of the country's population. The sclerophyllous forest and scrubland are therefore confined to the mountainous areas and it has practically disappeared, or exists in an extremely degraded manner in the lowlands where agriculture and cattle raising has been carried out since colonial times. In this same respect, Luebert and Becerra point out that effective protection of the sclerophyllous forest communities in the SNASPE is only 0.7% of its total area.

Luebert and Pliscoff (2006) state that in the case of the Andean Mediterranean Sclerophyllous Forest of *Kageneckia angustifolia* and *Guindilia trinervis*, there is at present 70% of residual area. Notwithstanding, this type of vegetation is represented only in very small surface areas of the protected wild areas of Yerba Loca and El Morado. With regard to the Andean Mediterranean Sclerophyllous Forest of *Quillaja saponaria* and *Lithrea caustica*, the remaining surface area is only a little over 50% with its protected area representing only 0.7%.

iv) Conservation of the Andean-Mediterranean Flora

Luebert and Becerra (1998) indicate that in the National System of Protected Areas (SNASPE) the Andean-Mediterranean vegetation represents only 1% of the total area. The conservation of the Andean species in central Chile is currently carried out in the Río Blanco Reserve (Region V), the El Morado Natural Monument (Metropolitan Region), the Yerba Loca Nature's Sanctuary (Metropolitan Region) and partially in the upper areas of the La Campana

(Region V, Natural Park) and El Roble (Metropolitan Region, Private Sanctuary) hills, located in the Coastal Mountain Range. We have no information about the flora and the vegetation in La Campana, whereas for the Yerba Loca Nature's Sanctuary and El Morado Natural Monument there is information about the flora but not about the existing vegetation communities.

Luebert and Pliscoff (2006) indicate that the residual are of the Andean floors is en general high, but the proportion of its area included in the SNASPE is extremely low, ranging between 1.7 and 2.4%.

To improve the protected coverage of the regional Andean-type vegetation, in its Regional Strategy for the Conservation of Biodiversity, CONAMA has designated three sites in the High Andean area of Santiago as conservation priorities: the "Upper Part of the Maipo River", the expansion of the El Morado Natural Monument and the Colorado-Olivares river canyons.

5.4.1.2 Methodology

The Baseline Study on flora and vegetation covered the Project's area of influence in four subareas or zones, namely:

i. Colorado River Basin
ii. Lo Encañado Lake Basin
iii. Yeso River Basin (upper)
iv. La Engorda Stream Basin

The visits to the study area were carried out in April 2005; December 2006; February and November 2007, and March 2008. When the prospection was conducted, dry herb species were found in the lower zones of the study area but in the High-Andean sector, located over 2000 m.a.s.l., the situation was quite the opposite as many species were in bloom.

The species detection method was conducted by means of inspection visits and observation with binoculars. The information was complemented with the analysis of aerial photographs of each of the basins.

On the other hand, this report includes results obtained in a campaign carried out in the autumn of 2005, mainly at the La Engorda and Lo Encañado sectors in the Project's prefeasibility study phase.

Finally, the results of the flora and vegetation related to the Project works are synthesized in vegetation maps, over which the Project's temporary and permanent facilities are placed.

A FLORA

The identification of most of the species was conducted onsite based on de specialist's experience. For the species that were identified onsite, the material was herborized and determined at the office with the help of the pertinent literature. The nomenclature of the species follows Marticorena and Quezada (1985), as well as the modern literature available.

The following types were considered for the analysis of the growth:

- *Tree:* ligneous species having few branches and one or few trunks.
- *Shrubs:* ligneous species, whose branches stem from the base.
- *Lianas:* climbing plants with a woody stem.
- *Succulents:* included in this category are species with succulent stems (cactaceae) and somewhat succulent leaves like the Puya (Bromeliaceae).
- *Perennial herbs:* included in this category are species whose individuals have underground resistance and shoot again in the spring.
- *Annual herbs:* Species that survive the unfavorable season only through their seeds.

The species in a conservation category are shown in accordance with Benoit /1989), subsequent pertinent publications (Baeza *et al* 1998, Belmonte *et al*, 1998 and Ravenna *et al*, 1998) and suggestions on conservation status published by CONAMA in its website (2005-2006).

The common names of the plants in Spanish used in the text were based on Baeza (1930), Navas (1973-1979) and Hoffmann (1979).

The results of flora corresponding to the area of influence of the Alto Maipo Hydroelectric Project are shown as tables and figures in general, for the entire area and specifically, for each basin of the study.

For each species the following was indicated: scientific name, common name, family, growth form and geographic origin (Chilean endemic species, native and allochthonous, feral) and their conservation category. For each basin, studies on the richness of its flora and the variation in the number of species according to growth form and geographic origin are provided.

B VEGETATION

The characterization of the natural vegetal communities and their maps was conducted using the map preparation methodology of the Land Occupation Maps (Etienne and Prado, 1982). They characterize the vegetation units according to predominance and physiognomy criteria. Abundance (coverage) of the species was visually estimated and the mapped units were denominated "vegetation formations."

For the study area, the biological types (physiognomic) considered are: "low ligneous" (LB) for shrubs and "herbaceous" (H) for perennial and annual herbs. Vegetation coverage was estimated according to the following scales.

- 1-5%: very scarse
- 5-10%: scarse
- 10-25%: very clear

- 25-50%: clear
- 50-75%: low density
- 75-90%: dense
- 90-100%: high density

The information obtained onsite is shown on maps at an appropriate scale for each of the basins or subareas of the study defined for this section in the Environmental Baseline of the Alto Maipo Hydroelectric Project.

5.4.1.3 Description of Results

A FLORA

In global terms, the flora of the sites visited totaled 306 species of vascular plants. The list of these plants, which includes their scientific name, common name, growth form, geographic origin and conservation category, is shown on Table 5.4.1.3.1.

The analysis of the flora according to its growth form and geographic origin is shown later on by geographic basin.

Threatened species

The following threatened species were recorded in the Project's area of influence:

1) Alstroemeriaceae

Alstroemeria exerens (Photograph 5.4.1.3.1): in the three altitude sites visited we observed individuals in a vegetative state, which because of their geographic distribution and the appearance of their leaves could belong to the species. This must be confirmed with observations in the flowering season. It corresponds to a species classified as "**insufficiently known**".

Photograph 5.4.1.3.1. Alstroemeria exerens: species classified as insufficiently known. Frequent individuals identified on the Project sites located over 2000 m.a.s.l. may belong to this species. The photograph does not correspond to the campaign because it flowers between January and February.

2) Bromeliaceae

Puya berteroniana (Photograph 5.4.1.3.2): a species considered **vulnerable** nationwide. It was exclusively found at the Colorado River, on a rocky hillside within the Project's area of influence. There are several individuals associated with sectors where the soil has significant amount of rocks.

Photograph 5.4.1.3.2. *Puya berteroniana*, a species classified as vulnerable. It is frequently found on rocky places of the Colorado River Canyon.

3) Cactaceae

Eriosyce (Neoporteria) curvispina: (Photograph 5.4.1.3.3): a species considered "**vulnerable**" nationwide. We found 5 individuals in the area of influence located in the Colorado River basin (E 38750391 – N 6291254, 1100 m altitude). The small population is located in the sclerophyllous forest sector with *Quillaja saponaria* and *Kageneckia angustifolia* (Photograph 5.4.1.3.4):

Photograph 5.4.1.3.3 and 5.4.1.3.4: *Eriosyce curvispina*, a cactaceae classified as vulnerable. It is scarse in the Colorado River valley, 1100 m.a.s.l.

4) Lauraceae

Cryptocarya alba: (Photograph 5.4.1.3.5): a tree species considered "**vulnerable**" nationwide. It was found in the El Manzano sector. In the area it forms a forest with high density and coverage.

Photograph 5.4.1.3.5: *Cryptocarya alba*. Classified as vulnerable. It forms a dense forest in the El Manzano sector of the Las Lajas plant.

5) Rosaceae

Kageneckia angustifolia (Photograph 5.4.1.3.6): a tree considered **vulnerable** in the Metropolitan Region. It is frequently present and locally abundant at between 1500 and 2000 m.a.s.l., particularly in the area of the Colorado River Valley. There are a large number of individuals as this species is one of the predominant of the formation.

Photograph 5.4.1.3.6: *Kageneckia angustifolia,* classified as vulnerable. It is frequently found in the Colorado River Valley, over 1,400 m.a.s.l. Left: habit. Right: fruit details.

6) Umbelliferae

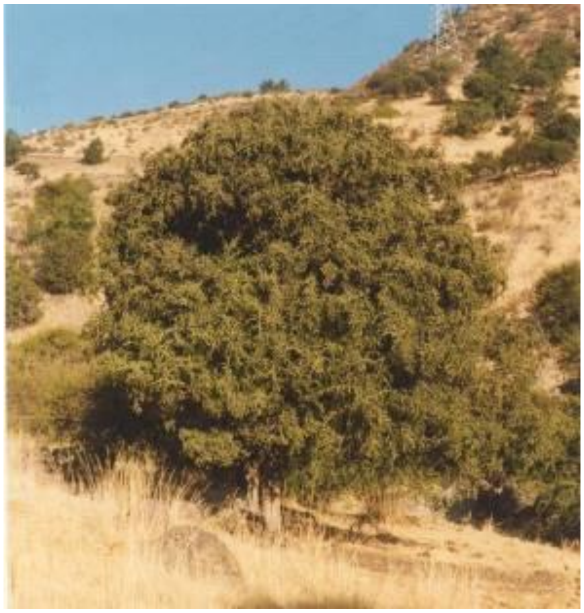
Laretia acaulis: a shrub that grows forming cushions close to the ground. It has been classified in the **vulnerable** category nationwide. Its presence is frequent and somewhat abundant in the La Engorda sector, where it grows on some hillsides (Photograph 5.4.1.3.7). It was also found in the Lo Encañado sector, where a specimen of the species grew in the direct area of influence, on the left margin of the El Manzanito stream (E. 396263; N. 6272866), at an altitude of 2450 m.a.s.l. One specimen was also detected in the Yeso River basin at an altitude of 2440 m.a.s.l. (UTM: E. 398183; N. 6272690).

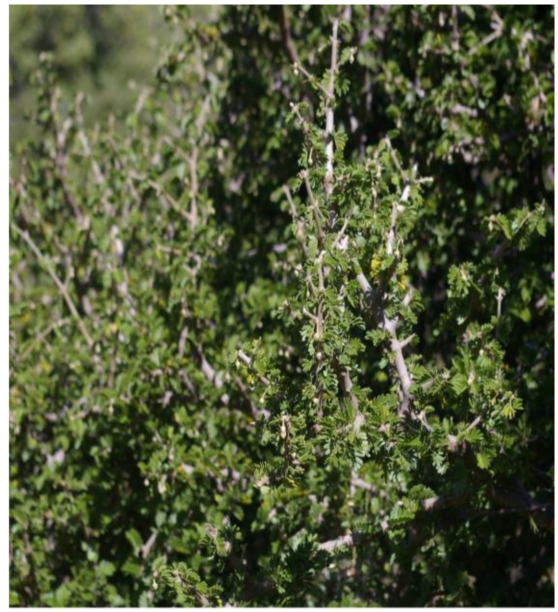
In accordance with the list of the third classification process approved by the CONAMA Advisory Board, based on the Regulation for the Classification of Wild Species (D.S. Nº75/2005), the *Laretia acaulis* is proposed as Out of Danger, because there is no information indicating that the species is in any risk of extinction or becoming rare.

Photograph 5.4.1.3.7: *Laretia acaulis,* classified as vulnerable. Frequently found in some sectors of La Engorda.

7) Zygophyllaceae

Porlieria chilensis, a species that grows on hillsides with good exposure to the sun at not over 1800 m.a.s.l., in the Colorado River sector, it was frequently found in 2 of the 4 formations of the sector. It has been classified in the **vulnerable** category nationwide (Photograph 5.4.1.3.8 and 5.4.1.3.9).





Photographs 5.4.1.3.8 and 5.4.1.3.9. *Porlieria chilensis*, a species that may be found in the lower part of the Project (Colorado River). The individual at the right grew at about 1100 m.a.s.l., on the left bank of the Colorado River. The individual at the left was found in the Maipo River basin.

Results according to zones

i Colorado River Basin

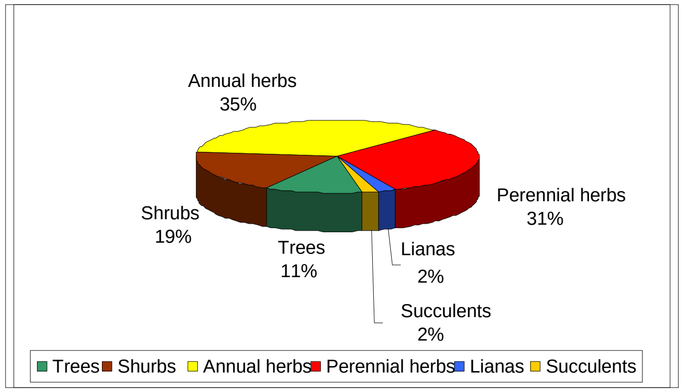
- *Richness*

We found 125 species of vascular plants in the explored area. The list of these plants, including their scientific name, common name, growth form, is shown on Table 5.4.1.3.2.

- *Growth Forms*

Figure 5.4.1.3.1 shows the distribution of the species according to their growth form. The most frequent life form among the plant species was that of the annual herb, which accounted for 35%; followed by perennial herbs 31%, shrubs 19%, and trees 11%. Annual herbs are frequent in zonal environments, where there is no presence of water, whereas perennial herbs grow in permanently wet places. Finally, shrubs and trees form part of the predominant zonal vegetation, the sclerophyllous forest.

Figure 5.4.1.3.1
Colorado River Flora: Growth Forms of Plants

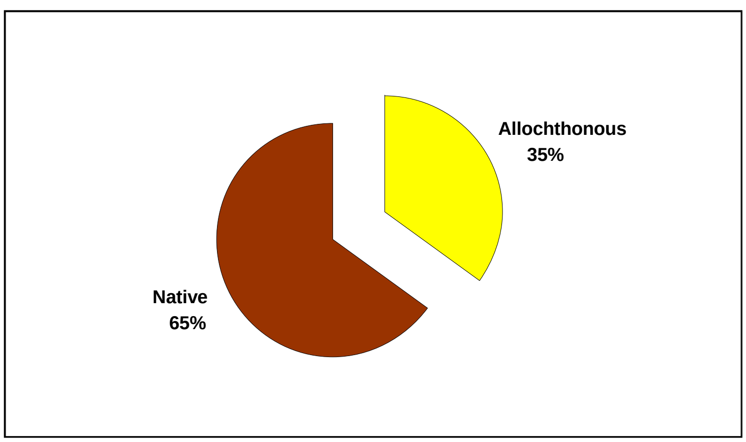


– *Geographic Origin*

Data on geographic origin of the plants in the area are shown on Figure 5.4.3.1.2. We can see that Native plants account for 65%, whereas Allochthonous plants, 35%.

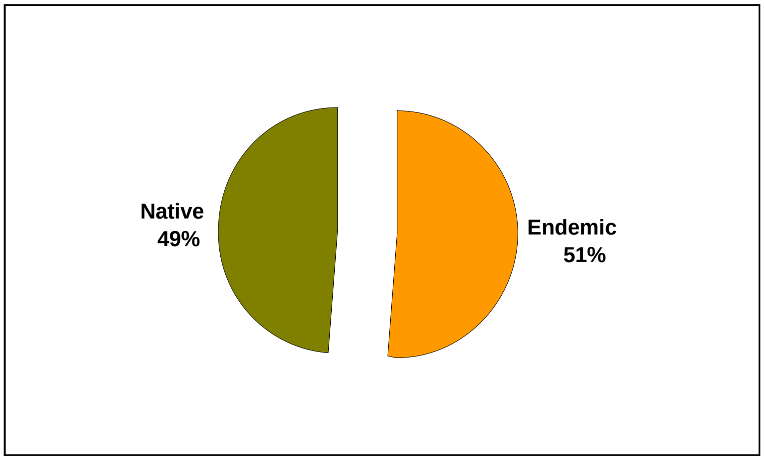
Figure 5.4.1.3.3 shows that 49% of the Native plants are species Endemic to Chile.

Figure 5.4.1.3.2
Colorado River. Flora: Geographic Origin of the Species



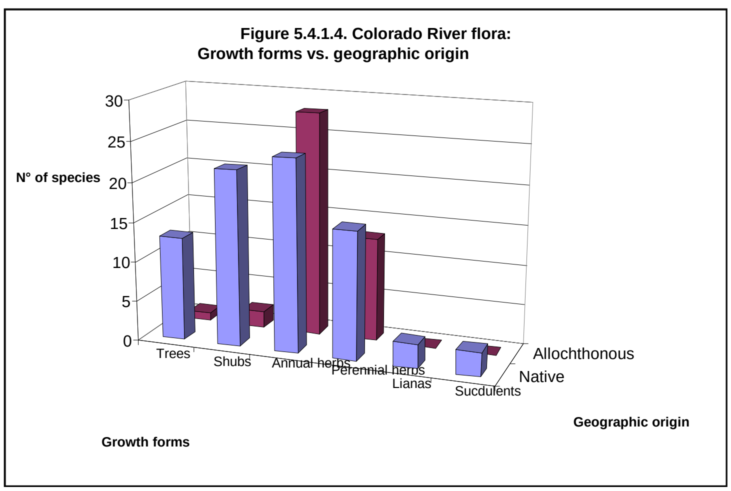
The results show two phytogeographic situations that are worth noting: like in the sclerophyllous forest environments, there is a considerable number of native species that are endemic to Chile, accounting for almost 50%. This corresponds to the endemism levels of Chile's Mediterranean zone. At the same time, the area of interest shows a considerable percentage of feral, allochthonous plants (35%), higher than for the Santiago basin (30%). This shows that this is an area that has been and continues being the object of human interventions that favor the invasion of allochthonous plants.

Figure 5.4.1.3.3
Colorado River. Flora: Endemic vs. Native Species



If we relate the geographic origin data with growth form data (Figure 5.4.1.3.4), we have that in the case of ligneous plants, in all cases there is a great majority of native plants; in the case of herbs, perennial herbs show an intermediate situation, whereas in the case of annual herbs, the largest number of species corresponds to feral, allochthonous plants. The data suggest that in sites where forests are preserved, most of the ligneous species—which predominate—are native. In those sites, however, where there is predomination of perennial herbs—wet prairies—or annual herbs—road edges and altered sites in the periphery of the sclerophyllous forest—feral, allochthonous plants predominate.

Figure 5.4.1.3.4
Colorado River. Flora: Growth Forms vs. Geographic Origin



- Species in conservation categories

Individuals of the following vulnerable species nationwide were found in the area: *Porlieria chilensis*, *Eriosyce curvispina* and *Puya berteroniana*; and at a regional level, *Cryptocarya alba* and *Kageneckia angustifolia*.

Aucayes Sector

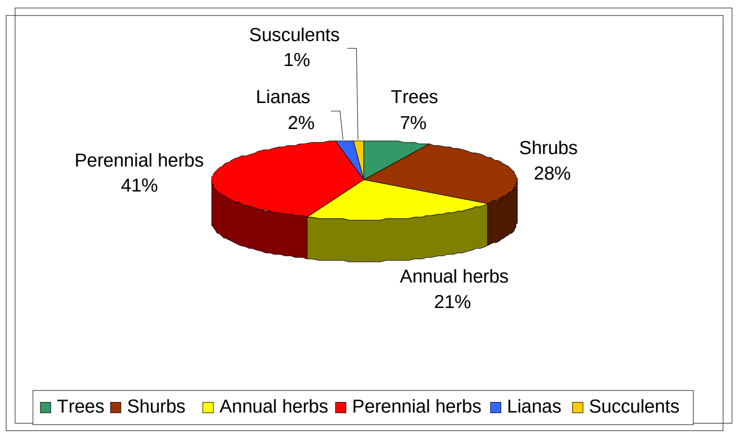
– *Richness*

We found 175 species of vascular plants in the explored area. The list of these plants, which includes their scientific name, common name, growth form, geographic origin and conservation category, is shown on Table 5.4.3.1.3.

– *Growth form*

Figure 5.4.1.3.5 shows the distribution of species by growth form. The most frequent life form among the species of plants was that of perennial herb (41%), followed by shrubs (28%), annual herbs (21%), and trees (7%). In sectors with lower altitude, there is predomination of trees, shrubs and annual herbs, and in the highest sectors, shrubs and perennial herbs.

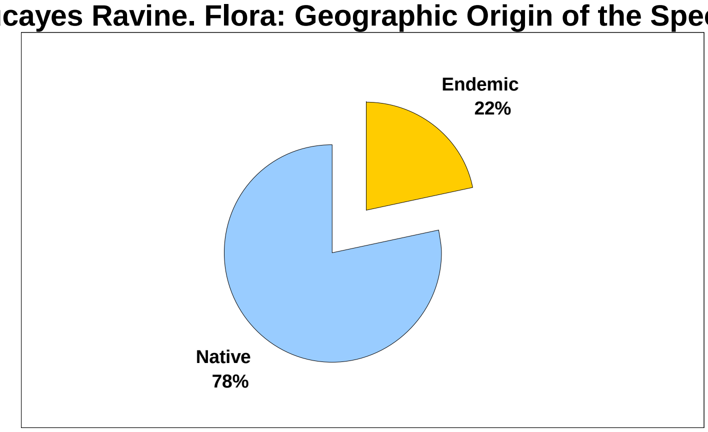
Figure 5.4.1.3.5
Aucayes Ravine. Growth Forms of Plants



– *Geographic Origin*

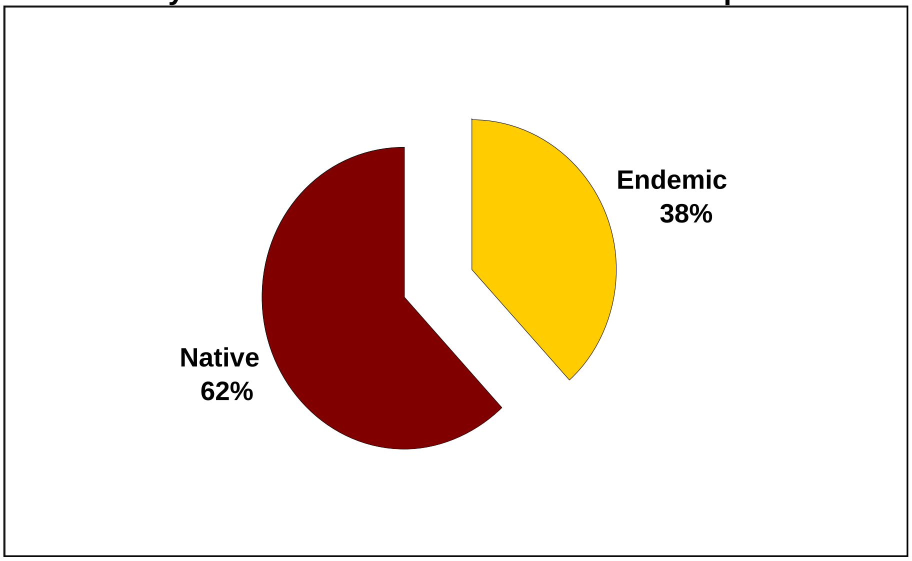
The geographic origin data of the plants in the area are shown on Figure 5.4.1.3.6. We can see that native plants account for 78% whereas allochthonous plants, 22%.

Figure 5.4.1.3.6
Aucayes Ravine. Flora: Geographic Origin of the Species



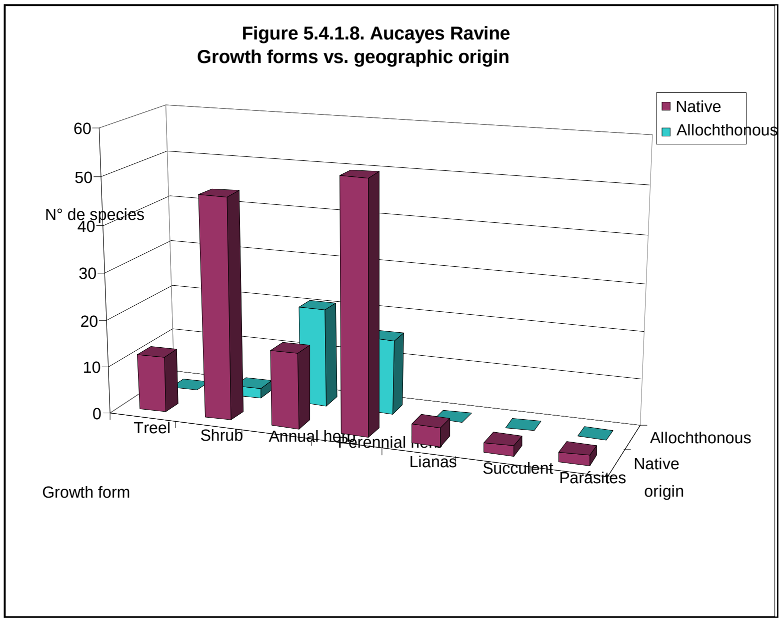
The results show that because this is an area that significant variations in altitude (1200-2500 m.a.s.l.), the endemic species are under 50% (Figure 5.4.1.3.7), somehow, 38% reflects the average condition of the mountain flora and scrubland; a situation that is similar to that of allochthonous species in relation to native species.

Figure 5.4.1.3.7
Aucayes Ravine. Flora: Endemic vs. Native Species



If we relate the data of geographic origin with those of growth forms (Figure 5.4.1.3.8), we have that for ligneous plants, in all cases there is a great majority of native plants; among herbs, perennial herbs show an intermediate situation; whereas among annual herbs, the greatest number of species corresponds to allochthonous plants. The data suggest that the allochthonous plants are concentrated in herbaceous forms, probably associated with dry or wet disturbed areas. In the first case, disturbances correspond to the destruction of the forest or scrubland, and in the second case, to the introduction of exotic cattle that propagates perennial herbs to wetlands or lands at higher elevations where the introduced species may withstand the summer drought.

Figure 5.4.1.3.8
Aucayes Ravine. Flora: Growth Forms vs. Geographic Origin



– *Species in Conservation Categories*

Individuals of *Kageneckia angustifolia* were frequently found in the area, and individuals of *Puya berteroniana* were abundantly locally found.

ii. Lo Encañado Lake Basin

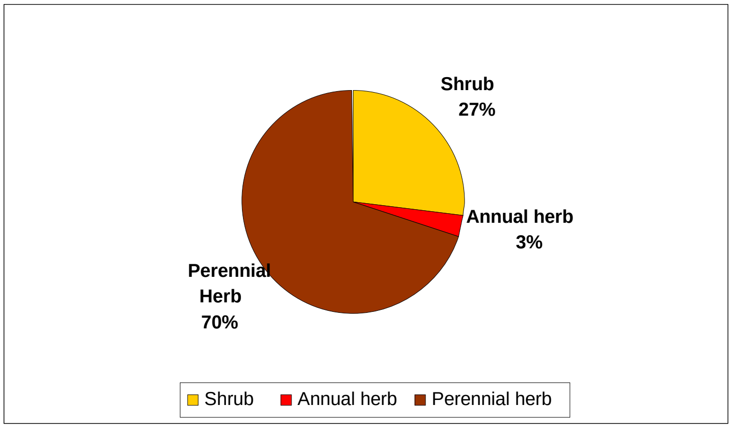
– *Richness*

A total of 78 species were found in the area. The list of the species including their scientific name, common name, growth form, geographic origin and conservation category is shown on Table 5.4.3.1.4.

– *Growth Forms*

The results are shown on Figure 5.4.1.3.9. We can see that there is predomination of perennial herbs (70%), followed by shrubs (27%) and there are also some annual herbs (3%).

Figure 5.4.1.3.9
Lo Encañado Lake Sector. Flora: Growth Forms of Plants



Most of the perennial herbs are characteristic of Andean environments, where the low temperatures make the germination and recruitment processes uncertain; therefore, annual species are absent or scarse. Although shrubs show smaller richness of species, they are still important because due to their abundance they define the type of landscape.

- *Geographic origin*

The results are shown on Figure 5.4.1.3.10. We can see that native species account for the great majority (90%). Among the native species, those endemic to Chile total 23% (Figure 5.4.1.3.11). Compared with sclerophyllous forests, mountain ecosystems show smaller levels of endemism and many Andean species are shared with other countries. On Figure 5.4.1.3.12 we can see the relationship between the growth forms and the geographic origin of the species. We see that most of the allochthonous plants are perennial herbs (7 species).

Figure 5.4.1.3.10
Lo Encañado Lake Sector. Geographic Origin of Plants

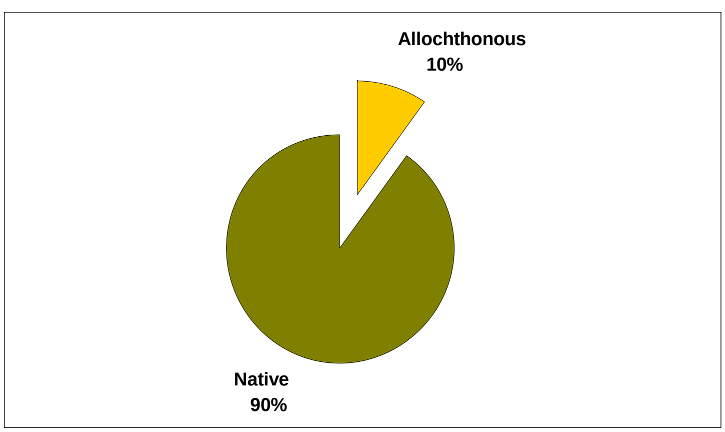


Figure 5.4.1.3.11
Lo Encañado Lake Sector. Endemic vs. Native Plant Species

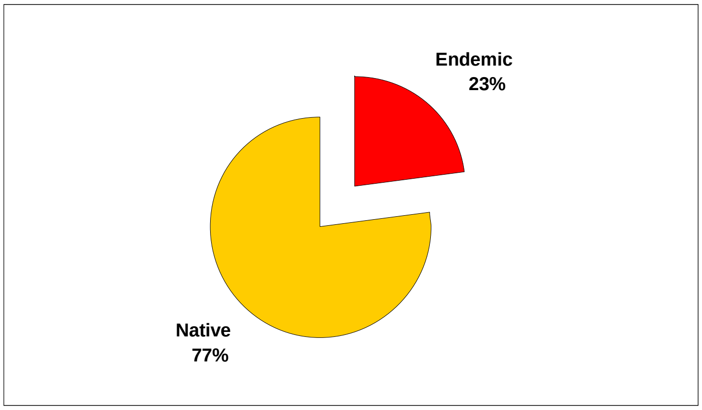
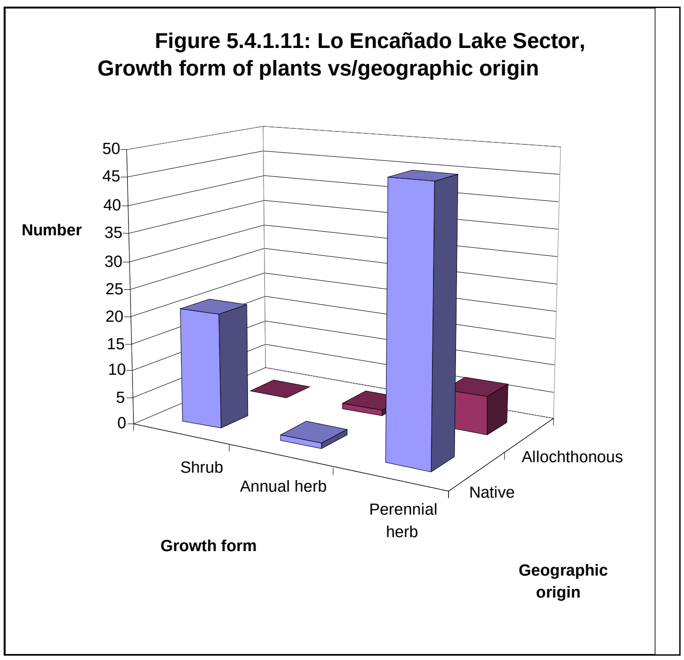


Figure 5.4.1.3.12
Lo Encañado Lake Sector. Growth Form of the Plants vs. Geographic Origin



Species in a conservation category

Two species in a conservation category were detected in the area: *Laretia acaulis*, vulnerable nationwide and *Alstroemeria exerens*, insufficiently known.

iii. El Yeso Reservoir Road Sector.

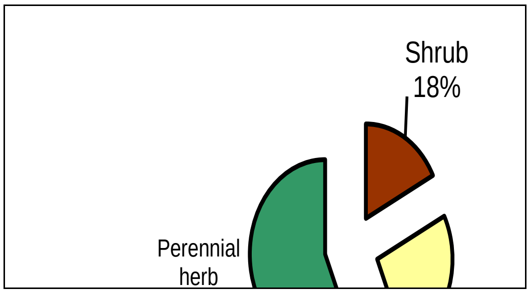
– *Richness*

The number of species totals 103. The list of the species, which includes their scientific name, common name, growth form, geographic origin and conservation category, is shown on Table 5.4.1.3.5.

– *Growth Forms*

In accordance with Figure 5.4.1.3.13, we can see that with regard to growth forms, 57% of the species are perennial herbs, 17% annual herbs and 26% shrubs.

Figure 5.4.1.3.13
Yeso River Valley. Growth Forms of Plants



– *Geographic Origin*

The data shown on Figure 5.4.1.3.14 indicate that 82% of the species are native and 18% feral, allochthonous. Among the native species, 15% are endemic to Chile (Figure 5.4.3.1.15).

Figure 5.4.1.3.14
Yeso River Valley. Geographic Origin of Plants

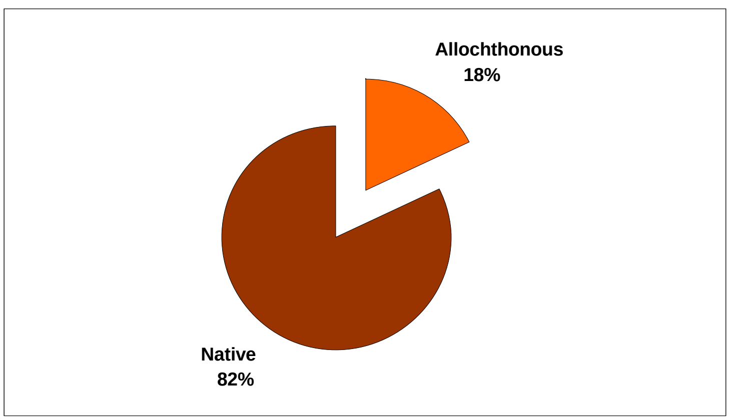
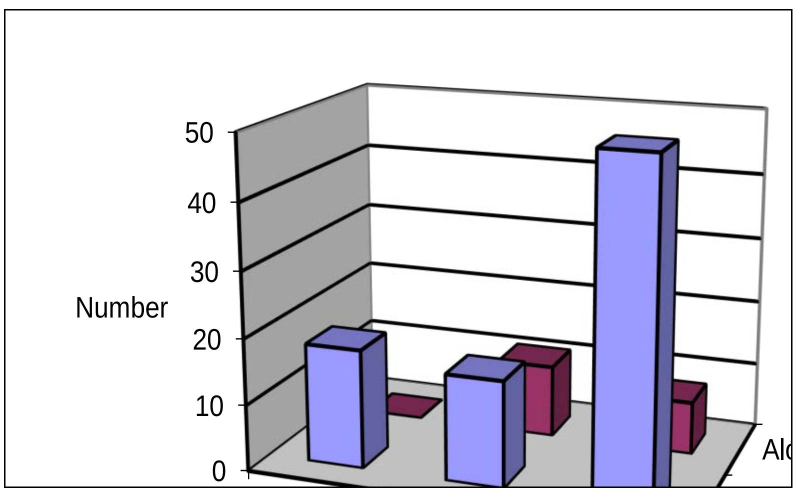


Figure 5.4.1.3.15
Yeso River Valley. Endemic vs. Native Plant Species

If we analyze the plants according to origin and growth form, we have that native plants occupy the three growth forms, whereas allochthonous are only annual (11) or perennial (8) herbs (Figure 5.4.1.3.16).

Figure 5.4.1.3.16
Yeso River Valley. Growth Forms of Plants vs. Geographic Origin



– *Species in a Conservation Category*

Two species in a conservation category were detected in the area: *Laretia acaulis*, vulnerable nationwide and *Alstroemeria exerens*, insufficiently known.

iv. La Engorda Sector

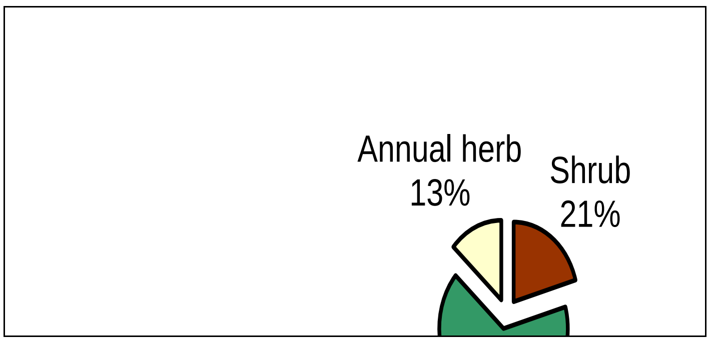
– *Richness*

A total of 97 species was found in the area. The list of the species, which includes their scientific name, common name, growth form, geographic origin and conservation category, is shown on Table 5.4.1.3.6.

– *Growth Forms*

Figure 5.4.1.3.17 shows that, with regard to growth forms, 66% of the species are perennial herbs, 13% annual herbs and 21% shrubs.

Figure 5.4.1.3.17
La Engorda Sector. Growth Forms of Plants



– *Geographic Origin*

The data shown on Figure 5.4.1.3.18 indicate that 91% of the species are native and 9%, feral, allochthonous. Among the native species, 15% are endemic to Chile (Figure 5.4.1.3.19).

Figure 5.4.1.3.18
La Engorda Sector. Geographic Origin of the Species

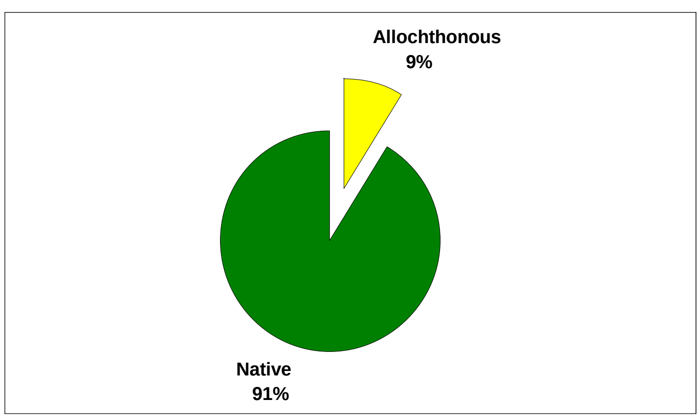
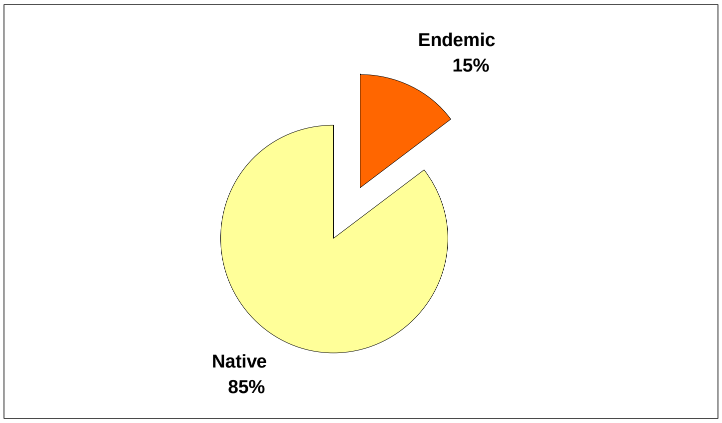
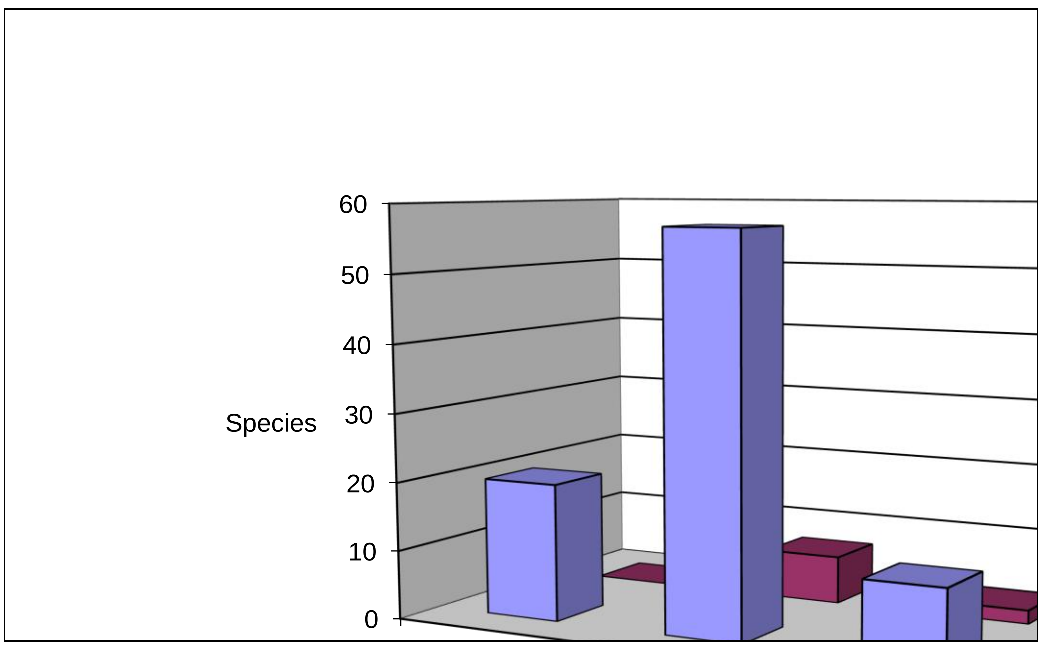


Figure 5.4.1.3.19
La Engorda Sector. Native vs. Endemic Species of Chile



If we analyze the plants according to origin and growth form, we have that native species occupy the three growth forms, accounting for the majority in the three, whereas allochthonous species are only herbs, perennial (7) or annual (2) (Figure 5.4.1.3.20).

Figure 5.4.1.3.20
La Engorda Sector. Growth Forms vs. Geographic Origin of plants



– *Species in a conservation category*

Two species in a conservation category were detected in the study area: *Laretia acaulis*, vulnerable and *Alstroemeria exerens*, insufficiently known.

A. VEGETATION

The results are presented by zone. The formations where the Project area vegetation was classified are shown on Tables 5.4.1.3.7 a 5.4.1.3.16; while their distribution, in relation to the Project works, is indicated on the vegetation maps shown on Figures 5.4.1.3.21 a 5.4.1.3.31.

i Colorado River Basin

– **Las Puertas Sector**

This area is completely located on the right margin of the river and it currently does not have any access. The formations shown on the mapping where extrapolated on the basis of the information of the formations observed upstream in the valley (Las Lajas and El Alfalfal-Los Maitenes) and observations made with binoculars of some of the area's sectors bordering the Colorado River.

The table with land occupation mapping describing the area's formations is shown on Table 5.4.3.1.7. The formations' distribution is shown on Figure 5.4.1.3.21.

LP-1: Low density, high ligneous formation (LA5 pd).
It appears with the physiognomy of a low density, sclerophyllous forest with over 60 % of tree coverage, and predominance of species like *Quillaja saponaria, Lithrea caustica* and *Kageneckia oblonga*. The height of the trees ranges mainly between 2 and 8 m. The formation is on a hillside exposed to the southeast with a gradient exceeding 50%.

LP-2: Low density, high ligneous formation (LA5 pd).
This unit is very similar to the previous one, with the difference that it has much lower coverage of *Quillaja saponaria*, which disappears as a predominant species. It is on a hillside exposed to the south, and its slope is equal or slightly under 50%.

LP-3: Dense, high ligneous formation (LA6 d).
The physiognomy of this formation is of a sclerophyllous forest. The predominant trees in this case are *Cryptocarya alba, Kageneckia oblonga, Lithrea caustica* and *Quillaja saponaria*. The height of the trees ranges between 2 and 8 meters. The formation is on a hillside exposed to the south. The *Cryptocarya alba* is a species classified as Vulnerable regionally.

LP-4: Dense, high and low ligneous formation (LA4 LB4 d).
It appears with the physiognomy of a dense sclerophyllous forest, with over 80% coverage, and the prevalence of species like *Quillaja saponaria*, *Lithrea caustica* and *Kageneckia oblonga*, and a shrubby stratum with predominance of *Colliguaja odorifera* and *Haplopappus diplopappus*. The height of the trees mainly ranges between 2 and 8 m. The formation is on a hillside exposed to the east with abrupt, rocky slopes.

LP-5: Dense, high ligneous formation (LA6 d).
It has the physiognomy of a dense sclerophyllous forest, with over 80% tree coverage, with predominance of species like *Quillaja saponaria* and *Lithrea caustica* (Lithrea caustica) and *Kageneckia oblonga*. The heights of the trees mainly range between 2 and 8 m. The formation is on a hillside exposed to the east.

LP-6: High and low ligneous formation (LA2 LB3 H3 pd).
The physiognomy of this formation is riparian scrub, with the presence of isolated trees. Among the predominant tree species is *Quillaja saponaria* and among the shrubs, *Baccharis linearis*. The coverage of the tree stratum does not exceed 10% and its height is between 4 and 8 meters. It also has an herbaceous stratum with predominance of *Bromus beteroanus* and *Avena barbata*. A terrace bordering the river was found.

LP-7: High and low ligneous formation with herbaceous plants (LA4 LB2 H3 d).
This formation corresponds to a sclerophyllous forest dominated in its tree stratum by *Quillaja saponaria* and *Acacia caven*, *Haplopappus diplopappus* in its shrub stratum, and *Nassella chilensis* in its herbaceous stratum. The formation is found in a steep hillside (gradient exceeding 50%) with northwest orientation, between the Colorado River and the road.

LP-8: Agricultural Zone
This is an agricultural zone with some houses and some isolated individuals of species belonging to the sclerophyllous forest.

– ***Windows 4 and 5 Sector - Las Lajas Tunnel***

In this sector, units CL-2, CY-1, CY-2, CY-3 and CY-4 do not show any interventions in accordance with the new Project changes.

The area's formations are shown on Table 5.4.1.3.8 and 5.4.1.3.9, and their distribution with respect to the Project works is illustrated on Figure 5.4.1.3.22.

CL-1: High density, high and low, ligneous formation with herbaceous plants (LA4 LB3 H5 md).
The formation's physiognomy is that of a park-type, sclerophyllous forest, where the spaces left by the trees are covered with a seasonal herbaceous cover. The trees are up to 10-12 m tall and the stratum's coverage is in the order of 25 to 50%. The most frequent trees are *Quillaja saponaria* and *Acacia caven*. The formation is in a sector with low gradient and north orientation (Photograph 5.4.1.3.10).

Photograph 5.4.1.3.10. Colorado River-Las Lajas. Formation CL-1. Sclerophyllous forest with *Quillaja saponaria* and *Acacia caven*.

CL-2: High density, high and low, ligneous formation (LA5 LB4 md).
The formation has the physiognomy of a sclerophyllous forest. The predominant trees are *Quillaja saponaria*, *Kageneckia angustifolia* and *Kageneckia oblonga*. By means of observation with binoculars, we observed that the formation's tree stratum coverage is in the range of 50 to 75% (Photograph 5.4.1.3.11). Among the species in a conservation category in the formation is *Kageneckia angustifolia*.

Photograph 5.4.1.3.11. Colorado River-Las Lajas. Formation CL-2. Sclerophyllous forest with *Quillaja saponaria*, *Kageneckia angustifolia* and *Kageneckia oblonga*.

CL-3: Very clear, low ligneous formation with succulent plants (LB3 S1 mc).
The formation presents a physiognomy of a scrubland with intermingled succulents, cactacea and bromeliacea. The predominant species among the shrubs are *Gymnophyton isatidicarpum* and *Proustia cuneifolia*, and among the succulents, *Echinopsis chilensis* and *Puya berteroniana*, the latter on sites with rock outcrops. The coverage of the shrub stratum is under 25%, it is found on the hillsides exposed to the north with sharp inclination. Among the species in a conservation category in the formation are the *Puya berteroniana*.

CL-4: Very clear, high and low, ligneous formation (LA2 LB 2, mc).
The formation's physiognomy is that of a park where we find isolated *Quillaja saponaria* trees in a herbaceous matrix, completely dry at the time of the sampling. It probably corresponds to a piece of post-crop or over-grazed seasonal pasture land. The *Quillaja saponaria* have the size of trees and they are up to 12 m tall. The formation is found on a small piece of flat land bordering the road to the left of the Colorado River.

CL-5: Scarse, high and low, ligneous formation (LA2 LB1, e).
The formation appears as a very open scrubland where we find specimens of *Acacia caven,* probably originated from seeds. This area, very likely corresponds to post-crop land which in the process of being colonized by the native ligneous vegetation. The *Acacia cavens* currently do not reach a height of 2 m. The formation was found in a sector bordering the road, on the left margin of the Colorado River.

CL-6 Low density, high, ligneous formation with shrubs and herbs (LA5 LB2 H1 pd).
The formation's physiognomy is that of a sclerophyllous forest. The predominant trees are *Quillaja saponaria* and *Maytenus boaria*, and it has a scarse shrub stratum with predominance of *Cestrum palqui*. Tree coverage is between 50 and 75%. *The Quillaja saponaria* have the size of trees reaching a height of up to 12 m; however, the formation is found in an intervened sector, where there are inhabited homes and cultivated vegetation. (Photograph 5.4.1.3.12).

Photograph 5.4.1.3.12. Formation CL-6. Sclerophyllous forest with *Quillaja saponaria* and *Maytenus boaria*, in an intervened sector adjoining inhabited homes and cultivated vegetation.

CL- 7 Residential area and cultivated vegetation.

CL-8 Low density, high, ligneous formation with shrubs, herbs and succulents (LA4 LB2 H2 S1 pd).
The physiognomy of the formation is that of a sclerophyllous forest. The predominant trees are *Porlieria chilensis*, *Lithrea caustica* and *Quillaja saponaria*; it has a scarse shrub stratum with predominance of *Trevoa quinquinervia*. Tree coverage is between 25 and 50%. The

Quillaja saponaria have the size of trees and are up to 10 m tall, the *Porlieria chilensis* and *Lithrea causticas* are smaller being up to 4 m tall. The formation is located on a level-ground area on kilometer 6 of the road that goes to El Alfalfal and the Colorado River. (Photograph 5.4.1.3.13).

CL-9 Clear, low ligneous formation with trees, herbs and succulents (LA2 LB3 H2 S1 c).
The physiognomy of the formation is that of a thorny scrubland where the predominant species are *Trevoa quinquinervia* and *Haplopappus foliosus*. It also has some isolated individuals of *Quillaja saponaria* and *Echinopsis chilensis*, and an herbaceous stratum dominated by *Vulpia myuros*. It is found on the edge of the road on a steep slope with a gradient of 45º.

Photograph 5.4.1.3.13 Formation CL-8. Sclerophyllous forest with *Porlieria chilensis*, *Lithrea caustica* and *Quillaja saponaria*, in a sector of the road that goes to El Alfalfal and the Colorado River.

CY-1: High density, high and low, ligneous formation (LA 5 LB4 d).
This formation corresponds to an open thorny sclerophyllous forest with predominance of *Quillaja saponaria*, *Acacia caven*, *Schinus polygama* and *Porlieria chilensis*. There is a higher stratum with *Quillaja saponaria*, of up to 10 m tall, and a lower stratum with *Acacia cavens* and *Porlieria chilensis*. The predominant species in the shrub stratum is *Gochnatia foliolosa*. The formation has high density coverage of about 80%. It is found on a terrace with little inclination at approximately 1050 m.a.s.l. Among the species in a conservation category are *Porlieria chilensis* and *Puya berteroniana* in sectors with rock outcrops.

CY-2: High density, high and low ligneous formation with succulent plants (LA5 LB5 S2).
The formation corresponds to an arborescent sclerophyllous scrubland with *Lithrea caustica*, *Kageneckia oblonga* and *Quillaja saponaria* in the tree stratum, which reaches a height of up to 3-12 m, the *Quillaja saponaria* emerging among the secondary growth of *Lithrea caustica* and *Kageneckia oblonga*. The predominant shrubs are *Gochnatia foliolosa*, *Colliguaja odorifera* and *Colletia hystrix.* The formation's coverage is high reaching 80%. It is found on a hillside, in some parts with a sharp inclination, and with south-west orientation (1050-1250 m.a.s.l.). Among the species in a conservation category we frequently find the *Porlieria chilensis*, *Eriosyce curvispina* and *Puya berteroniana*, the last two frequently in sectors with rock outcrops.

CY-3: Dense, high ligneous formation (LA 6, d).
This formation corresponds to a dense sclerophyllous forest, with a tree stratum of up to 10 m high and predomination of *Cryptocarya alba* accompanied of *Quillaja saponaria* and *Kageneckia oblonga*. Coverage is high and may reach up to 70%. It is likely that in the spring time there may be a herbaceous stratum. It is found in the bottom of ravines with good humidity. Among the species in a conservation category we found one of the predominant ones: *Cryptocarya alba*.

CY-4: Clear, high and low ligneous formation with succulent plants. (LA3 LB3 S1 c.)
Corresponds to an arborescent, thorny sclerophyllous scrubland with emergent *Quillaja saponaria* trees of up to 10 m tall and smaller trees about 2-3 meters tall of *Trevoa quinquinervia* and a shrub stratum of up to 150 cm high of *Colliguaja odorifera*. On places with rock outcrops we find succulents like *Puya berteroniana* and *Echinopsis chilensis*. The formation's coverage is 50%. The formation is on a hillside with south-east orientation and sharp inclination. Among the species in a conservation category we have the *Puya berteroniana* in sectors with rock outcrops; we cannot rule out the presence of *Porlieria chilensis* and *Eriosyce curvispina*.

– ***Alfalfal Sector***

The area's formations are shown on Table 5.4.3.1.10 and their distribution on Figure 5.4.1.3.23.

In this sector, units CA-5 and CA-6 do not show any interventions in accordance with the new changes of the Project

CA-1: High density, high and low ligneous formation with herbaceous and succulent plants (LA4 LB4 H4 S1 md):
The formation's physiognomy is that of an open sclerophyllous forest with a shrub stratum and another stratum of annual, seasonal herbs. The height of the trees is of up to 15 m, the shrub stratum does not exceed 2 m. Adding the three strata, and vegetation coverage is very high. The predominant species are *Quillaja saponaria*, *Kageneckia angustifolia* and *Schinus polygamus* among trees; *Colletia hystrix, Cestrum parqui* and *Muehlenbeckia hastulata* among shrubs; and *Bromus berterianus among herbs*. The formation corresponds to the vegetation of the hillside exposed to the south that is in the Alfalfal sector (1500 m.a.s.l.). Among the species in a conservation category we found the *Kageneckia angustifolia* (Photograph 5.4.1.3.14), in a sector bordering the river and adjoining an alfalfa field.

Photograph5.4.1.3.14. Colorado River-El Alfalfal: Formation CA-1. *Kageneckia angustifolia* and *Quillaja saponaria* forest.

CA-2: Clear, low ligneous formation with herbaceous plants (LB3 H4 c).
The physiognomy of the formation is that of a scrubland with a predominant tree stratum approximately 150-180 cm high, where *Baccharis salicifolia* and *Baccharis pingraea* dominate; among the herbs we can find *Erodium cicutarium* and on species of *Hydrocotyle* (Photograph 5.4.1.3.15). Vegetation coverage is of up to 40%. Vegetation develops in the Colorado River waterway, in the Alfalfal sector (1500 m.a.s.l.). No species in a conservation category were found in the formation.

Photograph5.4.1.3.15. Colorado River-El Alfalfal, CA 2, *Baccharis salicifolia* (stony sector) and *Hydrocotyle* formation in the backwater of the Colorado River.

CA-3: High density, low ligneous and herbaceous formation (LB1 H7 md).
The formation's physiognomy is that of a prairie with a dense herbaceous stratum and a not very abundant shrub stratum not over 50 cm high. The principal species in the herbaceous stratum are *Hirschfeldia incana*, *Hordeum murinum* and *Madia sativa*; a considerable part of the stratum's species are feral, allochthonous plants. Among the shrubs, the most abundant one is the *Baccharis pingraea* (Photograph 5.4.1.3.16). The formation's coverage is almost 100%. It was found in a wet sector of El Alfalfal, with upwelling of water and surface water runoff.

Photograph 5.4.1.3.16. Colorado River-El Alfalfal. Wet prairie in the sector where the water reservoir will be built. Formation CA-3.

CA-4: High, low, ligneous formation with herbaceous and succulent plants (LA4 LB4 H3 S1 md).
The formation's physiognomy is that of a sclerophyllous forest where evergreen trees are part a complex mosaic along with shrubs and annual herbs. In the areas that are most exposed to the sun we find some specimens of succulents. The trees reach a height of about 10-15 m, and tree stratum coverage ranges between 25 and 50 %. The understory has similar coverage and shrubs are not more than 150 cm high. The predominant tree species are *Quillaja saponaria* and *Schinus polygama* (Schinus polygama); among shrubs the *Colletia hystrix* (Colletia hystrix) predominates, and the *Echinopsis chilensis* (Echinopsis chilensis) among the succulents (Photograph 5.4.1.3.17). The formation's coverage is close to 100 %. It was found on a hillside with little inclination oriented to the north.

Photograph 5.4.1.3.17. Colorado River-El Alfalfal. Formation CA-4, sclerophyllous forest with sectors of scrubland with shrubs and *Echinopsis chilensis*.

CA-5: Dense, high and low, ligneous formation (LA4 LB3 d).
The formation's physiognomy is that of a sclerophyllous forest, where the evergreen trees alternate with summer evergreen and deciduous shrubs. The trees are between 10-12 m tall and the shrubs are not more than 1 m high and there is a low density, ephemeral herbaceous stratum. The predominant trees are *Quillaja saponaria* and *Kageneckia angustifolia* and the most frequent shrub is *Calceolaria hypericina*. The formation's coverage is up to 70% (Photograph 5.4.1.3.18). It is found on the hillsides oriented to the north at a somewhat higher elevation than the previous formation, on very stony soils that also have a sharp inclination. Among the species that are in a conservation category we have the *Kageneckia angustifolia*.

Photograph 5.4.1.3.18. Colorado River-El Alfalfal. Formation CA-5. *Quillaja saponaria* and *Kageneckia oblonga* sclerophyllous forest.

CA-6: High density, high and low ligneous formation with herbaceous and succulent plants (LA4 LB4 H4 S2 md).

The formation's physiognomy is that of a sclerophyllous forest, where the evergreen trees form a complex weft of shrubs, particularly on the most intervened sites. The trees are up to 15 m tall, especially the *Quillaja saponaria*; the co-predominant species, *Kageneckia oblonga* and *Acacia caven* have lower heights and branch out more. The formation has high coverage, trees reaching between 25 and 50%. Among the shrubs we find the *Muehlenbeckia hastulata* and *Colletia hystrix (*Photograph 5.4.1.3.19). The formation develops on hillsides oriented to the north. The presence of *Acacia caven* indicates the level of intervention. This species is more abundant in sectors with greater alteration. In sectors with surface rocks, the formation has succulents like *Echinopsis chilensis* and *Puya berteroniana*, which occupy sunny places. Among the species in a conservation category in the formation, we recorded *Puya berteroniana*.

Photograph 5.4.1.3.19. Colorado River-El Alfalfal. Formation CA-6. *Kageneckia angustifolia* and *Kageneckia oblonga* sclerophyllous forest.

CA-7: Clear, low ligneous formation with succulent plants (LB3 S2 c).
The formation's physiognomy is that of a scrubland of about 150 cm high with *Gymnophyton isatidicarpum* shrubs, which have quite a particular appearance as they lack leaves, alternating with succulent individuals like *Echinopsis chilensis* and *Puya berteroniana* (Photograph 5.4.1.3.20). The formation's coverage ranges between 20 and 30%. It is found on a hillside exposed to the north, with significant inclination and sectors with superficial rocks. Among the species in a conservation category in this formation, we recorded the *Puya berteroniana*.

Photograph 5.4.1.3.20. Colorado River-El Alfalfal. Formation CA-7. Scrubland with *Gymnophyton isatidicarpum* (Gi), Echinopsis chilensis (eC), and *Puya berteroniana (*pB) on rocky slopes.

CA-8: Crops area (ZC).
Corresponds to an area where *Medicago sativa* (alfalfa) is grown.

- ***El Trescientos Window Sector***.

In this sector, the vegetation does not show any intervention in accordance with the Project's new changes.

The area's formations are shown on Table 5.4.1.3.11, and their distribution in relation to the Project works are illustrated on Figure 5.4.3.1.24.

ZC – Annual crops located on a terrace area near the layout of route G-345.

CM – 1. Sclerophyllous forest with *Quillaja saponaria* and K*ageneckia angustifolia*, the canopy's coverage is between 75 and 100%. Among the species in a conservation category we found the *Kageneckia angustifolia*.

CM – 2. This formation develops in a sector of the hillside with steep inclination and the presence of erosion caused by irrigation channels. Its physiognomy is that of a very clear sclerophyllous scrubland with vegetation coverage of 10%. Among the dominant species we find *Quillaja saponaria* and *Kageneckia angustifolia*.

CM – 3. Scrubland with a predominant shrub stratum of about 150 cm high, where the dominant species are *Baccharis salicifolia* and *Baccharis pingraea*. There is 40% vegetation coverage and it develops in the waterway of the Colorado River in a very stony, low fluvial terrace sector.

CM - 4. Open sclerophyllous forest with a shrub stratum and seasonal, annual herb stratum. Vegetation coverage reaches 50%. The predominant species are *Quillaja saponaria* and *Kageneckia angustifolia*, and some succulent plants.

Estero Aucayes Sector

In this sector, units AU-1, AU-2, AU-3, AU-4, AU-5 and AU-6 do not show any intervention in accordance with the Project's new changes.

The area's formations are shown on Table 5.4.1.3.12., and their distribution is shown on Figures 5.4.1.3.25, 5.4.1.3.26, and 5.4.1.3.27

AU-1: Dense, herbaceous, low ligneous formation (LB5 H4 d).
It corresponds to a scrubland land formation of up to 70 cm high with shrubs and herbs forming a mosaic. The predominant species are *Guindilia trinervis*, *Colliguaja integerrima* and *Chuquiraga oppositifolia*, among shrubs, and *Poa gayana, Bromus berterianus* and *Acaena splendens* among herbs. Vegetation coverage is up to 70-80%. It is found on the hillsides exposed to the north at 200 m.a.s.l. in the muck piling sector (Window 2), with soil that is not too rocky. In an adjoining rocky sector a *Puya berteroniana* was observed.

AU-2: Low-density, herbaceous, low ligneous formation (LB4 H3, pd).
It corresponds to a scrubland-type formation of up to 40-60 cm high, with predominance of shrubs. The prevalent species are *Senecio glaber*, *Junellia scoparia* and *Mulinum spinosum*, among shrubs and *Madia sativa*, *Poa gayana* and *Bromus berterianus*, among herbs. Vegetation coverage is up to 50%. It is located on the hillsides with south orientation and some rocks. It was found at 2200 m.a.s.l. in the Windows 2 sector.

AU-3: High density, high and low ligneous formation with herbaceous plants. LA4 LB4 H4 md.
It corresponds to a forest-like formation with trees of up to 5 m tall, with predomination of *Escallonia myrtoidea*. The shrub stratum is 2-3 m high and the predominant species is *Buddleja globosa.* There is also a much lower herbaceous stratum which is formed predominantly by ciperaceae belonging to the genres *Scirpus*, *Carex* and *Eleocharis* and *Veronica anagallis-aquatica.* Vegetation coverage is 100%. It is found in ravines located at an elevation of about 2000 m.a.s.l.

AU-4: High density, herbaceous, low ligneous formation (high density LB5 H5).
It was found up to 2100 m.a.s.l. It corresponds to a scrubland-type formation of 70-120 cm high, with predominance of shrubs, the *Guindilia trinervia* reaching the greatest heights. The prevalent species are *Guindilia trinervis*, *Colliguaja integerrima* and *Tetraglochin alatum*, among shrubs, and *Madia sativa*, *Poa gayana* and *Bromus berterianus*, among herbs. Vegetation coverage is up to 90%. It is found on hillsides with little inclination or plains oriented to the south. In sites with greater inclination there is predominance of *T. alatum*.

AU-5: Low-density, herbaceous and low ligneous formation (LB4 H2 pd).
It corresponds to a 30-50 cm high, scrubland-type formation, with predominance of shrubs. The prevalent species are *Tetraglochin alatum*, *Nardophyllum lanatum*, *Chuquiraga oppositifolia*, and *Haplopappus velutinus*, among shrubs and *Poa gayana* and *Bromus berterianus*, among herbs. Vegetation coverage is up to 60%. It is found on hillsides exposed to the south. In the most disturbed sites the predominant species are *T. alatum* and *H. velutinus*, and in more stable sites, *N. lanatum*.

AU-6: High density, herbaceous, high and low ligneous formation (LA1 LB2 H7, md).
It corresponds to a wet dense prairie with gramineous and dicotyledonous plants. The herbaceous stratum predominates and the most abundant species are *Polypogon australis*, *Rumex crispus* and *Trifolium repens*. There is also a very discontinuous stratum of trees, especially *Baccharis pingraea*, and a stratum of isolated trees including isolated *Discaria chacaye and Schinus polygama* trees.

AU-7: High density, herbaceous, high and low, ligneous formation, with succulents (LA4 LB4 H3 S1 md).
The formation corresponds to an open forest forming a mosaic with shrubs. The tree stratum is dominated by *Kageneckia angustifolia* and reaches up to 9 m high. The shrub stratum is 60 cm. high and is dominated by *Colliguaja integerrima* and *Tetraglochin alatum*; there is also a herbaceous stratum and isolated individuals of succulents like *Echinopsis chilensis* and *Eriosyce curvispina*. The formation was found between 2050 and 1800 m.a.s.l., varying depending on the slope's exposure and the inclination. Among the formation's species in a conservation category are the *Kageneckia angustifolia* and *Eriosyce curvispina*.

AU-8: Dense high and low, ligneous formation, with herbaceous and succulent plants (LA4 LB3 H4 S1 d).
It corresponds to a more dense forest than that of the previous formation. The tree stratum is dominated by *Kageneckia angustifolia*, *Quillaja saponaria* and *Maytenus boaria*, in the wetter sectors, reaching a height of up to 15 m; the shrub stratum is 60 cm high and dominated by *Colliguaja integerrima* and *Proustia cuneifolia*; there is a herbaceous stratum with predominance of *Madia sativa* and *Conium maculatum*; and isolated individuals of succulents like *Echinopsis chilensis*. The formation was found between 1800 and 1550 m.a.s.l., varying depending on the hillside's exposure and inclination. Among the species in a conservation category, we have the *Kageneckia angustifolia*.

AU-9: Clear, high and low ligneous formation with succulent plants (LA 4 LB 1 S1, c).
It corresponds to a low, thorny forest with predominance of *Trevoa quinquinervia*, with trees 2-3 m tall, among which there is smaller density of older individuals of *Quillaja saponaria* and *Kageneckia angustifolia*. The formation's coverage is 40%. The formation grows in some sectors apparently after fires. It was found at between 1500 m and 1800 m.a.s.l., in different orientations and inclinations. Among the species in a conservation category is the *Kageneckia angustifolia*.

AU-10: Low-density, high and low ligneous formation with succulent plants (LA4 LB2 S1, pd).
It corresponds to a forest with a tree stratum 7-10 m high, with predomination of *Quillaja saponaria*, *Kageneckia oblonga* and *Lithrea caustica*, of which only the *Quillaja saponaria* more frequently shows a clearly tree form. In the shrub stratum we find *Gochnatia foliolosa* and *Baccharis rhomboidalis*; and there is a herbaceous stratum where in the summer *Vulpia myurus*, *Centaurea melitensis* and *Helenium aromaticum* predominate. The formation's vegetation coverage is 70% and it is found between 1600 m.a.s.l. up to the Colorado River Canyon, in the lower sector there is greater prevalence of *Quillaja saponaria.* Among the species in a conservation category we have *Kageneckia angustifolia*.

AU-11: Low-density, high and low, ligneous formation with succulents (LA3 LB3 H1 S1 d).
It corresponds to a sclerophyllous forest dominated by *Quillaja saponaria* and *Kageneckia oblonga*, in its tree stratum and by *Trevoa quinquinervia* and *Proustia cuneifolia*, in the shrub stratum (Photograph 5.4.1.3.21). In addition, it has a stratum of succulents including *Echinopsis chiloensis*, and *Puya berteroniana*.

The formation's coverage totals 50% and it is located on the spring that oriented to the southwest of the Aucayes Stream. The predominance of the tree species changes according to the hillside's exposure (south or southwest) and soil characteristics.

Photograph 5.4.1.3.21. Aucayes Sector, unit AU-11. Low-density, sclerophyllous forest with predominance of *Quillaja saponaria* and *Kageneckia oblonga*. The vegetation coverage and composition varies considerably depending on the hillside's exposure and soil characteristics.

AU-12: Very clear, low ligneous formation with tickets of *Quillaja saponaria* (LA2 LB3 H1 mc)
This formation is located in sectors bordering the Maitenes Plant Reservoir, which were removed to build the reservoir and were colonized principally by *Gymnophyton isatidicarpum, Trevoa quinquinervia* and *Tetraglochin alatum*. However, the formation has some isolated *Quillaja saponaria* individuals grouped in small thickets (Photograph 5.4.1.3.22). Vegetation coverage does not exceed 30%.

Photograph 5.4.1.3.22. Aucayes Sector, unit AU-12. Scrubland made up of *Trevoa quinquinervia* and *Gymnophyton*, and isolated *Quillaja saponaria*. The formation corresponds to a succession after the land to build the Maitenes Plant Reservoir was removed.

AU-13: Low-density, low ligneous formation with isolated trees (LA1 LB5 H2 pd).
The formation corresponds to scrubland that preferably develops on hillsides oriented to the north, with predominance of *Trevoa quinquinervia*, and the emergence of some isolated individuals of *Quillaja saponaria*, or *Kageneckia oblonga*. The formation's vegetation coverage does not exceed 60% (Photograph 5.4.1.3.23).

Photograph 5.4.1.3.23. Aucayes Sector, unit AU-13. Scrubland made up of *Trevoa quinquinervia* with *Quillaja saponaria* or isolated *Kageneckia oblonga*.

AU-14: Dense, high and low, ligneous formation with succulent plants (LA5 LB3 H2 S1 d).
This formation corresponds to a sclerophyllous forest dominated by *Quillaja saponaria*, *Kageneckia oblonga*, *Lithrea caustica* and *Kageneckia angustifoli* in the tree stratum; whereas in the shrub stratum there is predominance of *Schinus polygamus*, *Proustia cuneifolia*, and *Colletia hystrix*. It also has an herbaceous stratum with predominance of the introduced species *Vulpia myuros* and *Centaurea melitensis*, indicating a certain degree of

disturbance. Finally, the formation has a stratum of succulents, including *Puya berteroniana* and *Echinopsis chilensis*. The formation is located on a hillside exposed to the northwest, adjoining Route G-345 (main road to El Alfafal), and vegetation coverage is 90% (Photograph 5.4.1.3.24). Among the species in categories in this formation are the *Kageneckia angustifoli* and *Puya berteroniana*.

Photograph 5.4.1.3.24. Aucayes Sector, unit AU-14. The sclerophyllous forest seen from the edge of the road at kilometer 17. Heterogeneous formation with predominance of *Quillaja saponaria*, *Kageneckia oblonga*, *Lithrea caustic and Kageneckia angustifolia* (trees), *Schinus polygama*, *Proustia cuneifolia* and *Colletia hystrix* (shrubs), and *Puya berteroniana* and Echinopsis chilensis (succulent plants).

AU-15: Clear, low ligneous formation with succulent plants (LB2 H1 S3 c).
Formation located on a hillside exposed to the north, with steep inclination, adjoining Route G-345. The dominant species are *Proustia cuneifolia* and *Gymnophyton isatidicarpum* in the shrub stratum, and *Eschscholzia californica* and *Vulpia myuros* in the herbaceous stratum. The dominant stratum is that of succulents, where we can find *Echinopsis chiloensis* and *Puya berteroniana*, the latter classified in a conservation category. The formation's vegetation coverage does not exceed 30% because of the sharp inclination (Photograph 5.4.1.3.25).

Photograph 5.4.1.3.25. Aucayes Sector, unit AU-15. Scrubland made up of *Gymnophyton* and *Proustia cuneifolia* with *Puya berteroniana* and *Echinopsis chilensis*, on a hillside with sharp inclination.

AU-16: Low-density, low ligneous formation with herbaceous and succulent plants (LA2 LB4 H1 S1 pd).
The formation's physiognomy is that of a scrubland, where shrubs reach up to 1.5 m high, with vegetation coverage ranging between 25 and 50% (Photograph 5.4.1.3.26). Among the predominant shrubs we find *Guindilia trinervia*, *Colliguaja integerrima* and *Tetraglochin alatum*. In addition, the formation has a tree stratum grouped in small thickets with less than 10% coverage within the unit, with prevalence of *Kageneckia angustifolia*. The coverage of the herbaceous and succulent strata does not exceed 5% and are dominated by *Poa gayana* and *Eriosyce (Neoporteria) curvispina*.

This formation develops in the low area of the road leading to the reservoir, principally on slopes with northwest orientation.

The area shows extensive grazing, and among the species in a category of conservation are the *Kageneckia angustifolia*, classified as Vulnerable at a regional level, and *Eriosyce (Neoporteria) curvispina*, a species that grows on rock outcrops and is classified as Vulnerable nationwide.

Photograph 5.4.1.3.26: General view of unit AU-16. We can distinguish the *Kageneckia angustifolia* grouped in thickets within the unit.

AU-17: Clear, low ligneous formation with herbaceous and succulent plants (LA1 LB4 H1 S1 c).
The formation's physiognomy is that of a scrubland, where shrubs are up to 70 cm. high, with coverage ranging between 25 and 50% (Photograph 5.4.1.3.27). Among the predominant shrubs we find *Tetraglochin alatum* and *Gymnophyton isatidicarpum*. In addition the formation has a arborescent stratum that accounts for less than 5% of coverage and which is dominated by *Kageneckia angustifolia*. The herbaceous and succulent strata do not exceed 5% coverage and are dominated by *Acaena splendens* and *Eriosyce (Neoporteria) curvispina*.

This unit develops on steeper slopes, on the floor immediately above in elevation than the previous formation.

This formation also shows extensive grazing, and among the species in a conservation category we find *Kageneckia angustifolia*, regionally classified as Vulnerable, and *Eriosyce (Neoporteria) curvispina* classified as Vulnerable nationwide.

Photograph5.4.1.3.27: General view of la unit AU-17.

AU-18: Clear, low, ligneous formation with herbaceous plants (LB4 H1 c).
This formation corresponds to an Andean Scrubland up to 70 cm high, where shrubs and herbs form a mosaic (Photograph 5.4.1.3.28). The predominant species in the shrub stratum are *Tetraglochin alatum* and *Gymnophyton isatidicarpum*. The herbaceous stratum does not exceed 5% coverage and is dominated by *Poa gayana*. Vegetation coverage totals 50%.

The formation is found on a hillside with southeast orientation at 2300 m.a.s.l. Part of this unit would be affected by the compensation tank. No species classified in a conservation category were found in this sector.

Photograph 5.4.1.3.28: General view of the sector of the compensation tank. On the left we can see unit AU-19 and on the right unit AU-18.

AU-19: Low density, ligneous formation with herbaceous plants (LB5 H2 pd).6
It corresponds to an Andean Scrubland-type formation of up to 40 cm high, whose total coverage ranges between 50 and 70% (Photograph 5.4.1.3.28). The predominant species in the shrub stratum are *Tetraglochin alatum* and *Haplopappus velutinus*. The herbaceous stratum does not exceed 10% coverage and it is dominated by *Acaena splendens* and *Poa gayana*. In sectors with upwelling of water there are small zonal formations of *Discaria chacaye*.

The formation is found on a northwest exposure hillside. Part of this unit would be affected by the compensation tank and its access road. No species classified in a conservation category were found in this sector.

ii Yeso River Basin

The area's formations are shown on Table 5.4.1.3.13 and their distribution in relation to the Project works are illustrated on Figure 5.4.1.3.28.

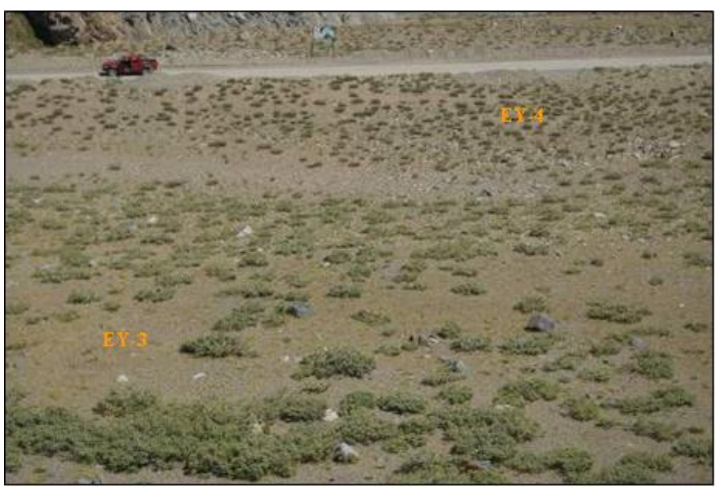
EY-1: High density, herbaceous formation (H7 md)
This is a wet prairie formed by perennial herbs. There is very high vegetation coverage (Photograph 5.4.1.3.29) with predomination of *Carex gayana, Juncus arcticus* and one Poa species apparently *P. pratensis*. The place shows intensive goat grazing.

Photograph 5.4.1.3.29. Yeso River (2420 m.a.s.l.). Formation EY-1. Wet prairie "hanging" on upwelling of water on the hillside. On the foreground we can see *Festuca kurtziana*.

EY-2: Low-density, ligneous formation with herbaceous plants (LB3 H4 pd).
It corresponds to a scrubland-type formation of up to 30 cm high with shrubs and herbs forming a mosaic. The predominant species are *Berberis empetrifolia* and *Chuquiraga oppositifolia* among shrubs, and *Poa gayana*, *Bromus tunicatus* among herbs (Photograph 5.4.1.3.30). With binoculars, we observed that vegetation coverage is up to 70%. Among threatened species we recorded the *Alstroemeria exerens*. The formation develops on the opposite side of the Yeso River and is adjacent to formation EE 2 in the El Encañado sector.

Photograph 5.4.1.3.30. Yeso River (2420 m.a.s.l.). Formation EY-2. High-Andean Low Scrubland on a very steep hillside.

EY-3: Clear, low ligneous formation with herbaceous plants (LB3 H3 c).
It corresponds to a scrubland-type formation up to 30 cm high with shrubs and herbs forming a mosaic. The dominant species are *Chuquiraga oppositifolia* among shrubs, and *Poa gayana* and *Stipa chrysophylla* among herbs (Photograph 5.4.1.3.31). Vegetation coverage is up to 40%. It is found on a steep slope with north orientation.



Photograph 5.4.1.3.31. Yeso River. High-Andean Scrubland formations with *Chuquiraga oppositifolia*, *Poa gayana* and *Stipa chrysophylla* (EY-3) as well as *Tetraglochin alatum* (EY-4).

EY-4: Clear, low ligneous formation with herbaceous plants (LB3 H3 c).
It corresponds to a scrubland-type formation of up to 30 cm high with shrubs and herbs forming a mosaic. The dominant species are *Chuquiraga oppositifolia*, *Tetraglochin alatum* and *Haplopappus anthylloides*, among shrubs and *Poa gayana* and *Stipa chrysophylla,* among herbs*.* Coverage vegetation is up to 40%. The formation grows in a sector with little inclination on the terraces adjoining the Yeso River, on both sides of the existing road. Among threatened species we recorded *Alstroemeria exerens* and *Laretia acaulis* (considered Out of Danger according to the third classification process approved by CONAMA's Advisory Board).

EY-5: High density, low ligneous formation with herbaceous plants (LB1 H7 md).
This formation corresponds to a prairie located under a hillside where a small watercourse emerges. Vegetation coverage is very high and it is made up mainly of herbaceous plants and a few shrub specimens. The predominant species are *Carex gayana, Eleocharis albibracteata* and *Juncus arcticus*; in some sectors there is prevalence of *Festuca kurtziana* (Photograph 5.4.1.3.32).

Photograph 5.4.1.3.32. Yeso River. Formation EY-5. Wet prairie with *Carex gayana* and *Eleocharis albibracteata*.

EY-6: Very clear, low ligneous formation with herbaceous plants (LA2 LB2 mc)
This formation corresponds to a very scarse scrubland with groups of *Cortaderia rudiuscula* growing in between. Some shrubs in the scrubland are up to 2 m high: *Discaria chacaye* and *Escallonia alpina*, and others like *Berberis empetrifolia* are lower. The formation is found on the banks of the Yeso River.

iii Lo Encañado Basin

In this sector, the mapping includes the results of the 2005 autumn campaign.

The area's formations are shown on Table 5.4.1.3.14 and their distribution in relation to the Project works is illustrated on Figure 5.4.1.3.29.

EE-1: High density, low ligneous formation with herbaceous plants (LB7 H7 md)
It corresponds to a scrubland-type formation up to 150 cm high. Among the herbs, there is predomination of *Ribes cucullatum*. As it is a wetland, we find hygrophilus plants like *Juncus arcticus* and *Polypogon australis* (Photograph 5.4.1.3.33). The formation grows on the banks of the river whose source is the Lo Encañado Lake.

Photograph 5.4.1.3.33. Lo Encañado. Manzanito Stream. Formation EE 1, scrubland with *Ribes cucullatum* and perennial herbaceous plants. On the background, on the hillside, we can see the High-Andean Low Scrubland (EE-2).

EE-2: Clear, low ligneous formation with herbaceous plants (LB3 H3 c).
It corresponds to a scrubland-type formation of up to 30 cm high where shrubs and herbs form a mosaic. The dominant species are *Berberis empetrifolia, Chuquiraga oppositifolia* and *Ephedra chilensis* among shrubs, and *Poa gayana* among herbs. Vegetation coverage is up to 40%. (Photograph 5.4.1.3.34)

Photograph 5.4.1.3.34. Lo Encañado: formation EE-2: High-Andean Low Scrubland.

EE-3: Low-density, low ligneous formation with herbaceous plants (LB4 H4 c)
It corresponds to a scrubland-type formation up to 30 cm high with shrubs and herbs forming a mosaic. The prevalent species are *Berberis empetrifolia*, *Ephedra chilensis* and *Chuquiraga oppositifolia,* among shrubs and *Poa gayana, Plantago grandiflora* and *Alstroemeria exerens* among herbs (Photograph5.4.1.3.35). Vegetation coverage is up to 60%. Among threatened species we recorded the *Alstroemeria exerens* and *Laretia acaulis* (considered Out of Danger in accordance with the third classification process approved by CONAMA's Advisory Board.

Photograph 5.4.1.3.35. Lo Encañado: formation EE-3: High-Andean Low Scrubland, a hillside sector with greater inclination and with herbaceous plants like *Plantago grandiflora* and *Alstroemeria exerens*.

EE-4: Dense, low ligneous formation, with herbaceous plants (LB5 H4, d)
This formation corresponds to a scrubland of shrubs up to 120 cm high with predominance of *Adesmia gracilis*, a thorny shrub and *Ephedra chilensis*. The herbs occupy the space in between the shrubs. Among herbs, there is predominance of *Plantago grandiflora* and *Acaena alpina*. Vegetation coverage is up to 90%. The formation is found in a depression.

EE-5: Clear, low ligneous formation, with herbaceous plants (LB2 H3 c)
The formation corresponds to a low scrubland. The prevalent species are *Laretia acaulis* and *Berberis empetrifolia*. The scrublands height does not exceed 30 cm. Among the shrubs there is a matrix of herbaceous plants with greater coverage with predominance of *Plantago grandiflora* and *Poa gayana*. Vegetation coverage in the formation is up to 50%. It is found on a hillside adjoining the depression with *Adesmia gracilis* (EE-4). It is worth noting that one of the predominant species, *Laretia acaulis* is considered **vulnerable** nationwide and considered Out of Danger according to the third classification approved by CONAMA's Advisory Board.

EE-6: High density, herbaceous formation (H7 d)
A high density prairie that grows on the ravine that feeds the Lo Encañado Lake, which constitutes the Project's principal flooding zone as it is the greatest depression in the area. The dominant species are the following perennial herbs: *Juncus arcticus*, *Eleocharis albibracteata* and *Acaena magellanica*. Vegetation coverage is up to 100%. (Photograph 5.4.1.3.36).

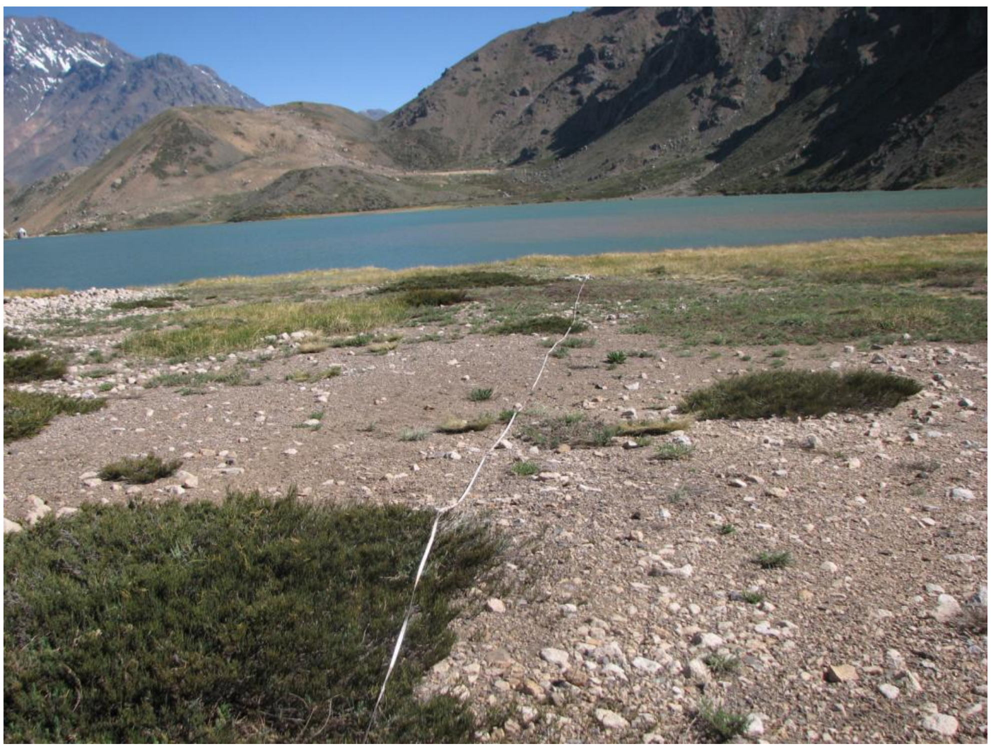
Photograph 5.4.1.3.36. Lo Encañado: formation EE-6: an extensive wet prairie in the area of the mouth of the Lo Encañado Ravine, which extends almost one kilometer along this ravine.

EE-7: High density, herbaceous formation with isolated shrubs (LB1 H6 md)
A wet prairie formation located on the south bank of the lake and on the base of a hillside exposed to the east on the edge of the large wet prairie (unit EE-6). The dominant species are *Juncus arcticus*, *Eleocharis albibracteata, Plantago lanceolata* and *Acaena magellanica*, which form the prairie which shows isolated groups of *Senecio eruciformis*. The vegetation coverage of this formation exceeds 90%. (Photograph 5.4.1.3.37)

Photograph 5.4.1.3.37. Lo Encañado: formation EE-7: small wet prairies on the south bank of the lake or on the edges of the wet prairie of the Lo Encañado Ravine.

EE-8: Dense, low ligneous and herbaceous formation (LB5 H3 d)
A low scrubland of the High Andean Steppe-type whose dominant species are the *Adesmia gracilis*, *Chuquiraga oppositifolia* and *Ephedra chilensis*, among the ligneous species. Among the herbaceous species, the *Poa holciformis* and *Acaena splendens* predominate. Vegetation coverage is up to 80%. The formation grows on the hillsides and on dry plains.

EE-9: Dense, low ligneous and herbaceous formation (LB4 H3 pd)
An Andean Scrubland formation, whose predominant species are *Ephedra chilensis* and *Berberis empetrifoli*. Total vegetation coverage is up to 40%. It grows on a drift of large rocks found near one of the banks of the lake (Photograph 5.4.1.3.38). On the high part of this unit, outside the area that will probably be flooded, two specimens of *Laretia acaulis* were found. This species is classified in a conservation category (considered Out of Danger by the third classification process approved by CONAMA's Advisory Board).



Photograph 5.4.1.3.38. Lo Encañado: formation EE-9: High-Andean Low Scrubland on a drift of stones that reaches the Lo Encañado Lake. We can see the presence of *Ephedra chilensis* and *Berberis empetrifolia*.

iv La Engorda Sector

The mapping in this sector includes the results of the 2005 autumn campaign.

The area's formations are shown on Table 5.4.1.3.15 and their distribution in relation to the Project works are illustrated on Figure 5.4.1.3.30

LE-1: Low-density, low ligneous and herbaceous formation (LB4 H3 pd)
This is a scrubland-type formation up to 30 cm high with shrubs and herbs forming a mosaic. The dominant species are *Chuquiraga oppositifolia* and *Haplopappus anthylloides*, among the shrubs and *Poa gayana*, *Stipa chrysophylla* and *Bromus tunicatu*s, among the herbs. Vegetation coverage is up to 80%. The formation was found on flat sites and on hillsides with little to moderate inclination on the bottom of the glacial valley without any evident waterway. (Photograph5.4.1.3.39)

Photograph 5.4.1.3.39. La Engorda, formation LE 1: High-Andean Low Scrubland, in the sector of the dump and camp. The predominant species are *Chuquiraga oppositifolia* and *Haplopappus anthylloides.*

LE-2: Clear, low ligneous and herbaceous formation (LB3 H2 c)
A scrubland-type formation up to 30 cm high with shrubs and herbs forming a mosaic. The dominant species are *Berberis empetrifolia*, *Ephedra chilensis* and *Chuquiraga oppositifolia* among the shrubs, and *Poa gayana*, and *Stipa chrysophylla* among the herbs. Vegetation coverage is up to 50%. The formation was found on the stony hillsides with greater inclination than the previous formation.

LE-3: Dense, low ligneous and herbaceous formation (LB5 H4 d)
This is a scrubland-like formation up to 30 cm high with shrubs and herbs forming a mosaic. The herb stratum is particularly dense in this community and it is formed by several herb species among which are the *Juncus arcticus*, a species that grows in very wet places. The dominant species are *Adesmia gracilis*, *Chuquiraga oppositifolia* and *Berberis empetrifolia* among the shrubs, and *Juncus arcticus*, *Poa gayana* and *Hordeum comosum* among the herbs (Photograph 5.4.1.3.40). Vegetation coverage is up to 90%. The high coverage of herbs and shrubs is apparently given by a relatively superficial aquifer. It corresponds to the area known as “vegas de La Engorda”, a sector whose vegetation is not exactly a prairie or wet prairie but rather, as it has been described, a dense scrubland with high coverage of herbs that grow on wet places (*Juncus arcticus*) and dry places (*Hordeum comosum* and *Poa gayana*).

In this unit we find more extended and defined wet prairies—although they are seasonal—on the low part of the unit, a place where the waterways of the Colina and La Engorda streams meet 2 or 3 m below the level of the terraces where the wet prairies are found; therefore, it is likely that they may have contributions and are maintained by the surface or subsurface runoffs that form the flood plain.

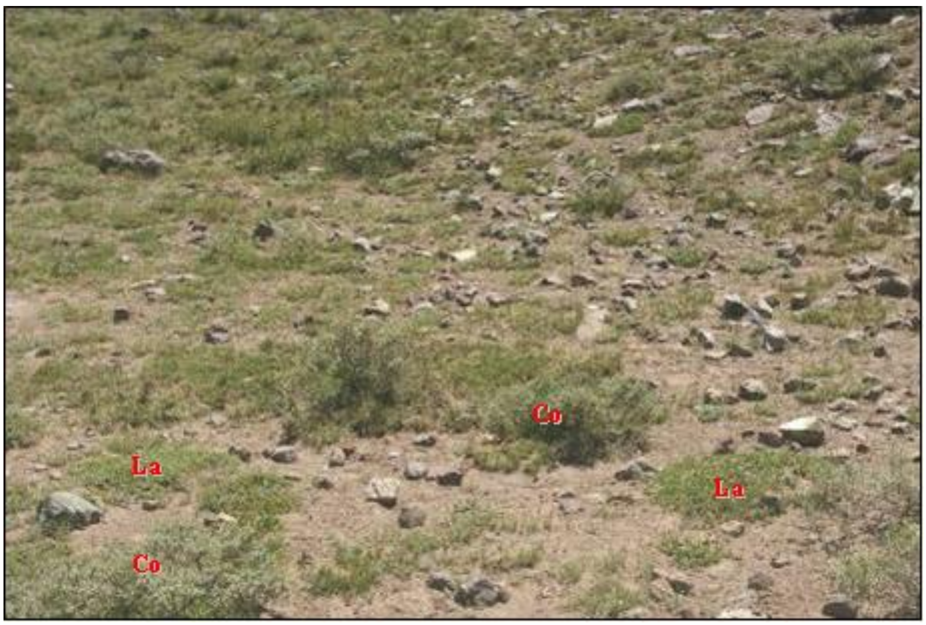
Photograph 5.4.1.3.40. La Engorda: formation LE-3. High-Andean Low Scrubland with *Chuquiraga oppositifolia* and *Berberis empetrifolia*. It corresponds to the sector known as "vegas" de La Engorda.

LE-4: High density, herbaceous formation (H7 md)
A wet prairie formed by perennial herbs with very high vegetation coverage. The predominant species are *Juncus arcticus*, *Agrostis leptotricha*, *Polypogon australis* and one species of *Deyeuxia*. It appears as a very narrow strip located on the margins of the small streams that run in the sector of the "vega de La Engorda". (Photograph 5.4.1.3.41).

Photograph 5.4.1.3.41. La Engorda, formation LE 4: a "vega" formation on the margins and some terraces of streams.

LE-5: Low-density, low ligneous with herbaceous formation (LB5 H2 pd)
This is a scrubland-type formation up to 30 cm high with shrubs and herbs forming a mosaic. The dominant species are *Chuquiraga oppositifolia* and *Ephedra chilensis*, among the shrubs, and *Poa gayana* and *Stipa chrysophylla* among the herbs. Vegetation coverage is up to 80%. It grows on the steep hillside adjoining “La Engorda”.

LE-6: Clear, low ligneous and herbaceous formation (LB4 H2 c)
It is a scrubland-type formation up to 30 cm high with shrubs and herbs forming a mosaic. The dominant species are *Chuquiraga oppositifolia*, *Ephedra chilensis, Haplopappus anthylloides* and *Laretia acaulis* among the shrubs, and *Poa gayana* and *Stipa chrysophylla* among the herbs (Photograph 5.4.1.3.42). Vegetation coverage is up to 50%. The formation is found on the hillsides with not too rocky soil, exposed to the south. Among the species classified in a conservation category we find the *Alstroemeria exerens and Laretia acaulis* (considered Out of Danger according to the classification process approved by CONAMA’s Advisory Board).



Photograph 5.4.3.1.42. La Engorda. Formation LE-6. High-Andean Low Scrubland with predominance of *Chuquiraga oppositifolia* (Co) and presence of *Laretia acaulis* (La).

v Las Lajas Discharge Sector

This sector is located on the banks of the Maipo River near the Las Lajas Bridge. The formation corresponds to a forest plantation between the Maipo River and route G-345. In this sector only one formation was recorded, which is shown on Figure 5.4.1.3.1 and on Table 5.4.1.3.16.

LL-1: Dense, high and low, ligneous formation with herbaceous plants (LA6 LB3 H2 d).
This formation corresponds to a forest plantation of Eucalyptus globulus, with remnants of sclerophyllous forest like *Cryptocarya alba* and *Lithrea caustica* among the trees, and *Muehlebeckia hastulata* and *Cestrum palqui* among the shrubs. There are also sectors on the river bank with riparian vegetation including *Cortaderia rudiuscula* and *Plantago lanceolata*. Among the species classified in a conservation category, we found several *Cryptocarya alba* individuals, a species regionally classified in the category of Vulnerable.

Table 5.4.1.3.1
Vascular Flora of the Project Area

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Zollnerallium andinum	Alliaceae		Perennial herb	Native	Not threatened
Alstroemeria angustifolia	Alstroemeriaceae	Liuto / Inca Lily	Perennial herb	Endemic	Not assessed
Alstroemeria exerens	Alstroemeriaceae	Liuto / Inca Lily	Perennial herb	Native	**Insufficiently known**
Rhodophiala rhodolirion	Amaryllidaceae		Perennial herb	Native	Not threatened
Lithrea caustica	Anacardiaceae	Litre / -	Tree	Endemic	Not threatened
Schinus polygama	Anacardiaceae	Huingán / -	Tree	Native	Not threatened
Cynanchum mucronatum	Asclepiadaceae		Shrub	Native	Not threatened
Cynanchum nummulariifolium	Asclepiadaceae		Shrub	Endemic	Not threatened
Berberis empetrifolia	Berberidaceae	Monte negro/Crown Barberry	Shrub	Native	Not threatened
Eccremocarpus scaber	Bignoniaceae	Chupa chupa / Glory Flower	Liana	Endemic	Not threatened
Cryptantha glomerulifera	Boraginaceae		Perennial herb	Native	Not assessed
Cryptantha sp.	Boraginaceae		Annual herb	Native	Not assessed
Cynoglossum creticum	Boraginaceae	Trupa / -	Perennial herb	Allochthonous	Without classification
Puya berteroniana	Bromeliaceae		Succulent	Endemic	**Vulnerable**
Echinopsis chilensis	Cactaceae		Succulent	Endemic	Not threatened
Eriosyce curvispina	Cactaceae	Quisquito / -	Succulent	Endemic	**Vulnerable**
Nastanthus spathulatus	Calyceraceae		Perennial herb	Native	Not assessed
Lobelia oligophylla	Campanulaceae		Perennial herb	Native	Not assessed
Cerastium arvense	Caryophyllaceae		Perennial herb	Allochthonous	Without classification
Cerastium glomeratum	Caryophyllaceae		Annual herb	Allochthonous	Without classification
Cerastium montioides	Caryophyllaceae		Perennial herb	Native	Not assessed
Silene andicola	Caryophyllaceae		Perennial herb	Native	Not assessed
Maytenus boaria	Celastraceae	Maitén / Mayten	Tree	Native	Not threatened
Chenopodium album	Chenopodiaceae	Quinguilla / White Goosefoot	Annual herb	Allochthonous	Without classification
Chenopodium ambrosioides	Chenopodiaceae	Paico / Wormseed	Annual herb	Native	Not assessed
Chenopodium vulvaria	Chenopodiaceae		Annual herb	Allochthonous	Without classification
Anthemis cotula	Compositae	Manzanillón / Chamomile	Annual herb	Allochthonous	Without classification
Baccharis linearis	Compositae	Romerillo / -	Shrub	Native	Not threatened
Baccharis pingraea	Compositae	Chilquilla / -	Shrub	Native	Not threatened

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Baccharis rhomboidalis	Compositae	Gaultro / -	Shrub	Endemic	Not threatened
Baccharis sagittalis	Compositae	Verbena tres esquinas / -	Shrub	Native	Not threatened
Baccharis salicifolia	Compositae	Chilca / Mule Fat	Shrub	Native	Not threatened
Carduus pycnocephalus	Compositae	Cardo / Italian Plumeless Thistle	Annual herb	Allochthonous	Without classification
Carthamus lanatus	Compositae	Cardo / Woolly Distaff Thistle	Annual herb	Allochthonous	Without classification
Centaurea calcitrapa	Compositae	Cizaña / Red Star-thistle	Annual herb	Allochthonous	Without classification
Centaurea melitensis	Compositae	Cizaña / Napa Thistle	Annual herb	Allochthonous	Without classification
Chaetanthera chilensis	Compositae		Perennial herb	Endemic	Not assessed
Chaetanthera euphrasioides	Compositae		Annual herb	Native	Not assessed
Chaetanthera moenchioides	Compositae		Annual herb	Endemic	Not assessed
Chaetanthera pusilla	Compositae		Annual herb	Native	Not assessed
Chuquiraga oppositifolia	Compositae	Yerba blanca / -	Shrub	Native	Not threatened
Cichorium intybus	Compositae	Achicoria / Chicory	Annual herb	Allochthonous	Without classification
Cirsium arvense	Compositae	Cardo negro / Creeping Thistle	Perennial herb	Allochthonous	Without classification
Conyza cf. gayana	Compositae		Perennial herb	Endemic	Not assessed
Crepis capillaris	Compositae		Annual herb	Allochthonous	Without classification
Erigeron andicola	Compositae		Perennial herb	Native	Not assessed
Filago gallica	Compositae		Annual herb	Allochthonous	Without classification
Gamochaeta americana	Compositae		Perennial herb	Native	Not assessed
Gamochaeta nivalis	Compositae		Perennial herb	Native	Not assessed
Gamochaeta sp.	Compositae		Perennial herb	Native	Not assessed
Gamochaeta stachydifolia	Compositae		Perennial herb	Native	Not assessed
Gnaphalium gayanum	Compositae	Vira vira / -	Perennial herb	Endemic	Not assessed
Gnaphalium philippi	Compositae	Vira vira / -	Annual herb	Endemic	Not assessed
Haplopappus anthylloides	Compositae		Shrub	Native	Not threatened
Haplopappus diplopappus	Compositae		Shrub	Native	Not threatened
Haplopappus schumanni	Compositae		Shrub	Endemic	Not threatened
Haplopappus velutinus	Compositae		Shrub	Native	Not threatened
Helenium aromaticum	Compositae	Póquil / -	Annual herb	Endemic	Not assessed

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Hypochaeris spp	Compositae		Perennial herb	Endemic	Not assessed
Lactuca serriola	Compositae		Annual herb	Allochthonous	Without classification
Leucheria congesta	Compositae		Perennial herb	Native	Not assessed
Leucheria rosea	Compositae		Perennial herb	Native	Not assessed
Leucheria viscida	Compositae	Blanquillo / -	Perennial herb	Endemic	Not assessed
Lucilia eriophora	Compositae		Perennial herb	Endemic	Not assessed
Madia chilensis	Compositae	Melosa / -	Annual herb	Native	Not assessed
Madia sativa	Compositae	Melosa / Coast Tarweed	Annual herb	Endemic	Not assessed
Matricaria discoidea	Compositae	Manzanilla / Disc Mayweed	Annual herb	Allochthonous	Without classification
Mutisia rosea	Compositae	Clavel del aire / -	Liana	Endemic	Not threatened
Mutisia sinuata	Compositae		Shrub	Native	Not threatened
Mutisia subulata fma. rosmarinifolia	Compositae		Shrub	Endemic	Not threatened
Nardophyllum lanatum	Compositae		Shrub	Native	Not threatened
Nassauvia aculeata	Compositae		Shrub	Native	Not threatened
Ophryosporus paradoxus	Compositae	Rabo de zorro / -	Shrub	Endemic	Not threatened
Perezia carthamoides	Compositae		Perennial herb	Native	Not assessed
Perezia nutans	Compositae		Perennial herb	Native	Not assessed
Phacelis retusa	Compositae		Annual herb	Native	Not assessed
Proustia cuneifolia	Compositae	Huañil / -	Shrub	Native	Not threatened
Senecio adenotrichius	Compositae	Yerba zonza / -	Shrub	Endemic	Not threatened
Senecio eruciformis	Compositae		Shrub	Endemic	Not threatened
Senecio fistulosus	Compositae		Shrub	Native	Not threatened
Senecio glaber	Compositae		Shrub	Native	Not threatened
Senecio microphyllus	Compositae		Shrub	Endemic	Not threatened
Senecio pentaphyllus	Compositae		Shrub	Endemic	Not threatened
Senecio polygaloides	Compositae		Shrub	Native	Not threatened
Senecio polygaloides	Compositae		Shrub	Native	Not threatened
Tanacetum parthenium	Compositae		Perennial herb	Allochthonous	Without classification
Taraxacum officinale	Compositae	Diente de león / Common Dandelion	Perennial herb	Allochthonous	Without classification
Tragopogon sp.	Compositae	Salsifí / -	Perennial herb	Allochthonous	Without classification

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Werneria pygmaea	Compositae		Perennial herb	Native	Not assessed
Convolvulus arvensis	Convolvulaceae	Correvuela / Field Bindweed	Perennial herb	Allochthonous	Without classification
Convolvulus demisssus	Convolvulaceae	Correvuela / -	Perennial herb	Native	Not assessed
Capsella bursa-pastoris	Cruciferae	Bolsa del pastor / Shepherd's Purse	Annual herb	Allochthonous	Without classification
Cardamine glacialis	Cruciferae		Perennial herb	Native	Not assessed
Cruciferae sp.	Cruciferae		Annual herb	Allochthonous	Without classification
Descurainia cumingii	Cruciferae		Annual herb	Native	Not assessed
Draba gilliesii	Cruciferae		Perennial herb	Native	Not assessed
Hirschfeldia incana	Cruciferae	Yuyo / Shortpod Mustard	Annual herb	Allochthonous	Without classification
Menonvillea purpurea	Cruciferae		Perennial herb	Endemic	Not assessed
Menonvillea scapigera	Cruciferae		Perennial herb	Native	Not assessed
Nasturtium officinale	Cruciferae	Berro / Watercress	Perennial herb	Allochthonous	Without classification
Sisymbrium orientale	Cruciferae	Mostacilla / Indian Hedgemustard	Annual herb	Allochthonous	Without classification
Carex andina	Cyperaceae		Perennial herb	Native	Not assessed
Carex gayana	Cyperaceae		Perennial herb	Native	Not assessed
Carex macloviana	Cyperaceae		Perennial herb	Native	Not assessed
Eleocharis albibracteata	Cyperaceae		Perennial herb	Native	Not assessed
Eleocharis macrostachya	Cyperaceae		Perennial herb	Native	Not assessed
Phylloscirpus acaulis	Cyperaceae		Perennial herb	Native	Not assessed
Aristotelia chilensis	Elaeocarpaceae	Maqui / Maquei	Tree	Native	Not threatened
Ephedra chilensis	Ephedraceae	Pingo pingo / -	Shrub	Native	Not threatened
Escallonia myrtoidea	Escalloniaceae	Lun / -	Tree	Native	Not threatened
Adesmia arachnipes	Fabaceae	Arvejilla / -	Perennial herb	Endemic	Not assessed
Adesmia confusa	Fabaceae	Espinillo / -	Shrub	Endemic	Not threatened
Adesmia papposa	Fabaceae	Arvejilla / -	Perennial herb	Native	Not assessed
Adesmia schneiderii	Fabaceae		Shrub	Endemic	Not threatened
Adesmia sp.	Fabaceae		Perennial herb	Native	Not assessed
Anarthrophyllum cumingii	Fabaceae		Shrub	Endemic	Not threatened
Astragalus cruckshanksii	Fabaceae	Yerba loca / -	Perennial herb	Native	Not assessed

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Medicago minima	Fabaceae		Annual herb	Allochthonous	Without classification
Medicago sativa	Fabaceae	Alfalfa / Lucerne	Perennial herb	Allochthonous	Without classification
Trifolium glomeratum	Fabaceae	Trébol enano/Clustered Clover	Annual herb	Allochthonous	Without classification
Trifolium repens	Fabaceae	Trébol blanco / White Clover	Perennial herb	Allochthonous	Without classification
Vicia andina	Fabaceae	Arvejilla / -	Perennial herb	Native	Not assessed
Azara petiolaris	Flacourtiaceae	Lilén / -	Tree	Endemic	Not threatened
Erodium cicutarium	Geraniaceae	Alfilerillo / Common Stork's-bill	Annual herb	Allochthonous	Without classification
Geranium core-core	Geraniaceae	Core core / Alderney Crane's-bill	Perennial herb	Native	Not assessed
Agrostis leptotricha	Gramineae	Pasto de vegas / -	Perennial herb	Native	Not assessed
Avena barbata	Gramineae	Teatina / Slender Oat	Annual herb	Allochthonous	Without classification
Bromus berterianus	Gramineae		Annual herb	Native	Not assessed
Bromus hordeaceus	Gramineae		Annual herb	Allochthonous	Without classification
Bromus scoparius	Gramineae		Annual herb	Allochthonous	Without classification
Bromus setifolius	Gramineae		Perennial herb	Native	Not assessed
Bromus tunicatus	Gramineae		Perennial herb	Native	Not assessed
Cortaderia rudiuscula	Gramineae	Cortadera / -	Perennial herb	Native	Not assessed
Deyeuxia sp.	Gramineae		Perennial herb	Native	Not assessed
Elymus angulatus	Gramineae		Perennial herb	Native	Not assessed
Festuca kurtziana	Gramineae		Perennial herb	Native	Not assessed
Hordeum comosum	Gramineae	Cebadilla / -	Perennial herb	Native	Not assessed
Hordeum murinum	Gramineae	Cebadilla / Mouse Barley	Annual herb	Allochthonous	Without classification
Lolium multiflorum	Gramineae	Ballica / Italian Ryegrass	Perennial herb	Allochthonous	Without classification
Lophochloa cristata	Gramineae		Annual herb	Allochthonous	Without classification
Melica violacea	Gramineae		Perennial herb	Endemic	Not assessed
Nasella chilensis	Gramineae	Coironcillo / -	Annual herb	Endemic	Not assessed
Piptochaetium stipoides	Gramineae		Perennial herb	Native	Not assessed
Poa denudata	Gramineae		Perennial herb	Native	Not assessed
Poa gayana	Gramineae	Coirón / -	Perennial herb	Native	Not assessed
Poa pratensis	Gramineae		Perennial herb	Allochthonous	Without classification
Poa secunda	Gramineae		Perennial herb	Native	Not assessed

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Polypogon australis	Gramineae	Cola de conejo / Chilean Rabbit's-foot Grass	Perennial herb	Native	Not assessed
Rytidosperma spp.	Gramineae		Perennial herb	Native	Not assessed
Scleropoa rigida	Gramineae		Annual herb	Allochthonous	Without classification
Stipa chrysophylla	Gramineae	Coirón Amarillo / -	Perennial herb	Native	Not assessed
Vulpia myurus	Gramineae	Pasto sedilla / Rat-Tailed Fescue	Annual herb	Allochthonous	Without classification
Ribes cucullatum	Grossulariaceae	Zarzaparrilla / -	Shrub	Native	Not assessed
Phacelia brachyantha	Hydrophyllaceae		Annual herb	Endemic	Not assessed
Phacelia cumingii	Hydrophyllaceae		Annual herb	Native	Not assessed
Phacelia secunda	Hydrophyllaceae	Cuncuna morada / -	Perennial herb	Native	Not assessed
Olsynium junceum	Iridaceae	Ñuño / -	Perennial herb	Native	Not threatened
Olsynium philippi	Iridaceae	Ñuño / -	Perennial herb	Endemic	Not threatened
Sisyrinchium adenostemum	Iridaceae	Huilmo / -	Perennial herb	Native	Not threatened
Solenomelus segethi	Iridaceae		Perennial herb	Native	Not threatened
Juncus arcticus	Juncaceae	Junco / Arctic Rush	Perennial herb	Native	Not assessed
Juncus bufonius	Juncaceae		Annual herb	Allochthonous	Without classification
Juncus estipulatus	Juncaceae		Perennial herb	Native	Not assessed
Luzula chilensis	Juncaceae		Perennial herb	Native	Not assessed
Lamium amplexicaule	Labiatae		Annual herb	Allochthonous	Without classification
Marrubium vulgare	Labiatae	Toronjil cuyano / Horehound	Perennial herb	Allochthonous	Without classification
Salvia verbenaca	Labiatae		Annual herb	Allochthonous	Without classification
Stachys grandidentata	Labiatae	Toronjilcillo / -	Perennial herb	Endemic	Not assessed
Stachys philippiana	Labiatae	Toronjilcillo / -	Perennial herb	Endemic	Not assessed
Wendtia gracilis	Ledocarpaceae		Shrub	Native	Not threatened
Cryptocarya alba	Lauraceae	Peumo / Red Cryptocarya	Tree	Endemic	**Vulnerable***
Linum bienne	Linaceae	Lino Silvestre / Pale Flax	Annual herb	Allochthonous	Without classification
Cajophora coronata	Loasaceae	Ortiga caballuna / -	Perennial herb	Native	Not assessed
Cajophora espigneira	Loasaceae	Ortiga caballuna / -	Perennial herb	Native	Not assessed
Loasa pallida	Loasaceae	Ortiga caballuna / -	Perennial herb	Endemic	Not assessed
Scyphantus elegans	Loasaceae	Monjita / -	Annual herb	Endemic	Not assessed
Malva nicaeensis	Malvaceae	Malva / Bull Mallow	Annual herb	Allochthonous	Without classification

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Modiola caroliniana	Malvaceae	Pila pila / Carolina Bristlemarrow	Perennial herb	Native	Not assessed
Acacia caven	Mimosaceae	Espino / Espino Caván	Tree	Native	Not threatened
Boerhavia discolor	Nyctaginaceae		Perennial herb	Native	Not assessed
Camisonia dentata	Onagraceae		Annual herb	Native	Not assessed
Epilobium glaucum	Onagraceae		Perennial herb	Native	Not assessed
Epilobium sp.	Onagraceae		Perennial herb	Native	Not assessed
Gayophytum humile	Onagraceae		Annual herb	Native	Not assessed
Gayophytum micranthum	Onagraceae		Annual herb	Native	Not assessed
Oenothera magellanica	Onagraceae	Don Diego de la noche / -	Perennial herb	Native	Not assessed
Oenothera rosea	Onagraceae		Perennial herb	Allochthonous	Without classification
Chloraea alpina	Orchidaceae		Perennial herb	Native	Not threatened
Chloraea bletioides	Orchidaceae	Lengua de loro / -	Perennial herb	Endemic	Not assessed
Oxalis laxa	Oxalidaceae	Culle / -	Annual herb	Native	Not assessed
Oxalis squamata	Oxalidaceae	Ojos del agua / -	Perennial herb	Native	Not assessed
Eschscholzia californica	Papaveraceae	Dedal de oro/California Poppy	Perennial herb	Allochthonous	Without classification
Plantago grandiflora	Plantaginaceae		Perennial herb	Native	Not assessed
Plantago lanceolata	Plantaginaceae	Siete venas/Ribwort Plantain	Perennial herb	Allochthonous	Without classification
Collomia biflora	Polemoniaceae		Annual herb	Native	Not assessed
Gilia crassiflora	Polemoniaceae		Annual herb	Native	Not assessed
Micrasteris gracilis	Polemoniaceae		Annual herb	Native	Not assessed
Muehlenbeckia hastulata	Polygonaceae	Quilo / Wirevine	Shrub	Native	Not threatened
Polygonum aviculare	Polygonaceae	Sanguinaria/Prostrate Knotweed	Annual herb	Allochthonous	Without classification
Rumex acetosella	Polygonaceae	Vinagrillo / Sheep Sorrel	Perennial herb	Allochthonous	Without classification
Calandrinia capitata	Portulacaceae		Annual herb	Endemic	Not assessed
Calandrinia cistiflora	Portulacaceae		Perennial herb	Native	Not assessed
Calandrinia cumingii	Portulacaceae		Annual herb	Native	Not assessed
Calandrinia grandiflora	Portulacaceae	Pata de guanaco / -	Perennial herb	Endemic	Not assessed
Calandrinia sericea	Portulacaceae	Hierba de la mistela / -	Perennial herb	Endemic	Not assessed
Calandrinia tricolor	Portulacaceae		Perennial herb	Native	Not assessed
Calandrinia umbellata	Portulacaceae		Perennial herb	Native	Not assessed

Species	Family	Common Name Spanish/English	Growth Form	Geographic Name	Conservation Category
Anagallis alternifolia	Primulaceae		Perennial herb	Native	Not assessed
Barneoudia chilensis	Ranunculaceae		Perennial herb	Native	Not assessed
Colletia hystrix	Rhamnaceae	Crucero/ -	Shrub	Native	Not threatened
Acaena alpina	Rosaceae	Clonqui / -	Perennial herb	Endemic	Not assessed
Acaena magellanica	Rosaceae	Trun / -	Perennial herb	Native	Not assessed
Acaena pinnatifida	Rosaceae	Cadilla / Argentinian Biddy-biddy	Perennial herb	Native	Not assessed
Acaena splendens	Rosaceae	Clonqui / -	Perennial herb	Native	Not assessed
Crataegus monogyna	Rosaceae	Peumo alemán / Hawthorn	Tree	Allochthonous	Without classification
Kageneckia angustifolia	Rosaceae	Franjel / -	Tree	Endemic	**Vulnerable***
Kageneckia oblonga	Rosaceae	Bollén / -	Tree	Endemic	Not threatened
Quillaja saponaria	Rosaceae	Quillay / Soapbark	Tree	Endemic	Not threatened
Rosa rubiginosa	Rosaceae	Rosa mosqueta / Seet-briar	Shrub	Allochthonous	Without classification
Rubus ulmifolius	Rosaceae	Zarzamora / Elmleaf Blackberry	Shrub	Allochthonous	Without classification
Tetraglochin alatum	Rosaceae	Horizonte / -	Shrub	Native	Not threatened
Galium eriocarpum	Rubiaceae		Shrub	Native	Not threatened
Galium suffruticosum	Rubiaceae		Shrub	Native	Not threatened
Quinchamalium chilense	Santalaceae	Quinchamalí / -	Perennial herb	Native	Not assessed
Quinchamalium parviflorum	Santalaceae		Annual herb	Endemic	Not assessed
Calceolaria arachnoidea	Scrophulariaceae	Capachito Rosado / -	Perennial herb	Endemic	Not assessed
Calceolaria corymbosa subesp. mimuloides	Scrophulariaceae	Capachito Amarillo / -	Perennial herb	Endemic	Not assessed
Calceolaria filicaulis subesp. luxurians	Scrophulariaceae	Capachito / -	Perennial herb	Native	Not assessed
Calceolaria hypericina	Scrophulariaceae	Capachito / -	Shrub	Endemic	Not threatened
Calceolaria polyfolia	Scrophulariaceae	Capachito / -	Shrub	Endemic	Not threatened
Melosperma andicola	Scrophulariaceae		Perennial herb	Native	Not assessed
Mimulus glabratus	Scrophulariaceae	Placa / Smooth Monkeyflower	Perennial herb	Native	Not assessed
Mimulus luteus	Scrophulariaceae	Placa, berro Amarillo / Monkey Musk	Perennial herb	Native	Not assessed
Verbascum thapsus	Scrophulariaceae	Hierba del paño / Great Mullein	Annual herb	Allochthonous	Without classification
Verbascum virgatum	Scrophulariaceae		Annual herb	Allochthonous	Without classification

Species	Family	Common Name Spanish/English	Growth Form	Geographic Name	Conservation Category
Veronica anagallis-aquatica	Scrophulariaceae		Perennial herb	Allochthonous	Without classification
Cestrum parqui	Solanaceae	Palqui / Green Cestrum	Shrub	Native	Not threatened
Lycium chilensis	Solanaceae	Coralillo / -	Shrub	Native	Not threatened
Nicotiana acuminata	Solanaceae		Annual herb	Native	Not assessed
Nicotiana corymbosa	Solanaceae		Annual herb	Native	Not assessed
Schizanthus sp.	Solanaceae		Perennial herb	Native	Not assessed
Tropaeolum polyphyllum	Tropaeolaceae		Perennial herb	Native	Not assessed
Anthriscus caucalis	Umbelliferae		Annual herb	Allochthonous	Without classification
Apium andinum	Umbelliferae		Perennial herb	Native	Not assessed
Bowlesia tropaeolifolia	Umbelliferae		Perennial herb	Native	Not assessed
Diposis bulbocastanea	Umbelliferae		Perennial herb	Endemic	Not assessed
Gymnophyton isatidicarpon	Umbelliferae	Bio bío / -	Shrub	Endemic	Not threatened
Hydrocotyle ranunculoides	Umbelliferae		Perennial herb	Native	Not assessed
Laretia acaulis	Umbelliferae	Llareta / -	Shrub	Native	**Vulnerable**
Mulinum spinosum	Umbelliferae	Neneo / -	Shrub	Native	Not threatened
Sanicula graveolens	Umbelliferae	Cilantro de cerro / Northern Sanicle	Perennial herb	Native	Not assessed
Torilis nodosa	Umbelliferae		Annual herb	Allochthonous	Without classification
Urtica sp.	Urticaceae	Ortiga caballuna / -	Perennial herb	Native	Not assessed
Valeriana sp.	Valerianaceae		Perennial herb	Native	Not assessed
Junellia spathulata	Verbenaceae		Shrub	Native	Not threatened
Phyla nodiflora	Verbenaceae		Perennial herb	Native	Not assessed
Viviania marifolia	Vivianiaceae	Te de burro / -	Shrub	Native	Not threatened

Table 5.4.1.3.2
Vascular Flora Sector Colorado River-El Alfalfal

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Crataegus monogyna	Rosaceae	Peumo alemán / Hawthorn	Tree	Allochthonous	Without classification
Rosa rubiginosa	Rosaceae	Rosa mosqueta / Seet-briar	Shrub	Allochthonous	Without classification
Rubus ulmifolius	Rosaceae	Zarzamora/Elmleaf Blackberry	Shrub	Allochthonous	Without classification
Anthemis cotula	Compositae	Manzanillón / Chamomile	Annual herb	Allochthonous	Without classification
Anthriscus caucalis	Umbelliferae		Annual herb	Allochthonous	Without classification
Avena barbata	Gramineae	Teatina / Slender Oat	Annual herb	Allochthonous	Without classification
Bromus hordeaceus	Gramineae		Annual herb	Allochthonous	Without classification
Carduus pycnocephalus	Compositae	Cardo/ Italian Plumeless Thistle	Annual herb	Allochthonous	Without classification
Carthamus lanatus	Compositae	Cardo/ Woolly Distaff Thistle	Annual herb	Allochthonous	Without classification
Centaurea calcitrapa	Compositae	Cizaña / Red Star-thistle	Annual herb	Allochthonous	Without classification
Centaurea melitensis	Compositae	Cizaña / Napa Thistle	Annual herb	Allochthonous	Without classification
Cerastium glomeratum	Caryophyllaceae		Annual herb	Allochthonous	Without classification
Chenopodium vulvaria	Chenopodiaceae		Annual herb	Allochthonous	Without classification
Crepis capillaris	Compositae		Annual herb	Allochthonous	Without classification
Erodium cicutarium	Geraniaceae	Alfilerillo / Common Stork's-bill	Annual herb	Allochthonous	Without classification
Filago gallica	Compositae		Annual herb	Allochthonous	Without classification
Hirschfeldia incana	Cruciferae	Yuyo / Shortpod Mustard	Annual herb	Allochthonous	Without classification
Hordeum murinum	Gramineae	Cebadilla / Mouse Barley	Annual herb	Allochthonous	Without classification
Lactuca serriola	Compositae		Annual herb	Allochthonous	Without classification
Linum bienne	Linaceae	Lino Silvestre / Pale Flax	Annual herb	Allochthonous	Without classification
Lophochloa cristata	Gramineae		Annual herb	Allochthonous	Without classification
Matricaria discoidea	Compositae	Manzanilla / Disc Mayweed	Annual herb	Allochthonous	Without classification
Polygonum aviculare	Polygonaceae	Sanguinaria / Prostrate Knotweed	Annual herb	Allochthonous	Without classification
Salvia verbenaca	Labiatae		Annual herb	Allochthonous	Without classification
Scleropoa rigida	Gramineae		Annual herb	Allochthonous	Without classification

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Sisymbrium orientale	Cruciferae	Mostacilla / Indian Hedgemustard	Annual herb	Allochthonous	Without classification
Torilis nodosa	Umbelliferae		Annual herb	Allochthonous	Without classification
Trifolium glomeratum	Fabaceae	Trébol enano/Clustered Clover	Annual herb	Allochthonous	Without classification
Verbascum thapsus	Scrophulariaceae	Hierba del paño / Great Mullein	Annual herb	Allochthonous	Without classification
Verbascum virgatum	Scrophulariaceae		Annual herb	Allochthonous	Without classification
Vulpia myurus	Gramineae	Pasto sedilla/Rat-Tailed Fescue	Annual herb	Allochthonous	Without classification
Cirsium arvense	Compositae	Cardo negro / Creeping Thistle	Perennial herb	Allochthonous	Without classification
Convolvulus arvensis	Convolvulaceae	Corrrevuela / -	Perennial herb	Allochthonous	Without classification
Cynoglossum creticum	Boraginaceae	Trupa / -	Perennial herb	Allochthonous	Without classification
Eschscholzia californica	Papaveraceae	Dedal de oro / California Poppy	Perennial herb	Allochthonous	Without classification
Lolium multiflorum	Gramineae	Ballica / Italian Ryegrass	Perennial herb	Allochthonous	Without classification
Marrubium vulgare	Labiatae	Toronjil cuyano / Horehound	Perennial herb	Allochthonous	Without classification
Medicago sativa	Fabaceae	Alfalfa / Lucern	Perennial herb	Allochthonous	Without classification
Nasturtium officinale	Cruciferae	Berro / Watercress	Perennial herb	Allochthonous	Without classification
Oenothera rosea	Onagraceae		Perennial herb	Allochthonous	Without classification
Plantago lanceolata	Plantaginaceae	Siete venas / Ribwort Plantain	Perennial herb	Allochthonous	Without classification
Taraxacum officinale	Compositae	Diente de león / Common Dandelion	Perennial herb	Allochthonous	Without classification
Trifolium repens	Fabaceae	Trébol blanco / White Clover	Perennial herb	Allochthonous	Without classification
Veronica anagallis-aquatica	Scrophulariaceae		Perennial herb	Allochthonous	Without classification
Azara petiolaris	Flacourtiaceae	Lilén / -	Tree	Endemic	Not threatened
Cryptocarya alba	Lauraceae	Peumo / Red Cryptocarya	Tree	Endemic	**Vulnerable ***
Kageneckia angustifolia	Rosaceae	Franjel / -	Tree	Endemic	**Vulnerable***
Kageneckia oblonga	Rosaceae	Bollén / -	Tree	Endemic	Not threatened
Lithrea caustica	Anacardiaceae	Lithrea caustica	Tree	Endemic	Not threatened
Porlieria chilensis	Zygophyllaceae	Guayacán / -	Tree	Endemic	**Vulnerable**

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Quillaja saponaria	Rosaceae	Quillay / Soapbark	Tree	Endemic	Not threatened
Trevoa quinquinervia	Rhamnaceae	Tralhuén / -	Tree	Endemic	Not threatened
Adesmia confusa	Fabaceae	Espinillo / -	Shrub	Endemic	Not threatened
Baccharis rhomboidalis	Compositae	Gaultro / -	Shrub	Endemic	Not threatened
Calceolaria polifolia	Scrophulariaceae	Capachito / -	Shrub	Endemic	Not threatened
Calceolaria thyrsiflora	Scrophulariaceae	Hierba dulce / -	Shrub	Endemic	Not threatened
Colliguaja odorifera	Euphorbiaceae	Colliguay / -	Shrub	Endemic	Not threatened
Gymnophyton isatidicarpon	Umbelliferae	Bio bío / -	Shrub	Endemic	Not threatened
Ophryosporus paradoxus	Compositae	Rabo de zorro / -	Shrub	Endemic	Not threatened
Podanthus mitique	Compositae	Mitiqui / -	Shrub	Endemic	Not threatened
Senecio adenotrichius	Compositae	Yerba zonza / -	Shrub	Endemic	Not threatened
Gochnatia foliolosa	Compositae	Mira-mira / -	Shrub	Endemic	Not threatened
Chaetanthera moenchioides	Compositae		Annual herb	Endemic	Not assessed
Clarkia tenella	Onagraceae	Huasita / -	Annual herb	Endemic	Not assessed
Gnaphalium philippi	Compositae	Vira vira / -	Annual herb	Endemic	Not assessed
Helenium aromaticum	Compositae	Póquil / -	Annual herb	Endemic	Not assessed
Madia sativa	Compositae	Melosa / Coast Tarweed	Annual herb	Endemic	Not assessed
Nasella chilensis	Gramineae	Coironcillo / -	Annual herb	Endemic	Not assessed
Phacelia brachyantha	Hydrophyllaceae		Annual herb	Endemic	Not assessed
Scyphantus elegans	Loasaceae	Monjita / -	Annual herb	Endemic	Not assessed
Alstroemeria angustifolia	Alstroemeriaceae	Liuto / Inca Lily	Perennial herb	Endemic	Not assessed
Calandrinia grandiflora	Portulacaceae	Pata de guanaco / -	Perennial herb	Endemic	Not assessed
Carex setifolia	Cyperaceae		Perennial herb	Endemic	Not assessed
Chloraea bletioides	Orchidaceae	Lengua de loro / -	Perennial herb	Endemic	Not assessed
Conyza cf. gayana	Compositae		Perennial herb	Endemic	Not assessed
Dioscorea humifusa	Dioscoreaceae	Jabón de monte / -	Perennial herb	Endemic	Not assessed
Hypochaeris spp	Compositae		Perennial herb	Endemic	Not assessed
Melica violacea	Gramineae		Perennial herb	Endemic	Not assessed
Stachys grandidentata	Labiatae	Toronjilcillo / -	Perennial herb	Endemic	Not assessed
Eccremocarpus scaber	Bignoniaceae	Chupa chupa / - Glory Flower	Liana	Endemic	Not threatened

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Mutisia rosea	Compositae	Clavel del aire / -	Liana	Endemic	Not threatened
Mutisia subulata	Compositae	Clavel del aire / -	Liana	Endemic	Not threatened
Echinopsis chilensis	Cactaceae		Succulent	Endemic	Not threatened
Eriosyce curvispina	Cactaceae	Quisquito / -	Succulent	Endemic	**Vulnerable**
Puya berteroniana	Bromeliaceae	Chagual / Blue Puya	Succulent	Endemic	**Vulnerable**
Acacia caven	Mimosaceae	Espino / Espino Caván	Tree	Native	Not threatened
Aristotelia chilensis	Elaeocarpaceae	Maqui / Maquei	Tree	Native	Not threatened
Escallonia myrtoidea	Escalloniaceae	Lun / -	Tree	Native	Not threatened
Maytenus boaria	Celastraceae	Maitén - Mayten	Tree	Native	Not threatened
Schinus polygama	Anacardiaceae	Huingán / -	Tree	Native	Not threatened
Baccharis linearis	Compositae	Romerillo / -	Shrub	Native	Not threatened
Baccharis pingraea	Compositae	Chilquilla / -	Shrub	Native	Not threatened
Baccharis salicifolia	Compositae	Chilca / Mule Fat	Shrub	Native	Not threatened
Calceolaria hypericina	Scrophulariaceae	Capachito / -	Shrub	Native	Not threatened
Cestrum parqui	Solanaceae	Palqui / Green Cestrum	Shrub	Native	Not threatened
Colletia hystrix	Rhamnaceae	Crucero / -	Shrub	Native	Not threatened
Galium spp.	Rubiaceae		Shrub	Native	Not threatened
Haplopappus velutinus	Compositae		Shrub	Native	Not threatened
Lycium chilensis	Solanaceae	Coralillo / -	Shrub	Native	Not threatened
Muehlenbeckia hastulata	Polygonaceae	Quilo / Wirevine	Shrub	Native	Not threatened
Proustia cuneifolia	Compositae	Huañil / -	Shrub	Native	Not threatened
Viviania marifolia	Vivianiaceae	Te de burro / -	Shrub	Native	Not threatened
Bromus berterianus	Gramineae	Tuca / Chilean Chess	Annual herb	Native	Not assessed
Calandrinia capitata	Portulacaceae		Annual herb	Native	Not assessed
Chenopodium ambrosioides	Chenopodiaceae	Paico / Wormseed	Annual herb	Native	Not assessed
Cryptantha sp.	Boraginaceae		Annual herb	Native	Not assessed
Madia chilensis	Compositae	Melosa / -	Annual herb	Native	Not assessed
Oxalis laxa	Oxalidaceae	Culle / -	Annual herb	Native	Not assessed
Phacelis retusa	Compositae		Annual herb	Native	Not assessed
Adesmia papposa	Fabaceae	Arvejilla / -	Perennial herb	Native	Not assessed
Boerhavia discolor	Nyctaginaceae		Perennial herb	Native	Not assessed

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Eleocharis macrostachya	Cyperaceae		Perennial herb	Native	Not assessed
Gamochaeta americana	Compositae		Perennial herb	Native	Not assessed
Gamochaeta stachydifolia	Compositae		Perennial herb	Native	Not assessed
Geranium core-core	Geraniaceae	Core core / Alderney Crane's-bill	Perennial herb	Native	Not assessed
Juncus stipulatus	Juncaceae		Perennial herb	Native	Not assessed
Mimulus glabratus	Scrophulariaceae	Placa / Smooth Monkeyflower	Perennial herb	Native	Not assessed
Modiola caroliniana	Malvaceae	Pila pila / Carolina Bristlemarrow	Perennial herb	Native	Not assessed
Oenothera magellanica	Onagraceae	Don Diego de la noche / -	Perennial herb	Native	Not assessed
Pasithea coerulea	Anthericaceae	Azulillo / -	Perennial herb	Native	Not threatened
Phacelia secunda	Hydrophyllaceae		Perennial herb	Native	Not assessed
Phyla nodiflora	Verbenaceae		Perennial herb	Native	Not assessed
Piptochaetium stipoides	Gramineae		Perennial herb	Native	Not assessed
Polypogon australis	Gramineae		Perennial herb	Native	Not assessed
Sysirinchium adenostemon	Iridaceae	Huilmo / -	Perennial herb	Native	Not assessed

Table 5.4.1.3.3
Vascular Flora Sector Colorado River- Aucayes

Species	Family	Common Name Spanish/English	Growth Form	Geographic Name	Conservation Category
Rosa rubiginosa	Rosaceae	Rosa mosqueta / Seet-briar	Shrub	Allochthonous	Without classification
Rubus ulmifolius	Rosaceae	Zarzamora / Elmleaf Blackberry	Shrub	Allochthonous	Without classification
Anthemis cotula	Compositae	Manzanillón / Chamomile	Annual herb	Allochthonous	Without classification
Carduus pycnocephalus	Compositae	Cardo/ Italian Plumeless Thistle	Annual herb	Allochthonous	Without classification
Carthamus lanatus	Compositae	Cardo/ Woolly Distaff Thistle	Annual herb	Allochthonous	Without classification
Centaurea melitensis	Compositae	Cizaña / Napa Thistle	Annual herb	Allochthonous	Without classification
Cichorium intybus	Compositae	Achicoria / Chicory	Annual herb	Allochthonous	Without classification
Hypochaeris glabra	Compositae	Hierba del chancho / Smooth Catsear	Annual herb	Allochthonous	Without classification
Lactuca serriola	Compositae		Annual herb	Allochthonous	Without classification
Matricaria discoidea	Compositae	Manzanilla / Disc Mayweed	Annual herb	Allochthonous	Without classification
Hirschfeldia incana	Cruciferae	Yuyo / Shortpod Mustard	Annual herb	Allochthonous	Without classification
Medicago minima	Fabaceae		Annual herb	Allochthonous	Without classification
Melilotus officinalis	Fabaceae	Trebillo / Ribbed Melilot	Annual herb	Allochthonous	Without classification
Trifolium glomeratum	Fabaceae	Trébol enano/Clustered Clover	Annual herb	Allochthonous	Without classification
Erodium cicutarium	Geraniaceae	Alfilerillo / Common Stork's-bill	Annual herb	Allochthonous	Without classification
Avena barbata	Gramineae	Teatina / Slender Oat	Annual herb	Allochthonous	Without classification
Bromus scoparius	Gramineae		Annual herb	Allochthonous	Without classification
Lophochloa cristata	Gramineae		Annual herb	Allochthonous	Without classification
Vulpia myurus	Gramineae	Pasto sedilla / Rat-Tailed Fescue	Annual herb	Allochthonous	Without classification
Verbascum thapsus	Scrophulariaceae	Hierba del paño / Great Mullein	Annual herb	Allochthonous	Without classification
Verbascum virgatum	Scrophulariaceae		Annual herb	Allochthonous	Without classification
Anthriscus caucalis	Umbelliferae		Annual herb	Allochthonous	Without classification
Conium maculatum	Umbelliferae	Cicuta / Poison Hemlock	Annual herb	Allochthonous	Without classification
Cynoglossum creticum	Boraginaceae	Trupa / -	Perennial herb	Allochthonous	Without classification
Cirsium arvense	Compositae	Cardo negro / Creeping Thistle	Perennial herb	Allochthonous	Without classification
Tanacetum parthenium	Compositae		Perennial herb	Allochthonous	Without classification
Taraxacum officinale	Compositae	Diente de león / Common Dandelion	Perennial herb	Allochthonous	Without classification
Convolvulus arvensis	Convolvulaceae	Correvuela / Field Bindweed	Perennial herb	Allochthonous	Without classification
Nasturtium officinale	Cruciferae	Berro / Watercress	Perennial herb	Allochthonous	Without classification
Medicago sativa	Fabaceae	Alfalfa / Lucerne	Perennial herb	Allochthonous	Without classification
Trifolium repens	Fabaceae	Trébol blanco / White Clover	Perennial herb	Allochthonous	Without classification
Poa pratensis	Gramineae		Perennial herb	Allochthonous	Without classification
Marrubium vulgare	Labiatae	Toronjil cuyano / Horehound	Perennial herb	Allochthonous	Without classification

Species	Family	Common Name Spanish/English	Growth Form	Geographic Name	Conservation Category
Lythrum hyssopifolium	Liythraceae		Perennial herb	Allochthonous	Without classification
Eschscholzia californica	Papaveraceae	Dedal de oro / California Poppy	Perennial herb	Allochthonous	Without classification
Plantago lanceolata	Plantaginaceae	Siete venas/Ribwort Plantain	Perennial herb	Allochthonous	Without classification
Rumex acetosella	Polygonaceae	Vinagrillo / Sheep Sorrel	Perennial herb	Allochthonous	Without classification
Rumex crispus	Polygonaceae	Romaza / Curled Dock	Perennial herb	Allochthonous	Without classification
Veronica anagallis-aquatica	Scrophulariaceae		Perennial herb	Allochthonous	Without classification
Lithrea caustica	Anacardiaceae	Litre / -	Tree	Endemic	Not threatened
Trevoa quinquinervia	Rhamnaceae	Tralhuén / -	Tree	Endemic	Not threatened
Kageneckia angustifolia	Rosaceae	Franjel / -	Tree	Endemic	**Vulnerable***
Kageneckia oblonga	Rosaceae	Bollén / -	Tree	Endemic	Not threatened
Quillaja saponaria	Rosaceae	Quillay / Soapbark	Tree	Endemic	Not threatened
Azara petiolaris	Salicaceae	Lilén / -	Tree	Endemic	Not threatened
Cynanchum nummulariifolium	Asclepiadaceae		Shrub	Endemic	Not threatened
Baccharis rhomboidalis	Compositae	Gaultro / -	Shrub	Endemic	Not threatened
Centaurea chilensis	Compositae	Flor del minero / -	Shrub	Endemic	Not threatened
Gochnatia foliolosa	Compositae	Mira-mira / -	Shrub	Endemic	Not threatened
Haplopappus multifolius	Compositae	Baylahuén / -	Shrub	Endemic	Not threatened
Haplopappus schumanni	Compositae		Shrub	Endemic	Not threatened
Mutisia acerosa	Compositae	Clavel del aire / -	Shrub	Endemic	Not threatened
Mutisia subulata fma. rosmarinifolia	Compositae		Shrub	Endemic	Not threatened
Senecio microphyllus	Compositae		Shrub	Endemic	Not threatened
Escallonia illinita	Escalloniaceae	Barraco / -	Shrub	Endemic	Not threatened
Colliguaja odorifera	Euphorbiaceae	Colliguay / -	Shrub	Endemic	Not threatened
Adesmia confusa	Fabaceae	Espinillo / -	Shrub	Endemic	Not threatened
Anarthrophyllum cumingii	Fabaceae		Shrub	Endemic	Not threatened
Pleurophora pungens	Lythraceae		Shrub	Endemic	Not assessed
Calceolaria hypericina	Scrophulariaceae	Capachito / -	Shrub	Endemic	Not threatened
Calceolaria thirsyflora	Scrophulariaceae	Capachito / -	Shrub	Endemic	Not threatened
Gymnophyton isatidicarpon	Umbelliferae	Bio bío / -	Shrub	Endemic	Not threatened
Chaetanthera moenchioides	Compositae		Annual herb	Endemic	Not assessed
Gnaphalium philippi	Compositae	Vira vira / -	Annual herb	Endemic	Not assessed
Helenium aromaticum	Compositae	Póquil / -	Annual herb	Endemic	Not assessed
Madia sativa	Compositae	Melosa / Coast Tarweed	Annual herb	Endemic	Not assessed
Nasella chilensis	Gramineae	Coironcillo	Annual herb	Endemic	Not assessed
Clarkia tenella	Onagraceae	Huasita	Annual herb	Endemic	Not assessed
Schizanthus pinnatus	Solanaceae		Annual herb	Endemic	Not assessed
Alstroemeria pallida	Alstroemeriaceae	Liuto	Perennial herb	Endemic	Not threatened

Species	Family	Common Name Spanish/English	Growth Form	Geographic Name	Conservation Category
Conyza cf. gayana	Compositae		Perennial herb	Endemic	Not assessed
Hypochaeris spp	Compositae		Perennial herb	Endemic	Not assessed
Leucheria floribunda	Compositae	Blanquillo / -	Perennial herb	Endemic	Not assessed
Adesmia arachnipes	Fabaceae	Arvejilla / -	Perennial herb	Endemic	Not assessed
Stachys grandidentata	Labiatae	Toronjilcillo / -	Perennial herb	Endemic	Not assessed
Loasa pallida	Loasaceae	Ortiga caballuna / -	Perennial herb	Endemic	Not assessed
Malesherbia linearis	Malesherbiaceae		Perennial herb	Endemic	Not assessed
Calandrinia grandiflora	Portulacaceae	Pata de guanaco / -	Perennial herb	Endemic	Not assessed
Calandrinia sericea	Portulacaceae	Hierba de la mistela / -	Perennial herb	Endemic	Not assessed
Calceolaria glandulosa	Scrophulariaceae	Capachito / -	Perennial herb	Endemic	Not assessed
Calceolaria petiolaris	Scrophulariaceae	Capachito / -	Perennial herb	Endemic	Not threatened
Calceolaria purpurea	Scrophulariaceae	Capachito Rosado / -	Perennial herb	Endemic	Not assessed
Viola sp.	Violaceae		Perennial herb	Endemic	Not assessed
Eccremocarpus scaber	Bignoniaceae	Chupa chupa / Glory Flower	Liana	Endemic	Not threatened
Mutisia ilicifolia	Compositae	Clavel del aire / -	Liana	Endemic	Not threatened

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Mutisia rosea	Compositae	Clavel del aire / -	Liana	Endemic	Not threatened
Mutisia subulata	Compositae		Liana	Endemic	Not threatened
Tristerix corymbosus	Loranthaceae	Quintral / -	Parasite	Endemic	Not threatened
Puya berteroniana	Bromeliaceae	Chagual / Blue Puya	Succulent	Endemic	**Vulnerable**
Echinopsis chilensis	Cactaceae	Quisco / -	Succulent	Endemic	Not threatened
Schinus montanus	Anacardiaceae	Litrecillo / -	Tree	Native	Not threatened
Schinus polygama	Anacardiaceae	Huingán / -	Tree	Native	Not threatened
Maytenus boaria	Celastraceae	Maitén - Mayten	Tree	Native	Not threatened
Escallonia myrtoidea	Escalloniaceae	Lun / -	Tree	Native	Not threatened
Acacia caven	Mimosaceae	Espino / Espino Caván	Tree	Native	Not threatened
Discaria chacaye	Rhamnaceae	Chacay / -	Tree	Native	Not threatened
Cynanchum mucronatum	Asclepiadaceae		Shrub	Native	Not threatened
Buddleja globosa	Buddlejaceae	Matico / - Orange-ball-tree	Shrub	Native	Not threatened
Baccharis linearis	Compositae	Romerillo / -	Shrub	Native	Not threatened
Baccharis pingraea	Compositae	Chilquilla / -	Shrub	Native	Not threatened
Baccharis sagittalis	Compositae	Verbena tres esquinas / -	Shrub	Native	Not threatened
Baccharis salicifolia	Compositae	Chilca / Mule Fat	Shrub	Native	Not threatened
Chuquiraga oppositifolia	Compositae	Yerba blanca / -	Shrub	Native	Not threatened
Haplopappus velutinus	Compositae	Buchu / -	Shrub	Native	Not threatened
Mutisia sinuata	Compositae	Clavel del aire / -	Shrub	Native	Not threatened
Nardophyllum lanatum	Compositae		Shrub	Native	Not threatened
Nassauvia aculeata	Compositae		Shrub	Native	Not threatened
Proustia cuneifolia	Compositae	Proustia cuneifolia / -	Shrub	Native	Not threatened
Senecio glaber	Compositae		Shrub	Native	Not threatened
Haplopappus uncinatus	Compositae	Buchu / -	Shrub	Native	Not threatened
Ephedra chilensis	Ephedraceae	Pingo pingo / -	Shrub	Native	Not threatened
Escallonia alpina	Escalloniaceae		Shrub	Native	Not threatened
Colliguaja integerrima	Euphorbiaceae	Colliguay / -	Shrub	Native	Not threatened
Adesmia gracilis	Fabaceae		Shrub	Native	Not threatened
Ribes polyanthes	Grossulariaceae	Zarzaparrilla / -	Shrub	Native	Not threatened
Muehlenbeckia hastulata	Polygonaceae	Quilo / Wirevine	Shrub	Native	Not threatened
Colletia hystrix	Rhamnaceae	Crucero / -	Shrub	Native	Not threatened
Tetraglochin alatum	Rosaceae	Horizonte / -	Shrub	Native	Not threatened
Galium suffruticosum	Rubiaceae		Shrub	Native	Not threatened
Guindilia trinervis	Sapindaceae	Guindillo / -	Shrub	Native	Not threatened
Cestrum parqui	Solanaceae	Palqui / Green Cestrum	Shrub	Native	Not threatened
Solanum ligustrinum	Solanaceae	Tomatillo / -	Shrub	Native	Not threatened

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Mulinum spinosum	Umbelliferae	Neneo / -	Shrub	Native	Not threatened
Valeriana stricta	Valerianaceae		Shrub	Native	Not threatened
Junellia scoparia	Verbenaceae		Shrub	Native	Not threatened
Viviania marifolia	Vivianiaceae	Te de burro / -	Shrub	Native	Not threatened
Chaetanthera euphrasioides	Compositae		Annual herb	Native	Not assessed
Madia chilensis	Compositae	Melosa / -	Annual herb	Native	Not assessed
Phacelis retusa	Compositae		Annual herb	Native	Not assessed
Descurainia cumingii	Cruciferae		Annual herb	Native	Not assessed
Astragalus pehuenches	Fabaceae		Annual herb	Native	Not assessed
Lupinus microcarpus	Fabaceae		Annual herb	Native	Not assessed
Bromus berterianus	Gramineae		Annual herb	Native	Not assessed
Collomia biflora	Polemoniaceae		Annual herb	Native	Not assessed
Schizanthus hookerii	Solanaceae		Annual herb	Native	Not assessed
Adiantum scabrum	Adiantaceae	Culantrillo / -	Perennial herb	Native	Not threatened
Argylia ascendens	Bignoniaceae		Perennial herb	Native	Not assessed
Gamochaeta stachydifolia	Compositae		Perennial herb	Native	Not assessed
Solidago chilensis	Compositae	Fulel-fulel / -	Perennial herb	Native	Not assessed
Convolvulus demisssus	Convolvulaceae	Correvuela / -	Perennial herb	Native	Not assessed
Carex gayana	Cyperaceae		Perennial herb	Native	Not assessed
Eleocharis albibracteata	Cyperaceae		Perennial herb	Native	Not assessed
Eleocharis macrostachya	Cyperaceae		Perennial herb	Native	Not assessed
Equisetum bogotense	Equisetaceae	Hierba del platero / Horsetail	Perennial herb	Native	Not threatened
Adesmia papposa	Fabaceae	Arvejilla / -	Perennial herb	Native	Not assessed
Geranium core-core	Geraniaceae	Core core / Alderney Crane's-bill	Perennial herb	Native	Not assessed
Cortaderia rudiuscula	Gramineae	Cortadera / -	Perennial herb	Native	Not assessed
Piptochaetium stipoides	Gramineae		Perennial herb	Native	Not assessed
Poa gayana	Gramineae	Coirón / -	Perennial herb	Native	Not assessed
Polypogon australis	Gramineae	Cola de conejo / Chilean Rabbit's-foot Grass	Perennial herb	Native	Not assessed
Rytidosperma spp.	Gramineae		Perennial herb	Native	Not assessed
Phacelia secunda	Hydrophyllaceae	Cuncuna morada / -	Perennial herb	Native	Not assessed
Olsynium junceum	Iridaceae	Ñuño / -	Perennial herb	Native	Not threatened
Sisyrinchium adenostemum	Iridaceae	Huilmo / -	Perennial herb	Native	Not threatened
Solenomelus segethi	Iridaceae		Perennial herb	Native	Not threatened
Juncus arcticus	Juncaceae	Junco / Arctic Rush	Perennial herb	Native	Not assessed
Epilobium sp.	Onagraceae		Perennial herb	Native	Not assessed

Ludwigia peploides	Onagraceae	Duraznillo de agua / Floating Primrose-willow	Perennial herb	Native	Not assessed
Oxalis lineata	Oxalidaceae	Vinagrillo / Sheep Sorrel	Perennial herb	Native	Not assessed
Oxalis squamata	Oxalidaceae	Ojos del agua / -	Perennial herb	Native	Not assessed
Anagallis alternifolia	Primulaceae		Perennial herb	Native	Not assessed
Acaena pinnatifida	Rosaceae	Clonqui / -	Perennial herb	Native	Not assessed
Acaena splendens	Rosaceae	Cadillo / -	Perennial herb	Native	Not assessed
Acaena pinnatifida	Rosaceae	Cadilla / Argentinian Biddy-biddy	Perennial herb	Native	Not assessed
Acaena splendens	Rosaceae	Clonqui / -	Perennial herb	Native	Not assessed
Cruckchanksia hymenodon	Rubiaceae		Perennial herb	Native	Not assessed
Quinchamalium chilense	Santalaceae	Quinchamalí / -	Perennial herb	Native	Not assessed
Mimulus glabratus	Scrophulariaceae	Placa / Smooth Monkeyflower	Perennial herb	Native	Not assessed
Mimulus luteus	Scrophulariaceae	Placa, berro Amarillo / Monkey Musk	Perennial herb	Native	Not assessed
Stemodia durantifolia	Scrophulariaceae		Perennial herb	Native	Not assessed
Hydrocotyle ranunculoides	Umbelliferae		Perennial herb	Native	Not assessed
Sanicula graveolens	Umbelliferae	Cilantro del cerro / Northern Sanicle	Perennial herb	Native	Not assessed
Urtica sp.	Urticaceae	Ortiga caballuna	Perennial herb	Native	Not assessed
Phyla nodiflora	Verbenaceae		Perennial herb	Native	Not assessed
Cuscuta microstyla	Convolvulaceae	Cabello de ángel	Parásita	Native	Not assessed

Table 5.4.1.3.4
Vascular Flora - Lo Encañado Lake Sector

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Zollnerallium andinum	Alliaceae		Perennial herb	Native	Not threatened
Alstroemeria exerens	Alstroemeriaceae	Liuto / Inca Lily	Perennial herb	Native	**Insufficiently known**
Rhodophiala rhodolirion	Amaryllidaceae		Perennial herb	Native	Not threatened
Cynanchum nummulariifolium	Asclepiadaceae		Shrub	Endemic	Not threatened
Berberis empetrifolia	Berberidaceae	Monte negro / Crown Barberry	Shrub	Native	Not threatened
Cryptantha glomerulifera	Boraginaceae		Perennial herb	Native	Not assessed
Chaetanthera chilensis	Compositae		Perennial herb	Endemic	Not assessed
Chuquiraga opositifolia	Compositae	Hierba blanca / -	Shrub	Native	Not threatened
Cichorium intybus	Compositae	Achicoria / Chicory	Annual herb	Allochthonous	Without classification
Cirsium arvense	Compositae	Cardo negro / Creeping Thistle	Perennial herb	Allochthonous	Without classification
Gnaphalium gayanum	Compositae		Perennial herb	Endemic	Not assessed
Haplopappus anthylloides	Compositae		Shrub	Native	Not threatened
Haplopappus diplopappus	Compositae		Shrub	Native	Not threatened
Leucheria viscida	Compositae	Blanquillo / -	Perennial herb	Endemic	Not assessed
Mutisia sinuata	Compositae		Shrub	Native	Not threatened
Mutisia subulata fma. *rosmarinifolia*	Compositae		Shrub	Endemic	Not threatened
Perezia carthamoides	Compositae		Perennial herb	Native	Not assessed
Senecio eruciformis	Compositae		Shrub	Endemic	Not threatened
Senecio fistulosus	Compositae		Shrub	Native	Not threatened
Senecio glaber	Compositae		Shrub	Native	Not threatened
Senecio pentaphyllus	Compositae		Shrub	Endemic	Not threatened
Senecio polygaloides	Compositae		Shrub	Native	Not threatened
Tragopogon sp.	Compositae	Salsifí / -	Perennial herb	Allochthonous	Without classification
Descurainia cumingii	Cruciferae		Annual herb	Native	Not assessed
Menonvillea purpurea	Cruciferae		Perennial herb	Endemic	Not assessed
Carex gayana	Cyperaceae		Perennial herb	Native	Not assessed
Carex macloviana	Cyperaceae		Perennial herb	Native	Not assessed
Ephedra chilensis	Ephedraceae	Pingo-pingo / -	Shrub	Native	Not threatened
Adesmia arachnipes	Fabaceae	Arvejilla / -	Perennial herb	Endemic	Not assessed
Adesmia gracilis	Fabaceae	Varilla / -	Shrub	Native	Not threatened
Adesmia schneiderii	Fabaceae		Shrub	Native	Not threatened
Anarthrophyllum cumingii	Fabaceae		Shrub	Endemic	Not threatened
Astragalus cruckshanksii	Fabaceae	Hierba loca / -	Perennial herb	Native	Not assessed

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Medicago sativa	Fabaceae	Alfalfa	Perennial herb	Allochthonous	Without classification
Trifolium repens	Fabaceae	Trébol blanco / White Clover	Perennial herb	Allochthonous	Without classification
Vicia andina	Fabaceae	Arvejilla / -	Perennial herb	Native	Not assessed
Agrostis leptotricha	Gramineae	Pasto de vegas	Perennial herb	Native	Not assessed
Bromus tunicatus	Gramineae	Pasto del perro	Perennial herb	Native	Not assessed
Elymus angulatus	Gramineae		Perennial herb	Native	Not assessed
Hordeum comosum	Gramineae	Cebadilla	Perennial herb	Native	Not assessed
Poa gayana	Gramineae	Coirón / -	Perennial herb	Native	Not assessed
Poa secunda	Gramineae		Perennial herb	Native	Not assessed
Polypogon australis	Gramineae	Cola de conejo / Chilean Rabbit's-foot Grass	Perennial herb	Native	Not assessed
Stipa chrysophylla	Gramineae	Coirón Amarillo / -	Perennial herb	Native	Not assessed
Ribes cucullatum	Grossulariaceae	Zarzaparrilla / -	Shrub	Native	Not assessed
Phacelia secunda	Hydrophyllaceae	Cuncuna morada / -	Perennial herb	Native	Not assessed
Olsynium philippi	Iridaceae	Ñuño / -	Perennial herb	Endemic	Not threatened
Sisyrinchium adenostemon	Iridaceae	Huilmo / -	Perennial herb	Native	Not threatened
Juncus arcticus	Juncaceae	Junco / Arctic Rush	Perennial herb	Native	Not assessed
Stachys grandidentata	Labiatae	Toronjilcillo / -	Perennial herb	Endemic	Not assessed
Cajophora coronata	Loasaceae	Ortiga caballuna / -	Perennial herb	Native	Not assessed
Cajophora espigneira	Loasaceae	Ortiga caballuna / -	Perennial herb	Native	Not assessed
Epilobium glaucum	Onagraceae		Perennial herb	Native	Not assessed
Chloraea alpína	Orchidaceae	Orquídea	Perennial herb	Native	Not threatened
Oxalis squamata	Oxalidaceae	Ojos del agua / -	Perennial herb	Native	Not assessed
Plantago grandiflora	Plantaginaceae		Perennial herb	Native	Not assessed
Plantago lanceolata	Plantaginaceae	Siete venas/Ribwort Plantain	Perennial herb	Allochthonous	Without classification
Muehlenbeckia hastulata	Polygonaceae	Quilo / Wirevine	Shrub	Native	Not threatened
Rumex acetosella	Polygonaceae	Acederilla	Perennial herb	Allochthonous	Without classification

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Calandrinia sericea	Portulacaceae	Hierba de la mistela / -	Perennial herb	Endemic	Not assessed
Calandrinia umbellata	Portulacaceae	Hierba de la mistela / -	Perennial herb	Native	Not assessed
Acaena alpina	Rosaceae	Clonqui / -	Perennial herb	Endemic	Not assessed
Acaena magellanica	Rosaceae	Trun / -	Perennial herb	Native	Not assessed
Acaena pinnatifida	Rosaceae	Cadilla / Argentinian Biddy-biddy	Perennial herb	Native	Not assessed
Acaena splendens	Rosaceae	Clonqui / -	Perennial herb	Native	Not assessed
Tetraglochin alatum	Rosaceae	Horizonte / -	Shrub	Native	Not threatened
Galium suffruticosum	Rubiaceae		Shrub	Native	Not threatened
Quinchamalium chilensis	Santalaceae	Quinchamalí / -	Perennial herb	Native	Not assessed
Calceolaria arachnoidea	Scrophulariaceae	Capachito morado / -	Perennial herb	Endemic	Not assessed
Calceolaria corymbosa subesp. *mimuloides*	Scrophulariaceae	Capachito amarillo / -	Perennial herb	Endemic	Not assessed
Calceolaria filicaulis subesp. *luxurians*	Scrophulariaceae	Capachito amarillo / -	Perennial herb	Native	Not assessed
Melosperma andicola	Scrophulariaceae		Perennial herb	Native	Not assessed
Mimulus luteus	Scrophulariaceae	Placa, berro Amarillo / Monkey Musk	Perennial herb	Native	Not assessed
Veronica anagallis-aquatica	Scrophulariaceae		Perennial herb	Allochthonous	Without classification
Schizanthus grahami	Solanaceae		Perennial herb	Native	Not assessed
Tropaeolum polyphyllum	Tropaeolaceae		Perennial herb	Native	Not assessed
Laretia acaulis	Umbelliferae	Llareta de Santiago / -	Shrub	Native	**Vulnerable**
Sanicula graveolens	Umbelliferae	Cilantro del cerro / Northern Sanicle	Perennial herb	Native	Not assessed

Table 5.4.1.3.5
Vascular Flora - Yeso River Valley Sector

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Zollnerallium andinum	Alliaceae		Perennial herb	Native	Not threatened
Alstroemeria exerens	Alstroemeriaceae	Liuto / Inca Lily	Perennial herb	Native	**Insufficiently known**
Rhodophiala rhodolirion	Amaryllidaceae		Perennial herb	Native	Not threatened
Berberis empetrifolia	Berberidaceae	Monte negro/Crown Barberry	Shrub	Native	Not threatened
Lobelia oligophylla	Campanulaceae		Perennial herb	Native	Not assessed
Cerastium arvense	Caryophyllaceae		Perennial herb	Allochthonous	Without classification
Cerastium montioides	Caryophyllaceae		Perennial herb	Native	Not assessed
Chenopodium album	Chenopodiaceae	Quinguilla / White Goosefoot	Annual herb	Allochthonous	Without classification
Baccharis pingraea	Compositae	Chilquilla / -	Shrub	Native	Not threatened
Baccharis sagittalis	Compositae	Verbena tres esquinas / -	Shrub	Native	Not threatened
Chaetanthera euphrasioides	Compositae		Annual herb	Native	Not assessed
Chaetanthera pusilla	Compositae		Annual herb	Native	Not assessed
Chuquiraga oppositifolia	Compositae	Yerba blanca / -	Shrub	Native	Not threatened
Gamochaeta sp.	Compositae		Perennial herb	Native	Not assessed
Gnaphalium gayanum	Compositae		Perennial herb	Endemic	Not assessed
Haplopappus anthylloides	Compositae		Shrub	Native	Not threatened
Haplopappus schumannii	Compositae		Shrub	Endemic	Not threatened
Nardophyllum lanatum	Compositae		Shrub	Native	Not threatened
Nassauvia aculeata	Compositae		Shrub	Native	Not threatened
Perezia carthamoides	Compositae		Perennial herb	Native	Not assessed
Senecio microphyllus	Compositae		Shrub	Endemic	Not threatened
Senecio pentaphyllus	Compositae		Shrub	Endemic	Not threatened
Senecio polygaloides	Compositae		Shrub	Native	Not threatened
Tanacetum parthenium	Compositae		Perennial herb	Allochthonous	Without classification
Taraxacum officinale	Compositae	Diente de león / Common Dandelion	Perennial herb	Allochthonous	Without classification
Werneria pygmaea	Compositae		Perennial herb	Native	Not assessed
Convolvulus arvensis	Convolvulaceae	Correvuela / Field Bindweed	Perennial herb	Allochthonous	Without classification
Convolvulus demissus	Convolvulaceae		Perennial herb	Native	Not assessed
Capsella bursa-pastoris	Cruciferae	Bolsa del pastor / Shepherd's Purse	Annual herb	Allochthonous	Without classification
Cardamine glacialis	Cruciferae		Perennial herb	Native	Not assessed
Cruciferae sp.	Cruciferae		Annual herb	Allochthonous	Without classification
Descurainia cumingiana	Cruciferae		Annual herb	Native	Not assessed

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Carex gayana	Cyperaceae		Perennial herb	Native	Not assessed
Eleocharis albibracteata	Cyperaceae		Perennial herb	Native	Not assessed
Phylloscirpus acaulis	Cyperaceae		Perennial herb	Native	Not assessed
Ephedra chilensis	Ephedraceae	Pingo pingo / -	Shrub	Native	Not threatened
Adesmia gracilis	Fabaceae	Varilla / -	Shrub	Native	Not threatened
Adesmia schneiderii	Fabaceae		Shrub	Endemic	Not threatened
Adesmia sp.	Fabaceae		Perennial herb	Native	Not assessed
Medicago minima	Fabaceae		Annual herb	Allochthonous	Without classification
Trifolium repens	Fabaceae	Trébol blanco / White Clover	Perennial herb	Allochthonous	Without classification
Erodium cicutarium	Geraniaceae	Alfilerillo / Common Stork's-bill	Annual herb	Allochthonous	Without classification
Bromus berterianus	Gramineae	Tuca / Chilean Chess	Annual herb	Native	Not assessed
Bromus scoparius	Gramineae		Annual herb	Allochthonous	Without classification
Bromus tunicatus	Gramineae		Perennial herb	Native	Not assessed
Cortaderia rudiuscula	Gramineae	Cortadera / -	Perennial herb	Native	Not assessed
Festuca kurtziana	Gramineae		Perennial herb	Native	Not assessed
Hordeum comosum	Gramineae	Cebadilla / -	Perennial herb	Native	Not assessed
Hordeum murinum	Gramineae	Cebadilla / Mouse Barley	Annual herb	Allochthonous	Without classification
Poa gayana	Gramineae	Coirón / -	Perennial herb	Native	Not assessed
Poa pratensis	Gramineae		Perennial herb	Allochthonous	Without classification
Poa secunda	Gramineae		Perennial herb	Native	Not assessed
Polypogon australis	Gramineae		Perennial herb	Native	Not assessed
Stipa chrysophylla	Gramineae	Coirón Amarillo / -	Perennial herb	Native	Not assessed
Phacelia cumingii	Hydrophyllaceae		Annual herb	Native	Not assessed
Phacelia secunda	Hydrophyllaceae		Perennial herb	Native	Not assessed
Olsynium philippi	Iridaceae	Ñuño / -	Perennial herb	Endemic	Not threatened
Sisyrinchium adenostemum	Iridaceae	Huilmo / -	Perennial herb	Native	Not threatened
Juncus arcticus	Juncaceae	Junco / Arctic Rush	Perennial herb	Native	Not assessed
Juncus estipulatus	Juncaceae		Perennial herb	Native	Not assessed
Lamium amplexicaule	Labiatae		Annual herb	Allochthonous	Without classification
Stachys philippiana	Labiatae	Toronjilcillo / -	Perennial herb	Endemic	Not assessed
Caiophora espigneira	Loasaceae		Perennial herb	Native	Not assessed
Loasa pallida	Loasaceae	Ortiga caballuna / -	Perennial herb	Endemic	Not assessed
Malva nicaeensis	Malvaceae	Malva / Bull Mallow	Annual herb	Allochthonous	Without classification
Camisonia dentata	Onagraceae		Annual herb	Native	Not assessed
Epilobium sp.	Onagraceae		Perennial herb	Native	Not assessed
Gayophytum humile	Onagraceae		Annual herb	Native	Not assessed
Gayophytum micranthum	Onagraceae		Annual herb	Native	Not assessed

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Oxalis squamata	Oxalidaceae	Ojos del agua / -	Annual herb	Native	Not assessed
Plantago grandiflora	Plantaginaceae		Annual herb	Native	Not assessed
Plantago lanceolata	Plantaginaceae	Siete venas/Ribwort Plantain	Annual herb	Allochthonous	Without classification
Collomia biflora	Polemoniaceae		Annual herb	Native	Not assessed
Gilia crassifolia	Polemoniaceae		Annual herb	Native	Not assessed
Micrasteris gracilis	Polemoniaceae		Annual herb	Native	Not assessed
Rumex acetosella	Polygonaceae	Vinagrillo / Sheep Sorrel	Perennial herb	Allochthonous	Without classification
Calandrinia capitata	Portulacaceae		Annual herb	Endemic	Not assessed
Calandrinia cistiflora	Portulacaceae		Perennial herb	Native	Not assessed
Calandrinia cumingii	Portulacaceae		Annual herb	Endemic	Not assessed
Calandrinia sericea	Portulacaceae	Hierba de la mistela / -	Perennial herb	Native	Not assessed
Calandrinia umbellata	Portulacaceae	Hierba de la mistela / -	Perennial herb	Native	Not assessed
Barneoudia chilensis	Ranunculaceae		Perennial herb	Native	Not assessed
Acaena alpina	Rosaceae	Clonqui / -	Perennial herb	Endemic	Not assessed
Acaena magellanica	Rosaceae	Trun / -	Perennial herb	Native	Not assessed
Acaena pinnatifida	Rosaceae	Cadillo / -	Perennial herb	Native	Not assessed
Acaena splendens	Rosaceae	Clonqui / -	Perennial herb	Native	Not assessed
Tetraglochin alatum	Rosaceae	Horizonte / -	Shrub	Native	Not threatened
Galium spp.	Rubiaceae		Shrub	Native	Not threatened
Quinchamalium chilense	Santalaceae	Quinchamalí / -	Perennial herb	Native	Not assessed
Calceolaria arachnoidea	Scrophulariaceae	Capachito rosado / -	Perennial herb	Endemic	Not assessed
Calceolaria filicaulis subesp.*luxurians*	Scrophulariaceae	Capachito / -	Perennial herb	Native	Not assessed
Mimulus glabratus	Scrophulariaceae	Placa / Smooth Monkeyflower	Perennial herb	Native	Not assessed
Verbascum thapsus	Scrophulariaceae	Hierba del paño / Great Mullein	Annual herb	Allochthonous	Without classification
Veronica anagallis-aquatica	Scrophulariaceae		Perennial herb	Allochthonous	Without classification
Nicotiana acuminata	Solanaceae		Annual herb	Native	Not assessed
Tropaeolum polyphyllum	Tropaeolaceae		Perennial herb	Native	Not assessed
Apium andinum	Umbelliferae		Perennial herb	Native	Not assessed
Diposis bulbocastanea	Umbelliferae		Perennial herb	Endemic	Not assessed
Hydrocotyle ranunculoides	Umbelliferae		Perennial herb	Native	Not assessed
Laretia acaulis	Umbelliferae	Llareta / -	Shrub	Native	**Vulnerable**
Mulinum spinosum	Umbelliferae	Neneo / -	Shrub	Native	Not threatened
Urtica sp.	Urticaceae	Ortiga caballuna / -	Perennial herb	Native	Not assessed
Valeriana sp.	Valerianaceae		Perennial herb	Native	Not assessed

Table 5.4.1.3.6
Vascular Flora - La Engorda Sector

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Zollnerallium andinum	Alliaceae		Perennial herb	Native	Not threatened
Alstroemeria exerens	Alstroemeriaceae	Liuto / Inca Lily	Perennial herb	Native	**Insufficiently known**
Rhodophiala rhodolirion	Amaryllidaceae		Perennial herb	Native	Not threatened
Cynanchum mucronatum	Asclepiadaceae		Shrub	Native	Not threatened
Berberis empetrifolia	Berberidaceae	Monte negro/Crown Barberry	Shrub	Native	Not threatened
Nastanthus spathulatus	Calyceraceae		Perennial herb	Native	Not assessed
Cerastium arvense	Caryophyllaceae		Perennial herb	Allochthonous	Without classification
Silene andicola	Caryophyllaceae		Perennial herb	Native	Not assessed
Chaetanthera euphrasioides	Compositae		Annual herb	Native	Not assessed
Chaetanthera pusilla	Compositae		Annual herb	Native	Not assessed
Chuquiraga opositifolia	Compositae	Yerba blanca / -	Shrub	Native	Not threatened
Erigeron andicola	Compositae		Perennial herb	Native	Not assessed
Gamochaeta nivalis	Compositae		Perennial herb	Native	Not assessed
Gnaphalium gayanum	Compositae	Vira vira / -	Perennial herb	Endemic	Not assessed
Haplopappus anthylloides	Compositae		Shrub	Native	Not threatened
Haplopappus schumanni	Compositae		Shrub	Endemic	Not threatened
Leucheria congesta	Compositae		Perennial herb	Native	Not assessed
Leucheria rosea	Compositae		Perennial herb	Native	Not assessed
Lucilia eriophora	Compositae		Perennial herb	Endemic	Not assessed
Mutisia sinuata	Compositae		Shrub	Native	Not threatened
Nardophyllum lanatum	Compositae		Shrub	Native	Not threatened
Nassauvia aculeata	Compositae		Shrub	Native	Not threatened
Perezia carthamoides	Compositae		Perennial herb	Native	Not assessed
Perezia nutans	Compositae		Perennial herb	Native	Not assessed
Senecio microphyllus	Compositae		Shrub	Endemic	Not threatened
Senecio pentaphyllus	Compositae		Shrub	Endemic	Not threatened
Senecio polygaloides	Compositae		Shrub	Native	Not threatened
Tanacetum parthenium	Compositae		Perennial herb	Allochthonous	Without classification
Taraxacum officinale	Compositae	Diente de león / Common Dandelion	Perennial herb	Allochthonous	Without classification
Convolvulus arvensis	Convolvulaceae	Correvuela / Field Bindweed	Perennial herb	Allochthonous	Without classification
Convolvulus demisssus	Convolvulaceae	Correvuela / -	Perennial herb	Native	Not assessed
Draba gilliesii	Cruciferae		Perennial herb	Native	Not assessed
Hirschfeldia incana	Cruciferae	Yuyo / Shortpod Mustard	Annual herb	Allochthonous	Without classification
Menonvillea scapigera	Cruciferae		Perennial herb	Native	Not assessed

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Carex andina	Cyperaceae		Perennial herb	Native	Not assessed
Carex gayana	Cyperaceae		Perennial herb	Native	Not assessed
Eleocharis albibracteata	Cyperaceae		Perennial herb	Native	Not assessed
Ephedra chilensis	Ephedraceae	Pingo pingo / -	Shrub	Native	Not threatened
Adesmia gracilis	Fabaceae	Varilla, espinillo / -	Shrub	Native	Not threatened
Adesmia sp.	Fabaceae		Perennial herb	Native	Not assessed
Astragalus cruckshanksii	Fabaceae	Yerba loca / -	Perennial herb	Native	Not assessed
Trifolium repens	Fabaceae	Trébol blanco / White Clover	Perennial herb	Allochthonous	Without classification
Bromus berterianus	Gramineae		Annual herb	Native	Not assessed
Bromus setifolius	Gramineae		Perennial herb	Native	Not assessed
Bromus tunicatus	Gramineae		Perennial herb	Native	Not assessed
Deyeuxia sp.	Gramineae		Perennial herb	Native	Not assessed
Poa denudata	Gramineae		Perennial herb	Native	Not assessed
Poa gayana	Gramineae	Coirón / -	Perennial herb	Native	Not assessed
Poa pratensis	Gramineae		Perennial herb	Allochthonous	Without classification
Rytidosperma spp.	Gramineae		Perennial herb	Native	Not assessed
Stipa chrysophylla	Gramineae	Coirón Amarillo / -	Perennial herb	Native	Not assessed
Ribes cucullatus	Grossulariaceae	Zarzaparrilla	Shrub	Native	Not threatened
Phacelia secunda	Hydrophyllaceae	Cuncuna morada / -	Perennial herb	Native	Not assessed
Olsynium junceum	Iridaceae	Ñuño / -	Perennial herb	Native	Not threatened
Olsynium philippi	Iridaceae	Ñuño / -	Perennial herb	Endemic	Not threatened
Sisyrinchium adenostemon	Iridaceae	Huilmo / -	Perennial herb	Native	Not threatened
Solenomelus segethi	Iridaceae		Perennial herb	Native	Not threatened
Juncus arcticus	Juncaceae	Junco / Arctic Rush	Perennial herb	Native	Not assessed
Juncus bufonius	Juncaceae		Annual herb	Allochthonous	Without classification
Juncus stipulatus	Juncaceae		Perennial herb	Native	Not assessed
Luzula chilensis	Juncaceae		Perennial herb	Native	Not assessed
Stachys philippiana	Labiatae		Perennial herb	Endemic	Not assessed
Wendtia gracilis	Ledocarpaceae		Shrub	Native	Not threatened
Epilobium glaucum	Onagraceae		Perennial herb	Native	Not assessed
Gayophytum humile	Onagraceae		Annual herb	Native	Not assessed
Gayophytum micranthum	Onagraceae		Annual herb	Native	Not assessed
Chloraea alpina	Orchidaceae		Perennial herb	Native	Not threatened
Oxalis squamata	Oxalidaceae	Ojos del agua / -	Perennial herb	Native	Not assessed
Plantago grandiflora	Plantaginaceae		Perennial herb	Native	Not assessed
Plantago lanceolata	Plantaginaceae	Siete venas / Ribwort Plantain	Perennial herb	Allochthonous	Without classification
Gilia crassiflora	Polemoniaceae		Annual herb	Native	Not assessed
Micrasteris gracilis	Polemoniaceae		Annual herb	Native	Not assessed

Species	Family	Common Name Spanish/English	Growth Form	Geographic Origin	Conservation Category
Calandrinia cumingii	Portulacaceae		Annual herb	Native	Not assessed
Calandrinia sericea	Portulacaceae		Perennial herb	Endemic	Not assessed
Calandrinia tricolor	Portulacaceae		Perennial herb	Native	Not assessed
Calandrinia umbellata	Portulacaceae		Perennial herb	Native	Not assessed
Anagallis alternifolia	Primulaceae		Perennial herb	Native	Not assessed
Acaena alpina	Rosaceae	Clonqui / -	Perennial herb	Endemic	Not assessed
Acaena magellanica	Rosaceae	Amor seco / -	Perennial herb	Native	Not assessed
Acaena pinnatifida	Rosaceae	Cadilla / Argentinian Biddy-biddy	Perennial herb	Native	Not assessed
Acaena splendens	Rosaceae	Clonqui / -	Perennial herb	Native	Not assessed
Galium eriocarpum	Rubiaceae		Shrub	Native	Not threatened
Quinchamalium parviflorum	Santalaceae		Annual herb	Endemic	Not assessed
Calceolaria arachnoidea	Scrophulariaceae	Capachito rosado / -	Perennial herb	Endemic	Not assessed
Calceolaria corymbosa subesp. mimuloides	Scrophulariaceae	Capachito / -	Perennial herb	Endemic	Not assessed
Calceolaria filicaulis subesp. luxurians	Scrophulariaceae	Capachito / -	Perennial herb	Native	Not assessed
Calceolaria hypericina	Scrophulariaceae	Capachito / -	Shrub	Endemic	Not threatened
Mimulus glabratus	Scrophulariaceae	Placa / Smooth Monkeyflower	Perennial herb	Native	Not assessed
Mimulus luteus	Scrophulariaceae	Placa / Monkey Musk	Perennial herb	Native	Not assessed
Nicotiana acuminata	Solanaceae		Annual herb	Native	Not assessed
Nicotiana corymbosa	Solanaceae		Annual herb	Native	Not assessed
Tropaeolum polyphyllum	Tropaeolaceae		Perennial herb	Native	Not assessed
Bowlesia tropaeolifolia	Umbelliferae		Perennial herb	Native	Not assessed
Laretia acaulis	Umbelliferae	Llareta / -	Shrub	Native	**Vulnerable**
Mulinum spinosum	Umbelliferae	Neneo / -	Shrub	Native	Not threatened
Sanicula graveolens	Umbelliferae	Cilantro de cerro / Northern Sanicle	Perennial herb	Native	Not assessed
Junellia spathulata	Verbenaceae		Shrub	Native	Not threatened

Table 5.4.1.3.7
Vegetation Map - Las Puertas Sector

Nº	Vegetatal Formation	Predominant Species	GA	SD%	Physiognomy
LP-1	LA5 pd	QS KO LC	3.5	30 - 40	Forest of *Quillaja saponaria-Lithrea caustica-Kageneckia oblonga*
LP-2	LA5 pd	KO LC	3.5	31 - 40	Forest of *Kageneckia oblonga* and *Lithrea caustica*
LP-3	LA6 d	CA QS KO LC	3.5	10 - 20	Forest of *Cryptocarya alba -Quillaja saponaria-Lithrea caustica-Kageneckia oblonga*
LP-4	LA4 LB4 d	QS KO LC Co Hd	3.5	5 - 10	Forest of *Quillaja saponaria-Lithrea caustica-Kageneckia oblonga*
LP-5	LA6 d	QS KO LC	3.5	10 - 20	Forest of *Quillaja saponaria-Lithrea caustica-Kageneckia oblonga*
LP-6	LA2 LB3 H3 pd	QS Bl ab bb	3.5	10 - 20	*Baccharis linearis* scrubland
LP-7	LA4 LB2 H3 d	QS AC Hd nc	3.5	5 - 10	Forest of *Quillaja saponaria-Acacia caven*
LP-8	ZA		6.1		Agricultural area

Predominant Species

Tree

LC: Lithrea caustica
QS: Quillaja saponaria
KO: Hageneckia oblonga
CA: Cryptocarya alba
AC: Acacia caven

Shrub

Bl: Baccharis linearis
Hd: Haplopappus diplopappus
Co: Colliguaja odorifera

Herb

ab: Avena barbata
bb: Bromus berteroanus
nc: Nassella chilensis

Coverage Range

1: 1 - 5 %, very scarse
2: 5 - 10%, scarse
3: 10 - 25%, very clear
4: 25 - 50%, clear
5: 50 - 75%, low-density
6: 75 -90%, dense
7: 90 - 100%, high density

Table 5.4.1.3.8
Vegetation Table - Las Lajas Tunnel Sector (A)

Nº	Vegetal Formation	Predominant Species	GA	SD %	Physiognomy
CL-1	LA4 LB3 H5 md	QS AC Bl Cp Pc ho ha hi	3.5	5 - 10	*Kageneckia angustifolia-Acacia caven* forest
CL-2	LA5 LB4 md	QS KA KO SP Ba	3.5	5 - 10	*Kageneckia angustifolia-Kageneckia angustifolia-Kageneckia oblonga* forest
CL-3	LB3 S1 mc	Gi Pc pB eC	3.1	Up to 70	*Puya berteroniana-Echinopsis chilensis* scrubland
CL-4	LA2 LB2 mc	QS AC Bl	3.2	Up to 70	Prairie with isolated trees
CL-5	LA2 LB1 e	AC Bl	3.3	Up to 80	Thorny trees on post-crop
CL-6	LA5 LB2 H1 pd	QS MB CP lv cc	3.5	10 - 20	Sclerophyllous forest
CL-7	Vegetación cultivada				
CL-8	LA4 LB2 H2 S1 pd	PC LC QS Tq vm ha eC	3.5	10 - 20	Sclerophyllous forest
CL-9	LA2 LB3 H2 S1 c	QS Tq vm eC	3.5	Up to 50	Thorny scrubland

Predominant Species

Tree	Shrub	Herb	Succulent	Coverage and density ranges
AC: Acacia caven	*Ba: Baccharis salicifolia*	*ha: Helenium aromaticum*	*eC: Echinopsis chilensis*	1: 1 - 5 %, very scarse
KA: Kageneckia angustifolia	*Bl: Baccharis linearis*	*hi: Hirschfeldia incana*	*pB. Puya berteroniana*	2: 5 - 10%, scarse
KO: Kageneckia oblonga	*Cp: Cestrum parqui*	*ho: Hordeum sp.*		3: 10 - 25%, very clear
QS: Quillaja saponaria	*Gi. Gymnophyton isatidicarpon*	*lv: Lactuca virosa*		4: 25 - 50%, clear
MB: Maytenus boaria	*Pc: Proustia cuneifolia*	*cc: Cynoglossum creticum*		5: 50 a 75%, low-density
PC: Porlieria chilensis	*Tq: Trevoa quinquinervia*	*vm: Vulpia myuros*		6: 75 - 90% dense
				7: 90 - 100%, high-density

Table 5.4.1.3.9
Vegetation Map - Las Lajas Tunnel Sector (B)

Nº	Vegetal Formation	Predominant Species	GA	SD%	Physiognomy
CY-1	LA 5 LB4 d	QS AC PC Gf Sp	3.5	10 - 25	Forest of *Acacia caven, Porlieria chilensis* and *Quillaja saponaria*
CY-2	LA5 LB5 S2 md	KO LC QS Gf Co Ch eC pB	3.5	5 - 10	Forest of *Kageneckia oblonga , Lithrea caustica* and Quill*aja saponaria*
CY-3	LA 6 d	CA QS KO	3.5	10 - 25	Forest of *Cyptocarya alba*, *Quillaja saponaria* and *Kageneckia oblonga*
CY-4	LA3 LB3 S1 pd	QS LC Tq Co, pB, eC	3.5	25 - 50	Forest of *Quillaja saponaria* and *Lithrea caustica*

Predominant Species

Tree	Shrub	Coverage and Density Rantes
LC: Lithrea caustica	*Ba: Baccharis salicifolia*	*1: 1 - 5 %, very scarse*
QS: Quillaja saponaria	*Ch: Colletia hystrix*	*2: 5 - 10%, scarse*
KO: Kageneckia oblonga	*Tq: Trevoa quinquinervia*	*3: 10 - 25%, very clear*
AC: Acacia caven	*Sp: Schinus polygamus*	*4: 25 - 50%, clear*
PC: Porlieria chilensis	*Gf: Gochnatia foliolosa*	*5: 50 - 75%, low-density*
CA: Cryptocarya alba	*Co: Colliguaja odorifera*	*6: 75 -90%, dense*
		7: 90 -100%, high density

Succulent

pB: Puya berteroniana
eC: Echinopsis chiloensis

Table 5.4.1.3.10
Vegetation Map of the El Alfalfal Sector

Nº	Vegetal Formation	Predominant Species	GA	SD%	Physiognomy
CA-1	LA4 LB4 H4 S1 md	QS KA SP Ch Pc Cp ab bb eC	3.5	5 - 10	Forest of *Quillaja saponaria-Kageneckia angustifolia* on south hillside
CA-2	LB3 H4 c	Ba Bp hy ec	3.2	60	*Baccharis salicifolia* scrubland (river bank)
CA-3	LB1 H7 md	Bp hi ms hm	3.1	0 - 5	Wet prairie (vega)
CA-4	LA4 LB4 H3 S1 md	QS SP Ch eC	3.6	10 - 25	Forest of *Quillaja saponaria- Schinus polygama* (north hillside)
CA-5	LA4 LB3 d	QS KA Cy	3.6	30	Forest of *Quillaja saponaria - Kageneckia angustifolia* (steep north hillside)
CA-6	LA4 LB4 H4 S2 md	QS KO Ac Pc Ch ab eC pB	3.5	10%	Forest of *Quillaja saponaria - Kageneckia oblonga*
CA-7	LB3 S2 c	Gi eC	3.2	70- 80	Scrubland of *Gymnophyton* and *Echinopsis chilensis*
CA-8	ZC	-	-	-	Crops and residential

Predominant Species

Tree	Shrub	Herbs	Succulents	Coverage and density ranges
KA: Kageneckia angustifolia	*Ac: Adesmia confusa*	*ab: Avena barbata*	eC: Echinopsis chilensis	1: 1 - 5 %, very scarse
KO: Kageneckia oblonga	*Ba: Baccharis salicifolia*	*bb: Bromus berterianus*	*pB: Puya berteroniana*	2: 5 - 10%, scarse
QS: Quillaja saponaria	*Bp:Baccharis pingraea*	*ec: Erodium cicutarium*		3: 10 - 25%, very clear
SP: Schinus polygamus	*Ch: Colletia hystrix*	*hi: Hirschfeldia incana*		4: 25 - 50%, clear
	Cp: Cestrum parqui	*hm: Hordeum murinum*		5: 50 - 75%, low-density
	Cy:Calceolaria hypericina	*hy: Hydrocotyle sp.*		6: 75 - 90%, dense
	Gi: Gymnophyton isatidicarpon	*ms: Madia sativa*		7: 90 - 100%, high density
	Pc. Proustia cuneifolia			

Table 5.4.1.3.11
Vegetation Mapping - El Trescientos Window Sector

Nº	Vegetal Formation	Predominant Species	GA	SD%	Physiognomy
CM – 1	LA5 LB4 d	QS KA SP Ba	-	-	Forest of *Quillaja saponaria-Kageneckia angustifolia*
CM – 2	LB3	QS KA mc	-	-	Sclerophyllous scrubland
CM – 3	LB3 h4 c	Ba Bp hy ec	-	-	Formation of *Baccharis salicifolia*
CM – 4	LA5 LB4 c	QS KA SP Ba	-	-	Clear forest of *Quillaja saponaria-Kageneckia angustifolia*

Speciess dominantes

Tree	Shrub	Herbs	Coverage and density ranges
KA: Kageneckia angustifolia	*Ac: Adesmia confusa*	*ab: Avena barbata*	1: 1 a 5 %, very scarse
QS: Quillaja saponaria	*Ba: Baccharis salicifolia*	*bb: Bromus berterianus*	2: 5 a 10%, scarse
SP: Schinus polygamus	*Bp:Baccharis pingraea*	*ec: Erodium cicutarium*	3: 10 a 25%, very clear
	Ch: Colletia hystrix	*hi: Hirschfeldia incana*	4: 25 a 50%, clear
	Cp: Cestrum parqui	*hm: Hordeum murinum*	5: 50 a 75%, low density
	Cy:Calceolaria hypericina	*hy: Hydrocotyle sp.*	6: 75 a 90%, dense
	Gi: Gymnophyton isatidicarpon	*ms: Madia sativa*	7: 90 a 100%, high density
	Pc. Proustia cuneifolia		

Table 5.4.1.3.12
Vegetation Map of the Quebrada Aucayes Area

No.	Vegetal Formation	Predominant Species	GA	SD%	Physiognomy
AU-1	LB5 H4 d	Gt Co Ci as pg bb	3.2		Andean scrubland
AU-2	LB4 H3 pd	Sg Js Ms as ms pg bb	3.2		Andean scrubland
AU-3	LA4 LB4 H4 md	EM Bg sa ea va	3.2		Ravine
AU-4	LB5 H5 md	Gt Ci Ta ms, pg, bb	3.2		Sub-Andean scrubland
AU-5	LB4 H 2 pd	Nl ,Ta,Co, Hv,bb, pg	3.2		Andean scrubland
AU-6	LA1 LB2 H7 md	DC SP Bp pa tr rc	3.1	5-10	Wet prairie
AU-7	LA3 LB4 H3 S1 md	KA Ci Ta	3.5		Low-density forest
AU-8	LA4 LB3 H4 S1 d	KA QS MB SP Ci Pc ms cm	3.5		Sclerophyllous forest
AU-9	LA4 LB1 S1 c	KA TQ QS Ci eC	3.2		Forest and thorny scrubland
AU-10	LA4 LB2 S1 pd	QS KO LC SP Br Gf eC ha ce vm	3.5		Sclerophyllous forest
AU-11	LA3 LB3 H1 S1 pd	QS KO Tq Pc pB eC		40-50	Sclerophyllous forest
AU-12	LA2 LB3 H1 mc	QS Gi Tq Ta vm		70-75	Thorny scrubland with thickets of *Quillaja saponaria*
AU-13	LA1 LB5 H2 pd	QS Tq Sp Cs ha		40-50	Thorny scrubland
AU-14	LA5 LB3 H2 S1 d	QS LC KO KA Sp Pc Ch cm vm pB eC		10-20	Sclerophyllous forest
AU-15	LB2 H1 S3 c	Pc Gi ec vm eC pB		70-80	Scrubland with succulents
AU-16	LA2 LB4 H1 S1 pd	KA Gt Ci Ta pg eC	3.2	20 - 40	Andean scrubland
AU-17	LA1 LB4 H1 S1 c	KA Ta Hu as eC	3.2	50	Andean scrubland
AU-18	LB4 H1 c	Ta Gi pg	3.2	50	Andean scrubland
AU-19	LB5 H2 pd	Hv Ta as pg	3.2	20 - 40	Andean scrubland

Predominant Species

Shrub
Gt: Guindilia trinervis
Co: Chuquiraga oppositifolia
Ci: Colliguaja integerrima
Sg: Senecio glaber
Js: Junellia scoparia
Ms: Mulinum spinosum
Bg: Buddleja globosa
Ta: Tetraglochin alatum
Nl: Nardophyllum lanatum
Hv: Haplopappus velutinus
Bp: Baccharis pingraea
Pc. Proustia cuneifolia
Br: Baccharis rhomboidalis
Gf: Gochnatia foliolosa
Tq: Trevoa quinquinervia
Ch: Colletia hystrix
Gi: Gymnophyton isatidicarpum

Herbes
pg: Poa gayana
bb: Bromus berterianus
as:Acaena splendens
ms: Madia sativa
pa: Polypogon australis
tr: Trifolium repens
rc: Rumex crispus
cm: Conium maculatum
ha: Helenium aromaticum
ce: Centaurea melitensis
vm: Vulpia myurus
ec: Eschscholzia californica

Coverage and density ranges
1: 1 - 5 %, very scarse
2: 5 - 10%, scarse
3: 10 - 25%, very clear
4: 25 - 50%, clear
5: 50 - 75%, low density
6: 75 - 90%, dense
7: 90 - 100%, high density

Table 5.4.1.3.13
Vegetation Map - Yeso River Area

No.	Vegetal Formation	Predominant Species	GA	SD%	Physiognomy
EY-1	H7 md	cg ja pp	3.1	1%	Wet prairie
EY-2	LB3 H4 pd	Be Co bt py	3.1	30%	Low scrubland
EY-3	LB3 H3 c	Co py sc	3.1	60%	Low scrubland
EY-4	LB3 H3 c	Co Ta Ha py bt	3.1	60%	Low scrubland
EY-5	LB1 H7 md	Bp Bs ea cg ja	3.1	1%	Wet prairie
EY-6	LB2 H2 mc	Ea,Be,Dc,cr	3.1	75%	Low scrubland

Predominant Species

Shrubs

Be: Berberis empetrifolia
Bp: Bacharis pingraea
Bs:Baccharis sagittalis
Co. Chuquiraga oppositifolia
Ha: Haplopappus anthylloides
Ta: Tetraglochin alatum

Hierbas

bt: Bromus tunicatus
cg: Carex gayana
ea: Eleocharis albibracteata
ja: Juncus arcticus
pp: Poa pratensis

Coverage and Density Ranges

1: 1 - 5 %, very scarse
2: 5 - 10%, scarse
3: 10 - 25%, very clear
4: 25 - 50%, clear
5: 50 - 75%, low density
6: 75 - 90%, dense
7: 90 - 100%, high density

Table 5.4.1.3.14
Vegetation Map - Lo Encañado Lake Area

No.	Vegetal Formation	Predominant Species	GA	SD%	Physiognomy
EE-1	LB7 H7 md	Rc ja pa	3	1 - 5%	Stream-edge scrubland
EE-2	LB3 H3 c	Be Co Ec py	3	60%	Low scrubland
EE-3	LB 4 H4 pd	Be Ec Co py pg al	3	30%	Low scrubland
EE-4	LB 5 H4 d	Ag, Ec, pg, aa,ap,py	3	10 - 25 %	Low scrubland
EE-5	LB2 H3 c	La, Be, pg, py,aa	3	50 - 75 %	Low scrubland
EE-6	H7 d	ja ea am	3	0 - 5%	Wet prairie
EE-7	LB1 H6 md	Se ja ea pl am	3	5%	Wet prairie and prairie edge
EE-8	LB5 H3 d	Co Ec Ag ph as	3	20 - 35%	Andean scrubland
EE-9	LB4 H3 pd	Be Ec ps ls ap	3	30 - 40%	Andean scrubland

Predominant Species

Shrub

Be:Berberis empetrifolia
Co: Chuquiraga oppositifolia
Ec: Ephedra chilensis
Rc: Ribes cucullatum
La: Laretia acaulis
Ag: Adesmia gracilis

Herbs

al: Alstroemeria exerens
ja: Juncus arcticus
pg: Plantago grandiflora
py: Poa gayana
as: Acaena splendens
ea: Eleocharis albibracteata
am: Acaena magellanica
ap: Acaena pinnatifida
ls: Lathyrus subandinus

Coverage and density ranges

1: 1 - 5 %, very scarse
2: 5 - 10%, scarse
3: 10 - 25%, very clear
4: 25 - 50%, clear
5: 50 - 75%, low-density
6: 75 - 90% dense
7: 90 - 100%, high density

Table 5.4.1.3.15
Vegetation Map - La Engorda Area

Nº	Vegetal Formation	Predominant Species	GA	SD%	Physiognomy
LE-1	LB4 H3 pd	Co Ha py bt sc	3.2	20 - 30	Low scrubland
LE-2	LB3 H2 c	Be Ec Co sc py	3.2	25 - 50	Low scrubland
LE-3	LB5 H4 d	Ag Co Be ja py hc	3.2	Up to 10	Low scrubland with dense herbaceous stratum
LE-4	H7 md	ja al pa ds	3.2	Up to 5	Prairie, stream edge
LE-5	LB5 H2 pd	Co Ec sc py	3.2	20 - 30	Low scrubland
LE-6	LB4 H2 c	Co,Ha, Ec, La, sc, py	3.2	25 - 50	Low scrubland

Predominant Species

Shrub	Herbs	Coverage and Density Ranges
Co: Chuquiraga oppositifolia	*py: Poa gayana*	1: 1 - 5 %, very scarse
Ha: Haplopappus anthylloides	*bt: Bromus tunicatus*	2: 5 - 10%, scarse
Be: Berberis empetrifolia	*sc: Stipa chrysophylla*	3: 10 - 25%, very clear
Ec: Ephedra chilensis	*ja: Juncus arcticus*	4: 25 - 50%, clear
Ag: Adesmia gracilis	*al: Agrostis leptotricha*	5: 50 - 75%, low-density
La: Laretia acaulis	*pa: Polypogon australis*	6: 75 - 90%, dense
	ds: Deyeuxia sp.	7: 90 - 100%, high density

Table 5.4.1.3.16
Vegetation Map - Las Lajas Discharge Sector

No.	Vegetal Formation	Predominant Species	GA	SD%	Physiognomy
LL-1	LA6 LB3 H2 d	EG CA LC Cr Cp Mh vm pl	6.0	20 - 30	Forest plantation

Predominant Species

Trees
EG: Eucalyptus globulus
CA: Cryptocarya alba
LC: Lithrea caustica

Shrubs
Mh: Muehlenbeckia hastulata
Cp: Cestrum palqui
Cr: Cortaderia rudiuscula

Herbs
vm: Vulpia myuros
pl: Plantago lanceolata

Coverage and Density Ranges
1: 1 - 5 %, very scarse
2: 5 - 10%, scarse
3: 10 - 25%, very clear
4: 25 - 50%, clear
5: 50 - 75%, low density
6: 75 - 90%, dense
7: 90 - 100%, high density

5.4.1.4 Conclusions

A FLORA

Richness of species

The study conducted identified the presence of 258 species in the PHAM'S area of influence. This number of species may seem low if we consider the different environments visited; however, they constitute relatively small areas and a significant part of them are located on the Andean floor where there is less richness.

Growth Forms

In the sectors located under 1700 m.a.s.l., there is predomination of forest formations with prevalence of trees. Over 2000 m.a.s.l., trees disappear and the growth form that predominates in the physiognomy is that of low bushes not over 50 cm high, which alternate with turfs of grass with hard leaves. This pattern is somewhat different in the wet prairies, where perennial herbs predominate without any counterbalance, although they are spatially restricted to the environment immediately around the watercourses in the PHAM's area of influence.

Geographic Origin

In general, native species predominate in the area with the presence of feral, allochthonous plants principally in sites that have already been altered by human activities, particularly under 2000 m.a.sl. It is worth noting that 40% of the species recorded in the Colorado River sector are feral, allochthonous plants. This can be explained by the fact that the area shows strong anthropic alteration because of its proximity to access routes or due to the introduction of crops.

The pattern shown by the species endemic to Chile is that they diminish with altitude, reaching the greatest values in the sclerophyllous forest environment (43%) and starting to become less in the higher parts (15% en el Yeso and La Engorda). These values are to be expected given their direct phytogeographic ratio with the flora on the eastern side of the Andes.

The allochthonous species in the El Colorado-El Alfalfal sector are mostly annual herbs, although there are also perennial herbs and even shrubs and trees. In the Andean areas, most of the herbs are perennial and they are found on wetter areas.

Threatened Species

In the Colorado River-El Alfalfal area, which is the sector located at a lower altitude, the threatened species identified are:

- *Kageneckia angustifolia*: found forming forests and scrubland, and it predominates in several of the formations described for the sector. It is found over 1400 m.a.s.l. and it grows up to 2000 m.a.s.l., depending on the substrate and exposure.

- *Puya berteroniana* (*P. alpestris*): it forms part of the scrubland oriented to the north, on places where there are rock outcrops. It is found up to 1900 m.a.s.l. In the area, it forms part of at least one vegetal formation in the El Colorado-El Alfalfal sector (CA-6) and in the exit of the Las Lajas tunnel (CL-3).

- *Eriosyce curvispina* (*Neoporteria curvispina*): it was identified only once (3-5 individuals) in a *Quillaja saponaria* and *Kageneckia angustifolia* forest in the El Colorado-El Alfalfal sector.

- *Porlieria chilensis*: it was found in the EY-2 formation of the El Colorado-Las Bayas sector.

- *Cryptocarya alba*: This is a species of tree that is frequently and abundantly found in the sector forming a dense forest. It grows in the El Manzano and Colorado-Las Bayas sectors, in the CY-3 formation.

In the three High-Andean sectors we found two species of conservation interest:

- *Laretia acaulis*: It has scarse in the El Yeso River and Lo Encañado sectors, where we only recorded two individuals. In the La Engorda sector, its presence is frequent and it is a predominant species in one of the formations (LE-6).

- *Alstroemeria exerens*, a perennial herb with underground organs, which is part of the Low Andean Scrubland. It is frequent and abundant on some hillsides of the Lo Encañado sector (EE-3).

B VEGETATION

El Colorado-El Alfalfal Sector

The vegetation units found in the area correspond to those proposed by Gajardo (1994). The vegetation of the area studied fits in the Andean Sclerophyllous Forest formation, with presence according to the composition of the units of the associations: *Quillaja saponaria-Lithrea caustica*, *Cryptocarya alba-Lithrea caustica, Puya berteroniana-Adesmia confusa* and *Acacia caven-Lithrea caustica*. The formation is distributed between the Maipo and Cachapoal River basins, with the upper limit located at 1300-1800 m.a.s.l. depending on the elevation and exposure. In sectors located at greater altitude, the units found include species of the Andean Sclerophyllous Scrubland with the presence of some of the predominant species like *Kageneckia angustifolia* and *Guindilia trinervia.*

In relation to the vegetation floors proposed by Luebert & Pliscoff (2006), the sector's vegetation belongs to the Andean Mediterranean Sclerophyllous Forest floor of *Quillaja saponaria* and *Lithrea caustica*, although it is influenced by the effect of the altitude by the presence of species of the Andean Mediterranean Sclerophyllous Forest like *Kageneckia angustifolia* and *Guindilia trinervis*. The typical Mediterranean Sclerophyllous Forest is distributed on the low hillsides of the mountain ranges (200-1700 altitude), between the regions of Valparaíso and O'Higgins.

Andean Sectors

The units located on the Andean floor according to Gajardo's proposal (1994) correspond to the High-Andean Steppe of the Santiago Mountain Range; which is distributed on the mountain ranges over 2000 m.a.s.l. between the regions of Coquimbo and O'Higgins. The units recorded in the Project area, according to the composition and the predominant species, belong principally to the *Chuquiraga oppositifolia-Mulinum spinosum* association; widely distributed in the formation.

With respect to the proposal made by Luebert & Pliscoff (2006), the area's vegetation is found in what they consider the Andean Mediterranean Low Scrubland of *Chuquiraga oppositifolia* and *Nardophyllum lanatum*. The floor is distributed on the Andes Mountains between the regions of Coquimbo and O'Higgins, at between 2000 and 2600 m.a.s.l.

Conservation Aspects

The threatened species that are most sensitive due to their conservation status are the following:

- *Laretia acaulis*, (considered Out of Danger according to the third classification process approved by the CONAMA Advisory Board) in the Yeso River and Lo Encañado sectors, because it is a scarse plant in that sector and it is probably in the lower distribution limit in the area. In the La Engorda sector the species reaches high densities.

- *Eriosyce curvispina* and *Kageneckia angustifolia*: show a wide distribution in the Estero Aucayes sector.

- *Puya berteroniana*. Abundant populations of this species were identified in the study area.

- Among the trees of the sclerophyllous forest, there are two threatened species, namely the *Cryptocarya alba*, which is scattered in the Las Puertas sector, and the *Porlieria chilensis*, which is a dominating part of the sclerophyllous forest in the low sector of the Colorado River.

Formations

The following has been concluded for the vegetation formation of conservation interest:

- Forests: in the area of the Colorado River there are numerous areas occupied by formations that according to the “operative” definition of the law must be treated as “forests.” A sensitive aspect is the presence of forests of *Kageneckia angustifolia,* particularly between 1300 and 1700 m.a.s.l., and populations of *Quillaja saponaria*.

- Andean scrubland: according to the results of the study, the Andean formations are widely distributed both along the country and in the Project area.

- Wetlands: Places with high vegetal productivity and azonal distribution. In the Andean sector some formations corresponding to this type of vegetation were found at Lo Encañado (Figure 5.4.1.3.29), in the El Yeso basin (Figure 5.4.1.3.28) and at La Engorda (Figure 5.4.1.3.30).

Regarding the La Engorda summer grazing sector, in the previous campaigns it was established that it is a sector with peculiar vegetation because it does not have the physiognomy of a prairie. In fact, the vegetation rather corresponds to a scrubland with a particularly abundant herbaceous stratum, with the presence of wetland species like *Juncus arcticus*, which probably indicate the existence of a surface aquifer. There are true wet prairies with predominance of prairies only along the watercourses, showing variable widths, which in general do not exceed 2 m in the area of the PHAM. Notwithstanding, in November 2007, wet prairie formations were found between the Colina and La Engorda streams, and the environs of the Estero Stream, which had not been detected in previous campaigns because the wet prairie’s coverage at the end of the summer and autumn diminishes significantly, probably due to the less availability of water and excessive grazing.

In other words, these prairies are of a seasonal nature, and they are associated with surface and subsurface watercourses that feed the streams.

In addition Appendix 42 contains a Vegetation Study of the La Engorda Summer Grazing Sector where two very different units were identified, associated with different water requirements. The unit that depends most of the water resource is the wet prairie, which in this case is characterized by the dominant presence of *ciperacea* and *gramineae*. This unit probably is benefitting from some surface aquifer that appears in the sector below La Engorda.

Although the scrubland vegetation of *Chuquiraga oppositifolia* is classified as zonal and does not depend on the water resource (surface runoff), apparently because of its high coverage, it also benefits from some type of aquifer. If changes in water availability in the aquifers should occur, we predict a gradual change of the wet prairie association to that of a scrubland.

5.4.1.5 Bibliographical references

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5.4.2 Fauna

5.4.2.1 Introduction

According to Gajardo (1994) the bedrock of the Maipo River canyon is characterized by Sclerophyllous Forest and Scrubland formations. Sub regions in the area are characterized by Sclerophyllous Forest formations.

The Andean vegetation of the study area is set in the Andes Highland Steppe of the Cordillera de Santiago, which represents the upper altitudinal limit for the vegetation of the central zone Cordillera de los Andes. Due to the highly abrupt nature of the mountainous relief, this vegetation formation is discontinuous and in some places takes on the appearance of a highland desert. As to vegetable species, there is a predominance of xerophyte features, with pulvinate shrubs and herbs, as well as tufted grasses (Gajardo 1994).

In the sclerophyllous forest subregion, dominant species include trees and tall shrubs, often with the appearance of “*monte*” or arborescent scrubland, which represent a state of natural regeneration of the associations that have been subject to human impact (tree felling, fires).

The physiography of the Andean landscape corresponds to an area with large mountain chains that form different canyons, associated to some watercourses in run-off seasons.

Despite its easy access and closeness to population centers, the Andes mountain range in the Metropolitan Region has been understudied from a spatial and biological point of view, in spite of the high degree of endemic species of flora and fauna (Myers et al. 2000) and the presence of ecosystems that are crucial for the natural development of biological cycles.

The faunal composition of the sclerophyllous scrubland includes endemic and some introduced species, i.e., assemblages whose diversity (richness: abundance ratio) is determined by the degree of anthropization of the study areas. The Andean Highland system is an environment that stands out for its high degree of naturalness, although it is not free from anthropic pressure due to different production activities such as cattle raising (summer pastures) and mining. From this point of view, the vertebrate community associated to this environment exhibits a high degree of singularity, as it makes up a combination of characteristic species of restricted distribution.

5.4.2.2 Objectives

General Objective

To describe fauna diversity in the area of influence of the Alto Maipo Hydroelectric Project.

Specific Objectives

- To determine the species richness of terrestrial vertebrate fauna (amphibians, reptiles, birds and mammals) in the area of the Project.

- To describe the abundance and spatial distribution of terrestrial vertebrate fauna present in the area of the Project.

- To determine the presence of species undergoing conservation problems in the study area.

- To recognize microhabitats or features of the Andean highland landscape and of sclerophyllous forest formations that may provide a home to wild terrestrial fauna.

5.4.2.3 Methodology

The overall fauna characterization was based on bibliographic information and review of earlier studies; additionally, field campaigns were made that allowed for surveying fauna diversity in the study area. The richness and abundance of amphibian, reptile, bird, and mammal species in the study area were estimated through a sampling campaign. The campaigns were carried out in autumn (April 15-16, 2005), summer (March 18, 2008) and spring (December 8-10, 2006).

The specialists surveyed the study area that comprises the sclerophyllous scrubland associated to the Colorado River and the low sub-Andean scrubland and Andean highland steppe in the zones of La Engorda Canyon, El Morado Stream, Lo Encañado Lagoon and the sector of El Manzanito Stream, El Yeso River and Reservoir, the Aucayes Stream, Aucayes-Maitenes and the Aucayes Alto sector.

The methodology used for characterizing the fauna is explained on the basis of three areas:

a) Colorado River, La Engorda Canyon-El Morado Stream, Lo Encañado Lagoon-El Manzanito Stream, El Yeso Reservoir and River, and Aucayes Stream.
b) Aucayes-Maitenes
c) Aucayes Alto.

Each of these areas is in turn divided into transects that facilitate conducting the study.

a) Colorado River, La Engorda Canyon-El Morado Stream, Lo Encañado Lagoon-El Manzanito Stream, El Yeso Reservoir and River, and Aucayes Stream (April 15-16, 2005; December 8-10, 2006).

To record the richness and abundance of the terrestrial vertebrate fauna, thirty-two transects were made, out of which seven correspond to the Colorado River, seven to the meadows of La Engorda and El Morado Stream sector, five to Lo Encañado Canyon and El Manzanito, four associated to El Yeso Reservoir and River, and nine to the Aucayes Stream (see Table 5.4.2.1).

Table 5.4.2.1
Coordinates of Fauna Sampling Points

Río Colorado	La Engorda-Estero El Morado	Lo Encañado-Estero El Manzanito	Embalse y Río El Yeso	Estero Aucayes
368092-6286045	407357-6259448	395480-6273772	397556-6272020	388136-6285506
368687-6283766	407417-6259709	395514-6273610	397829-6272161	387575-6285029
375702-6284982	407096-6259823	395645-6273419	397984-6272200	387171-6284846
380784-6287479	405825-6261223	396274-6272872	399794-6274735	385701-6285426
380286-6287384	405873-6261015	395681-6271652		385416-6286240
388905-6291995	405754-6259950			384899-6285860
387745-6291568	405613-6260097			382800-6288045
				378285-6287197
				378983-6287150

The following general methodology was used for recording fauna:

1. Mammals were recorded by means of direct evidence (observations) whenever possible, and by indirect evidence such as feces, bone remains, footprints and burrows.

2. Surveys were made to determine the richness of bird fauna by making direct observations of the different species using 7 x 35 binoculars.

3. Species richness of amphibians and reptiles was determined by actively searching for adult individuals, larvae, feces, among other direct and indirect pieces of evidence. In some cases observation required the use of binoculars to ensure species identification.

The overall list of species involved in both studies, plus a list of potential species based on their distribution, the abundance of species in each study and total for both studies, as well as the conservation status of the observed and potential species were recorded.

For a specification and taxonomy of the species present in the region of the Project the following references were used: Cofré & Marquet (1999) and Muñoz & Yañez (2000) for mammals; Araya *et al*. (1995) and Jaramillo *et al*. (2003) for birds, and Capurro (1958), Donoso-Barros (1966), Valencia & Veloso (1981), Díaz (1983), Veloso & Navarro (1988), Nuñez (1992), Formas (1995), Carothers et al. (1997) and Jaramillo *et al*. (1998), Carothers & Jaksic (2001), and Díaz-Páez & Ortiz (2003) for amphibians and reptiles. To determine the conservation status of the species, information from the Agricultural and Livestock Service's (SAG) (1998) statutory Hunting Regulations was used.

b) Aucayes-Maitenes (November 15, 2007)

Two sectors with well-defined interventions can be defined in the study area: one is the sector where muck disposal and a camp will be set up during the construction of the project; the other is where an access road will be built. Additionally, there are two spots that cross the river and are defined as "water intakes". Due to the singular nature of the bird species associated to watercourses, they have been separated into a particular sector. Thus, three sectors have been identified:

- Muck disposal sector
- Service road sector
- Existing water intake sector

To characterize the fauna component, all the sectors in the area of influence were traversed and 24 fauna observation points were set up (Table 5.4.2.2).

Table 5.4.2.2
Coordinates of Fauna Observation Points – Aucayes-Maitenes

Fauna Observation Points	UTM (m) Coordinates	Fauna Observation Points	UTM (m) Coordinates
1	19 H 383403 6288878	13	19 H 383212 6288558
2	19 H 383403 6288800	14	19 H 383149 6288678
3	19 H 383260 6288942	15	19 H 383397 6288444
4	19 H 383401 6289014	16	19 H 383463 6288376
5	19 H 383428 6288873	17	19 H 383577 6288157
6	19 H 383574 6288794	18	19 H 383246 6288643
7	19 H 383683 6288666	19	19 H 383514 6288212
8	19 H 383782 6288472	20	19 H 383729 6287959
9	19 H 383829 6288097	21	19 H 383245 6288639
10	19 H 383934 6288269	22	19 H 383473 6288346
11	19 H 383934 6288177	23	19 H 383587 6288141
12	19 H 383773 6287787	24	19 H 383729 6287844

In the Muck Disposal sector[1] fauna was recorded as follows:

1. Mammals were recorded by means of direct evidence (observations) whenever possible, and by indirect evidence such as feces, bone remains, footprints and burrows.

2. To determine the richness of bird fauna, direct observations of the different species were made using 8 x 43 binoculars in each of the fauna observation points set up, as well as along an approximately 30-m wide 1,000 m long transect across the study area.

3. Species richness of reptiles was determined by actively searching for adult individuals, among other direct and indirect pieces of evidence, in the various environments surveyed along an 8-m wide 600 m long transect across the area to be intervened.

In the Road sector fauna was recorded as follows:

1. Mammals were tracked by an intensive visual survey of the area, seeking evidence of their presence, considering feces, forage and other organic vestiges.

2. To determine the richness of bird fauna, 30 m wide transects were made along the layouts, and the individuals detected were recorded either visually or by sound.

3. Reptiles were tracked by an intensive visual survey of the area, considering different habitat conditions.

[1] The area that will be used for storing and stockpiling materials during the execution of the project. works,

In the Water Intake sector fauna was recorded as follows:

1. To determine the richness of amphibians, intensive surveys were carried out on the sites designated for future water intakes. Each 25 m^2 point was tracked by examining these animals' holes and eventual shelters visually and by hand.

2. To determine the richness of bird fauna, the surroundings of the site identified as Water Intake were traversed in order to detect the presence of individuals both visually and by sound.

c) Aucayes-Alto (March 18, 2008)

Two sectors with well-defined interventions were established in the area of influence: one is the so-called "Tank" sector where a dam will be set up; the other is the area where a service road will be built. The latter was divided into two sectors on account of its size along an altitudinal gradient and the difference in the associated environments. Thus, three sectors have been identified:

- Tank Sector[2]
- Upper Road Sector
- Lower Road Sector

To characterize the fauna component, all the sectors in the area of influence were walked through and 14 fauna observation points were set up for the Tank Sector (Table 5.4.2.3), 17 fauna observation points for the Upper Road Sector (Table 5.4.2.4) and five fauna observation points for the Lower Road Sector (Table 5.4.2.5).

Table 5.4.2.3
Coordinates of Fauna Observation Points – Aucayes Alto, Tank Sector

Fauna Observation Points	UTM Coordinates (PSad 56)		Altitude (m.a.s.l.)
1	6284376	385558	2482 m
2	6284417	385471	2524 m
3	6284412	385444	2527 m
4	6284368	385338	2541 m
5	6284311	385349	2550 m
6	6284308	385376	2549 m
7	6284320	385537	2495 m
8	6284338	385615	2497 m
9	6284337	385717	2479 m
10	6284337	385763	2484 m
11	6284350	385796	2480 m
12	6284414	385792	2469 m
13	6284446	385772	2461 m
14	6284520	385778	2457 m

[2] Alfalfal II head tank

Table 5.4.2.4
Coordinates of Fauna Observation Points – Aucayes Alto, Upper Road Sector

Fauna Observation Points	UTM Coordinates (PSad 56)		Altitude (m.a.s.l.)
1	6284901	385817	2384 m
2	6284899	385793	2371 m
3	6284979	385643	2364 m
4	6285025	385582	2354 m
5	6284960	385508	2350 m
6	6284828	385411	2292 m
7	6284884	385340	2322 m
8	6284928	385332	2313 m
9	6284979	385308	2314 m
10	6284979	385280	2312 m
11	6284920	385219	2318 m
12	6284771	385197	2317 m
13	6284744	385250	2312 m
14	6284655	385062	2320 m
15	6284738	384757	2300 m
16	6284833	384704	2294 m
17	6284911	384434	2252 m

Table 5.4.2.5
Coordinates of Fauna Observation Points – Aucayes Alto, Lower Road Sector

Fauna Observation Points	UTM Coordinates (PSad 56)		Altitude (m.a.s.l.)
1	6285162	384797	2122 m
2	6285451	384781	2014 m
3	6285511	384893	2000 m
4	6285702	384700	1938 m
5	6286012	385052	1860 m

In the Tank Sector[3] fauna was recorded as follows:

1. Mammals were recorded by means of direct evidence (observations) whenever possible, and by indirect evidence such as feces, bone remains, footprints and burrows.

2. To determine the richness of bird fauna, direct observations of the different species were made using 10 x 43 binoculars in each of the fauna observation points set up, as well as along an approximately 30-m wide 500 m long transect across the study area.

3. Species richness of reptiles was determined by actively searching for adult individuals, among other direct and indirect pieces of evidence, in the various environments surveyed along an approximately 8-m wide 500 m long transect across the area to be intervened.

3 The area where a water storage tank will be installed.

In the Upper Road and Lower Road Sectors[4] fauna was recorded as follows:

1. Mammals were tracked by an intensive visual survey of the area, seeking evidence of their presence, considering feces, forage and other organic vestiges.

2. To determine the richness of bird fauna, 30 m wide transects were made along the layouts, and the individuals detected were recorded either visually or by sound.

3. To detect reptiles, individuals were tracked by an intensive visual survey of the area, considering different habitat conditions.

Categorization criteria for terrestrial vertebrate fauna with conservation problems

With the fauna information from field surveys, conservation categories were established pursuant to Hunting Law 19,472, which recognizes the following categories:

B= A species catalogued as beneficial for forestry, farming and livestock activities
S= A species catalogued as having reduced population densities
E= A species catalogued as beneficial for maintaining the equilibrium of natural ecosystems
P= Endangered
V= Vulnerable
R= Rare
I= Insufficiently Known

According to the *International Union for Conservation of Nature, the terms below are understood as follows:*

- *Endangered (P)*: Taxa facing a high risk of becoming extinct and whose survival is unlikely if adverse causal factors continue in operation.

- *Vulnerable (V):* Taxa whose conservation status is believed likely to change into Endangered in the near future if the threat causing factors continue operating.

- *Rare (R):* Taxa with small world populations that are currently neither Endangered nor Vulnerable but are at risk.

- *Insufficiently Known (I):* Taxa assumed to belong to one of the above categories, but for which there is no certainty due to the scanty information available.

4 Area where a service road is planned to be built.

5.4.2.4 General Results

a) Colorado River, La Engorda Canyon-El Morado Stream, Lo Encañado Lagoon-El Manzanito Stream, El Yeso Reservoir and River, and Aucayes Stream.

Between both field campaigns, a total of 86 species was recorded: three amphibians, nine reptiles, 70 bird species out of which nine are predatory birds, 10 waterfowls and 51 non-predatory birds; four species are mammals. Twenty-five species were recorded in the autumn season, in Lo Encañado sector, and 71 during the spring season; 53 species are new entries for all areas of this study (see Table 5.4.2.6).

In this manner, 37 species were found in the Colorado River sector, 27 in La Engorda and El Morado sector, 43 in Lo Encañado and El Manzanito sector, the latter not intervened by the Project, 19 species in El Yeso River sector and 39 in the Aucayes Stream (see Table 5.4.2.6).

Table 5.4.2.6
Observed Species Richness

Clasificación		Areas de Estudio					
Especies		Río Colorado	La Engorda-El Morado	Lo Encañado-Estero El Manzanito		El Yeso	Estero Aucayes
Nombre Científico	Nombre Común	Estudio 2	Estudio 2	Estudio 1	Estudio 2	Estudio 2	Estudio 2
CLASE ANFIBIOS							
FAMILIA BUFONIDAE							
Bufo spinolosus	Sapo espinoso			X	X		X
FAMILIA LEPTODACTYLIDAE							
Alsodes nodosus							X
Pleurodema thaul	Sapito de cuatro ojos	X		X			
CLASE REPTILES							
FAMILIA TROPIDURIDAE							
Liolaemus altissimus	Lagartija parda		X	X	X		
Liolaemus fuscus	Lagartija oscura	X					
Liolaemus lemniscatus	Lagartija lemniscata	X					X
Liolaemus monticola	Lagartija de los montes	X	X				X
Liolaemus moradoensis	Lagartija de El Morado		X				
Liolaemus nigroviridis	Lagartija negroverdosa		X	X	X	X	X
Liolaemus tenuis	Lagartija esbelta						X
Liolaemus valdesianus	Lagartija de Valdés		X				
FAMILIA TEIIDAE							
Callopistes palluma	Iguana	X					
CLASE AVES							
AVES RAPACES							
FAMILIA CATHARTIDAE							
Vultur gryphus	Cóndor		X		X	X	X
FAMILIA ACCIPITRIDAE							
Parabuteo unicinctus	Peuco	X					
Geranoaetus melanoleucus	Aguila	X	X				X
Buteo polyosoma	Aguilucho		X	X	X	X	
Buteo albigula	Aguilucho chico						X
FAMILIA FALCONIDAE							
Phalcoboenus megalopterus	Carancho cordillerano			X	X		
Milvago chimango	Tiuque	X					
Falco sparverius	Cernícalo	X			X	X	
FAMILIA STRIGIDAE							
Bubo virginianus	Tucúquere						X
AVES ACUATICAS							
FAMILIA PHALACROCORACIDAE							
Phalacrocorax brasilianus	Cormorán				X		
FAMILIA ARDEIDAE							
Ardea alba	Garza grande	X					
Nyctycorax nyctycorax	Huairavo			X			
FAMILIA ANATIDAE							
Cloephaga picta	Caiquén				X		
Merganetta armata	Pato cortacorriente				X		X
Lophonetta specularoides	Pato juarjual			X			
Anas flavirostris	Pato jergón chico			X			
Anas georgica	Pato jergon grande			X	X		
FAMILIA RALLIDAE							
Fulica armillata	Tagua común			X	X		
Fulica leucoptera	Tagua chica				X		
AVES NO RAPACES							
FAMILIA TINAMIDAE							
Nothoprocta perdicaria	Perdiz					X	
FAMILIA CHARADRIIDAE							
Vanellus chilensis	Queltehue	X					
FAMILIA SCOLOPACIDAE							
Gallinago paraguaiae	Becacina			X			
FAMILIA THINOCORIDAE							
Thinocorus orbignyanus	Perdicita cojón		X			X	
FAMILIA PHASIANIDAE							
Callipepla californica	Codorniz	X					X
FAMILIA COLUMBIDAE							
Zenaida auriculata	Tórtola	X					
Columbina picui	Tortolita cuyana	X					
Metriopelia melanoptera	Tortolita cordillerana		X	X	X	X	X

Clasificación		Areas de Estudio					
Especies		Río Colorado	La Engorda-El Morado	Lo Encañado-Estero El Manzanito		El Yeso	Estero Aucayes
Nombre Científico	**Nombre Común**	**Estudio 2**	**Estudio 2**	**Estudio 1**	**Estudio 2**	**Estudio 2**	**Estudio 2**
FAMILIA PSITACIDAE							
Psilopsianon aurifrons	Perico cordillerano				X		
FAMILIA TROCHILIDAE							
Patagona gigas	Picaflor gigante	X					X
Sephanoides galeritus	Picaflor chico	X					
Oreotrochilus leucoplerus	Picaflor cordillerano		X		X		X
FAMILIA PICIDAE							
Colaptes pitius	Pitío	X					X
Picoides lignarius	Carpinterito	X					X
FAMILIA FURNARIIDAE							
Geositta cunicularia	Minero				X	X	X
Geositta rufipennis	Minero cordillerano		X	X	X	X	
Upucerthia dumetaria	Bandurrilla				X	X	
Leptasthemura aegithaloides	Tijeral	X			X		X
Asthenes modesta	Canastero chico		X		X		
Asthenes humicola	Canastero	X					X
Cinclodes fuscus	Churrete acanelado	X		X	X		X
Cinclodes patagonicus	Churrete común	X	X		X		
Chilia melanura	Chiricoca						X
FAMILIA RHINOCRYPTIDAE							
Scytalopus fuscus	Churrín		X	X			
Pteroptochos megapodios	Turca	X					X
Scelorchilus albicollis	Tapaculo	X					
FAMILIA TYRANNIDAE							
Agriornis livida	Mero						X
Muscisaxicola maculirostris	Dormilona chica		X		X		
Muscisaxicola flavinucha	Dormilona fraile		X			X	
Muscisaxicola albilora	Dormilona de ceja blanca		X		X	X	X
Elaenia albiceps	Fío-fío	X					X
Anairetes parulus	Cachudito	X					X
FAMILIA PHYTOTOMIDAE							
Phytotoma rara	Rara				X		
FAMILIA HIRUNDINIDAE							
Tachycineta leucopyga	Golondrina chilena	X					X
Pygochelidon cyanoleuca	Golondrina de dorso negro		X	X	X	X	X
FAMILIA TROGLODYTIDAE							
Troglodytes aedon	Chercán	X		X	X	X	X
FAMILIA MUSCICAPIDAE							
Turdus falcklandii	Zorzal	X					X
FAMILIA MIMIDAE							
Mimus thenca	Tenca	X					X
FAMILIA EMBERIZIDAE							
Sicalis luteola	Chirihue	X					
Sicalis auriventris	Chirihue dorado		X	X	X	X	
Zonotrichia capensis	Chincol	X	X	X	X	X	X
Curaeus curaeus	Tordo	X					X
Sturnella loica	Loica	X					X
FAMILIA FRINGILIDAE							
Phrygilus gayi	Cometocino de Gay		X	X	X	X	X
Phrygilus fruticeti	Yal		X				X
Phrygilus alaudinus	Platero	X	X			X	
Phrygilus unicolor	Pájaro plomo		X		X	X	
Melanodera xhantograma	Yal cordillerano			X			
Diuca diuca	Diuca	X					X
Carduelis uropygialys	Jilguero cordillerano		X	X	X		
Carduelis barbatus	Jilguero	X					
CLASE MAMIFEROS							
FAMILIA SPALOCOPOCIDAE							
Spalocopus cyanus	Cururo			X	X		
FAMILIA CRICETIDAE							
Abrothrix olivaceus	Ratón oliváceo		X				
FAMILIA CANIDAE							
Pseudalopex culpaeus	Zorro culpeo			X	X		
FAMILIA LEPORIDAE							
Lepus europaeus	Liebre			X			X

The great majority of the species (representing all the classes under study) occupy terrestrial environments (sclerophyllous forest and scrubland below 2,000 m.a.s.l.; sub-Andean scrubland and Andean highland grassland above 2,000 m.a.s.l.), while the number of species that occupy aquatic media (river and stream watercourses below 2,000 m.a.s.l.; meadows, lagoons, and river and stream watercourses above 2,000 m.a.s.l.) is smaller; therefore, birds are almost the exclusive inhabitants of these environments. Amphibians and some non-predatory birds occupy both environments, see Table 5.4.2.7.

Table 5.4.2.7
Species Preferences for the Studied Environments

Clasificación		Ambientes	
Especies		Acuático	Terrestre
Nombre Científico	**Nombre Común**		
CLASE ANFIBIOS			
FAMILIA BUFONIDAE			
Bufo spinolosus	Sapo espinoso	X	X
FAMILIA LEPTODACTYLIDAE			
Alsodes nodosus		X	X
Pleurodema thaul	Sapito de cuatro ojos	X	X
CLASE REPTILES			
FAMILIA TROPIDURIDAE			
Liolaemus altissimus	Lagartija parda		X
Liolaemus fuscus	Lagartija oscura		X
Liolaemus lemniscatus	Lagartija lemniscata		X
Liolaemus monticola	Lagartija de los montes		X
Liolaemus moradoensis	Lagartija de El Morado		X
Liolaemus nigroviridis	Lagartija negroverdosa		X
Liolaemus tenuis	Lagartija esbelta		X
Liolaemus valdesianus	Lagartija de Valdés		X
FAMILIA TEIIDAE			
Callopistes palluma	Iguana		X
CLASE AVES			
AVES RAPACES			
FAMILIA CATHARTIDAE			
Vultur gryphus	Cóndor		X
FAMILIA ACCIPITRIDAE			
Parabuteo unicinctus	Peuco		X
Geranoaetus melanoleucus	Aguila		
Buteo polyosoma	Aguilucho		X
Buteo albigula	Aguilucho chico		X
FAMILIA FALCONIDAE			X
Phalcoboenus megalopterus	Carancho cordillerano		X
Milvago chimango	Tiuque		X
Falco sparverius	Cernícalo		X
FAMILIA STRIGIDAE			
Bubo virginianus	Tucúquere		X
AVES ACUATICAS			
FAMILIA PHALACROCORACIDAE			
Phalacrocorax brasilianus	Cormorán	X	
FAMILIA ARDEIDAE			
Ardea alba	Garza grande	X	
Nyctycorax nyctycorax	Huairavo	X	
FAMILIA ANATIDAE			
Merganetta armata	Pato cortacorriente	X	
Lophonetta specularoides	Pato juarjual	X	
Anas flavirostris	Pato jergón chico	X	
Anas georgica	Pato jergon grande	X	
FAMILIA RALLIDAE			
Fulica armillata	Tagua común	X	
Fulica leucoptera	Tagua chica	X	
AVES NO RAPACES			
FAMILIA TINAMIDAE			
Nothoprocta perdicaria	Perdiz		X
FAMILIA CHARADRIIDAE			
Vanellus chilensis	Queltehue	X	X
FAMILIA SCOLOPACIDAE			
Gallinago paraguaiae	Becacina	X	X
FAMILIA THINOCORIDAE			
Thinocorus orbignyanus	Perdicita cojón		X
FAMILIA PHASIANIDAE			
Callipepla californica	Codorniz		X
FAMILIA COLUMBIDAE			
Zenaida auriculata	Tórtola		X
Columbina picui	Tortolita cuyana		X
Metriopelia melanoptera	Tortolita cordillerana		X

Clasificación		Ambientes	
Especies		Acuático	Terrestre
Nombre Científico	**Nombre Común**		
FAMILIA PSITACIDAE			
Psilopsianon aurifrons	Perico cordillerano		X
FAMILIA TROCHILIDAE			
Patagona gigas	Picaflor gigante		X
Sephanoides galeritus	Picaflor chico		X
Oreotrochilus leucoplerus	Picaflor cordillerano		X
FAMILIA PICIDAE			
Colaptes pitius	Pitío		X
Picoides lignarius	Carpinterito		X
FAMILIA FURNARIIDAE			
Geositta cunicularia	Minero		X
Geositta rufipennis	Minero cordillerano		X
Upucerthia dumetaria	Bandurrilla		X
Leptasthemura aegithaloides	Tijeral		X
Asthenes modesta	Canastero chico	X	X
Asthenes humicola	Canastero		X
Cinclodes fuscus	Churrete acanelado	X	X
Cinclodes patagonicus	Churrete común	X	X
Chilia melanura	Chiricoca		X
FAMILIA RHINOCRYPTIDAE			
Scytalopus fuscus	Churrín	X	X
Pteroptochos megapodios	Turca		X
Scelorchilus albicollis	Tapaculo		X
FAMILIA TYRANNIDAE			
Agriornis livida	Mero		X
Muscisaxicola maculirostris	Dormilona chica	X	X
Muscisaxicola flavinucha	Dormilona fraile	X	X
Muscisaxicola albilora	Dormilona de ceja blanca	X	X
Elaenia albiceps	Fío-fío		X
Anairetes parulus	Cachudito		X
FAMILIA PHYTOTOMIDAE			
Phytotoma rara	Rara		X
FAMILIA HIRUNDINIDAE			
Tachycineta leucopyga	Golondrina chilena	X	X
Pygochelidon cyanoleuca	Golondrina de dorso negro	X	X
FAMILIA TROGLODYTIDAE			
Troglodytes aedon	Chercán		X
FAMILIA MUSCICAPIDAE			
Turdus falcklandii	Zorzal		X
FAMILIA MIMIDAE			
Mimus thenca	Tenca		X
FAMILIA EMBERIZIDAE			
Sicalis luteola	Chirihue		X
Sicalis auriventris	Chirihue dorado		X
Zonotrichia capensis	Chincol		X
Curaeus curaeus	Tordo		X
Sturnella loica	Loica		X
FAMILIA FRINGILIDAE			
Phrygilus gayi	Cometocino de Gay		X
Phrygilus fruticeti	Yal		X
Phrygilus alaudinus	Platero		X
Phrygilus unicolor	Pájaro plomo		X
Melanodera xhantograma	Yal cordillerano		X
Diuca diuca	Diuca		X
Carduelis uropygialys	Jilguero cordillerano		X
Carduelis barbatus	Jilguero		X
CLASE MAMIFEROS			
FAMILIA SPALOCOPOCIDAE			
Spalocopus cyanus	Cururo		X
FAMILIA CRICETIDAE			
Abrothrix olivaceus	Ratón oliváceo		X
FAMILIA CANIDAE			
Pseudalopex culpaeus	Zorro culpeo		X
FAMILIA LEPORIDAE			
Lepus europaeus	Liebre		X

According to their range of distribution, 35 species are rated as potential species: six reptiles, 17 birds (four predatory birds, four waterfowl, and nine non-predatory birds) and 12 mammals (see Table 5.4.2.8). Most of the species show a wide range of altitudinal distribution and occupy environments involving sclerophyllous scrubland/forest formations and sub-Andean scrubland as well as Andean highland steppe; an important proportion is characteristic of sub-Andean and Andean highland environments (above 2,000 m.a.s.l.). Additionally, the number of species that inhabit terrestrial environments trebles the number of those living in aquatic environments (see Table 5.4.2.8).

Table 5.4.2.8
Potential Species for the Study Area

Clasificación		Según Distribución		Por Ambientes	
Especies		Bajo los 2000 msnm	Sobre los 2000 msnm	Acuático	Terrestre
Nombre Científico	Nombre Común				
CLASE REPTILES					
FAMILIA COLUBRIDAE					
Philodryas chamissonis	Culebra de cola larga	X	X	X	X
FAMILIA TROPIDURIDAE					
Liolaemus chiliensis	Lagarto chileno	X			X
Liolaemus fitzgeraldi	Lagartija de Fitzgerald	X			X
Liolaemus leopardinus	Lagartija leopardo		X		X
Liolaemus schroederi	Lagarto de Schroeder	X			X
Phymaturus flagellifer	Matuasto		X		X
CLASE AVES					
AVES RAPACES					
FAMILIA ACCIPITRIDAE					
Circus cinereus	Vari	X	X		X
FAMILIA FALCONIDAE					
Polyborus plancus	Traro		X		X
Falco femoralis	Halcón perdiguero	X	X		X
Falco peregrinus	Halcón peregrino	X	X		X
AVES ACUATICAS					
FAMILIA PODICIPEDIDAE					
Rollandia rolland	Pimpollo	X	X	X	
FAMILIA ANATIDAE					
Cloephaga melanoptera	Piuquén		X		
FAMILIA LARIDAE					
Larus serranus	Gaviota andina		X	X	
FAMILIA RALLIDAE					
Pardirallus sanguinolentus	Pidén	X	X	X	
AVES NO RAPACES					
FAMILIA CHARADRIIDAE					
Phegornis mitchellii	Chorlito cordillerano		X	X	X
FAMILIA CAPRIMULGIDAE					
Caprimulgus longirostris	Gallina ciega	X			X
FAMILIA THINOCORIDAE					
Attagis gayi	Perdicita cordillerana				X
FAMILIA FURNARIIDAE					
Xolmis pyrope	Diucón	X	X		X
Colorhamphus parvirostris	Viudita	X	X		X
FAMILIA TYRANNIDAE					
Agriornis montana	Mero gaucho		X		X
Muscisaxicola cinerea	Dormilona cenicienta		X	X	X
Muscisaxicola macloviana	Dormilona tontito	X	X	X	X
FAMILIA MOTICILLIDAE					
Anthus correndera	Bailarín chico		X		X
CLASE MAMIFEROS					
FAMILIA VESPERTIOLINIDAE					
Lasiurus borealis	Murciélago colorado		X		X
FAMILIA CRICETIDAE					
Loxodontomis pikumche					X
Phyllotis darwini	Lauchón orejudo de Darwin	X	X		X
Phillotis xanthopigus	Lauchón orejudo andino		X		X
Abrothrix andinus	Laucha andina		X		X
FAMILIA CHINCHILLIDAE					
Lagidium viscacia	Viscacha de montaña		X		X
FAMILIA CANIDAE					
Pseudalopex griseus	Zorro chilla	X	X	X	X
FAMILIA MUSTELIDAE					
Galictis cuja	Quique	X	X	X	X
Conepatus chinga	Chingue	X	X	X	X
FAMILIA FELIDAE					
Lynchailurus colocolo	Gato colocolo		X		X
Puma concolor	Puma		X		X
Oncyfelis guigna	Güiña		X		X
FAMILIA CAMELIDAE					
Lama guanicoe	Guanaco		X		X

A. Species Richness by Class

The Andean spiny toad, *Bufo spinolosus,* the black spiny-chest frog, *Alsodes nodosus* and the four-eyed frog, *Pleurodema thaul*, are the three species of amphibians recorded during spring and autumn, respectively (see Table 5.4.2.6).

Seven new reptile species were recorded during the spring campaign; out of the records obtained, only the brown lizard, *Liolaemus altissimus* and the blackish-green lizard, *L. nigroviridis* were observed in autumn (see Table 5.4.2.6).

Birds formed the most heterogeneous group, with non-predators being the most representative of the study area. During the spring of 2006 fifteen species more than in the autumn of 2005 were recorded; several of them were recorded in the Colorado River sector, below 2,000 m.a.s.l., representative of the habitats corresponding to the sclerophyllous scrubland vegetation formations (see Table 5.4.2.6).

In the case of mammals, a larger number of records were obtained during the autumn campaign. Just like in this campaign, the records were obtained from indirect pieces of evidence such as feces and holes (see Table 5.4.2.6).

B. Species Richness by Study Area

- **Colorado River**

During the spring campaign, 37 species were counted: one amphibian, four reptiles and 31 birds (four predatory birds, one waterfowl and 27 non-predatory birds).

In the Maipo River discharge zone (see Photograph 5.4.2.1) the identification of the following species is worth noting:

- The elegant tree iguana, *Liolaemus lemniscatus* (see Photograph 5.4.2.1), a species typical of pastureland environments in the sclerophyllous scrubland, was the only reptile observed. Even though this species was relatively less abundant with respect to observations made by the specialists in similar environments, it should be the most abundant in the area, as it is the most common and abundant in the central valley (Mella, 2005).

- The white-crested elaenia, *Elaenia albiceps,* a summer migratory species, quite abundant both in anthropized and wild environments. It makes use of native and foreign vegetation to develop its life history features; however, it has the peculiarity of living preferably in very tall trees or tree-like shrubs, a characteristic that may serve as an indicator in the event that flora pertaining to these strata is removed.

Photograph 5.4.2.1. Elegant Tree Iguana, *Liolaemus lemniscatus*.

In Las Lajas Tunnel sector associated to windows 1 and 3 and on the road crossing to the muck disposal and camp sector, species characteristic of sclerophyllous scrubland associated to very tall soapbark tree forest were observed. The following species are worth noting:

- The elegant tree iguana, *Liolaemus lemniscatus,* is the most abundant lizard in these vegetation formations.

- The brown tree iguana, *Liolaemus fuscus* (see Photograph 5.4.2.2), is a common, but not abundant species (Mella, 2005); due to its saxicolous habits, it was observed preferably on bare rocks and zones, retreating under rocks or isolated low bushes in the presence of the specialists. In this case, two individuals were recorded in the above-mentioned areas; this proportionately indicates a low abundance with respect of the number of elegant tree iguana individuals observed.

- The iguana, *Callopistes palluma* (see Photograph 5.4.2.3), is an uncommon species; it emerges and develops most of its life history features during the summer season, for which reason it is considered to exhibit a short reproductive episode. Although it is deemed to be an abundant species (Mella, 2005), the single record obtained coincides with other observations made in similar environments of Chile's central region, with respect to the low number of individuals over large areas, including those where it should be more abundant, such as rocky and sunny environments.

- Birds in the Rhinocryptidae family such as the moustached turka, *Pteroptochos megapodius,* and the white-throated *Scelorchilus albicollis*, are walking birds as the other representatives of this family. Although they are abundant species in the central region of the country (in the study area about five individuals were observed and three were heard within a 50 m radius), their regional distribution is restricted (IV to VII regions) and they are strongly associated with humid, rocky slopes with low bushes, i.e., vulnerable environments in high-impact zones.

- Woodpeckers (FAM: Picidae), a common, but not abundant species whose importance lies in that they get their food (xilofagous insects) from mature trees, notably, in this case, the soapbark tree, *Quillaja saponaria,* and the frangel, *Kageneckia angustifolia.*

Photograph 5.4.2.2. Brown Tree Iguana, *Liolaemus fuscus*. A species declared to be "Out of Danger."

Photograph 5.4.2.3. Iguana, *Callopistes palluma*. A "Vulnerable" Species.

In the siphon and surge tank sector close to El Alfalfal power plant and the Quempo Stream[5], species associated to the Colorado River were recorded, with the following being worth noting:

- Amphibian larvae, probably of the four-eyed frog, *Pleurodema thaul* (see Photograph 5.4.2.4). Observation of larvae was specifically carried out in stagnant waters on the banks of the main watercourse of the Colorado River; here the number of larvae is high, a common situation during the initial stages of these vertebrates. However, it was not possible to observe adult individuals, who can provide information about the number of individuals that reach adulthood both as a measure of reproductive success and as the likelihood of setting up future viable generations from a

[5] Not intervened by the Project.

metapopulation standpoint.

On the northern slopes where the channel has been planned, near the frangel, *Kageneckia angustifolia* forest, the following species of interest were identified:

- The mountain lizard, *Liolaemus monticola* (see Photograph 5.4.2.5) is the second most abundant after the elegant tree iguana; this species makes use of a wide variety of habitats, from xeric to forests, but always associated to rocks, as was demonstrated in the field.

- The dusky-tailed canastero, *Asthenes humicola*; even though it is relatively abundant below 2,000 m.a.s.l. in the central region of Chile, its importance lies in the fact that it is endemic.

Photograph 5.4.2.4. Larvae, probably pertaining to the four-eyed frog, *Pleurodema thaul*. A "Vulnerable" Species.

Photograph 5.4.2.5. Mountain Lizard, *Liolaemus monticola.* A "Vulnerable" Species.

- ***La Engorda Ravine and El Morado Stream***

Twenty-five species were identified in La Engorda Ravine and El Morado Stream sector, all of them representatives of Andean highland environments, with few species distributed below 2,000 m.a.s.l. Three species belong to the reptile class, 21 to the bird class (3 are predatory and 18 are non-predatory birds), and one species to the mammalia class (see Table 5.4.2.6).

The great majority of the species, most of them characteristic of Andean highland environments, was found in habitats with pulvinate shrub/herb species and tufted grasses. The following are worth mentioning:

- The brown lizard, *Liolaemus altissimus*, a widely distributed species in the central Andean Cordillera; it is even more abundant in the Metropolitan Region, as evidenced by the observations made in the field campaign carried out in spring 2006.

- The Andean lizard, *Liolaemus moradoensis* (see Photograph 5.4.2.6), described only for this Andean canyon in the Metropolitan Region. During the spring survey, only three isolated individuals were recorded under similar habitat conditions (on small rocks amidst vegetation, far from lacustrine areas) in the vegetation unit consisting of low woody plants with dense to sparse herbaceous plants.

- The Lo Valdés lizard, *Liolaemus valdesianus* (see Photograph 5.4.2.7), characteristic of the Metropolitan Region, quite abundant (Mella, 2005), as shown in this study, at least in this area, as it was the second most abundant after *L. altissimus.*

- The blackish-green lizard, *Liolaemus nigroviridis*, is considered uncommon and abundant (Mella, 2005); this time it proved to be non-abundant in this study area; it forms associations with the species mentioned above.

- Birds such as the rufous-banded miner, *Geositta rufipennis*, the greater yellow-finch, *Sicalis auriventris* and the grey-hooded sierra-finch, *Phrygilus gayi* (see Table 5.4.2.6); although these are quite abundant and with wide latitudinal distribution, they are exclusive of Andean regions and are well accustomed to this type of vegetation.

- In the sector covered by wet meadows, i.e., vegetation in watercourses emerging from flooded grounds, the following species should be highlighted:

- Larvae of Andean spiny toad, *Bufo spinolosus* (see Photograph 5.4.2.8); the record apparently corresponds to the first emergence in the summer period, after ice thawing and an increase in temperatures. As in the case with *Pleurodema thaul*, an abundant number of larvae in the initial stage of these species were recorded; however, no adults that may lead to estimating a viable adult population were recorded.

- Birds of the genus *Muscisaxicola*, they obtain their food from land environments, e.g., vegetated with low woody plants. Usually seen perched. There is high abundance of these species in the Andean region; actually, they are the most frequent and common.

- In full-flowing watercourses, mainly along riverbanks or stream banks, the following species are worth noting:

- Birds such as the dark-bellied cinclodes, *Cinclodes patagonicus* and the dusky tapaculo, *Scytalopus fuscus*: these species are non-abundant, but common; they were observed foraging along watercourses, sometimes standing on rocks inside watercourses and retreating to cavities under large rocks in the presence of the specialists (see Table 5.4.2.6).

Photograph 5.4.2.6. Andean Lizard, *Liolaemus moradoensis*. A species rated as “Rare”

Photograph 5.4.2.7. Lo Valdés Lizard, *Liolaemus valdesianus*.

Photograph 5.4.2.8. Larvae of Andean spiny toad, *Bufo spinolosus*. A “Vulnerable” Species.

At the top of the hills forming La Engorda Canyon, predatory birds of particular interest due to their importance in the food chain of the vertebrate communities in the central Andean region were recorded. The following species are worth noting:

- The condor, *Vultur gryphus*, the eagle, *Geranoaetus melanoleucus* and the variable hawk, *Buteo polyosoma*; only a couple of individuals of each species were recorded. These are common, but non-abundant species widely distributed over the central Andean Cordillera and their degree of threat is associated to the presence of human beings moving into more pristine areas (see Table 5.4.2.6).

In the sector of El Morado Stream, corresponding to a stonier area of sedimentary origin where the muck disposal sector and camp have been planned, the above-mentioned lizard species (the brown lizard, *Liolaemus altissimus,* the Andean lizard, *Liolaemus moradoensis,* Lo Valdés lizard, *Liolaemus valdesianus* and the blackish green lizard, *Liolaemus nigroviridis*), as well as the mountain lizard, *Liolaemus monticola,* were frequently observed. The most abundant were *L. altissimus and L. valdesianus.*

Other species that may describe the type habitat of El Morado Stream are:

- Birds such as the rufous-collared sparrow, *Zonotrichia capensis*, the black-winged ground dove, *Metriopelia melanoptera*, the Cordilleran canastero, *Asthenes modesta*, the mourning sierra-finch, *Phrygilus fruticetti* and the band-tailed sierra-finch, *Phrygilus alaudinus* (in order of abundance) were frequently observed over the large rocks in this study area (see Table 5.4.2.6).

The olive grass mouse, *Abrothrix olivaceus*, could be recorded among the rocks, when a dried corpse in medium-well state of preservation was found. Even though this is quite an abundant species in sclerophyllous scrubland areas, its populations begin declining with altitude. In rocky areas, they dig tunnels and, in some cases, they use burrows such as those abandoned by the subterranean rodent cururo.

- ***Lo Encañado and El Manzanito***

Forty-three species were recorded in Lo Encañado and El Manzanito sector as a result of two surveys (autumn 2005 and spring 2006). Two species were amphibians, two were reptiles, 39 were birds (four predatory birds, nine aquatic birds and 26 non predatory birds) and three are mammals (see Table 5.4.2.6).

In Lo Encañado Lagoon, three new species could be observed in spring:

- The neotropic cormorant, *Phalacrocorax brasilianus*: only one individual.
- The upland goose, *Cloephaga picta*, an inhabitant from the austral winter in the central region of Chile (Jaramillo et al. 2003): two couples. An apparently non-abundant species in the central region, it is quite abundant in Patagonia.
- The white-winged coot, *Fulica leucoptera*: only one individual, although this does not mean it is non-abundant in the Andean Cordillera of central Chile. This species forms abundant communities with the red-gartered coot, *Fulica armillata* and the red-fronted coot, *Fulica rufifrons*.

In lagoons formed by the ravines flowing into Lo Encañado Lagoon, this time one hundred individuals of the Andean spiny toad could be seen (Photograph 5.4.2.9) and a similar amount of larvae. In addition to this, the presence of the four-eyed frog was recorded in autumn.

In connection with mammals, once again tunnels indicating the presence of the subterranean rodent cururo, *Spalacopus cyanus,* were recorded around the lagoon, as well as fox feces most probably from the culpeo fox, *Pseudalopex culpaeus*, as presumed in the autumn campaign (see Table 5.4.2.6).

Photograph 5.4.2.9. Andean Spiny Toad, *Bufo spinolosus*. A "Vulnerable" Species.

In the sector where the road adjacent to the lagoon has been planned, which is characterized by the abundance of large rocks and low thorny shrubs with sparse herbaceous plants, a large number of birds could be seen, out of which the following are worth noting:

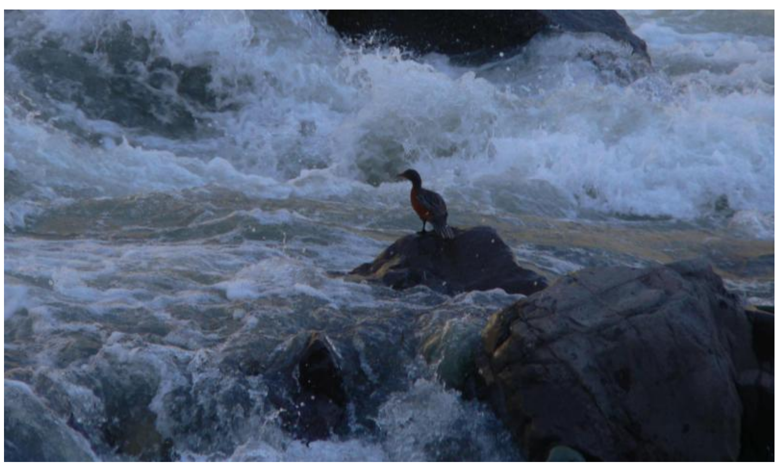
- The rufous-tailed plant cutter, *Phytotoma rara*, only one of which was recorded. This is a unique herbivore species in Chile, and this would appear to be its altitudinal limit.
- The scale-throated earth creeper, *Upucerthia dumetaria*, the plumbeous sierra-finch, *Phrygilus unicolor,* and the yellow-rumped Siskin, *Carduelis uropygialis*, considered to have reduced population densities, are frequent inhabitants of rocky Andean environments.

Both in this zone and in other similar ones at a lower altitude –where the channel, road, muck disposal sector and camp have been planned– adjacent to El Manzanito Stream, other non-predatory birds descriptive of this type of habitat (high percentage of bare rocks and soil with the presence of formations of low, woody shrubs with dense to sparse herbaceous plants) were observed:

The greater yellow-finch, *Sicalis auriventris*, the rufous-banded miner, *Geositta rufipennis* (see Photograph 5.4.2.10), white-browed ground-tyrant, *Muscisaxicola albilora*, the scale-throated earth creeper, *Upucerthia dumetaria*, and the yellow-bridled finch, *Melanodera xanthogramma* (in order of abundance) were observed mainly perched on rocks and feeding on seeds supplied by the dominant vegetation (see Table 5.4.2.6).

Photograph 5.4.2.10. Rufous-banded Miner, *Geositta rufipennis*.

In Lo Encañado Lagoon, El Manzanito Stream, in a fast-flowing area, on large rocks inside the watercourse, it was possible to record the torrent duck, *Merganetta armata*, identified as a female individual (see Photograph 5.4.2.11). This species is well-established in Andean river and stream water bodies, as it uses them as corridors during low altitude flying and perches on rocks sticking out of the water.



Photograph 5.4.2.11. Torrent Duck, *Merganetta armata*.

Finally, through the literature it is possible to determine the presence of the cocoi heron *(Ardea cocoi)* and stripe-backed bittern *(Ixobrychus involucris),* both listed as Rare in the *Red Book* of *Chilean Terrestrial Vertebrates;* and the Perico cordillerano (Psilopsianon aurifrons), included in the Hunting Law regulations as featuring a reduced population density, and occasionally recorded throughout most of its range of distribution, and during local migration of its populations. Also recorded is the presence of the cougar (*Felis concolor*), rated as Vulnerable, and the culpeo fox (*Canis culpaeus*), rated as Insufficiently Known: both mammals with wide-ranging home territories and great territorial mobility.

- ***El Yeso River***

In El Yeso River and Reservoir sector 19 species were recorded: one reptile and 18 birds, three of which are predators and 15 are non-predators (see Table 5.4.2.6).

In the reservoir area the following species of interest were recorded:

- The blackish-green lizard, *Liolaemus nigroviridis* (see Photograph 5.4.2.12) on rocky ground in the hills circumscribing the reservoir. The number of individuals counted was low (i.e., two individuals) bearing in mind that this is a common, but non-abundant species.

On the other hand, in the area adjacent to the siphon location, which is a wet meadow formed by highly abundant perennial herbs, the following species of interest were observed:

- The American kestrel, *Falco sparverius*, was observed (only one individual) in the central Los Andes area; it inhabits open places and is probably associated to some constructions and cattle that were grazing in the area.

- The grey-hooded sierra-finch, *Phrygilus gayi*, a highly appealing, colorful species, is highly abundant in this place and in the remaining study areas.

- In the sector where the camp and muck disposal sector have been planned, the following species of interest were observed.

- The grey-breasted seedsnipe, *Thinocorus orbignyianus* (see Photograph 5.4.2.13), which was found building a nest under rocks in an environment almost deprived of vegetation. Non-abundant, but common, it is a species restricted only to Andean environments (see Table 5.4.2.6).

Photograph 5.4.2.12. Blackish-green Lizard, *Liolaemus nigroviridis*. A species rated as “Vulnerable”.

Photograph 5.4.2.13. Grey-breasted Seedsnipe, *Thinocorus orbygnianus*.

- ***Aucayes Stream***

Thirty-nine species were identified in the Aucayes Stream. Through fauna observation points set up between 1,000 m.a.s.l and 2,400 m.a.s.l., species that regularly inhabit sclerophyllous scrubland and sub-Andean landscapes –and that exhibit a wider altitudinal distribution (even as far as the coast)– could be surveyed. In a smaller proportion, species that are more frequently spotted in Andean habitats than in habitats below 2,000 m.a.s.l., were observed. Examples of these are the mountain lizard, *Liolaemus monticola*, the white-sided hillstar, *Oreotrochilus leucopleurus,* the black-winged ground dove, *Metriopelia melanoptera* and the white-browed ground-tyrant, *Muscisaxicola albilora*. The dominant landscape is generally characterized by flat lands with greater accumulation and soil formation, and abundant vegetable species covering extensive areas. Worth mentioning are species and formations associated to frangel (*Kageneckia angustifolia*), soapbark tree (*Quillaja saponaria*), mayten tree (*Maytenus boaria*) and tralhuen (*Trevoa quinquinervia*) forests.

In general, the most common species are the most abundant due to their versatility in using habitats at different altitudes.

Some species of interest observed in this study area are described below.

- The black spiny-chest frog *Alsodes nodosus* (see Photograph 5.4.2.14); this endemic species associated to the Aucayes and El Toyo Stream is less common in the Andean Cordillera than the Andean spiny toad, which by comparison was highly abundant.

- The elegant tree iguana, *Liolaemus lemniscatus* and the tree-dwelling lizard, *L. tenuis* (see Photograph 5.4.2.15), were common and abundant below 2,000 m.a.s.l. associated to areas with extensive vegetation cover.

- *Liolaemus monticola* and *L. nigroviridis* were common, but less abundant than the above mentioned ones, above 2,000 m.a.s.l.

- The great horned owl, *Bubo virginianus*, a widely distributed species in the country; as most predatory birds, it is relatively non-abundant, but important in the food chain.

- The white-throated hawk, *Buteo albigula*, a characteristic bird of Andean environments, is an uncommon species in the central zone, with its populations increasing with latitude going south; it becomes more common in the southern temperate forests, where it is more abundant and faces a lesser degree of threat.

- The crag chilia, *Chilia melanura*, an endemic species in our country whose distribution is restricted to pre-Andean coastal and Andean environments between the V and VI Regions, is relatively unattractive and therefore uncommon, although no actual data of its population sizes is available.

- Relatively abundant in comparison to the other two study areas were the *Pícidos pitío,* Chilean flicker, *Colaptes pitius* and the striped woodpecker, *Picoides lignarius*, which were observed to have a strong association with mature frangel and soapbark tree forests.

Photograph 5.4.2.14. Black Spiny-chest Frog *Alsodes nodosus*. (Conservation status: “Endangered”).

Photograph 5.4.2.15. Tree-dwelling Lizard, *Liolaemus tenuis*.

C. Potential Species

In general, birds constitute the dominant group, followed by reptiles and mammals.

In the case of reptiles associated to sclerophyllous forest formations, greater species richness is to be expected, at least in the high Andes. Above 2,000 m.a.s.l. –i.e., the limit where vegetation characterizes the sclerophyllous and sub-Andean scrubland of Andean habitats– lower richness, but greater abundance is to be expected due to the high rock density, procumbent, thorny vegetation and, in some cases, tunnels dug by fossorial mammals.

In the case of predatory birds, their wide-ranging home territory allows them to occupy a large variety of habitats, although some species such as the crested caracara, *Polyborus plancus*, are restricted to Andean habitats –an interesting situation from the point of view of using spatial axes.

Among aquatic birds, above 2,000 m.a.s.l. the number of species decreases with altitude, although they are characteristic of highland lakes and lagoons. Towards lower areas characterized by dominant sclerophyllous formations and where river and stream watercourses form part of the landscape, a greater diversity of species also includes non-predatory birds that live in terrestrial environments.

Non-predatory birds are quite abundant above and below 2,000 m.a.s.l.; however, each of the environments is represented by a large number of species characteristic of the altitudinal bio geographical conditions prevailing in the Andean Cordillera.

Historically, Andean mammals have consisted of several large sized species that have either become uncommon, have been displaced or have become regionally extinct such as the herbivorous camelid guanaco, *Lama guanicoe,* and the southern viscacha, *Lagidium viscacia*.

Table 5.4.2.8 shows the potential species for the study area, both for sclerophyllous scrubland, Andean scrubland, and Andean highland meadows.

D. Species with Conservation Problems

Sixteen of the species recorded have a conservation status; most of them belong to the reptile class, followed by amphibians, mammals, and birds (see Table 5.4.2.9).

Two species are rated as **Endangered**: one is the *Alsodes nodosus*, a frog recorded in the Aucayes and El Toyo Stream; the latter forms part of the indirect area of influence of the Project. Two short-tailed individuals were observed. The other is the cururo, *Spalacopus cyanus*, a fossorial rodent that had quite a few active burrows in the area of Lo Encañado Lagoon during both surveys; it is a species that exhibits gregarious habits and complex social relationships.

Eight species are rated as **Vulnerable**:

- The Andean spiny toad, a species recorded at the larva stage in La Engorda Ravine, and both as larvae and adults in Lo Encañado Lagoon sector.
- The four-eyed frog, recorded in the sector of the channel, muck disposal, camp, siphon and surge tank close both to El Alfalfal power station and to the Quempo Stream and Lo Encañado Lagoon.
- The elegant tree iguana, along the Colorado River in the zone where it discharges into the Maipo River and Las Lajas Tunnel sector.
- The mountain lizard, spotted in the sector of the channel, muck disposal, camp, siphon and surge tank close both to El Alfalfal power station and to the Quempo and El Morado Streams.
- The blackish-green lizard, recorded in the canyon of La Engorda Ravine, and areas adjacent to El Yeso reservoir.
- The iguana, observed in Las Lajas Tunnel sector associated to window 1 and 3.
- The condor, spotted in sector of La Engorda Ravine, Lo Encañado Lagoon and El Yeso reservoir.
- The snipe, recorded in the sector of Lo Encañado Lagoon.

Four species are rated as **Rare**:

- The Andean lizard (*L. a. moradoensis*), a sub-species of *Liolaemus altissimus*; although not catalogued as a sub-species in terms of conservation status, it is identified with the status of its species.
- The brown lizard, which was observed in the sector of La Engorda Ravine, El Morado Stream, Lo Encañado Lagoon, and El Manzanito Stream.
- Lo Valdés lizard, observed in La Engorda Canyon.
- The white-throated hawk, observed in the Aucayes Stream.

One species is rated as **Insufficiently Known**: the culpeo fox, which was indirectly detected in the sector of Lo Encañado Lagoon (see Table 5.4.2.9).

Finally, one species is rated as **Out of Danger**: the brown tree iguana, observed in the sector of Las Lajas Tunnel associated to window 1 and 3.

Thirteen of the observed species are endemic to Chile, with reptiles being the group with the largest number of species. Five birds are endemic to the Mediterranean region of central Chile, out of which four were observed; all of them except for the partridge pertain to sclerophyllous environments below 2,000 m.a.s.l. (see Table 5.4.2.9).

Forty-two of the species recorded are considered as beneficial for forestry, farming and livestock activities; it should be noted that all predatory birds, woodpeckers, hummingbirds, *furnariidae, rhinocryptidae* and *tyrannides* are in this category. Twenty species have reduced population densities, especially the reptiles, and bird species associated to the Andean high mountain range, e.g., the *Fringillidae*. Forty-two species are considered as beneficial for the operation of ecosystems; again in this case, reptiles, predatory birds and tyrannidae are worth noting. The quail, *Callipepla californica* and the hare, *Lepus capensis*, are introduced species (see Table 5.4.2.9).

In the study area corresponding to the Colorado River, five species with a conservation status were counted: one amphibian and four reptiles, most of them rated as Vulnerable. In the sector of La Engorda Ravine and El Morado Stream, six species with a conservation status were found: five reptiles (two rated as Vulnerable and three as Rare) and the condor, rated as Vulnerable. In the area of Lo Encañado Lagoon, seven species with a conservation status were found: one Endangered (the cururo), four Vulnerable (two amphibians, one reptile, and one non-predatory bird), one Rare (a reptile) and one Insufficiently Known (the culpeo fox). In the sector of El Yeso River and reservoir, two species with a conservation status of Vulnerable were found: the blackish-green lizard and the condor. In the sector of the Aucayes Stream, eight species with a conservation status were found: one of them rated as Endangered, six as Vulnerable and one as Rare. Eight have reduced population densities. Reptiles are the main group with a conservation status and reduced population densities (see Table 5.4.2.9).

Among the potential species to be found in the area of influence of the project, 18 have a conservation status, with reptiles and mammals being the classes with the largest number of representatives (see Table 5.4.2.10). One reptile and five mammals are rated as Endangered, most of them also considered to have reduced population densities. Three species are rated as Vulnerable (one reptile, one predatory bird and one mustelid), and six species are Rare (two reptiles, two aquatic birds, the rufous-bellied seedsnipe among birds, and the skunk among mammals). Six species are endemic to our country: three reptiles and three mammals. Three species are rated as Inadequately Known: two are lizards and the fox, among the large mammals. Reptiles and mammals group the largest number of species with reduced populations (see Table 5.4.2.10).

Table 5.4.2.9
Conservation Status of Observed Species

Clasificación		Estado de conservación			
Especies		Cartilla de Caza (1)			
Nombre Científico	**Nombre Común**	**Zona Centro**	**B**	**S**	**E**
CLASE ANFIBIOS					
FAMILIA BUFONIDAE					
Bufo spinolosus	Sapo espinoso	V	B		E
FAMILIA LEPTODACTYLIDAE					
Alsodes nodosus En		P		S	E
Pleurodema thaul	Sapito de cuatro ojos	V			E
CLASE REPTILES					
FAMILIA TROPIDURIDAE					
Liolaemus altissimus En	Lagartija parda	R		S	E
Liolaemus fuscus En	Lagartija oscura	F	B		E
Liolaemus lemniscatus	Lagartija lemniscata	V		S	E
Liolaemus monticola En	Lagartija de los montes	V		S	E
Liolaemus moradoensis En	Lagartija de El Morado	R		S	E
Liolaemus nigroviridis En	Lagartija negroverdosa	V		S	E
Liolaemus tenuis	Lagartija esbelta	V		S	E
Liolaemus valdesianus En	Lagartija de Lo Valdés	R		S	E
FAMILIA TEIIDAE					
Callopistes palluma En	Iguana	V		S	E
CLASE AVES					
AVES RAPACES					
FAMILIA CATHARTIDAE					
Vultur gryphus	Cóndor	V	B		E
FAMILIA ACCIPITRIDAE					
Parabuteo unicinctus	Peuco	*	B		E
Geranoaetus melanoleucus	Aguila	*	B		E
Buteo polyosoma	Aguilucho	*	B		E
Buteo albigula	Aguilucho chico	R	B	S	E
FAMILIA FALCONIDAE					
Phalcoboenus megalopterus	Carancho cordillerano	*	B		E
Milvago chimango	Tiuque	*	B		E
Falco sparverius	Cernícalo	*	B		E
FAMILIA STRIGIDAE					
Bubo virginianus	Tucúquere	*	B		E
AVES ACUATICAS					
FAMILIA PHALACROCORACIDAE					
Phalacrocorax brasilianus	Cormorán	*			
FAMILIA ARDEIDAE					
Ardea alba	Garza grande	*	B		
Nyctycorax nyctycorax	Huairavo	*			E
FAMILIA ANATIDAE					
Cloephaga picta	Caiquén	*			
Merganetta armata	Pato cortacorriente	*		S	
Lophonetta specularoides	Pato juarjual	*			
Anas flavirostris	Pato jergón chico	*			
Anas georgica	Pato jergon grande	*			
FAMILIA RALLIDAE					
Fulica armillata	Tagua común	*			
Fulica leucoptera	Tagua chica	*			
AVES NO RAPACES					
FAMILIA TINAMIDAE					
Nothoprocta perdicaria En	Perdiz	*			
FAMILIA CHARADRIIDAE					
Vanellus chilensis	Queltehue	*	B		E
FAMILIA SCOLOPACIDAE					
Gallinago paraguaiae	Becacina	V	B		
FAMILIA THINOCORIDAE					
Thinocorus orbignyanus	Perdicita cojón	*		S	
FAMILIA PHASIANIDAE					
Callipepla californica	Codorniz	**			
FAMILIA COLUMBIDAE					
Zenaida auriculata	Tórtola	*			
Columbina picui	Tortolita cuyana	*			E
Metriopelia melanoptera	Tortolita cordillerana	*			E

Clasificación		Estado de conservación			
Especies		Cartilla de Caza (1)			
Nombre Científico	**Nombre Común**	**Zona Centro**	**B**	**S**	**E**
FAMILIA PSITACIDAE					
Psilopsianon aurifrons	Perico cordillerano	*		S	E
FAMILIA TROCHILIDAE					
Patagona gigas	Picaflor gigante	*	B		E
Sephanoides galeritus	Picaflor chico	*	B		E
Oreotrochilus leucoplerus	Picaflor cordillerano	*	B		E
FAMILIA PICIDAE					
Colaptes pitius	Pitío	*	B		
Picoides lignarius	Carpinterito	*	B	S	
FAMILIA FURNARIIDAE					
Geositta cunicularia	Minero	*	B		
Geositta rufipennis	Minero cordillerano	*	B		
Upucerthia dumetaria	Bandurrilla	*	B	S	
Leptasthemura aegithaloides	Tijeral	*	B		
Asthenes modesta	Canastero chico	*	B		
Asthenes humicola	Canastero	*	B		
Cinclodes fuscus	Churrete acanelado	*	B		
Cinclodes patagonicus	Churrete común	*	B		
Chilia melanura En	Chiricoca	*	B		
FAMILIA RHINOCRYPTIDAE					
Scytalopus fuscus	Churrín	*	B		
Pteroptochos megapodios En	Turca	*	B		
Scelorchilus albicollis En	Tapaculo	*	B		
FAMILIA TYRANNIDAE					
Agriornis livida	Mero	*	B		E
Muscisaxicola maculirostris	Dormilona chica	*	B		E
Muscisaxicola flavinucha	Dormilona fraile	*	B		E
Muscisaxicola albilora	Dormilona de ceja blanca	*	B		E
Elaenia albiceps	Fío-fío	*	B		E
Anairetes parulus	Cachudito	*	B		E
FAMILIA PHYTOTOMIDAE					
Phytotoma rara	Rara	*		S	E
FAMILIA HIRUNDINIDAE					
Tachycineta leucopyga	Golondrina chilena	*	B		E
Pygochelidon cyanoleuca	Golondrina de dorso negro	*	B		E
FAMILIA TROGLODYTIDAE					
Troglodytes aedon	Chercán	*	B		E
FAMILIA MUSCICAPIDAE					
Turdus falcklandii	Zorzal	*			
FAMILIA MIMIDAE					
Mimus thenca En	Tenca	*	B		
FAMILIA EMBERIZIDAE					
Sicalis luteola	Chirihue	*			
Sicalis auriventris	Chirihue dorado	*			
Zonotrichia capensis	Chincol	*	B		
Curaeus curaeus	Tordo	*			
Sturnella loica	Loica	*			E
FAMILIA FRINGILIDAE					
Phrygilus gayi	Cometocino de Gay	*			E
Phrygilus fruticeti	Yal	*			
Phrygilus alaudinus	Platero	*		S	
Phrygilus unicolor	Pájaro plomo	*		S	
Melanodera xanthograma	Yal cordillerano	*		S	
Diuca diuca	Diuca	*			
Carduelis uropygialys	Jilguero cordillerano	*		S	
Carduelis barbatus	Jilguero	*			
CLASE MAMIFEROS					
FAMILIA SPALOCOPOCIDAE					
Spalocopus cyanus	Cururo	P			
FAMILIA CRICETIDAE					
Abrothrix olivaceus	Ratón oliváceo	*			
FAMILIA CANIDAE					
Pseudalopex culpaeus	Zorro culpeo	I			E
FAMILIA LEPORIDAE					
Lepus europaeus	Liebre	**			

Table 5.4.2.10
Conservation Status of Potential Species

Clasificación		Estado de conservación			
Especies		Cartilla de Caza (1)			
Nombre Científico	Nombre Común	Zona Centro	B	S	E
CLASE REPTILES					
FAMILIA COLUBRIDAE					
Philodryas chamissonis En	Culebra de cola larga	V	B		E
FAMILIA TROPIDURIDAE					
Liolaemus chiliensis	Lagarto chileno	I	B		E
Liolaemus fitzgeraldi	Lagartija de Fitzgerald	R		S	E
Liolaemus leopardinus En	Lagartija leopardo	R		S	E
Liolaemus schroederi En	Lagarto de Schroeder	I		S	E
Phymaturus flagellifer	Matuasto	P		S	E
CLASE AVES					
AVES RAPACES					
FAMILIA ACCIPITRIDAE					
Circus cinereus	Vari	*	B		E
FAMILIA FALCONIDAE					
Polyborus plancus	Traro	*			
Falco femoralis	Halcón perdiguero	*	B		E
Falco peregrinus	Halcón peregrino	V	B	S	E
AVES ACUATICAS					
FAMILIA PODICIPEDIDAE					
Rollandia rolland	Pimpollo	*			E
FAMILIA ANATIDAE					
Cloephaga melanoptera	Piuquén	R			
FAMILIA LARIDAE					
Larus serranus	Gaviota andina	R		S	
FAMILIA RALLIDAE					
Pardirallus sanguinolentus	Pidén	*	B		
AVES NO RAPACES					
FAMILIA CHARADRIIDAE					
Phegornis mitchellii	Chorlito cordillerano	*	B	S	
FAMILIA CAPRIMULGIDAE					
Caprimulgus longirostris	Gallina ciega	*	B		E
FAMILIA THINOCORIDAE					
Attagis gayi	Perdicita cordillerana	R		S	
FAMILIA FURNARIIDAE					
Xolmis pyrope	Diucón	*	B		E
Colorhamphus parvirostris	Viudita	*	B		E
FAMILIA TYRANNIDAE					
Agriornis montana	Mero gaucho	*	B		E
Muscisaxicola cinerea	Dormilona cenicienta	*	B		E
Muscisaxicola macloviana	Dormilona tontito	*	B		E
FAMILIA MOTICILLIDAE					
Anthus correndera	Bailarín chico	*	B		E
CLASE MAMIFEROS					
FAMILIA VESPERTIOLINIDAE					
Lasiurus borealis	Murciélago colorado	*	B		
FAMILIA CRICETIDAE					
Loxodontomis pikumche En		*			
Phyllotis darwini En	Lauchón orejudo de Darwin	*			
Phillotis xanthopigus	Lauchón orejudo andino	*		S	
Abrothrix andinus	Laucha andina	*			
FAMILIA CHINCHILLIDAE					
Lagidium viscacia En	Viscacha de montaña	P		S	
FAMILIA CANIDAE					
Pseudalopex griseus	Zorro chilla	I			E
FAMILIA MUSTELIDAE					
Galictis cuja	Quique	V	B		E
Conepatus chinga	Chingue	R	B		E
FAMILIA FELIDAE					
Lynchailurus colocolo	Gato colocolo	P	B	S	E
Puma concolor	Puma	P			E
Oncyfelis guigna	Güiña	P	B	S	E
FAMILIA CAMELIDAE					
Lama guanicoe	Guanaco	P		S	

(1): Hunting Regulations, Agriculture and Livestock Service (SAG), 1998.

In: Endemic Species
I: Insufficiently Known
A. Indeterminate threat

R: Rare
V: Vulnerable
P: Endangered
I: Insufficiently Known
* = With no conservation status
** = Dangerous or invasive for men and natural and/or agricultural environments.
B. A species catalogued as beneficial for forestry, farming and livestock activities
S: A species catalogued as having reduced population densities
E: A species catalogued as beneficial for maintaining the equilibrium of natural ecosystems

b) **Aucayes-Maitenes**

A. Species Richness and Conservation Status

The presence of three vertebrate orders was detected in the study area: 19 families and 25 species (Table 5.4.2.11).

Table 5.4.2.11
Species List of Terrestrial Vertebrates Detected in the Muck Disposal Sector

Species	Common Name	Protection		Origin (3)	Dump Sector	Road Sector	Water Intake Sector
		CP (1)	EC (2)				
REPTILIA							
TROPIDURIDAE							
Liolaemus lemniscatus	Elegant Tree Iguana	S, E	V	Native	2	6	
Liolaemus nitidus	Shining Tree Iguana	S, E	V	Native	1		
Liolaemus monticola	Mountain Lizard	S, E	V	Native	4	3	
Liolaemus tenuis	Tree-dwelling Lizard	S, E	V	Native		3	
TEIIDAE							
Calopistes palluma	Chilean Iguana	S, E	V	Native		1	
COLUBRIDAE							
Phyllodria camissonis	Long-tailed Snake	B, E	V	Native		1	
BIRDS							
ANATIDAE							
Merganetta armata	Torrent duck	S		Native			1
CATHARTIDAE							
Vultur gryphus	Condor	B, E	V	Native	1		
ODONTOPHORIDAE							
Callipepla californica	Quail			Introduced		6	
COLUMBIDAE							
Metriopelia melanoptera	Black-winged Ground Dove			Native	10		
PICIDAE							
Picoides lignarius	Striped Woodpecker	B, S		Native		2	
FURNARIIDAE							
Cinclodes patagonicus	Dark-bellied Cinclodes	B		Native			2
Leptasthenura aegithaloides	Plain-mantled Tit-Spinetail	B		Native	2	1	
TYRANNIDAE							
Elaenia albiceps	White-crested Elaenia	B, E		Native	6	4	
HIRUNDINIDAE							
Tachycineta meyeni	Chilean Swallow	B, E		Native	12	3	
TROGLODYTIDAE							
Troglodytes aedon	House Wren	B, E		Native		11	
TURDIDAE							
Turdus falklandii	Austral Thrush			Native	1	1	
MIMIDAE							
Mimus thenca	Chilean Mockingbird	B		Endemic	4	1	
ICTERIDAE							
Curaeus curaeus	Austral Blackbird			Native		3	
EMBERIZIDAE							

Species	Common Name	Protection		Origin (3)	Dump Sector	Road Sector	Water Intake Sector
		CP (1)	EC (2)				
Diuca diuca	Common Diuca-Finch			Native	3	5	

Species	Common Name	Protection		Origin (3)	Dump Sector	Road Sector	Water Intake Sector
		CP (1)	EC (2)				
Phrygilus patagonicus	Patagonian Sierra-Finch	E		Native		3	
Zonotrichia capensis	Rufous-collared Sparrow	B		Native	5	4	
RHINOCRIPTIDAE							
Pteroptochos megapodius	Moustached Turka	B		Endemic	1	1	
MAMMALIA							
CANIDAE							
Pseudalopex sp	Fox	E	I	Native		X	
LEPORIDAE							
Oryctolagus cuniculus	Rabbit			Introduced	1	1	

Notes: (1) Protection criteria (CP)
E= A species catalogued as beneficial for maintaining the equilibrium of natural ecosystems
B= A species catalogued as beneficial for forestry, farming and livestock activities
S= A species catalogued as having reduced population densities
(2) Conservation Status (EC) for the Central Zone – Chile.
P = A species with a conservation status of Endangered
V = A species with a conservation status of Vulnerable
R = A species with a conservation status of Rare
I = A species with a conservation status of Insufficiently Known
(3) Origin
N = Native
E = Endemic
I = Introduced

B. Species Richness and Abundance by Study Area

- Muck Disposal Sector

In the area of influence of the muck disposal sector, the presence of three vertebrate orders was detected: 11 families and 14 species (Table 5.4.2.11).

a. Reptiles

A total of three species belonging to one family was recorded. The most abundant species on the site was *Liolaemus monticola*. Although the area designated for stockpiling and storing materials is subject to a high degree of alteration, this does not prevent herpetozoa from inhabiting it. The three species found have a conservation status of Vulnerable (Table 5.4.2.12).

Table 5.4.2.12
Relative Abundance of Reptiles in the Muck Disposal Sector

Species	Common Name	Relative Abundance
TROPIDURIDAE		
Liolaemus lemniscatus	Elegant Tree Iguana	28.57%
Liolaemus nitidus	Shining Tree Iguana	14.28%
Liolaemus monticola	Mountain Lizard	57.15%

Photograph 5.4.2.16. Adult individual of Shining Tree Iguana (*Liolaemus nitidus*) in the future muck disposal zone of the project.

Photograph 5.4.2.17. Adult individual of Mountain Lizard (*Liolaemus monticolis*) in the future muck disposal zone of the project.

Photograph 5.4.2.18. Adult individual of Elegant Tree Iguana (*Liolaemus lemniscatus*) in the future muck disposal zone of the project.

b. Birds

Ten bird species belonging to nine families were recorded in the Dump Sector. The most abundant species were *Tachycineta melleny* and *Metriopelia melanoptera*. Two endemic species were also recorded: *Mimus thenca* and *Pteroptochos megapodius*. Finally, one species having a conservation status of Vulnerable was recorded: the *Vultur gryphus* (Table 5.4.2.13).

Table 5.4.2.13
Relative Abundance of Birds in the Muck Disposal Sector

Species	Common Name	Relative Abundance
Vultur gryphus	Condor	2.22%
Metriopelia melanoptera	Black-winged Ground Dove	22.22%
Lepthastenura aegithaloides	Plain-mantled Tit-Spinetail	4.44%
Elaenia albiceps	White-crested Elaenia	13.33%
Tachycineta meyeni	Chilean Swallow	26.66%
Turdus falklandii	Austral Thrush	2.22%
Mimus thenca	Chilean Mockingbird	8.88%
Diuca diuca	Common Diuca-Finch	6.66%
Zonotrichia capensis	Rufous-collared Sparrow	11.11%
Pteroptochos megapodius	Moustached Turka	2.22%

Photograph 5.4.2.19. Adult individual of Black-winged Ground Dove (*Metriopelia melanoptera*) in the future muck disposal zone of the project.

Photograph 5.4.2.20. Young individual of Condor (*Vultur gryphus*) flying over the zone designated for the future materials stockpiling area of the project.

c. Mammals

The only wild mammal species recorded during the survey of the muck disposal sector was the *Oryctolagus cuniculus*, an introduced species considered harmful for production agro ecosystems.

- Road Sector

In the area of influence of the Road Sector, the presence of three vertebrate orders was detected: 16 families and 20 species (Table 5.4.2.14).

a. Reptiles

A total of five species belonging to three families was recorded. The most abundant species on the site was *Liolaemus lemniscatus*. The presence of larger-size reptiles such as *Callopistes palluma* and *Phylodryas chamissonis* is worth noting. With respect to species with conservation problems, the five species detected in the sector are listed as Vulnerable (Table 5.4.2.14).

Table 5.4.2.14
Abundance of Reptiles in the Road Sector

Species	Common Name	Relative Abundance
Liolaemus tenuis	Tree-dwelling Lizard	21.42%
Liolaemus lemniscatus	Elegant Tree Iguana	42.86%
Liolaemus monticola	Mountain Lizard	21.42%
Callopistes palluma	Chilean Iguana	7.14%
Phylodryas chamissonis	Short-tailed Snake	7.14%

Photograph 5.4.2.21. Adult specimen of Long-tailed Snake (*Phyllodryas chamissonis*) found on the layout of the future road of the project.

Photograph 5.4.2.22. Adult individual of Chilean Iguana (*Callopistes palluma*) found in the layout of the future road of the project.

b. Birds

Thirteen bird species belonging to 11 families were recorded in the Road Sector. The most abundant species were *Troglodytes aedon* and *Callipepla californica*. Two endemic species were also recorded: *Mimus thenca* and *Pteroptochos megapodius*. Finally, no species with conservation problems were recorded (Table 5.4.2.15).

Table 5.4.2.15
Relative Abundance of Birds in the Road Sector

Species	Common Name	Relative Abundance
Picoides lignarius	Striped Woodpecker	4.44%
Troglodytes aedon	House Wren	24.44%
Callipepla californica	Quail	13.33%
Elaenia albiceps	White-crested Elaenia	8.88%
Lepthastenura aegithaloides	Plain-mantled Tit-Spinetail	2.22%
Turdus falklandii	Austral Thrush	2.22%
Mimus thenca	Chilean Mockingbird	2.22%
Diuca diuca	Common Diuca-Finch	11.11%
Phrygilus patagonicus	Patagonian Sierra-Finch	6.66%
Zonotrichia capensis	Rufous-collared Sparrow	8.88%
Pteroptochos megapodius	Moustached Turka	2.22%
Curaeus curaeus	Austral Blackbird	6.66%

c. Mammals

Two mammal species belonging to two families were recorded. Both observations were made by indirect methods (feces). In the case of *Oryctolagus cuniculus*, this is an introduced species considered harmful for production agro ecosystems. The other species was *Pseudalopex* sp., a genus that could correspond to either of the two fox species present in the area. In this regard, both species are rated as Insufficiently Known for the area.

Photograph 5.4.2.23. Fox feces (*Pseudalopex sp.*) in the layout of the future road of the project.

- Existing Water Intake Sector

The presence of only two bird species was detected (Table 5.4.2.11).

a. Birds

In connection with this group, two bird species characteristic of river environments were detected: *Merganetta armata* and *Cinclodes patagonicus*. Their relative abundance was not calculated as their species richness was low. Neither of the species recorded has conservation problems (Table 5.4.2.11).

Photograph 5.4.2.24. Adult male individual of Torrent Duck (*Merganetta armata*) found on the stream.

Photograph 5.4.2.25. Stream area adjacent to future road works, close to the so-called "Water Intake" site.

c) Aucayes Alto

B. Species Richness and Conservation Status

The presence of three vertebrate orders was detected in the study area: 16 families and 26 species (Table 5.4.2.16).

Table 5.4.2.16
Species List of Terrestrial Vertebrates Detected in the Different Sectors

Species	Common Name	Protection		Origin (3)	Tank Sector	Upper Road Sector	Lower Road Sector
		CP (1)	EC (2)				
REPTILIA							
TROPIDURIDAE							
Liolaemus lemniscatus	Elegant Tree Iguana	S, E	V	Native			2
Liolaemus monticola	Mountain Lizard	S, E	V	Endemic		3	1
Liolaemus moradoensis	Andean Lizard	S, E	R	Endemic	20		
Liolaemus nigroviridis	Blackish-green Lizard	S, E	V	Endemic	42	33	
Liolaemus leopardinus	Leopard Tree Iguana	S, E	R	Endemic	4	3	
Liolaemus valdesianus	Lo Valdés Lizard	S, E	R	Endemic		6	
BIRDS							
CATHARTIDAE							
Vultur gryphus	Condor	B, E	V	Native	5		
FALCONIDAE							
Phalcoboenus megalopterus	Mountain Caracara	B, E		Native	2		
Falco femoralis	Aplomado Falcon	B, E		Native		1	
COLUMBIDAE							
Metriopelia melanoptera	Black-winged Ground Dove			Native		30	1
TROCHILIDAE							
Sephanoides sephanoides	Green-backed Firecrown	B, E		Native			2
PICIDAE							
Colaptes pitius	Chilean Flicker	B, S		Native			1
FURNARIIDAE							
Geositta cunicularia	Common Miner	B		Native		1	
RHINOCRIPTIDAE							
Pteroptochos megapodius	Moustached Turka	B		Endemic		1	4
TYRANNIDAE							
Elaenia albiceps	White-crested Elaenia	B, E		Native			3
Muscisaxicola cinerea	Cinereous Ground-Tyrant	B, E		Native		1	
Anairetes parulus	Tufted Tit-Tyrant	B, E		Native			2
TROGLODYTIDAE							
Troglodytes aedon	House Wren	B, E		Native			1
MIMIDAE							
Mimus thenca	Chilean Mockingbird	B		Endemic			3
FRINGILLIDAE							
Phrygilus alaudinus	Band-tailed Sierra-Finch	S			7	3	8
Phrygilus fruticeti	Mourning Sierra-Finch	E		Native			7
Zonotrichia capensis	Rufous-collared	B		Native			7

Species	Common Name	Protection		Origin (3)	Tank Sector	Upper Road Sector	Lower Road Sector
		CP (1)	EC (2)				
	Sparrow						
MAMMALIA							
CANIDAE							
Pseudalopex sp	Fox	E	I	Native	X	X	X
LEPORIDAE							
Oryctolagus cuniculus	Rabbit			Introduced		X	X
RODENTIA							
OCTODONTIDAE							
Octodon degu	Degu			Endemic			X
MURIDAE							
Phyllotis xanthopygus	Yellow-rumped Leaf-eared Mouse	S		Native	X		

Notes: (1) Protection criteria (CP)
E= A species catalogued as beneficial for maintaining the equilibrium of natural ecosystems
B= A species catalogued as beneficial for forestry, farming and livestock activities
S= A species catalogued as having reduced population densities
(2) Conservation Status (EC) for the Central Zone – Chile.
P = A species with a conservation status of Endangered
V = A species with a conservation status of Vulnerable
R = A species with a conservation status of Rare
I = A species with a conservation status of Insufficiently Known
(3) Origin
N = Native
E = Endemic
I = Introduced

B. Species Richness and Abundance by Study Area

- Tank Sector

In the area of influence of the Tank Sector, the presence of three vertebrate orders was detected: 10 families and 8 species (Table 5.4.2.17).

a. Reptiles

A total of three species belonging to one family was recorded. The most abundant species on the site was *Liolaemus nigroviridis*. The area designated for the tank does not prevent habitation by herpetozoa. The three species found have a conservation status of Vulnerable (1), and Rare (2) (Table 5.4.2.17).

Table 5.4.2.17
Relative Abundance of Reptiles in the Tank Sector

Species	Common Name	Relative Abundance
TROPIDURIDAE		
Liolaemus moradoensis	Andean Lizard	30.30%
Liolaemus nigroviridis	Blackish-green Lizard	63.64%
Liolaemus leopardinus	Leopard Tree Iguana	6.06%

Photograph 5.4.2.26. Adult individual of Blackish-green Lizard (*Liolaemus nigroviridis*) in the Tank Sector.

Photograph 5.4.2.27. Adult individual of Lo Valdés Lizard (*Liolaemus valdesianus*) in the Tank Sector.

Photograph 5.4.2.28. Adult individual of Andean Lizard (*Liolaemus moradoensis*) observed in the Tank Sector.

b. Birds

Three bird species belonging to three families were recorded in the Tank Sector. The most abundant species was *Phrygilus alaudinus*. In addition, one species having a conservation status of Vulnerable was recorded: the *Vultur gryphus* (Table 5.4.2.18).

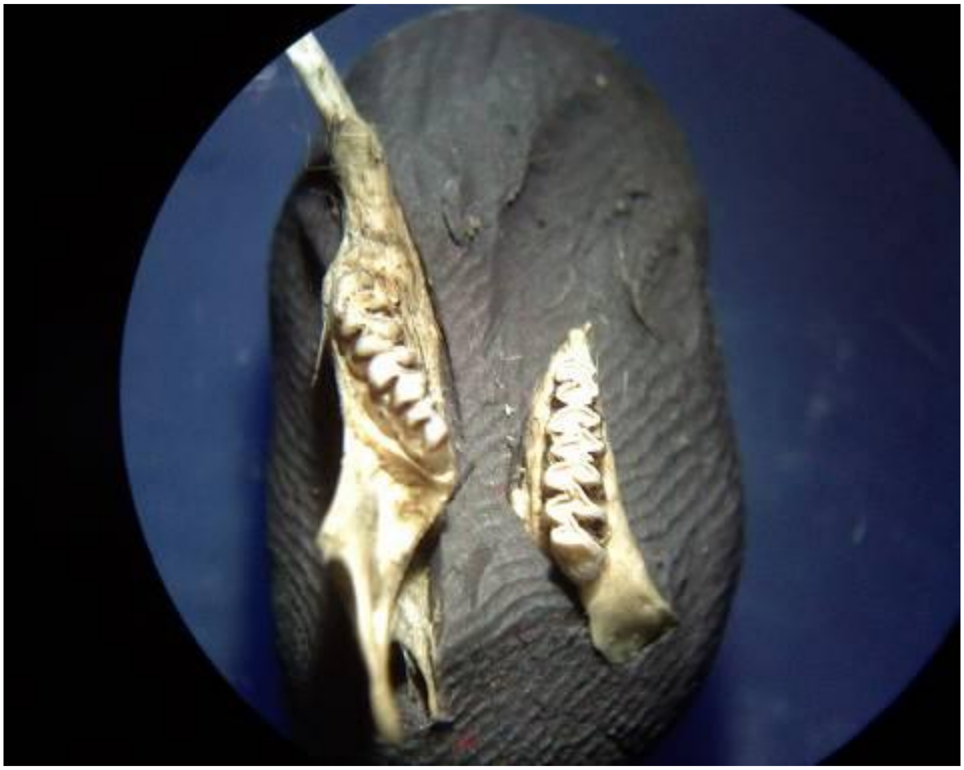
Table 5.4.2.18
Relative Abundance of Birds in the Tank Sector

Species	Common Name	Relative Abundance
Vultur gryphus	Condor	35.71%
Phalcoboenus megalopterus	Mountain Caracara	14.29%
Phrygilus alaudinus	Band-tailed Sierra-Finch	50.00%

c. Mammals

The wild mammal species recorded during the survey of the Tank Sector were *Pseudalopex sp*., recorded by observation of feces, and *Phyllotis xanthopygus*, recorded through bone remains in fox feces collected.

Photograph 5.4.2.29. Feces of Yellow-rumped Leaf-eared Mouse (*Phillotys xanthopygus*) found in the Tank Sector.



Photograph 5.4.2.30. Bone remains of Yellow-rumped Leaf-eared Mouse (*Phyllotys xanthopygus*) found in fox feces collected in the Tank Sector.

Photograph 5.4.2.31. Feces of Fox (*Pseudalopex sp*.) collected in the Tank Sector.

Photograph 5.4.2.32. Area of influence of the project, zone designated for the future dam, Tank Sector.

- Upper Road Sector

In the area of influence of the Upper Road Sector, the presence of three vertebrate orders was detected: nine families and 12 species (Table 5.4.2.16).

a. Reptiles

A total of four species belonging to one family was recorded. The most abundant species on the site was *Liolaemus nigroviridis*. As to species with conservation problems, two of them are rated as Vulnerable, and two as Rare (Table 5.4.2.19).

Table 5.4.2.19
Abundance of Reptiles in the Upper Road Sector

Species	Common Name	Relative Abundance
Liolaemus monticola	Mountain Lizard	6.66%
Liolaemus nigroviridis	Blackish-green Lizard	73.36%
Liolaemus leopardinus	Leopard Tree Iguana	6.66%
Liolaemus valdesianus	Lo Valdés Lizard	13.32%

Photograph 5.4.2.33. Adult individual of Mountain Lizard (*Liolaemus monticola*) recorded in the future road of the project, Upper Road Sector.

b. Birds

In the upper part of this Sector condor nests were observed on a steep slope that exhibits caves with rests of feces at the entrance. The use of these caves by *Vultur gryphus* for nesting purposes, even in a gregarious fashion, is common in Andean sectors exhibiting these conditions. However, the site is far from the areas of influence.

Photograph 5.4.2.34. Condor (*Vultur gryphus*) nesting place near the future road layout, Upper Road Sector.

Additionally, six bird species belonging to six families were recorded in the Upper Road Sector. The most abundant species was *Metriopelia melanoptera*. One endemic species was also recorded: the *Pteroptochos megapodius*. Finally, no species with conservation problems were recorded (Table 5.4.2.20).

Table 5.4.2.20
Relative Abundance of Birds in the Upper Road Sector

Species	Common Name	Relative Abundance
Falco femoralis	Aplomado Falcon	2.70%
Metriopelia melanoptera	Black-winged Ground Dove	81.09%
Geositta cunicularia	Common Miner	2.70%
Pteroptochos megapodius	Moustached Turka	2.70%
Muscisaxicola alpina	Cinereous Ground-Tyrant	2.70%
Phrygilus alaudinus	Band-tailed Sierra-Finch	8.11%

Photograph 5.4.2.35. Adult individual of Cinereous Ground-Tyrant (*Muscisaxicola cinereus*) observed in the Upper Road Sector.

c. Mammals

Two mammal species belonging to two families were recorded. Both observations were made by indirect methods (feces). In the case of *Oryctolagus cuniculus*, this is an introduced species considered harmful for production agro ecosystems. The other species was *Pseudalopex* sp., a genus that could belong to any of the two fox species present in the area. In this regard, both species are rated as Insufficiently Known for the area.

Photograph 5.4.2.36. Overview of the future road layout zone, Upper Road Sector.

- Lower Road Sector

In the area of influence of the Lower Road Sector, the presence of three vertebrate orders was detected: 12 families and 16 species (Table 5.4.2.16).

a. Reptiles

Two species belonging to one family were recorded. The most abundant species on the site was *Liolaemus lemniscatus*. In terms of conservation status, both species are rated as Vulnerable (Table 5.4.2.21).

Table 5.4.2.21
Abundance of Reptiles in the Lower Road Sector

Species	Common Name	Relative Abundance
Liolaemus lemniscatus	Elegant Tree Iguana	66.66%
Liolaemus monticola	Mountain Lizard	33.34%

b. Birds

Eleven bird species belonging to eight families were recorded in the Lower Road Sector. The most abundant species were *Phrygilus fruticeti* and *Zonotrichia capensis*. Two endemic species were also recorded: *Pteroptochos megapodius* and *Mimus thenca*. Finally, no species with conservation problems were recorded (Table 5.4.2.22).

Table 5.4.2.22
Relative Abundance of Birds in the Lower Road Sector

Species	Common Name	Relative Abundance
Metriopelia melanoptera	Black-winged Ground Dove	2.56%
Sephanoides sephanoides	*Green-backed Firecrown*	5.12%
Colapses pitius	Chilean Flicker	2.56%
Pteroptochos megapodius	Moustached Turka	10.26%
Elaenia albiceps	White-crested Elaenia	7.69%
Anairetes parulus	Tufted Tit-Tyrant	5.12%
Troglodytes aedon	House Wren	2.56%
Mimus thenca	Chilean Mockingbird	7.69%
Phrygilus alaudinus	Band-tailed Sierra-Finch	20.51%
Phrygilus fruticeti	Mourning Sierra-Finch	17.94%
Zonotrichia capensis	Rufous-collared Sparrow	17.94%

c. Mammals

Three mammal species belonging to three families were recorded. All these observations were made by indirect methods (feces). In the case of *Oryctolagus cuniculus*, this is an introduced species considered harmful for production agro ecosystems. The other species were *Pseudalopex* sp., a genus that could belong to either of the two fox species present in the area, and *Octodon degus*. In the case of the fox species, both species are rated as Insufficiently Known for the area.

Photograph 5.4.2.37. Feces of Degu (*Octodon degu*) in the Lower Road Sector.

Photograph 5.4.2.38. Feces of fox (*Pseudalopex sp*.) exhibiting a clear frugivorous trend, found in the Lower Road Sector.

5.4.2.5 Arthopod Survey

A survey was conducted of arthropods associated to two of the main ecosystems in the Alto Maipo Sector, Cordillera Central de los Andes, which will be intervened by the project (see Attachment 23). The purpose of this survey was to identify species present in these project areas and that might be affected by the project. The ecosystems involved are:

1) Highland meadow in La Engorda Sector. Approximate location: UTM coordinates 19H 407500 6265000. Approximate altitude: 2,500 m.
2) Sclerophyllous Forest of the Aucayes-Maitenes Sector. Approximate location: UTM coordinates 19H 382500 6287500. Approximate altitude: 1,250 m.

This survey made it possible to assess the specific composition of the terrestrial arthropod fauna and its abundance. It was carried out on March 15-16, 2008, a date that coincides with the end of the reproductive period of many insect species, and thus ensures that the results will be a representative sample of the biodiversity of the organisms associated to the environments surveyed.

After applying the methodologies (see Attachment 23) to each type of arthropod fauna in each of the abovementioned sectors, the following results were obtained:

<u>Highland meadow in La Engorda Sector</u>

a) Butterflies

Ninety-eight *lepidopteran* individuals representing six species and four families were detected (Table 5.4.2.23). The most abundant species was *Yramea lathonioides* (61.2%). Of the six species detected, two are endemic to Chile and three to Chile and Argentina. Of the species detected, *Yramea lathonioides* is considered to exhibit high habitat specificity and restricted altitudinal distribution, being found preferably in high-altitude herbaceous steppe environments between 1,700 and 3,200 m.a.s.l. (Table 5.4.2.23). The remaining species have a wide geographical distribution and are found in different types of habitats; however, in most cases, their hosts and specific ecological requirements are still unknown (Table 5.4.2.23).

Table 5.4.2.23
Species List and Abundance of Butterflies Detected in the Meadows of La Engorda Sector

Species	Vernacular Name (Sp/Eng)	Longitudinal Distribution	Altitudinal Distribution	Endemicity	Habitat	Host	Relative Abundance
HESPERIIDAE							
Butleria elwesi Evans, 1939	Hesperia de Elwes	V- X Regions	Coastal-Andean	Chile, Argentina (Neuquén-Chubut)	Miscellaneous environments	Unknown	1.02%
LYCANIDAE							
Strymon eurytulus Hubner, 1819	Scrub Hairstreak	III- X Regions	Coastal-Andean	Chile	Miscellaneous environments	Unknown	1.02%
NYMPHALIDAE							
Yramea lathonioides (Blanchard 1982)	Mariposa pintada de la altura	III- XII Regions	1,700-3,200 masl	Chile, Argentina (Mendoza southward)	Grasslands	Unknown	61.2%
Vanesa carye (Hubner, 1806)	Four-eyed Lady	I- XII Regions	Coastal-Andean	From Venezuela to Chile	Miscellaneous environments	Miscellaneous species of the Malvaceae family	2.04%
Cosmosatyrus chilensis chiliensis (Guerín, 1832)	Satírido negro común	III- XII Regions	Coastal-Andean	Chile, Argentina (Chubut-Santa Cruz	Natural shrubs and grasses	Unknown	27.5%
PIERIDAE							
Tatochila autodice blanchari (Butler, 1881)	Mariposa blanca común	I- X Regions	Coastal-Andean	Chile	Miscellaneous environments	Miscellaneous species (e.g., *Brassic*a, *Tropaeolum*)	7.14%

b) Epigeal arthropods

A total of 187 individuals belonging to 11 epigeal arthropod species were counted during the sampling campaigns conducted in the meadows of La Engorda Sector (Table 5.4.2.24). Coleoptera was the most diversified order (6 spp). The most abundant species were Eupodidae sp. (68.89%) and *Iridomyrmex humilis* (17.64%). A total of six species are endemic to Chile, most of them with a wide geographical distribution and low habitat specificity. However, in nearly all cases no information is available about hosts or other specific ecological requirements (Table 5.4.2.24).

Table 5.4.2.24
Species List and Abundance of Epigeal Arthropods Detected in the Meadows of La Engorda Sector

Species	Vernacular Name (Sp/Eng)	Longitudinal Distribution	Altitudinal Distribution	Endemicity	Habitat	Host	Relative Abundance
ACARI							
Eupodidae **Eupodidae *sp.***	Acaro rojo	Unknown	Unknown	Cosmopolitan Family	Wetlands	Unspecified	68.89%
COLEOPTERA							
Bruchidae ***Lithraeus* sp.**	Bruco	Unspecified	Up to 3500 masl	Chile	Forest and scrubland	Litre tree and other sclerophyllous species	0.53%
Carabidae *Mimodromius chilensis*	Cascarudo	IV- X Regions	Up to 3500 masl	Chile	Forest and scrubland	Unspecified	0.53%
Curculionidae *Cylydrorhinus* sp.	Gorgojo	III- X Regions	Up to 4000 masl	Chile	Low vegetation	Unspecified	1.6%
Staphyllinidae ***Eudera sculptilis***		Unspecified	Unspecified	Chile	Forest and scrubland	Unspecified	3.2%
Staphyllinidae ***Atheta obscuripennis***		Unspecified	Unspecified	Chile	Forest and scrubland	Unspecified	0.53%
Tenebrionidae *Scotobius punctatus*	Tenebrio	III-IX Regions	Unspecified	Chile	Miscellaneous environments	Unspecified	2.67%
HOMOPTERA							
Psyllidae **Psyllidae *sp.***	Lerp insects	Unspecified	Unspecified	Cosmopolitan Family	Miscellaneous environments	Unspecified	3.74%
Cicadellidae ***Exitianus obscurinervis***	Langostino venas oscuras	I-VI Regions	Unspecified	America	Miscellaneous environments	Miscellaneous grass species	0.53%
HYMENOPTERA							
Formicidae *Iridomyrmex humilis*	Hormiga Argentina	I- XII Regions	Unspecified	Cosmopolitan	Miscellaneous environments	Unspecified	17.64%

Aucayes-Maitenes Sector Forest Formations

a) Foliage Arthropods

In the foliage sampling campaigns conducted in the **Sclerophyllous Forest, Aucayes-Maitenes Sector**, a total of 60 insect individuals belonging to 10 species and four orders were counted (Table 5.4.2.25). The most diversified order was Hemiptera (four spp) and the most abundant was *Leptoglossus chilensis* (26.6%). A total of two species are endemic to Chile and three to Chile and Argentina. Most of them show a wide geographical distribution, low habitat and host specificity (Table 5.4.2.25).

Table 5.4.2.25
Species List and Abundance of Foliage Arthropods Collected in the Sclerophyllous Forest of the Aucayes-Maitenes Sector

Species	Vernacular Name (Sp/Eng)	Longitudinal Distribution	Altitudinal Distribution	Endemicity	Habitat	Host	Relative Abundance
COLEOPTERA							
Cerambycidae ***Strongylaspes limae*** Guérin-Menéville, 1830	Cruz de Malta	III-VIII Regions	Unspecified	South America	Miscellaneous environments	Lenga, soapbark and other native trees	1.66%
Coccinellidae ***Adalia angulifera*** Mulsant 1850	Chinita	III-X Regions	Unspecified	Southern tip of America	Miscellaneous environments	Miscellaneous hosts	18.33%
Curculionidae ***Cyphometopus sp.*** Blanchard, 1851	Gorgojo, burrito	I-X Regions	Unspecified	Chile	Miscellaneous environments	Native vegetation	5%
HEMIPTERA							
Coreidae ***Leptoglossus chilensis*** Spinola	Brown Chilean leaffooted bug	III-X Regions	Unspecified	Chile and Argentina	Miscellaneous environments	Miscellaneous fruit trees	26.6%
Pentatomidae ***Podisus chilensis* (Spinola)**	Chinche de espina negra	V-X Regions	Unspecified	Chile and Argentina	Miscellaneous environments	Miscellaneous native tree and shrub species	3.33%
Pentatomidae ***Nezara viridula* Lineo**	Southern green stink bug	V-XII Regions	Unspecified	Worldwide distribution	Miscellaneous environments	Miscellaneous hosts	6.67%
Reduviidae ***Zelus cervicalis*** Stal	Chinche	V-VI Regions	Unspecified	Introduced	Low vegetation, Central Valley, precordillera sectors	Miscellaneous hosts	15%
HYMENOPTERA							
Formicidae ***Camponotus chilensis*** Smith, 1858	Hormigón negro	III-X Regions	Unspecified	Chile and Argentina	Miscellaneous environments	Miscellaneous hosts	13.3%
Formicidae ***Camponotus distinguendus*** (Spinola)	Hormiga peluda blanca	III-X Regions	Unspecified	Chile and Argentina	Miscellaneous environments	Miscellaneous hosts	8.33%
ORTHOPTERA							
Acrididae ***Trimerotopes ochraceipennis*** (Blanchard)	Langosta cordillerana	I-XII Regions	Coastal areal-3500 m	Chile	Arid, open and sunny places	Miscellaneous grass and herb species.	1.66%

b) Epigeal arthropods

In the sampling of epigeal arthropods associated with the sclerophyllous forest of the Aucayes-Maitenes Sector, a total of 56 insect individuals belonging to 12 species were counted (Table 5.4.2.26). Coleoptera was the most diversified order (5 spp). The most abundant species were Diplocoelus sp. (32.14%) and *Camponotus chilensis* (30.35%). A total of three species are endemic to Chile and two to Chile and Argentina (Table 5.4.2.26). Most of them show a wide geographical distribution and low habitat specificity. In some cases, no known information is available about hosts or other specific ecological requirements.

Table 5.4.2.26
Species List and Abundance of Epigeal Arthropods Collected in the Sclerophyllous Forest Formations of the Aucayes-Maitenes Sector

Species	Vernacular Name (Sp/En)	Longitudinal Distribution	Altitudinal Distribution	Endemicity	Habitat	Host	Relative Abundance
BLATTARIA							
Blattellidae ***Blatella germanica*** (Lineo)	Barata germánica	I- XII Regions	Unspecified	Cosmopolitan	Miscellaneous environments	Miscellaneous hosts	1.78%
COLEOPTERA							
Archeocrypticidae **Archeocrypticidae sp.**		Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	1.78%
Biphyllidae ***Diplocoelus sp.***		Unspecified	Unspecified	Unspecified	Unspecified	Unspecified	32.14%
Carabidae ***Callidula nigrofasciata*** (Solier)	Carábido de manchas amarillas	IV-X Regions	Up to 1500 masl	Chile and Argentina	Arborescent and wooded environments	Unspecified	1.78%
Staphyllinidae ***Atheta obscuripennis***		Unspecified	Unspecified	Chile	Scrubland	Unspecified	1.78%
Tenebrionidae ***Nycterinus rugiceps australis*** Peña 1971	Tenebrio	V-VI Regions	Coastal area-2800 masl	Chile	Miscellaneous environments	Unspecified	1.78%
HOMOPTERA							
Cicadellidae ***Exitianus obscurinervis*** (Stal)	Langostino de venas oscuras	I-VI Regions	Unspecified	America	Miscellaneous environments	Miscellaneous grass species	3.57%
HYMENOPTERA							
Formicidae ***Camponotus chilensis*** Smith, 1858	Hormigón negro	III-X Regions	Unspecified	Chile and Argentina	Miscellaneous environments	Miscellaneous hosts	30.35%
Formicidae ***Solenopsis gayi*** (Spinola)	Hormiga fuego	I-XII Regions	Unspecified	Cosmopolitan	Miscellaneous habitats	Unspecified	1.78%
Formicidae ***Iridomyrmex humilis*** (Mayr)	Hormiga Argentina	I-XII Regions	Unspecified	Cosmopolitan	Miscellaneous habitats	Unspecified	1.78%
ORTHOPTERA							
Grillidae ***Acheta assimilis*** (Fabricius)	Grillo alado negro	I-XII Regions	Unspecified	Cosmopolitan	Light-protected humid places	Miscellaneous hosts	8.9%
Grillidae ***Hoplosphyrum griseus*** (Philippi)	Grillo chico alado	IV-X Regions	Unspecified	Chile	Miscellaneous habitats	Miscellaneous hosts	12.5%

To view the arthropod fauna survey in greater detail, see Attachment 23.

Photograph 5.4.2.39. Area of influence of the project, La Engorda Sector.

Photograph 5.4.2.40. Epigeal arthropod pitfall traps, Aucayes-Maitenes Sector.

5.4.2.6 Conclusions

The vegetation in the sclerophyllous forest of the central zone of Chile has a high degree of endemicity. Forty-five percent (45%) of the plants is restricted and inhabits exclusively this area, which is in turn associated with a vulnerable endemic fauna (Arroyo *et al.* 1999). Zones such as soapbark, *Quillaja saponaria,* peumo, *Cryptocaria alba* and frangel, *Kageneckia angustifolia* forests and all their other biotic and physical components make up habitats of interest for fauna. These species are represented in different vegetation formations:

- *Quillaja saponaria* is found in abundance up to 2,000 m.a.s.l. and is a species protected by law;
- *Kageneckia angustifolia* is found making up forests and scrubland between 1,400 m. and 2,000 m.a.s.l. and even higher.

The protection of these forests, capable of sustaining a great diversity of vertebrates depending on exposure, altitude, age, and canopy height, inexorably entails the conservation of its associated fauna.

In the area of influence of the Colorado River, La Engorda Canyon-El Morado Stream, Lo Encañado Lagoon-El Manzanito Stream Sector, El Yeso Reservoir and River, and Aucayes River, a total of 86 species was recorded, including three amphibians, nine reptiles, 70 bird species of which nine are predatory birds, 10 aquatic birds and 51 non-predatory birds; four species belong to the mammal class. Of the total number of species recorded, 25 were observed in autumn in Lo Encañado sector and 71 were observed in springtime. According to the different sectors that make up the area of influence, 37 species were recorded in the Colorado River; 27 in the sector of La Engorda Ravine and El Morado, 43 species in the sector of Lo Encañado and El Manzanito, 19 in the sector of El Yeso River and 39 in the Aucayes Stream.

In the area of influence of Aucayes-Alto, 26 species were recorded: six reptiles, 16 birds and four mammals. According to the different sectors that make up this area of influence, eight were recorded in the Tank sector, 12 in the Upper Road sector, and 16 in the Lower Road sector.

In the area of influence of Aucayes-Maitenes, 25 species were recorded: six reptiles, 17 birds and two mammals. According to the different sectors that make up this area of influence, 11 species were recorded in the Muck Disposal sector, 20 in the Road sector, and only two bird species in the Water Intake sector.

Most of the individuals were observed in sub-Andean and Andean environments above 2000 m.a.s.l. (except for the Aucayes Maitenes area, where no Andean highland species could be observed); this is due, on the one hand, to the larger number of sampling points and, on the other, to the diversity of habitats available to the species as a result of vegetation diversity. In fact, environments in this sector are characterized by Andean scrubland and wet meadows, i.e., formations of ecological importance in the conservation of terrestrial vertebrates, out of which birds are the dominant group, followed in importance by reptiles, and then by mammals.

In the case of wet meadows, these exhibit a high degree of intervention as a result of grazing, but with differentiated intensities according to the study area (e.g. El Yeso exhibits a higher degree of alteration than that observed at La Engorda). Notwithstanding the above, these also sustain a large number of species, especially birds and amphibians. In the Andean scrubland, on the other hand, important vertebrates such as reptiles were observed; their importance lies in their degree of threat (conservation status), endemicity, population size and restricted population.

Overall, the number of species with a conservation status in the sectors of the Colorado River, La Engorda Canyon-El Morado Stream, Lo Encañado Lagoon-El Manzanito Stream, El Yeso Reservoir and River, and Aucayes Stream amounts to 16, most of which belong to the reptile class. Two of these species are rated as “Endangered” (the frog *Alsodes nodosus* and the cururo), eight as “Vulnerable” (two amphibians, four reptiles, one predatory bird and one non-predatory bird), four as “Rare” (three reptiles and one predatory bird), one “Insufficiently Known” (the culpeo fox) and one as “Out of Danger” (the brown tree iguana). In the Aucayes Maitenes sector eight species with a conservation status were recorded: seven are rated as “Vulnerable” (seven reptiles and one bird) and one as “Insufficiently Known” (a mammal). In the Aucayes Alto sector eight species with a conservation status were observed, out of which four are rated as “Vulnerable” (three reptiles and one bird), three reptiles are rated as “Rare”, and one mammal species is rated as “Insufficiently Known”.

Below 2,000 m.a.s.l., the most sensitive species belong to the reptile class and share a similar degree of threat (conservation status), endemicity and population size. This includes some of the potential reptile species, which taken together add up to several species rated as “Vulnerable” and “Rare”. Observed species include the elegant tree iguana, mountain and tree-dwelling lizards, and the iguana (“Vulnerable”). Potential species worth noting are the Fitzgerald lizard, *Liolaemus fitzgeraldi* (“Vulnerable”), and the endemic species *L. moradoensis, L. valdesianus, L. nigroviridus* and *L. leopardinus* (Veloso & Navarro 1988).

As to birds, of all the species detected in all sectors, only the Vultur gryphus (condor) has a conservation status of Vulnerable for the central zone. However, given its life history and ecological features, it should not be considered as restrictive. In terms of taxonomic singularity, two endemic species were recorded: the *Pteroptochos megapodius* (moustached turka) and *Mimus thenca* (Chilean Mockingbird) (Valencia & Veloso 1981). Of the mammal species detected in the study area, *Pseudalopex sp.* is rated as Insufficiently Known for the central zone of Chile, whichever of the two fox species (culpeo or grey) is involved (SAG 1998).

In the arthropod collections carried out on March 15-16, 2008 in the meadows of La Engorda sector and forest of the Aucayes-Maitenes, Alto Maipo sector, a total of 37 species belonging to insect orders LEPIDOPTERA, COLEOPTERA, HEMIPTERA, HOMOPTERA, HYMENOPTERA, BLATTARIA and ORTHOPTERA, and to the arachnid species ACARI were recorded. Of the total number of species recorded, 12 are endemic to Chile and eight to Chile and Argentina, most with a wide geographical distribution in the country and low habitat specificity. Although this may suggest low species susceptibility to the execution of the project works, there is an evident lack of information about their hosts or other specific ecological requirements. As suggested earlier, arthropods in this zone should be considered as having a conservation status of Insufficiently Known.

5.4.3 Aquatic Flora and Fauna

5.4.3.1 Introduction

The following is a description of the lake and water courses found within the area of the PHAM, listing their macro invertebrate and benthic microalgae, plankton components; the ictiologic fauna and its aquatic habitat in terms of the main physicochemical parameters (see section 5.3.5.2).

The water bodies described are the Colorado and Yeso rivers, and the tributaries of the higher basin of the Volcán River. All these water courses show a marked naval regime, and their heavier flow rates caused by the cordilleran snowmelts occur during December and January.

5.4.3.2 Methodology

A field survey was carried out in November 2006, to characterize the limnology in the area of influence of the PHAM. This covered the higher basin sectors of the Volcán River, as well as the Lo Encañado, Yeso, El Colorado and Maipo Rivers. In all the sectors, the water quality was determined by means of direct sampling in the respective basins.

The information obtained during a campaign carried out in April 2005 was integrated as a complement. That survey was carried out on the upper tributaries of the Volcán River basin, as part of the PHAM pre-feasibility studies, where that sector was considered as environmentally sensitive.

The location of each sampling point of the April 2005 and November 2006 campaigns is shown on tables 5.4.3.1 and 5.4.3.2, respectively. Said points are shown in Figure 5.3.5.6 A, B and C, attached to section 5.3.5,

Table 5.4.3.1
Sampling Sectors Location April 2005 Campaign

N°	Sampling Points	UTM Coordinates	
		East	
1	La Engorda Stream	408,028	6,259,724
2	Stream 1; between the La Engorda and Colina Streams (50 m from La Engorda Stream)	408160	6,260,094
3	Colina Stream	408164	6,260,099
4	Stream 2, confluence between La Engorda and Colina	407301	6,259,788

Table 5.4.3.2
Sampling Sectors Location November 2006 Campaign

Stations	Sector	Sampling Points	UTM Coordinates	
			East	North
1	Upper basin Volcán River	La Engorda Stream (catchments zone)	407.401	6.259.712
2		Colina Stream (catchments zone)	407.091	6.260.730
3		El Morado Stream (catchments zone)	406.193	6.259.012
4		El Volcán River	403.274	6.257.048
5	Yeso River Basin	Yeso River (catchments zone)	396.534	6.270.780
6		Cortaderas Stream	394.994	6.268.252
7	Lo Encañado Pond Sector	Lo Encañado Pond	395.471	6.273.716
8			394.800	6.273.990
9		El Manzanito Stream	396.187	6.272.939
10	Colorado River Basin	Colorado River (zone of the future Alfalfal load chamber).	388.704	6.291.940
11		Quempo Stream	387.804	6.292.262
12		Aucayes Stream (catchments zone)	382.743	6.288.874
13		Colorado River (zone of the Las Lajas tunnel crossing)	380.744	6.287.505
14	Maipo River Basin	Maipo River (discharge zone)	365.369	6.283.512

The methods employed to describe the relevant aquatic biota parameters are set out below:

- **Benthic macro invertebrate fauna:** Benthos samples were gathered using a Surnet having an area of 625cm^{2} so as to describe the benthic fauna and the food supply represented by the aquatic Macroinvertebrate. The samples were fixed in situ with 5% formalin and taken to the laboratory for identification and counting of individuals.

- **Benthic microalgae flora:** Samples were taken with a 1cm diameter core over the substrate in the benthic zone of the water courses so as to assess the composition and abundance of the benthic microalgae ensembles. The samples were fixed in situ with 10% formalin and analyzed in the laboratory under optical microscopy, 1000 enlargement. Taxonomic identification was carried out following the Lopretto & Tell (1995) and Round *et al* (1996) descriptions.

- **Fish fauna:** The collection of fishes in the rivers and at the borders of the Lo Encañado pond was done using electric fishing. This technique was applied in one of the river banks using a portable Coffelt electrical fishing device and manual collection gear. A 100m long area was covered, and a search effort of 30 minutes approximately was carried out at each sampling point. The captured specimens were identified at the species level and fixed in situ with 10% formaldehyde. The total length (, total weight eviscerated weight and gonads development were measured (according to the Calvo & Dadote scale, 1972). The Condition factor (K) and the Eviscerated Condition Factor (K evisc.) as K = (PT/lT3) * 1.000 (Lagler, 1956).

- **Macrophytes flora:** A visual survey over an approximate 20m linear distance of the bank sector of each stretch studied was conducted.

5.4.3.3 Results

A: April 2005 Campaign – Upper Volcán River Sector

i. Benthic Macroinvertebrate Fauna

- La Engorda Stream Two benthic Macroinvertebrate taxa were detected: Chironomidae and Baetidae (See Table 5.4.3.3). The total abundance of individuals reached 133.3 ind/m^2 (See Table 5.4.3.3). The taxa found in the La Engorda Stream are tolerant to organic matter contamination: this indicates that habitat conditions are unfavorable for aquatic biota.

- Stream 1. Two taxa of benthic macro invertebrate were detected: Chironomidae and Baetidae (See Table 5.4.3.3). The total abundance of individuals reached 188.9 ind/m^2 (See Table 5.4.3.3). The taxa found in the La Engorda Stream are tolerant to organic matter contamination, thus indicating that habitat conditions are unfavorable for aquatic biota.

- Colina Stream Two benthic macro invertebrate taxa were detected: Chironomidae and Leptophlebidae (See Table 5.4.3.3). The total abundance of individuals reached 177.8 ind/m^2 (See Table 5.4.3.3). The *Chironomidae* taxa tolerate organic matter contamination, differing from *Leptophlebidae* which is sensitive. These results indicate that the habitat conditions for aquatic biota are more favorable than those of the La Engorda Stream.

- Stream 2. Two taxa of benthic macro invertebrate were detected: Chironomidae and Baetidae (See Table 5.4.3.3). The total abundance of individuals reached 133.9 ind/m^2 (See Table 5.4.3.3). The taxa found in this stretch of the Stream, downstream the confluence of all the streams being surveyed, are tolerant to organic matter contamination, indicating unfavorable conditions for the aquatic biota.

Table 5.4.3.3
Benthic Macroinvertebrate Fauna in the Volcán River Sub-basin
April 2005 Campaign

Taxa			Stations			
Order	**Family**	**Genus**	**Colina**	**Engorda**	**Stream 1**	**Stream 2**
Ephemeroptera	Leptophlebiidae	*Meridialaris*	11.1			
Diptera	Chironomidae		166.7	44.4	155.6	122.2
Ephemeroptera	Baetidae	*Deceptiviosa*				11.1
Ephemeroptera	Baetidae	*Andesiops*		88.9	33.3	
Richness			**2**	**2**	**2**	**2**
Total Abundance			**177.8**	**133.3**	**188.9**	**133.3**

Source: Fauna Survey - Alto Maipo Project Baseline, 2005.

ii. Ictic fauna

No fishes were detected in the surveyed area

B: November 2006 Campaign

i. Upper Volcán River Sector

- *Benthic Macroinvertebrate Fauna*

Between 0 and 7 Benthic macro invertebrate taxa were detected in the streams of the upper sector of the El Volcán River and in the river itself (See table 5.4.3.4). The total abundance of individuals varied between 0 ind/m^2 (El Volcán River) and 611.1 ind/m^2 (La Engorda Stream). The predominant taxa varied among the water courses. The predominant taxa at the La Engorda Stream were *Hyalella* sp., (Amphipoda) while the taxa *Massartellopsis irarrazavali* (Ephemeroptera) predominated in the Colina Stream; the Chironomidae (Diptera) and *M. irarrazavali* (Ephemeroptera) taxa predominated in the El Morado Stream. No benthic macro invertebrate taxa were detected in the El Volcán River. According to the predominant benthic taxa indicators of organic contamination, the La Engorda Stream showed taxa highly tolerant to organic matter (Family Hyalellidae and Order Chironomidae) and is therefore typified as being in a high organic matter contamination condition. Conversely, the Colina Stream showed a predominance of taxa sensitive to organic contamination (Leptophlebidae Family) and is therefore typified as a system having low organic matter contamination. The El Morado Stream showed a predominance of sensitive taxa (Leptophlebidae Family) and tolerant (Order Chironomidae) so its condition would then be that of medium organic contamination

Table 5.4.3.4

Benthic Macroinvertebrate Fauna Upper Sector – El Volcán River.
November 2006 Campaign

Taxa	La Engorda	Colina	El Morado	El Volcán River
ORDER TRICHOPTERA	0	0	11.1	0
Fam. Rhyacophilidae	0	11.1	0	0
Cl. Crustacea	0	0	0	0

Taxa	La Engorda	Colina	El Morado	El Volcán River
ORDER AMPHIPODA	0	0	0	0
Fam. Hyalellidae	0	0	0	0
Gen. Hyalella	466.7	0	0	0
ORDER DIPTERA	0	0	0	0
Fam. Chironomidae	44.4	0	222.2	0
Fam. Blephaceridae	0	0	0	0
Gen. *Edwardsina*	0	55.6	11.1	0
Fam. Athericidae	0	0	0	0
Gen. *Atherix*	0	0	11.1	0
ORDER EPHEMEROPTERA	0	0	0	0
Fam. Baetidae	0	0	0	0
Gen. *Andesiop*	0	0	0	0
A. peruvianus	0	0	22.2	0
Gen. *Deceptiviosa*	0	0	0	0
D. ardua	33.3	0	0	0
Fam. Leptophlebiidae	0	0	0	0
Gen. *Massartellopsis*	0	0	0	0
M. irarrazavali	0	211.1	133.3	0
Gen. *Meridialaris*	0	0	0	0
M. chiloeense	11.1	44.4	33.3	0
PH. ANNELIDA	0	0	0	0
Cl. Oligochaeta	55.6	0	0	0
Total Abundance (ind/m^2)	**611.1**	**322.2**	**433.2**	**0**
Taxa richness (N° of taxa)	**5**	**4**	**7**	**0**

Source: Fauna Survey - Alto Maipo Project Baseline, 2006.

- ***Benthic Microalgae Flora***

There were differences in the number of benthic microalgae taxa among the catchments sector of the El Volcán water courses. Taxa richness varied between 4 and 12 benthic microalgae taxa. The Colina Stream and the El Volcán River showed the highest number of taxa (12 and 10 taxa respectively) while the La Engorda and El Morado streams showed 7 and 4 taxa respectively (See Table 5.4.3.5). The highest abundance value was found at the La Engorda Stream and El Volcán River, indicating habitat conditions comparatively more favorable than those of the other water courses of the sector. The predominant species in the La Engorda Stream was *Achnanthidium minutissimum,* and *Surirella minuta* predominated in the El Volcán River. In the Colina Stream, *Surirella minuta* was predominant, and no predominant taxa were found in the El Morado Stream. Conversely, the highest benthic microalgae ensembles biological diversity was found in the Colina Stream (3.43 bits) followed by the El Volcán River (2.53 bits, see Table 5.4.3.5).

Table 5.4.3.5
Benthic Microalgae Flora Upper Sector – El Volcán River.

Taxa	La Engorda	Colina	El Morado	El Volcán River
Achnanthidium minutissimum	2,553.9	1.49	0	44.1
Adlafia minuscula	212.8	0	0	0
Cocconeis placentula v euglypta	0	0	0.37	0
Cymbella affinis	0	2.98	0	88.2
Cymbella helvetica	0	2.24	0	44.1
Diatoma moniliformis	0	0	0.75	88.2
Fragilaria capucina v vaucheriae	0	2.24	0	44.1
Fragilaria zeilleri	0	2.61	0	0
Gomphonema angustatum	212.8	0	0	44.1
Gomphonema angustum	0	0.75	0	0
Navicula gregaria	212.8	0	0	44.1
Nitzschia palea	0	0.75	0	0
Nitzschia spp	212.8	0.75	0	0
Pennada	532.1	1.86	1.12	110.2
Planothidium lanceolatum	0	0	0	44.1
Reimeria sinuata	0	1.49	0	0
Rhoicosphenia abbreviata	0	0.75	0	0
Surirella minuta	532.1	1.49	0.75	551.0
Taxa richness (N° of taxa)	**7**	**12**	**4**	**10**
Total abundance (cel/mm^2)	**4,469**	**19.4**	**3.0**	**1.102**
Biological diversity (bits)	**2.03**	**3.43**	**1.91**	**2.53**

- **Fish Fauna**

No fishes were detected in the water bodies of the surveyed area. This result is frequent during spring time in high altitude water courses due to their heavy sediments loads; this generates a temporary displacement towards water courses having a more transparent water column. This result is corroborated by specialized literature.

- **Macrophytes Flora**

No Macrophytes flora was detected in the water bodies studied.

ii. Yeso River Sector

- ***Benthic Macroinvertebrate Fauna***

Four benthic macro invertebrate taxa were detected in the sampled reach of the Yeso River. The total abundance of individuals was 111.4 ind/m^2. The *Simulium* sp. (Diptera) taxon predominated. Based on the predominance of diptera, the Yeso River reach surveyed can be typified as having a medium organic contamination condition. There was a higher abundance of benthic macro invertebrate in the Cortaderas Stream as compared to the Yeso River. Eight taxa were detected in the Cortaderas Stream and the abundance was of 788.9 ind/m^2 (See Table 5.4.3.6).

Table 5.4.3.6
Benthic Macroinvertebrate Fauna Yeso River Sector

TAXA	Yeso River	Cortaderas Stream
ORDER DIPTERA		
Fam. Chironomidae	11.1	255.5
Fam. Simulidae	0	22.2
Simulium sp.	77.8	0
Fam. Empididae	0	11.1
ORDER EPHEMEROPTERA		
Fam. Baetidae	0	0
Deceptiviosa sp.	0	0
Andesiops peruvianus	0	0
Deceptiviosa torrens	11.1	122.2
Massartellopsis irarrazabali	0	266.7
Fam. Leptophlebiidae	0	0
Meridialaris diguillina	0	0
Meridialaris laminata	11.1	0
ORDEN TRICHOPTERA		
Hydrobiosidae sp.	0	22.2
ORDER COLEOPTERA		
Elmidae	0	44.4
Ph. Annelidae		
Oligochaeta	0	44.4
Total Abundance (ind/m^2)	**111.4**	**788.9**
Taxa richness (N° of taxa)	**4**	**8**

- ***Benthic Microalgae Flora***

Ten benthic microalgae taxa were detected in the Yeso river (See Table 5.4.3.7). The predominant species were *Cymbella affinis*, *Diatoma moniliformis* and *Synedra acus*. The total cell abundance reached 10.192 cels/mm^2; this is a comparatively high value among the water bodies of the surveyed area. Microalgae diversity in the Yeso River reached median levels among the values detected in the surveyed area (2.56 bits, See Table 5.4.3.7). There were 8 benthic microalgae taxa in the Cortaderas Stream, a total abundance of 2.310 cel/mm^2 and the biological diversity was 1.41 bits; these values are lower than those found in the Yeso River.

Table 5.4.3.7

Benthic Microalgae Flora Yeso River Sector

TAXA	Yeso River	Cortaderas Stream
Achnanthidium minutissimum	1.099	0
Cyclotella ocellata	566	0
Cymbella affinis	3.331	0
Cymbella helvetica	400	0
Cymbella microcephala	133	0
Cymbella sp.	0	1.403
Denticula sp.	0	165
Diatoma moniliformis	2.798	0
Encyonema silesiacum	0	82.5
Fragilaria	0	82.5
Gomphonema olivaceum	67	82.5
Hannaea arcus	0	82.5
Nitzschia dissipata	333	0
Pennada ind.	133	330
Synedra ulna	0	82.5
Synedra acus	1.332	0
Taxa richness (N° of taxa)	**10**	**8**
Total abundance (cel/mm^2)	**10.192**	**2.310**
Biological diversity (bits)	**2.56**	**1.41**

- ***Fish Fauna***

The presence of the salmoniform introduced species *Salmo trutta* (brown trout) was detected in the surveyed reach of the Yeso River. In spite of a strong searching effort, only three adult specimens were captured. Two females and a male. The average length of the specimens was 20.5 Â± 3.8 cm and the total weight 130 Â± 75.6 g. The average eviscerated weight was 117.7 Â± 68, 1 g (See Table 5.4.3.8). Conversely, the Cortaderas Stream showed an abundant population of introduced *Salmo trutta* fish, situated 100m from the confluence sector of the Cortadera Stream with the Yeso river. The average length of the specimens was 15.9 Â± 2.6 cm and the total weight 115.5 Â± 40.1 g. The average eviscerated weight was 90.3 Â± 68, 1 g (See Table 5.4.3.8). The average eviscerated condition factor shown by the specimens was 13.1 Â± 1.2.

Table 5.4.3.8

Fish Fauna Yeso River Sector

Sampling site	Taxa	Common name	Total length (cm)	Total weight (g)	Eviscerated weight (g)	Condition factor K_{evis}	Sex
Yeso River	*Salmo trutta*	Brown trout	21.0	125	113	12.2	Female
	+*Salmo trutta*	Brown trout	16.5	57	52	11.6	Female
	+*Salmo trutta*	Brown trout	24	208	188	13.6	Male
Cortaderas Stream	+*Salmo trutta*	Brown trout	34.5	41	390	9.5	F
	+*Salmo trutta*	Brown trout	31.5	310	295	9.4	F
	+*Salmo trutta*	Brown trout	29.1	288	220	8.9	F
	+*Salmo trutta*	Brown trout	27	205	188	9.6	F
	+*Salmo trutta*	Brown trout	26.1	200	180	10.1	F
	+*Salmo trutta*	Brown trout	25.2	160	140	8.7	F
	+*Salmo trutta*	Brown trout	23	90	60	4.9	F
	+*Salmo trutta*	Brown trout	9.7	11.2	10.9	11.9	F
	+*Salmo trutta*	Brown trout	9	8.8	7.5	10.3	F
	+*Salmo trutta*	Brown trout	7.5	7.9	7.4	17.5	M
	+*Salmo trutta*	Brown trout	6.9	7.5	6.9	21.0	F
	+*Salmo trutta*	Brown trout	6.5	606	5.9	21.5	F
	+*Salmo trutta*	Brown trout	7.7	6.2	5	11.0	F
	+*Salmo trutta*	Brown trout	6.9	5.2	4.1	12.5	F
	+*Salmo trutta*	Brown trout	6.5	5.5	5	18.2	F
	+*Salmo trutta*	Brown trout	6.2	4.9	4	16.8	M
	+*Salmo trutta*	Brown trout	6.2	5.9	5	21.0	M

- ***Macrophytes Flora***

No Macrophytes were found in the studied stretch during the survey period.

iii. Lo Encañado Pond Sector

- ***Benthic macro invertebrate fauna***

Seven benthic Macroinvertebrate taxa were detected in the sampled stretch of the El Manzanito Stream (See Table 5.4.3.9). The total abundance of individuals was 2,566.7 ind/m^2. The Chironomidae Diptera predominated. Based on the predominance of chironomidae, the reach surveyed in the El Manzanito Stream can be typified as having a medium organic contamination condition.

The analysis of the zooplankton fauna of the Lo Encañado pond showed an abundant ensemble, where the calanoid copepod *Boeckella* was predominant and, secondarily, the presence of the *Diaptomus* sp. and *Ceriodaphnia dubia* taxa.

Table 5.4.3.9
Macrozoobenthic Fauna of the El Manzanito Stream

Taxa	El Manzanito Stream
ORDER TRICHOPTERA	0
Fam. Rhyacophilidae	11.1
ORDER EPHEMEROPTERA	0
Fam. Baetidae	0
Gen. *Deceptiviosa*	0
D. ardua	55.6
D. torrens	44.4
ORDER COLEOPTERA	0
Fam. Elmidae	0
Elmis sp.	33.3
ORDER DIPTERA	0
Fam. Chironomidae	1,955.6
Fam. Simulidae	0
Gen. Simulium	55.6
PH. ANNELIDA	0
ORDER OLIGOCHAETA	411.1
Total Abundance (ind/m^2)	**2,566.7**
Taxa richness (N° of taxa)	**7**

Benthic Microalgae Flora

The richness of planktonic microalgae in the discharge and catchments sectors varied between 6 and 15 taxa (See Table 5.4.3.10). The predominant species in both sampled sectors was *Achnanthidium minutissimum*, which showed a relative abundance over 40%. Taxa diversity varied between 1.84 and 2.72 bits. The El Manzanito Stream showed a phytoplankton taxa richness of 20 taxa. The predominant species was *Achnanthidium minutissimum* which confirms the drainage condition of the Lo Encañado pond (See Table 5.4.3.10). The highest diversity and richness in this sector was found in the El Manzanito Stream, due to the discharge of taxa from the Lo Encañado pond, to which is added the taxa ensemble generated in the stream itself.

Table 5.4.3.10
Planktonic Microalgae Flora in the South-western sector of the Lo Encañado Pond and the drainage area toward the El Manzanito Stream

Taxa	Lo Encañado Pond		El Manzanito Stream
	Discharge Sector	Intake Sector	
Achnanthidium minutissimum	45.5	41.3	48.7
Adlafia minuscula	0	0	0.64
Cocconeis placentula v euglypta	0	0	7.05
Cyclotella meneghiniana	0.75	0	3.21
Cyclotella ocellata	4.48	0	1.28
Cymbella affinis	5.97	0	5.13
Cymbella helvetica	0.75	0	0
Cymbella microcephala	0	0	1.28
Diatoma moniliformis	0	0	6.41
Encyonema minutum	15.7	4.4	3.85
Fragilaria brevistriata	0	0	0.64
Fragilaria capucina v gracilis	8.96	0	0.64
Fragilaria capucina v vaucheriae	1.49	0	0
Fragilaria pinnata	0	0	2.56
Gomphonema angustum	1.49	0	1.28
Gomphonema minutum	1.49	0	7.05
Hannaea arcus	0.75	4.35	0
Navicula capitatoradiata	0.75	0	1.28
Navicula clementis	0	4.35	0
Navicula cryptotenelloides	0	41.30	0
Nitzschia gracilis	2.99	0	0.64
Nitzschia spp	5.22	4.35	5.77
Nizschia dissipata	0	0	1.28
Pennada	3.73	0	0.64
Synedra ulna	0	0	0.64
Taxa richness (N° of taxa)	**15**	**6**	**20**
Relative abundance (%)	**100.0**	**100.0**	**100.0**
Biological diversity (bits)	**2.72**	**1.84**	**2.91**

- ***Fish Fauna***

The presence of the introduced salmoniform species *Salmo trutta* (brown trout) was detected in the Lo Encañado Pond. Five adult specimens were captured, two females and three males. The average length of the specimens was 18.3 Â± 3.7 cm and the total weight 119 Â± 67.7 g. The average eviscerated weight was 109.4 Â± 68, 1 g (See Table 5.4.3.8). The average eviscerated condition factor shown by the specimens was 16.7 Â± 2.9.

The same species introduced in the Lo Encañado pond, the salmoniform *Salmo trutta* (brown trout), was found in the reach of the El Manzanito Stream corresponding to the drainage of the pond. Three adult specimens were captured: two females and one male. The average length of the specimens was 16.3 Â± 1.5 cm and the total weight 87 Â± 29.1 g. The average eviscerated weight was 79 Â± 68, 1 g (See Table 5.4.3.11). The average Eviscerated Condition Factor shown by the specimens was 17.7 Â± 2.6.

Table 5.4.3.11
Fish fauna in the South-western sector of the Lo Encañado Pond and the drainage area toward the El Manzanito Stream

Sector	Taxa	Common name	Total length (cm)	Total weight (g)	Evisc, weight (g)	Condition factor K_{evis}	Sex
Lo Encañado Pond Sector	+*Salmo trutta*	Brown trout	20.0	140	129	16.1	Female
	+*Salmo trutta*	Brown trout	16.5	68	62	13.8	Female
	+*Salmo trutta*	Brown trout	16.0	80	68	16.6	Male
	+*Salmo trutta*	Brown trout	24.0	229	215	15.6	Male
	+*Salmo trutta*	Brown trout	15.0	78	73	21.6	Male
El Manzanito Stream	+*Salmo trutta*	Brown trout	18	120	112	19.2	Female
	+*Salmo trutta*	Brown trout	16	65	60	14.6	Female
	+*Salmo trutta*	Brown trout	15	76	65	19.3	Male

- ***Macrophytes Flora***

No Macrophytes were found in the studied stretch of the El Manzanito Stream during the survey period. However the Lo Encañado pond showed a thin line of *Miriophyllum* surrounding the water body.

iv. El Colorado Sector

- ***Benthic macro invertebrate fauna***

Two benthic macro invertebrate taxa were detected in the Colorado river reach (Table 5.4.3.12). The taxa were Chironomids of the *Simulium* and *Edwardsina* genera, their abundance was very low. No benthic Macroinvertebrate taxa were found in the reach of the Colorado river situated in the discharge sector of the aqueduct.

A different situation was detected in the Aucayes and Quempo Streams. Four benthic macro invertebrates were detected in the first of them: The *Simulium* diptera, the Ephemeroptera *A.peruvianus,* the *M. Laminata* and the Oligochaeta taxa, while 8 taxa and the predominant Chironomids and Ephemeroptera M. laminatta were found at the Quempo Stream. The total abundance in the tributary streams (155.6 and 277.8 ind/m^2) was also higher than in the Colorado River (0-22.2 ind/m^2). Based on the predominance of Chironomidae y Oligochaeta, the reach of the Colorado River in the sector of the regulation pond and the Aucayes and Quempo Streams can be typified in a median contamination condition due to organic matter, respectively.

Table 5.4.3.12
Benthic Macroinvertebrate Fauna Sector of the Aqueduct stretch of the Colorado River and its Tributaries. November 2006

Taxa	Colorado River at the Regulation Pond	Quempo Stream	Aucayes Stream	Colorado River Aqueduct Crossing
ORDER DIPTERA				
Fam. Chironomidae	11.1	33.3	0	0
Gen. *Simulium*	0	0	77.8	0
Gen. *Edwardsina*	11.1	0	0	0
ORDER EPHEMEROPTERA				
Fam. Baetidae	0	0	0	0
Gen. *Andesiop*	0	0	0	0
A. peruvianus	0	22.2	22.2	0
Fam. Leptophlebiidae	0	0	0	0
Gen. *Meridialaris*	0	0	0	0
M. laminata	0	66.7	77.8	0
M. diguillina	0	11.1	0	0
ORDER TRICHOPTERA				
Hydrobiosidae	0	11.1	0	0
Phylum Annelida	0	0	0	0
Class Oligochaeta	0	11.1	100.0	0
Total Abundance (ind/m^2)	**22.2**	**155.6**	**277.8**	**0**
Taxa richness (N° of taxa)	**2**	**6**	**4**	**0**

- ***Benthic Microalgae Flora***

The taxa richness was similar among the water bodies in the Colorado River and its tributaries, the Aucayes and Quempo Streams (See Table 5.4.3.13). Between 9 and 10 benthic microalgae taxa were detected in the Colorado River and between 10 and 12 taxa in the streams. Conversely the total cell abundance was different in these water systems. The higher abundance was detected in the Quempo Stream (288.8 cel/mm^2) while the lower abundance was found in the Aucayes Stream (9.7 cel/mm^2), see Table 5.4.3.13. The predominant species were *Planothidium lanceolatum* (Colorado River), *Fragilaria capuchina* (Aucayes Stream) and Gomphonema spp (Quempo Stream). Diversity was comparatively high as compared to the water bodies in the area studied and varied between 0.41 and 3.17 bits (See Table 5.4.3.13).

Table 5.4.3.13
Benthic Microalgae Flora Colorado River and Tributaries sector

Taxa	Colorado River at the Regulation Pond	Quempo Stream	Aucayes Stream	Colorado River Aqueduct Crossing
Achnanthidium minutissimum	0	0	0	4.97
Chaetoceros sp	0	0	0.75	0
Cocconeis placentum	0	8.3	0	0
Cymbella affinis	1.49	0	0	0
Cymbella helvetica	2.24	0	0.37	0
Cymbella sp	0	0	0	4.97
Denticula	0	16.5	0	0
Diatoma moniliformis	0.75	0	0	2.49
Encyonema minutum	0	16.5	0.75	0
Encyonema silesiacum	0	8.3	0	0
Fragilaria capucina v vaucheriae	0	8.3	2.24	4.97
Fragilaria fasciculata	0	0	0	2.49
Fragilaria pinnata	0.75	0	0	0
Gomphoneis minuta	0	8.3	1.12	4.97
Gomphonema olivaceum	0.75	24.8	0.75	7.46
Gomphonema spp	1.12	66.0	0.75	0
Hannaea arcus	1.49	33.0	0	0
Monoraphidium sp	0	74.3	0	0
Nitzschia dissipata	0.75	0	0.75	0
Oscillatoria limosa	0	8.3	0	0
Pennada	2.24	0	0.75	4.97
Planothidium lanceolatum	0	0	0	14.91
Rhoicosphenia abbreviata	0.75	0	1.49	0
Synedra ulna	0	16.5	0	0
Taxa richness (N° of taxa)	**10**	**12**	**10**	**9**
Total abundance (cel/mm^2)	**12.3**	**288.8**	**9.7**	**52.2**
Biological diversity (bits)	**3.17**	**0.41**	**3.15**	**2.95**

- ***Fish Fauna***

A low fish abundance was detected in the reach of the Colorado River studied, which was predictable due to the high sediments load carried by the river during the period of the survey. One specimen of the native *Trichomycteris aerolatus* species was captured, specifically in the stretch coring the aqueduct. The adult specimen measured 11.5 cm and weighed 14.0 g, its eviscerated weight was 10.9 g. (See table 5.4.3.14). The condition factor of the specimen was 7.2. A juvenile specimen of the introduced salmoniform *Oncorhynchus mykiss* (rainbow trout) the sex was undetermined (See Table 5.4.3.14). No fish fauna was detected in the Quempo Stream.

Table 5.4.3.14
Fish Fauna Colorado River and Aucayes and Quempo Tributaries Sector

Sector	Taxa	Common name	Total length (cm)	Total weight (g)	Evisc, weight (g)	Condition factor K_{evis}	Sex
Colorado River	*Trichomycteris areolatus*	Catfish	11.5	14.0	10.9	7.2	Male
Aucayes Stream	*Oncorhynchus mykiss*	Rainbow trout	3.1	0.1	-	-	Und.
Quempo Stream	-	-	0	0	-	-	-

Und = Undetermined

- ***Macrophytes Flora***

No macrophytes were found in the studied stretch during the survey period.

v. Maipo Sector

- ***Benthic Macroinvertebrate Fauna***

Low richness as well as low abundance of benthic macro invertebrate taxa was detected in the discharge reach of the Maipo River. There was one taxa with a total abundance of 11.1 ind/m^2. The species detected was an Oligochaeta. In spite of the low abundance, the presence of the *Oligochaeta* taxa in this reach of the Maipo River allows to typify it in a median to high organic matter contamination.

- ***Benthic Microalgae Flora***

The highest taxa richness among the water bodies studied was detected in the discharge stretch of the Maipo River (14 taxa) (See Table 5.4.3.15). Total cell abundance was also comparatively high (5.120 cel/mm^2) – See Table 5.4.3.15). The predominant species were *Cymbella helvetica* and *Surirella minuta*. Diversity was comparatively high as regards the rest of the water bodies of the area studied (See Table 5.4.3.15).

Table 5.4.3.15

Benthic Microalgae Flora Maipo River Sector

TAXA	Maipo River
Cymbella helvetica	1.590.8
Diatoma moniliformis	198.8
Encyonema minutum	99.4
Gomphonema olivaceum	198.8
Navicula cryptotenella	99.4
Navicula gregaria	298.3
Navicula lanceolata	198.8
Navicula spp	99.4
Navicula viridula v linearis	298.3
Navicula viridula v viridula	198.8
Nitzschia dissipata	397.7
Pennada	99.4
Reimeria sinuata	99.4
Surirella minuta	1,242.8
Taxa richness (N° of taxa)	**14**
Total abundance (cel/mm^2)	**5,120**
Biological diversity (bits)	**3.06**

- ***Fish Fauna***

No fish were found in the studied stretch of the Maipo River during the survey period.

- ***Macrophytes Flora***

No macrophytes taxa were found in the studied stretch of the Maipo River during the survey period.

5.4.3.4 Conclusions

A: Richness and abundance of Aquatic Biota

The fish ensemble in the studied area can be typified as of low richness and scarcity of individuals, especially in the Upper Sector of the El Volcán River and in the Maipo River, where no fish were detected during the study period. This result is frequent during spring time in high altitude water courses due to the heavy sediments loads carried by the water courses; this generates a temporary displacement if the individuals towards water courses having a more transparent water column, such as the tributaries to the main rivers (Duarte *et al,* 1971). . Low fish abundance was found in the other surveyed sectors; the ensembles were practically monospecific and dominated by the introduced species *Salmo trutta* (brown trout).

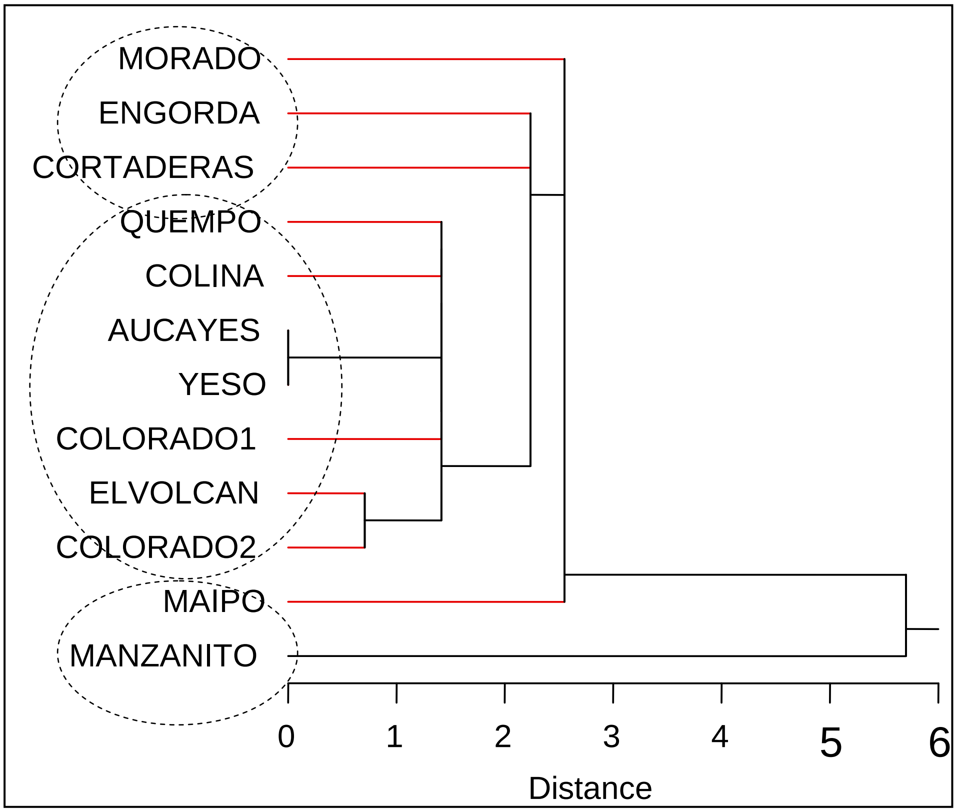
The habitat of the fish and the benthic flora and fauna differed among the water courses. The benthic taxa richness was low in the studied area and differed among the water courses in the area of influence of the Project (See Table 5.2.3.16). The water courses having less richness in phytobenthos were the La Engorda and El Morado Streams. The remainder of the water bodies showed richness between 9 and 14 taxa. However, due to the zoobenthos richness, the El Volcán, Colorado and Maipo rivers showed lesser values and richness varied between 4 and 7 taxa in the remainder of the systems.

The integral analysis carried out, based on the phytobenthos and zoobenthos richness, allows setting three groups among the sampling points. The first group is made up of the Quempo, Colina Aucayes Streams and the El Volcán and Colorado rivers, which showed median phythobenthos richness values (9-12 taxa) and zoobenthos (0-6 taxa). The second group is constituted by the El Manzanito Stream and the Maipo River, which showed high phytobenthos richness values (14 and 20 taxa) and median zoobenthos richness values (1 and 7 taxa) (Figure 5.4.3.1). The third group is made up by the El Manzanito Stream and the Maipo River, which showed high phytobenthos values (14 and 20 taxa) and median zoobenthos values (1 and 7 taxa) (Figure 5.4.3.1). There was no presence of macrophytes flora in the water bodies of the area studied, excepting scarce presence in the Quempo Stream.

Table 5.4.3.16
Comparative analysis of the Biota Richness in the PHAM Area of Influence.

N°	Sampling Area	Sampling Point	Phythobenthos Richness N° of taxa	Zoobenthos Richness N° of taxa	Presence of Macrophytes Pres/abs	Presence of Fishes Pres/abs
1	Upper basin Volcán River	La Engorda Stream	7	5	0	0
2		Colina Stream	12	4	0	0
3		El Morado Stream	4	7	0	0
4		El Volcán River	10	0	0	0
5	Yeso River Basin	Yeso River	10	4	0	1
6		Cortaderas Stream	8	8	0	1
7	Lo Encañado Pond Sector	Discharge Sector	15	-	1	1
8		Intake Sector	6	-	1	1
9		El Manzanito Stream	20	7	0	1
10	Colorado River Basin	Colorado River Accumulation Pond	10	2	0	0
11		Quempo Stream	12	6	0	0
12		Aucayes Stream	10	4	0	1
13		Colorado River Aqueduct crossing zone	9	0	0	1
14	Maipo River Discharge zone	Maipo River	14	1	0	0

Figure 5.4.3.1
Grouping of the Water Courses based on the Phytobenthos (Benthic Microalgae) and Zoobenthos (Benthic Macroinvertebrates) richness
Hierarchical Classification Analysis



The abundance of individuals also differed between the water courses of the Project area of influence (See Table 5.2.3.17). A first group was formed by the Colina, El Morado, Aucayes, Quempo Streams and the Colorado River showed low phytobenthos abundance and low to median zoobenthos values. The second group was formed by the La Engorda and Cortaderas Streams and the El Volcán and Maipo rivers, which showed low to middle zoobenthos abundance and high phytobenthos abundance. The third group contained the El Manzanito Stream, which showed the highest zoobenthos abundance in the area studied and the fourth group was formed by the Yeso River, which showed the highest phythobenthos abundance in the studied area (See Figure 5.4.3.2).

The integral analysis made, based on the phytobenthos and zoobenthos abundance, allows to state that the La Engorda and Cortaderas Streams as well as the El Volcán, Maipo and Yeso rivers show the higher abundance of phytobenthic taxa of the area studied and that the highest zoobenthic taxa was detected in the El Manzanito Stream. These systems offer the greatest food offer for the fishes; this indicates that these systems are the most favorable habitat for fish populations. Conversely, the lesser benthos abundance was found in the Colorado River and the Quempo, Aucayes, Colina and El Morado Streams.

The Quempo, Cortaderas, Manzanito Streams and the Lo Encañado Pond are part of the indirect influence area of the project, and are not intervened by it.

Figure 5.4.3.2
Grouping of the Water Courses based on the Phytobenthos (Benthic Microalgae) and Zoobenthos (Benthic Macroinvertebrates) richness Hierarchical Classification Analysis

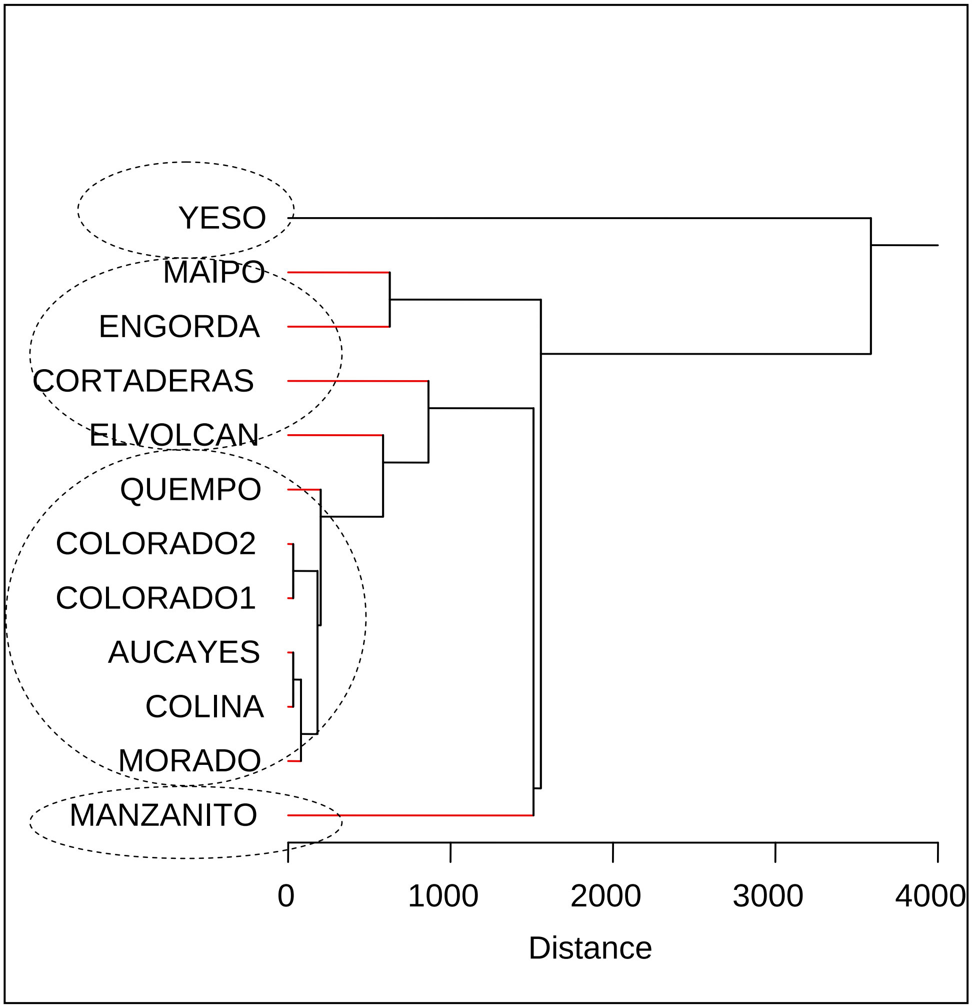


Table 5.4.3.17
Comparative Analysis of Biota Abundance in the Area of influence of the PHAM

N°	Sampling Point	Phythobenthos Abundance cel/mm^2	Zoobenthos Abundance ind/m^2	Presence of Macrophytes Pres/abs	Relative Fish Abundance
1	La Engorda Stream	4,469	611.1	0	0
2	Colina Stream	19.4	322.2	0	0
3	El Morado Stream	3.0	433.2	0	0
4	El Volcán River	1,102	0.0	0	0
5	Yeso River	10.192	111.4	0	1
6	Cortaderas Stream	2,310	188.9	-	1+
7	Lo Encañado Pond	-	-	1	1
8		-	-	1	1
9	El Manzanito Stream	100.0	2,566.7	0	1
10	Colorado River Accumulation Pond	12.3	22.2	0	0
11	Quempo Stream	288.9	155.6	1	0
12	Aucayes Stream	9.7	277.8	0	1
13	Colorado River Aqueduct crossing zone	52.2	0.0	0	1
14	Maipo River	5.120	11.1	0	0

+ High abundance

B. Fish Fauna

From a theoretical point of view, it is possible to affirm that the abundance differences of the benthic biota indicate difference in the habitat conditions specifically that of the food offer for the fish. However, the results showed that the presence of fish in the study area was independent from the food offer, as there were fish in places with high and also low benthos abundance. These results suggest that the presence of fishes during the study period is due to factors other than food availability, as is the higher or lower load of particles in suspension. As evidence of the above, there is the fact that the higher number of fishes was detected in sectors having low particles in suspension loads, such as the Aucayes, Cortaderas, El Manzanito streams and the Yeso River.

Therefore, the low fish fauna found in the studied area during the spring period would be modulated by the physical conditions of the habitat, basically the particles in suspension load. This is a natural condition in the cordilleran sectors of the temperate climate basins, where a greater surface runoff takes place during the thaw period, significantly affecting the dispersion of the fishes and causing their displacement to places with less turbidity.

The environmental requirements of the native species differ from those of the introduced species. The favorable habitat for the *T. areolatus* population is an heterogeneous rocky substrate, with gravel and pebbles between 3 and 10cm, high transparency. oxygen concentration in the water column and low stream velocity. These attributes were predominantly found in the surveyed area of the El Volcán and Yeso rivers. However, *T. areolatus* was not found in those systems and only specimens of the introduced *Salmo trutta* species were found in the Yeso River. The Colorado River was the single sampling sector where *T. areolatus* was found although it does not have a favorable substrate for its development. These results indicate that the type of substrate is not modulating the fish populations during the present study period.

A characteristic of the upper basin of the Maipo River sector where the study area is found is the presence of a fish ensemble where the introduced *O. mykiss* and *S. trutta* species predominate (Duarte et al, 1971). The introduction of these highly invasive Ictic species, aggressive towards native species, has had historic and present unfavorable effects upon the native fish ensembles of the country (Soto et al 2006). This is due to the seeding of ova for sporting and recreational purposes, mainly in the reach of the Maipo River between the La Obra and Tejas Verdes sectors (Duarte et al 1971). Those species have generated a highly disturbed condition in the study area and for this reason at present there is a low presence of fishes in the upper reaches of the basin (from the Maipo River source to the La Obra sector) and in the lower middle basin (from La Obra to Tejas Verdes) (Duarte et al 1971). The study area is located in the upper sector and therefore the findings of the introduced species *O. mykiss* and *S. trutta*, coincide with the existing antecedents for this basin: Duarte et al (1971), Vila et al (1999) and DGA (2004). These results allow stating the biologic ensembles of the study area have been frequently disrupted by natural and anthropic conditions, mainly associated to irrigation, power generation and recreation activities in the basin (DGA, 2004). Therefore and from a biological conservation point of view, it is possible to assign a low environmental valuation to the study area.

5.5 HUMAN ENVIRONMENT

5.5.1 General Description

5.5.1.1 Introduction

The occupation of space by different groups of people is directly related to the characteristics of those groups, which take advantage of the existence of natural resources to create settlements of different sizes. The settlements evolve according to the development achieved by each group of people, and the development process is explained by the particular characteristics and the existence and access to services, equipment, and infrastructure.

In view of the above, the main social information corresponding to demographic elements, housing, education, health, employment, poverty, and social welfare of the populated localities existing in the area of influence of the Project is provided below. A description of the main economic and productive activities that are carried out in the area is also included.

Information for the different levels of the area of influence of the Project is presented, considering the five dimensions referred to in Article 8 of the Regulations of the EIAS, which are geographic, demographic, anthropological, socio-economic and basic social welfare dimensions.

5.5.1.2 Methodology

One of the elements considered in preparing this section is experience-based knowledge of the different groups of people, using the technique of Direct Observation of the ways of life and customs, which was carried out during field visits to the area of influence of the Project. Informal conversations were also held with inhabitants of the area of influence, who were approached while they were in transit from one place to another or selling a product or service.

A sequential analysis is presented, which ranges from the regional level to the provincial, then the communal, and ends with the localities in the area of direct influence of the Project. They are El Alfalfal, Los Maitenes, El Canelo, El Manzano, San Gabriel, El Romeral, El Volcán, Lo Valdés, and Baños Morales, all located in the area of influence of the Project.

In quantitative terms and in terms of representative population indices, information was compiled from different census records[1].

[1] Data Record of 1982 - 1992 – 2002 Censuses, INE

Sources consulted for the social and economic description were public agencies[2], socioeconomic surveys, interviews, and field visits. Special emphasis was placed on the study of the Communal Development Plan (PLADECO) and Sustainable Environmental Planning prepared for the commune of San José de Maipo in 2002.

5.5.1.3 Geographic Dimension

A. Location and Placement Pattern

The community of San José de Maipo is located in the mountainous sector of the Metropolitan Region, in the great fluvial system of the Maipo, which is considered to be the most important one in the region.

The main characteristic of the geomorphology of the commune corresponds to its purely glacial origin, with steep slopes, deep glacial canyons surrounded by abrupt, soaring mountains where important erosive and sedimentary processes occur that determine the physiognomy of the area.

In this geographic context, the communal borders are:

- To the north, Region V of Valparaíso.
- To the south, Region VI of Libertador General Bernardo O´Higgins.
- To the east, Republic of Argentina.
- To the west, the communes of Lo Barnechea, La Reina, Peñalolén, La Florida, Puente Alto and Region VI.

The commune is part of the Metropolitan Region, and it is located specifically in the Cordillera Province, which has the largest surface area in the regional context, as shown in Table 5.5.1.1.

Table 5.5.1.1
Surface Areas of the Provinces in the Metropolitan Region

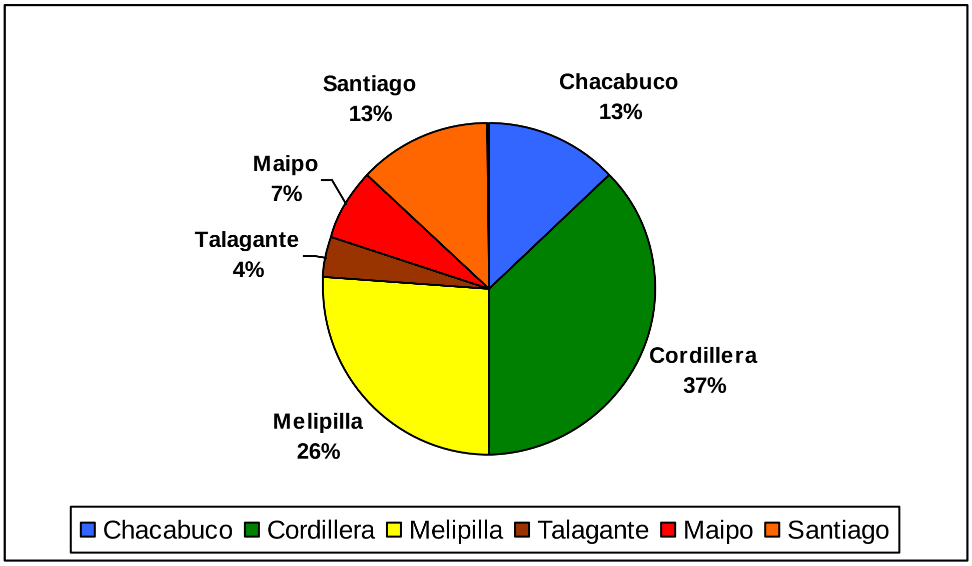
Province	Surface Area (Km^2)
Chacabuco	2,076.10
Cordillera	5,528.30
Melipilla	4,065.70
Talagante	582.3
Maipú	1,120.50
Santiago	2,030.30
Total	15,403.20

Source: INE, 2005.

[2] MIDEPLAN and the Illustrious Municipality of San José de Maipo.

Figure 5.5.1.1 shows the percentage distribution of the regional territory, reflecting the predominance of the Cordillera Province in the surface area.

Figure 5.5.1.1
Distribution of Provincial Surface Areas in the Metropolitan Region



Source: INE, 2005.

According to this information, the Cordillera Province, where the commune of San José de Maipo is located, covers 5,528.30 Km^2, which makes it the largest province in the region, with 37% of the total surface area.

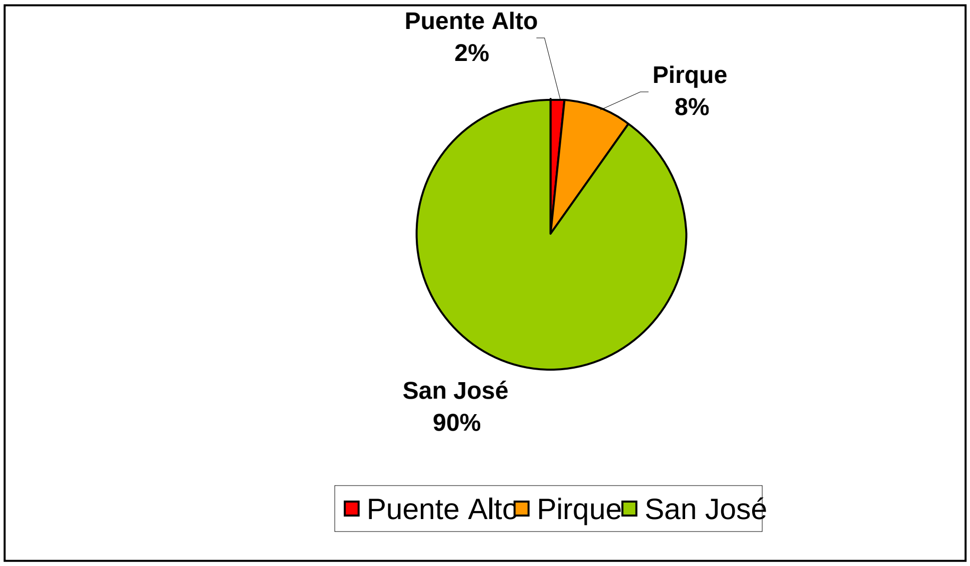
The Commune of San José de Maipo in the Cordillera Province has the largest surface area, with 4,994.8 Km^2, which represents 90% of the surface area of the province, as shown in Table 5.5.1.2 and Figure 5.5.1.2.

Table 5.5.1.2
Surface Areas of the Communes in the Cordillera Province

Commune	Surface Area (Km^2)
Puente Alto	88.2
Pirque	445.3
San José de Maipo	4,994.8
Total	**5,528.30**

Source: INE, 2005.

Figure 5.5.1.2
Distribution of Communal Surface Areas in the Cordillera Province



Source: INE, 2005.

The location of the commune of San José de Maipo is totally determined by the geomorphology of the sector with its repeated forms of a narrow valley, where the population is located in fluvial canyons, specifically on small fluvial, glacial, and volcanic terraces at the bottom of the valley. Thus, although the area of the community is the largest of all the communes in the Province, the surface area where the population can actually settle is small.

The settlement pattern that can be seen throughout the whole commune is linear, with route G-25 being the main highway. The localities where most of the population is concentrated branch out from this road and are connected by it to one another. There are other smaller roads that fork off of route G-25 along which small localities are also located with a significantly smaller concentration of population and a higher degree of isolation from the communal center and the Metropolitan Region.

B. General occupation of the territory

The commune is made up, geomorphologically, of the main valley of the Maipo, as well as three principal secondary valleys, corresponding to the Volcán, Colorado and Yeso rivers. The main characteristics of the localities that are associated with those valleys are shown below:

1. **Maipo River Valley**: the localities of La Obra, Las Vertientes, El Canelo, El Manzano, Guayacán, El Melocotón, San Alfonso, El Ingenio, San Gabriel, El Volcán, Las Melosas and San José de Maipo are located in this section. The latter is the capital of the commune and the only settlement considered to be Urban by INE.

The stretch between La Obra and San José de Maipo is the most heavily populated sector of the commune, with the most equipment and supply of services, mainly concentrated in the capital of the commune and the surrounding area. The most important economic activities in the area include commercial activities that are directly related to the affluence of tourists, such as restaurants, the sale of typical products, and contemplation of nature and attractions along the fluvial corridor of the Maipo River, which can be visited via route G-25.

2. **El Volcán River Valley:** The localities of El Romeral, El Volcán, Baños Morales, and Lo Valdés are located in this valley. The origin of the valley is based on mining activity. Another economic activity that has developed gradually in this area of the commune is tourism, mainly in the villages of Baños Morales and Lo Valdés. This area is in demand from different economic strata and special interest groups, which range from middle-low sectors in the Metropolitan Region that visit the popular Baños de Colina and the Baños Morales hot springs to special interest groups like local and foreign mountain climbers in Lo Valdés and the El Morado Sanctuary.

3. **Colorado River Valley:** two populated entities are located here, which arose from the development of the Los Maitenes and El Alfalfal hydroelectric facilities. The villages of the same name that emerged in those places correspond to small localities isolated from the center of the commune, because they are located on a road that forks off of route G-25. The traditional economic activity that is still carried out by local residents is cattle raising, and the figure of the cowboy is well known. Gradually, these groups of people are also venturing into tourism, but in this case the tourism is almost exclusively aimed at special interest groups focused on mountain sports.

4. **Yeso River Valley:** the main populated area in the Yeso River valley corresponds to the camp at the El Yeso reservoir. This reservoir plays a key role in the water supply of Greater Santiago. It is located at high altitude in the commune, and the access road is hard to drive on most of the year so it is not very populated; there is a locality called El Romeral, which is located on route G-25 near the confluence of the Yeso and Volcán rivers.

The city of San José de Maipo, capital of the commune, is located on a broad sector of terraces and, unlike the other sectors of the commune; it has appropriate environmental conditions for human settlement. The urban location is a Checkerboard type, with a town square that includes the most important services: Town Hall, three schools, banks, pharmacies, telecommunications, post office, police, and cathedral, among others.

C. Transportation

Because of the weather and morphological conditions and the sparse population, there is little integration and connectivity in the commune. There are only two main access roads to the community, both paved, which are Route G-25 (which connects the commune and Puente Alto) and the El Toyo road, Route G-421, which connects the commune and Pirque.

Route G-25, called *Camino al Volcán*, runs for more than 100 kilometers in the commune, bordering the Maipo River for most of its length and then continuing along the Volcán River. This Route runs perpendicular to the mountains for 20 km to El Guayacán where it turns right and continues south for 12 km to San Alfonso. It then continues in an eastwardly direction, passing through San Gabriel where it becomes a dirt road and finally ends in Baños Colina. Several forks of this road connect with other localities.

The roads that branch off of route G-25 include route G-345, which connects with the hydroelectric plants and the localities of Los Maitenes and El Alfalfal, and route G-455, which connects with the area of the El Yeso reservoir. Finally, the connecting road between the locality of Las Vertientes and route G-25 is route G-421, an alternative road that connects San José de Maipo and Pirque.

5.5.1.4 Demographic Dimension

A. Population Growth

The Cordillera Province is the second largest province in terms of inhabitants in the Metropolitan Region, with 522,856 persons. It is widely surpassed by the province of Santiago with 4,668,473 inhabitants, which is the most populated province in the country.

Table 5.5.1.3 shows the data on population, surface area, and population density of the provinces in the Metropolitan Region.

Table 5.5.1.3
Demographic Data on the Provinces in the Metropolitan Region

Province	Population	Surface area (Km^2)	Density ($Inhab/Km^2$)
Santiago	4,668,473	2,030	2,299.74
Cordillera	522,856	5,528	94.58
Maipo	378,444	1,121	337.59
Talagante	217,449	582	373.62
Melipilla	141,165	4,066	34.72
Chacabuco	132,798	1,076	123.42

Source: INE, 2006.

Despite having the second largest population in the Region, the Cordillera Province has one of the lowest population densities in the region due to its extensive surface area. This is a result of the fact that the inhabitable territory in the province is scarce because most of the land corresponds to the Andes Mountains and formations arising from the morphogenetic processes that have occurred in the area where the slopes and soil characteristics do not permit the settlement of population.

Table 5.5.1.4 shows the population figures compiled by the INE in the last period between censuses for the Cordillera Province and the three communes that make it up.

Table 5.5.1.4
Demographic Evolution of the Cordillera Province and its Communes

Commune	1992	2002	% of Growth
Country	13,348,401	15,116,435	11.70
Metropolitan Region	5,257,937	6,061,185	13.25
Cordillera Province	277,687	522,856	46.89
Communes			
Puente Alto	254,673	492,915	48.33
Pirque	11,646	13,376	12.93
San José de Maipo	11,368	16,565	31.37

Source: INE, 2006.

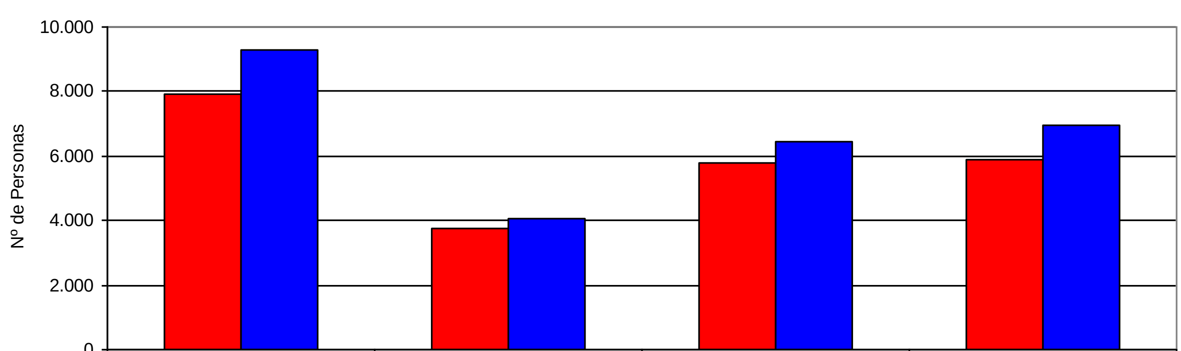
The biggest percentage of growth is shown in the Cordillera Province with 46.89% between censuses, which is much higher than the regional and national growth figures of 13.25% and 11.70%, respectively.

At the commune level, Puente Alto shows explosive growth compared with the other communes in the province and the country, with growth of 48.33%. The commune of San José de Maipo is in second place with 31.37%, and the commune with the lowest growth is Pirque with 12.93%.

The commune of San José de Maipo shows the lowest proportion of urban population in the province, with 1.82% of the total. Nevertheless, the number of persons who live in the city, compared with the other localities is quite high, with 69.61% of the total population in 2002 (9,311 persons) and only the remaining 30.39% in the rural sector (4,065 persons).

Figure 5.5.1.3 shows the data on urban-rural location and sex in the commune of San José de Maipo for the period between censuses.

Figure 5.5.1.3
Growth between Censuses



	Población Urbana	Población rural	Mujeres	Hombres
1992	7.911	3.735	5.762	5.884
2002	9.311	4.065	6.429	6.947

Source: INE, 2006.

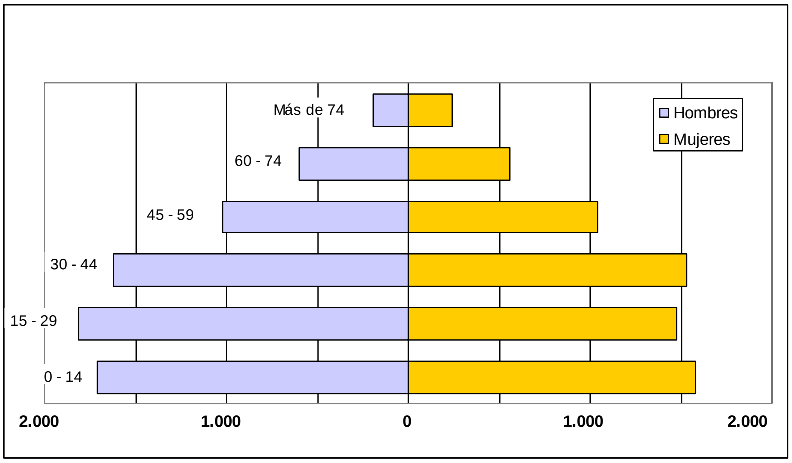
The urban population in the community increased from 67.93% in 1992 to 69.61% in 2002 whereas it dropped for the rural sector from 32.07% to 30.39%, which shows an increase and reduction of about two points in both cases, which could be due to intra-communal migratory movement. The urban population of the commune corresponds exclusively to the people who live in the city of San José de Maipo.

The number of men compared to women in the community is higher in both censuses; the largest percentage was observed in 2002 with 51.94% and 48.06%, respectively.

B. Age distribution according to sex

Figure 5.5.1.4 shows the age distribution in the commune according to the sex of the population, according to the Census for 2002.

Figure 5.5.1.4
Age Distribution According to Sex



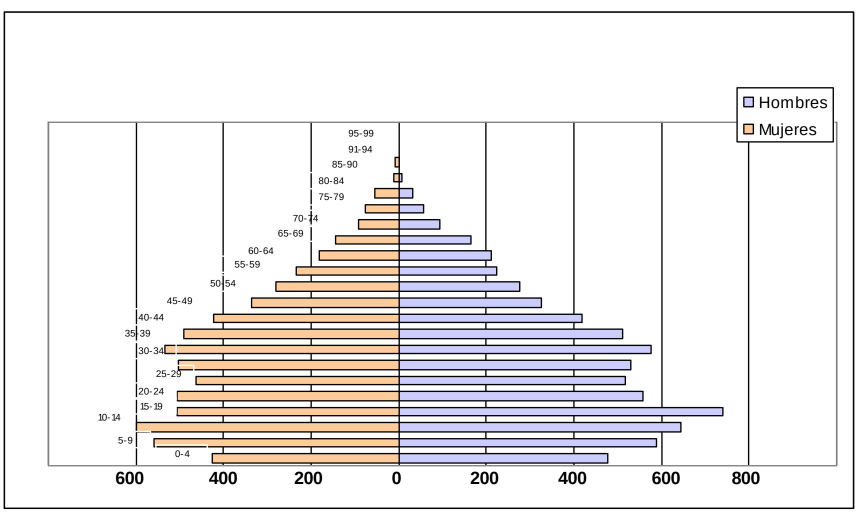
Source: INE, 2006

The population in the communal territory is 51.9% male and 48.1% female. The age groups with the largest numbers of population include 0-14 years, with 24.60%, followed by 15-29 years with 24.57%, and in third place 30-44 years with 23.53%, totaling more than 70% of the population. This indicates the strong presence of family groups composed of couples of young and middle-aged adults with school-age children.

C. Migratory Flows

Figure 5.5.1.5 shows the age groups every five years for the Commune of San José de Maipo.

Figure 5.5.1.5
Age Groups Every 5 Years



Source: INE, 2006.

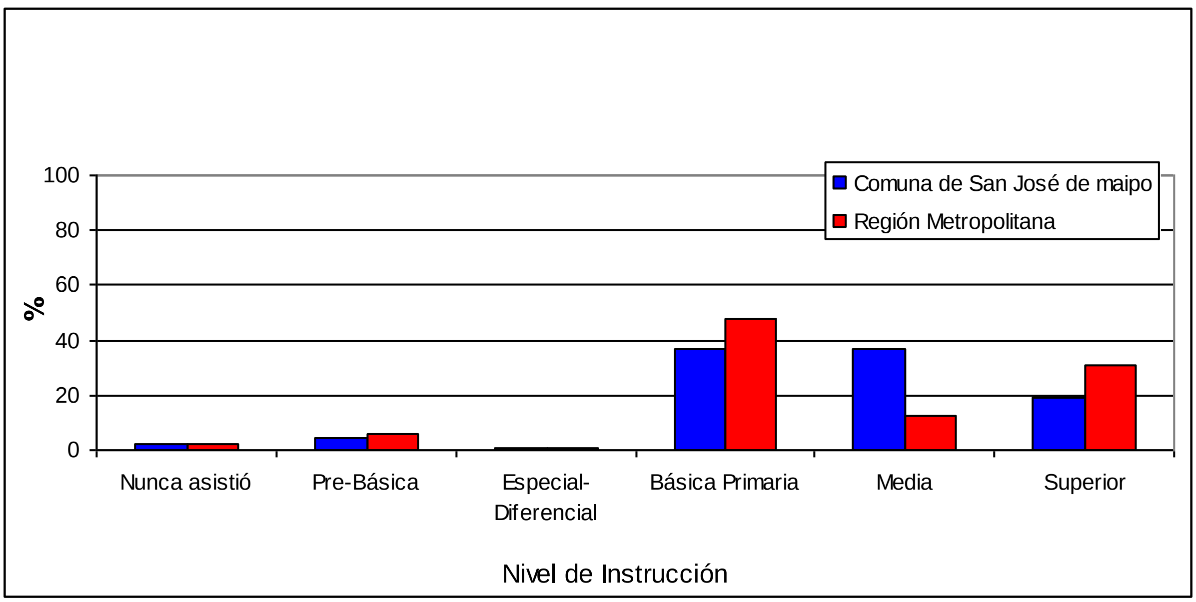
An interesting aspect is the important participation of young people of both sexes, especially of school age, with a slight decrease in women, which leads to an assumption of low emigration in this age group (which generally emigrates from more isolated, rural places in search of employment and education). This situation could be caused by the presence of High Schools in the community, and also because the connectivity makes it possible to travel for work or education to other communities in Greater Santiago while maintaining a residence in the community. Another element that could explain this situation is the establishment of family groups of young adults in different areas in the commune, who have emigrated from more densely populated sectors of the Metropolitan Area of Santiago in an effort to improve their quality of life. This situation will increase with the accelerated development of condominium-type real estate projects in the community.

In the groups corresponding to young adults there is a slight reduction, which could be due to emigration from the commune in an effort to satisfy the needs for higher education and employment; this reduction, however, is not significant.

D. School Enrollment

Figure 5.5.1.6 shows the level of education of the population with ages equal to, or above, 5 years of age, at the communal and regional level.

Figure 5.5.1.6
Level of Education in Population 5 Years of Age or More



Source: INE, 2006.

Only 1.98% of the total population over 5 years of age states it has never attended any formal establishment of education. When comparing the commune of San José de Maipo and the Metropolitan Region, the biggest differences are seen in higher education, with 19.04 in the commune and 30.78% in the region, which is due to the lack of establishments of higher education and the significant participation of rural population in the total population of the commune. Another important difference is seen in primary elementary education (1st to 6th grades), with 37.02% for the commune and 47.99% in the Metropolitan Region.

On the other hand, 37.02% of the population says it has studied or is studying in high school, and this percentage is 12.51% for the Metropolitan Region

The population equal to, or above, 10 years of age corresponds to 11,326 people, 96.71% of whom are literate and 3.29% are illiterate.

F. Poverty

i. Population According to Poverty Line

The population according to the poverty line in the Commune of San José de Maipo and the Metropolitan Region for 2003 is structured as shown in Table 5.5.1.5

Table 5.5.1.5
Population According to Poverty Line, Comparison among Years 1998, 2000 and 2003

Situation of Poverty	Commune of San José de Maipo		Metropolitan Region	
	No. of Persons	%	No. of Persons	%
1998				
Indigent	564	4.7	203,248	3.5
Not Indigent Poor	1,065	8.8	698,362	11.9
Not Poor	10,492	86.6	4,946,630	84.6
2000				
Indigent	530	4.3	258,760	4.3
Not Indigent Poor	1,810	14.7	713,160	11.8
Not Poor	9,995	81.1	5,049,441	83.9
2003				
Indigent	530	4.30	179,154	2.85
Not Indigent Poor	1,810	14.67	643,533	10.23
Not Poor	9,995	81.03	5,468,497	86.92

Source: INE, 2006.

According to the table above, the percentage of Indigent Population is lower in 2003 than 1998 in the commune, dropping from 4.7% to 4.3%, respectively. These values are higher in both years than the data compiled for the Metropolitan Region where the proportion of indigent population is 3.5% in 1998 and 2.9% in 2003.

The Not Indigent Poor population increased in the commune from 8.8% in 1998 to 14.7% in 2003, which is quite significant. The opposite occurred in the Metropolitan Region where the percentage of Not Indigent Poor population dropped from 11.9% in 1998 to 10.2% in 2003.

As a result of the above, the Not Poor population was lower in 2003 than in 1998, with 86.6% and 81.0%, respectively. The opposite occurred in the Metropolitan Region with 84.6% in 1998 and 86.9% in 2003.

ii. Household Income Level

Table 5.5.1.6 shows the earned income of the commune compared with the regional for 2003, also indicating the level of monetary subsidies.

Table 5.5.1.6
Household Income Level

Level	Earned Income		Monetary Subsidy		Monetary Income	
	No.	%	No.	%	No.	%
Metropolitan Region	718,961	99.48	3,724	0.52	722,685	100
San José de Maipo	590,652	99.28	4,270	0.72	594,922	100

Source: INE, 2006.

The earned income of the region is higher than the communal, with 99.48% and 99.28%, respectively. The monetary subsidy of the commune is higher than the regional, at 0.72%, while it is 0.52% at the regional level. This is consistent with the higher levels of poverty in the commune, which mean the State plays a larger subsidiary role.

5.5.1.5 Anthropological Dimension

As stated by Spanish chroniclers, there were aboriginal peoples who circulated around and/or settled on the mountainous land in what is now known as the commune of San José de Maipo. Based on ethno-historical and ethno-linguistic information, these indigenous peoples have been called Chiquillanes (“Bush” in the Mapuche language), but there is no archeological proof to confirm that name as the numerous remains found in the area were not sufficiently conserved to be studied. The original inhabitants were eliminated, presumably by the confrontation with Spanish troops and during the process involving the mixing of the races.

The ancient pre-Hispanic inhabitants of the Cajón del Maipo were dedicated to hunting guanacos and *southern Andean deer*, selling the meat of those animals and the salt they extracted from the lagoons in the area, as well as collecting wild fruit. They also practiced agriculture, thanks to the abundance of natural resources in that vast territory.

Although no clear influence of the original peoples can be seen in the current ways of life and customs, there is still a strong connection between the predominant economic activities and the use of local natural resources, which is visible in the traditional mining industry, the production of walnuts and almonds, and nature tourism.

In colonial times the connection between the population and the use of natural resources was seen in a number of factors like the origin of San José de Maipo, the main population center and current capital of the commune, which developed from the first silver mine in the country, called San Pedro Nolasco (located 25 kilometers from San José de Maipo) and founded in 1790. This deposit produced the most important foreign currency of the time for the Kingdom of Chile, which caused a significant migration of miners with their families, who founded the Villa de San José de Maipo in 1792.

Other mining deposits that were worked at the time were located in the San Lorenzo and San Gabriel mountains, which contributed to the mining boom.

There was also an increase in livestock breeding during the colonial period. This activity was closely related to mining because the mining works required a large number of animals to look for new mines and then work them. This is where the image of the cowboy emerges, which remains to this day. These herders went up into the Andes every summer to pasture their animals. They also participated in importing cattle from Argentina to supply meat to the Metropolitan Region.

During the period of Independence, this territory became very important because the “Las Pircas” and “Los Piuquenes” mountain passes were used by the guerrilla leader Manuel Rodríguez and by an expedition of the Liberation Army of San Martín. The mountain passes were also used for cattle trade with Argentina, which explains why the Customs Checkpoint was located in El Manzano. This checkpoint started to fall into disuse and finally disappeared because of the installation of the International Pass in Los Andes, which replaced the old roads into the neighboring country through the Cajón del Maipo.

Construction of the railroad was a determining factor in the development of the commune. The military railroad was laid in 1908 from Puente Alto to the village of San Gabriel. Its main purpose was to transport ore from the sector of El Volcán. The railroad was gradually expanded into the commune, and new localities were founded. This small railroad was inaugurated in stages: to El Canelo (km. 13) in 1910, to El Melocotón (km. 35) in 1911, and to El Volcán (km. 60) in 1914.

The military railroad thus became a key tool in the economic and demographic growth of the commune. Although the motivation for founding the railroad was economic, it was transferred to the Army, because in addition to its economic role, it was also a training tool for the Army in matters that were considered strategic at the time.

Over time, the railroad included the transportation of ore, cattle, and also passengers, both local and from Santiago; the latter visited the Cajón del Maipo in search of open air and contact with nature. The latter motivation is still valid, and it is one of the main reasons the area is frequented by tourists and visitors. It also explains why numerous Chileans and foreigners have settled in the community.

The train was very slow, rarely going more than 25 km/h, so it was replaced by the automobile as soon as that mode of transportation became popular. Service to San José de Maipo was cut back around 1980, and it closed definitively in 1985 when the tracks were removed.

Numerous attempts have been made in the last few years to rebuild the railroad, but in response to a new economic activity this time, tourism. The project of the Governor´s Office of the Cordillera Province is one of those attempts. In the framework of the celebrations of the Bicentennial of Chilean Independence, it proposed gradually rehabilitating the railroad from El Manzano to San José de Maipo and finally to El Volcán, and the proposal was accepted in January 2006[3].

The gold, silver and copper mines, as well as the railroad, belong to the past, but they left the stamp of mining and the railroad as a legacy, which have become components of the community identity.

Natural resources continue to be exploited today in the area of the Cajón del Maipo, such as water to supply potable water for the city of Santiago, the extraction of ore and arids, and the production of hydroelectric power, as well as cattle-raising and production of almonds, walnuts and honey, and the gradual, but growing, development of tourism, especially ecotourism.

Despite the differences between one locality and another, the natural conditions of the Cajón del Maipo and the general isolation of the community in the context of the Metropolitan Region have shaped a local culture where permanent contact with nature is the common denominator.

Regarding organizational culture, this commune stands out as one of the first in the country whose residents organized them to deal with an environmental conflict. The conflict in question was sparked by the introduction of natural gas into the central zone of Chile after Argentina deregulated and privatized the energy sector, enabling the two countries to sign a Gas Integration Protocol in 1995. A gas pipeline was built to transport the gas, which crossed the border near the Maipo volcano at 3,400 meters altitude and then crossed the length of the commune of San José before descending towards Puente Alto[4].

Civic concern with the construction of the pipeline was generally focused on impacts on the landscape and risks to the safety of the population and the environment. In order to address the conflict, the community carried out a number of actions including meetings with the authorities, street protests, events, letters, etc. After a long negotiation process, the community and the company reached agreements that involved a number of measures, including payment to the owners of the land where the pipeline passed.

[3] http://www.amigosdeltren.cl/ferrochile/historia/elvolcan/histo_volcan_es.php
[4] http://www.agnchile.cl/cobertura/cobertura1.html

5.5.1.6 Socioeconomic Dimension

A. Economically Active Population (E.A.P.)

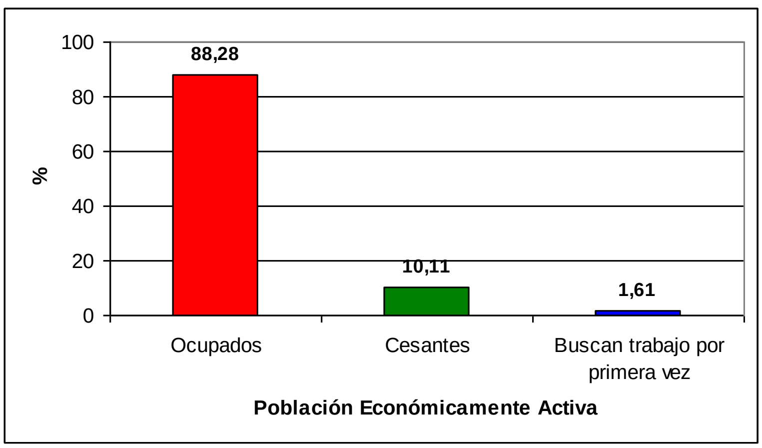
The labor force of the commune includes 10,085 persons (75.4% of the communal population), 56.09% of which belongs to the E.A.P. (5,657 persons) and the remaining 43.91% (4,428 persons) to the Non-Economically Active Population (N.E.A.P.). The distribution of the E.AP... by condition of activity is shown in Table 5.5.1.7 and Figure 5.5.1.7.

Table 5.5.1.7
E.A.P. by Condition of Activity, Commune of San José de Maipo, 2002

Condition of Activity	No. of Persons	%
Employed	4,994	88.28
Unemployed	572	10.11
Looking for Work for the first time	91	1.61
TOTAL	5,657	100

Source: INE, 2005.

Figure 5.5.1.7
Condition of Activity of E.A.P.



Source: INE, 2005.

According to the above, 88.28% of the total E.A.P. in the commune in 2002 was employed, while the level of unemployed was 10.11%. The E.A.P. looking for work for the first time was equivalent to 1.61% of the regional total.

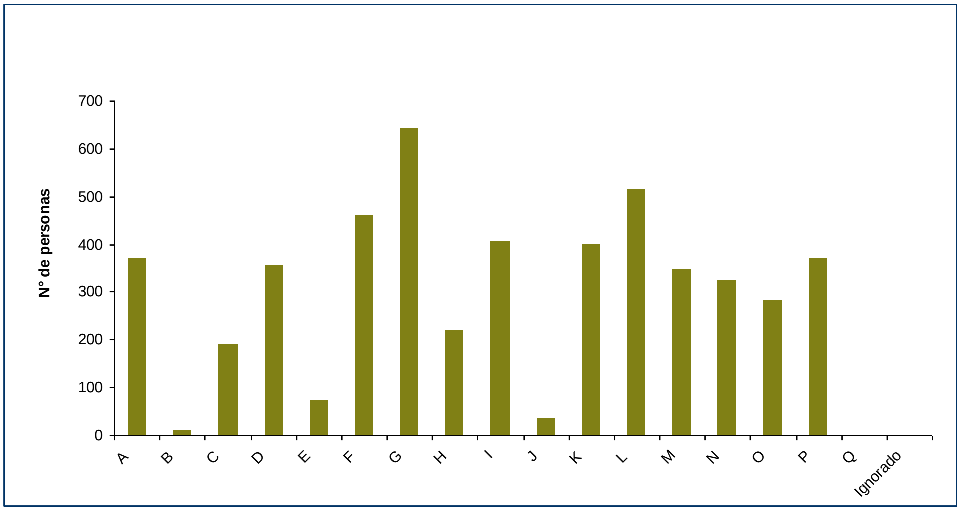
The employed E.A.P. in the commune according to the 2002 Census (4,994 inhabitants) worked in the economic activities listed in Table 5.5.1.8 and shown in Figure 5.5.1.8.

Table 5.5.1.8
Distribution of the E.A.P. according to Type of Economic Activity, Metropolitan Region, 2002

	Type of Economic Activity	No. of Persons	%
A	Agriculture, fishing, cattle-raising and hunting	370	7.41
B	Fishing	9	0.18
C	Working mines and quarries	190	3.8
D	Manufacturing industries	356	7.13
E	Supply of electricity, water and gas	73	1.46
F	Construction	459	9.19
G	Wholesale and retail trade, car and motorcycle repair	643	12.88
H	Hotels and restaurants	219	4.39
I	Transportation, storage and communications	405	8.11
J	Financial brokerage	34	0.68
K	Real estate, entrepreneurial and rental activities	398	7.97
L	Public Administration and defense; social security plans and union plans	514	10.29
M	Teaching	346	6.93
N	Social and health services	324	6.49
O	Other activities involving community, social and personal services	282	5.65
P	Private homes with domestic service	371	7.43
Q	Extraterritorial organizations and agencies	1	0.02
-	Unknown	0	0
	TOTAL	**4,994**	**100**

Source: INE, 2005.

Figure 5.5.1.8
Distribution of E.A.P. according to Type of Economic Activity
Metropolitan Region, 2002



Source: INE, 2005.

Considering this information, 12.88% of the employed E.A.P. is dedicated to wholesale and retail trade and car and motorcycle repair, which is the highest percentage. This partially reflects the fact the commune is able to provide its own supply in view of its geographic condition. 10.29% of the employed E.A.P. works in Public Administration and Defense and social security and union plans, which is reasonable since it is a vast territory with two small-scale, but historical, border passes, and a population that requires services like a civil registry, health, municipal, etc. because of its geographic isolation. Construction follows slightly lower with 9.18%, which reflects the dynamism in this area as a result of the tourist activity and an increase in population, among other variables.

The rest of the employed E.A.P. is dedicated in smaller percentages to different types of activity, with the area of transportation, storage, and communications occupying 8.11%. The following activities represent 7%: Agriculture, fishing, cattle-raising and hunting, manufacturing industries, real estate, entrepreneurial and rental activities, and private homes with domestic service.

In the category of agriculture, fishing, cattle-raising and hunting, production of dried fruit has been developing, especially almonds and, increasingly, walnuts; in livestock-raising traditional breeding of cattle is observed, part of which comes from other communes and regions of the country and involves taking the animals to graze during the summer in the vast mountains of the commune, and there is also breeding of goats with a supply of byproducts, especially goat cheese.

According to data from the Communal Planning Secretariat of San José de Maipo in 2000, the companies in the commune, according to their economic activity, are the ones listed in Table 5.5.1.9

Table 5.5.1.9
Companies by Economic Activity in the Commune of San José de Maipo, January 2000

Sector	Activity	No. of Companies			
		MR	Cordillera Province	Commune	Intra-Provincial % of Distribution of Companies by Economic Activity
Primary	Agriculture, Forestry and Fishing	9,842	276	23	2.3
	Mining	585	63	12	0.5
Secondary	Manufacturing industries	23,576	721	13	5.9
	Electricity, light and water	391	22	2	0.2
	Construction	14,485	830	2	6.8
Tertiary	Trade	116,192	6,770	167	55.7
	Transportation and communications	23,027	1,086	32	8.9
	Finances	35,142	678	10	5.6
	Social and personal services	31,531	1,394	26	11.5
	Other activities	4,627	318	19	2.6
Total Companies		**259,398**	**12,158**	**306**	**100.0**

Source: SECPLAC, 2005.

In the commune of San José de Maipo, as in the Metropolitan Region and the Cordillera Province, most of the companies are devoted to trade (167) and to transportation and communications (32), all in the tertiary sector. In general they are small companies, some of them family companies. They are followed by companies devoted to Agriculture and Mining, corresponding to the primary sector.

There are informal sources of work related to tourism, mountaineering, cattle-raising, production and sale of food products, handicrafts, and harvesting walnuts and almonds, for which unskilled labor is used generally on a temporary basis.

The initiatives related to *tourism and mountaineering* are identified and characterized in section 5.6.2.4 of this Study and Appendices 35 and 36.

Livestock breeding is focused on raising cattle, sheep, horses, and hogs to a lesser degree. These activities, except for hogs, are closely related to the grazing activity where cattle is herded up to pasture in the high mountains during the Spring-Summer season and to lower sectors of the mountains in the Autumn-Winter. Horse breeding is a potential resource with prospects for both commercial production and tourist purposes. This potential is due to the fact that the use of grazing areas has increased at the present time for tourist and mountaineering expeditions, drawn by the attractions there, which enable the cowboys to offer their services as guides as well as horses and mules. They also act as guides during explorations for the mining studies that are carried out in the zone. Another activity developed frequently in this area is the sale of meat and artisanal dairy products (mainly cheese and milk). That activity is based on small-scale breeding of goats and cattle.

There is not any group in the community at the present time that unites all the cattle men in the area, although they tend to organize by localities, making up small groups, mostly oriented towards tourism (see Table 5.5.1.10). Most of the cattle breeders in the commune work in local development programs, and most of them are concentrated in the localities of El Alfalfal, San Gabriel and Baños Morales.

Table 5.5.1.10
Cattle-Raising Groups in the Community of San José de Maipo

Group	Locality
Agrupación Las Tórtolas	Los Maitenes
Agrupación Ganadera Los Maitenes	Los Maitenes
Agrupación Quempo Turismo	Los Maitenes and El Alfalfal
Agrupación El Relvo	El Alfalfal
Agrupación de Trabajadores, Productores, Ganaderos y Artesanos de San José	San José
Agrupación Ganadera Fundo El Toyo	El Toyo
Club de huasos y amigos El Ingenio	El Ingenio
Expediciones Inti	San Gabriel
Asociación “Senderos del Maipo”	San Gabriel
Agrupación Turística “Vientos Cordilleranos”	San Gabriel
Río Negro Cabalgatas	--
Cabalgatas Romeral	Romeral
Sonajera	--
Asociación de ganaderos “Cóndores del Volcán”	El Volcán

Source: Office of Tourism and Office of the Local Development Program, Illustrious Municipality of San José de Maipo.

The 2006 Mayor´s Public Account of the Municipality of San José de Maipo establishes the following projects related to cattle-raising that were executed between April 2006 and March 2007 in the community[5].

[5] Projects declared by the Communal Planning Office (SECPLAC) and the Local Development Program Office (PRODESAL) in the 2006 Mayor´s Public Account of the Illustrious Municipality of San José de Maipo, April 2007.

Table 5.5.1.11
Projects Executed in the Area of Influence of the PHAM

Project	Locality	Source of Financing
Purchase of veterinary materials (sheep, goats and horses)	Communal Project	“Local Development Bond” Funds
Purchase of materials for cattle-raisers	Communal Project	“Local Development Bond” Funds
Rural Tourism Course for cowboys in San Gabriel and El Volcán under the responsibility of the Werquèn Ecotourism Group	San Gabriel and El Volcán	“Specialist Bond” Funds
Vaccination plan (sheep, goats, and horses)	Communal Project	“Specialist Bond” Funds
Course in “First Aid in remote areas”. Mr. Francisco Garrido in charge of Rural Tourism.	El Alfalfal	“Specialist Bond” Funds

Source: 2006 Mayor´s Public Account, Municipality of San José de Maipo, April 2007.

As indicated in section 5.6.2.3 of this EIS, trade and service in the area of influence of the project takes place mainly on both sides of route G-25, and it is specially developed in the nerve centers of the different populated localities that are located along its route. Commercial activities include basic trade (groceries, sundries, delicatessens, stationery stores, liquor stores, bakeries, hardware stores, bars and restaurants, among others) while more specific trade, like pharmacies or dry cleaners, is mainly located in the populated center of San José de Maipo.

Trade of typical and/or homemade products (kneaded bread, empanadas, cheese) also exists along route G-25 located in different places, and this situation is repeated on the roads that lead to tourist attractions like G-345 (Colorado River) and/or the G-25 fork, which leads to the area of the El Yeso reservoir where the supply of typical products is smaller and directly related to the existing isolated houses.

Trade and related establishments constitute the most developed economic base in the commune. In fact, trade is the economic activity that concentrates the largest amount of the labor force employed in the commune (11%), where the nature of employment in that activity is “unskilled salespeople of sales and services.” In the trade category, there are tourist activities that occupy 35.42% of the commercial equipment.

5.5.1.7 Dimension of Basic Social Welfare

A. Access to Constructed Environment

In general terms and considering the conditions of its location, the situation of the commune is relatively favorable regarding equipment, especially in the educational sphere, with the presence of establishments of different levels in the extensive territory of the commune, including establishments in significantly isolated localities like Las Melosas.

i. Educational Establishments

There are a total of 19 educational establishments in the commune, 11 of which report directly to the Municipal Corporation. Table 5.5.1.12 shows a detailed list of same.

Table 5.5.1.12
Directory of Educational Establishments According to Type of Enrollment, 2005

Establishment	No.	Type of Enrollment				Total Enrollment
		Nursery school	Elementary	High School	Special	
Liceo Polivalente San José de Maipo	118			x		461
Escuela Básica Julieta Becerra Álvarez	628	x	x			526
Escuela Básica El Canelo	632	x	x			227
Escuela Básica El Melocotón	638	x	x			338
Escuela básica de Concentración Fronteriza	629	x	x			164
Escuela Básica Bocatoma Maitenes	630					S/I
Escuela Básica Fronteriza	631		x			21
Escuela Básica La Obra	634	x	x			38
Escuela Integradora El Manzano	635					0
Escuela	636	x	x			56
Escuela Básica Las Melosas	637		x			6
Escuela Rafael Eyzaguirre		x	x	x		1,150
Escuela de Párvulos Las Vertientes	61	x				26
Colegio Rafael Eyzaguirre		x	x			575
Colegio Apóstol San Lucas de San José de Maipo	1729					S/I
Escuela Básica El Sauce	126					S/I
Colegio particular Andino Antuquelén			x	x		171
Colegio Particular Almenar del Maipo		x	x	x		S/I

Source: System of territorial information on education and information collected in the field.

According to the above, the educational supply in nursery school and kindergarten education (5 years of age) and elementary (6 to 13) is broad whereas it is moderate for high school education. The community has four establishments offering high school education: two that belong to the Municipal Corporation (Liceo Polivalente San José de Maipo and Rafael Eyzaguirre) and two private schools (Colegio Particular Andino Antuquelén and Almenar del Maipo).

According to the source consulted, the supply of special education establishments is non-existent. Residents of El Manzano stated in an interview that the Escuela Integradora El Manzano supplied the demand for that kind of establishment, but it closed in 2006, and therefore there is a deficit in this educational sector.

In San José, the capital of the commune, there is a wide array of basic services, along with stores, automatic teller machines, gas stations, banks, public utility offices, etc.

ii. Access to Basic Services

-Access to power line

According to the data in the 2002 Census, there is acceptable coverage in the commune in access to power, as shown in Table 5.5.1.13. Only 3.48% of the total occupied private houses do not have service.

Table 5.5.1.13
Houses According to Origin of Electricity

Origin of electricity	Total occupied private houses	Total persons in occupied private houses
Public system (Electricity Co.)	3,310	12,093
Private or community generator	98	361
Solar panel	3	6
No electricity	123	331
Total	3,534	12,791

Source: INE, 2005.

- Access to Potable Water

Coverage of this basic service is significantly lower than it is for electricity, leaving a percentage of the population that is mainly supplied by springs and in some cases by rivers in the area. Table 5.5.1.14 shows the situation of access to potable water.

Table 5.5.1.14
Houses According to Origin of Water

Origin of Water	Total Occupied Private Houses	Total Persons in Occupied Private Houses
Public system (Potable Water Co.)	2,771	10,225
Well or draw-well	53	153
River or spring	710	2,413
Total	**3,534**	**12,791**

Source: INE, 2005.

- Access to Sewer System

Coverage of this service is 84.01%, which indicates that 11.57% of the occupied houses use the alternative of a pit latrine, with the resulting negative environmental impact associated with this practice due to the inappropriate disposal of sewage (see Table 5.5.1.15)

Table 5.5.1.15
Houses According to Origin of Sewer System

Origin of Sewer System	Total Occupied Private Houses	Total Persons in Occupied Private Houses
Connected to sewer system	2,969	10,831
Connected to septic tank	39	154
Pit latrine	409	1,430
Latrine over stream or canal	9	32
Chemical toilet	12	40
No toilet (WC)	96	304
Total	**3,534**	**12,791**

5.5.2 Localities Situated in Direct Area of Influence of the Project

This section includes a complete socioeconomic description of the localities in the area of influence of the Project, which are El Canelo, El Manzano, Los Maitenes, El Alfalfal, San Gabriel, El Romeral, El Volcán, Lo Valdés and Baños Morales.

5.5.2.1 Geographic Dimension

The area of study is located in the commune of San José de Maipo, whose main axis is the valley of the Maipo River, composed of a group of localities that extend from the entrance to the commune at 1,000 m.a.s.l. in the locality of La Obra, continuing on to the city of San José de Maipo at 1,600 m.a.s.l., and climbing through the valley of the Maipo river. The valley of the Colorado River is reached by taking a fork located between the localities of El Canelo and El Guayacán at an approximate altitude of 1,000 m.a.s.l. This road continues to climb through the valley of the Colorado River, where Los Maitenes and El Alfalfal are located. Continuing on Route G-25 in a southeasterly direction, the road reaches the localities of San Gabriel, El Romeral, El Volcán, Lo Valdés and Baños Morales.

A. Location and Placement Pattern

The different localities in the area of influence of the Project are located around the main water courses in the commune of San José de Maipo, which are the Maipo, Colorado, Yeso and Volcán rivers. Thus, the placement of the localities is directly related to the main connecting road in the area, which is route G-25 that runs from the locality of Las Vizcachas to the sector of El Volcán. An important part of the localities have been situated, since their origin, along that route with subsequent growth and expansion onto the flat land existing between route G-25 and the mountains that surround the valleys of the rivers mentioned.

A list follows of the location and placement pattern of the localities in the direct area of influence of the Project.

El Alfalfal and Los Maitenes: These localities are situated along Route G-345, which runs parallel to the Colorado River, on the little flat land that exists in this canyon. The locality of Los Maitenes is located at lower altitude, whereas El Alfalfal is at the crowning of the public road.

El Manzano: Located in the valley of the Maipo River, connected directly to the communal and provincial capital by route G-25.

El Canelo: In a similar situation to El Manzano, because it is also located in the valley of the Maipo River, connected directly to the communal and provincial capital by route G-25.

Baños Morales: Located in the valley of the El Volcán River in one of the most remote populated areas of the commune, which suffers from inclement winter weather.

Lo Valdés: The locality of Lo Valdés is located, like Baños Morales, in the valley of the El Volcán River, in one of the most remote populated areas of the commune, which suffers from inclement winter weather.

El Volcán: A former mining and cattle-raising settlement that is also located in the valley of the El Volcán River so it has very similar conditions to the other populated areas, but it is at an advantage because public transportation only comes this far.

El Romeral: Located in the valley of the El Volcán River, so it has very similar conditions to the other populated areas like San Gabriel.

San Gabriel: This locality is situated in the valley of the Maipo River, and it is connected directly to the communal and provincial capital by route G-25.

There is no populated settlement in the valley of the Yeso River (except the camp for workers at the El Yeso Reservoir), whereas the localities of San Gabriel and El Romeral are located near the confluence of the Yeso and Volcán rivers.

B. Communication and Transportation

The main road in the communal territory is Route G-25, which is paved and in fair condition. There are two lanes in each direction, and there is no sidewalk along many stretches. Route G-345 forks off from G-25, and it goes to the localities of Los Maitenes and El Alfalfal. This road is in good condition as far as El Alfalfal; then it becomes a dirt road and access is limited by a barrier marking the beginning of a private road. There is no public transportation in this sector.

Route G-455 is a gravel road that connects the area of the El Yeso reservoir. Because of its placement and the weather conditions in the area, it is closed when there are landslides, heavy rain, and intense snowfall.

In the specific case of the locality of Baños Morales, access and communication with the rest of the community is scarce and difficult, because it does not have a flow of public transportation, as public transportation only goes as far as the locality of El Volcán. The road is a dirt road, which can be driven on perfectly well by vehicles with simple traction, but in the fall and winter it is complicated by the rainfall and snowfall that occurs there, causing landslides that usually cut off the population.

C. Use of the Territory

A list follows of the use or enjoyment that each one of the localities in the direct area of influence of the Project makes of the territory.

Alfalfal and Los Maitenes: Although in terms of territory they are two different settlements of people, they will be treated as one unit because they generally act as such: their inhabitants share productive activities, many are related by blood, and they participate in the same soccer club called "Los Maitenes," although the field is located in El Alfalfal. Notwithstanding the above, they have separate Neighborhood Associations since this is more favorable for them in their relationship with the Municipality and other organizations.

To illustrate the situation of land use, one can see in the aerial photograph the use of the territory for housing purposes in the locality of Los Maitenes (see Appendix 38), which reveals they are small plots, homogenous in size, whose use is almost strictly residential since their size does not even permit subsistence agriculture. The large piece of land that is seen in use for agricultural purposes corresponds to alfalfa crops that are administered by the Army. In El Alfalfal the condition of land use is similar, since the inhabitants only have small lots that are almost exclusively used for residential purposes.

Both villages exhibit little dynamism on the subject of land use and ownership or occupation thereof. The land continues to be owned mostly by traditional families who preserve its original use, including the few larger pieces of land that are used for agriculture, which have been in the hands of the Army of Chile and the Ministry of National Property almost exclusively for three decades.

Thus, in agriculture, only a few parcels can be seen at the present time that produce alfalfa, because the local residents stopped growing vegetables in the 1970s since they are not owners and had to work the land on a sharecropping basis with the Army (which administers the land), which was not economically profitable for them. Therefore, their system for supplying fruits and vegetables is based partly on the purchase from a trader who brings them products in a truck every week.

El Manzano: There are 16 traditional families in this locality, small farmers or former small farmers, and several of these families are still engaged in activities related to small-scale cattle raising despite the intense fragmentation of the property and the sale of property to new residents that are joining the community, most of them as owners of rural residential properties. Some of the new owners carry out their economic activities in the commune, but another group works in companies, institutions or organizations domiciled in other communes in the Metropolitan Region and the country.

Most of the traditional families are concentrated in a limited sector located in the eastern half of the locality, who has gotten rid of land they used to use for agriculture, producing for their own consumption and the market, in order to sell the land to the new owners.

On the subject of land, as can be seen in Appendix 38, this is a locality where more of the land is used for housing north of Route G-25, which climbs along the northeast bank of the El Manzano stream. To the north of the route there is marked segmentation of land for housing, whereas to the south of this route there are still larger plots of land intended for agricultural use, but they are also being fenced in and absorbed for housing.

El Canelo: A few traditional families that are dedicated to cattle-raising activities are settled in this locality. These families correspond to small-scale cattle farmers, who complement the productive activity of raising animals with income from trade (most of them have businesses on the side of the road that goes through El Canelo) and the salaried work of some of the members of the family group.

As in El Manzano, agricultural practices have tended to disappear as a result of the lack of space signified by the fragmentation and sale of property.

Baños Morales: Located in the valley of the El Volcán River in one of the most remote populated areas of the community, it is more of a way station than a permanent settlement of cattle farmers. Except for some seasonal sites located in the far eastern part of town, which belong to these groups of cattle farmers, the rest of the houses in the locality are private houses that are occupied in the summer and establishments intended to accommodate mountaineers and tourists who come to the hot springs, which generates the identity of a mountain resort with a small stable population.

Regarding land use, as can be seen in Appendix 38, the aerial photograph shows that this is a village whose housing is concentrated around two centers (one of them significantly larger), both on the same side of the El Volcán River. In both cases they are small lots, almost completely intended for housing, without any evidence of agricultural use.

Lo Valdés: Like Baños Morales this locality is also a mountain resort and distribution center for tourist and sports activities.

El Volcán: This is an old mining and cattle-raising settlement, with advantageous conditions of access to public transportation that comes as far as El Volcán.

El Romeral: Regarding land use and its relationship to the economic activities of its residents, most of them are dedicated to taking care of rural residential properties and growing alfalfa, and some heads of household work as drivers and employees at the gypsum plant that belongs to the El Volcán mining company. An analysis of the aerial photograph that is shown in Appendix 38 shows the marked predominance of industrial activities in proportion of land use and, second, agricultural use, to the detriment of residential use which is quite scarce and scattered.

Camino Río Yeso: In this sector there are six families who have traditionally been dedicated to cattle raising, although currently this activity is insufficient to assure subsistence, resulting in an important migration of young people to join the salaried labor world and contribute to their families with income. Nevertheless, the settlement of a family (Campos) can be confirmed on one side of the road parallel to the El Yeso River near the confluence with the Maipo River, which owns a considerable number of livestock (150 goats, 180 sheep, 75 head of cattle and 60 horses).

The agricultural activity that existed a few years ago on a small scale where potatoes, beans and vegetables were sowed mainly for self-consumption is not practiced at the present time. The families engaged in cattle raising have to pay the landowners in order to pasture their animals so their activity is becoming increasingly less profitable.

5.5.2.2 Demographic Dimension

A. Population

According to information from the last population and housing census of the National Statistics Institute, 2002, the localities with the largest populations correspond to El Canelo, El Manzano, and San Gabriel, all located in the Maipo River valley and connected directly to the communal and provincial capital by route G-25. The localities of Los Maitenes and El Alfalfal, located in the Colorado valley, have a population of 100 to 150 inhabitants. The localities that are situated in the Volcán River valley have the smallest population, all of them with fewer than 100 inhabitants, as shown in table 5.5.1.16.

Table 5.5.1.16
Total Population

Locality	Total
El Canelo	2562
El Manzano	1022
Los Maitenes	98
El Alfalfal	149
San Gabriel	761
El Romeral	44
Baños Morales	34
El Volcán	96
Lo Valdés	48

Source: Census 2002.

Considering the information presented in the preceding table, some characteristics of the number of inhabitants of the localities in the direct area of influence of the Project can be established.

Alfalfal y Los Maitenes: These localities have a population of 149 and 98 inhabitants respectively, which comparatively places them in an intermediate range in the context of the commune.

El Manzano: In the context of the direct area of influence of the Project, this is one of the villages with the largest population.

El Canelo: This locality is also shown as one of the most numerous in population for the area of influence.

Baños Morales y Lo Valdés: The population recorded for the 2002 Census reveals that thee and other populated settlements in the Colorado valley have the smallest population, with fewer than 100 inhabitants.

El Volcán: Its history as an old mining and cattle-raising settlement explains its larger population compared with its immediate context.

El Romeral: Its location in the El Volcán River valley causes the presence of very similar determining factors in terms of the small number of inhabitants.

San Gabriel: This locality is undergoing an intense transformation and demographic growth, where the few traditional families that have lived there for some time have been joined by a significant immigrant population, mainly families from different places in the commune who have been settled in public housing developments. San Gabriel is one of the localities with the highest population in the area of influence identified in this Study.

B. Distribution of the Population According to Urban/Rural Area

According to information available from the census, 100% of the population of all the localities in the area of influence of the Project has been classified as rural, except for the locality of El Canelo where 96.7% of the population has been classified as urban.

Table 5.5.1.17
Distribution of the Population According to Urban/Rural Area

Locality	Total	Urban	% of Urban Pop.	Rural	% of Rural Pop.
El Canelo	2562	2477	96.7	85	3.3
El Manzano	1022			1022	100
Los Maitenes	149			149	100
El Alfalfal	422			422	100
San Gabriel	761			761	100
El Romeral	44			44	100
Baños Morales	34			34	100
El Volcán	96			96	100
Lo Valdés	48			48	100

Source: Census 2002.

Classification of the localities as rural responds to the number of inhabitants that they have and the type of economic activity that most of the population is dedicated to. El Canelo, corresponds to a group of houses with more than 2,000 inhabitants, where 50% or more of the economically active population is dedicated to secondary and/or tertiary activities.

C. Distribution of the Population by Sex

The following table shows the distribution of the population according to sex for the localities that are part of the area of influence of the Project.

In this table one can see that, except for the locality of El Canelo, there is a higher number of males; the localities of El Alfalfal and Lo Valdés are noticeable in this regard, with 87.9% and 85.4%, respectively, of their population being male.

Table 5.5.1.18
Distribution of the Population According to Sex

Locality	Total	Men	% Men	Women	% Women
El Canelo	2562	1276	49.8	1286	50.2
El Manzano	1022	525	51.4	497	48.6
Los Maitenes	149	81	54.4	68	45.6
El Alfalfal	422	371	87.9	51	12.1
San Gabriel	761	397	52.2	364	47.8
El Romeral	44	27	61.4	17	38.6
Baños Morales	34	22	64.7	12	35.3
El Volcán	96	49	51.0	47	49.0
Lo Valdés	48	41	85.4	7	14.6

D. Distribution of the Population by Age Range

The distribution of the population according to age group, according to the 2002 census records, makes it possible to confirm the absence of population in certain age groups in some localities. In the locality of El Romeral there is no population in the ranges of 15-19 and 75-79 years; in Baños Morales there is no population in the 5-9 year range, and there is no one over 65 years of age; in Lo Valdés there is no population under 10 years of age, between 15-19, or older than 70. On the other hand, the population in the localities of Baños Morales and Lo Valdés is mainly concentrated between 25 and 44 years of age (Baños Morales) and between 20 and 39 years (Lo Valdés); the population in the locality of El Alfalfal is especially concentrated between 25-34 years. This fact makes it possible to hypothesize about a productive vocation that favors the establishment of persons in a specific age group, such as the mining activities carried out in Lo Valdès and the development of tourism in the area of Baños Morales.

Table 5.5.1.19
Distribution of Population by Age Group

Categories	El Canelo	El Manzano	Los Maitenes	El Alfalfal	El Romeral	San Gabriel	Baños Morales	El Volcán	Lo Valdés
1. 0-4	7.34	7.05	2.84	11.41	9.09	9.72	2.94	8.33	0.00
2. 5-9	7.53	10.37	2.13	5.37	9.09	9.86	0.00	7.29	0.00
3. 10-14	8.47	10.18	3.32	10.07	9.09	12.48	5.88	8.33	2.08
4. 15-19	7.22	7.93	56.4	7.38	0.00	6.31	2.94	6.25	0.00
5. 20-24	7.22	7.53	12.56	6.04	4.55	8.28	2.94	5.21	16.67
6. 25-29	7.53	5.97	4.74	11.41	4.55	7.49	11.76	5.21	12.50
7. 30-34	7.22	8.12	2.13	10.07	9.09	6.70	17.65	5.21	1458
8. 35-39	8.55	9.30	3.32	8.05	4.55	9.46	14.71	9.38	20.83
9. 40-44	7.85	7.34	4.74	6.71	9.09	6.31	14.71	10.42	6.25
10. 45-49	6.40	6.26	1.9	6.04	9.09	4.47	5.88	6.25	6.25
11. 50-54	5.70	4.79	1.9	4.7	6.82	4.07	8.82	4.17	6.25
12. 55-59	4.84	4.11	0.95	4.03	9.09	4.99	2.94	5.21	4.17
13. 60-64	4.14	3.91	1.18	2.01	4.55	3.29	5.88	5.21	6.25
14. 65-69	2.97	3.03	0.47	2.68	6.82	2.63	0.00	5.21	2.08
15. 70-74	2.81	2.54	0.71	1.34	2.27	1.18	0.00	5.21	0.00
16. 75-79	1.99	0.39	0.71	1.34	0.00	1.45	0.00	1.04	0.00
17. 80 and over	2.22	1.17			2.27	1.31	2.94	2.08	2.08

Another outstanding element is the high concentration of population between 15 and 24 years in the locality of Los Maitenes, which can be attributed to a certain type of educational equipment; a similar hypothesis may explain the fact that in the locality of El Manzano there is an important number of inhabitants between 5-14 years of age.

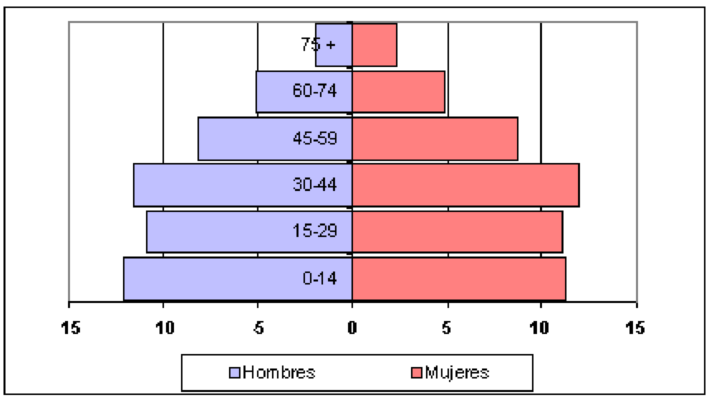
Available information makes it possible to affirm that the population of the localities included in the area of influence of the Project is young, with an important number of inhabitants in the age groups considered to be economically active (15-65).

E. Distribution of Population by Sex and Age

The information presented in the preceding paragraph is complemented by the relational analysis between the information about population by sex and by age groups for each one of the localities situated in the area of influence of the Project, which is shown in the population pyramids and respective analysis, presented below.

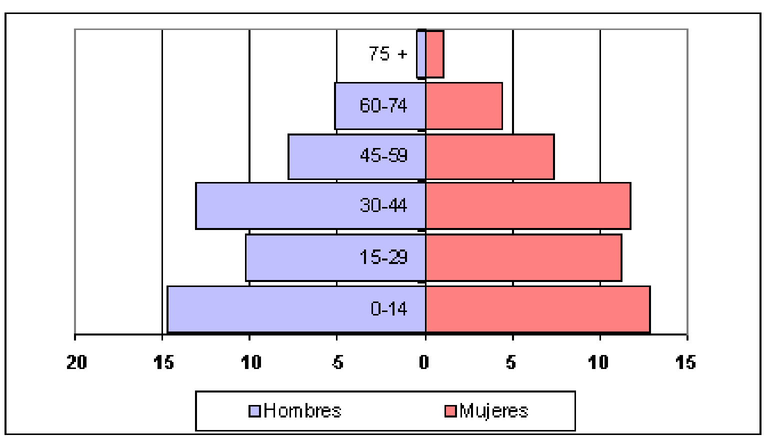
The locality of El Canelo shows a population pyramid that indicates the presence of population of both sexes in each one of the defined ranges. The high presence of population between 0 and 44 years is noticeable, whereas the proportion between men and women in each one of the age ranges is similar (see Figure 5.5.1.9).

Figure 5.5.1.9
El Canelo Population Pyramid



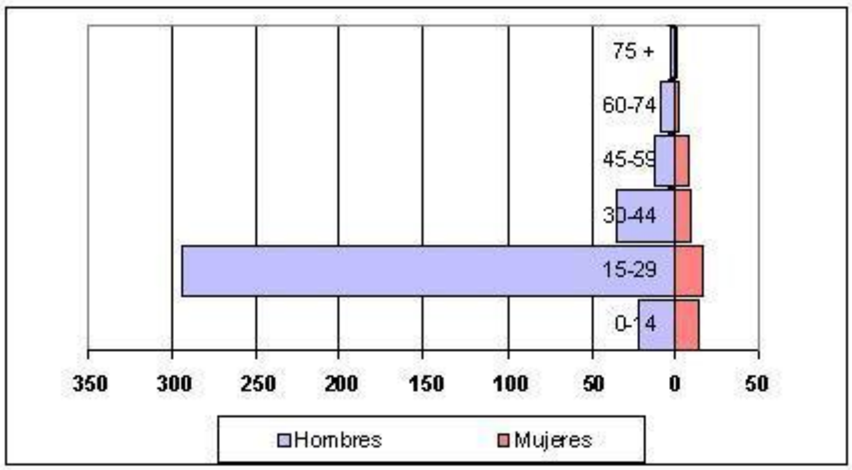
The locality of El Manzano shows a more irregular pyramid than the preceding case. Although the population is concentrated in the ranges under 44 years of age, the proportion of men and women in the 15-29 age range inclines towards women, whereas in the 0-14 and 30-44 ranges it inclines toward men. As in the case of the locality of El Canelo there is no relevant predominance of any age range (see Figure 5.5.1.10).

Figure 5.5.1.10
El Manzano Population Pyramid



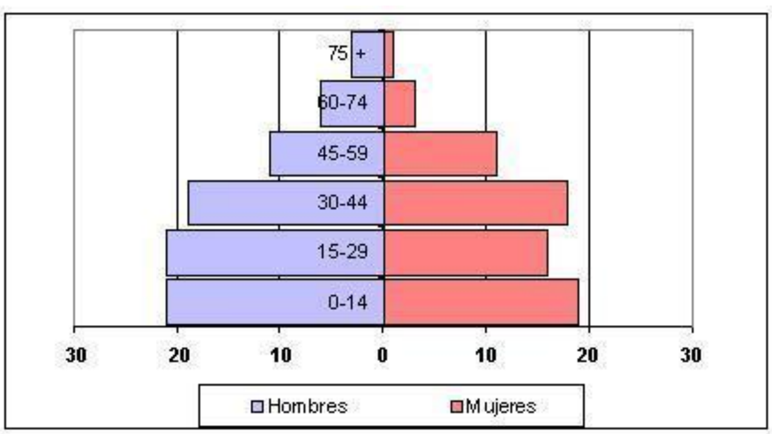
El Alfalfal shows a marked concentration of population between 15 and 19 years, covering 56.4% of the total population, with a majority of men. The explanation for that fact would lie in the labor situation of the locality (related to energy generation and the presence of Armed Forces personnel). Second, 12.56% of the population is between 20 and 24 years of age, the only age ranges that concentrate an important part of the population (see Figure 5.5.1.11).

Figure 5.5.1.11
El Alfalfal Population Pyramid



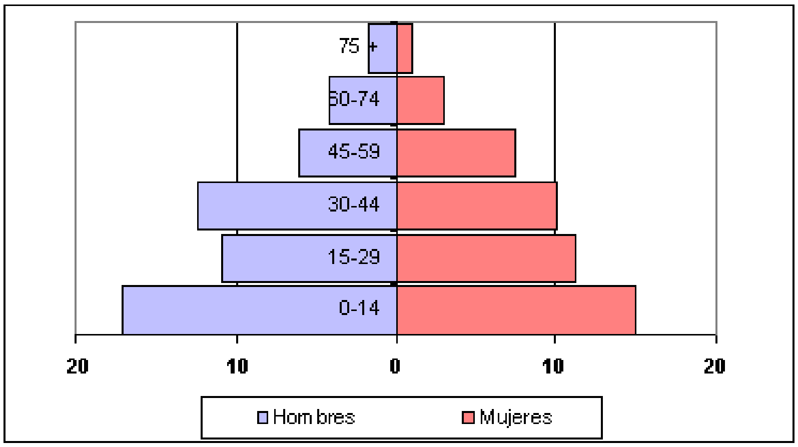
Los Maitenes has a more common distribution of the population with an important concentration in the 0-4 year range (11.41%) and 10 to 14 years (10.7%) for minors, and 20 to 29 (11.41%) and 30 to 34 (10.07%), all of which indicates a young population, without an extremely marked predominance of any age range (see Figure 5.5.1.12).

Figure 5.5.1.12
Los Maitenes Population Pyramid



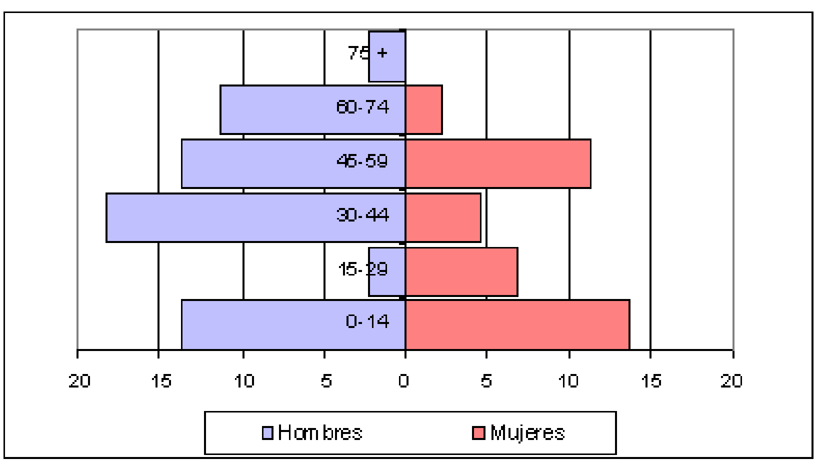
The locality of San Gabriel shows a characteristic pyramid of a young population with a high concentration of population younger than 44 years of age and a fairly broad population base below 14 years (concentrating 32% of the total) with little presence of adult population over 60 years of age. Although there is a general predominance of men, no special concentration is seen in any age range (see Table 5.5.1.13).

Figure 5.5.1.13
San Gabriel Population Pyramid



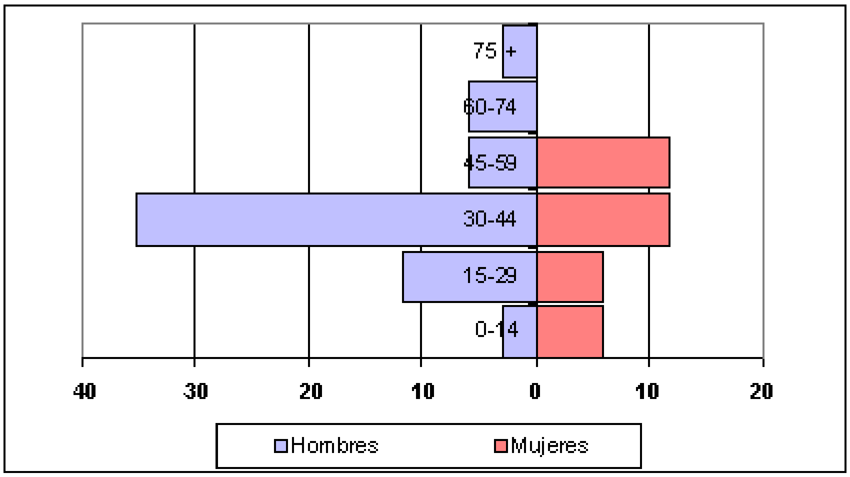
The locality of El Romeral shows quite an asymmetrical population pyramid. There is a significant presence of men, especially in the age ranges between 30 and 75 years. There is a low presence of young population, especially men, between 15 and 29 years; this is an element that could be explained by the absence of opportunities in high school, and technical school and/or higher education (see Figure 5.5.1.14).

Figure 5.5.1.14
El Romeral Population Pyramid



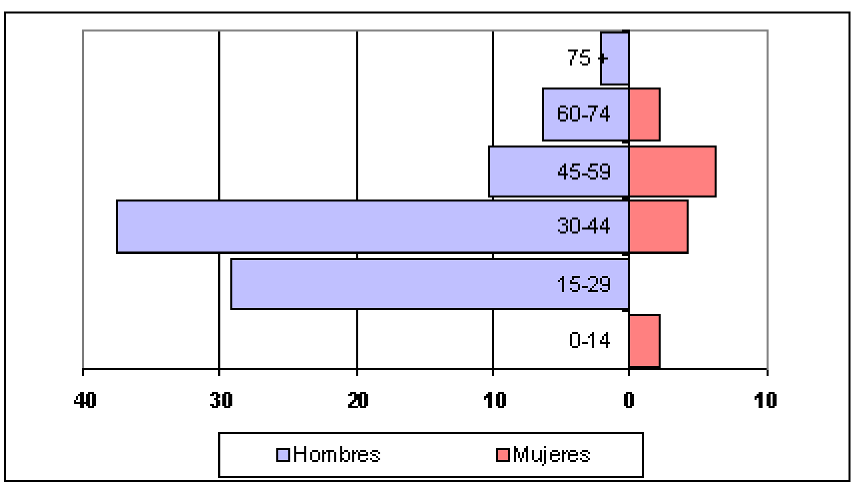
The localities of Baños Morales and Lo Valdés are characterized, as in the preceding case, by an asymmetrical population pyramid. In both cases there is a high concentration of male population, which generally varies between 65 and 85%, respectively. In the case of Baños Morales, the men are concentrated especially in the 30-44 year range, and in the case of Lo Valdés, in the 15-29 and 30-44 ranges. Despite this, in the locality of Lo Valdés no men are recorded between 0 and 14 years (see Figures 5.5.1.15 and 5.5.1.16).

Figure 5.5.1.15
Baños Morales Population Pyramid



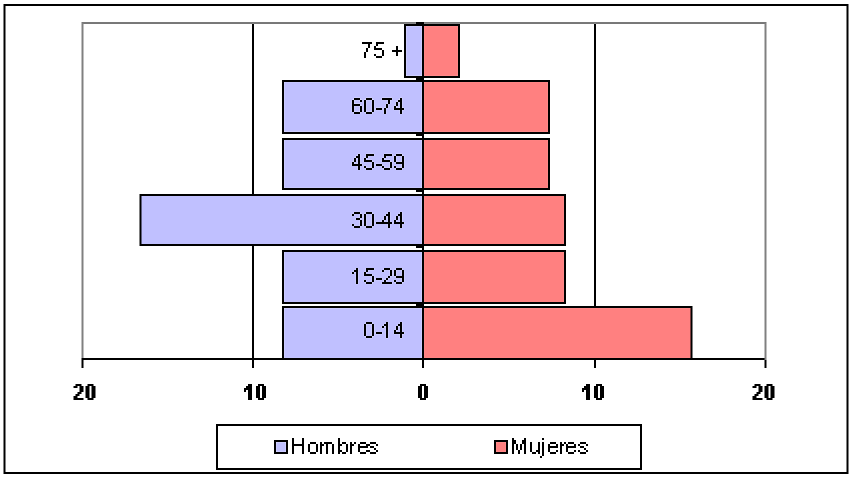
In the locality of Lo Valdés women represent 15% of the total population. No women are recorded in the age ranges between 15 and 29 years and over 75 years; in the locality of Baños Morales, women represent 35% of the population while no women are recorded over 60 years (see Figures 5.5.1.15 and 5.5.1.16).

Figure 5.5.1.16
Lo Valdés Population Pyramid



The locality of El Volcán has a very particular population pyramid since in general the composition of the age ranges is regular. The 0-14 year range stands out where the presence of women represents 16%, while in the 30-44 year range men represent 17% of the total population. The 15-29, 45-59, and 60-74 ranges represent between 15 and 16% each one, with an almost equivalent participation of men and woman (see Figure 5.5.1.17).

Figure 5.5.1.17
El Volcán Population Pyramid



F. School Enrollment

Census information about the last level completed in formal education indicates that the localities in the area of influence of the Project have a good level of enrollment, because the percentage of population that never received any formal education and/or only completed pre-primary education is low, except for the locality of Los Maitenes, where this figure reached a total of 10.8% (see Table 5.5.1.20).

Table 5.5.1.20
Last Level of Formal Education Completed

Summary	El Canelo	El Manzano	Los Maitenes	El Alfalfal	San Gabriel	El Romeral	Baños Morales	El Volcán	Lo Valdés
1. Never Attended	0.5	2.7	8.1	0.8	4.8	37.5	0.0	2.1	0.0
2. Pre-Primary	3.6	4.8	2.7	0.0	1.7	0.0	0.0	4.3	0.0
3.Special/Differential	1.9	1.9	0.0	0.0	0.8	25.0	0.0	2.1	0.0
4. Elementary /Primary	31.8	36.2	48.6	24.4	51.3	25.0	13.6	51.1	22.0
5. General High School	21.8	21.1	13.5	28.3	28.0	0.0	18.2	23.4	36.6
6. Humanities	4.1	2.9	1.4	0.0	3.6	0.0	4.5	2.1	2.4
7. Commercial High School	2.1	0.6	4.1	8.0	0.6	0.0	9.1	2.1	0.0
8. Industrial High School	4.1	1.9	14.9	24.7	3.4	0.0	18.2	8.5	4.9
9. Agricultural High	0.3	0.0	1.4	0.3	0.3	0.0	13.6	2.1	2.4

Summary	El Canelo	El Manzano	Los Maitenes	El Alfalfal	San Gabriel	El Romeral	Baños Morales	El Volcán	Lo Valdés
School									
11. Teacher Training School	0.3	0.2	0.0	0.0	0.0	0.0	4.5	0.0	0.0
12. Women´s Technical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	00

Summary	El Canelo	El Manzano	Los Maitenes	El Alfalfal	San Gabriel	El Romeral	Baños Morales	El Volcán	Lo Valdés
13. Technical Training Center	2.5	3.5	2.7	0.8	0.3	4.2	0.0	0.0	0.0
14. Professional Institute	5.2	4.8	1.4	9.7	2.8	8.3	0.0	0.0	12.2
15. University	21.5	19.5	1.4	3.0	2.5		18.2	2.1	19.5
General total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The percentage of population that completed elementary education, as the last level, fluctuates between 51.3% in San Gabriel and 13.6% in Baños Morales. The percentage of population that completed general high school, as the last level, varies between 13.5% in Los Maitenes and 36.6% in Lo Valdés.

A particular analysis of each one of the localities in the area of influence of the Project is shown below:

El Canelo: 31.8% of the population completed elementary or primary education and 21.8% completed general high school. In this locality 21.5% of the population has a university education.

El Manzano: shows high percentages of population that completed elementary or primary and general high school education (36.2 and 21.1%, respectively) and 19.5% that has a university education.

Los Maitenes: It has a large percentage of the population that completed elementary education (48.6%), 13.5% general high school education, and 14.9% industrial high school education, which contrasts with the 8.1% that never had any formal education.

El Alfalfal: about 25 % of its population completed, as the last level formal level, elementary education; 25% completed general high school education, and another 25% completed industrial high school education. Nine percent completed a technical professional level.

San Gabriel: 51.3% of the population completed primary education, as the last level; in other words, they completed 8th grade, and 28% completed general high school education.

El Romeral: a high proportion (37.5 %) of the population states it never received any formal education. It also has 25% of the population that completed special education and 25% that only completed elementary education.

Baños Morales: 18.2 % completed industrial high school and 13.6% completed Agricultural High School education. In addition, 13.6% and 18.2% completed elementary and general high school, respectively.

El Volcán: more than half of the population of the locality of El Volcán has only completed the level of elementary education (51.1%) and 23.4% completed general high school.

Lo Valdés: 12.2 % and 19.5 % of its population state they have finished the professional institute level and the university level, respectively. Twenty-two percent completed elementary education and 36.6% completed general high school.

5.5.2.3 Anthropological Dimension

Different human groups are distinguished in the area of influence of the project that has settled in the different localities mentioned above. In general these groups can be separated into two major sectors: the ones that come from traditional communities and the ones that have settled in the last few decades on rural residential properties or have been attracted by the ecotourism industry.

In considering this situation, there are different ways of perceiving and valuing the environment, either according to the composition of these groups, and also by the existence of marked differences in relation to their cultural characteristics, social and economic relations, kinship structures, beliefs, values, and attitudes that all form the concept of cultural identity.

Cultural change based on the variables of rurality-urbanity or traditionalism-modernism is part of a process that started many years ago, so it is not possible now to place the situation of these communities on a continuum that extends from the rural to the urban. What is really observed is the coexistence of these two forms in the social organization of these communities, motivated partly by the proximity to Santiago and the development of communications. It should be pointed out that all the traditional families interviewed in the ethnographic study (See Appendix 34) have relatives in the city, which produces an intense exchange of information and the adoption of elements that can be considered part of modernity, without failing to conserve traditional features in the cultural composition and forms of socioeconomic organization.

Bearing in mind the socio-cultural context described above, regarding feelings of rootedness and belonging, there is a certain gradation in its intensity according to the different periods when the territory was populated. Clearly the traditional families experience a different form of attachment and belonging to the territory, because they have lived all their processes of socialization and endoculturation in it, often for several generations. This does not mean that the new inhabitants do not feel any kind of attachment, only that this sense of belonging is not found in the deepest and most unconscious roots of the individuals but on the surface, and they can be perfectly rationalized and verbalized. It is much harder for the individuals that belong to traditional communities to express this feeling in words.

An example of this different perception and evaluation of the environment is the linguistic difference between *buitre* (vulture) and *cóndor* (condor). The traditional inhabitants use the word *buitre* to refer to this bird, a voice full of negative connotations, since to them it is despicable because it is a scavenger and eats baby animals; therefore, it represents a threat to their livestock. On the other hand, to the new inhabitants the same bird is called a *cóndor*; it is emblematic because it is on our national seal and needs to be protected for its conservation.

Another example is the perception of the mountains. To the traditional inhabitants, the mountains represent a living entity, feminine in gender, with its own will, that can benefit or destroy man, but to the new inhabitants the mountains represent esthetics, sports and/or environmental values, among others.

These differences in the appreciation of the environment by the traditional human groups and new inhabitants transcends the merely conceptual realm, moving these opposing positions into the tangible reality and resulting in a conflict of interest regarding ownership and use of the land, because the new owners, based on their objectives involving environmental conservation, have restricted or prohibited the old cattle-raising inhabitants from crossing their land.

A more in-depth analysis of each one of the human groups on this subject is shown in Appendix 34.

On the other hand, for years the traditional communities have used the sectors located in the high mountains of the commune of San José de Maipo; that is where the cowboys determine their pasturing areas for goats, sheep, horses and cows. The development of pasturing, which has been a traditional practice for many years, is in decline, but it remains throughout the year with the seasonal grazing of the summer and winter pastures. The summer pastures take place in the Spring-Summer season, and they use the highest sectors of the micro-watersheds[6] where Andean bushes and the high Andean steppe predominate. In the winter the cattle is transferred to the lower sectors of the micro-watersheds[7] during the Autumn-Winter (see list in section 5.6.2.1). As a counterpart, the use of grazing areas has increased for expeditions of mountain climbers and tourists attracted by the beauty of the area so cowboys offer their services as guides, as well as horses and mules. They also offer support for explorations of the mining studies that are carried out in the zone. Another activity that is frequently developed by the population in the area corresponds to the sale of artisanal meat and dairy products (mainly cheese and milk), an activity based on the small-scale raising of goats and cows.

Currently, there is no group that unites all the cowboys in the area, although they tend to organize by localities, forming small groups that are basically oriented towards tourism[8]. Most of the cattle men in the commune work in local development programs, and most of them are concentrated in the localities of El Alfalfal, San Gabriel, and Baños Morales.

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[6] From the sectors of El Manzanito, El Volcán, Los Chacales, Los Aucayes and Lagunillas to the border with Argentina. (Source: Semi-structured interview with a cowboy in the commune, March 2007).

[7] Upper watershed of the El Manzanito stream, Los Aucayes and El Volcàn river, and from the sector of Los Chacayes to Romeral and the mountains near the locality of San José. (Source: Idem above)

[8] Agrupación de ganaderos "Cóndores del Volcán", Agrupación Pequeños Ganaderos de Maitenes, Agrupación de Trabajadores, Productores, Ganaderos y Artesanos de San José, Agrupación Turística "Vientos Cordilleranos", Cabalgatas Quempo Turismo, Expediciones Inti, Arrieros del Sendero del Maipo, Cabalgatas Romeral, entre otras. (Source: Municipal Tourism Office of San José de Maipo)

The main problem associated with grazing is related to the payment for use of each property used to pasture the animals during the summer and winter and also to permit the animals cross private properties on the routes of horseback rides[9]. On the other hand, the tourist focus of the commune promotes the formation of groups of tourists, but it creates mostly temporary jobs during the summer. The current need to create the foundation for sustainable high-mountain territorial management at a communal level may be seen by the groups of cowboys as an impediment to the use of pasture land in an effort to establish conservation sites in areas traditionally used for grazing. Finally, the experience of development programs in the area indicates that cowboys are not interested in collective work; they prefer to develop activities like tourism independently, and they also state that their migrating lifestyle prevents them from forming stronger bonds in their associations.

Generally, the inhabitants in the area of influence of the Project have developed a lifestyle based on coexistence with the mountains, a slower pace of living, and activities based on working the land and the existing resources.

A. Inter-locality Family Relations

Family relationships in the localities in the direct area of influence of the Project (see details in Appendix 34) are described below.

Alfalfal and Los Maitenes: Despite the transformations in subsistence agriculture, cattle-raising activities continue. A significant proportion, consisting of more than 50% of the families, maintains the form of production involving migratory grazing, which implies following the different cycles of the animals (feeding, mating, and breeding) and moving through the foothills and mountains with the cattle. Almost 100% of the families are linked to grazing, as a result of the family ties that relate them to one another, which determines that in all of the family groups there is at least one member dedicated to cattle raising, who, in several cases, is in charge of herding his own animals, the animals of other members of the extended family, and even other family groups, in the foothills and mountains.

El Manzano: Among the traditional families where cattle-raising subsists there are family ties and, therefore, in some cases one of the members of the family group is in charge of pasturing the cattle of different members of the family group. The new residents are new families, not members of the original families who have returned.

El Canelo: As in the case of El Manzano, among the traditional families where cattle-raising subsists, there are certain family ties and, therefore, in some cases one of the members of the family group is in charge of pasturing the cattle that belongs to different members of the family group.

The new residents are basically new families, not members of the original families who have returned.

Baños Morales: On the subject of grazing, there is a group of families who reside permanently outside the locality and are related by family ties. They own the herds

[9] Payment per head of cattle during summer and winter pasturing is CLP$ 400 per month. Payment per horse in the case of horseback rides is CLP$ 10,000 per day. (Source: Municipal Office of Rural Development of the commune of San José de Maipo, March 2007).

individually, but the work of transferring and caring for the animals is collective. These families come from the sector of Chacritas (Núñez), El Volcán (Venegas-Nuñez) and San José de Maipo (Núñez). A family of cattle breeders from Punitaqui has also settled in the sector. Their herd of goats stays in Curacaví during the winter, and they are transferred in trucks to Baños de Morales when the spring-summer season begins.

The seasonal cattle raisers of Baños Morales are organized in the "Asociación de Talajeros de Baños Morales," which among other things is dedicated to tourism, an activity that earns them significant income and is complemented by cattle-raising.

Lo Valdés: In this locality there are no families engaged in cattle raising, except for one family that is basically dedicated to tourism and keeps a small herd of ten sheep that is not taken up into the mountains, because they are fed alfalfa pellets. There is also a family from Santiago (headed by a foreigner who is building a lodge for tourists), which keeps a small herd of goats in partnership with the Núñez from Chacritas, who manage their cattle. The rest of the locality consists of the Lo Valdés lodge (formerly, the German lodge*)* and a few houses that are occupied during summer vacations.

El Volcán: At the present time 25 families live in El Volcán, who have remained in the locality despite the intense migration of the last few years due to the end of the mining activity, unemployment, isolation, constant traffic of trucks that transport limestone from Minera El Volcán to the plant in El Romeral, and the reduction in herds (See Annex 34).

El Romeral: Among the inhabitants who remain there are a few cases related by blood, but this is not a predominant factor (see Appendix 34).

Sector of Yeso River road: A few of the inhabitants who remain there are related by blood but, unlike other groups, in this case the ownership of the cattle is individual, and there are no collective initiatives for cattle work.

San Gabriel: Due to the intensive transformation in the population that the locality is undergoing, no important marked networks of kinship are recorded (see Appendix 34).

C. Membership in Ethnic Groups

From an ethnic point of view, none of the localities exhibit an important participation of ethnic groups; on the contrary, this participation is small. There are only Mapuches in the localities of El Canelo, El Manzano, El Alfalfal and San Gabriel, but their presence is very moderate, as shown in the following Table 5.5.1.21.

Table 5.5.1.21
Ethnic Groups in Localities in Area of Influence

Summary	Atacameño	Aymara	Mapuche	Rapa Nui	Yamana (Yagán)	None of the Above	Total
El Canelo	1	1	58	3	1	2498	2562
El Manzano	0	2	15	2	0	1003	1022
El Alfalfal		1	14		1	406	422
Los Maitenes			1			148	149
El Romeral	0	0	0	0	0	44	44
San Gabriel	0	0	22	0	0	739	761
Baños Morales	0	0	0	0	0	34	34
El Volcán	0	0	3	0	0	93	96
Lo Valdés	0	0	3	0	0	45	48

D. Population According to Religious Beliefs

On the subject of religious beliefs, the situation does not show any singularities in any of the localities, as the Catholic religion is predominant followed at a distance by the Evangelical religion. The other options are insignificant in the total population of each one of the localities, as shown in Table 5.5.1.22.

Table 5.5.1.22
Religious Beliefs in Localities

Summary	Catholic	Evangelical	Jehovah's Witness	Jewish	Mormon	Muslim	Orthodox	Another Religion or Belief	None, Atheist, Agnostic	Total
El Canelo	1300	133	48	6	5	2	1	168	301	1964
El Manzano	544	36	12	1	0	1	2	37	107	740
El Alfalfal	296	62	2		1	2		7	17	387
Los Maitenes	101	2	2					3	1	109
San Gabriel	446	19	5	1	2	0	0	8	36	517
El Romeral	24	2	0	0	0	0	0	1	5	32
Baños Morales	24	1	0	0	0	0	0	2	4	31
El Volcán	50	10	6	0	0	0	0	5	2	73
Lo Valdés	35	4	0	0	0	0	0	0	8	47

Source: INE, 2005.

5.5.2.4 Socioeconomic Dimension

The labor force of the localities in the area of influence is composed of 30-40% of the population except for the localities of El Alfalfal, Baños Morales, and Lo Valdés where the labor force represents 83.6%, 70.6% and 87.5%, respectively, of the total population.

Regarding the kinds of work, there are high percentages of salaried workers, especially in the localities of El Alfalfal, Lo Valdés, Los Maitenes, and San Gabriel (93.5 %, 85.7 %, 81.97 % and 81.12 %, respectively) – see Table 5.5.1.23 -.

Table 5.5.1.23
Type of Work of the Labor Force

Summary	Salaried Worker	Domestic Service Worker	Self-employed Worker	Employer, Businessman or Boss	Unpaid Relative	General Total	% of Total Population
El Canelo	613	105	254	88	14	1074	41.9
El Manzano	245	21	97	23	7	393	38.5
El Alfalfal	330	2	15	5	1	353	83.6
Los Maitenes	50	4	6	0	1	61	40.9
San Gabriel	202	7	26	1	13	249	32.7
El Romeral	7	3	9	0	0	19	43.2
Baños Morales	16	0	4	3	1	24	70.6
Lo Valdés	36	1	4	1	0	42	87.5
El Volcán	22	2	7	0	1	32	33.3

Source: INE, Population and Housing Census 2002
Anyone who is 15 years old or older is considered a worker, if he is included in one of the following categories: paid worker or person who works for family member without pay.

The categorization of economic activities in the area of influence of the Project is shown below, considering the CIIU (Uniform International Industrial Classification). The main purpose of this categorization is to offer a group of categories of activities that can be used when the statistics for those activities are differentiated (see Table 5.5.1.24).

Table 5.5.1.24
Percentage of Employed According to CIIU Code

	El Canelo	El Manzano	El Alfalfal	Los Maitenes	El Romeral	San Gabriel	Baños Morales	El Volcán	Lo Valdés
0. Unknown	8.9	1.6	11.6	0.0	5.9	4.8	12.5	18.8	0.0
1. Armed forces, uniformed and plainclothes police	0.0	0.0	68.8	0.0	0.0	1.6	0.0	3.1	0.0
12. Directors of company (that has 3 or more directors)	1.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13. Managers of small companies (that has 1 or 2 directors)	7.4	5.3	0.3	1.6	17.6	3.6	4.2	3.1	4.8
21. Professionals of physical sciences, chemistry and mathematics and engineering	4.2	2.5	0.3	0.0	0.0	0.0	4.2	0.0	0.0
22. Professionals of the biological sciences, medicine and health	3.7	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	El Canelo	El Manzano	El Alfalfal	Los Maitenes	El Romeral	San Gabriel	Baños Morales	El Volcán	Lo Valdés
23. Education professionals	4.5	6.1	0.0	1.6	0.0	3.2	4.2	0.0	0.0
24. Other professionals, scientists, and intellectuals	5.2	3.6	0.0	0.0	0.0	0.4	0.0	0.0	0.0
31. Medium-level technicians and professionals of physical and chemical sciences, engineering and related fields	2.3	4.3	0.0	0.0	5.9	1.2	0.0	0.0	0.0
32. Medium-level technicians and professionals of the biological sciences, medicine and health	0.2	0.3	0.0	0.0	0.0	1.6	0.0	3.1	0.0
33. Skilled workmen and technical instructors	0.5	0.0	0.0	1.6	0.0	0.4	0.0	0.0	0.0
34. Other technicians	8.7	6.1	13.0	3.3	0.0	4.8	12.5	0.0	9.5
41. Office workers	4.6	3.6	0.0	8.2	0.0	5.2	20.8	0.0	7.1
42. Employees who deal directly with public	1.3	1.0	0.0	1.6	0.0	0.4	4.2	0.0	0.0
51. Workers in personal services, protection and security	3.7	6.6	0.8	14.8	0.0	6.0	12.5	6.3	21.4
52. Models, salespeople and demonstrators	4.5	3.6	0.0	3.3	0.0	1.2	0.0	0.0	0.0
61. Farmers and skilled workers in market-oriented agricultural, forestry and fishing operations	3.7	9.4	0.8	16.4	5.9	7.2	8.3	9.4	0.0
71. Skilled and unskilled workers in the extractive industries and construction	3.8	2.8	0.6	1.6	11.8	6.4	8.3	6.3	11.9
72. Skilled and unskilled workers in metallurgy, mechanical construction and related	2.6	3.8	0.0	4.9	0.0	4.4	0.0	0.0	2.4
73. Precision mechanics, artisans, workmen in graphic arts and related	2.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74. Other skilled workers, unskilled workers, and artisans in mechanical arts and other trades	1.4	1.5	0.0	0.0	0.0	2.8	4.2	0.0	2.4
81. Operators of fixed facilities and related	1.5	0.3	0.3	0.0	5.9	2.0	0.0	0.0	2.4
82. Machine operators and fitters	1.9	1.0	0.0	1.6	0.0	9.6	0.0	0.0	23.8
83. Drivers of vehicles and operators of heavy and mobile	4.9	2.8	0.6	4.9	23.5	11.6	0.0	3.1	7.1

	El Canelo	El Manzano	El Alfalfal	Los Maitenes	El Romeral	San Gabriel	Baños Morales	El Volcán	Lo Valdés
equipment									
91. Unskilled workers in sales and services	14.2	10.2	2.0	23.0	17.6	7.6	0.0	21.9	4.8
92. Farming, forestry, fishing laborers and related	0.5	1.5	0.0	3.3	0.0	2.8	0.0	15.6	0.0
93. Mining, construction, manufacturing industry and transportation laborers	2.3	2.5	0.8	8.2	5.9	10.8	4.2	9.4	2.4
General Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Considering the information shown on the table above, some aspects of the socioeconomic characteristics of the population of the localities that are part of the area of influence of the Project can be established.

El Canelo: this locality has 14.2% classified as unskilled workers in sales and services; 8.7% in the category of other technicians; 7.4% are directors of companies that have three or more directors; 5.2% are other professionals, scientists, and intellectuals; fewer than 5% are in activities like education professionals, office workers and models, salespeople and demonstrators.

El Manzano: 10.2% are classified as unskilled workers in sales and services; 9.4% as farmers and skilled workers in market-oriented agricultural, forestry and fishing operations; with about 6% classified in the three following categories; teachers, other technicians, and workers in personal services, protection and security. The 2002 Census classified 17.6% as unknown.

El Alfalfal: 68.8% of the employed belong to the Armed Forces, *Carabineros* and *Investigaciones* (uniformed and plainclothes police), and 13% belong to technical personnel. This data corroborates information about the composition of the population according to age range and sex, which is highly concentrated in men between 15 and 29 years of age.

Los Maitenes: is more diversified than El Alfalfal, because 23% are classified as unskilled workers in sales and services; 16.4% are classified as farmers and skilled workers in market-oriented agricultural, forestry and fishing operations; 14.8% are classified as workers in personal services, protection and security, and 8.2% are classified as office workers.

San Gabriel: 11.6% of the employed are occupied as drivers of vehicles and operators of heavy and mobile equipment; 10.8% as laborers in mining, construction, the manufacturing industry and transportation, and 9.6% as machine operators and fitters. These data confirm that labor residing in San Gabriel is highly specialized.

El Romeral: 23.5% of the employed are drivers of vehicles and operators of heavy and mobile equipment and 17.6% are unskilled workers in sales and services and managers of small companies that have one or more directors; 11.8% are skilled workers and operators in the extractive and construction industries; 5.9% include mid-level technicians and professionals in the physical and chemical sciences, engineering and related fields, farmers, operators of fixed and related facilities and construction laborers.

Baños Morales: 20% of the employed are classified as office workers; 12.5% are classified in the three following activities: other technicians, workers in personal services, protection and security, and unknown.

Lo Valdés: the labor force is concentrated in operators of machinery and fitters (23.8%), workers in personal, protection and security services (21.4%), and skilled and unskilled workers in metallurgy, construction, mechanics and related fields (11.9%).

El Volcán: 21.9% of the labor force has been classified as unskilled workers in sales and services; 15.6% as agricultural, forestry, fishing and related laborers. On the other hand, 18.8% was classified as unknown.

As indicated in section 5.5.1.6 of this Chapter, there are informal sources of work related to tourism, mountaineering, cattle-raising, production and sale of food products, handicrafts, harvesting walnuts and almonds for which, in general, and unskilled labor is employed on a temporary basis. The localities belonging to the direct area of influence of the Project are characterized below in greater detail.

El Canelo: For tourism and mountaineering this locality acts as the reception and distribution center, with trade established on the side of the road offering food services to tourists and visitors. For cattle-raising, the traditional families move through the Las Tórtolas sector.

El Manzano: Cattle-raising is practiced along the El Manzano stream and in the Las Monjas sector with difficult access to grazing places because some owners have decided to close off their property to this activity. For tourism and mountain sports, El Manzano is a reception and distribution center, which has tourist facilities where traditional families and new residents find work.

Alfalfal and Los Maitenes: These localities barely have any tourist infrastructure, but certain tourist activities are carried out there, including also an important part of the activities involving the mountains and open-air education. The promoters of those activities come mainly from outside those communities. Nevertheless, the cattle men, based on their knowledge of the mountains and their ownership of horses and mules, are active in tourist and sports activities and open-air education as guides, an activity that earns them a supplementary income.

San Gabriel: This is a locality that has a population with fewer resources and a high number of new families. The local economic activities are mainly traditional cattle-raising, and the people who still practice it do so along the San Nicolás Stream. Tourist activity includes camp sites and inns where residents of the locality can find work.

El Romeral: The few residents, mostly heads of household, are dedicated to taking care of rural residential properties and growing alfalfa. Some of them work as drivers and employees at the gypsum plant that belongs to Minera El Volcán. The only family of cattle men that still remains there takes its animals to the sector of Las Melosas.

El Volcán: There has been an increase in unemployment in the last few years due to the end of mining activity. Resident families are currently dedicated to creating supplementary income by selling cheese to tourists, collecting metal from mining sites, selling fossils to tourists and, significantly, through cattle raising. A geographic problem that affects them today is the poor quality of the road, which could have economic repercussions because it determines a marked seasonality for the spontaneous tourist activity that takes place around the locality and enables them to sell certain products.

Lo Valdés: This is a mountain resort, with a small stable resident population, dedicated mostly to taking care of the tourist facilities. As in El Volcán, a geographic problem that affects them today is the poor quality of the road, which could have economic repercussions because it determines a marked seasonality for tourist activity.

Baños Morales: This is also a locality with little permanent population, especially dedicated to activities related to taking care of tourists and tourist facilities. As in El Volcán and Lo Valdés, a geographic problem that affects them today is the poor quality of the road, which could have economic repercussions because it determines a marked seasonality for tourist activity.

A. Condition of Poverty

To determine and characterize the zones of social risk in the localities of El Canelo, El Manzano, El Alfalfal, Los Maitenes, Baños Morales and Lo Valdés, two indicators were considered: levels of poverty and education.

Since the official source that measures and characterizes poverty – the CASEN survey – does not have data at the locality level, but at the communal level, it was decided to consult primary sources, particularly the Municipality of the commune of San José de Maipo and to complement it with information created by means of the ethnographic study (See Appendix 34).

The poverty level of the local population was inferred from municipal information about people holding a CAS Card who came to the Municipality to ask for some kind of subsidy or assistance between 2004 and 2007. The Municipality of San José de Maipo does not separate Los Maitenes and Alfalfal as different localities, but for purposes of this information it considers them to be one single administrative unit, like El Romeral with El Volcán and Baños Morales with Lo Valdés.

People holding a CAS Card and the percentage of the total local population they represent is shown in the following table:

Table 5.5.1.25
Persons Holding a CAS Card

Localities	No. of Persons	%	Total Population
El Canelo	0	0.00	2,562
El Manzano	6	0.59	1,022
Los Maitenes and Alfalfal	0	0.00	571
El Romeral and El Volcán	3	2.14	140
Baños Morales and Lo Valdés	0	0.00	82

Source: Information from Municipality of San José de Maipo, 2007[10]

Table 5.5.1.25 shows for all the localities a low – or zero – percentage of persons holding a CAS Card so it may be inferred that the demand for subsidies is low, which is the option that communities in extreme poverty habitually resort to. In particular, El Romeral and El Volcán stands out as a unit, with 2.14% of persons holding a CAS Card, which indicates a larger population that requires state aid; therefore, it would be the area with the highest concentration of poverty among the ones consulted by the authorities.

In regard to the level of education, it may be inferred from Table 5.5.1.20 that the level of education of the population of El Canelo, El Manzano and Baños Morales-Lo Valdés is above the communal level, as 19.04% of the population reached Higher Education (Higher education center and University). On the other hand, the localities of Los Maitenes-Alfalfal and El Romeral-El Volcán show significantly less favorable figures than the other localities and the communal level, especially El Romeral-El Volcán.

If both variables are observed, poverty and education level, the localities of El Romeral and El Volcán are the areas with higher social risk because they have, on the one hand, a higher percentage of persons holding a CAS Card, from which it is inferred there is a higher number of economically vulnerable people, who require state support. On the other hand, they are the localities with the lowest level of education, showing a higher percentage of persons who only went through elementary school –the highest percentage of all the localities analyzed- and a very low percentage of persons with higher or university education.

[10] This information was provided by Ana Loyola Rojas, in charge of the Social Protection Card. Municipality of San José de Maipo.

5.5.2.5 Dimension of Basic Social Welfare

A. Housing

According to the 2002 Census, in the localities in the area of influence of the Project a total of 1913 houses was recorded, with 70.7% inhabited permanently and 29.3% unoccupied. The localities with the largest number of houses correspond to the localities with the highest population. Table 5.5.1.26 shows the total number of houses, broken down by condition of occupancy.

Table 5.5.1.26
No. of Houses by Condition of Occupancy by Locality

Locality	No. of Houses Occupied by Present Persons	No. of Houses Occupied by Absent Persons	No. of Unoccupied Houses	Total
El Canelo	683	6	114	803
El Manzano	279	5	81	365
El Alfalfal	22	0	0	22
Los Maitenes	35	1	34	70
San Gabriel	220	16	53	289
El Romeral	16			16
Baños Morales	14	4	174	192
Lo Valdés	14		22	36
El Volcán	38		82	120
General total	**1321**	**32**	**560**	**1913**
%	**69.05**	**1.67**	**29.27**	**100**

Source: INE, Population and Housing Census 2002

Looking at the information in Table 5.5.1.27 the high percentage of unoccupied houses in the localities of Baños Morales, El Volcán and Lo Valdés stands out so it may be inferred that they are second homes.

Table 5.5.1.27
Percentage of Houses by Condition of Occupancy by Locality

Locality	% of Houses Occupied by Present Persons	% of Houses Occupied by Absent Persons	% of Unoccupied Houses	Total
El Canelo	85.1	0.7	14.2	100
El Manzano	76.4	1.4	22.2	100
El Alfalfal	100.0	0.0	0.0	100
Los Maitenes	50.0	1.4	48.6	100
San Gabriel	76.1	5.5	18.3	100
El Romeral	100.0	0.0	0.0	100
Baños Morales	7.3	2.1	90.6	100
Lo Valdés	38.9	0.0	61.1	100

Locality	% of Houses Occupied by Present Persons	% of Houses Occupied by Absent Persons	% of Unoccupied Houses	Total
El Volcán	31.7	0.0	68.3	100
General Total	**69.05**	**1.67**	**29.27**	**100**

Source: INE, Population and Housing Census 2002

Considering the data presented in the table above, some characteristics of the number of houses and their condition of use by locality can be established.

Alfalfal and Los Maitenes: The number of occupied houses is very similar for the two localities, unlike the number of unoccupied houses which equals the occupied houses in Los Maitenes, reflecting a significant migratory process. In El Alfalfal 100% of the houses are occupied by persons who are present.

El Manzano: There are a considerable number of unoccupied houses, which correspond to houses that are not used as permanent residences because of local emigration and also houses that are second homes on rural residential properties; the second homes are located on land acquired mostly from the original families.

El Canelo: As in El Manzano, there are a considerable number of unoccupied houses, which correspond to houses that are not used as permanent residences because of local emigration and also houses that are second homes on rural residential properties; the second homes are located on land acquired mostly from the original families.

Baños Morales y Lo Valdés: The number of unoccupied houses reveals the presence of second homes. The people who remain in the locality are almost exclusively engaged as caretakers for the buildings, tourist establishments, and mining claims.

El Volcán: The number of unoccupied houses reveals it to be a destination for tourism and second homes, and also the strong migratory process it is experiencing.

El Romeral: Although according to the 2002 Census, it had 16 houses, at the time all occupied, at the present time according to the results of the ethnographic study (see Appendix 34), the situation has changed, showing a clear trend toward emigration. In fact, several of these houses are only inhabited by the heads of household while the children remain in Puente Alto with their mothers because of the problem of elementary and high school education, if they remain in this locality during the winter when the road is frequently cut off.

San Gabriel: An important number of occupied houses are recorded for this locality in the 2002 Census.

B. Access to Basic Services

Regarding access to basic services, the availability of sewer systems and potable water for houses in the localities in the area of influence of the Project is analyzed below, based on information from the Population and Housing Census of 2002.

i. Origin of Public Lighting

Considering the information shown in the following table, it may be verified that 91.8% of the houses in the area of influence of the Project have access to electric power through the Public Electricity System. 5.5% of the houses do not have public lighting.

Table 5.5.1.28
Number of Houses According to Origin of Electric Lighting

Locality	Public System (Electric Co.)	Own or Community Generator	Solar Panel	Does not have	General Total
El Canelo	653	10		17	680
El Manzano	264	1		14	279
El Alfalfal	23	3		4	30
Los Maitenes	29	7			36
San Gabriel	204	5		8	217
El Romeral	11			4	15
Baños Morales		2	1	10	13
Lo Valdés	4	1		3	8
El Volcán	20	5		13	38
General Total	**1208**	**34**	**1**	**73**	**1316**
%	**91.8**	**2.6**	**0.1**	**5.5**	**100.0**

Source: INE, Population and Housing Census, 2002

There is a low percentage of houses with independent systems for power generation, either through their own generator or a community generator or through installation of solar panels; both categories include 2.7% of the existing houses in the localities in the area of influence of the Project. Baños Morales is an exception as it does not have access to the public electricity system. On the other hand, in the locality of Los Maitenes 100% of the houses have some kind of electric power, either through a connection to the public electric system or through a private or community generator.

The rest of the localities, in different proportions, have houses without public light or they have access through private methods like solar panels and generators and connection to the public electric system. The latter shows general coverage that exceeds in all cases 50% of the houses. It may be inferred that the houses with their own systems of electric power supply correspond to isolated houses located in outlying sectors of each one of the localities.

ii. Origin of the Water

Regarding the origin of the water in the houses in the localities in the area of influence of the Project, information provided by the 2002 Census indicates that 70.5% of the houses are connected to the public potable water system, whereas 28% of the houses are supplied with water from rivers, springs, and streams in the natural physical environment of the localities.

Table 5.5.1.29
Number of Houses According to the Origin of Water by Locality in the Area of Influence of the Project

Locality	Public System (Potable Water Co.)	Well or Draw-well	River, Spring, Stream	General Total
El Canelo	599	4	77	680
El Manzano	177	11	91	279
El Alfalfal	3	-	27	30
Los Maitenes	-	-	36	36
San Gabriel	142	-	75	217
El Romeral	1	2	12	15
Baños Morales	5	-	8	13
Lo Valdés	-	-	8	8
El Volcán	1	2	35	38
General Total	**928**	**19**	**369**	**1316**
%	**70.5**	**1.4**	**28.0**	**100.0**

Source: INE, Population and Housing Census, 2002

Table 5.5.1.30
Percentage of Houses According to the Origin of Water by Locality in the Area of Influence of the Project

Locality	% of Houses Connected to Public System (Potable Water Co.)	% of Houses with Well or Draw-well	% of Houses Supplied by River, Spring, Stream	General Total
El Canelo	88.1	0.6	11.3	100.0
El Manzano	63.4	3.9	32.6	100.0
El Alfalfal	10.0	0.0	90.0	100.0
Los Maitenes	0.0	0.0	100.0	100.0
San Gabriel	65.4	0.0	34.6	100.0
El Romeral	6.7	13.3	80.0	100.0
Baños Morales	38.5	0.0	61.5	100.0
Lo Valdés	0.0	0.0	100.0	100.0
El Volcán	2.6	5.3	92.1	100.0

Source: INE, Housing and Population Census, 2002

The localities that are largely connected to the public potable water supply system are El Canelo with 88 % of the houses and San Gabriel, with 65.4 %.

In terms of potable water supply from local rivers, springs and streams, 100% of the houses in the localities of Los Maitenes and Lo Valdés are supplied from these sources. Also, 90% of the houses in the localities of El Volcán and El Alfalfal are supplied with water from that same source. The following Table shows a list of the local rivers, springs, and streams that are a source of potable water in the localities around the area of Works of the Project.

Table 5.5.1.31
Local Rivers, Springs, and Streams that are the Source of Potable Water in Localities near the Area of the Project

Locality	Source of Supply
El Canelo	Aguas Andinas
El Manzano	El Manzano Stream
El Alfalfal	Las Hualtatas Spring
Los Maitenes	Aucayes Stream
San Gabriel	Aguas Andinas
El Romeral	Spring
Baños Morales	Spring
Lo Valdés	Spring
El Volcán	Spring

Water from a system involving catchment tanks is used in the following localities: Los Maitenes, El Alfalfal, El Romeral, El Volcán, Baños Morales, Lo Valdés and El Yeso where water catchment comes from eternal snows. At the communal level potable water from Aguas Andinas is supplied directly to the following localities: La Obra, Vertientes, Canelo, Guayacán, San José de Maipo, Melocotón and San Gabriel (PLADECO San José de Maipo, 2002-2006).

Potable water is supplied to El Manzano from water catchment at the El Manzano intake, which delivers water to the El Manzano Potable Water Community and distributes it directly to each property.

In the sector of Los Maitenes the population is supplied with water by means of an intake directly from the Aucayes stream, which is stored for distribution in tanks with an approximate total capacity of 10,000 liters. In the sector of El Alfalfal the population is directly supplied by two springs from a place known as Las Hualtatas, and it is conveyed to tanks with an approximate total capacity of 10,000 liters for distribution.

The rest of the localities in the commune have the following sources of potable water supply:

Table 5.5.1.32
Local Rivers, Springs, and Streams that are a Source of Potable Water in Localities Distant from the Area of the Project

Locality	Source of Supply
La Obra	Aguas Andinas
Las Vertientes	Aguas Andinas
Guayacán	Aguas Andinas
San José de Maipo	Aguas Andinas
El Melocotón	Rural Potable Water
San Alfonso	Rural Potable Water
El Boyenar	Independent Potable Water System
El Ingenio	Independent Potable Water System
Las Melosas	Spring

Source: Customer Service Department of Aguas Andinas, Sanitation Department of the Municipality of San José de Maipo, and Department of the Sanitary Program of the Metrop. Region of the DOH.

iii. Sanitation Facilities

Information in the 2002 census indicates that 82.6% of the houses in the area of influence of the Project are connected to a sewer system, 11.8% of them have pit latrines, 1.4% are connected to septic tank systems, 0.1% of the cases have chemical toilets, and 3.6% of the houses do not have any sanitation facilities.

Table 5.5.1.33
Number of Houses According to Availability of Sanitation Facilities (Sewer System) by Locality in the Area of Influence of the Project

Locality	Connected to Sewer System	Connected to Septic Tank	Pit Latrine	Latrine over Stream or Canal	Chemical	Does not have	General Total
El Canelo	601	8	61	-	-	10	680
El Manzano	227	2	32	-	-	18	279
El Alfalfal	25	-	3	-	1	1	30
Los Maitenes	32	-	3	1	-	-	36
San Gabriel	164	6	33	6	-	8	217
El Romeral	7	1	5	-	-	2	15
Baños Morales	5	1	5	-	-	2	13
Lo Valdés	4	-	2	-	-	2	8
El Volcán	22	-	11	-	-	5	38
Total General	**1087**	**18**	**155**	**7**	**1**	**48**	**1316**
%	**82.6**	**1.4**	**11.8**	**0.5**	**0.1**	**3.6**	**100.0**

Source: INE, Population and Housing Census, 2002

The analysis by locality confirms that 13.2% of the houses in the locality of Lo Valdés do not have any sanitation facilities whereas more than 10% of the houses in the localities of Baños Morales, El Romeral and El Volcán do not have any sanitation facilities; it may be inferred that these percentages are represented by isolated cases (2 and 5 houses).

Table 5.5.1.34
Percentage of Houses According to Availability of Sanitation Facilities (Sewer System) by Locality in the Area of Influence of the Project

Locality	Connected to Sewer System	Connected to Septic Tank	Pit Latrine	Latrine over Stream or Canal	Chemical	Does not have	General Total
El Canelo	88.4	1.2	9.0	0.0	0.0	1.5	100.0
El Manzano	81.4	0.7	11.5	0.0	0.0	6.5	100.0
El Alfalfal	83.3	0.0	10.0	0.0	3.3	3.3	100.0
Los Maitenes	88.9	0.0	8.3	2.8	0.0	0.0	100.0
San Gabriel	75.6	2.8	15.2	2.8	0.0	3.7	100.0
El Romeral	46.7	6.7	33.3	0.0	0.0	13.3	100.0
Baños Morales	38.5	7.7	38.5	0.0	0.0	15.4	100.0
Lo Valdés	50.0	0.0	25.0	0.0	0.0	25.0	100.0
El Volcán	57.9	0.0	28.9	0.0	0.0	13.2	100.0

Source: INE, Population and Housing Census, 2002

The locality with the lowest proportion of houses connected to a sewer system corresponds to Baños Morales. On the other hand, Los Maitenes, El Canelo, El Alfalfal and El Manzano are largely supplied by the public system in the following percentages: 88.9 – 88.4 – 83.3 and 81.4%, respectively.

C. Access to Built Environment

In general each locality has certain equipment, some very elementary and others more complete. Although San José is the supply center, others act as micro-centers. A general characterization of the equipment in the different localities in the area of influence of the Project is shown below.

El Canelo: has an elementary school, fire station, restaurants and established trade.

El Manzano: has sectors for camping and picnics and areas for the sport of rock-climbing; it has a school offering special education, a private school, and established trade.

Los Maitenes and El Alfalfal: two hydroelectric power plants (Maitenes and El Alfalfal) are located in the sector. One of the Routes of Chile, inaugurated in 2003 by the Ministry of National Property, starts in this area. There is a school, a social center, a polyclinic, and a police station in the sector of Los Maitenes. In Alfalfal, there is an elementary school.

San Gabriel: has a border checkpoint (obligatory checkpoint for anyone going into the high mountains), as well as a municipalized school.

El Volcán: this is a small village, with one street. It has a chapel, a first-aid station, and a plainclothes police station.

El Romeral: it has basic trade.

Lo Valdés: there is an event center and a vacation center.

Baños Morales: it has two thermal pools, which are administered by the inhabitants of the locality.

D. Access to Natural Environment

All of the localities in the area of influence of the Project have access to the natural environment. In fact, a significant number of them are located in areas with an environment that has barely been intervened so the local population has easy access to natural areas.

The watercourses and their valleys, as well as the existing mountain chains, are an important part of the natural environment in the area. Despite the fact that local roads are not very well developed, and their use is strongly determined by weather conditions, existing roads permit access to sectors where the public can enjoy the natural environment. Despite this, there is a noticeable lack of paths for pedestrians, with the respective associated tourist infrastructure, which provide efficient and informed access to the natural areas in the local territory.

5.5.3 Conclusions

Considering that the characterization of the socioeconomic environment was made by presenting the situation and information about the commune first, and then presenting a complete characterization of the localities in the area of influence of the PHAM, the conclusions of this section are shown in a similar manner. Conclusions about the communal situation are presented first, and then conclusions about each populated locality.

Communal Level

In relation to the ***geographic dimension,*** the PHAM is located administratively in the commune of San José de Maipo, in the high mountains of the Metropolitan Region of Santiago. This commune is part of the Cordillera province, which has the largest surface area in the Metropolitan Region with 5,528.30 km^2. In the province, the commune of San José de Maipo has the largest surface area, with 4,994.8 km^2 (90% of the total provincial surface area).

The Cordillera province has the second largest number of inhabitants in the Metropolitan Region with 522,856 persons, but it has one of the lowest regional population densities due to its extensive surface area, which generally corresponds to the Andes mountains, a sector with high peaks where the population cannot establish permanent settlements.

The commune of San José de Maipo is located in the great fluvial system of the Maipo, which determines a linear pattern of settlement along the main axis, route G-25, where the localities are established; other localities are located on secondary roads that run parallel to the main tributaries of the Maipo river, like the Colorado, Yeso and Volcán Rivers. Some of the important secondary roads where human settlements are recorded include route G-345, which connects with the localities of Los Maitenes and El Alfalfal; route G-455, which connects with the sector of the El Yeso reservoir; and the continuation of route G-25 where the localities of El Romeral, El Volcán, Lo Valdés and Baños Morales are located.

The ***demographic dimension*** reveals that the commune of San José de Maipo had a population of 16,565 inhabitants in 2001 with an urban population that rose from 67.93% in 1992 to 69.61% in 2002; the population that lives in rural areas dropped from 32.07% to 30.39% in the same period. According to data on the situation of poverty in the commune, in 2003 4.3% of the population was in the indigent range, 14.67% was non-indigent poor, and 81.03% of the communal population was considered not poor.

Regarding distribution by sex and age, the population in the communal territory is 51.9% male and 48.1% female. The age groups with the largest population correspond to 0-14 years (24.60%), 15-29 years (24.57%) and 30-44 years (23.53%). Considering these data, the strong presence of family groups composed of couples of young and middle-aged adults with school-age children can be seen. A related aspect in regard to migratory flows is the presence of a young population of both sexes in the communal territory. This indicates the low emigration of this age group in contrast to the national trend of young people to emigrate from isolated, rural places in search of better education and job opportunities.

Only 1.98% of the total community population over 5 years of age declares it has never attended any formal educational establishment. 96.71% of the total population equal to, or over, 10 years of age is considered to be literate population, and the remaining 3.29% is illiterate.

Regarding the ***anthropological dimension***, it can be stated that the ancient pre-Hispanic inhabitants of the Cajón del Maipo were dedicated to hunting guanacos and southern Andean deer, selling the animals' meat, extracting salt from lagoons in the area, collecting wild fruit, and engaging in agriculture. Although at the present time there is no clear influence of the original peoples in current lifestyles and customs, there is still a strong connection between the predominant economic activities and the use of local natural resources.

The main population center and capital of the commune, San José de Maipo, developed from the first silver mine in the country, called San Pedro Nolasco (located 25 kilometers from San José de Maipo) and founded in 1790. This deposit produced the most important foreign currency of the time for the Kingdom of Chile, which caused a significant migration of miners with their families, who founded the Villa de San José de Maipo in 1792.

A determining factor in the development of the commune was the construction of the railroad. The military railroad was laid from Puente Alto to the village of San Gabriel in 1908. Its main purpose was to transport ore from the sector of El Volcán. The railroad was gradually expanded into the commune, and new localities were founded. The railroad was finally closed in 1985, and the tracks were completely removed.

In regard to the ***socioeconomic dimension***, the locality of San José de Maipo fulfills the role of supplier of goods and services to the localities in the area of influence of the Project. When the city of San José is not sufficient to supply local demand, the closest center is Puente Alto. The localities of Los Maitenes and El Alfalfal are a special case as they are located outside the urban center of the commune at a similar distance from Puente Alto and San José de Maipo, with even easier access to San José de Maipo than Puente Alto, because there is better collective transportation.

The economy of the commune is based on the exploitation and use of the diverse, rich local natural resources. This can be seen in different factors ranging from the fact the main populated center and current capital of the commune owes its origins to the first silver mine in the country, the provision of potable water to the city of Santiago, the production of hydroelectric power, cattle raising, and the production of almonds, walnuts, and honey. There is also the vigorous growth of the tourist industry, especially ecotourism, as a result of the rich natural patrimony of the area.

According to statistical data, 75.4% of the population corresponds to the communal labor force. Of this total, 56.09% represents the economically active population (E.A.P), while 43.91% corresponds to the non-economically active population (N.E.A.P.). In 2002 the E.A.P. included a total of 88.28% employed, 10.11% unemployed and 1.61% looking for work for the first time. The largest proportion (12.88%) of the E.A.P. was dedicated to wholesale and retail trade, and car and motorcycle repair, which partially reflects the commune’s ability to supply itself in consideration of its geographic condition. 10.29% of the E.A.P. worked in Public Administration and Defense and social security and union plans, which is reasonable since it is a vast territory with two small-scale, but historical, border passes, and a population that requires services like a civil registry, health, municipal, etc. because of its geographic isolation. Construction accounted for 9.19%, which reflects the dynamism in this area resulting from the tourist activity and an increase in population. Informal sources of work should also be mentioned, related to tourism, production and sale of food products, handicrafts, harvest of walnuts and almonds, for which, in general, unskilled labor is employed on a temporary basis.

Livestock raising activities are focused on cattle, sheep, horses, and hogs to a lesser degree. These operations, except for hogs, are closely related to the grazing activity where cattle is herded up to the high sectors of the mountains in the Spring-Summer season and to lower sectors of the mountains in the Autumn-Winter. Currently, there is no group in the commune that brings all the cattle farmers in the area together, although they tend to organize by localities, forming small groups mainly oriented towards tourism. Most of the cattle farmers in the commune work in local development programs, which are mainly located in El Alfalfal, San Gabriel and Baños Morales. Trade and related establishments constitute the most developed base of the commune, and it concentrates the largest amount of the labor force employed in the community (11%) where the nature of employment in that activity is "unskilled salespeople of sales and services." Tourist activities fall in the trade category, which occupy 35.42% of the commercial infrastructure.

The situation of the communal population in regard to the ***basic social welfare dimension*** is relatively favorable, especially in the educational sphere, with a total of 19 educational establishments in the commune of different levels, 11 of which report directly to the Municipal Corporation. Regarding access to basic services, only 3.48% of the total occupied private houses do not have access to electric power. Regarding access to potable water, 78.4% of the total occupied private houses are connected to the public system, while the remaining 21.6% are supplied by springs and rivers in the area. Finally, 84% of the total occupied private houses have access to a sewer system so the remaining 16% solves sewage disposal by other solutions (connection to septic tank, pit latrine, latrine over stream or canal, chemical toilet). 2.7% does not have any kind of solution for the disposal of sewage in their house.

Localities in Direct Area of Influence of the Project

In relation to the ***geographic dimension***, the different localities in the area of influence of the Project are located around the main watercourses in the commune of San José de Maipo, corresponding to the Maipo, Colorado, Yeso, and Volcán Rivers. In fact, the localities of El Canelo and El Manzano are located on the upper terrace of the Maipo River. The localities of Los Maitenes and El Alfalfal are located in the valley of the Colorado River, and the localities of Baños Morales, El Volcán and Lo Valdés are located in the valley of the El Volcán River. There is no populated settlement in the valley of the Yeso River (except for the workers' camp at the El Yeso Reservoir), while the localities of San Gabriel and El Romeral are located near the confluence of the Yeso and Volcán Rivers. The main road in the communal territory is Route G-25, which Route G-345 forks off from, connecting with the localities of Los Maitenes and El Alfalfal. In addition, route G-455 connects with the area of the El Yeso reservoir.

The use of the territory varies according to the geographic location of the localities and their access. In the case of Los Maitenes and Alfalfal, use of the territory is strictly residential, since the dimensions of those localities do not permit the development of subsistence agriculture. El Manzano and El Canelo are strongly fragmented localities due to the sale of properties and the increase in the development of second residences or rural residential properties. Baños Morales, located in the valley of the El Volcán River, is one of the most remote populated areas in the commune and is more of a way station than a permanent settlement of cattle farmers; its housing use is concentrated around two centers (one of them is significantly larger), both on one side of the El Volcán River. In the locality of El Romeral land use is related to the economic activities of the people who live there, most of whom are dedicated to caring for smallholdings and growing alfalfa; some heads of household work as drivers and employees at the gypsum plant of the El Volcán mining company. Finally, agricultural activity on the Yeso River road, which existed until a few years ago on a small scale involving mostly potatoes, beans, and vegetables that were planted for self-consumption, is not practiced at this time. Cattle-raising families have to pay the landowners for grazing, making their activity increasingly unprofitable.

Data on the ***demographic dimension*** indicates that the localities with the largest populations correspond to El Canelo, El Manzano, and San Gabriel. The populations of Los Maitenes and El Alfalfal are between 150 and 430 inhabitants. The localities in the Volcán River valley have the smallest populations, all with fewer than 100 inhabitants. All of the localities are rural entities except for El Canelo, which has an urban area that concentrates 96.7% of the total population. The distribution of the population according to sex indicates that except for the locality of El Canelo, there is a higher number of men in the different localities, especially El Alfalfal and Lo Valdés with male populations of 87.9% and 85.4%, respectively. This situation can be explained by the type of activities carried out in those localities, which are hydroelectric and mining projects, respectively. The information on distribution according to age range indicates that the distribution is directly related to the type of activities carried out, with a productive vocation that favors the establishment of persons in specific age ranges, like the mining activities developed in Lo Valdés and the development of tourism in the area of Baños Morales. It is also possible to establish that the population of the localities included in the area of influence of the Project is characterized as being young, with a significant population in the age ranges considered to be economically active (15-65 years of age).

Finally, in regard to the information on education, considering the last level of formal education completed, the localities in the area of influence of the Project show a good level of schooling since the percentage of population that never had any formal education and/or only completed pre-primary education is low, except for the locality of Los Maitenes where this figure was 10.8%.

Regarding the ***anthropological dimension***, different human groups are distinguished in the area of influence of the Project that are settled in the different localities indicated above. In general, these groups can be separated into two main sectors: the ones that come from traditional communes and the ones that have settled in the last few decades on rural residential properties or have been attracted by the ecotourism industry. The sectors located in the high mountains of the commune of San José have been used for many years by local cowboys as a grazing area for goats and cows. This activity has declined as these lands have been used increasingly for tourist and mountaineering expeditions so the local cowboys offer their services as guides, as well as their horses and mules. Another activity that the population in the area frequently carries out is the sale of artisanal dairy products (mainly cheese and milk), which is an activity based on the small-scale raising of goats and cattle.

The local population has developed a way of life where it has modified its routines and has succeeded in living with the significant differences between the various localities and the relative isolation caused by the lack of public transportation that affects some localities like Los Maitenes, El Alfalfal, and the sector of the El Yeso reservoir.

Regarding membership in ethnic groups, no group has a relevant participation in any of the localities. There is a Mapuche group in the localities of El Canelo, El Manzano, El Alfalfal, and San Gabriel, but it is moderate in size. With regard to religious beliefs, the Catholic religion is predominant, followed at a distance by the Evangelical churches, while the remaining options are insignificant.

In relation to the ***socioeconomic dimension,*** the labor force represents 30 to 40% of the total population, except for the localities of El Alfalfal, Baños Morales, and Lo Valdés where the labor force represents over 70% of each one of the localities. This situation is due to the fact the total population in those localities is low, and there is a small number of the population under 15 and over 65 years of age. According to the type of job, both salaried and self-employed workers are present. There are informal sources of work in the area of influence of the Project related to tourism, mountaineering, cattle-raising, production and sale of food products, handicrafts, harvest of walnuts and almonds, for which, in general, unskilled labor is employed on a temporary basis.

In terms of the condition of poverty that exists for all the localities in the area of influence there is a low –or zero- percentage of persons with CAS Cards so that it may be inferred that the demand for subsidies is low, which is the channel that communes in extreme poverty usually resort to frequently. In particular, El Romeral and El Volcán correspond to the unit that stands out with 2.14% of persons with CAS Cards, indicating a higher presence of population that requires state aid so this would be the area with the highest concentration of poverty among the ones consulted by the authorities.

On the dimension of ***basic social welfare,*** each locality has basic infrastructure that is very elementary in some cases and more complete in others. Although San José is the supply center for all the communal territory, other localities act as micro-centers. That is the case of El Canelo and El Manzano, which act in some cases as suppliers of equipment and services for the localities of Los Maitenes and El Alfalfal, while San Gabriel serves as a micro-center for the localities in the valley of the Volcán River.

There is a total of 1926 houses in these localities, with 70.8% that are occupied permanently and 29.2% that are unoccupied. The localities of Baños Morales, Lo Valdés, and El Volcán are especially relevant, with an important number of houses in the category of *second homes.* In relation to the origin of public lighting, 91.8% of the houses have access to electric power from the Public Electricity System while 5.5% of the houses do not have public lighting. Regarding potable water, 70.5% of the houses are connected to the public potable water system while 28% of the houses are supplied with water by rivers, springs, and streams in the environs of the localities. Finally, in relation to access to sewer systems, 82.6% of the houses are connected to a sewer system, 11.8% have a pit latrine, 1.4% are connected to a septic tank system, 0.1% have a chemical toilet, and 3.6% of the houses do not have any sanitation facilities. In Baños Morales 38.5% of the houses are connected to sewer systems, and a similar percentage of houses dispose of sewage through a pit latrine.

All of the localities in the area of influence of the Project have access to the natural environment, but the lack of pedestrian paths should be pointed out, with the respective associated tourist infrastructure that provides efficient, informed access to the natural areas in the local territory.

5.6 CONSTRUCTED MEANS

5.6.1 Infrastructure and equipment

5.6.1.1 Introduction

This section provides the background on the constructed environment and specifically the background associated to the existing and projected infrastructure and equipment in the existing locations in the Project influence area.

In order to document the existing and projected infrastructure and equipment in the Project influence area, the plan, in first place, is to collect bibliographic background, referring to San José de Maipo PLADECO, the OTAS Project and the information obtained in town hall dependencies; likewise, information was obtained through the Internet, mainly data regarding projects and research developed in San José de Maipo municipality area.

As a second measure, this information was updated and expanded on the different field campaigns conducted in the framework of the present baseline.

The background associated to the infrastructure and equipment on the Project influence area is presented on the sections below, broken down by issues and associated to the existing settlements in the Project influence area, which includes the locations of El Canelo, El Manzano, Los Maitenes, El Alfalfal, San Gabriel, El Romeral, El Volcán, Baños Morales and Lo Valdés. Similarly, the background for the existing equipment in each location is presented.

5.6.1.2 Infrastructure

A Public Service Cover

Overall, it is possible to state that 80% of the cabins located in PHAM project influence area are connected to water main system; the remaining part covers its needs using wells and septic tanks. Some locations have an agreement with Puente Alto Town Hall, which ensures the availability of special trucks to clean the septic tanks. Specifically, El Volcán village has a partial water main system which discharges a flow into the El Volcán River.

Regarding the drinking water supply for human consumption, it comes from different sources. In the location of El Canelo and San Gabriel, water supply is provided by Aguas Andinas; in El Manzano there is a mixed supply through Aguas Andinas Company and community participation; in El Alfalfal and Los Maitenes the supply is provided by water collection from mountain streams and springs; San Gabriel has different supply alternatives, which considers provision from the Town Hall Emergency System, Aguas Andinas and supply from streams using pipelines that belong to local inhabitants.

At El Volcán drinking water supply is provided by the existing stream from the former Parcelita Mine. Baños Morales and Lo Valdés locations receive drinking water supply from streams and community associations. In short, more than 70% of the households are connected to the public drinking water main system.

B. Drinking Water Production Infrastructure

The high watershed from Yeso River is used preferably as a water collection area for the production of drinking water by Aguas Andinas Company, main concessionary in Santiago Metropolitan Area.

For this activity, a series of works and facilities were constructed along the main water flow from Yeso River, as well as, on the different streams that provide waterflow for drinking water. In this sense, the utilization of water from Negra and Lo Encañado lakes stands out as storage and regulation units, the first one corresponds to the main dinking reservoir in the Metropolitan Region.

As mentioned above, these water bodies regulate the water flow that is returned to the streams in the area, such as the Yeso River and El Manzanito stream (discharge regulated from Lo Encañado Lake). This last section is denominated **Mountain Range Aqueduct – Negra Lake**, which runs from Negra Lake to the Las Vizcachas drinking water production plant, and operates since early twentieth century. At present, the aqueduct has damages on its higher portion and operates only from Romazas y Azulillo collection facilities downstream.

The main facilities on Negra Lake Aqueduct system are briefly described below:

i. Route and main characteristics

It is possible to conduct the regulated flows from Negra and Lo Encañado lakes, and also the contributions from the different streams that are incorporated along their course, from Lo Encañado Lake to the Las Vizcachas drinking water production plant with a total length of 56 km.

The aqueduct begins in Azulillos drains (Azulillos[1] collection facility) and runs through the section Lo Encañado - San Nicolás between the stream courses from Manzanito and Yeso River; from San Nicolás to San Gabriel, follows the northern bank of Yeso River and from San Gabriel follows along Maipo River to Vizcachas.

[1] The collection facilities are special chambers that consist of gates to drain part of the conducted flow, which normally reaches values of 2-3 m3/s

The main characteristics of this canalization are presented below:

Length	: 58 Km
Conduction capacity	: 4.0 m^3/s
Wet section	: 1.86 m^2
Material	: Simple concrete fabricated in situ
Mean slope	: 4 °/o.

The section along the whole route is formed by two vertical walls united by a foundation block and a circular arch-shaped top vault. The foundation block has bigger radius than the vault.

Figure 5.6.1.1 presents the Negra Lake Mountain Range Aqueduct and identifies the main works of this drinking water collection and transportation system.

Figure 5.6.1.1
Negra Lake Mountain Range Aqueduct Superficial Production System

ii. Special Characteristics

At present, the aqueduct has 7 operational collection facilities. The aqueduct also has vents made of metal tubes that jut out of the terrain 2.5-4.5 m regularly spaced. In order to cross canals and ravines, the aqueduct has 10 inverted siphons with inlet and outlet chambers. Also, along its route the aqueduct has 36 tunnels, with segments lengths of 100-1,200 m and a total extension of 12.8 km.

iii. Contributions on road – Negra Lake Aqueduct

Delivery (Km)	**Collector name**
0,0	Azulillos Drains
0,42	Romazas Canal
7,43	El Manzanito regulation natural canal at San Nicolás
7,43	Yeso River
7,55	San Nicolás Stream
48,26	El Manzano Stream
55,25	El Canelo Stream

The provided water is intercepted by the streams and canals due to existing collection works. The Negra Lake System catchments are located within PHAM borders and they are described below.

- Azulillos Drains Subterranean Catchment

Azulillos Drains are located 2.300 m.a.s.l. at the base of a mountain range and form the first contribution; therefore, they are the initial site of Negra Lake Mountain Range Aqueduct.

They form a series of drains that collect the subterranean waters from the infiltrations corresponding to Negra and Lo Encañado lakes, and their discharges. The Azulillos Drains are the only subterranean source in this production system. Just downstream the catchment - at 200 m - the Azulillos collection facility is located, where water enter into the aqueduct. Likewise, this work allows diverting the water into the river.

- Romazas catchment and canal

The Romazas Canal conducts water from Manzanito Stream and discharges it at km 0.42 in the Mountain Range Aqueduct.

This work consists of a mobile barrier composed by 5 openings with flat gates. All the openings are manually operated and are preceded by board gates in order to dam water in the pool upstream. The catchment capacity is 3 m^3/s. Next to the stream bank there is a structure that has 3 manually operated flat gates, which allow catching the water that later passes through a rectangular-shaped sluice of about 30 m long and finally deliver the water to Romazas Canal. This canal is rectangular-shaped and made of masonry.

The width of its section is 1.5 m. The canal ends on a lateral outlet provided with 8 openings that allow discharging into the aqueduct. It features a manually operated flat gate on its side downstream, which allows discharging the surplus water or cleaning the canal.

- Catchment in the Manzanito regulated stream in San Nicolás

This water intake is located in San Nicolás facility (property of Aguas Andinas) in the confluence of the stream and the Yeso River. It is located at Km 7.43 in the Mountain Range Negra Lake Aqueduct.

This work catches the water from El Manzanito stream. The work consists of a stone barrier along the waterway, a lateral wall and two funnel-type sand traps, in order to discharge at the Mountain Range Aqueduct. It has a capacity of 3,5 m^3/s.

C. Water collection infrastructure

The following collection works are located in the PHAM influence area, between the collection zone in El Volcán sector and the Project discharge sector (Las Lajas sector).

On Annex 12, a scheme is appended in order to illustrate the location of works in the Project influence area.

Table 5.6.1.1
Existing water intakes in PHAM influence area

Basin	Water intake	Northern coord. (UTM)	Eastern coord. (UTM)	Hydrographic source
Yeso River	El Manzanito	6265353.63	392580.9	El Manzano Stream
	Los Piuches	6261487.12	390670.58	Yeso River
	San Gabriel	6260685.99	388580.14	Yeso River
Volcán River	Del Fundo	6257965.03	393706.6	Volcán River
	Romeral	6258043.94	392620.29	Volcán River
	La Junta del Fundo	6258358.68	389864.35	Volcán River
Maipo River	Cauquino	6283674.71	368675.39	1st section of Maipo River

Source: Irrigation National Commission and DGA, 2008

The source of information is the Irrigation National Commission. The source of this information corresponds to the DGA Water Resource Information Center (water intake cadaster for the first section of Maipo River, 1988) DGA has no information on the water right property (if there is one), possibly because it is previous to the creation of the cadaster. Neither there is information about these works in Monitoring Board from Maipo River. This Board gathers major associations, which maintain leveraging actions of the water.

In March 2008, a field visit was conducted in order to check the existence of the catchment works in the waterways of Maipo, Yeso and Volcán rivers. The field verification results of the above mentioned works are described below:

Table 5.6.1.2
On site water intake review result, upstream of the PHAM discharge in Las Lajas sector

Basin	Water intake	Current situation
Yeso River	Los Piuches	The presence of works is not observed, only the construction with stones of a stream diversion along the left bank of the Yeso River. After that, there is a ditch completely dry, evidence that is idle for a long time.
	San Gabriel	There is a diversion in the stream constructed with stones on the right bank of the Yeso river, which carries the water into a ditch.
Volcán River	Del Fundo	A diversion was observed on the left bank of the Volcán River, constructed with stones, which carries water to a ditch.
	Romeral	It was not possible to verify on site the location of this collection. According to consultations to the local inhabitants, there is no water intake. Neither it was possible to verify its location based on aerial geo-referenced pictures.
	Junta del Fundo	It presents a low stone wall across the Volcán River which diverts the water to the right bank, in order to carry water through a ditch.
Maipo River	Cauquino	There is a diversion on the left bank of the Maipo River about 40 meters, which carries the water to a fence that marks the beginning of Cauquino channel. It consists of concrete tube sections (D=90 cm approx.), stone masonry sections and dirt sections (80 cm wide and 50 cm deep).

Note: The Manzanito water was not inspected as it corresponds to a work located on the stream with the same name, therefore it is outside the influence area affected by the PHAM collection in Yeso River.

D. Energy and Communications

All the existing locations in the Project influence area feature electric energy cover. Despite the above and considering the existence of a significant number of isolated dwellings located, mainly in peripheral areas, 5.5% of homes in populated localities recognized in the area of direct influence area of PHAM, do not feature electric energy cover.

Regarding communications, the different locations have land line telephone service. Likewise, there is cell phone coverage, which varies depending on the company and the topographic characteristics of each of the locations.

E. Public utilization spaces: Interior roads, surface quality and green areas

Each location has a different road structure, with levels of development and features that are directly related to topographic conditions and the growth and expansion of each of the locations. This situation is similar with regard to the quality of existing surfaces and green areas in different locations.

Overall, it may be noted that all the locations on the Project influence area have a poorly developed internal road pattern, also highlighting the null paving in these roads; in the same way, the scanty and almost no development presented by the parallel paths to G-25 route is important.

In locations where the road becomes a more developed plot, corresponding to El Canelo and El Manzano, the internal roads are unpaved and perpendiculars to G-25 Route, which communicate with the dwells located along such routes, and are unpaved and strongly affected by the rains, mainly during winter.

Regarding the existing green areas in the locations, it is possible to note that they have scant development. In this sense, only the existence of some green areas in those locations that have a central square (San Gabriel and El Volcán) is registered. Likewise, the development and maintenance of trees on the main access roads to the villages is registered.

5. 6. 1. 3 ***Equipment***

A. General equipment

The characterization of the existing equipment in the towns of the Project influence area is carried out considering the kinds of equipment set forth in Article 2.1.33 of the General Urban Development and Construction Regulation.

The table below presents a summary of the existing equipment at the indicated locations.

Table 5.6.1.3
Summary of equipment in locations within Project influence area

Locations	Worship and culture	Education	Health	Safety	Trade	Services	Sport	Leisure
El Canelo		1 primary school		1 Fire Department	4 restaurants 4 stores			3 facilities equipped with swimming pool
El Manzano	Catholic chapel Event center	1 private secondary school 1 special school			6 restaurants 4 stores		1 soccer field	1 vacation center Swimming pool and other facilities
El Alfalfal		1 primary school						
Los Maitenes		1 primary school	1 general hospital	1 Police post (Carabineros)				
San Gabriel		1 primary school		1 Police post (Carabineros)				
El Romeral					1 store			
El Volcán	1 Catholic chapel	1 abandoned school	1 Minsal general hospital	1 Police post (Investigaciones)	1 store			
Lo Valdes	1 event center							1 vacation center Swimming pool and other facilities
Baños Morales	1 Catholic chapel		Thermal waters	1 Fire Department 1 shelter of Socorro Andino	4 stores	CONAF office		1 community area

According to PLADECO 2002-2006, in the municipality of San José de Maipo, health sector does not currently have all the equipment and skills required to prevent the residents having to travel to Puente Alto or other medical facility. The locations within the Project area of influence have the following establishments:

- General hospital Los Maitenes.
- Rural emergency centers: in San Gabriel and El Volcán.

Each of these emergency centers has SOME and OIRS, a box for each professional, waiting room, education room, storage of medicines (Central Warehouse in Las Vertientes General Hospital), dental room (San Gabriel), phones (except El Volcan General Hospital) and radio communication equipment, housing for local residence, a transport vehicle adapted for medical transportation.

In the Security area locations within the Project influence area have the following establishments:

- Carabineros station: San Gabriel and Los Maitenes border post.
- Fire Department: El Canelo and Baños Morales.
- Socorro Andino Brigade: Baños Morales.
- Investigaciones Station: El Volcan.

The remoteness of El Volcano, Baños Morales and Valdés from the structural axis of the municipality makes evident the need of the inhabitants for the installation of a police post.

Moreover, the current supply of firefighters in the Project influence area is not always sufficient to meet any and all claims demands from fire related incidents.

Finally, public safety activities promoted by the municipality are conducted using a Mobile Legal Aid Unit, based on an agreement signed with the Ministry of Justice through Judicial Assistance Corporation, providing direct attention and free social legal to the inhabitants.

B. Roads and transportation

i. Introduction

The communication between areas is possible through connecting roads to allow the transportation of not only goods and raw materials, but also enable the movement of people between these same territories, thus allowing the satisfaction of needs ranging from access to basic services to activities related to economic and productive development, recreation and leisure.

For a full characterization of the current status of existing and planned roads in the Project influence area, we proceeded to collect and review diverse bibliographic background (PLADECO Diagnostics, OTAS, Internet, etc.), which was subsequently updated and complemented with information gathered from various site visits conducted in November 2006 and 2007.

Considering the above mentioned, this section provides background of the current condition of the routes to be used by PHAM, in terms of the infrastructure, supply and demand offered by the existing roads in PHAM influence area, and a description of the future major road projects.

ii. Influence area

PHAM Direct Influence Area consists of a set of roads and intersections between Departamental Avenue (La Florida Municipality) and the sector of Lo Valdes along G-25 Road, including G-345 Road (access to Alfalfal Facility) and G-455 Road (access to El Yeso reservoir). It also consists of the most relevant intersections on G-25 Road, between the intersection with Departamental Avenue and the intersection of G-25 Road with the access road to Baños Morales.

Moreover, for different work fronts considered by the PHAM, provides for the use of existing roads and build roads that connect to each other sectors where they located the camps for workers, tasks facilities, sites stockpile of marinas, etc. These roads also will connect with the public roads in specific sectors outlined below.

Thus, the influence area and connecting to the project are:

a) <u>Transportation routes from/to work sites at Maipo Discharge</u>:

- La Florida Av. (G-25 Road) from Departamental Av. (Km 0.00) up to Km. 23.4 approx, where work accesses are planned.

b) <u>Transportation route from/to worksites in Alfalfal II and Las Lajas</u>:

- La Florida Av. (G-25 Road) from Departamental Av. to Los Maitenes access (G-345 Road).
- Access to Los Maitenes (G-345 Road), from Camino al Volcán (G – 25 Road) to Alfalfal II y Las Lajas work sector.

c) <u>Transportation route from/to worksites in Lo Encañado – El Yeso</u>:

- - La Florida Av. (G-25 Road) from Departamental Av. to G-455 Road.
- G-455 Road, from Camino al Volcán (G-25 Road) to worksite in Lo Encañado and El Yeso.

d) <u>Transportation route from/to worksites in El Yeso</u>:

- La Florida Av. (G-25 Road) from Departamental Av. to Baños Morales sector.
- From Baños Morales sector (G-25 Road) to worksite in El Volcán.

The tables below indicate the sections and intersections that will be used during the execution of PHAM as transportation roads:

Table 5.6.1.4
Route sections

Tramo	Ruta	Entre	Comuna	Kilometro		Longitud (Km.)
				Inicio	Fin	
1	G-25	Departamental y Diego Portales	L a Florida	0	6	6
2	G-25	Diego Portales y Eyzaguirre	Puente Alto	6	11,5	5,5
3	G-25	Eyzaguirre (Las Vizcachas) y Ruta G-345	Puente Alto	11,5	28,3	16,8
4	G-25	Ruta G-345 y Acceso Norte a San José de Maipo	San José de Maipo	28,3	32,7	4,4
5	G-25	Acceso Norte y Acceso Sur a San José de Maipo	San José de Maipo	32,7	38,1	5,4
6	G-25	Acceso Sur a San José de Maipo y Puente El Yeso	San José de Maipo	38,1	56,8	18,7
7	G-25	Puente El Yeso y Baños Morales	San José de Maipo	56,8	83,3	26,5
8	G-345	Ruta G-25 y Acceso a Central Alfalfal	San José de Maipo	0	22,8	22,8
9	G-455	Ruta G-25 y Sector del Embalse El Yeso	San José de Maipo	0	23	23

Source: Own elaboration.

Table 5.6.1.5
Relevant intersections

Punto	Entre	Comuna
1	Av. La Florida / Av. Departamental	La Florida
2	Av. La Florida / Rojas Magallanes	La Florida
3	Av. La Florida / Trinidad Oriente	La Florida
4	Av. La Florida / San José de la Estrella	La Florida
5	Av. Camilo Henríquez / Av. Diego Portales	La Florida y Puente Alto
6	Av. Camilo Henríquez / El Peñón	Puente Alto
7	Av. Camilo Henríquez / Eyzaguirre	Puente Alto
8	Ruta G-25 / Acceso a Ruta G-421	Puente Alto
9	Ruta G-25 / Ruta G-345	San José de Maipo
10	El Volcán / Cañada Norte	San José de Maipo
11	Comercio / Cañada Norte	San José de Maipo
12	Ruta G-25 (Camino al Volcán) / Ruta G-421	San José de Maipo
13	Ruta G-25 (Camino al Volcán) / Ruta G-455	San José de Maipo
14	Ruta G-25 (Camino al Volcán) / Ruta G-465	San José de Maipo

Elaboración Propia

A graphic representation of the Direct Influence Area is provided in the figures below.

Figure 5.6.1.2
Project Influence Area

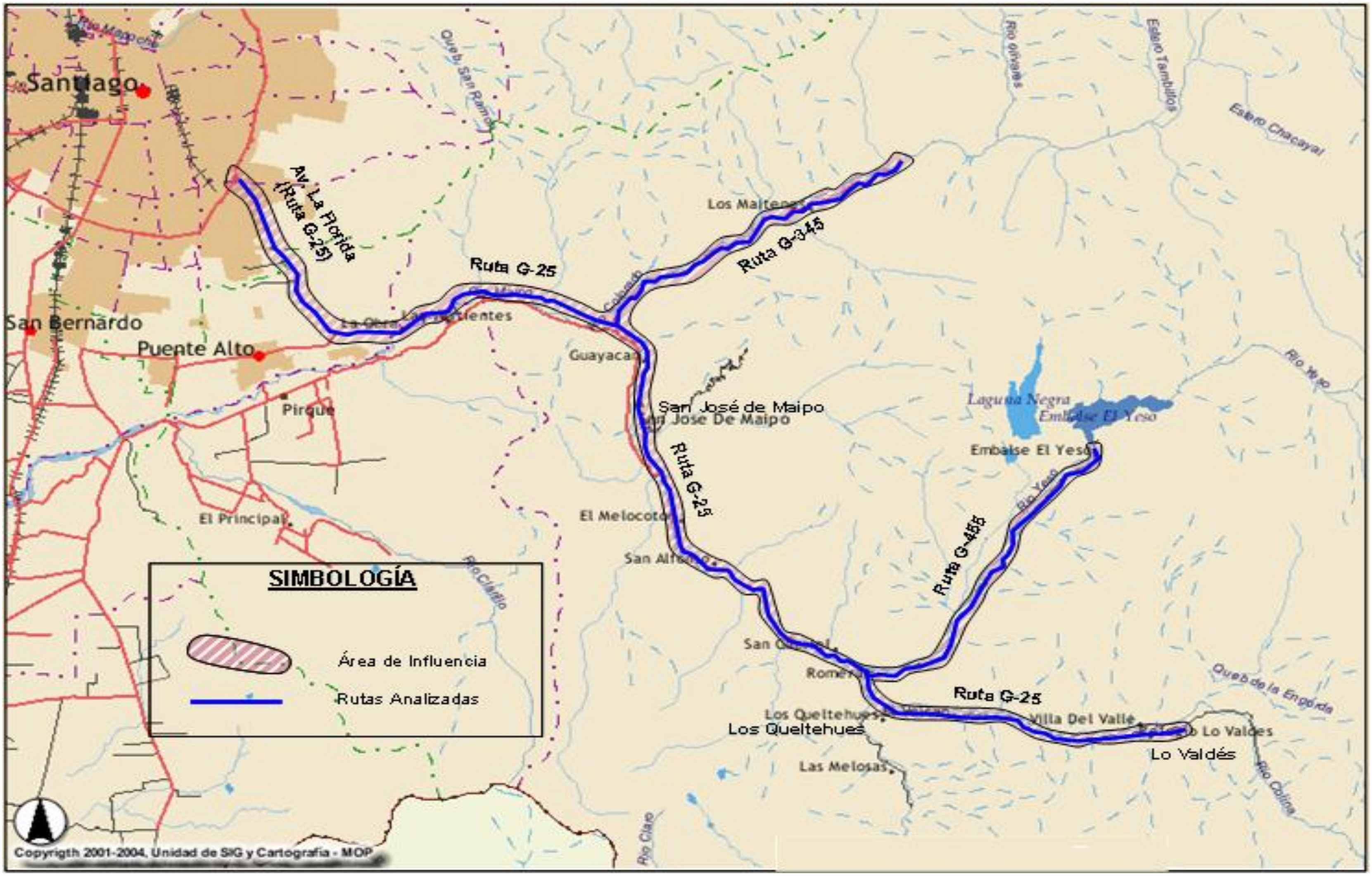


Figure 5.6.10.3
Transportation routes to works in Las Lajas works and Maipo River discharge

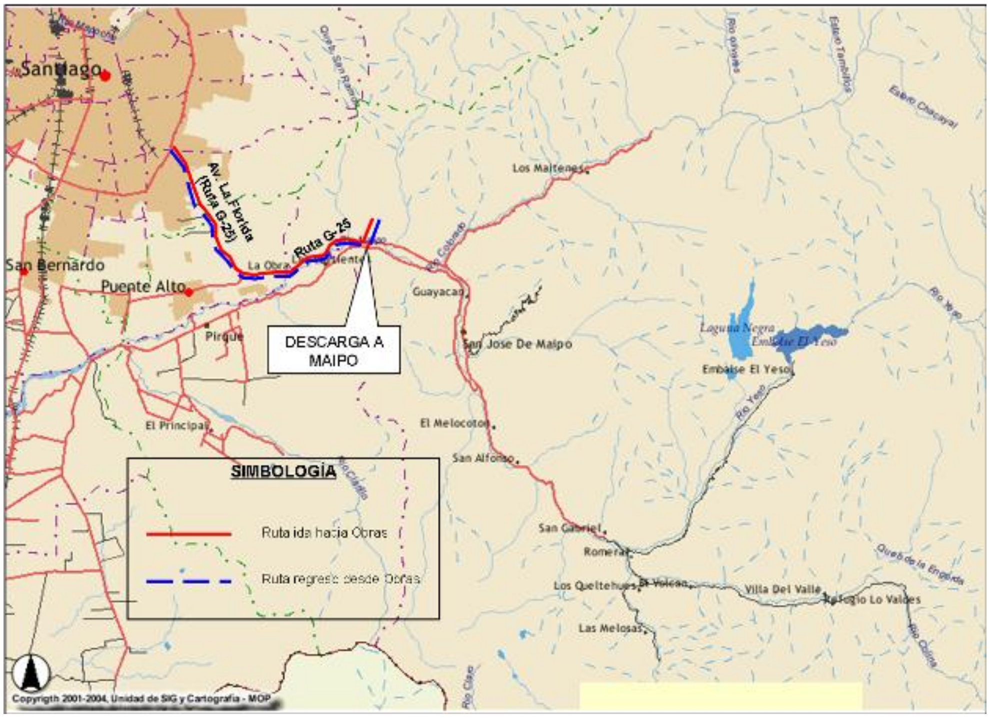


Figure 5.6.1.4
Transportation routes to Alfalfal II Facility – Las Lajas works

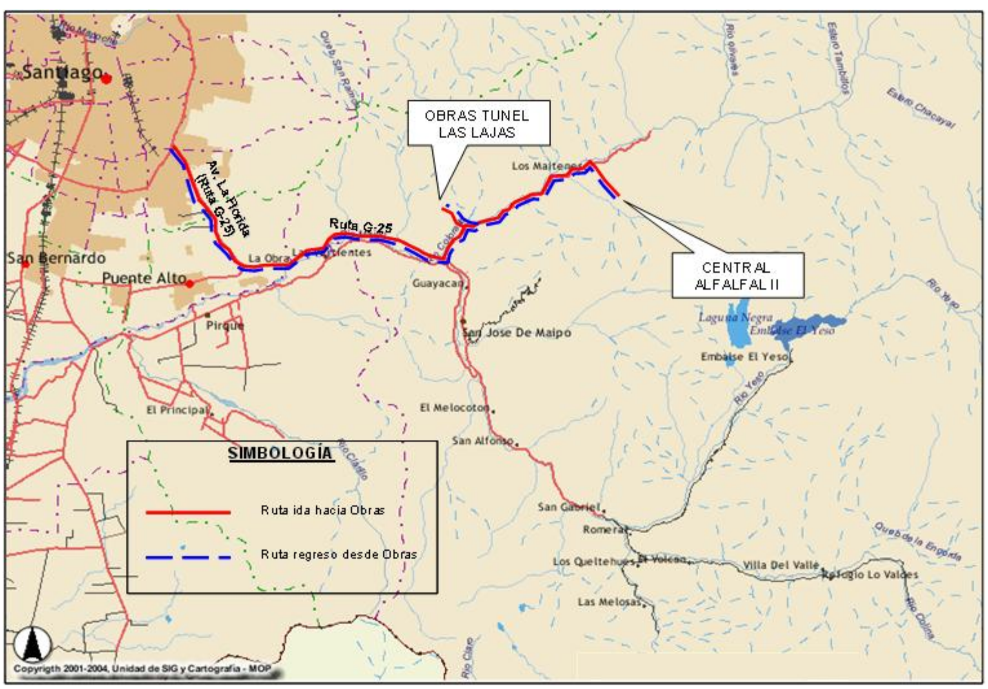


Figure 5.6.1.5
Transportation routes to Lo Encañado and El Yeso work sector

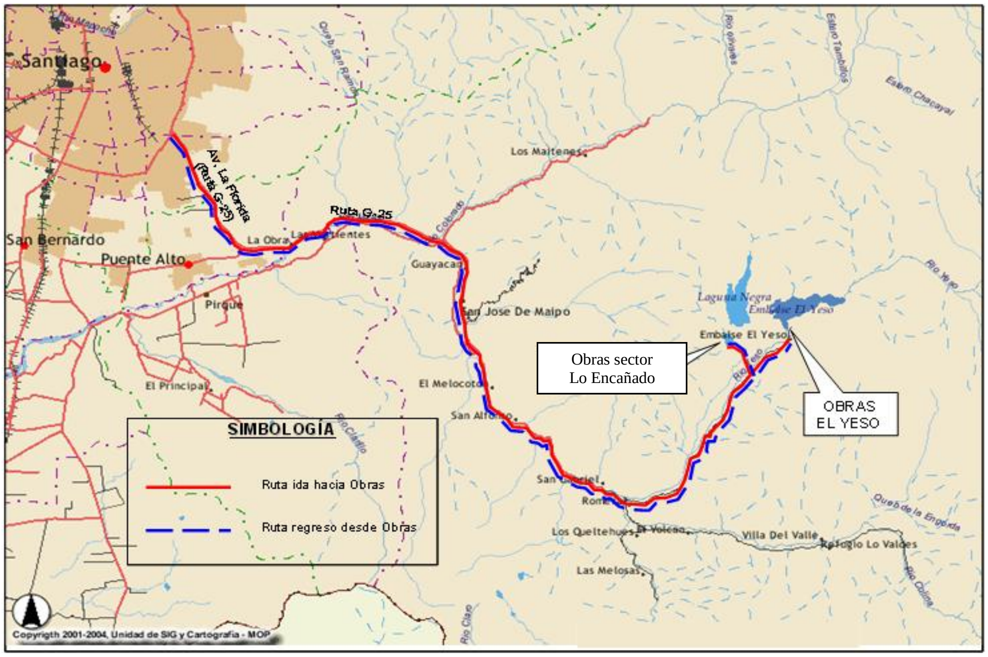
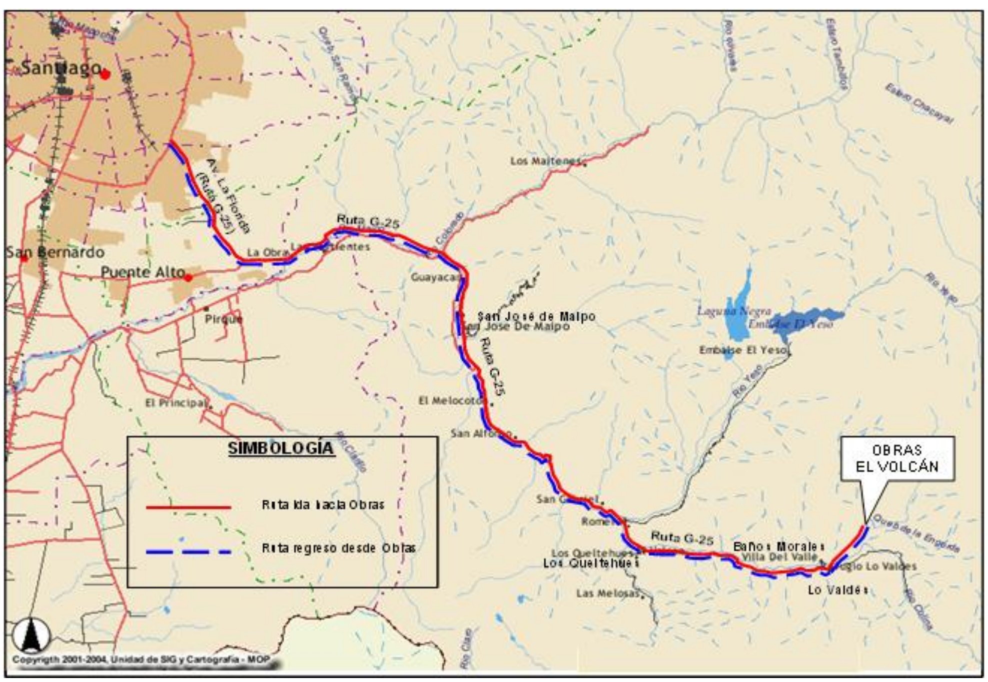


Figure 5.6.1.6
Transportation routes to El Volcan works



iii. Current road availability

The Project influence area considers the existence of only one axis road that connects the Maipo Canyon area with the urban area of Santiago, including also interconnection pathways with that route, which are preferably used in mining and activities related to tourism developed in the area.

Moreover, the Project area features development of some communication roads executed and maintained by privates.

Thus, first, we present the characterization of existing public roads in PHAM influence area, to incorporate later the information gathered about private roads and other background on the development of new road infrastructure in the area.

iii. Public roads

The existing public roads in the Project influence area feature 3 main routes: G-25, G-455 and G-345. These routes present some branches or secondary roads, which begin from one of these pathways. Their main characteristics are described below.

G-25 Road

The main road and interconnection in the transportation and communication system of San Jose Municipality is G – 25 Road. This route is also the main access to Santiago. G-25 Road begins in its intersection with Departmental Avenue (La Florida Municipality) and ends in El Volcan.

In general, it has a pavement in fair condition. It has two tracks in each direction and lacks berm in many places.

G-25 Road, also known as El Volcan, extends over 100 kilometers, the first section along the northern and northeastern bank of Maipo River, and then it continues along northern bank of El Volcan River. This route penetrates perpendicularly into the mountain range for 20 Km up to Guayacan, where it turns right and then continues south 12 Km to San Alfonso. Then it turns eastbound passing San Gabriel, where the pavement ends and the road is completed up to Baños Colina. Based on this route there are several branches that connect the main road to the other locations.

The last sections of G-25 Road present recurring deterioration due to factors related to low temperatures and high traffic, mainly provided by large trucks and the tonnage associated to mining activities.

An important part of the settlement registered in Cajon del Maipo area is originated by this means of communication. Likewise, there is the development of business activities in a large portion of the route. A major factor to be considered is the saturation of the structuring road, especially during weekends, due to heavy influx of tourists.

As noted above, a complete description is presented below on the characteristics and condition of G-25 Road, differentiating various sections along its development. Subsequently, there is a complete description of the main intersections developed along this route, identifying the type of the existing crossing and the main road conflicts observed.

Table 5.6.1.6
Section 1: G-25 Road (La Florida Avenue), between Departamental Avenue and Diego Portales Avenue

Parameter	Description
	La Florida Avenue is a structuring, collecting and distributing road that runs through La Florida Municipality from North to South and vice versa, connecting with main avenues, such as the Americo Vespucio Beltway, and Macul and Departmental Avenues. It links La Florida and Puente Alto municipalities. The avenue has a broad cross-section, composed of a double paved roadway, with median strip, lighting and side streets located alternately to either side of the road, or both sides in some sectors, always separated from the main road. It also has sidewalks and buildings on both sides. Public transportation transits on the side streets mostly, leaving the main road almost exclusively for other types of vehicles.
Stretch length	6 kilometers.
Roadway type	Each roadway is paved and has two tracks for each direction of traffic. In the inputs and outputs to the side streets, there are fast and slow tracks, allowing relatively fluid access to or from the main road.
Roadway width	7 meters.
Median strip width	It varies between 5 and 25 meters.
Number of tracks	Four (two on each transit direction).
Track width	3.5 meters.
Pavement type	Asphalt carpet in fair to good condition.
Longitudinal slope	Plane.
Curb	On both sides of driveway
Pedestrian sidewalks	On both sides, made of concrete and in good condition.
Posts	On both sides of driveway and in the center.
Current vehicle transit	High.
Maximum allowed speed	60 Km/h.
Vehicle congestion	At rush hours during morning and evening, mainly in the intersection of Departamental Av.

Parameter	Description
Road signage	Adequate. Overall in good condition.
Pavement demarcation	Adequate, overall in good condition.
Road conflicts	At the intersection with Departmental Avenue, at the beginning of the G-25 Road, vehicles that turn from east in Departmental Avenue southbound towards La Florida Avenue get stuck in a queue that interferes with traffic flow that circulates in La Florida Av northbound. At Km 0.5 after Departmental Av., at the right side of La Florida Av., a street market is established on Saturdays, causing a conflict between vehicles and pedestrians. Another conflict is observed on the congestion that occurs at the access of Parque El Prado Cemetery, where the arrival of funeral processions accumulates a large number of vehicles on the track reserved for turning left, which is increased by vehicles parked haphazardly, occupying all the adjacent roads, including the median strip of La Florida Av.
Intersection with other avenues	The most important intersections are: Departamental Av., Walter Martínez Av., Jerónimo de Alderete, Rojas Magallanes, Enrique Olivares, Santa Amalia, Trinidad Av., the access to Parque El Prado Cemetery, San José de la Estrella Av. and Diego Portales Av. (26^{th} bus stop).
Observations	Among the existing intersections along this route, there is only one underpass at the intersection with Walter Martinez Avenue, where La Florida Avenue presents an underpass. The remaining intersections are all at level and most of them are regulated by traffic lights or priority signals. For pedestrian crossing runways, there are walkways arranged at various points of the route, accordingly to the existence of bus stops.

Table 5.6.1.7
Section 2: G-25 Road (Camilo Henriquez Av.), between Diego Portales and Eyzaguirre Av. (Las Vizcachas crossroads)

Parameter	Description
	Continuing towards the Cajon del Maipo, G-25 Road receives its name from Camilo Henríquez Av. It corresponds to an urban structuring that collects and distributes traffic flows to different municipalities in Santiago.
Stretch length	5.5 kilometers.
Roadway type	This stretch presents a cross section composed of a paved double lane, with median strip with green areas and lighting. The side streets exist only in the accesses to residential areas, shopping centers, schools and service stations. Near the end of the stretch, reaching the crossing of Las Vizcachas, the separated driveways have a gap between them, which reaches about 2 meters high. Each roadway is paved, in good condition and has two tracks for each direction of traffic. There are sectors where the number of tracks increases to three, but in short sections.
Roadway width	7 meters.
Median strip width	3 meters in the narrowest sector and 25 meters in the widest sector.
Number of tracks	Four, two on each transit direction.
Track width	3.5 meters.
Type and condition of pavement	Asphalt carpet in good condition.
Longitudinal slope	Plane.
Posts	Medium and low tension line with concrete posts on both sides of walkway, with lighting. Lightposts are located on the median strip with metal posts.
Curb	On both sides of driveway.
Pedestrian sidewalks	On both sides, made of concrete, except on some specific places.
Current vehicle transit	Medium
Maximum allowed speed	60 Km/h.
Vehicle congestion	Not appreciated.

Parameter	Description
Road signage	Adequate.
Pavement demarcation	Adequate, fair to good condition.
Road conflicts	At the intersection with Eastern Gabriela Avenue, Transantiago articulated buses, which are incorporated into La Florida Av. northbound have problems due to the turning radii that gets stuck with the median strip of La Florida Av., interfering with the traffic of vehicles heading north and resulting in queues of vehicles to stop until the bus can make the move completely. No other conflicts are seen in this stretch as it is located practically on the outskirts of the urban area, traffic flows decrease markedly with respect to the previous stretch and intersections are not affected.
Intersection with other avenues	The most important intersections are: Diego Portales Avenue (26^{th} bus stop), Los Toros Avenue, Gabriela Oriente Avenue, El Peñón and Eyzaguirre avenues, at the convergence of three branches at level, which allows the access to Puente Alto and Cajon del Maipo.
Observations	All existing intersections along this section are standard and are controlled by traffic lights or priority signals. In general, there is plenty of road signs and appropriate pavement marking in advance that inform the driver and channel traffic flows in the corresponding tracks.

Table 5.6.1.8
Section 3: G-25 Road (El Volcan Road), between Eyzaguirre and G-345 Road (Access to Los Maitenes)

Parameter	Description
	Entering into Cajon del Maipo, G-25 Road is called El Volcan Road. This section of the route, which starts at Km 11.5, crosses several adjacent locations such as Las Vizcachas, La Obra, Las Vertientes, El Canelo and El Manzano, until reaching the intersection with G-345 Road, Km 28.3, which is located at the access of Los Maitenes and El Alfalfal. La Obra is located at Km 15, this is an urban area with housing and commerce establishments located on both sides of road. The limit of Puente Alto is at Km 15.2, San José de Maipo Municipality of the Cordillera province starts at this point.
Stretch length	16.8 kilometers.
Roadway type	The section continues on dual carriageway, but separated only by continuous centerline. The road is 12 meters wide in total and it has two tracks for each direction of traffic. It develops in a straight, flat area that ends at Km 15 approximately where the roads are completely separated, with each one of them being 6 meters wide and one-way traffic with two lanes of traffic to the same direction. No berms. Between Km 16.4 and 16.9 Km, the tracks come together again, resulting in a single carriageway with three lanes of traffic, two for the direction of traffic to Santiago and one to San Jose de Maipo. This area corresponds to a hill with steep slope. At km 16.9 the road begins again with a simple bidirectional carriageway 6 m wide and a track for each direction of traffic, without berms.
Roadway width	It varies between 6 and 12 meters.
Number of tracks	Four (two on each transit direction) until Km. 16.4. Between Km. 16.4 and Km. 16.9, the road presents 3 circulation lanes to Santiago and one to San José de Maipo (as commented above). At Km 16.9 until the end of the stretch the road presents 2 tracks, one per traffic direction.
Track width	3 meters.
Type and condition of pavement	Asphalt carpet in fair to good condition with small potholes in specific areas.
Berms	Inexistent.
Slope geometry	There are some level stretches at the beginning of the road, there are some moderate slope sector that are important on some sectors.

Parameter	Description
Flat geometry	There are some horizontal curves with small radius, but typically adequate for the road operation.
Posts	Made of concrete, on both sides of the roadway to the area where the carriageway is divided. At that point they exist on the side of the road, lighting exists on populated areas and in curves.
Current vehicle transit	Medium
Maximum allowed speed	50 Km/h in general.
Vehicle congestion	Inexistent.
Road signage	Adequate, in good condition.
Pavement demarcation	Adequate, in fair condition.
Road conflicts	Generally inexistent, except for the sectors associated with horizontal curvature and poor visibility, which in any case have adequate signage as well as continuous line. In populated areas, mainly in near schools adjacent to the road, there are traffic lights operating based on the entry and exit of students, there are zebra crossings on the road of the route in specific sectors with appropriate signage, the demarcation of these crosswalks can be seen in fair condition.
Pass through populated zones	Las Vizcachas, La Obra, Las Vertientes, El Canelo and El Manzano
Observations	At Km. 16.9, there is Carabineros checkpoint and speed is normally reduced due to the Police presence.

Table 5.6.1.9
Section 4: G-25 Road, (El Volcan Road), between G-345 Road and the Northern access to San Jose de Maipo

Parameter	Description
	In this stretch of road shops and houses can be seen on both sides of the road. It is characterized by a little steep stretch of curves and straight sections. There are some steep slopes in specific sectors; in general the slopes and gradients are moderate.
Stretch length	4.4 kilometers
Roadway type	In this section the road has a constant cross section with a simple two-way paved road with 6 meters width, the closing line and building in urban areas is located approximately 2 meters from the road, there is narrow berm on both sides of the road.
Roadway width	6 meters.
Number of tracks	2 tracks, one on each traffic direction.
Track width	3 meters.
Type and condition of pavement	Asphalt carpet in fair to good condition, with some specific potholes.
Berm type	Made of asphalt, 1 meter wide approx. on both sides of the roadway.
Flat geometry	There are some horizontal curves with small radius, but typically adequate for the road operation.
Slope geometry	There are some steep slopes in specific sectors; the slopes and gradients are moderate overall.
Posts	Medium tension posts made of concrete on the right side, changing to the left side at Km 18.9. Lighting is on the right side and only present on populated areas and curves.
Current vehicle transit	Medium
Maximum allowed speed	50 Km/h.
Restrictions	No overtaking on curve sectors.
Road signage	Adequate, in good condition.
Demarcation	Adequate, in fair condition.
Road conflicts	Inexistent.

Parameter	Description
Pass over populated areas	Guayacán
Observations	At the end of this stretch, the access to San Jose de Maipo has separated roadways (one in and out). When reaching the bifurcation after a curve sector that ends very close to the mentioned bifurcation.

Table 5.6.1.10
Section 5: G – 25 Road, (El Volcán Road), San José de Maipo urban sector

Parameter	Description
	At the access to San Jose de Maipo, G-25 Road (El Volcan Road) again presents separated carriageways, resulting in two one-way roads across the urban area of the town in opposite directions. The transit to the mountain range is limited by the town center to buses and light vehicles. For the road with one way direction from Santiago to San Gabriel, the route remains under the name of El Volcan Road. Instead, the traffic to Santiago is along Comercio Street.
Stretch length	5.4 kilometers
Roadway type	It features separated roadways, resulting in two-way roads with 7 m width, which is actually two city streets.
Roadway width	7 meters.
Number of tracks	Two on each transit direction.
Track width	3.5 meters.
Type and condition of pavement	Asphalt carpet in good condition.
Pedestrian walkway	Made of concrete with one meter width on both sides of the roadway.
Flat geometry	Straight throughout the stretch.
Slope geometry	It does not feature slopes and is a completely plane sector.
Posts	Concrete posts on the right side of the streets (El Volcan Road and Commerce Street) with lighting and medium to low tension line.
Current vehicle transit	Medium
Maximum allowed speed	50 Km/h.

Parameter	Description
Restrictions	There is a restriction for heavy vehicles (trucks), which are deflected to Cañada Norte Street, preventing their traffic through the downtown area of San José de Maipo. In urban zones, the speed operation are restricted by the existence of regulatory signals or Police presence.
Road signage	Adequate, in good condition.
Demarcation	Adequate, overall in good condition.
Road conflicts	Inexistent.
Relevant intersections	Urban intersections with Cañada Norte, Cuatro Norte, Dos Sur and Cañada Sur streets.
Observations	At most intersections there are zebra crossings, painted regularly and in good condition. The intersection with Cañada Sur Street is located at km 34.2 (dual carriageway), which must be traveled in about 80 m to retake G-25 Road towards El Volcan. The urban zone ends after 150 meters.

Table 5.6.1.11
Section 6: G-25 Road, (El Volcan Road), between the access to San José de Maipo and the El Yeso Bridge

Parameter	Description
	In this section the two roads again unite and the resulting road remains with the same characteristics than before entering San José de Maipo, until beyond San Gabriel River reaching El Yeso Bridge. In this stretch there is a significant flow of trucks over two axles, creating risky situations in other drivers.
Stretch length	18.7 kilometers
Roadway type	The road is a simple, one-way road for each direction of traffic. It also has dirt berms with 1 meter width and closing line about 2 meters from the edge of the roadway. There is a narrow and winding section between Km 48.5 and Km 49, where the route of the road is developed in mixed profile, with a retaining wall on the right side of 0.6 m in height, which acts as a defense roadside. The left side is the hill, where there are normally minor landslides.
Roadway width	6 meters.
Number of tracks	2 tracks, one on each traffic direction.
Track width	3 meters.

Parameter	Description
Type and condition of pavement	Asphalt carpet in good condition. El Yeso Bridge is located at Km 56.8 where the pavement ends, continuing a gravel road of varying width between 5 and 6 meters, the type of the road is a fair condition carpet with plenty of potholes due to the trucks traffic of truck and poor sanitation in the sector. Generally there are no berms or sanitation devices, so the water runs freely on the road.
Berm type	Approximately one meter wide, often granular berms. From Km. 56.8 on the road has no berm due to the characteristics of the carpet.
Flat geometry	Steep sector with some horizontal curves of small radius, but typically adequate for the road operation.
Slope geometry	It presents slopes and gradients with minor inclination. Beyond the bridge located at Km. 60.7, there is a gravel road with an intense slope and great length.
Posts	Medium tension concrete posts on the right side, lighting on curve sector and populated settlements adjacent to the road.
Current vehicle transit	Low.
Maximum allowed speed	50 Km/h.
Restrictions	In San Gabriel travelling speed is restricted to 30 Km/h and the Police control of vehicles is mandatory on both traffic directions.
Road signage	Adequate, in good condition.
Demarcation	Adequate, overall in good condition.
Road conflicts	Most of gypsum carrying trucks travel to Santiago at excess speed.
Pass over populated areas	The main settlements are El Melocotón, San Alfonso and San Gabriel.
Relevant intersections	G-355 Road (Lagunillas access), G-421 Road (El Toyo Access), access to “El Ingenio” and the intersection of G-455 Road (El Yeso Reservoir access). All of them consist of a T bifurcation with a branch that links with G-25 Road.
Observations	Given the important attraction of the area, light vehicle traffic significantly strongly increases on weekends and the traffic of trucks decreases dramatically.

Table 5.6.1.12
Section 7: G-25 Road, (El Volcan Road), between El Yeso Bridge and Baños Morales

Parameter	Description
	From this point until the end of the stretch, the road has a winding route with gravel carpet and an irregular topography that has characteristics of mountain roads, lush vegetation can be seen in specific sectors hindering visibility. In this section of the route, the river is on the left side and the hill on the right side. After the El Yeso Bridge, there is a strong gradient of great length, which slows down traffic. When getting closer to El Volcan and Baños Morales the use of trucks is more evident, due to the presence of gypsum furnaces and the decrease of light vehicles traffic on weekdays.
Stretch length	26.5 kilometers.
Roadway type	In this section the road is 6 meters wide on average, with closing lines on both sides, located immediately to the edges of the road, at Km 2 after the intersection of access to Los Queltehues the road presents a mixed profile, along the hill on the right side and along El Volcan River on the left side. There are specific widenings on several places at the left side of the road. There are also 2 or 3 passes of water on the road that in times of winter produce interruptions in the road, such as Las Amarillas, this area also suffers material sliding from the hill located on the right side.
Roadway width	6 meters in general. With sectors wider or narrower.
Type and condition of pavement	The carpet is made of granular material with an apparent salt treatment in populated areas to avoid raising dust as a result of passing vehicles. In most of the route of this section the carpet is "rough" and presents some potholes due to the large number of heavy trucks that circulate.
Berm type	Inexistent.
Flat geometry	Steep sector with some horizontal curves of small radius, but typically adequate for the road operation.
Slope geometry	It presents little steep slopes and gradients, highlighting the ones located at the bridge exit, which is 5 to 6%.
Posts	Low tension posts on the right side and lighting on settlements adjacent to the road.
Current vehicle transit	Medium.
Maximum allowed speed	50 Km/h.
Restrictions	Use of chains on the wheels during winter season.
Road signage	Adequate, overall in good condition.
Road conflicts	Sector with traffic mainly from trucks with more that 2 axis, which circulate at a greater speed than the limit.
Pass over populated areas	El Volcan and Lo Valdes as the most important settlements.

Parameter	Description
Observations 	In some sections the route is equipped with speed bumps and works which are suitable for heavy Vehicle traffic. These works allow crossing the channels from streams that exist in the sector. In some cases the work wall is covered by a significant layer of granular material that may fall on the stream, causing obstruction danger. It should be noted that the Road Department is developing a detailed engineering study for paving the El Yeso – El Volcan Bridge, which includes improving the road over a length of 12 kilometers, in regard to extensions, pavement and sanitation.

G-455 Road

Its route begins at the intersection with G-25 Road and communicates with the El Yeso reservoir area, corresponding to a path that has a granular gravel carpet. Because of its location and derived from the climatic conditions prevailing in the area in summer season, this route is interrupted occasionally due to landslides, heavy rain and heavy snowfall. Below there is a detailed characterization of G-455 Road.

Table 5.6.1.13
G-455 Road

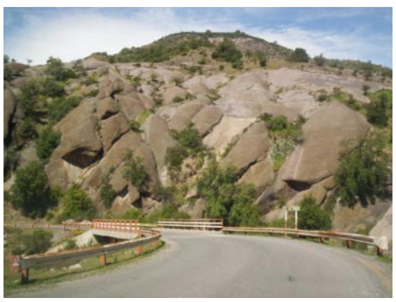
Parameter	Description
	This road has a mountain nature and connects the El Yeso Reservoir and Termas del Plomo thermal waters with G-25 Road. In the first kilometers it has wide level areas and vegetation on both sides, reaching the El Yeso Reservoir, with the road platform on a mixed profile and the El Yeso River on the left side. At the intersection with Route G-25 is located a gypsum processing plant which generates a significant amount of trucks in the industry.
Stretch length	23 kilometers approx.
Roadway type	In this section the carpet is a gravel road with a width of nearly 6 meters. Lines are located close to both sides immediately on the edges of the road. At Km 2 going up to the reservoir, the closing line disappears. Poor sanitation, in some areas the carpet is invaded by streams or waterways.
Roadway width	6 meters, reaching a little less than 5 meters on the steepest sectors.
Type and condition of pavement	The gravel road in the first 500 meters has a better compaction due to the movement of trucks. In some sectors the carpet is invaded by streams or riverbeds, cracking the pavement.
Berm type	Inexistent.
Flat geometry	Completely winding with very sharp curve sectors. Also presents straight and level sector at the beginning of the stretch.
Slope geometry	Sharp slopes and gradients between Km 10 and Km 14 approx.
Posts	Low tension concrete posts on the right side. Without lines at the end of the stretch.

Parameter	Description
Current vehicle transit	Very low, except on special periods when it has heavy truck traffic from Chacay (Km 10 approx.) to the El Romeral processing plant (20 to 30 travels on a daily basis)
Maximum allowed speed	The road has no speed restrictions. It is suitable for an travelling speed of 50 Km/h on straight sections and 30 km/h as maximum speed on curve areas for light vehicles.
Restrictions	It is recommended to travel using chains during winter season. In such period, interruptions in the road are frequent due to heavy snow.
Road signage	Only on the first 500 meters of the road. There is an important sector that presents buried metal pipes on both sides of the road (vertical delineators in orange), which are used during periods of snow as guidance in relation to the height of the snow and recognition of the route for purposes of clearing machinery operation.
Road conflicts	There are sectors of stones that suffer road interruptions. Poor visibility in the first kilometers as a result of the vegetation. Some sectors of the road with curves also have poor visibility. Another conflict is caused by the occasional traffic of animals along the route.
Pass over populated areas	Few houses are seen along the road.
Observations	There are some works built in stone masonry and concrete, in areas of streams that cross the road. The amount of sewers or sewage disposal works in the road is insufficient. There are several areas where the streams cross it, without works or drains. As of November 2007, personnel began the construction of at least 4 stone masonry speed bumps in the road.

G-345 Road

It communicates from its intersection with G-25 Road and El Alfalfal/Los Maitenes Sector, on the southern side of the Colorado River. It corresponds to a road that presents asphalt pavement, which is observed in good condition and a bidirectional track, which serves mainly to connect to the Los Maitenes and El Alfalfal hydroelectric plants. Below there is a detailed characterization of G-345 Road.

Table 5.6.1.14
G-345 Road

Parameter	Description
	G-345 Road corresponds to a mountain road, with a course is developed parallel to Colorado River. It allows direct access to Los Maitenes and El Alfalfal hydroelectric plants. The 22.8 km route, lies on the access to the grounds of El Alfalfal plant, where written permission is required to enter. A little further the asphalt pavement ends and the road has a graveled carriageway 8 m wide, very well packed, which complies with the capacity and security requirements required for the passage of heavy trucks using the road. The inner bridges have similar characteristics to those in the rest of the section and its maintenance is the sole responsibility of the owner of the site.
Stretch length	22.8 kilometers. Until restricted access sector.
Roadway type	The road is developed mostly on a mixed profile. It has a single two-way carriageway where there are certain sections in each of the platform extensions where it is possible to park. The route is equipped with numerous drains and bridges that allow the crossing of the stream canals that exist in the sector. In general, sanitation is adequate, except in specific sectors where the curbs require maintenance. At Km 22.8 the asphalt pavement ends and the road has a graveled carriageway, very well packed, which complies with the capacity and security requirements required for the passage of heavy trucks using the road.
Roadway width	6 meters in general.
Number of tracks	2 tracks, one on each traffic direction.
Track width	3 meters in total.
Pavement condition	Asphalt carpet in good condition. At Km 22.8 the surface changes to a graveled carpet very well compacted.
Berm type	Inexistent.

Parameter	Description
Flat geometry	Winding road with curves of adequate radius for design speed.
Slope geometry	The road presents a sustained and moderate slope in its length. At km 15.1 Los Maitenes uphill begins with sharp radius curves and sustained slope.
Current vehicle transit	Low.
Maximum allowed speed	The maximum permitted for light vehicles is 60 Km/h, whereas the maximum speed for trucks and buses is 45 Km/h.
Restrictions	Several stretches have prohibition of overtaking, especially in sectors of demarcated with continuous line in the axis of the carriageway. In some sections the travelling speed is limited to 20 or 30 Km/h, depending on the sinuosity of the section or the proximity of a mining plant.
Road signage	It is adequate and fully serves the requirement of providing information to drivers.
Demarcation	Adequate, in good condition.
Road conflicts	Inexistent.
Pass over populated areas	Cerro Colorado Military Base is located at Km 5.2, where there is a vehicle control barrier. Minera Río Colorado is located at Km 11. Maitenes Facility access is located at Km 13.7. Access to El Alfalfal Plant premises is located at Km 22.7.
Observations	Overall road traffic is low, but it presents a great number of large trucks with loads that sometimes exceed 30 tons. The trucks transport gypsum and copper concentrate minerals. At several points along the route there are warning signs indicating "Caution heavy trucks on the road". There are also vertical signals that indicate the presence of animals on the road.

G-421 Road

It connects San José de Maipo Municipality to Pirque Municipality. It is located on the south bank of Maipo River in the stretch from the southern part of San Jose de Maipo to Pirque. It presents rough pavement. It is bidirectional and connects Las Vertientes with G-25 Road.

iii. Private roads

Route to Lo Encañado Lake and Negra Lake

The route to Negra Lake corresponds to a bifurcation of G-455 Road. It is located on the northern bank of the river and its purpose is to connect with the lake of the same name. It is an unpaved road with one track, in fair to poor condition. Because of the characteristics of its design and due to climatic conditions prevailing in the area during winter, the route is interrupted in case of landslides, heavy rain and heavy snowfall.

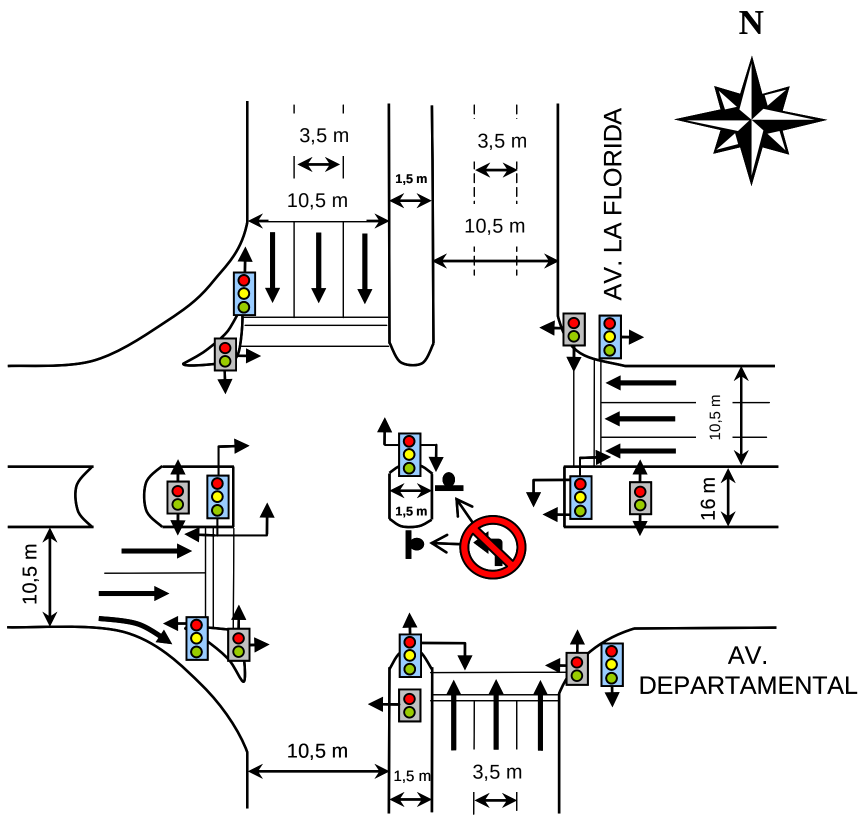
It corresponds to a private road owned by Aguas Andinas and authorization from the company is required to use it.

iv. Intersections

Intersection Nº 1: La Florida Av./Departamental Av.

i. Type: Level crossroads of four branches regulated by traffic light.
ii. Observed conflict: Left turning from Eastern Departamental to Southern La Florida, due to the scarce reserve capacity of La Florida Av. median strip.

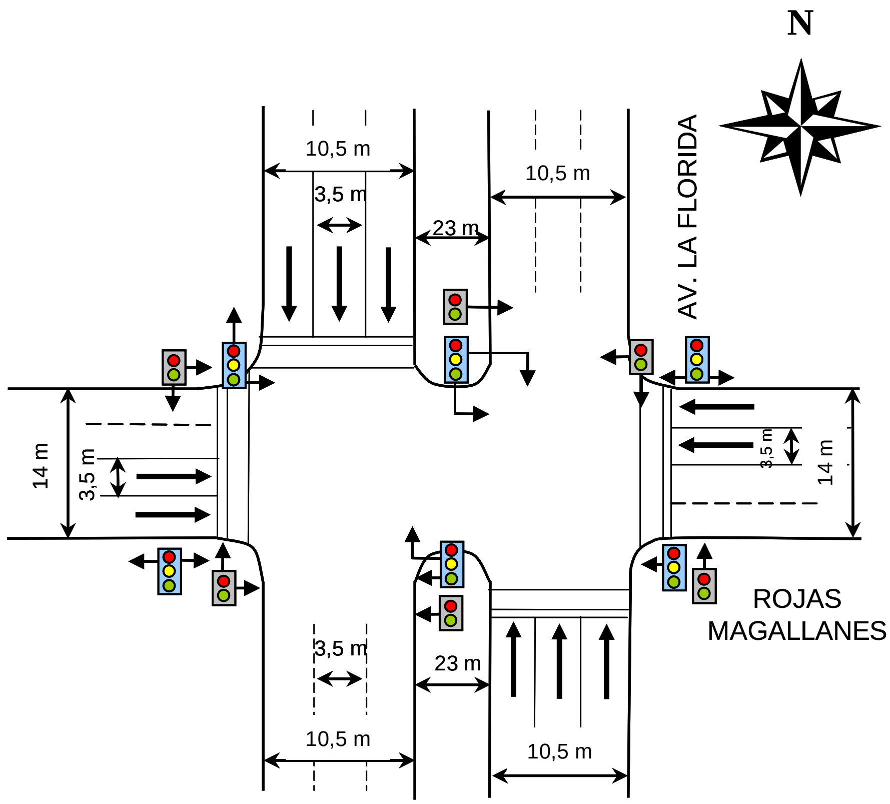
Figure 5.6.1.7
Checkpoint N°1



Intersection Nº 2: La Florida/Rojas Magallanes Av.

iii. Type: Level crossroads of four branches regulated by traffic light.
iv. Observed conflict: Long vehicle queues from Eastern Rojas Magallanes, especially at morning rush hour.

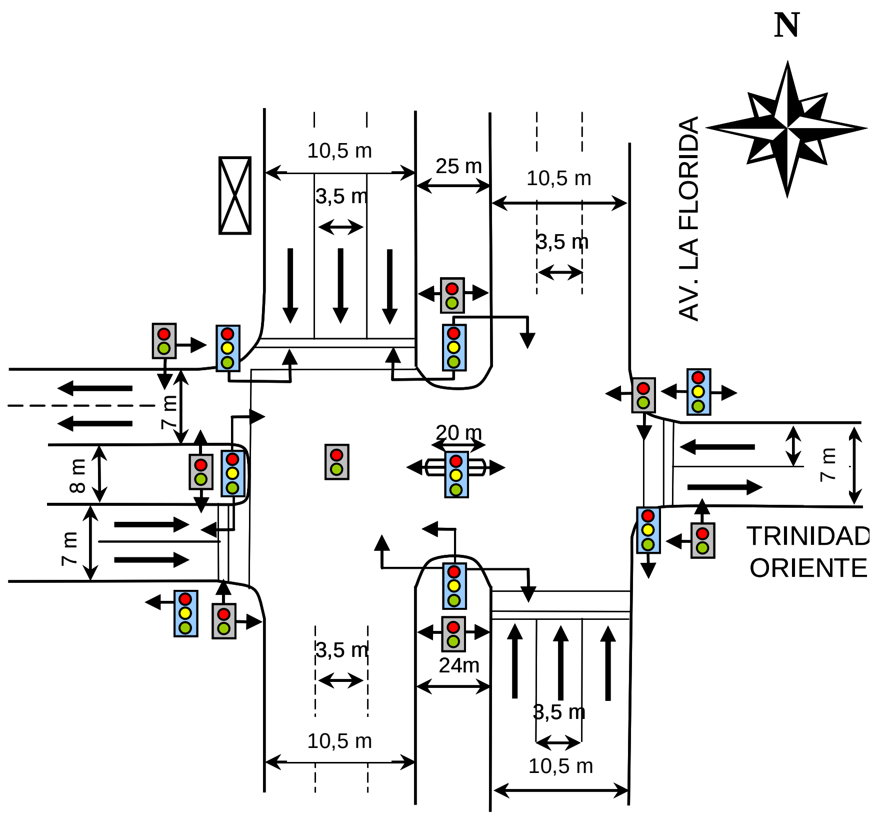
Figure 5.6.10.8
Checkpoint N° 2



Intersection Nº 3: La Florida/Eastern Trinidad Av.

v. Type: Level crossroads of four branches regulated by traffic light.
vi. Observed conflict: Long vehicle queues accumulated trying to turn left from Northern La Florida to Eastern Trinidad.

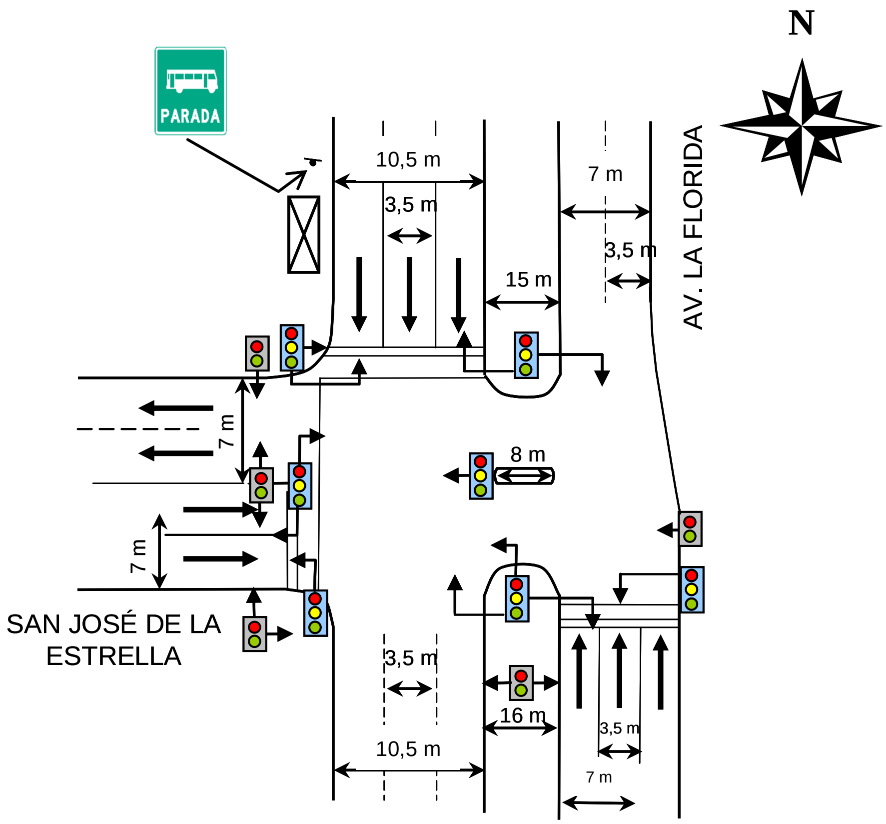
Figure 5.6.1.9
Checkpoint N° 3



Intersection Nº 4: La Florida/San José de la Estrella Av.

vii. Type: Level intersection of three branches, regulated by traffic light.
viii. Observed conflict: Formation of long vehicle queues trying to turn left from San José de la Estrella to Northern La Florida, especially at morning rush hour.

Figure 5.6.1.10
Checkpoint N° 4

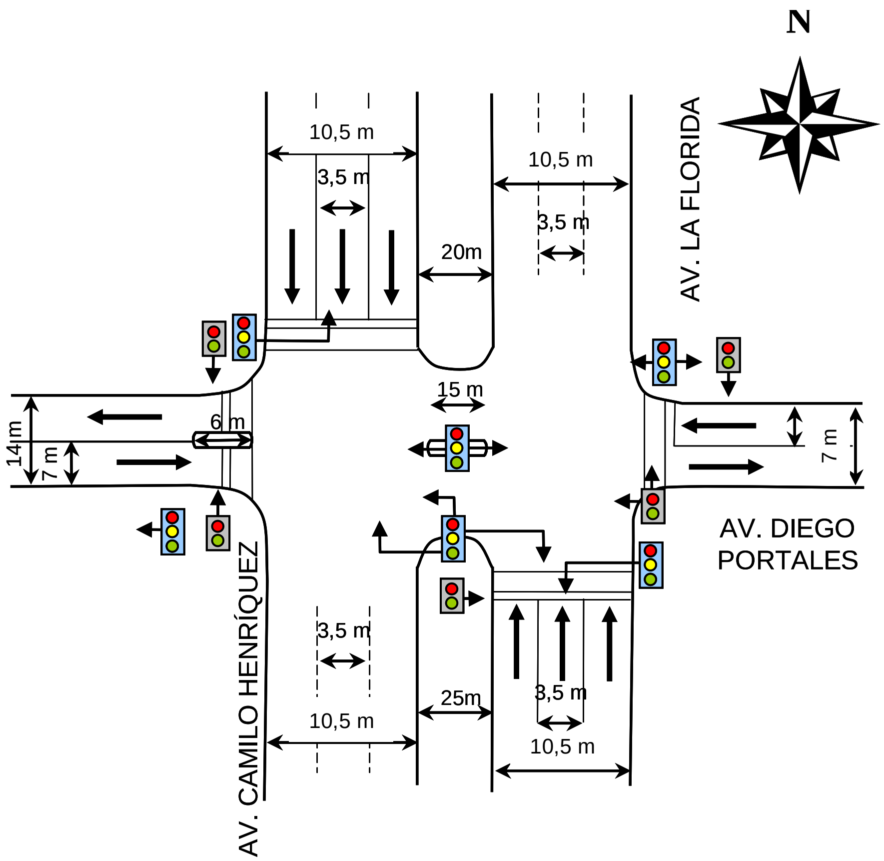


Intersection Nº 5: Camilo Henríquez Av./Diego Portales Av.

ix. Type: Level crossroads of four branches regulated by traffic light.

x. Observed conflict: The Eastern Diego Portales branch has a 7 m wide bidirectional roadway. Large number of vehicles coming from the newly constructed condominiums and the reduced width of carriageway generates queues and delays to users, especially in the morning rush hour.

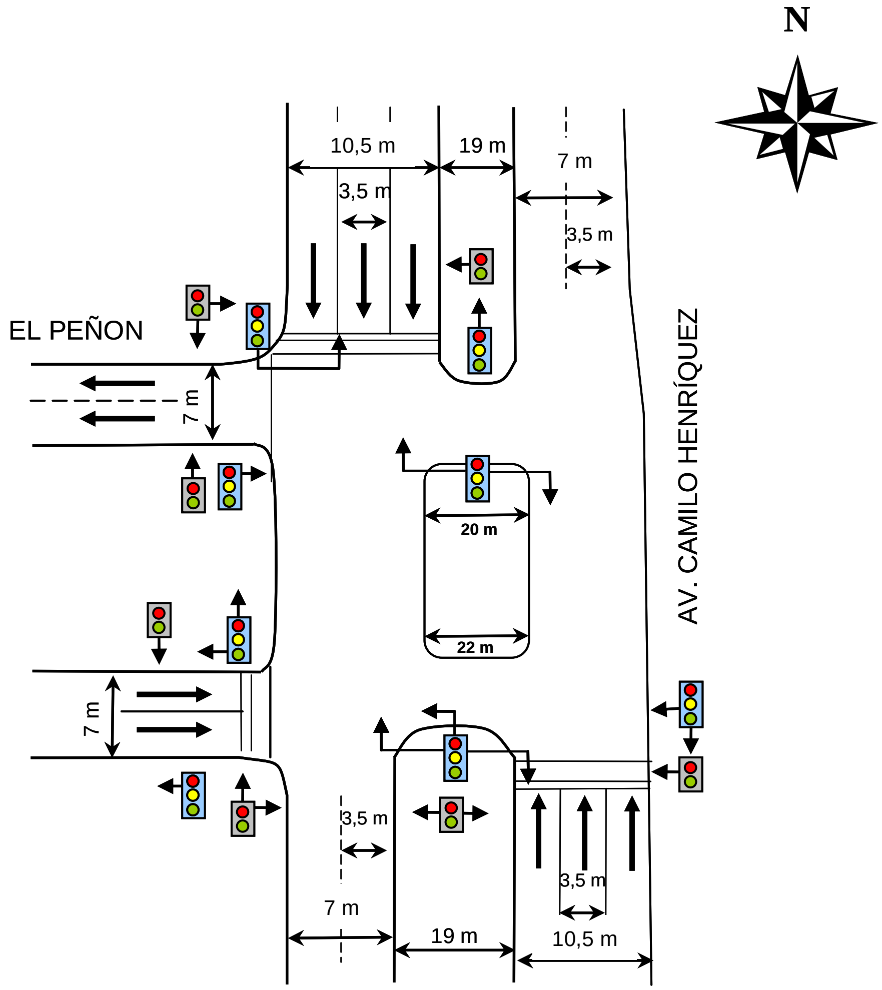
Figure 5.6.1.11
Checkpoint N° 5



Intersection Nº 6: Camilo Henríquez / El Peñón Av.

xi. Type: Level intersection of three branches, regulated by traffic light.
xii. Observed conflict: No appreciated, except for the high traffic volumes developed normally at rush hours. In general, the intersection runs smoothly.

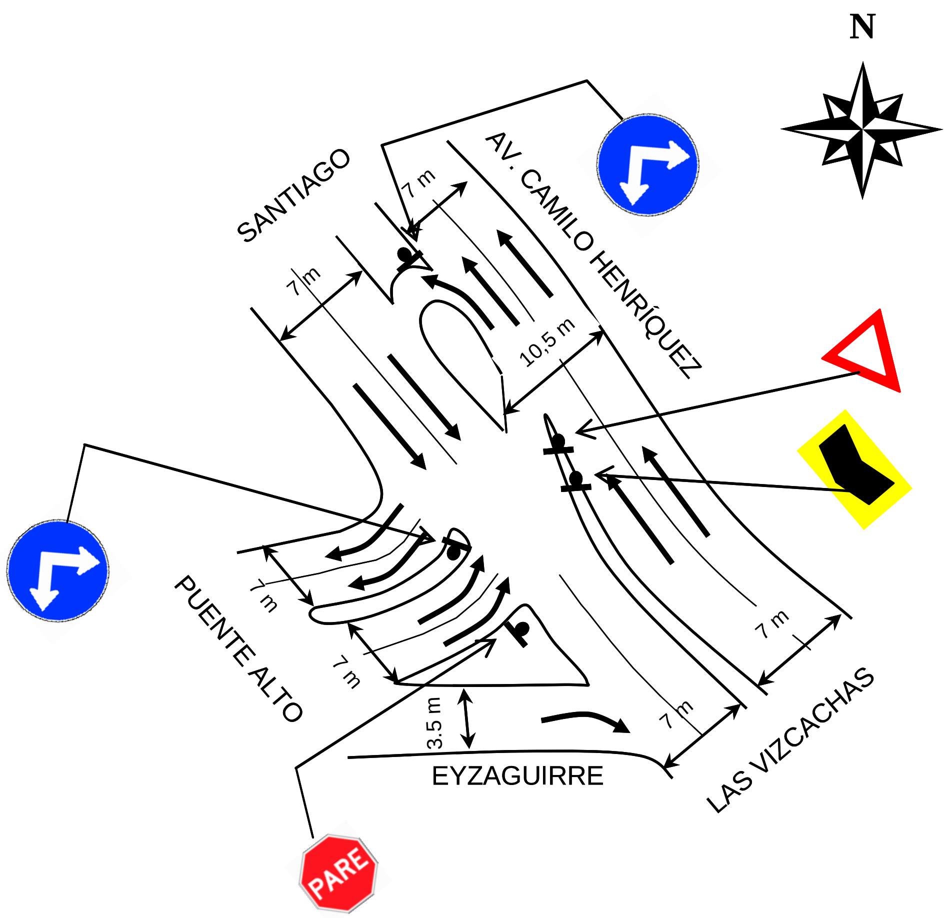
Figure 5.6.1.12
Checkpoint N° 6



Intersection Nº 7: Camilo Henríquez / Eyzaguirre Av.

xiii. Type: Level intersection with three branches, regulated by regulatory stop and yield signals.
xiv. Observed conflict: In this intersection traffic volumes are considerably lower than in Avenida Florida all day long, except in the morning rush hour because significant increases in traffic flows converge in the intersection from Puente Alto and San Jose de Maipo. Nevertheless, the road operation from the intersection during the rest of the day is generally smooth.

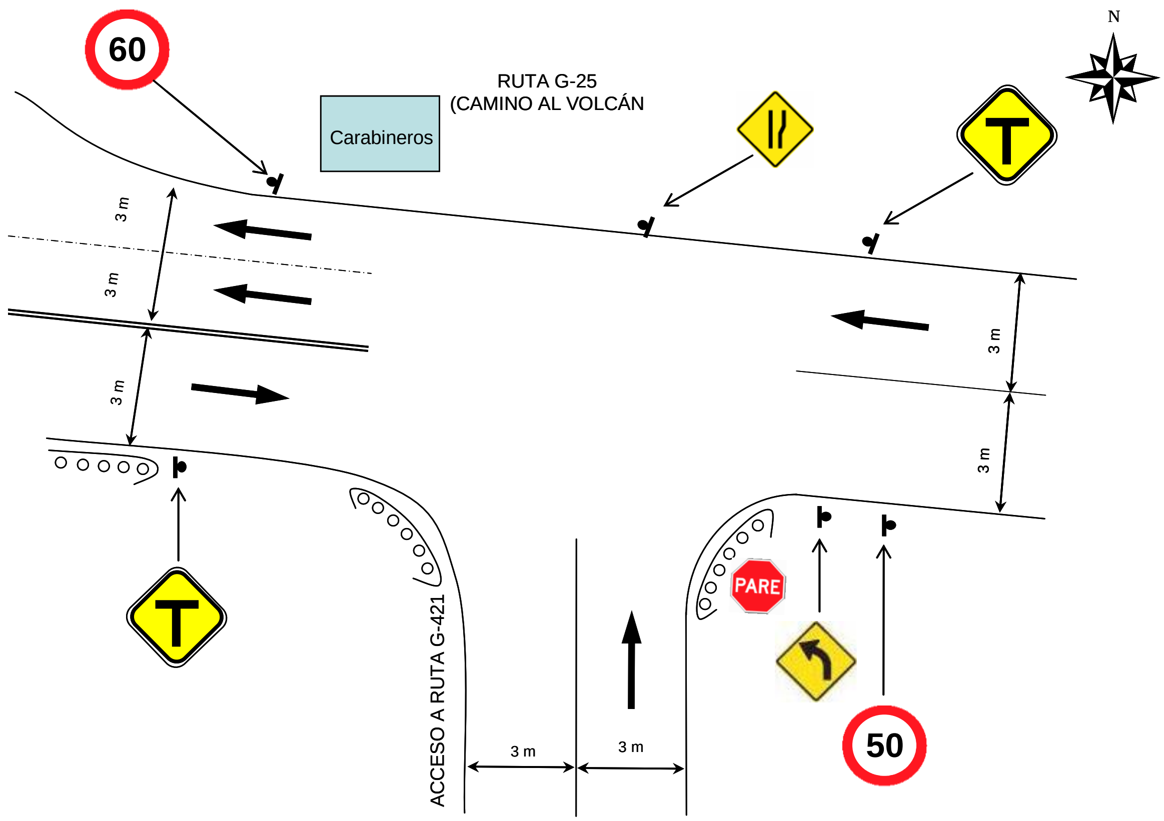
Figure 5.6.1.13
Checkpoint N° 7



Intersection Nº 8: G-25 Road (El Volcan Road)/G-421 Road access

xv. Type: Level intersection of three branches, regulated by stop regulatory signal.
xvi. Observed conflict: No road conflicts are appreciated. Presence of Carabineros (Police) influences on the intersection operation. Vehicles transit at low speed.

Figure 5.6.1.14
Checkpoint N° 8

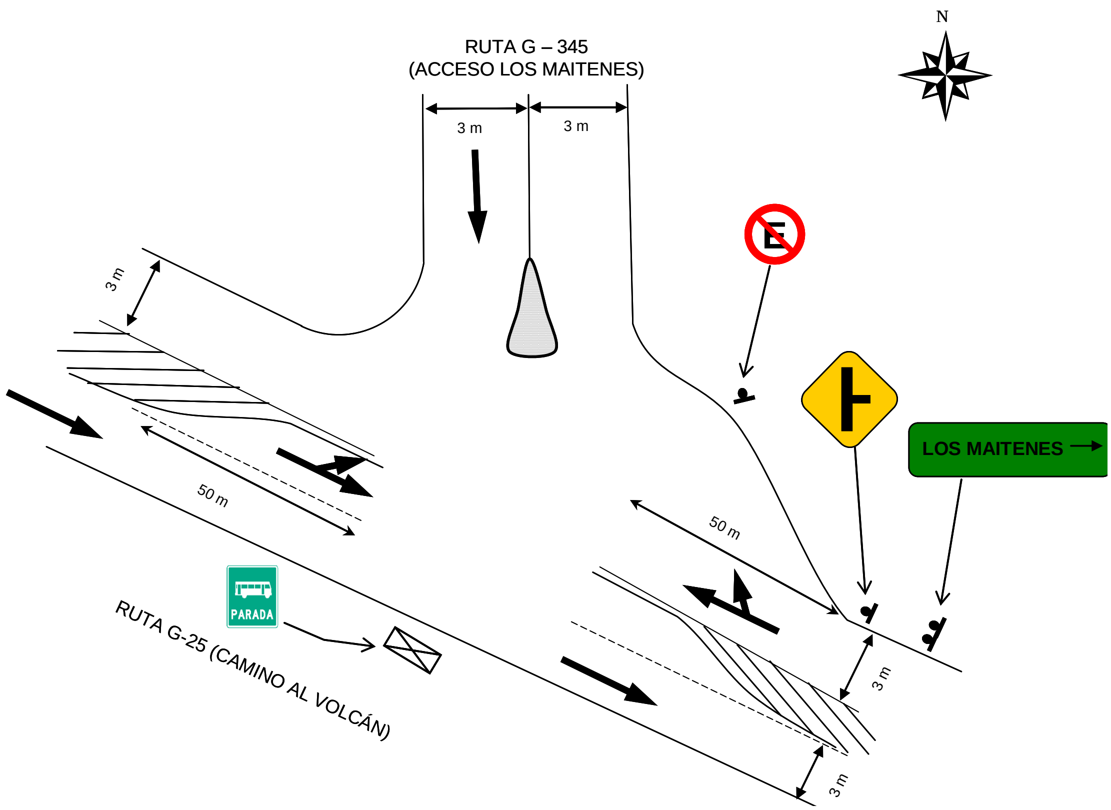


Intersection Nº 9: G-25 Road (El Volcan Road)/G-345 Road

xvii. Type: Level intersection of three branches, regulated by stop regulatory signal, located on a rural zone.

xviii. No road conflicts are appreciated.

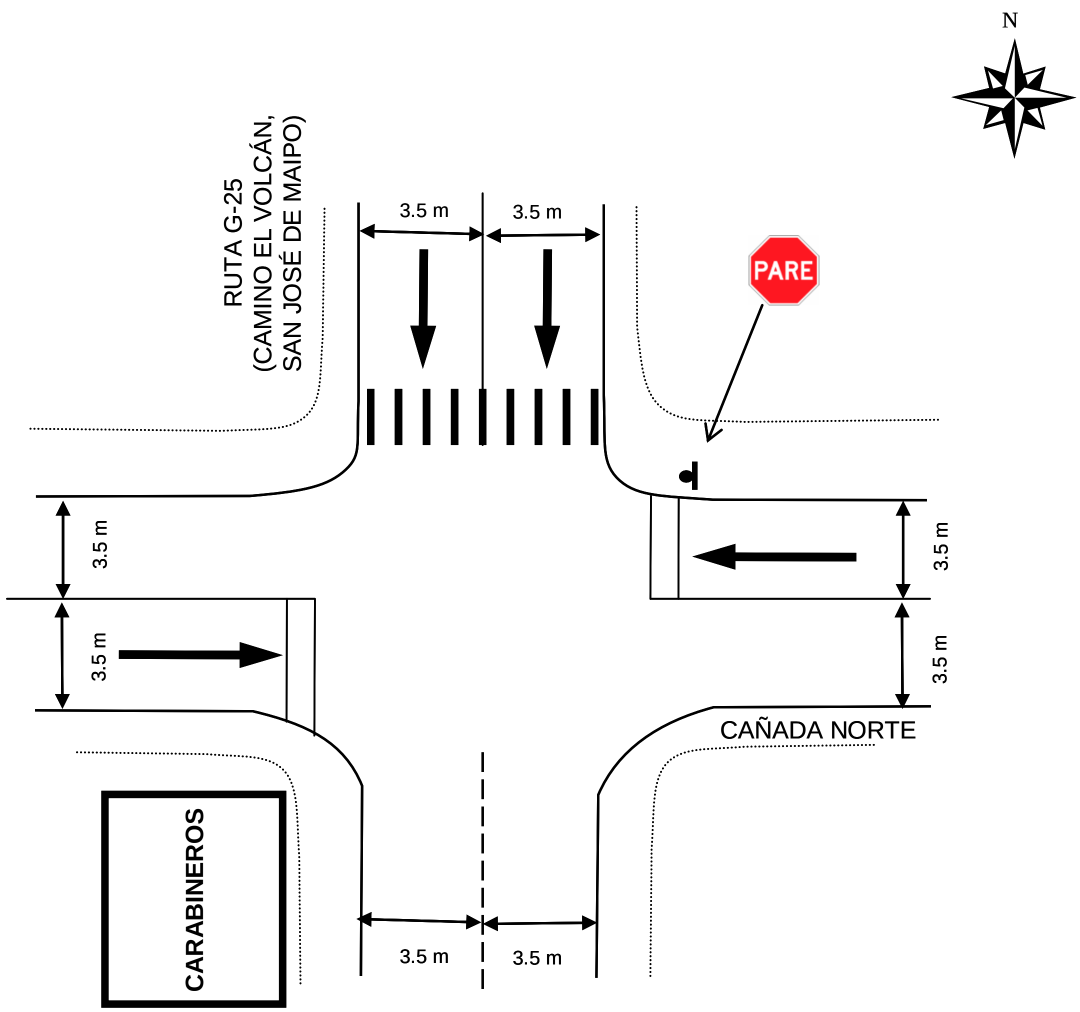
Figure 5.6.1.15
Checkpoint N° 9



Intersection Nº 10: G-25 Road (El Volcan Road)/Northern Cañada

xix. Type: Level crossing with four branches, regulated by regulatory stop sign, located in the urban area of San José de Maipo.
xx. No road conflicts are appreciated.

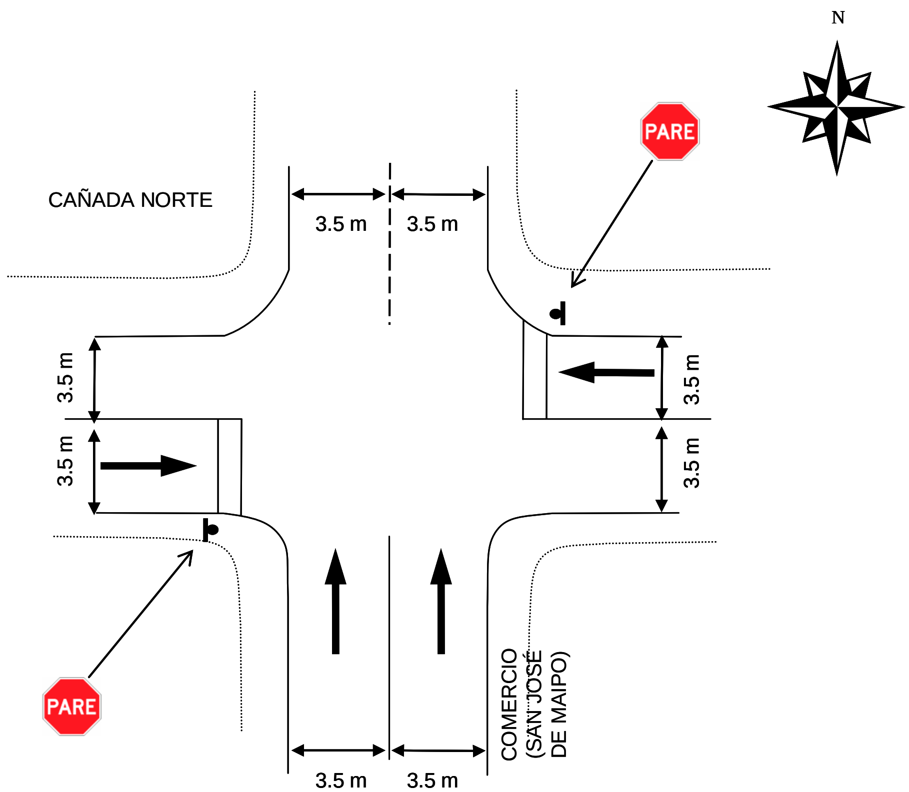
Figure 5.6.1.16
Checkpoint N° 10



Intersection Nº 11: Comercio/Northern Cañada

xxi. Type: Level crossing with four branches, regulated by regulatory stop sign, located in the urban area of San José de Maipo.
xxii. No road conflicts are appreciated.

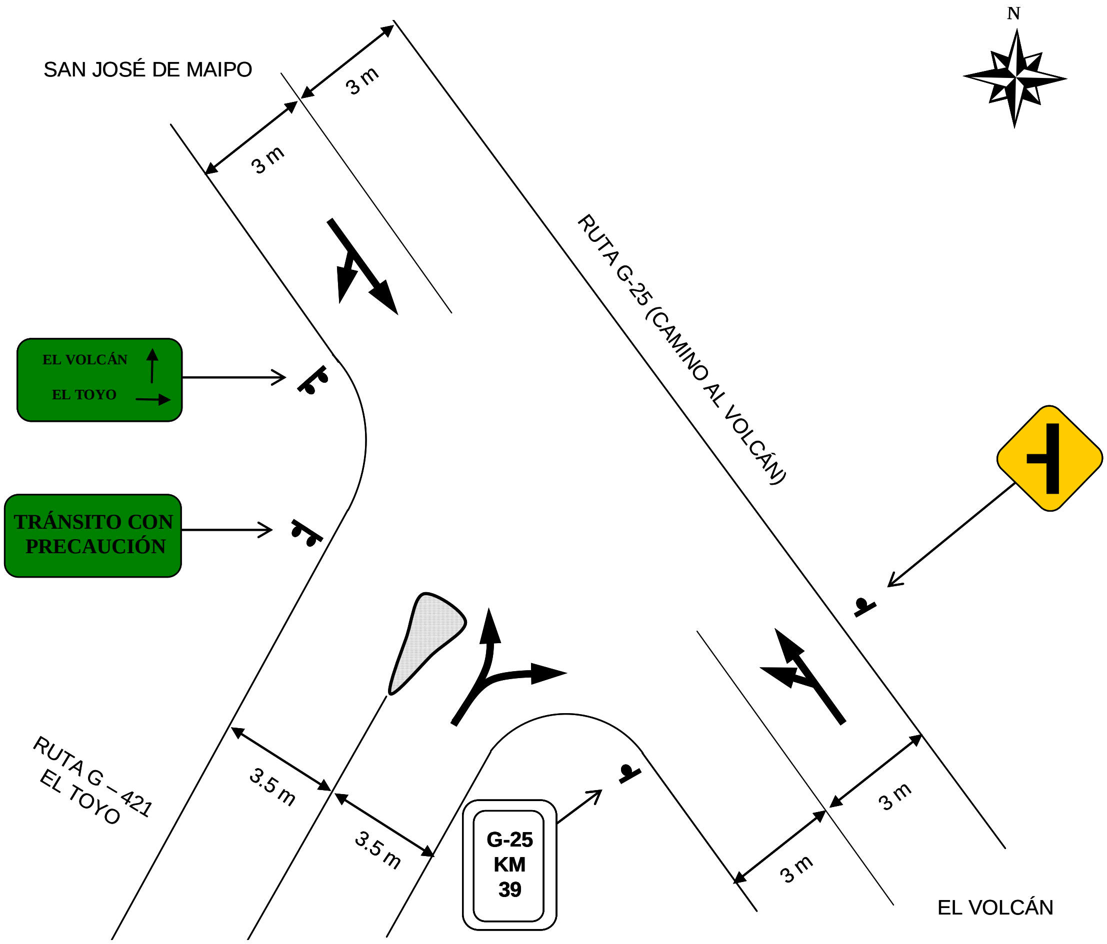
Figure 5.6.1.17
Checkpoint N° 11



Intersection Nº 12: G-25 Road (El Volcan Road)/El Toyo access

xxiii. Type: Level intersection of three branches, non-regulated.
xxiv. No road conflicts are appreciated.

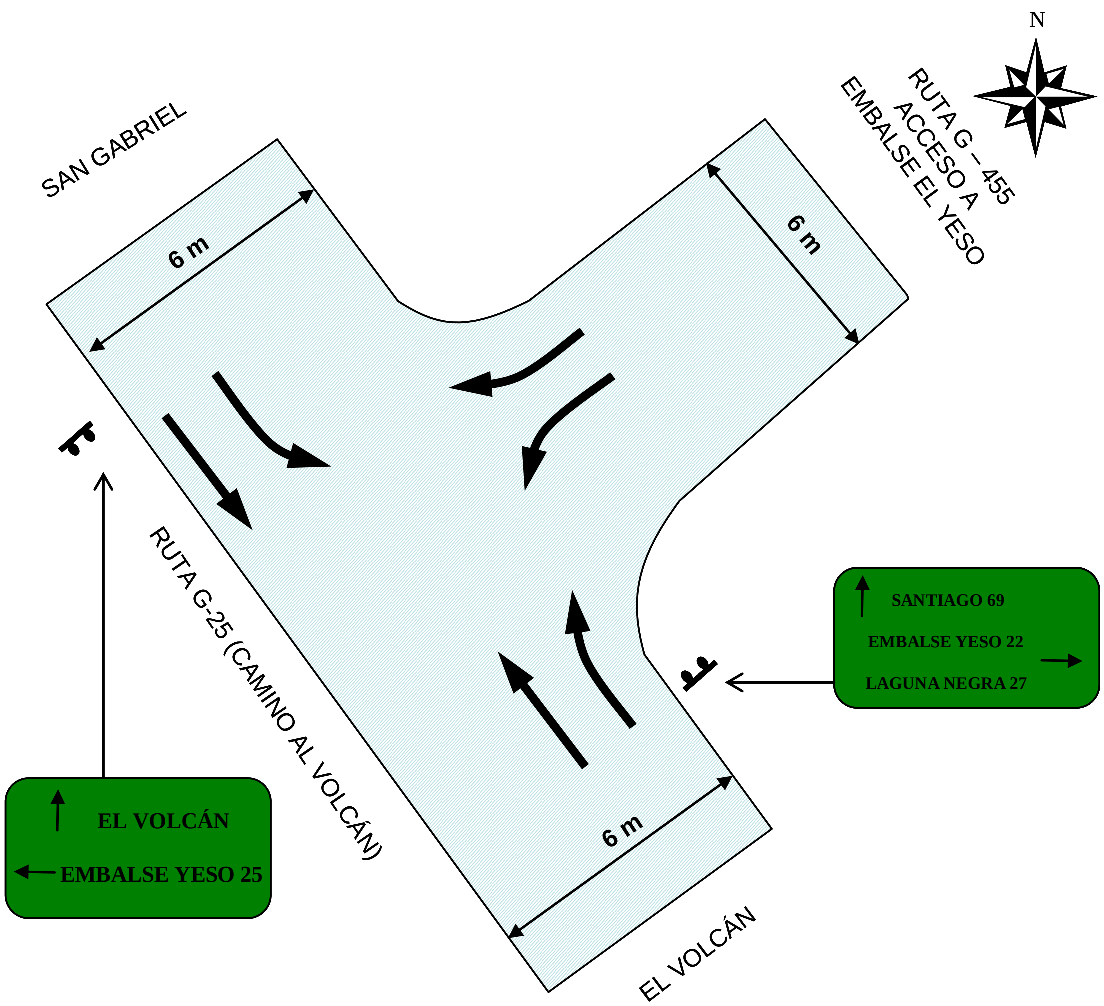
Figure 5.6.1.18
Checkpoint N° 12



Intersection Nº 13: G-25 Road (El Volcan Road)/G-455 Road

xxv. Type: Level intersection of three branches, non-regulated and unpaved.
xxvi. No road conflicts are appreciated.

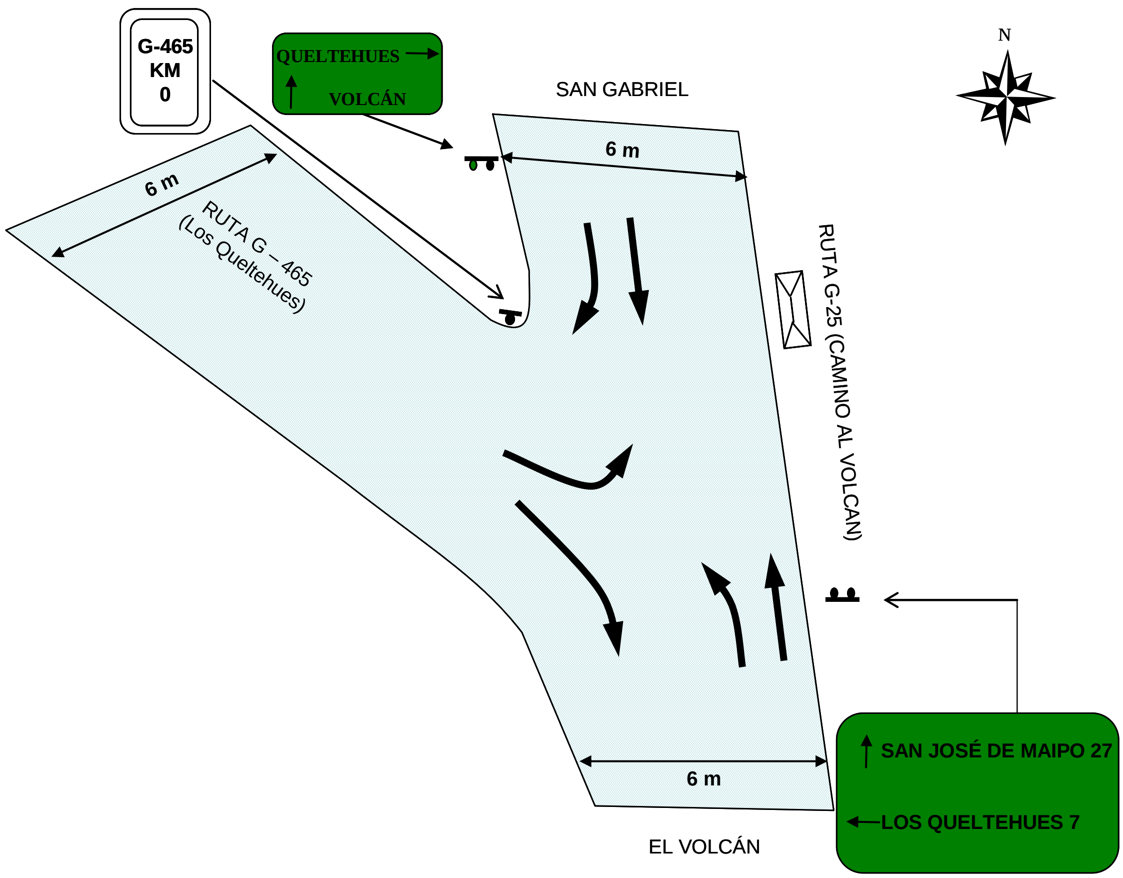
Figure 5.6.1.19
Checkpoint N° 13



Intersection Nº 14: G-25 Road (El Volcan Road)/G-465 Road

xxvii. Type: Level intersection of three branches, non-regulated and unpaved.
xxviii. Conflicts observed: Restrictive turning angle.

Figure 5.6.1.20
Checkpoint N° 14



v. Current road demand

In order to identify the normal traffic volume of the road network that involves the influence direct area, i.e., when fully developed work activities, and student production sector, the Consultant made measurements of traffic flow, on Thursday November 23, 2006 and on November 15, 2007, at various intersections located along the proposed route.
The points identified are described below:

Intersections measurement points

- Point Nº 1: La Florida Av./Departamental Av. (La Florida) intersection
- Point Nº 2: La Florida Av./Rojas Magallanes (La Florida) intersection
- Point Nº 3: La Florida Av./Eastern Trinidad Av. (La Florida) intersection
- Point Nº 4: La Florida Av./San José de la Estrella (La Florida) intersection
- Point Nº 5: Camilo Henríquez Av./Diego Portales Av. (Puente Alto) intersection
- Point Nº 6: Camilo Henríquez Av./El Peñón Av. (Puente Alto) intersection
- Point Nº 7: Camilo Henríquez / Eyzaguirre (Las Vizcachas) intersection
- Point Nº 8: El Volcan Road (G-25 Road)/G-421 Road to Las Vertientes (San José de Maipo) intersection
- Point Nº 9: El Volcan Road (G-25 Road)/G-345 Road to Los Maitenes access (San José de Maipo) intersection
- Point Nº 10: El Volcán Road (G-25 Road)/Northern Cañada (San José de Maipo) intersection
- Point Nº 11: Comercio/Northern Cañada (San José de Maipo) intersection
- Point Nº 12: El Volcán Road (G-25 Road)/G-421 Road to El Toyo (San José de Maipo) intersection
- Point Nº 13: El Volcan Road (G-25 Road)/G-455 Road to El Yeso Reservoir access (San José de Maipo) intersection
- Point Nº 14: El Volcan Road (G-25 Road)/G-465 Road to Los Queltehues access (San José de Maipo) intersection

Direct measurement points

- Point Nº 15: Direct on G-455 Road
- Point Nº 16: Direct on G-25 Road across El Volcan
- Point Nº 17: Direct on G-25 Road across Baños Morales.

The registers were performed for 12 continuous hours, from 7:00 to 19:00, each hour divided into periods of 15 minutes in order to meet changes in flows within the time limit and thus allow more accurately the peak periods along the day.

The vehicle type classification was the following:

LV	: Light vehicles (cars, station wagons and pick-up trucks)
C2E	: 2 axis trucks
C+2E	: Trucks with more than 2 axis
BTB	: Buses and small buses

Figure 5.6.1.21 presents the location of all the measuring points, while Figure 5.6.1.22, shows the vehicle movements in each intersection or control point, and Annex 14 "Traffic measurements" incorporates the templates corresponding to conducted measurements.

Figure 5.6.1.21
Location of road demand measurement points

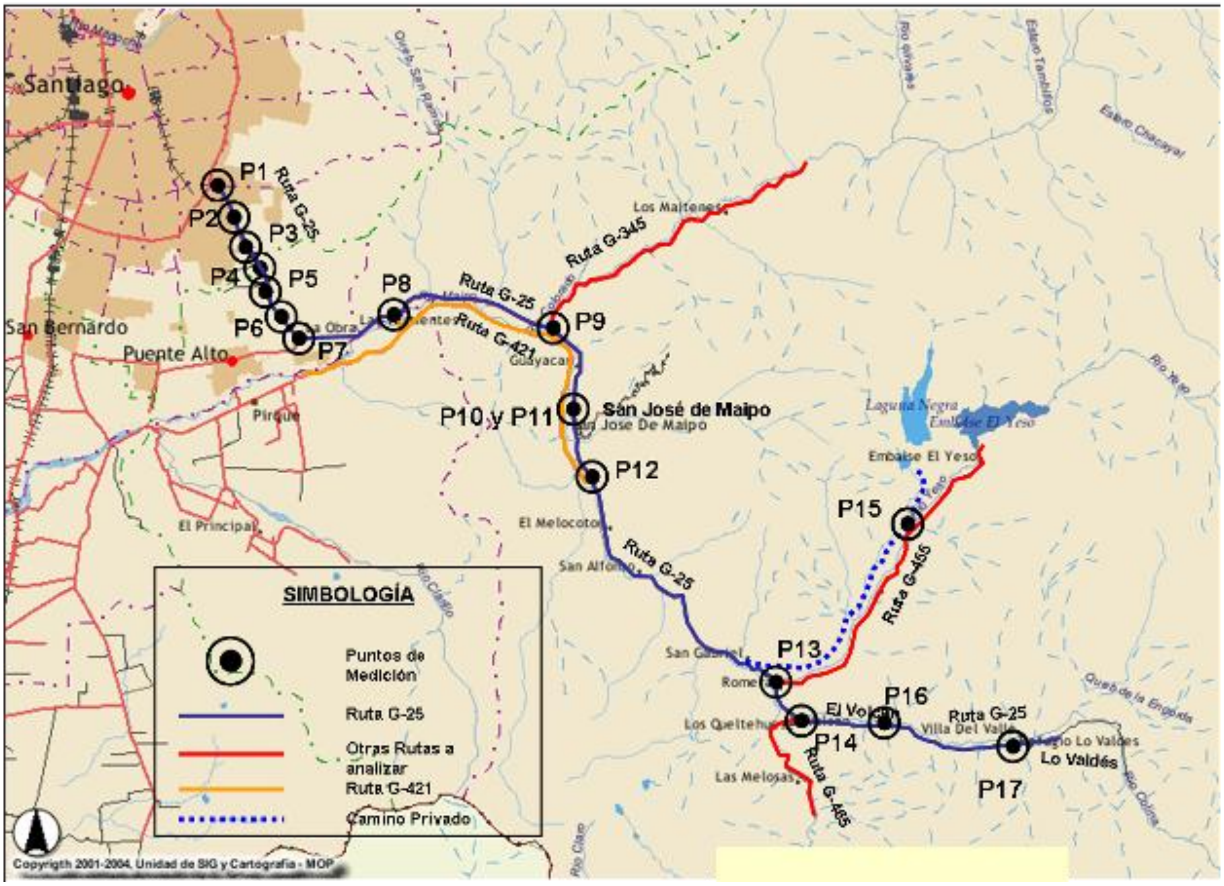
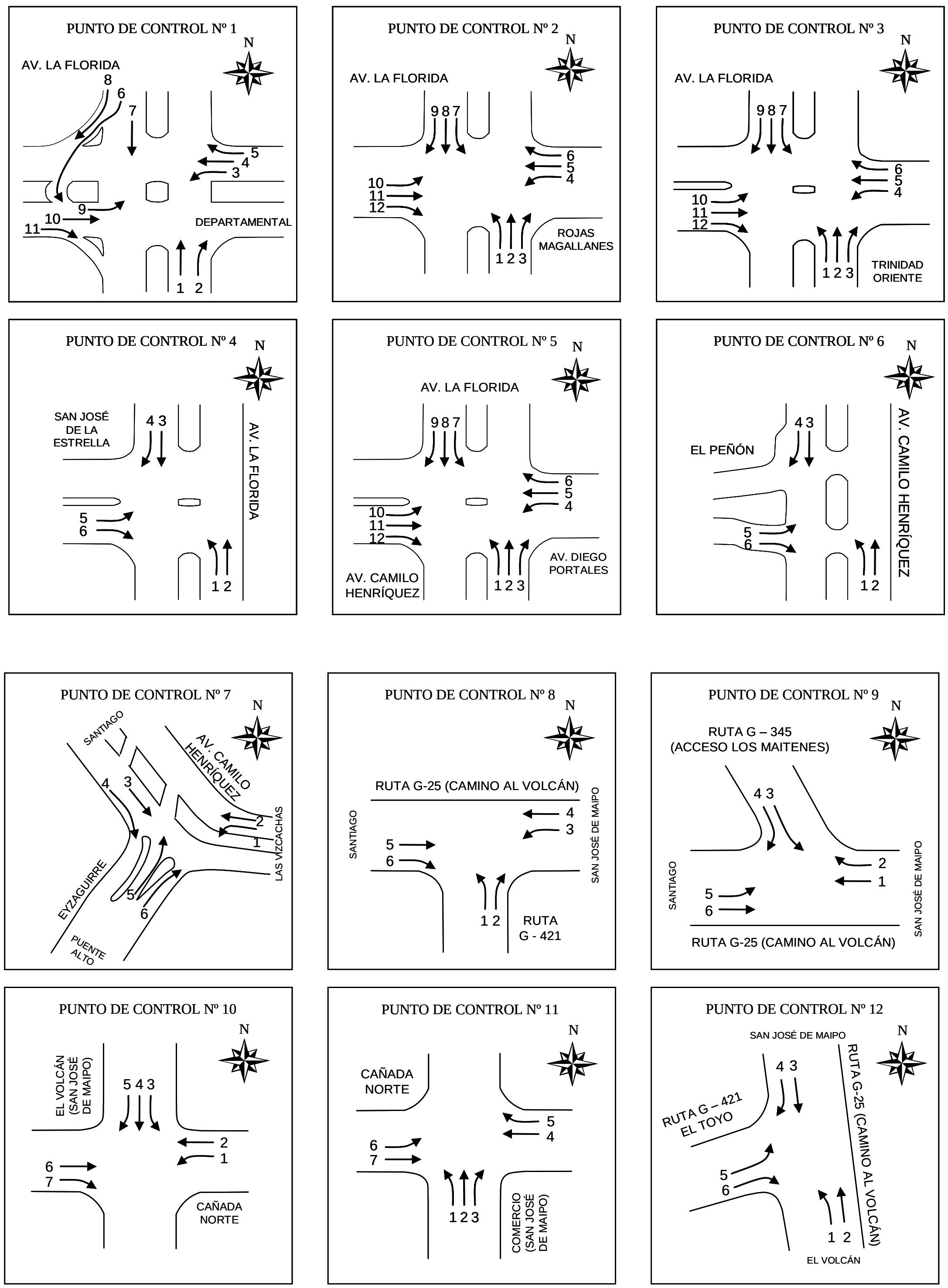
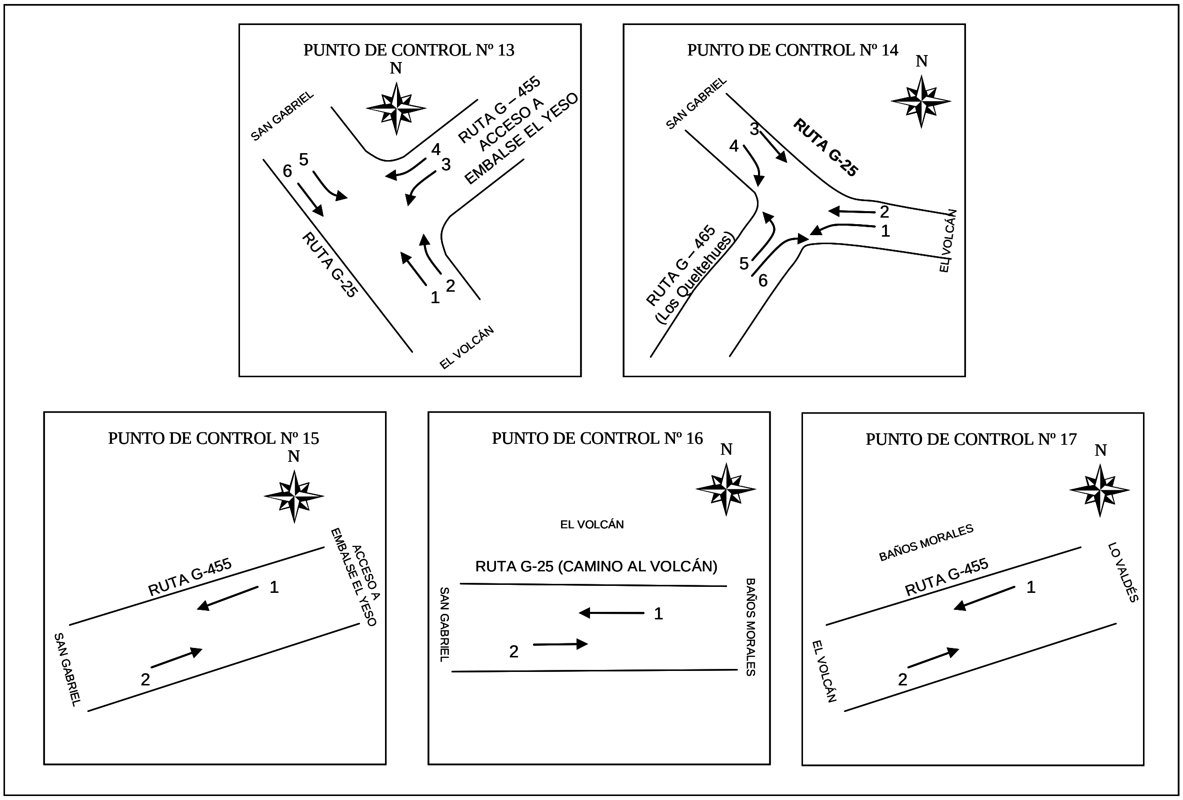


Figure 5.6.1.22
Vehicle movements measured in each measurement point in intersection or direct travel





vi. Graphic flow versus time in intersection measurement points

The graphic flows versus time presented below allow to appreciate variations experimented by the traffic on each intersection in the measurement points (point 1 to 14), during the complete measurement period with flows expressed in equivalent vehicles.

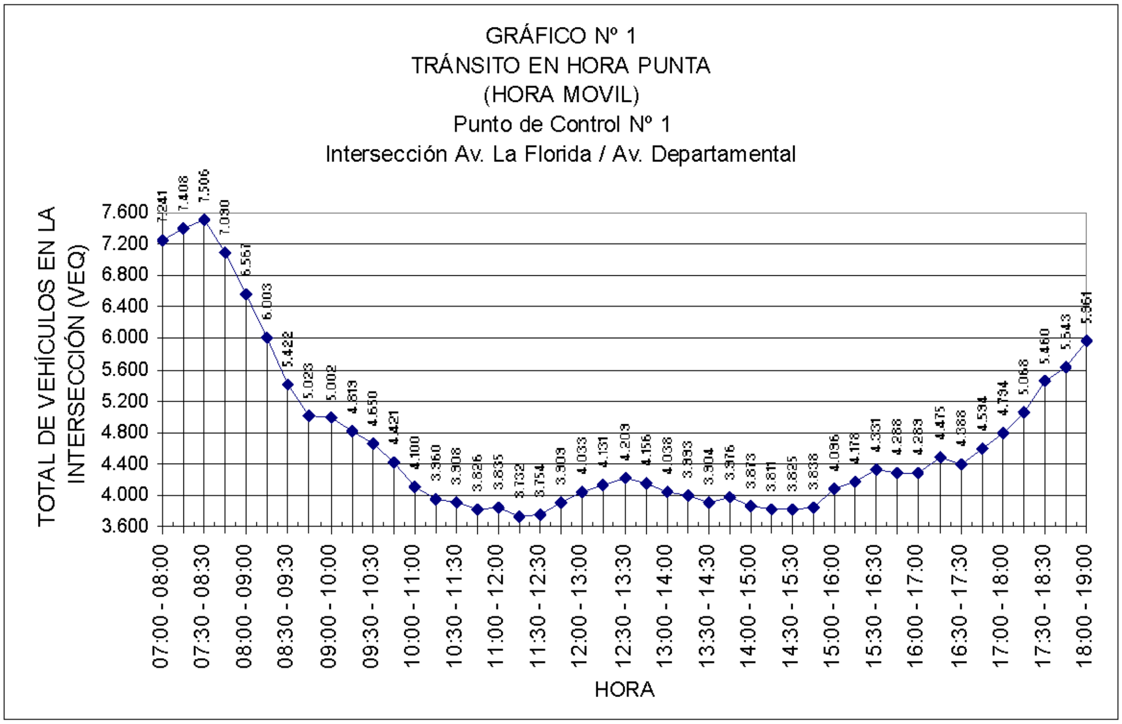


GRÁFICO Nº 1
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 1
Intersección Av. La Florida / Av. Departamental
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
HORA

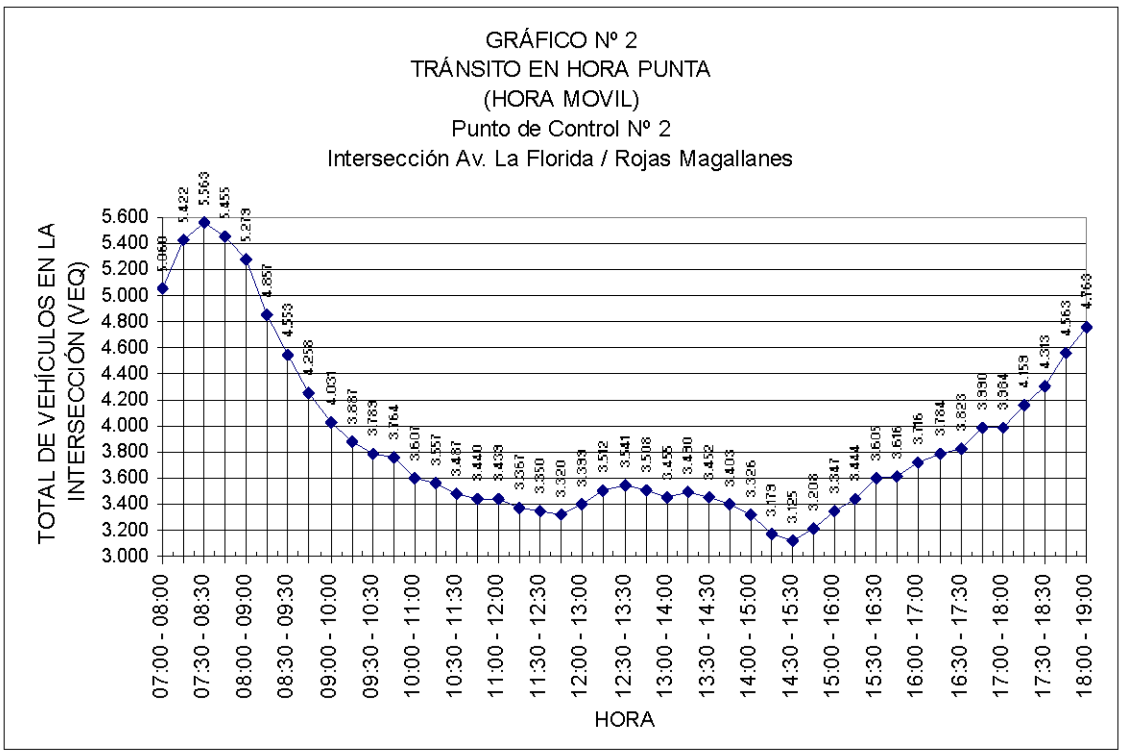


GRÁFICO Nº 2
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 2
Intersección Av. La Florida / Rojas Magallanes
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
HORA

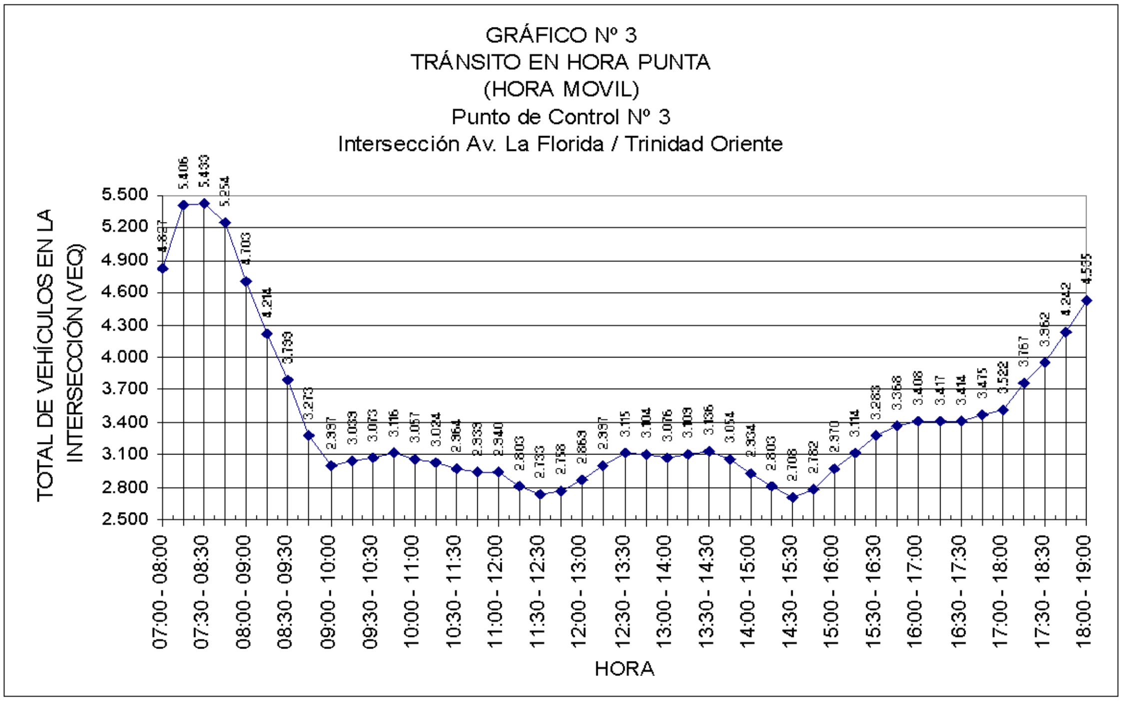


GRÁFICO Nº 3
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 3
Intersección Av. La Florida / Trinidad Oriente
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
5.500
5.200
4.900
4.600
4.300
4.000
3.700
3.400
3.100
2.800
2.500
4.827
5.406
5.433
5.254
4.703
4.214
3.789
3.273
2.997
3.039
3.073
3.116
3.057
3.024
2.964
2.939
2.940
2.803
2.733
2.758
2.863
2.997
3.115
3.104
3.076
3.103
3.136
3.054
2.934
2.803
2.708
2.782
2.970
3.114
3.283
3.368
3.408
3.417
3.414
3.475
3.522
3.767
3.962
4.242
4.535
07:00 - 08:00
07:30 - 08:30
08:00 - 09:00
08:30 - 09:30
09:00 - 10:00
09:30 - 10:30
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16:30 - 17:30
17:00 - 18:00
17:30 - 18:30
18:00 - 19:00
HORA

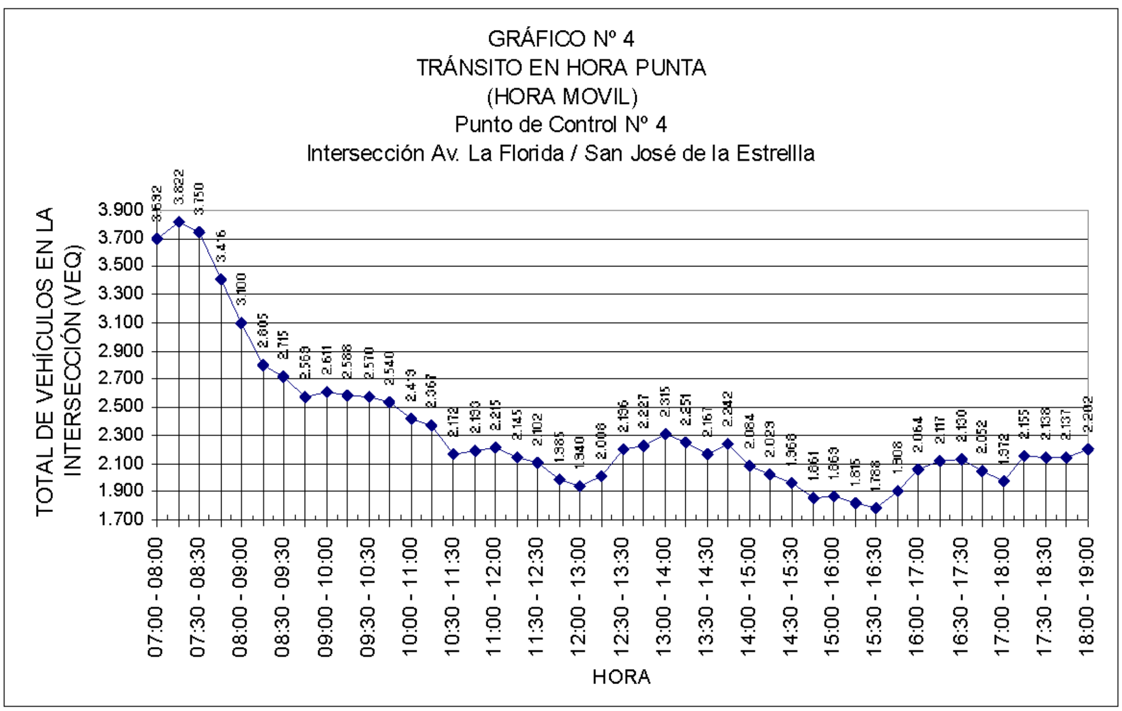
GRÁFICO Nº 4
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 4
Intersección Av. La Florida / San José de la Estrellla
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
3.900
3.700
3.500
3.300
3.100
2.900
2.700
2.500
2.300
2.100
1.900
1.700
3.692
3.822
3.750
3.416
3.100
2.805
2.715
2.569
2.611
2.588
2.570
2.540
2.419
2.367
2.172
2.193
2.215
2.145
2.102
1.985
1.940
2.008
2.196
2.227
2.315
2.251
2.167
2.242
2.084
2.023
1.968
1.861
1.869
1.815
1.788
1.908
2.064
2.117
2.130
2.052
1.972
2.155
2.138
2.137
2.202
07:00 - 08:00
07:30 - 08:30
08:00 - 09:00
08:30 - 09:30
09:00 - 10:00
09:30 - 10:30
10:00 - 11:00
10:30 - 11:30
11:00 - 12:00
11:30 - 12:30
12:00 - 13:00
12:30 - 13:30
13:00 - 14:00
13:30 - 14:30
14:00 - 15:00
14:30 - 15:30
15:00 - 16:00
15:30 - 16:30
16:00 - 17:00
16:30 - 17:30
17:00 - 18:00
17:30 - 18:30
18:00 - 19:00
HORA

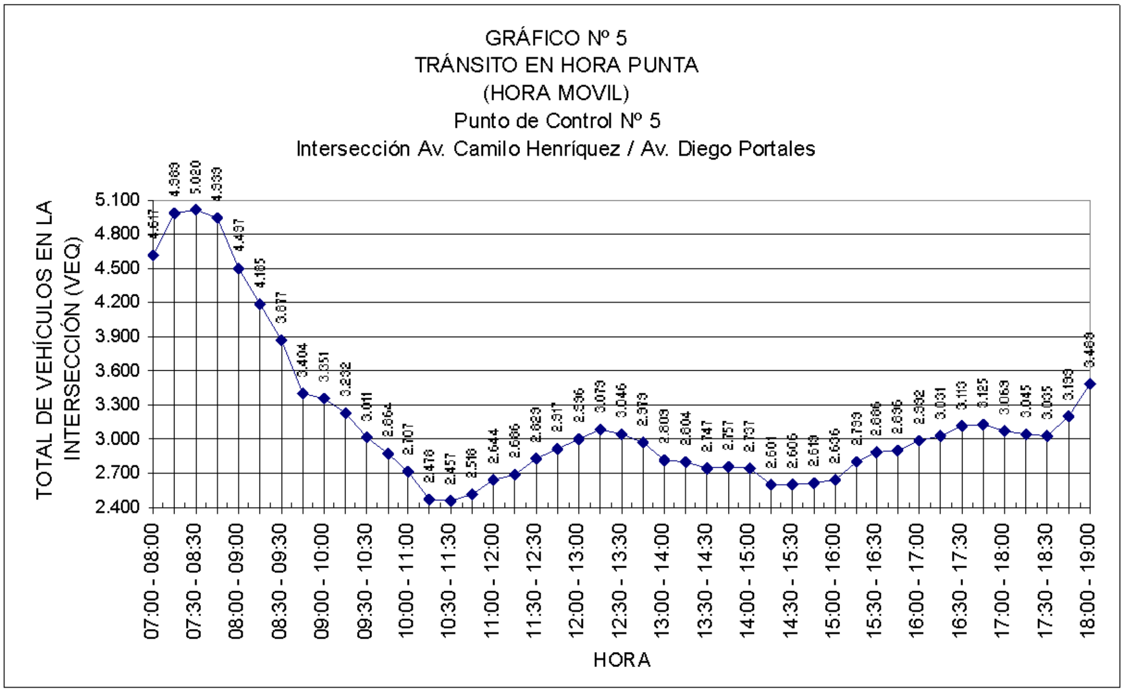
GRÁFICO Nº 5
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 5
Intersección Av. Camilo Henríquez / Av. Diego Portales
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
5.100
4.800
4.500
4.200
3.900
3.600
3.300
3.000
2.700
2.400
4.617
4.989
5.020
4.939
4.497
4.185
3.877
3.404
3.351
3.232
3.011
2.864
2.707
2.478
2.457
2.518
2.644
2.686
2.829
2.917
2.996
3.079
3.046
2.979
2.809
2.804
2.747
2.757
2.737
2.601
2.606
2.619
2.636
2.799
2.886
2.896
2.992
3.031
3.113
3.125
3.069
3.045
3.035
3.193
3.489
07:00 - 08:00
07:30 - 08:30
08:00 - 09:00
08:30 - 09:30
09:00 - 10:00
09:30 - 10:30
10:00 - 11:00
10:30 - 11:30
11:00 - 12:00
11:30 - 12:30
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15:00 - 16:00
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16:00 - 17:00
16:30 - 17:30
17:00 - 18:00
17:30 - 18:30
18:00 - 19:00
HORA

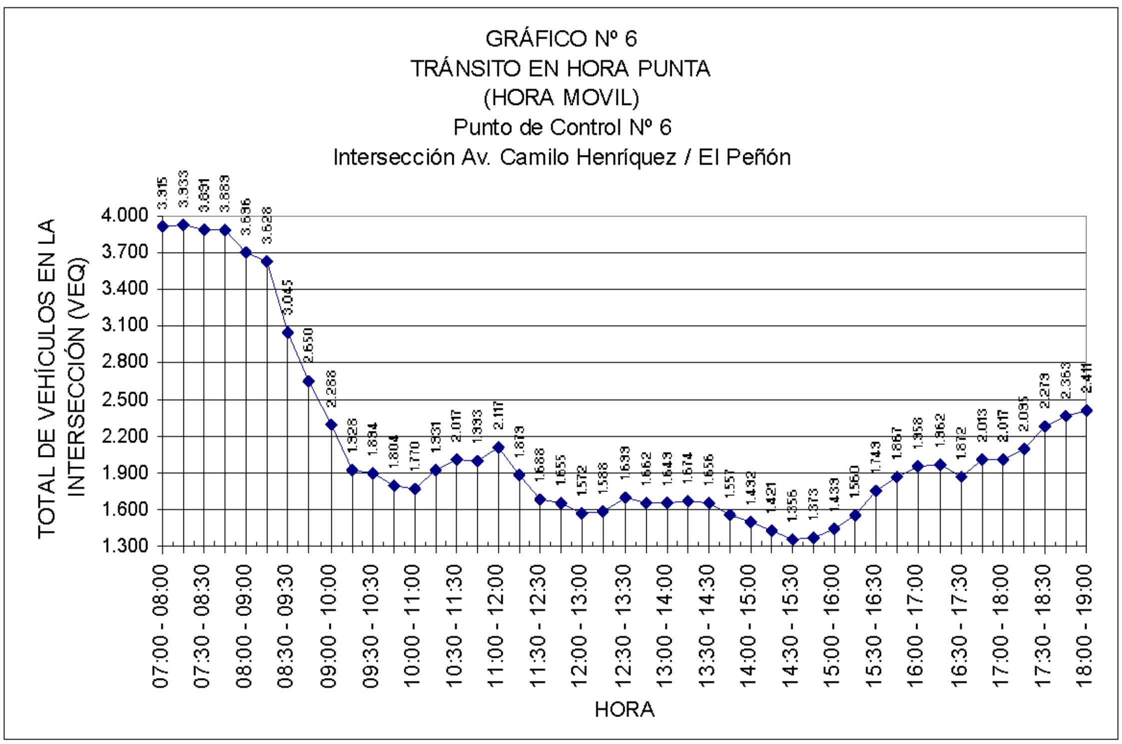
GRÁFICO Nº 6
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 6
Intersección Av. Camilo Henríquez / El Peñón
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
4.000
3.700
3.400
3.100
2.800
2.500
2.200
1.900
1.600
1.300
3.915
3.933
3.891
3.883
3.696
3.628
3.045
2.650
2.288
1.928
1.894
1.804
1.770
1.931
2.017
1.993
2.117
1.879
1.688
1.655
1.572
1.588
1.699
1.662
1.649
1.674
1.656
1.557
1.492
1.421
1.356
1.373
1.439
1.560
1.743
1.867
1.958
1.962
1.872
2.013
2.017
2.095
2.273
2.363
2.411
07:00 - 08:00
07:30 - 08:30
08:00 - 09:00
08:30 - 09:30
09:00 - 10:00
09:30 - 10:30
10:00 - 11:00
10:30 - 11:30
11:00 - 12:00
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15:00 - 16:00
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16:00 - 17:00
16:30 - 17:30
17:00 - 18:00
17:30 - 18:30
18:00 - 19:00
HORA

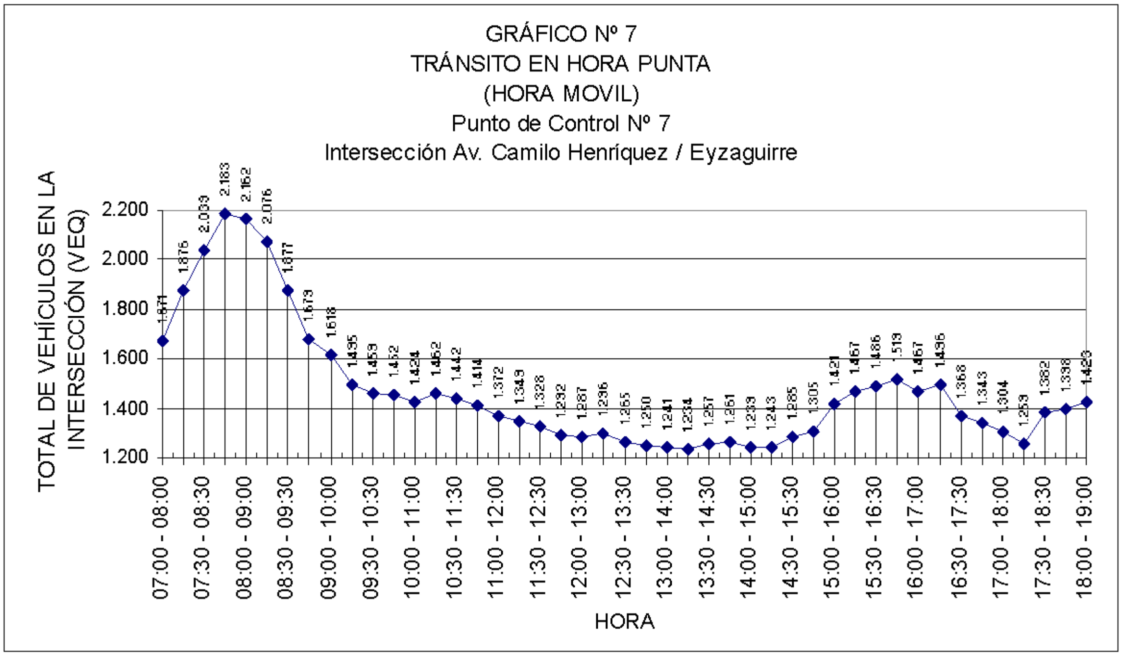
GRÁFICO Nº 7
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 7
Intersección Av. Camilo Henríquez / Eyzaguirre
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
2.200
2.000
1.800
1.600
1.400
1.200
1.671
1.876
2.039
2.183
2.162
2.076
1.877
1.679
1.618
1.495
1.459
1.452
1.424
1.462
1.442
1.414
1.372
1.349
1.328
1.292
1.287
1.296
1.265
1.250
1.241
1.234
1.257
1.261
1.239
1.243
1.285
1.305
1.421
1.467
1.486
1.513
1.467
1.496
1.368
1.343
1.304
1.253
1.382
1.398
1.423
07:00 - 08:00
07:30 - 08:30
08:00 - 09:00
08:30 - 09:30
09:00 - 10:00
09:30 - 10:30
10:00 - 11:00
10:30 - 11:30
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15:00 - 16:00
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16:00 - 17:00
16:30 - 17:30
17:00 - 18:00
17:30 - 18:30
18:00 - 19:00
HORA

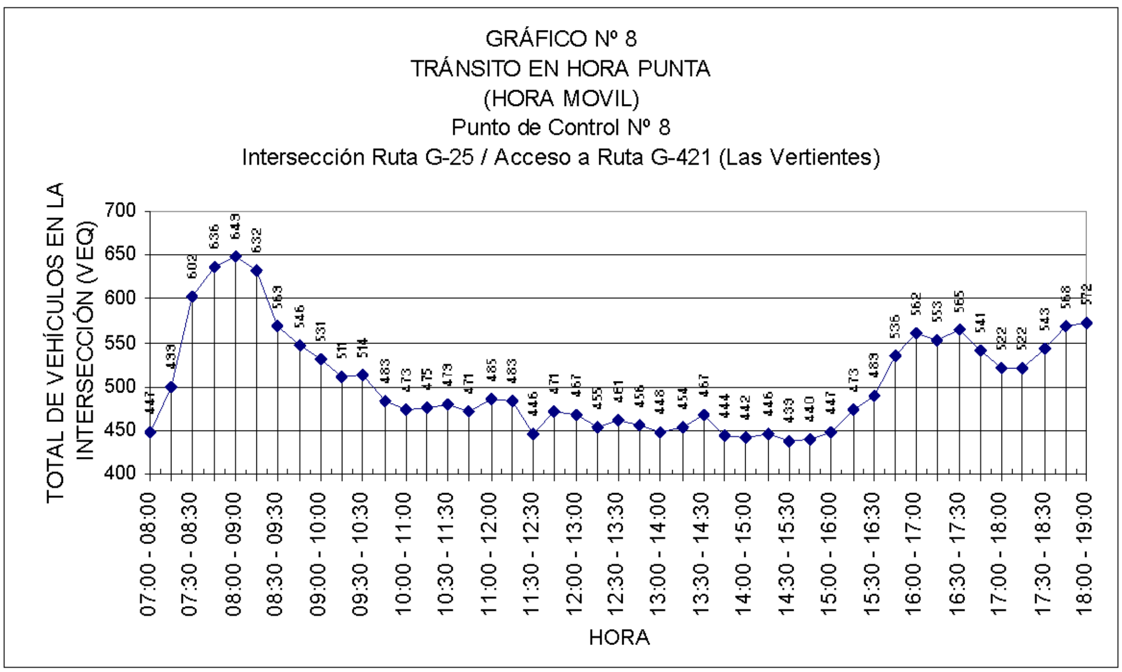
GRÁFICO Nº 8
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 8
Intersección Ruta G-25 / Acceso a Ruta G-421 (Las Vertientes)
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
700
650
600
550
500
450
400
447
499
602
636
649
632
569
546
531
511
514
483
473
475
479
471
485
483
446
471
467
455
461
456
448
454
467
444
442
446
439
440
447
473
489
536
562
553
565
541
522
522
543
568
572
07:00 - 08:00
07:30 - 08:30
08:00 - 09:00
08:30 - 09:30
09:00 - 10:00
09:30 - 10:30
10:00 - 11:00
10:30 - 11:30
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15:00 - 16:00
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16:00 - 17:00
16:30 - 17:30
17:00 - 18:00
17:30 - 18:30
18:00 - 19:00
HORA

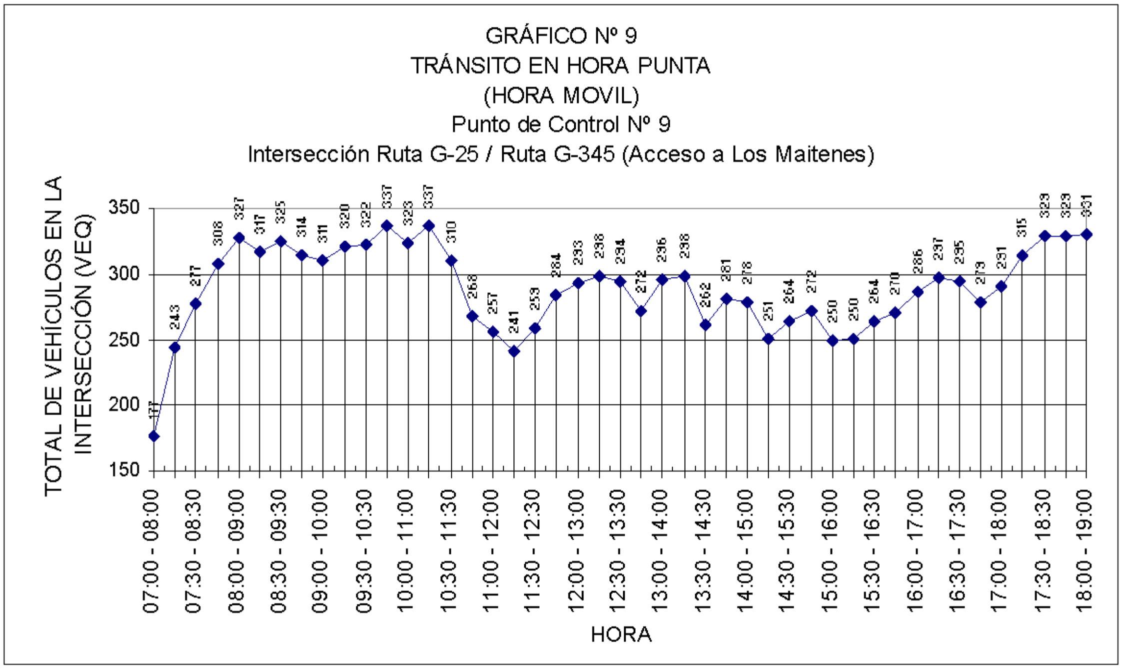
GRÁFICO Nº 9
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 9
Intersección Ruta G-25 / Ruta G-345 (Acceso a Los Maitenes)
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
350
300
250
200
150
07:00 - 08:00
07:30 - 08:30
08:00 - 09:00
08:30 - 09:30
09:00 - 10:00
09:30 - 10:30
10:00 - 11:00
10:30 - 11:30
11:00 - 12:00
11:30 - 12:30
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16:00 - 17:00
16:30 - 17:30
17:00 - 18:00
17:30 - 18:30
18:00 - 19:00
HORA

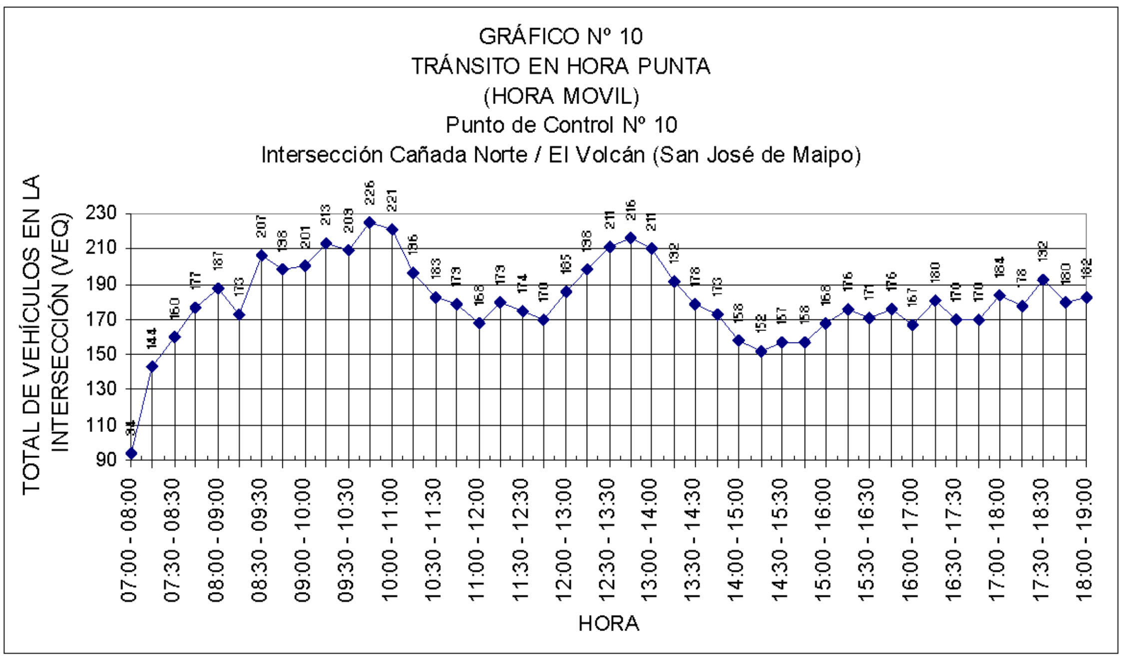
GRÁFICO Nº 10
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 10
Intersección Cañada Norte / El Volcán (San José de Maipo)
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
230
210
190
170
150
130
110
90
07:00 - 08:00
07:30 - 08:30
08:00 - 09:00
08:30 - 09:30
09:00 - 10:00
09:30 - 10:30
10:00 - 11:00
10:30 - 11:30
11:00 - 12:00
11:30 - 12:30
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15:00 - 16:00
15:30 - 16:30
16:00 - 17:00
16:30 - 17:30
17:00 - 18:00
17:30 - 18:30
18:00 - 19:00
HORA

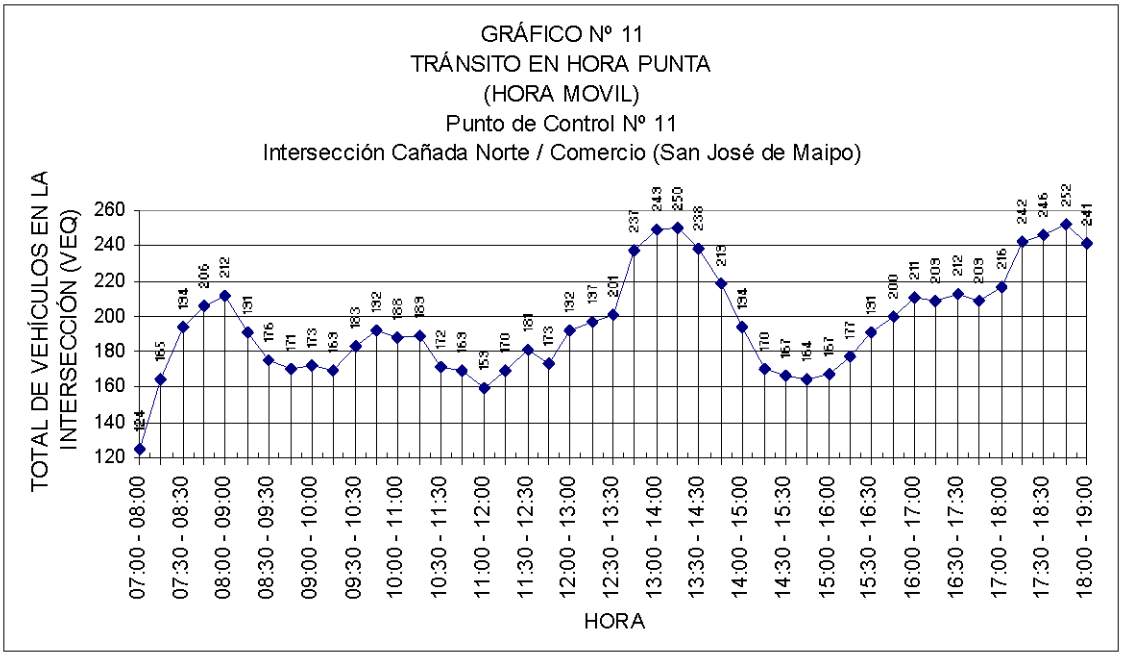


GRÁFICO Nº 11
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 11
Intersección Cañada Norte / Comercio (San José de Maipo)
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
HORA

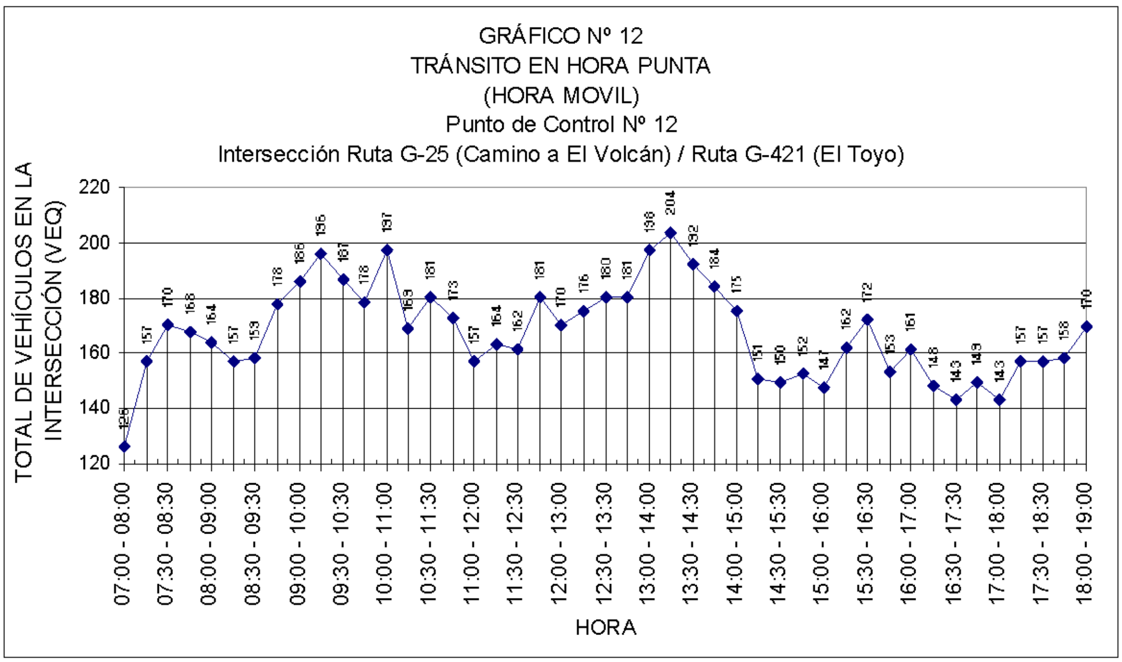
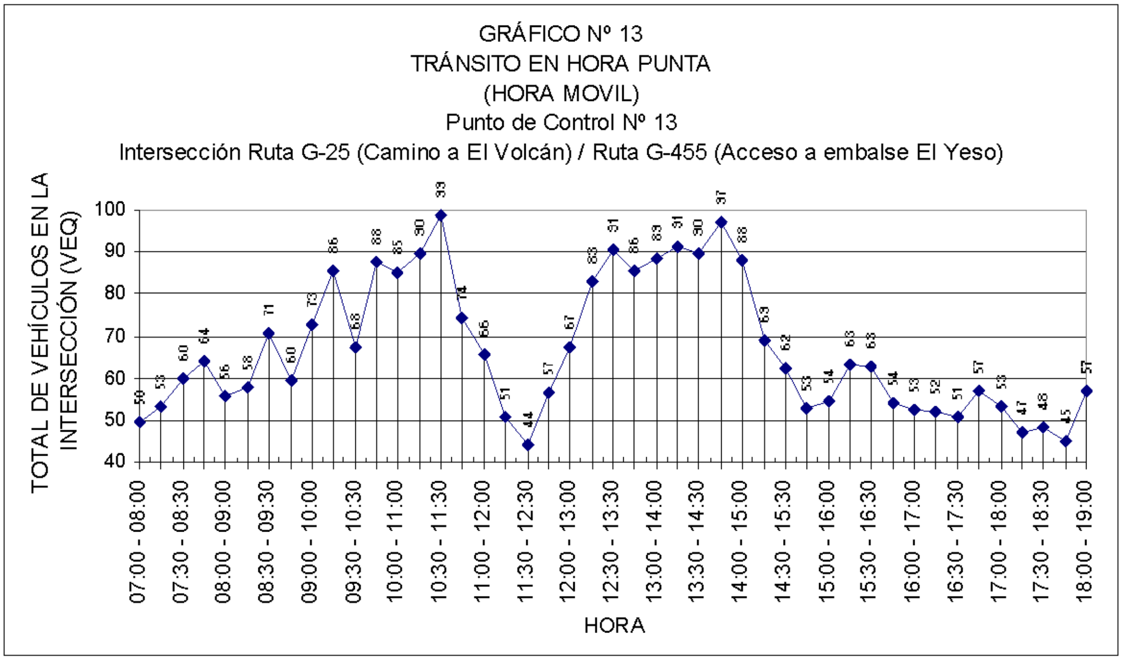
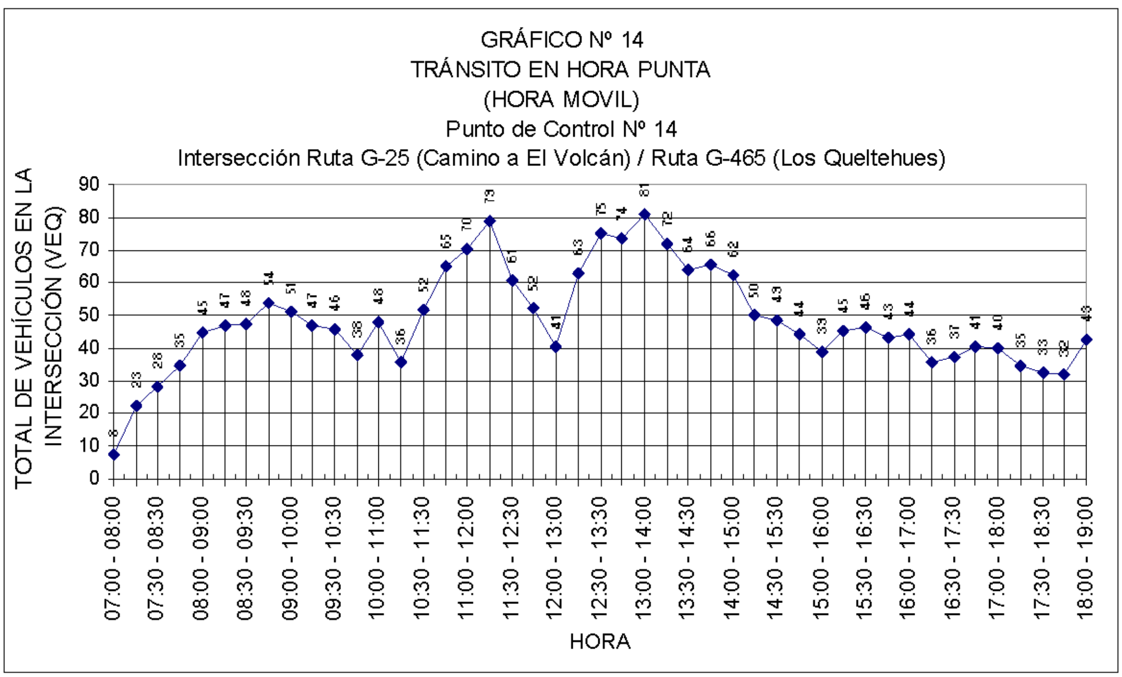


GRÁFICO Nº 12
TRÁNSITO EN HORA PUNTA
(HORA MOVIL)
Punto de Control Nº 12
Intersección Ruta G-25 (Camino a El Volcán) / Ruta G-421 (El Toyo)
TOTAL DE VEHÍCULOS EN LA INTERSECCIÓN (VEQ)
HORA





Based on the traffic measurements presented on the graphics above, three rush hours were determined during the day. Morning rush, noon rush and evening rush.

The vehicle volumes contained in these rush periods, were converted to equivalent flows with factors recommended by the Urban Road Manual from the Ministry of Housing and urbanism, in Volume 3: “Recommendations for element design of urban road infrastructure”. This transformation is intended to represent the reduction effect of one track reduction, in terms of total vehicle per hour. Each commercial vehicle (trucks and buses) has the effect of several light vehicles in traffic flow.

Table 5.6.1.15
Equivalence factors per vehicle type

Vehicle type	Equivalence factor
Light vehicles	1
2 axis trucks	2
+2 axis trucks	2.5
Small buses	1.65
Buses	2

The table below presents the rush hours defined in each of the determined measurement points.

Table 5.6.1.16
Rush hours in G-25 Road

PUNTO Nº	INTERSECCIÓN	PUNTA MAÑANA	PUNTA MEDIODÍA	PUNTA TARDE
1	Av. La Florida / Departamental	07:30 a 08:30	12:30 a 13:30	18:00 a 19:00
2	Rojas Magallanes / Av. La Florida	07:30 a 08:30	12:30 a 13:30	18:00 a 19:00
3	Av. La Florida / Trinidad Oriente	07:30 a 08:30	12:30 a 13:30	18:00 a 19:00
4	Av. La Florida / San José de la Estrella	07:15 a 08:15	13:00 a 14:00	18:00 a 19:00
5	Av. La Florida / Av. Diego Portales	07:30 a 08:30	12:15 a 13:15	18:00 a 19:00
6	Av. La Florida / El Peñón	07:15 a 08:15	11:00 a 12:00	18:00 a 19:00
7	Ruta G-25 / Eyzaguirre	07:45 a 08:45	11:00 a 12:00	15:45 a 16:45
8	Acceso a Ruta G-421 (Las Vertientes) / Ruta G-25	08:00 a 09:00	11:00 a 12:00	18:00 a 19:00
9	Ruta G-345 (Acceso a Los Maitenes) / Ruta G-25	09:45 a 10:45	12:15 a 13:15	18:00 a 19:00
10	Cañada Norte / El Volcán	09:45 a 10:45	12:45 a 13:45	17:30 a 18:30
11	Cañada Norte / Comercio	08:00 a 09:00	13:15 a 14:15	17:45 a 18:45
12	Ruta G-421 / Camino al Volcán	09:15 a 10:15	13:15 a 14:15	15:30 a 16:30

Source: Own elaboration.

Table 5.6.1.17 presents the vehicle flows in equivalent vehicles, for each of the points and rush periods identified above.

Table 5.6.1.17
Rush hour flows
Vehicle total in the intersection (veh./hour)

PUNTO Nº	INTERSECCIÓN	PUNTA MAÑANA	PUNTA MEDIODÍA	PUNTA TARDE
1	Av. La Florida / Departamental	7506	4209	5961
2	Rojas Magallanes / Av. La Florida	5563	3541	4763
3	Av. La Florida / Trinidad Oriente	5433	3115	4535
4	Av. La Florida / San José de la Estrella	3822	2315	2202
5	Av. La Florida / Av. Diego Portales	5020	3079	3489
6	Av. La Florida / El Peñón	3933	2117	2411
7	Ruta G-25 / Eyzaguirre	2183	1372	1519
8	Acceso a Ruta G-421 (Las Vertientes) / Ruta G-25	649	485	572
9	Ruta G-345 (Acceso a Los Maitenes) / Ruta G-25	337	298	331
10	Cañada Norte / El Volcán	226	216	192
11	Cañada Norte / Comercio	212	250	252
12	Ruta G-421 / Camino al Volcán	196	204	172

Source: Own elaboration.

Considering the presented background, it is evident that the total of vehicles measured per intersection is greater in urban stretches of G-25 Road, decreasing substantially from Las Vizcachas to El Volcan.

iv. Road projects in PHAM area

All the information obtained indicates that until the considered date no significant changes will be registered in the road offer, except in the stretch between San Gabriel and El Volcan, which currently is developing the G-25 Road Improvement Engineering Study, Yeso Bridge – El Volcan sector, commissioned by the Department of Roads of Public Work Ministry. It is expected that the engineering study be completed in the first quarter of 2008 and work bidding be requested in November of the same year, to start improving the road approximately in January 2009

The project consists of asphalt paving a total length of 12 kilometers of road and the project objective is to ensure traffic and connectivity of G-25 Road between the El Yeso bridge and 69.3 km beyond El Volcan, projecting improvement works, surfacing according to the requests of current and future burden and widening of the platform, among others. The study begins in the entry corner of El Yeso Bridge approximately at 57,300 km and ends at km 69,300 beyond the town of El Volcan, almost where the platform ends in a mixed profile. The current roadway is made of asphalt pavement with variable width between 5 and 7 meters.

Another project that is mentioned, but at very preliminary level, is that the Road Department has recently conducted studies on the layout and design of G-25 Road, consisting of solving, along with road peers, the passage by the urban centers, such as El Canelo, El Manzano, San José de Maipo, El Melocoton and San Alfonso. To ensure the tourism role of the route, it is necessary to conceive alternatives for the traffic of larger vehicles. In any case, clearly the possible realization of a project like the one mentioned, would be for a later date to the horizon of interest.

A third project is in preliminary stage, but of great importance, which is the reactivation of the Puente Alto Railway – El Volcan, in the section between El Manzano and San José de Maipo. The project is designed only for tourism purposes in the first instance and depending on the outcome of the idea, it would be possible to extend it up to El Volcan.

5.6.2 Economic and productive activities

The economic base of San José de Maipo Municipality lies on farming and cattle, which takes place mainly in the valleys of Maipo and Colorado rivers where the climate and soil favor the generation of pasture, essential for the development of livestock. The extraction of aggregates and non-metallic mining is also important, as well as, the production of drinking and irrigation water, and energy. Finally, consistent with the natural attractions found throughout the municipality, the development of tourism activities is remarkable.

In the municipality of San José de Maipo, 54.5% of companies is engaged in commercial activity (including mining sector), 10.4% are engaged in transportation and communications and the third major activity based on the number of registered companies is agriculture and forestry.

Transportation sector (dedicated to mining and aggregates) and trade are the activities that concentrate greater amounts of sales. About 60% of businesses are located in the sales section between 0 and 600 UF (valued on 1997), most of these companies correspond to trade activities.

Table 5.6.2.1
Number of companies by activity and sales in San José de Maipo (in UF, 1997)

Activity	Sales											
	0-600	**601-1.200**	**1.201-2.400**	**2.401-5.000**	**5.001-10.000**	**10.001-15.000**	**15.001-20.000**	**20.001-25.000**	**25.001-50.000**	**50.001-100.000**	**100.001- or more**	**Total**
Agriculture, silviculture, fishing	17	1	2	1	2							23
Mining	3		2	3	2	2						12
Manufacture industries	7	3	2			1						13
Electricity, gas and water	1	1										2
Construction	2											2
Trade	101	33	12	13	4	2		1	1			167
Transportation and communications	15	6	5	2	2	1		1				32
Finance	6	1	1	1	1							10
Social and personal services	15	3	5	1	2							26
Other activities[2]	14	3	2									19
Total companies	**181**	**51**	**31**	**21**	**13**	**6**	**0**	**2**	**1**	**0**	**0**	**306**

Source: SERPLAC survey, Metropolitan Region, based on Tax Service, Declaration of April 1998.

It is important to note that Cordillera Province (which is inside the municipality of San José de Maipo) presents the greatest growth of microenterprises in the Metropolitan Region. In turn, small businesses have had the greatest impact on business growth in the Metropolitan Region, with an annual variation of 5.3% for 2002. Likewise, Provincia Cordillera is ranked as the largest province specialized on mining activity.

5. 6. 2. 1 Agricultural sector

The relative importance of agriculture lies in the area used for this work and the significant number of economically active people linked to the activity. From the economic point of view it is necessary to specify the area used by farms, which is described below:

Table 5.6.2.2
Surface of agricultural exploitations (He) in San José de Maipo Municipality

Farming soil	
	Surface (He)
Total	858
Permanent annual farming	425
Permanently planted and rotation farming prairies	313
In fallow and rest	121
OTHER SOILS	

[2] Retired workers, pensioners, students, housewives, and religious people.

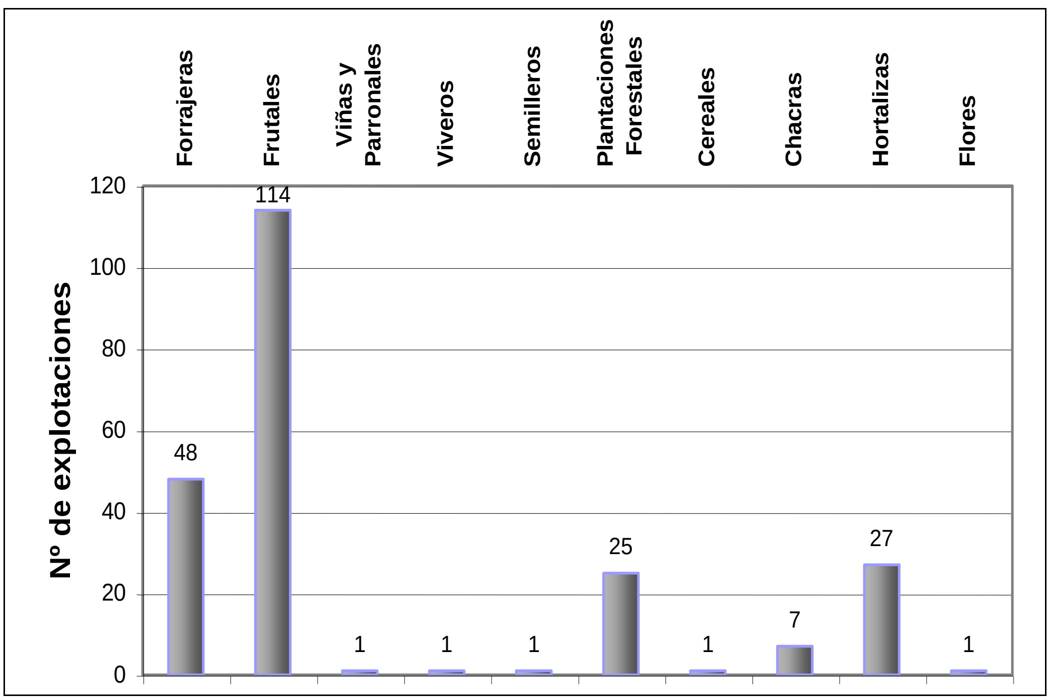
Farming soil	
Total	489.611
Improved prairies	126
Natural prairies	73.913
Forest plantations	1.308
Natural forests and hills (exploited and unexploited)	29.171
Direct use (construction, road, canals, lakes)	1813
Sterile (aggregate, stony areas, sandy areas)	383.279
TOTAL OF HECTARES	**490.469**

SERPLAC, 2002

In terms of area occupied by exploitation, it demonstrates the importance of permanent annual crops and natural grasslands, associated with livestock use (important for municipality).

The communal area available for cultivation is 266,449 hectares, and it is occupied mainly by fruit crops; in second order of importance forest plantations, fodder crops and vegetables are highlighted. Less presence of the cultivation of cereals, flowers, vines and seedlings (see Figure 5.6.2.1). There are no records of industrial crops.

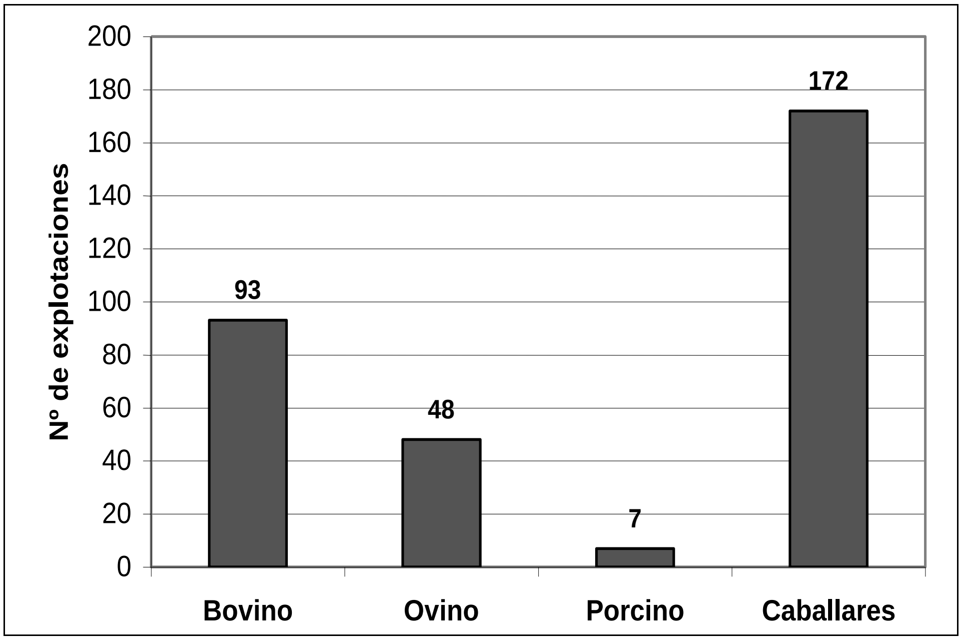
Figure 5.6.2.1
Exploitations by cultivation



On the other hand, according to the information gathered, forestry in the district has 10 areas of operation in an surface of 11,976 hectares.

Moreover, the municipality of San José de Maipo is designated as the 5th district of the country with the greatest potential in terms of its agricultural land, corresponding to 490,469 hectares in operation with 171 farms. The main exploitations are listed below: Bovines, ovines and equines. The least exploited species is the pig. This situation is described in the figure below.

Figure 5.6.2.2
Agricultural exploitations



Horse exploitation is presented as a potential resource with prospects, both commercial production and tourism purposes.

A. Pasture activity

Below there is a list of the names of families dedicated farming in locations within the Project direct influence area. Annex 34 of this study presents a detail of traditional families and the type of cattle they own.

Alfalfal and Los Maitenes: Ranching is developed throughout the year as during the summer (summer pastures) the cattle ascend to higher altitudes on El Alfalfal, looking for tender grasses, while during the winter cattle is located near the town, and in an intermediate zone at the beginning of the spring where animals breed. Regarding the traditional routes, farmers of El Alfalfal-Los Maitenes use two routes, one follows the Colorado River basin and the other is along Olivares River. A detail of the traditional routs for both locations is presented below:

i. Colorado River route: Beginning at La Paloma stream, where the animals spend the winter, the sector is located above the barrier installed by the company GENER. From La

Paloma, cattle moves towards the east as spring and summer months go by in order to spend the summer grazing, going down the Colorado River, until the Tupungato canyon, the Museum canyon and the Cinque meadow. However, there are intermediate steps in the journey that match the life cycles of animals, as the land called Potrero Nuevo, where from October to early December hosts the "calving", which is the birth of the offspring. From there displacement inward is resumed, to the meadows of Aguas Buenas, Novillo Cuyo, Reicano, Parraguirre, etc. During late summer the return begins, the animals stay in Potrero Nuevo until April, then they go down to hibernate near La Paloma stream.

A group of pastors from local sources are added, the so-called "costinos" from the towns of Curacaví (Metropolitan Region) and Colliguay (Valparaiso Region), which handle a large volume of cattle (averaging 1,000 to 1,500 heads of cattle), as opposed to local groups, which can be categorized as small farmers (on average 15 heads of cattle and 15 heads of horses, which in some cases also add up to a few goats).

These groups move their livestock by truck to Los Maitenes, and then begin the ascent of the cattle along the road, entering through gate of the plant Alfalfal 1, finally locating them in the meadows of the Museum and Cinque canyons. Meanwhile local pastors move their animals into the Tupungato canyon.

ii. <u>The route along Olivares stream:</u> It begins by herding in the area of El Durazno, adjacent to The Alfalfal by the northeast, where cattle conduct their winter quarters. From there, they move to the confluence of Olivares stream with Colorado River, through Olivares stream and make a stopover in the sectors of Los Maitenes and El Frío for "calving", resuming their movement later in December to Vegas Amarillas sector. At early fall, the cattle go back along the same route and stopovers. Some groups of Costinos from Curacaví and Colliguay also follow the route of the Olivares stream.

Groups of farmers who travel along Colorado must pay for pasture rights to Minera Río Colorado the summer grazing and to the Army of Chile in the winter pastures. Last year, they had to pay $ 300 or $ 400 pesos per goat or sheep on a monthly basis and $ 1,800 per animal for the season, while the price for bovines and horses ranged from $ 6,000 to $ 7,000 pesos per animal for the season.

In the case of summer pastures in Olivares stream, the groups that stay on the left bank of the stream in the sector of Vegas Amarillas do not pay pasture rights (the area belongs to the Ministry of National Assets), while the groups that stay on the right bank must pay pasture rights to the Army. It is verified that local groups locate themselves on the left bank, while the “costinos” stay in the right bank.

El Manzano: Livestock activity occurs during summer (summer pastures) in the top of the village and during winter the activity is held in the lower areas near G-345 Road. As for the traditional routes, farmers of this location use two routes, one follows El Manzano stream and the other moves along Las Monjas sector. A detail of the traditional routs for both locations is presented below:

i. The route of El Manzano: It begins by herding in the area called El Durazno on one side of the stream and three kilometers from the village. From there, livestock move as the season progresses, following the watershed of the stream to a place called Vega Honda.

ii. The route of Las Monjas sector: Cattle remains during winter in east side from highway to Los Maitenes-Alfalfal, at kilometer 5, in order to penetrate by herding as spring/summer months go by, along the basin of Las Monjas sector to a sector called Las Vegas del Culen.

Pasture rights must be paid on both sectors. On the road along El Manzano stream, payment must be made to the owner of El Manzano farm, and for Las Monjas sector, payment must be made to the new owners of this property (formerly part of El Manzano farm), who are foreign persons and are part of an ecological community and, according to local informants, have reported that from April 2008 on they will interrupt the access of farmers.

El Canelo: Livestock activity is developed both during summer (summer pastures) and winter (wintering) in Las Tortolas sector, located between Km 5 and lowest sectors, near G-345 Road. Regarding the route used by farming families in this location, this is only one area and it is described below:

i. <u>Las Tórtolas sector</u>: Both wintering period and summer period occur in this sector, which is located between Km 5 and Km 9 of the road to Los Maitenes. The movement of livestock occurs on a very specific and restricted area. During the winter, the cattle remains in the areas near the road and as the spring/summer season progresses, they move to the southeast, to the limit of Lagunillas farm, where the owner of the property does not allow access, according to the information provided by local respondents. The livestock returns at the beginning of fall to the initial location.

These families are partners of "Group of Small Ranchers of Las Tortolas Farm", which also includes families settled between Km 6 and Km 13 of Los Maitenes highway. There are family ties with these families, which determine some forms of collective work and, in some cases, the common property of the herds.

The movement of ranchers to the place where animals stay is conducted by herding, as access is only by following trails located at Km 9. In the case of the ranchers who stay in the signalized section of the highway to Los Maitenes, it is verified that they travel with their animals along one side of the road, in order to travel to Las Tortolas following the trail mentioned above by herding.

Regarding the payment of pasture rights at Las Tortolas farm, $1.200 per animal must be paid to the Army on a monthly basis. However, during the current season, due to the lack of grass, ranchers will be exempt from this payment, but will be forced to buy so it will be obliged to buy alfalfa at a price of $ 2,000 approx. for bale.

Baños Morales: Livestock activities take place mainly in spring/summer months (summer pastures). Ranchers departing from Baños Morales use different routes and areas, which are detailed below:

i. The canyons between El Morado and Las Placas stream: During the summer grazing season, one sector is the area between El Morado and Las Placas stream, which belongs to Quebrada de Morales farm. Farmers pay pasture rights to the respective landowners. The families in the municipality who use these areas for grazing come from Chacritas, El Volcan, San Jose de Maipo, Queltehues and Romeral.

ii. La Engorda ravine sector: It is used for summer grazing and belongs to the farm owned by Covarrubias family, who pay pasture rights. In this sector, families come from the already mentioned villages in the municipality.

iii. Del Volcan River: "Costinos" use this route to travel up to Nieves Negras, El Azufre and Carreño canyons, with an approximate volume of 500 bovines. Pasture rights must be paid to the respective landowners in all these sectors.

Some groups make stopovers on La Arena and El Clarillo sectors during the first month of the spring/summer grazing (October), in order to travel deep into the most profound of the routes mentioned above as the season progresses.

In the case of Núñez-Venegas families, they concentrate the animals during the winter in El Volcan sector. Herds coming from El Romeral remain at El Piche sector during the winter, near this location. Herds of small farmers in El Volcan spend the winter in the vicinity of their settlements. The same applies to the herds of the Covarrubias family, settled in Queltehues sector and occupying the meadows of La Engorda ravine during the spring/summer pastures.

Lo Valdes: Given the characteristics of this location, it is not possible to establish own trail routes. The spring/summer pastures occur to the only family that handles their animals (goats) to the care of another farmer between the sector of El Morado and Las Placas streams.

El Volcan: The pastoral industry is an important factor for the economy of the families that remain in the sector, complemented by the production of vegetables for home consumption, the sale of cheese to tourists, the collection and sale of tools used for the former mining sites, and even the sale of fossils.

Regarding the rancher routes in El Volcan, these are 3 and correspond to:

i. El Yesillo sector, from the water intake to the South
ii. El Morado stream
iii. Colina stream

These small ranchers follow different routes during the summer pastures. Some groups access into the area through El Yesillo, from the El Volcan water intake southbound. Other groups follow the route of El Morado stream. Some groups remain in the sector or travel to Chacritas, but most of them move their cattle along the Colina stream. From April, the herds return to their wintering sites that are located in areas adjacent to the location.

El Romeral: On this community, grazing has practically disappeared as a result of migration and productive transformation, only one family remains dedicated to the activity and its area spring/summer grazing area is located in Las Melosas sector to the South (see Annex 34).

Yeso River road sector: The families engaged in farming are identified in greater detail in Annex 34. Usually the families of small farmers, except one, manage livestock both during winter and summer in the sector, making trips to the east only up to Km 17.

There are two grazing routes, corresponding to:

i. La Engorda Ravine: One family exceeds the perimeter area to the village, so in order to access into La Engorda Ravine, it travels during the summer grazing to Baños Morales by truck up to the area of El Volcan intake, and continues from there by herding up to the meadows in La Engorda Ravine.

ii. El Yeso River: "Costinos" cattle also travel over this sector from Curacaví, Colliguay and Melipilla, which provide a greater volume of animals, between 1,000 and 1,500 ovines and 600 to 700 goats. These cattle are located in the deepest canyons of the mountain range, following the basin of El Yeso River and are transported only to kilometer 14 by vehicle, from there they must resume the hedging due to the sharp curves in the route.

San Gabriel: Regarding the trail route and grazing areas, the situation is as follows:

i. San Nicolás Stream until the vicinity of San Lorenzo Hill and Negra Lake.

The summer grazing traditional route is one. The cattle travel along San Nicolas Stream until the vicinity of San Lorenzo Hill, where they stay from October to November. From this date, they turn east to graze during the summer period in the vicinity of the Negra Lake. In April, the return is performed by the same route, during the winter the cattle stay in the low section of San Nicolas stream.

El Romeral: Ranching has practically disappeared as a result of migration and productive transformation, the only family that keeps this activity uses Las Melosas sector as sites for summer pastures.

Yeso River road sector: Grazing occurs in the vicinity of El Yeso reservoir and La Engorda stream, therefore there are two overlapping areas: One in the access path to El Yeso reservoir and the other in the lower part of the meadow in La Engorda ravine.

San Gabriel: Pasture during summer grazing occurs on San Nicolas Stream until the vicinity of San Lorenzo Hill, where the cattle stay from October to November. From this date, they turn east to graze during the summer period in the vicinity of the Negra Lake. In April, the return is performed by the same route, during the winter the cattle stay in the low section of San Nicolas stream.

5.6.2.2 ***Mining sector***

The mining activities are related to the exploitation of gypsum and limestone deposits. In the Project environment, mining activities are located mainly in the upper basin of El Volcan and Yeso rivers. Likewise, in the area of Colorado River, it is possible to observe the development of a plant owned by Minera Rio Colorado, which processes limestone.

5.6.2.3 ***Trade and service sector***

Activities are developed mainly on both sides of G-25 Road with a special development in the center of the different populated areas that are located along its route. Thus, among the business activities registered, it can be observed a basic type of trade (groceries, bazaars, food stores, bookstores, liquor stores, bakeries, hardware stores, bars and restaurants, among others) and the more specific trade, such as pharmacies or dry cleaners, preferably they can be found in the town of San José de Maipo

In the same way and in isolation along the G-25 Road, there is trade of local and/or homemade products (homemade bread, pies, cheeses), a situation that is repeated on the routes that connect with attractions, such as G-345 Road (Colorado River) and/or the bifurcation of G-25 Road, which communicates with the El Yeso reservoir area, where the offer of local products is less and directly related to the existing isolated houses.

Trade and similar establishments are the most developed economic base of the commune. In fact, trade is the economic activity that focuses the biggest quantity of utilized labor in the municipality (11%), where the character of the occupation in that activity is 'unqualified sellers of products and services'. Tourism activities is classified within the trade type of business, which occupy 35.42% of commercial equipment.

Regarding the equipment, it is mainly linked to the mix supply and tourism of pubs and restaurants. It is observed poorly developed infrastructure for tourism, hotels and recreational type.

The overview of the existing equipment in San José de Maipo Municipality by year 2002 is presented below.

Table 5.6.2.3
Equipment for commercial activity, by class and type of commercial activity

Commercial activity		% Commercial equipment
Class	**Type**	
Supply	Mix	24,63
	Market	15,17
	Services	10,95
Tourism	Hotels or clubs	9,45
	Restaurants or pubs	21,39
	Cabins or picnic	2,99
	Recreational	1,49
Productive	Technical professional services	0,00
	Workshops	9,20
	Extractive	3,23
	Manufacturing	0,50
	Warehouse	1,00
	Commercial equipment total	**100,00**

5.6.2.4 Tourism sector

Although the municipality of San José de Maipo is established as an important corridor of different types of infrastructure and services for the metropolitan area, it does not make a distinct economic benefit. Currently, and according to historical economic activity, the main economic activities are of primary kind (agriculture and livestock, mining, aggregate extraction).

The main companies in the tertiary sector showing growth, like the national trend, are the small businesses, whether commercial type or other. Trade is the fastest growing category in the decade 1992-2002, generating employment and support to tourism, although the labor lacks qualification.

The demand for land in the locations of Las Vertientes, The Canelo, El Manzano and El Ingenio has become a growing trend in the last five years, which means an increase in land value. In some areas of these locations inhabitants of Santiago have built secondary houses, however, these new inhabitants do not exploit trade or development activities, because they visit the area only for short terms for tourism or provision, making a less intensive use of the location services.

Considering the existence of a series of natural attractions, landscape sceneries and the ever-increasing demand by users and tourists (domestic and foreign), tourism activity has not yet been considered as the community economic base, with the development and implementation of plans and programs to promote business, infrastructure and tourism services.

Therefore, it is estimated that in the near future tourism activity should become the hub of community growth, based on the development and operation of local small tourism service providers of varying quality. This will require training and educating workers in tourism, offering work sources within the municipality and leveraging the landscape knowledge possessed by local people.

Considering the above, the following is a register of tourism offer and tourism related infrastructure existing in the Project influence area.

A. El Canelo - El Manzano Sector

The sector has a number of attractions that are closely related to natural areas in the vicinity of the locations of El Canelo and El Manzano. The sector has scenic resources and geological formations, waterfalls, variety of vegetation and associated fauna.

The locations of El Canelo and El Manzano correspond to distribution and excursion centers, due to their geographical characteristics and the existence of tourism facilities, which are located largely on the banks of G-25 Road, on the banks of Maipo River and vicinity of El Manzano stream.

The main tourism corridor corresponds to the route along G-25 Road, which has a visual range that varies between 50 and 500 m. The landscape shows forested landscapes (with some commercial farms, such as almond), mountain walls showing dense vegetation, low shrubs and plantations, and areas devoid of vegetation.

Many of these attractions are not seasonal, because they do not lose their value as they maintain accessibility and provide enjoyment throughout the year along G-25 Road, which connects Santiago with San Jose de Maipo. The relief present in the location of El Manzano gives good conditions that allow the practice of climbing and free climbing. For these activities, the traditional family involvement is limited mainly to act as guides, much more than as operators or entrepreneurs.

Unlike El Manzano, the location El Canelo has greater capacity in terms of supply of services, especially facilities that provide food.

Further details on tourism and mountain sports are presented in Annex 35 “Complementary register of attractions and tourism services in the Municipality of San José de Maipo” and Annex 36 “Register of high-mountain activities”.

i. Current tourism activities

In this area it is possible to observe development of different tourism activities, predominantly those in which there is a relationship with a particular space or natural site (special interests). Despite this, it is possible to identify activities related to historic sites and archaeological heritage, among others.

The predominant activities in the sector are:

- **Purchase of handicrafts**: In every age, visitors can acquire craftwork made on local stone.

- **Walking and Hiking:** There are several options for hiking in the sector. Due to geographical characteristics, they do not require great effort. These walks will not involve high demands and are suitable for all ages.

- **Picnic:** There are at least 3 areas recognized for picnic. This activity takes place during the day and people have the opportunity to swim in rivers and streams. This activity is one of the greatest preferences by tourists who visit the location and is restricted by the climatic factor.

- **Photo:** The area is visited by amateur and professional photographers.

- **Horseback riding:** This activity is performed with poor organization and lack of experts (guides, instructors).

- **Wildlife watching:** Tourists carry out activities related to photography and simple observation of the Andean landscape.

- **Swimming:** The activity is carried out particularly in the area known as Pozas Azules, in El Manzano, mainly in summer.

- **Visits to historical monuments:** This item includes visits to parishes, churches and railway stations, among others. These visits are not guided, and there is no associated information material.

- **Day Excursions:** Mainly in the area of El Manzano. These activities are self-taught, since there are no guided tours.
- **Gastronomy:** The sector has a wide range of restaurants and teahouses, which deliver a wide range of foods, usually throughout the year.

- **Expeditions, trekking, environmental education, sport events:** Some of these activities are easily accessible by visitors, while others have some degree of difficulty, especially in winter.

ii. Tourism facilities

- Offer of tourism facilities

▪ Accommodation

In this sector, 4 types of tourist accommodation facilities can be observed: camping, lodges, cabins and second homes. In general, in this sector it is possible to find basic accommodation and more specialized sites.

- **Camping:** Conditioned by the climatic factor. El Manzano campsite is highlighted and located immediately upstream of the confluence of the stream with the G-25 Road, with basic health infrastructure and equipment for tourists who stay in place. It provides access to El Manzano stream, trekking paths, free climbing sites in rock, among other attractions. This site receives a large influx of visitors.

- **Lodges:** They have developed spontaneously and feature no standardization or uniformity of service and performance. They are generally concentrated in populated areas.

- **Cabins:** the majority are areas of considerable size for the provision of houses. Each house has a capacity for 6 people, on average, and only feature food service. They do not feature service standardization and consistency in offers.

- **Secondary home:** In both locations it is possible to find houses that are a second home, sited on plots from 1,000 m^2 and more.

- Food and Leisure:

The gastronomic offer is varied. It is not specialized, as small businesses try to cover as much of an offer to make their business profitable. For this reason, a restaurant in the evening can operate as a tea room and at night as pub.

During the day, there are spas, swimming pools, camping, sports clubs and theme parks. At night you can find discos, pub, restaurants and soda fountains.

Many of these activities are concentrated and/or have greater intensity during summer, but given favorable access granted G-25 Road, the sector addresses a undetermined tourism demand over the year.

iii. Tourism infrastructure

- **Road condition:** There is a road (G-25), which has pavement in good condition. In some areas, the road narrows, but this situation is not a major problem for vehicular traffic.

- **Roadside and tourism signage:** Road signage in the sector is poor, considering the significant traffic flow it receives. Tourist signs are scarce and in some cases inexistent.

- **Viewpoints and trails:** The sector presents viewpoints and trails, but these are not identified or marked, in general, they are located within campgrounds and other places used for recreation.

- **Trails:** The sector has a large number of access paths to the various attractions, which are not properly labeled and marked.

- **Walkboards and bridges:** There are no walkboards. In relation to the bridges developed along G-25 Road, they are in good condition overall.

- **Tourist Information Office:** The existence of a tourism information office in the sector is not registered.

- **Parking or detention areas:** there are no suitable and signaled sites to stop and/or park, only a few commercial establishments have adequate parking spaces to their service (mostly restaurants).

- **Transportation types:** Access to the sector is through buses that operate throughout the year.

- **Near urban centers:** The most important urban center in the sector (excluding the location of El Canelo) that has, but not limited, health centers, and information security, aside from tourism services for food, shelter and recreation. It corresponds to the local municipality center, San José de Maipo.

- **Communication level:** There is telephone service coverage on a large portion of the sector.

B. Los Maitenes – El Alfalfal Sector

The sector has a limited tourism development, but has great potential, considering the number of attractive features, with an environment that presents extensive mountain ranges that surround the main waterway sector (Colorado River). It has large pools of low gradient valley surrounded by several scenic resources, and snowy peaks, glaciers, waterfalls, variety of vegetation and associated fauna, natural hot springs, volcanoes, glaciers.

In general, the type of tourism that takes place in the sector is mostly oriented to special interests, where tourists have the possibility of entering the environment and guide themselves through the different existing trails. The main activities developed in the area correspond to trekking, hiking and archaeological research. The sector shows a marked seasonality, since during the winter months presents access difficulties due to heavy rains and snowfall.

At present, the locations do not have basic tourist facilities to meet the needs of tourists visiting the area, regarding accommodation, food or entertainment, with the exception of the "Casa Patronal Los Maitenes" Inn located in El Colorado Road, with year-round operation, owned by Chilean police (Carabineros).

Regarding the basic infrastructure, it presents a paved road in good condition to El Alfalfal in the high mountain; access is only possible through a private road owned by GENER S.A. The tourism and roadside signage is poor and deteriorated, in some sectors it is inexistent; it lacks public transport for access into the area.

The major tour operators in the sector are two: the first has its headquarters in San Alfonso and offers products related to adventure tourism, through activities such as trekking, hiking, horseback riding, climbing, river kayaking, rafting and watching flora and fauna, with a strong ecological and educational content. Its offer is available throughout the year, being strongly influenced by climatic conditions. The second operator corresponds to a group of local entrepreneurs with FOSIS support for the development of its activities, which as it was stated above complements its activity with livestock and provides knowledge on the mountain environment and feature interesting guides.

Annex 9 identifies the various tourist attractions in the Project influence area and the different roads currently used in mountain activities. Annex 35 is presented complementarily for greater details.

In terms of mountaineering activities in Los Maitenes and El Alfalfal, climbing, hiking, geological and archaeological research are common practices. Moreover, in the Olivares River (Project indirect influence area), climbing activities are carried out in medium and high altitude (mountaineering) representing great physical effort, being performed mainly by experts and athletes with basic mountaineering abilities who develop this activity. Usually these activities are intensified in the spring and summer months, decreasing towards the winter months as weather conditions make impossible the development of the activity with acceptable safety levels For further details, Annex 36 “Register of high-mountain activities” is presented.

Additionally, in the Olivares River basin, the first multi-purpose park will be located in the Chilean Andes, mainly for active tourism, conservation, education and scientific research with different activities for the 4 seasons. This project will generate a tourism base of accommodation, food, housing and various tourist services for mountain activities, which will be aesthetically harmonious with the landscape and, as the conservation of resources will give the possibility to preserve the touristic patrimony that consists of high rank attractions. In the lower section of the river, basic equipment will be installed generating a tourism center.

i. Current tourism activities

The activities undertaken in this sector are oriented ecotourism and adventure tourism with different intensity levels (related to the physical demands that this entails). Also there are less physically demanding activities related to environmental observation, resting and recreation. These activities are:

- **Ascents in medium and high altitude (mountaineering):** These activities take place mainly in the Olivares River canyon. This activity is developed by people with the basic knowledge on mountaineering, preferably during spring and summer.

- **Camping and picnic:** spontaneous activity that takes place outdoors, in areas where conditions are suitable, as the sector does not have tourism facilities.

- **Wildlife watching:** Tourists carry out activities related to photography and simple observation of the Andean landscape.

- **Thermal waters:** Tupungato Thermal Waters present a marked seasonality, because the access is difficult in the winter months.

In general, the type of tourism that takes place in the sector is mostly oriented to special interests, where tourists have the possibility of entering the environment and guide themselves through the different existing trails. The sector shows a marked seasonality, since during the winter months presents access difficulties due to heavy rains and snowfall.

ii. Tourism facilities

- Offer of tourism facilities

- Accommodation

No establishments are registered for tourism accommodation in the zone.

- Food and leisure

There is no register of food service establishment or tourism recreation facilities.

- Tourism operators in the municipality or operating in the municipality

Two tourism operators were identified in the sector. The first has its headquarters in San Alfonso, while the second corresponds to a group of local entrepreneurs with FOSIS support for the development of their activities.

iii. Tourism infrastructure

- **Road condition:** Paved road to El Alfalfal, which continues to high mountains with gravel road, featuring marked difficulty in accessing the Olivares River canyon sector.

- **Roadside and tourism signage:** Roadside signage is inadequate, deteriorated and/or is misplaced. Meanwhile, tourism signs are nonexistent.

- **Viewpoints and trails:** There are no tourism viewpoints; there are a lot of unmarked trails.

- **Walkboards and bridges:** No bridges or walkboards were identified in the zone.

- **Shelters:** No touristic shelters are registered in the zone.

- **Tourist Information Office:** No tourism information offices were identified in the sector.

- **Parking or detention areas:** The area has no authorized, demarcated and signposted parking and/or detention areas.

- **Transportation types:** Public transportation is nonexistent, the main means of mobilization are private cars and private transportation.

- **Near urban centers:** There are no locations within this area, but the closest one corresponds to San Jose de Maipo, with health services, Police, telephone and garage, aside from tourism services for food, shelter and recreation.

- **Communication level:** The relief characteristics prevent the correct operation of mobile and fixed telephone network.

C. San Gabriel, El Romeral and El Yeso Sector - Lo Encañado Lake

The El Yeso reservoir area has scarce tourism development, not considering the equipment and infrastructure, despite the quantity of tourists that visit the sector. In the El Yeso reservoir area, medium and high mountain climbing are developed, especially in Mountain Tour Unit and Meson Alto hills respectively, the first site represents a higher level of development of tourism operation and the second is used by groups of experienced climbers, most of them do not require tourism services offered by operators. Usually these activities are intensified in the spring and summer months, decreasing towards the winter months due to weather conditions. This activity combines disciplines or activities such as rock, ice or mixed climbing and reaches heights ranging from 2,324 m on Loma de Diablo Hill on El Melocoton, up to 5,257 m in the Meson Alto Hill in the El Yeso reservoir. The main attractions are the El Yeso reservoir, Termas del Plomo, Negra and Lo Encañado lakes, and the main heights of mountain ranges (Picos Negros, Cortadero, San Francisco, Mesón Alto and Punta Esmeralda hills).

Access to the El Yeso reservoir is thorough a dirt road, with a time of arrival at the dam of about two hours due to the difficulty of the route and its condition. On the other hand, access to Lo Encañado lake is through a private road (Aguas Andinas S.A.), because of this situation no tourism activities are performed in the sector. Further details on tourism and mountain sports are presented in Annex 35 and 36 respectively.

San Gabriel acts as a tourism facility in the area, but its development is based on its potential rather than actual use, since it has a quantity, quality and diversity of tourism establishments necessary to operate as such. The current tourism plant is located mainly on the sides of G-25 Road, on the banks of the Maipo River and San Gabriel Stream.

Access is through G-25 Road, where transport is rare, public locomotion passes twice a day, but there are buses and taxis available.

The town of San Gabriel features the following tourism attractions: Natural site, cultural demonstrations and climbing sites.

The activities undertaken in this area are closely related to the natural attractions, especially with mountains and water resources, which have characteristics of ecotourism and adventure with different levels of intensity (regarding the physical demands that this entails). Also there are less physically demanding activities related to environmental observation, resting and recreation.

In the town, it is possible to identify tourism accommodation establishments such as, lodges and camping. The lodges have medium-sized equipment and facilities, and its main differentiator from other tourist facilities is the development of typical food products based on local and German tradition. The campsites in the area are generally located along the banks of a river course, which allows camping tourists to bathe without leaving the campsite. Their service is based solely on the provision of camping sites with grill and benches, without other services such as food and recreation.

The major tour operator in the area, CASCADE EXPEDICIONES, has facilities for operation in the town of San Alfonso. This operator offers products related to adventure tourism, through activities such as trekking, hiking, horseback riding, climbing, river kayaking, rafting and wildlife watching, with a strong ecological and educational. Its offer is available throughout the year, being strongly influenced by climatic conditions. Further details on tourism and mountain sports are presented in Annex 35 and 36 respectively.

Finally, El Romeral village does not have tourism facilities, however, in its surroundings, as in El Volcan, geological observation and archaeological research can be performed easily, due to the characteristics of landforms and the quality and quantity of findings discovered by both tourists and professionals (see details in Annex 35 and 36).

i. Current tourism activities

The activities undertaken in this sector are oriented ecotourism and adventure tourism with different intensity levels (related to the physical demands that this entails). At the same time there are less physically demanding activities related to environmental observation, resting, recreation and leisure. These activities are:

- **Walk and excursion:** Especially around the Yeso River canyon. The realization of this activity is permanent; however, it is determined by the climatic conditions. The characteristics in the area allow for spontaneous development of these activities.

- **Ascents in medium and high altitude (mountaineering):** Picos Negros, Cortadero, San Francisco, Mesón Alto and Punta Esmeralda hills; an important part of these activities are performed by groups of experienced climbers, those who do not require tourism services offered by operators. This sector presents marked seasonality, developed primarily during the summer. This activity combines disciplines like rock, ice or mixed climbing.

- **Climbing:** Performed under the operation of adventure tourism companies and athletes on an individual basis. The development of this activity is permanent and conditioned by climatic factor.

- **Horseback riding:** Generally carried out throughout the sector. They are usually full day activities, which have characteristics of soft adventure, although there are passages of great difficulty and duration. All these activities are conducted on an ongoing basis, being conditioned by climatic factor.

- **Bathing in rivers and lakes:** Conducted in a particular way during the summer, this activity is concentrated in the El Yeso reservoir.

- **Picnic:** its performance is spontaneous because of the lack of suitably qualified places for such purposes.

- **Fishing:** Specifically in Negra and Lo Encañado lakes in the El Yeso reservoir; it is a spontaneous activity and is performed since decades in the summer.

- **Wildlife watching:** Due to the landscape features of this area, this is a recurrent activity in this sector.

- **Thermal waters:** Specifically at Termas del Plomo. It presents a marked seasonality, because access to them is difficult in the winter months. It has no infrastructure.

- **Cyclism:** Activities of conventional cycling or cycletourism, as well as mountain biking, along the path that connects the El Yeso reservoir and through the road that connects the Lo Encañado Lake.

- **Windsurf:** Sailing activity practiced in El Yeso reservoir in summer due to high wind conditions prevailing at the site. This activity has no infrastructure or support services on site.

ii. Tourism facilities

- Offer of tourism facilities

- Accommodation

No accommodation sites were identified in the sector.

- Food and leisure

Only one restaurant is registered at the junction of G-25 and G-345 roads, which is oriented as a restaurant for haul truck drivers who travel to/from Lo Valdes and El Yeso.

No specific sites for leisure were identified in the sector.

- Tourism operators in the municipality or operating in the municipality

Tourism operators who perform activities related to trekking, hiking, horseback riding, climbing, river kayaking and observation of flora and fauna were identified, with strong ecological and educational content, mainly associated with the El Yeso reservoir and Termas del Plomo. Its offer is made throughout the year, being influenced by climatic conditions.

iii. Tourism infrastructure

- **Road condition:** The route to El Yeso reservoir has traffic problems because it is a gravel road difficult to use due to winter weather conditions.

- **Roadside and tourism signage:** Roadside signage is inadequate and poorly located, while tourist signs are nonexistent.

- **Viewpoints and trails:** No viewpoint facilities were identified, despite of the different sites for installation. With regard to trails, these are mainly in the El Yeso reservoir area and Termas del Plomo, however, there is no signage to allow a self-guided trails.

- **Walkboards and bridges:** No bridges and/or walkboards are registered.

- **Shelters:** No tourism shelters were identified. There is only register of an Army shelter (Los Chorreadores), located in the vicinity of El Yeso reservoir, which is abandoned.

- **Tourist Information Office:** There is no tourism office.

- **Parking or detention areas:** no clearly marked and delineated parking spaces and/or detention areas were identified the sector.

- **Transportation types:** There is no public transportation in this sector. During the weekend there is a large influx of tourists, mini buses and tour buses, from Santiago (mostly).

- **Near urban centers:** There are no urban centers within this sector. The town of San Gabriel is the main population center nearby, which offers health services, Police, telephone and garage.

- **Communication level:** The relief characteristics of the sector prevent the correct operation of mobile and fixed telephone network.

D. El Volcan, Baños Morales and Lo Valdés zone

The sector El Volcan - Baños Morales, as the name implies, includes the sectors of El Volcan, Lo Valdes and Baños Morales sectors. This area has attractions corresponding to El Volcán Road, El Volcán village, Maipo River route, Baños Morales, Lo Valdés, Elda Chocolate Confectioner and El Morado Natural Monument.

Considering the conditions and characteristics of this area, the main attractions are located in an area of medium and high altitude. An important part of these attractions correspond to the classification of Natural Sites.

El Volcan, Baños Morales and Lo Valdes settlements serve as distribution centers and stay place for tourists.
Overall, this area has a tourism base that consists of formal tourism accommodation establishments, which are mostly hostels or shelters, there are also second home houses. The food establishments correspond to the same shelters or hostels, as they provide food service separately, if required by a tourist. Both tourism and food equipment is developed exclusively in Baños Morales and El Volcan, the areas of El Morado, Las Placas and La Engorda streams present no tourism infrastructure.

As distribution centers and accommodation for tourists, one can point the locations of El Volcan, Baños Morales and Lo Valdés. El Volcan had great development because it was a mining settlement, for this reason it presents scenic and historical value constructions, however, at present it has no proper tourism facilities. Regarding Baños Morales, this sector concentrates most of tourism facilities and bases its development on activities related to the natural attractions of El Morado and the thermal waters rich in sodium, chloride and potassium. Finally, in Lo Valdes the highlight is the Refugio del Alemán Lodge, specialized on medium and high mountain tourism.

This sector has public transportation only to and from El Volcan. This area is characterized by climatic events that cause landslides generating isolation on a regular basis. However, in these emergencies, the municipality is prepared for rescue, often with the support of the mining company located in Lo Valdes providing heavy equipment for clearing roads.

Baños Morales currently concentrates most of tourism facilities in the area, that meet the basic requirements for the stay of tourists. The town bases its development on the activities related to the natural attractions in El Morado and activities in thermal waters rich in sodium, chloride and potassium. Most of the population participates in tourism activities, including farmers with a relative residence status as stated above. The main attractions are located in the medium and high mountain. An important part of these attractions are classified as Natural Sites and connected by trails, paths and El Volcan road.

El Volcan had great development because it was a mining settlement, for this reason it presents scenic and historical value constructions; however, at present it has no proper tourism facilities and features less development on surrounding communities.

Lo Valdes acts as distribution center and stay of tourists, highlighting the presence of Refugio del Alemán Lodge, specialized on medium and high mountain tourism. Considering the conditions and characteristics of Lo Valdes, the main attractions are located in an area of medium and high altitude. An important part of these attractions are classified as Natural Sites and connected by trails, paths and El Volcan road. In the area it is possible to observe four types of tourist accommodation: lodges, cabins, camping and second homes.

i. Current tourism activities

Activities conducted in this area are related to ecotourism and adventure tourism with different intensity levels (related to the physical demands that this entails). Also there are less physically demanding activities related to environmental observation, resting and recreation. These activities are:

- **Walk and excursion:** Mainly around Baños Morales and Lo Valdés. The realization of this activity is permanent; however, it is determined by the climatic conditions. The characteristics in the area allow for spontaneous development of these activities.

- **Medium and high mountaineering:** Developed in Baños Morales, specifically in the El Morado Natural Monument and the surrounding hills to Lo Valdes (e.g. Valdés hill, 3620 m). Usually these activities are conditioned by the climatic conditions and are intensified in the spring and summer months.

- **Climbing:** Near Lo Valdes, conducted mainly under the operation of experts from Club Alemán de Andinismo (German Mountaineering Club). The development of this activity is permanent, being determined by weather conditions.

- **Horseback riding:** Focused on Baños Morales. The development of this activity is permanent, being determined by weather conditions.

- **Picnic:** Its realization is spontaneous because of the scarce suitable places for such purposes, although Lo Valdes has some degree of development for the realization of this activity but it is conditioned by the climatic factor.

- **Geological observation and archaeological research:** It is done across the sector, however, El Volcan is the location where it is possible to easily conduct this activity due to the characteristics of landforms and the quality and quantity of findings discovered, both by tourists and professionals. It is also relevant the trade of fossils or archaeological findings, which is done individually by the inhabitants of the sector, mainly in the field located between El Romeral and El Volcan.

- **Wildlife watching:** This is a recurrent activity due to the landscape features of the sector. Usually it is possible to see tourists doing activities related to photography and simple contemplation of the landscape, the Andean foothills and fauna representative of the place.

- **Thermal waters:** On Baños Morales. It presents a marked seasonality, because access to them is difficult in the winter months. Tourists spontaneously perform this activity due to lack of operators.
- **Cyclism:** It is possible to see conventional cycling or cyclotourism activities, as well as mountain biking. The activity is performed by amateurs and professionals under training, performing throughout the year, in consideration of weather conditions.

ii. Tourism facilities

- Offer of tourism facilities

- Accommodation

It is possible to identify four types of tourist accommodation: Lodges, cabins, campgrounds and second homes, which are located mainly on Baños Morales and Lo Valdés.

- **Lodges:** They are located mainly on Baños Morales. Its equipment and facilities are of medium size and quality, and provide other services and facilities such as organization of scheduled events, horseback riding and excursions organized with certain degree of swimming pools and playgrounds.

  With regard to the quality of service, it is not standardized and there is an optimum relationship between the offered quality and price.

- **Cabins:** Establishments in this category correspond to cabin complexes located exclusively on Lo Valdes. Each cabin, on average, has a capacity for 5 people, and only some of the provide food service; however, they feature kitchens and basic equipment.

- **Camping:** The main site corresponds to the authorized site located in the El Morado National Park. The service is based solely on the provision of camping sites with grill and benches, without other services such as food and recreation.

  Due to the small number of such establishments, many visitors camp in inappropriate site, causing environmental damage in some areas of river banks, becoming a problem for local authorities and the community.

- **Secondary home:** The main focus of the second residence is Baños Morales.

- Food and leisure

In relation to food service, restaurants also serve as guest houses. The cuisine offered is mainly typical Chilean food, mixed with German traditions, but lately tending to international cuisine. Likewise, there are some soda fountains, which are used mainly by the local community.
In relation to recreation, El Morado National Park is the main attraction of the sector, which, among others highlights, has picnic areas, camp sites and hiking trails. The site is managed by CONAF.

- Tourism operators in the municipality or operating in the municipality

One major operator is identified in the zone, featuring facilities for operation in the town of San Alfonso. This operator offers products related to adventure tourism, through activities such as trekking, hiking, horseback riding, climbing, river kayaking, rafting and wildlife watching, with a strong ecological and educational. Its offer is available throughout the year, being strongly influenced by climatic conditions.

iii. Tourism infrastructure

- **Road condition:** G-25 Road corresponds to a dirt road in good condition overall, but it has some sections where traffic can only be one vehicle at a time. Other sectors present flow of smaller streams and alluvial materials that disrupt the traffic in the road, making the journey difficult for simple traction vehicles. There are no signalized places for detention.

- **Roadside and tourism signage:** There is relatively good roadside signage; however, it is limited to the long distances between locations and in some sections presents visibility problems (shrubs adjacent to the road). Tourism signs are poor.

- **Viewpoints:** Within the area there is one viewpoint identified, which is located in the El Morado Natural Monument, in the area of the Montaña del Leon, along with the lake and glacier named El Morado. The viewpoint is called Las Panimavidas.

- **Trails:** There is a large number of trails in the area, however, their course must be done by people familiarized with the zone, since there is no signage to allow a self-guided trails. A highlighted trail is El Ventisquero (6 km or 1.5 hours approx.) within the El Morado National Park.

- **Tourist Information Office:** There is no such office, however, at the entrance of the Natural Monument El Morado, there is a CONAF office intended to preserve the monument and inform tourists about the protected area.

- **Parking or detention areas:** No parking spaces were identified correctly delimited and demarcated.

- **Transportation types:** Public transportation in this area presents some deficiencies in terms of bus availability. Buses departure towards El Volcan from Parque O'Higgins every day at 12:30 and 18:00 hours. In January and February, buses depart to Baños Morales on a daily basis at 07:15 pm and from March to October only on Saturdays, Sundays and holidays at the same time. With respect to private transportation in tourism, during weekends it is possible to see an increasing number of tourism mini buses and tour buses, from Santiago (mostly) towards the area of Lo Valdés and Baños Morales.

- **Near urban centers:** The town of San Gabriel corresponds to the nearest settlement, as it presents health services, police (Carabineros), telephone and garage, apart from basic tourist services for food, shelter and recreation.

- **Communication level:** There are no public phones and the relief of the place prevents the operation of mobile telephones.

5.6.3 Conclusions

The Project direct influence area has characteristics that indicate its rural setting, highlighting the fact of a low settlement, extensive land occupation, and the concentration of population in some major locations and the relative isolation of some of the locations on the territory of the Municipality of San José de Maipo.

Considering the history of the existing infrastructure in the project area and in relation to sanitary infrastructure, it is possible to note that over 80% of dwells located on the PHAM influence area are connected to the sewer system, otherwise, they feature septic tanks, wells or other solution (as in the case of El Volcán location, which has a partial discharge to the river of the same name).

The supply of drinking water is provided by different sources, mainly the supply delivered by Aguas Andinas and provisioning conducted in some areas through collection made from different mountain streams and springs. The entire municipality territory has electricity and telephone coverage, both mobile and land line (except on high mountain areas). Regarding the water collection works in the Project influence area, it was possible to verify the existence of works on Maipo, Yeso and Volcan rivers, **between the water collection zone at the El Volcan and the Project discharge sector (sector Las Lajas)**.

The local roads within locations present little development, with a smaller number of interconnection paths, and minimal and, in some cases, inexistence of parallel roads to the main road of the area, corresponding to the G-25; it is important to notice that all inner roads are unpaved and strongly affected by winter rains. Public green areas have little development, being restricted to public areas made up of existing central squares in some locations (San Gabriel and El Volcán).

The road infrastructure has limited development, with a structural road (G-25) which connects and provides access to all the populated locations, while stressing the secondary roads G-455 and G-345. These three roads form the road grid that connects and provides access to the different existing locations in the Project influence area. They correspond to roads in fair or good condition, having in common the fact of having two-way paths that (in the case of G-25) collapse with the influx of tourists, mainly on weekends According to traffic measurements performed at major intersections of G-25 Road, three peak times were identified, those with increased vehicular traffic in the urban stretches of the route, falling considerably when entering into the Maipo River Canyon in Las Vizcachas sector. Additionally, there is development of private roads, roads that are used as access to the areas of Lo Encañado Lake and Laguna Negra.

An important feature of the area corresponds to the transport situation in the area, because there is only one line of public transportation service (Metrobus) and three collective taxi lines. These lines have an hourly established frequency, with times of day when there is no public transportation. It is also important to note that Colorado River Canyon (locations of Los Maitenes and El Alfalfal) has no public transportation system.

With regard to economic and productive activities, it can be observed that the economic base of San José de Maipo Municipality lies on farming and cattle, which takes place mainly in the valleys of Maipo and Colorado rivers where the climate and soil favor the generation of pasture, essential for the development of livestock. The extraction of aggregates and non-metallic mining is also important, as well as, the production of drinking and irrigation water, and energy. Finally, consistent with the natural attractions found throughout the municipality, the development of tourism activities is remarkable.

The grazing activities that take place in the agricultural sector are determined by the traditional use made by families of different locations over the territory, distinguishing the presence of livestock in different areas depending on the season (summer pastures and winter pastures).

In the mining sector, extraction activities are related to the exploitation of gypsum and limestone deposits, located mainly in the upper watershed of Volcán and Yeso rivers.

The trade and service sector is developed mainly on both sides of the G-25 Road with a special development in the center of the different populated areas that are located along its route. In isolation along the route G-25, there are trade activities based in local products and/or homemade (homemade bread, pies, cheese), a situation that is repeated on the routes that connect with touristic attractions, such as G-345 (Colorado River) and/or the bifurcation of G-25, which communicates with the El Yeso Pondage area.

In relation to existing equipment in the locations of the Project influence area, it presents evident rural characteristics with limited development on educational equipment (3 elementary schools, one private high school and one special school), health equipment (emphasizing only the existence of one polyclinic and one emergency center) and services (featuring only one CONAF office). Likewise, there is scanty development of sport and recreational public equipment, and private equipment has more relevance.

In relation to tourism, it is possible to note that this activity presents a significant seasonality in the months of September and March, as during the rest of the year weather conditions strongly determine the development of tourism. It is quite possible to distinguish four differentiated sectors corresponding to the development of existing water streams in PHAM area. Indeed, first, in the area of the Colorado River Basin there is intense touristic activity related to observation and touring developed in the middle and lower Colorado River, which is determined by the lack of touristic infrastructure. Access to upper Colorado River is controlled by private, this situation conditions the access to the attractions located in the upper Colorado River. A second area is represented by tourism in the middle of the Maipo River, with the development of tourism infrastructure in existing towns along the route G-25, with ready access most of the year. The third sector of Yeso River is marked by the lack of tourist infrastructure, this situation forces an important portion of tourism in the area to be informal and spontaneous in the same way, the sector does not have a populated area that serves as “center” for the development of tourism activities, while at the same time, is strongly determined by climatic conditions, which sometimes lead to the closure of the route G-455. Finally, the fourth sector, the Volcan River, features the existence of associated tourism infrastructure primarily in Baños Morales, an important tourist sector, in addition, includes the development of spontaneous and informal tourism in the upper Volcano River and its tributaries. Although this sector is also strongly determined by climatic conditions, this situation is mitigated by the support provided by existing mining trucks in Lo Valdes sector, which help to clear the route.

As a general conclusion, it may be noted that while there is little development of equipment and infrastructure at existing locations in the Project influence area, these areas should be sufficient for the existing population at present. However, the development and distribution deficiency is confirmed when observing the distance and difficulties of access to some of the locations to existing equipment. This situation increases when observing tourism development and the considerable potential in this activity. With this situation in mind, municipality and local equipment should be increased in order to strengthen the tourism and thus promote the growth and development of the local economy.

5.7 LAND USE AND LAND USE PLANNING INSTRUMENTS

5.7.1 Current Land Use

5.7.1.1 Introduction

Human activity in the territory leads to different types of land use that vary in intensity, magnitude, and duration, depending on climatic conditions, relief and local topography, among other factors that determine the occupational pattern of a given territory and enable certain activities to be carried out to a greater or lesser degree.

This section presents general information on settlement patterns and land uses in the territories that are within the Project's area of influence, particularly the upper sub basins of the Yeso and Volcán rivers and in the middle reaches of the Colorado and Maipo river sub basins.

In the abovementioned zone, current land uses are markedly determined by geographic conditions and relief features and by the prevailing high altitude climatic conditions, which severely limit human activity in the zone both physically and in regard to access.

5.7.1.2 Methodology

To characterize current land uses in the Project's area of influence the study considered the analysis carried out during the preparation of the San José de Maipo Municipal Development Plan (PLADECO) and information contained in the Environmentally Sustainable Land Use Planning Study (OTAS) prepared for the municipality of San José de Maipo, both of which were carried out in 2002.

The second stage consisted of validating and/or updating this information through field campaigns, thematic mapping and aerial photography.

Primary sources were also consulted (via personal interviews) in order to identify the different types of permanent and temporary land use practiced in the Project's area of influence.

5.7.1.3 Results

The different land uses identified in the Project's area of influence are presented below. The characterization can also be seen in Figures 5.7.1.1 –A, B, C and D-[1].

[1] Figure 5.7.1.1 presents only anthropic uses recognized in the Project's area of influence.

FIGURE 5.7.1.1-A Current Land Use - Upper Volcán River Basin

FIGURE 5.7.1.1-B Current Land Use - Yeso River Valley Sector

FIGURE 5.7.1.1-C Current Land Use - Qda. Aucayes–Colorado River sector

FIGURE 5.7.1.1-D Current Land Use - Las Lajas Tunnel Discharge Sector

A. Residential

The Project's area of influence includes populated areas with different population densities and settlement patterns; thus, occupation is more concentrated in some areas while in others there are only isolated dwellings.

More densely populated areas include the localities of El Canelo and El Manzano, while less densely occupied areas include the villages of El Alfalfal, Los Maitenes, San Gabriel, El Romeral, El Volcán, Lo Valdés and Baños Morales.

Sectors with isolated dwellings can also be identified on the periphery of populated areas and situated along the roads that run to El Yeso reservoir and to Laguna Lo Encañado.

B. Deposits and/or extraction sites

Regarding extraction land use, a distinction can be made between sites used for mineral extraction activities (mines) and those used to extract aggregates.

i. Mining activity

Mining extractive activities are related to the development of gypsum and limestone deposits. In the Project area extractive activities are located primarily in the upper Volcán and Yeso river basin. An area where limestone is extracted has also been recorded in the Colorado River sector.

ii. *Extraction of aggregates*

The main sectors where aggregates are extracted in the Project's area of influence are the south-western sector of Baños Morales, near the village of El Volcán, and northeast of the village of Los Maitenes.

Other aggregate extraction sites near the banks of the Maipo River include sectors adjacent to the villages of Los Queltehues and San Gabriel, the northern sector of San José de Maipo and near the village of El Canelo.

C. Agriculture and Livestock

Agricultural and/or livestock activities have been registered in different sectors of the Project's area of influence but are mainly concentrated between the villages of Los Maitenes and El Alfalfal (Colorado River valley) and around Las Melosas near the confluence of Maipo and Volcán rivers.

A significant portion of the land use for agriculture and livestock is located in the Maipo River valley, most notably between Los Queltehues and San Gabriel, surrounding the town of San José de Maipo, between the village of Guayacán and the confluence of the Colorado and Maipo rivers, and between El Manzano and Las Vertientes.

Agricultural activity is based mainly on the cultivation of annual and perennial crops, grasslands sown on a permanent or rotating basis, and fallow land. The main types of crops grown in the areas and sectors indicated include grains, small- and large-scale vegetable and fruit production, annual and perennial forage, and vineyards. Other agricultural activity includes nurseries, seed production, and forestry

Livestock raised in the territory include bovine cattle, sheep, horses, goats, and, to a lesser extent, hogs and camelids.

It is worth noting the use of seasonal grasslands for smaller livestock, especially at the bottom of ravines and on the floodplains, shores and banks of mountain lakes and streams, in summer pastures (*veranadas*). Included in this category are the Andean meadows associated with the Yeso reservoir and Laguna Lo Encañado, as well as the areas alongside the Morado, Las Placas, and La Engorda and Colina streams. This activity is also practiced in sectors with steep slopes where seasonal grasses grow as a result of topographical and hydrological conditions and solar exposure.

D. Energy infrastructure

A series of hydroelectric plants are located within the municipal territory, taking advantage of the abundant water resources available in the high mountain zone of Metropolitan Santiago.

These are generally located in areas with low population density off public roads, in areas with limited access that can only be arrived at via private roads that are usually owned by the electricity companies themselves.

The table below shows the main hydroelectric plants in the municipality of San José de Maipo.

Table 5.7.1.1
Hydroelectric Plants in the Municipality of San José de Maipo

Plant Name	Capacity (MW)	Location
Volcán Power Plant	13	On the Volcán River, south of the village of Los Queltehues and near the confluence of the Volcán and Maipo rivers
Los Queltehues Power Plant	48.9	On the Volcán River, northeast of the village of Los Queltehues near the confluence of the Volcán and Maipo rivers
Los Maitenes Power Plant	30.8	On the Colorado River, north of the village of Los Maitenes
El Alfalfal Power Plant	178	On the Colorado River, north of the village of El Alfalfal

Source: PRMS, 1994; Muñoz, C.; Orellana, J. (1996)

Installations associated with hydroelectric energy generation in the zone also include transmission lines. These are situated parallel to the principal natural waterways in the area and connect the hydropower plants to Chile's Central Interconnected System (SIC). The main transmission lines follow the course of the Maipo River from the generating plants at Volcán and Queltehues; a further transmission line runs along the Volcán River valley almost to Baños Morales, and other lines run north through the Yeso and Colorado river valleys (to the Alfalfal and Maitenes plants).

E. Commerce

Most commercial land use occurs along both sides of Route G-25 and is especially concentrated in the population centers located along the route. Commercial activities registered include basic commerce (grocery stores, variety stores, take-out shops, stationary stores, liquor stores, bakeries, hardware stores, bars and restaurants, among others), while more specialized services such as pharmacies and drycleaners tend to be located in the center of the town of San José de Maipo.

In addition to the above, along the entire length of Route G-25 there are individual kiosks and shops selling local traditional and/or home-made goods (home-made bread, empanadas). These are also found along the routes that run between the main highway and tourist attractions in the zone, such as Route G-345 (Colorado River) and the bifurcation of Route G-25, Route G-455, which provides access to the area around the Yeso reservoir. The existence of fossil stands in the Volcan River sector should also be noted.[2]

F. Facilities and Services

The main service area in the Project's area of influence is the municipal seat of San José de Maipo, where services available include banks, government and business offices, medical and dental clinics, post offices, notary publics and other services. Given the limited number of inhabitants in the zone, the services offered are basic.

Facilities are also concentrated in the town of San José de Maipo and include a police station (Carabineros), primary health care centers, educational and social service establishments, sports facilities and religious and cultural centers such as churches, museums, libraries and others.

It should also be noted that some basic community facilities are available in other locations in the Project's area of influence, including social centers, sports complexes, neighborhood association headquarters, and community halls.

G. Tourism and Entertainment

The Cajón del Maipo area is generally considered to be a tourist and entertainment zone owing to its proximity to Santiago and beautiful scenery, added to the fact that both getting there and getting around are relatively easy for most of the year (see details in Annex 35).

For these reasons, tourism here is based on "touring and sightseeing" in which visitor's journey around the area, mainly along Route G-25, stopping to observe and enjoy the sights.

Indeed, the banks of the valley's rivers and streams are often occupied by such visitors, especially on weekends. A notable example is the El Manzano sector, where visitors take

[2] Considering the cartographic scale and the distribution of commerce in the Project's area of influence, Figure 5.7.1.1 shows a strip of 50 m on each side of Route G-25, including commercial and tourism uses in the localities of the Project's area of influence. This strip includes the bulk of tourism and commercial activities in the Project's area of influence, which are located alongside the entire length of Route G-25.

advantage of the large natural pools that form on the waterway, especially where the El Manzano stream crosses under Route G-25. In some cases such spontaneous recreational activity is accompanied by camping by visitors occupying the flat areas around the riverbanks. This activity generates a large quantity of waste that becomes a form of visual contamination and also pollutes the existing waterways. Upstream from where Route G25 crosses over El Manzano stream there is a private campground that includes a trail network. Beyond El Manzano, the same activities are replicated in the natural pools and ponds that are found at higher altitudes around the Volcán, Colorado, Yeso and Maipo rivers. It should be noted that the difficulty of accessing these sectors, both in terms of access routes and physical expenditure, means that these sectors are used less, and mainly by skilled outdoor enthusiasts or individuals familiar with the area who tend to be more environmentally aware and therefore produce less waste than sporadic visitors.

Another tourist hub is the area known as Cascada de Las Ánimas, near the village of San Alfonso. This zone offers hiking and excursions on horseback along trails that run through a private estate, as well as rafting along the Maipo River.

Tourism activities are also offered in the areas surrounding the Yeso reservoir and Baños Morales and consist mainly of trekking, excursions on horseback, and contemplative activities, as well as canoeing. Trekking also occurs upstream of Route G25 into the interior of El Manzano valley.

The areas around the Volcán and Yeso rivers also contain some unmaintained walking trails that visitors use for hiking and nature appreciation. This area has no tourism infrastructure or facilities (scenic lookouts, signage, roadside rest stops, and campgrounds) and tourism is mainly informal, consisting of small groups that visit here in spring and summer.

Near Laguna Lo Encañado, where access is controlled (along a private road owned by Aguas Andinas), there is no tourism activity.

Tourism registered for the Colorado River sector includes touring and sightseeing, despite the lack tourism infrastructure and facilities in the zone. These activities are practiced along Route G-345, which is in good condition.[3]

5.7.2 Current and Forthcoming Planning Instruments

The PHAM is located in the municipality of San José de Maipo, in the southeastern sector of the Santiago basin within Cordillera Province. The territory is governed by a series of planning instruments that define permitted and unpermitted land uses on the one hand and environmental protection requirements on the other.

5.7.2.1 Land Use Planning Instruments

A. Santiago Metropolitan Master Plan

[3] Considering the cartographic scale, the existence and location of tourist attractions, and the main tourist circuits and access routes, Figure 5.7.1.1 displays a 500m strip along the main access routes, trails and tourist circuits, which together represent tourism usage in the Project's area of influence.

The Santiago Metropolitan Master Plan (Plan Regulador Metropolitano de Santiago, PRMS) defines two macro areas for the purpose of guiding the urban development process:

- Urban Metropolitan Area
- Area of Limited or No Urban Development

The **Metropolitan Urban Area** corresponds to the territory within the **Urban Boundary** that, owing to it capacity, has been set aside to accommodate the growth of the urban population and its activities up to 2020. This area consists of the urbanized area of Metropolitan Santiago and the built up zones of municipalities included in the present plan. In the case of San José de Maipo municipality, the areas inside the current urban boundaries are considered urbanized areas.

An **Area of Limited or No Urban Development** is understood as lands within municipalities included in the Plan that have not been defined as Metropolitan Urban Areas and in which only those urban activities expressly indicated in Title 8 of the Ordinance are acceptable.

The abovementioned Title provides that any constructions and/or buildings set up for purposes other than those defined for any Area with Limited or No Urban Development must be authorized by the Metropolitan Region Secretariat of the Ministry of Housing and Urbanism, which may grant authorization after consulting with the corresponding public agencies. In the specific case of Areas of Natural Value and/or Areas of Agricultural and/or Livestock Interest, a prior report of approval must be issued by the Regional Secretariat of the Ministry of Agriculture.

The Project is situated in the municipality of San José de Maipo, for which the following planning areas have been defined (specific zones are underlined). See Figure 5.7.2.1

- Urban Metropolitan Area
    - <u>Mixed Residential Areas</u>
- Area of Limited or No Urban Development
    - Areas of high risk to human settlement
        - Areas of natural risk
            - From flooding:
                - <u>Ravines</u>
            - From rockslides and soil subsidence
            - From excavation and mining activities
            - Areas of geophysical risk associated with natural events
                - <u>Areas of risk associated with landslides</u>
        - Areas at risk from hazardous activities
    - Areas of natural value and/or agricultural and/or livestock interest
        - <u>Areas of ecological preservation</u> (preservation of snow resources, protection of water sources, protected wilderness areas)
        - <u>Areas of ecological preservation with controlled development</u>
    - Areas safeguarding Metropolitan infrastructure
        - <u>Safeguarding sanitation infrastructure</u>
        - <u>Safeguarding energy infrastructure</u>

Figure 5.7.2.1. Santiago Metropolitan Master Plan

The sections below describe the features of each type of zone identified in the municipal territory:

i. Urban Metropolitan Area: Mixed Residential Area

This corresponds to the Urban Metropolitan Area territory in which the following activities are permitted: residential use, facilities, production and storage of inoffensive goods, and infrastructure and transportation. Notwithstanding the above, the provisions of Title 8 of the abovementioned Ordinance must be adhered to, respecting the limits to urban development set out for areas described in Article 8.2.1.

Corresponding to areas within the Urban Boundaries currently in place for the municipal territory.

ii. Area with Limited or No Urban Development with high risk to human settlements

Risk-prone areas are generally territories with features that require human settlements to be partially limited or prohibited.

- *Areas of natural risk associated with ravines*

Constructions and urban developments that are to be located in ravines must first have studies and plans approved by the corresponding public authorities that ensure normal water runoff and the protection of slopes and ravine walls, before municipal permission can be granted. Likewise, municipal permission shall only be granted once the works associated with the above mentioned plans have been found to be acceptable.

In addition, in the resulting restricted zones the only permitted uses shall be green spaces and/or sports and recreational–tourism activities with the minimum complementary installations, and outdoor activities that do not involve high concentrations or the prolonged presence of people.

For the purposes of this Plan, ravine areas shall include the watercourses themselves and adjacent bands of land delimited by lines parallel to each bank, as indicated below:

In the Cajón del Maipo sector, in the ravines illustrated in plan RM-PRM-92-1-B, according to the General Ordinance of the PRMS, a protective strip at least 40 m wide is established, measured from the respective bank.

The water intakes, river defenses and siphons to be used in the PHAM are planned for this zone.

- *Areas of geophysical risk associated with slides*

These are areas in which massive slides of material could occur such as avalanches, mudslides, rockslides, landslips, rock falls, or detachments of other material due to seismic activity, rainfall, snow load and/or melt water, or increased runoff through ravines.

In such areas the only permitted activities are forestation and outdoor recreation, with the minimum complementary installations. Any outdoor activities practiced must not involve high concentrations or the prolonged presence of people.

Installations may not alter the landscape or interfere with the natural runoff of water in streams and/or ravines.

No installations or constructions of any kind are permitted in lands adjacent to streams at a distance of less than 40 meters from each bank, and greater buffer zones are established in certain cases.

For the municipality of San José de Maipo the following areas have been identified:

1. La Obra
2. Quebrada El Añil
3. Quebrada La Buitrera / Colorado River
4. Quebrada Guayacán
5. Quebrada El Almendro / Guayacán
6. San José de Maipo
7. Lagunillas
8. Estero San José
9. San Alfonso
10. El Ingenio
11. San Gabriel
12. Quebrada Las Amarillas

iii. Area of Limited or No Urban Development, Natural Value: Areas of ecological preservation

These are areas that are kept in their natural state to safeguard and contribute to the natural balance and environmental quality and to preserve the landscape heritage.

<u>These zones include the upper sectors of water basins and micro basins; water reservoirs and natural waterways; snow preserves set aside for preservation both as a source of potable water and to prevent construction on ski hills; mountain summits and rock towers; flora enclaves and fauna refuges; and the above-cited landscape components.</u>

This zone has a variety of sites classified as Protected Wilderness Areas that are included in this category, each with their applicable legislative provisions. These include National Parks, National Reserves, Areas Complementary to Protected Wilderness Areas and that correspond to Nature Sanctuaries, Areas of Scientific Interest, and generally all areas currently classified as Natural Reserves, Natural Monuments, and Protected Areas.

Within these areas the only permitted activities are those that safeguard their natural value, and as such land uses are limited to the following: scientific, cultural, educational, recreational, sports and tourism, with the minimum buildings and/or installations required to allow those activities.

The legal provisions governing these activities and their complementary uses such as safety and communications equipment, health, commerce and public parking, shall be defined by the Metropolitan Region Secretariat of the Ministry of Housing and Urbanism on a case by case basis, taking into account the specific features of the site and pertinent studies approved by the corresponding authorities.

Project approval shall in any case depend on the assessment and approval by the corresponding official agencies of an Environmental Impact Study, to be submitted by the interested party.

Agricultural, livestock and forestry activities may be carried out in a controlled manner, with conditions set out by the applicable authorities through plans approved by those services. These plans must include controlling and monitoring systems for approval to be granted.

In these limited use areas the Project envisions the construction of roads, canals and spoil heaps from tunnel boring.

iv. Area of Limited or No Urban Development, Natural Value: Areas of Ecological Protection with Controlled Development (P.E.D.C.)

These are areas in which agricultural, livestock and/or forestry activities are permitted as well as certain urban activities, provided that the natural environment is preserved and interventions that occur contribute to improving environmental quality and/or increasing landscape value.

The following requirements must be met in order to obtain approval for projects in these areas that include urban activities:

a. The entire project implemented in the area or areas must include tree planting on no less than 25% of the entire area with native and exotic species, as set out in the project approved by the respective Ministry of Agriculture agency.

b. Where the placement of the planned project involves cutting of trees, these must be replaced on the same land with double the number of tree species that were cut, notwithstanding the abovementioned 25% forestation provision.

c. The cutting of trees must be carried out in accordance with all applicable legal provisions currently in force.

d. Installations, buildings and/or trees planted must not alter the natural runoff of water from the streams and ravines involved.

e. No installations or constructions of any kind are permitted less than 40 m from the respective bank of the waterway.

f. Projects implemented in such areas must include soil control and conservation measures for existing gullies and any other relief features. For this purpose a corresponding report issued by the pertinent authority or service shall be required. Similar precautions must be included for steep slopes and any interventions that deteriorate soil, water, flora and/or fauna resources.

g. One dwelling per property is permitted. A caretaker's dwelling may be built on the same property provided that it meets the social housing specifications set out in Articles 7.1.2 and 7.1.4. of the General Urbanism and Construction Ordinance.

In PEDC areas of the Cajon del Maipo the following activities may be carried out under the conditions established by the respective authorities:

- Intensive agriculture
- Forestation
- Reforestation with native and exotic species
- Extensive livestock raising and pastoral activity

Other permitted uses must meet the following technical-urban specifications:

Table 5.7.2.1
Technical Urban Specifications in force for
Areas of Ecological Protection with Controlled Development (P.E.D.C.)

Permitted Use	Minimum Property Size (ha)	Coefficient for Maximum Area Constructed
Agri-residential lots	4.0	0.02
Green space, sporting and recreation, scientific and cultural facilities	4.0	0.02
Tourism and entertainment, health and religion	4.0	0.02

Source: Art. 8.3.1.2, Ordenanza PRMS, August 2002.

In this area the Project includes the construction of roads, water discharge works and the Las Lajas Power Plant Command building.

v. Area of Limited or No Urban Development, Safeguarding Metropolitan Infrastructure

– *Safeguarding sanitation infrastructure: Sources of potable water and potable water treatment plants*

These include:

- Laguna Negra
- El Yeso Reservoir
- Laguna del Encañado

Permitted activities and extractive activities occurring in the defined and graphed protected area (in plan RM-PRM-92-1-B, under the General Ordinance of the PRMS) require a specific environmental impact study before being approved.

The Project includes the use of water from the El Yeso reservoir.

– *Safeguarding sanitation infrastructure: Aqueducts*

This corresponds to the strips of land bordering aqueducts and that constitute rights of way for those aqueducts. The use and delimitation of these lands must be in accordance with the provisions of the Water Code (DFL N° 1.122 of 1981 of the Ministry of Justice). The following aqueducts are included in this category:

- Laguna Negra Aqueducts
- Second Laguna Negra Aqueduct

The Project does not include works in this protected zone.

– *Safeguarding energy infrastructure: Electricity substations and transmission lines*

The entire perimeter of these must have a 20 m wide band of trees. In this zone, only works and installations directly related to the operation of the abovementioned works are permitted.

B. Municipal Master Plan

The San José de Maipo Municipal Master Plan is currently being updated.

5.7.2.2 Environmental Protection Instruments

A. Biodiversity Conservation Strategy for the Metropolitan Region of Santiago

This instrument is fundamental to the future conservation and sustainable use of the region's diverse flora and fauna. It originated in Chile's ratification of the International Convention on Biological Diversity in 1994, the Government's Environmental Agenda for 2002–2006, and the National Biodiversity Conservation Strategy approved by the CONAMA Ministerial Council in 2003.

The Regional Strategy sets out the official framework for the conservation of 23 priority sites with a combined area of 1,076,149 hectares that contain a wealth of natural heritage that requires protection. These sites are:

1. Cantillana Mountain Chain
2. El Roble
3. Alto Maipo River Basin
4. El Morado
5. Olivares and Colorado rivers, Tupungato
6. Batuco Wetlands
7. Andean Foothills
8. El Yali Ravine Basin
9. Clarillo River
10. Andean Highlands
11. Southern Border Corridor (Angostura
12. Chacabuco-Peldehue
13. Fundo Huechún
14. Maphco River Basin Highlands
15. Colina-Lo Barnechea
16. Mallarauco
17. San Pedro Northeast
18. Cerro Lonquén
19. Cerro Águilas
20. Melipilla-San Antonio Mountains
21. Las Lomas-Cerro Pelucón
22. Altos de Jahuel-Huelquén Mountains
23. Cerro Chena

Of these 23 sites, five are linked in some way to the municipal territory. As Figure 5.7.2.2 shows, a large portion of the municipal territory of San José de Maipo is included within the Biodiversity Conservation Strategy.

Figure 5.7.2.2
Priority Sites of the Metropolitan Region of Santiago

The priority sites represented in the municipality of San José de Maipo are:

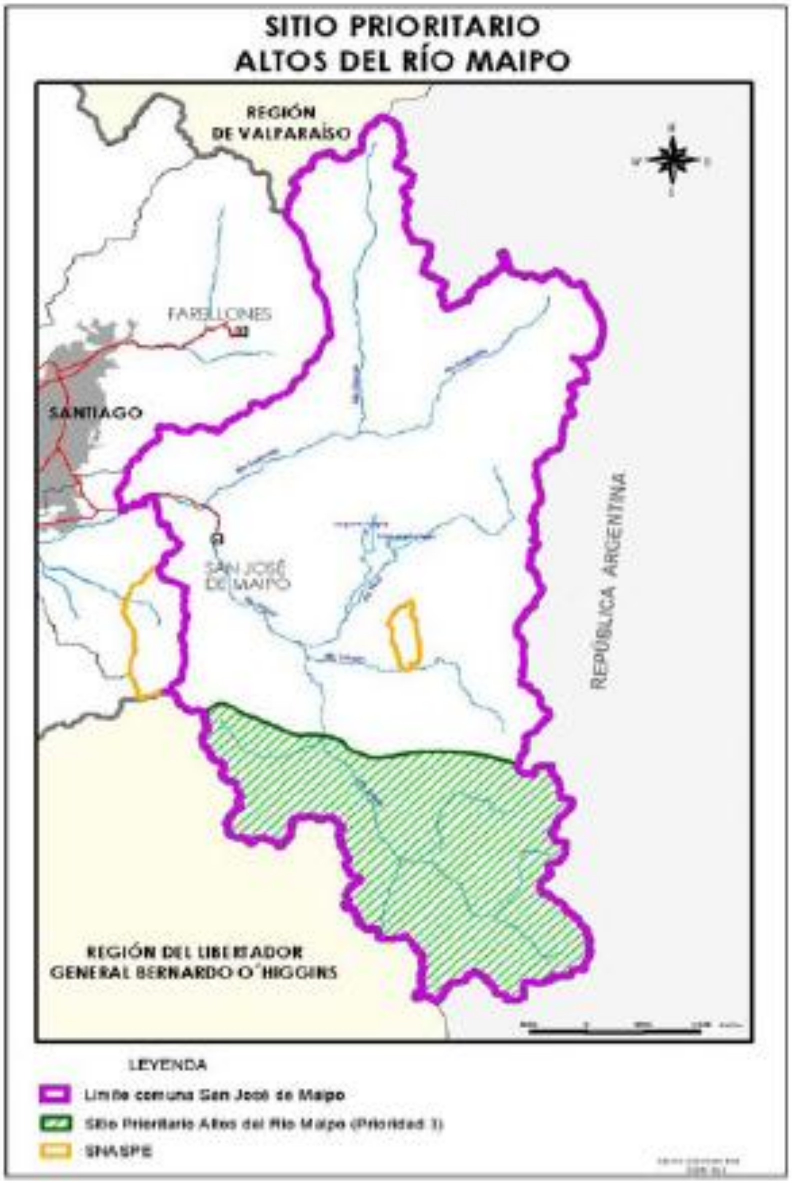
- **Nº 3 Upper Maipo River:** This site covers 126,622 ha in the southern sector of San José de Maipo municipality.
- **Nº 4 El Morado:** This site covers 141,827 ha in the center of San José de Maipo municipality and in the far eastern sectors of La Florida and Peñalolén municipalities.
- **Nº 5 Olivares and Colorado rivers, Tupungato** This site covers 110,438 ha in the northern sector of San José de Maipo municipality.
- **Nº 9 Clarillo River: This site covers 62,346 ha and covers the western part of San José de Maipo municipality, the eastern sector of Pirque municipality, and the eastern edge of the municipality of Paine.**
- **Nº 10 Andean Highlands Zone: This site covers 83,366 ha in the eastern sector of San José de Maipo municipality that borders Argentina.**

As the above descriptions show, sites 3, 4, 5 and 10 are located in the Project's area of influence; each of these will therefore be described in greater detail below.

Priority Site Nº 3 - Upper Maipo River Basin

This site is located in the upper third of the Maipo River basin in the southern sector of the Andes Power Plant, and covers 126,622 ha in the southern portion of San José de Maipo municipality.

Figure 5.7.2.3
Priority Site Nº 3 - Upper Maipo River Basin



In regard to protection instruments, this site is classified as an area of ecological preservation under the Santiago Metropolitan Master Plan and is within the "no hunting" zone of Santiago Andino.

It is a crucial site for the protection of high altitude ravine and wetland microhabitats that are unique ecosystems with high faunistic value.

The predominant plant formation is High Andean Steppe of Santiago, and the site accounts for 65% of the area covered by this formation in the Region. This formation currently has a good conservation status that is related to the lack of pressure from anthropic activity in the zone. The site also contains 5% of the region's Andean Sclerophyllous Forest formation.

The site is a major corridor for animal species moving between Chile and Argentina, such as *Puma concolor* (Puma) and *Lama guanicoe* (Guanaco), which are endangered, and *Bolborhynchus aurifrons* (mountain parrot).

In regard to aquatic communities, this is one of the sites with the greatest wealth of benthonic macro invertebrates in the Maipo River.

The principal threats here include:

- Unregulated cattle driving activities
- Risk of toxic spills into water bodies from human activity in the area.

Site Nº 4 El Morado:

This site covers 141,827 ha and involves the sub basins of the Yeso, Volcán and Colorado rivers in the central zone of San José de Maipo municipality. It includes the El Volcán sector as well as El Morado Natural Monument, with two water bodies of regional importance–the El Yeso reservoir and Laguna Negra.

The area of the site above 1000m in altitude is classified as an area of ecological preservation under the Santiago Metropolitan Master Plan and is within the Santiago Andino “no hunting” zone.

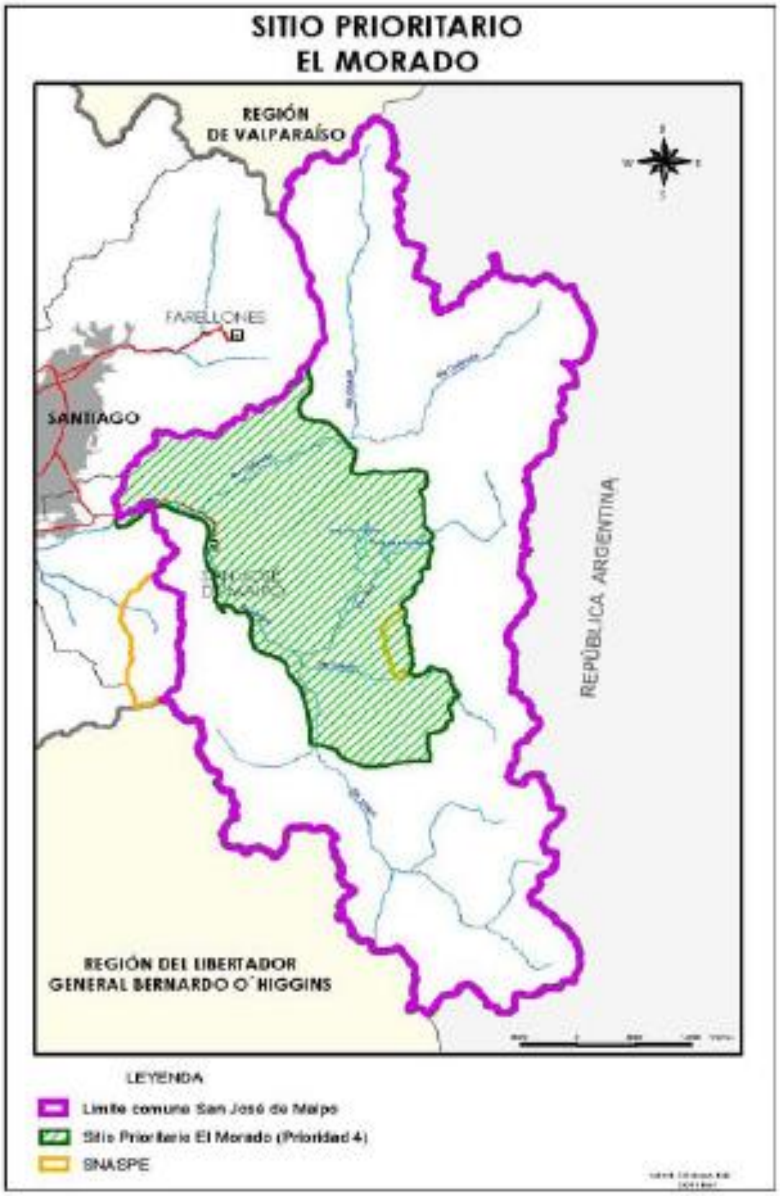
It is a crucial site for the protection of high mountain ravine and wetland microhabitats.

In regard to aquatic communities, this site has the greatest wealth of benthonic macro invertebrates in the Maipo River. It is also recognized for the value of El Morado Natural Monument.

It is also a globally important site for the diversity of its reptile species, notably the presence of *Pristidactylus volcanensis* (Gruñidor El Volcán), a lizard that is endemic to the Metropolitan Region and is currently classified as endangered.

The zone is highly diverse in terms of flora and fauna, with many endemic and threatened species.

Figure 5.7.2.4
Priority Site Nº 4 - El Morado



The sector of San Gabriel is a major corridor for animal species moving between Chile and Argentina, such as *Lama guanicoe huanacus* (guanaco) in the central zone. This species is currently endangered in the Metropolitan Region of Santiago. Other notable features include a stand of *Austrocedrus chilensis* (Mountain Cypress), which contains trees more than 2000 years old, and the high mountain wetlands, which are of great faunistic interest. Another relevant feature of the zone is the confluence of major sub basins, such as that of the Yeso and Volcán rivers.

The predominant plant formations here correspond to high Andean Steppe of Santiago at the highest altitudes, and Andean Sclerophyllous Forest, which contain mainly *Lithraea caustica* (Litre) and *Quillaja saponaria* (Quillay) species. The site accounts for 20% of the Andean Sclerophyllous Forest found in the region and 6% of its High Andean Steppe.

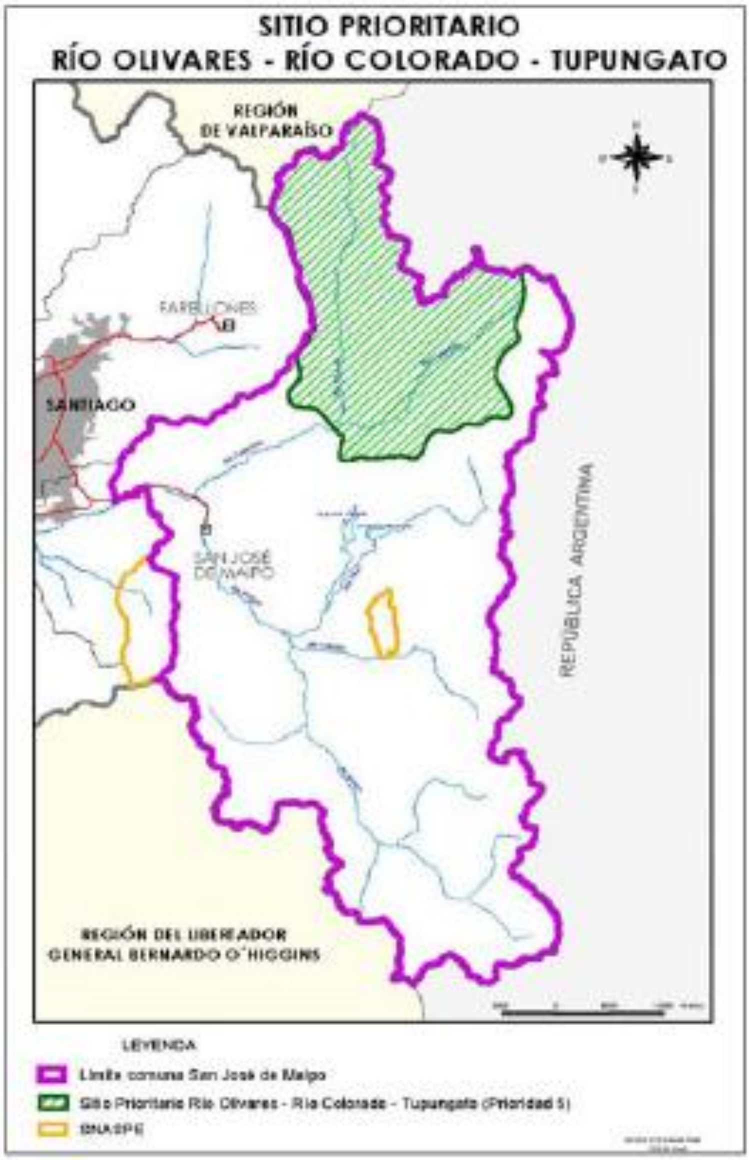
The principal threats here include:

- Intense human activity, which has increased gradually as the built up area of Santiago has expanded
- Unregulated cattle driving activities
- Unregulated nomadic pastoral activity
- Highly vulnerable water resources
- Extraction of endemic flora
- Intense mining activity (gypsum, limestone and copper) with possible discharges into water basins
- Habitat fragmentation
- Extraction of aggregates

Site Nº 5 - Olivares and Colorado rivers, Tupungato

This site covers 110,438 ha in the northern sector of the municipality of San José de Maipo.

Figure 5.7.2.5
Priority Site Nº 5 - Olivares and Colorado rivers, Tupungato



In regard to legal protection instruments, this site is classified as an area of ecological preservation under the Santiago Metropolitan Master Plan and is within the "no hunting" zone of Santiago Andino.

It is a highly important site for the protection high mountain ravine and wetland microhabitats. The zone features a large variety of habitats, including streams, canyons, mountain chains and glaciers, and is also a crucial site for the protection of the region's water resources, which enhances its biological wealth. Difficult access has kept the area in a highly natural state that benefits the Andean flora and fauna found there.

Its predominant plant formations are High Andean Steppe of Santiago (with 17% of all area covered by this formation in the region) and Andean Sclerophyllous Forest (with 5% of the region's total). Notable plant species include *Guindilia trinervis* (Guindillo), *Haploppapus canescens* (Hierba del chivato), *Puya berteroriana* (Chagual), *and Maytenus boaria* (Maitén) and *Quillaja saponaria* (Quillay).

The principal threats here include:

- Forestry, mainly the extraction of *Laretia acaulis* for firewood, as it has a high wood heat value
- Collection, extraction and sale of native and endemic flora
- Hunting, capture and sale of threatened and endangered animals
- Overgrazing of Andean meadows and natural grasslands
- Unregulated tourism
- Extraction of aggregates from waterways and alluvial terraces
- Mining activity with weak control and enforcement

Priority Site Nº 10 – Andean Highland Zone

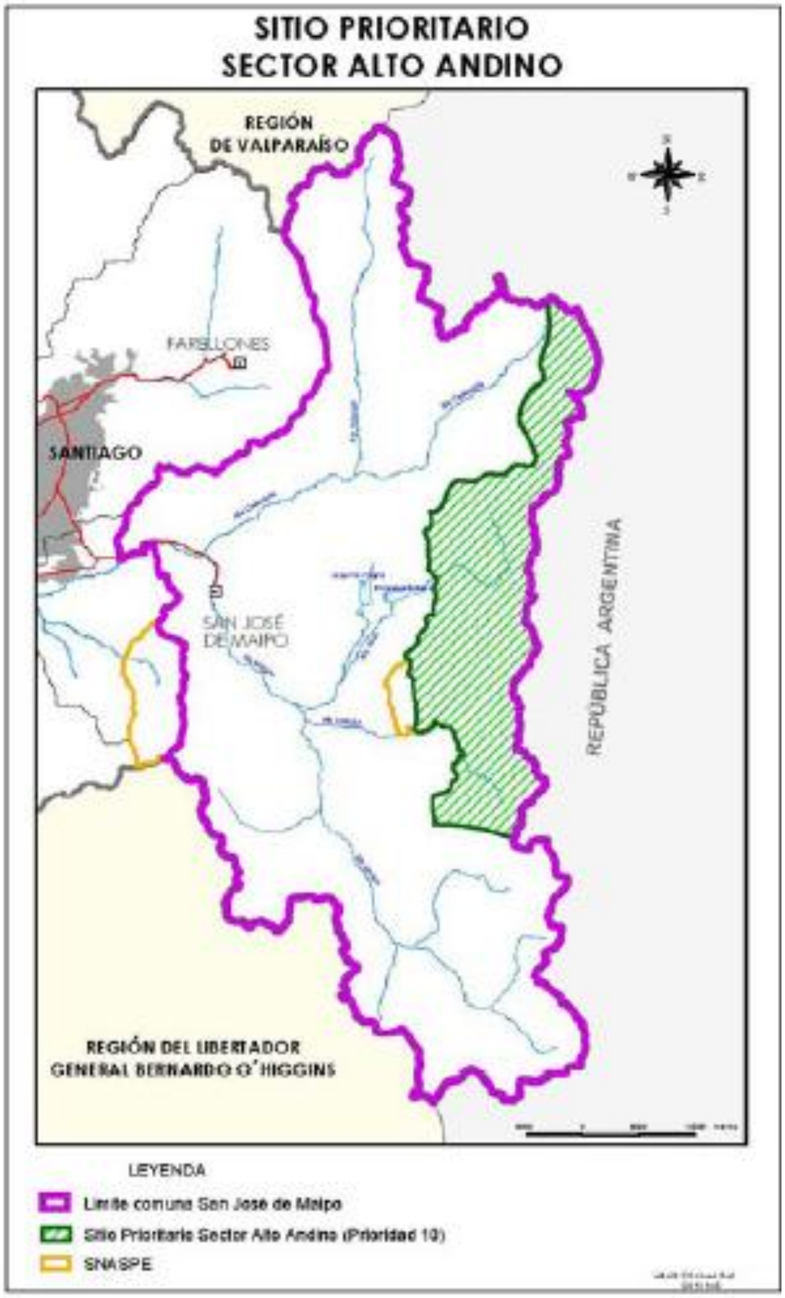
This site covers an area of 83,366 ha in the eastern sector of San José de Maipo municipality that borders Argentina.

The entire site is classified as an area of ecological preservation under the Santiago Metropolitan Master Plan.

It is a very important site for the protection of high mountain ravine and wetland microhabitats and is notable for the large number of glaciers it contains, which ensure the region's water supply in dry periods. It is also considered a biological corridor as it connects the headwaters of the Mapocho and Maipo rivers.

Endangered species present here include *Puma concolor* (Puma) and *Lama guanicoe* (Guanaco), while vulnerable species include *Vultur gryphus* (Condor), which ranges over Chilean and Argentinean territory.

Figure 5.7.2.6
Priority Site Nº 10 – Andean Highland Zone



The site's main plant formation is High Andean Steppe, characterized by spiny bush species such as *Chuquiraga oppositifolia* (Chuquiraga), *Mulinum spinosum* (neneo), *Berberis empetrifolia* (Zarcilla), *Azorella madreporica* (Llareta) and *Laretia acaulis* (Llaretita). It also contains High Andean Sclerophyllous Scrubland.

Lastly, it should be noted that in 2005, CONAMA RM approved plans of action for the 2005–2010 period for seven of the 23 priority sites identified in the Biodiversity Conservation Strategy, including the 4 priority sites that fall within the PHAM area of influence: Upper Maipo River, El Morado, Olivares and Colorado rivers and Tupungato, and the Andean Highlands Sector.

B. Santiago Andino Protection Zone

Exempt Decree 693 of 2003 establishes a 30-year conservation period for 661,057 hectares of territory in the mountainous zone of the Metropolitan Region's Santiago and Cordillera provinces (Figure 5.7.2.7). The decree protects fauna species present in the natural environments of the Colorado, Yeso, Volcán, Maipo, San Francisco, and Molina basins and those of their affluents, as well as the flora and fauna habitats of the Andean Sclerophyllous Forest, highland meadows and steppes, and relic stands of Mountain Cypress (Ciprés de la Cordillera).

Figure 5.7.2.7
Santiago Andino Protection Zone

The existence of 4 priority sites within the territory of San José de Maipo municipality (sites 3, 4, 5 and 10) led to the formulation of an integrated Plan of Action that covers all four sites. This Plan, the **"Santiago Andino Plan of Action,"** includes two initiatives currently under development—the Santiago Andino Project and the San José de Maipo Tourism Zone, which are described below.

1. Santiago Andino Project:

This public-private initiative is officially named **"Santiago Andino: For the Protection of Threatened High Andean Ecosystems and Species of Global Importance in the Central Andes of the Metropolitan Region."** The project is being organized by the Metropolitan Region Agriculture and Livestock Service (SAG RM), the Metropolitan Region National Forestry Service (CONAF RM), Fundación Chile Sustentable and Fundación Sociedades Sustentables. Its objective is to <u>conserve, restore and protect *in situ* high mountain ecosystems of the Central Chilean Andes</u> of global importance that are currently threatened. These ecosystems include formations of Andean Mediterranean Forest and Scrubland as well as High Andean Steppe.

To date, the project's main achievements and activities have been:

- A public-private agreement signed between the Metropolitan Region Agriculture and Livestock Service (SAG RMS) and the Chilean Army to established a context for coordination and cooperation between the two entities to help protect and preserve the renewable natural resources and biodiversity within the "Río Colorado" property
- A public-private agreement signed by ten property owners (CORFO, CONAF RMS, the Metropolitan Region Secretariat (SEREMI) of the National Property Ministry, Chile Deportes, the Chilean Army and five private entities) that is aimed at increasing legal protections to enhance biodiversity conversation in the Project area
- Installation of a Wild Fauna Rehabilitation Center in the Cascada Las Ánimas estate, located within Priority Site Nº 4 identified in the Biodiversity Conservation Strategy for the Metropolitan Region of Santiago
- Implementation of soil restoration plans for two private properties (Fundo Lagunilla and Cascada las Ánimas)
- Study to develop a property management plan for sustainable livestock raising in Fundo Lagunilla
- Compilation of scientific, environmental, social and economic information on the area
- Declaration of a "No Hunting Zone" in the territory included in the Santiago Andino Plan of Action
- Training courses for hunting enforcement officers
- Installation of signage in key areas of the territory
- Creation of a webpage to disseminate the project

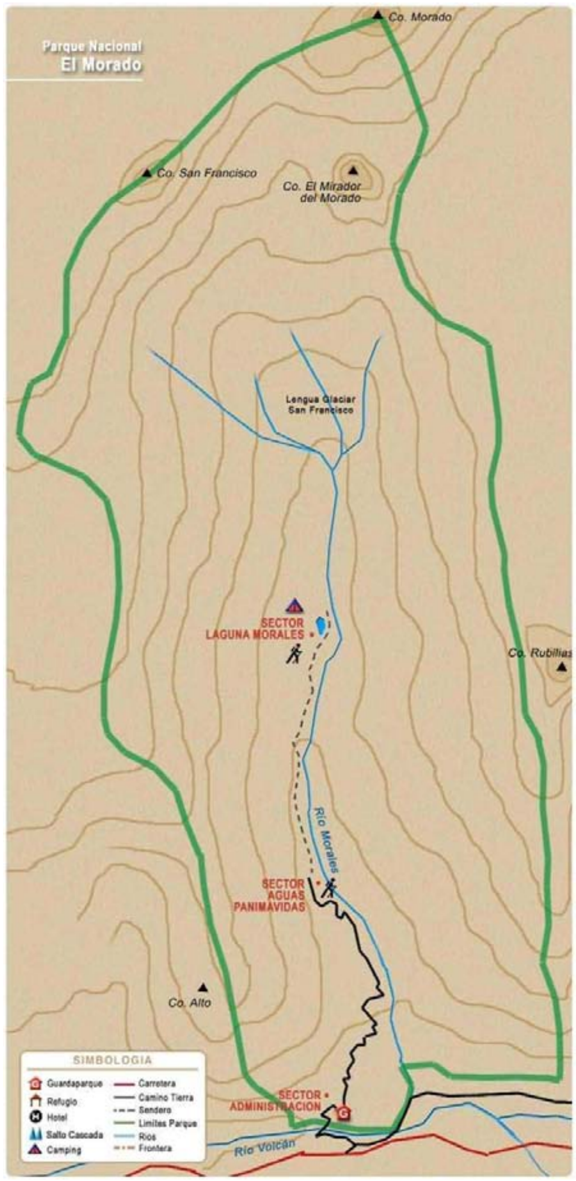
C. El Morado Natural Monument

El Morado Natural Monument is characterized by the presence of native flora and fauna species. Its aim is to preserve the natural, cultural and scenic environment and, where compatible with this objective, to carry out educational, recreational and research activities.

The site was declared a Natural Monument on July 19, 1974 through Ministry of Agriculture Supreme Decree 162, which established "El Morado National Tourism Park" on the public lands within Quebrada de El Morado water basin, located between the spurs of Cerro El Morado.

El Morado National Tourism Park was reclassified as El Morado Natural Monument under Ministry of Public Property Supreme Decree 2.581, published in the official gazette on September 16, 1995. Today, the Monument covers an area of 3009 ha (Figure 5.7.2.8).

Figure 5.7.2.8
El Morado Natural Monument



D. San Francisco de Lagunillas and Quillayal Nature Sanctuary

Ministry of Education Supreme Decree 775, enacted on April 8, 2008, declared the properties of San Francisco de Lagunillas and Quillayala, located in San José de Maipo municipality, Cordillera Province, Metropolitan Region, as a “Nature Sanctuary.”

This protected area covers approximately 13,426 hectares of mountain ecosystem with two ecoregions: High Andean Sclerophyllous Scrubland and Forest and High Andean Steppe These ecoregions are reservoirs of a significant variety of the national biodiversity and are within the geographic area that sustains a major part of Central Chile’s biodiversity, containing a significant array of native flora and fauna that includes some endemic species.

The borders of the Sanctuary trace a polygon through a series of landmarks, as follows: El Manantial y Luncito, Quebrada El Almendro, Vertientes Potrerillos and Quebrada El Guayacán, Meseta Bollenar and Morro Quillayal, Loma La Greda, then descending to the Colorado River and continuing along its course to Quebrada el Buitre and Paico, then rising to the summit of Cerro Morado.

The outline continues to Morro La Tinaja then drops down to Loma La Vela to Panteón, passing by Cerro La Tinaja, Morro La Hoya, Portillo Ojos de Agua and Punta Sattle, Morro Bayo, along the summit of Morro La Tetona then to Portezuelo El Pedernalillo, with peaks of 3430 and 3870 m, to Cerro Piuquencillo, at 3686m and at 3429 m, Cerrilladas de Piuquencillos, Portezuelo Los Peladeros, to the 3408 m summit of Cerro San Lorenzo, then running east along Quebrada La Calchona, between Quebrada La Calchona and Quebrada Bolsico, continuing to Estero la Calchona above Melocotón Alto, through Quebrada Melocotón, across Cerro Puntilla Licán to Estero San José and Estero El Sauce, by Puente Blanco, then continuing up Camino Lagunillas to the Sitio Fiscal, then rising up the slope to Cerro Divisadero.

5.7.2.3 San José de Maipo Tourism Zone (Zona de Interés Turístico, ZOIT)

According to Article 11º of Law Decree 1.224, dated 1975, which establishes the National Tourism Service: “The areas of the territory that are especially attractive for tourism may be declared National Tourism Zones or Centers.”

The municipality of San José de Maipo was declared a Tourism Zone in 2001. As such it is subject to the provisions of the Resolution declaring National Tourism Zones or Centers, namely that all activities in the zone that affect its conservation, all urbanization, all services and facilities required for tourism use must be carried out in accordance with the corresponding Land Use Plan prepared by the National Tourism Service in coordination with the corresponding public entities and services. These Plans must be established in a Supreme Decree drafted by the National Tourism Service and published in the Official Gazette. In the case of San José de Maipo municipality, this plan has not yet been formulated.

In the context of the San José de Maipo Tourism Zone (ZOIT), a Multisectoral Council was formed to draft a Tourism Land Use Plan (PLOT). The council members include representatives from Metropolitan Region offices of the Agriculture and Livestock Service (SAG RM), the National Environmental Commission (CONAMA RM), and the Ministry of

Housing and Urbanism (SEREMI de Vivienda y Urbanismo), as well as from the Metropolitan Santiago Regional Government (GORE RM), Fundación Chile Sustentable, the National Tourism Service and the Municipality of San José de Maipo.

A. Olivares River – Gran Salto Heritage Route

i. General Information

The Olivares River – Gran Salto Heritage Route is part of the “Rutas Patrimoniales” (Heritage Routes) program created by the Ministry of National Property. The program was established to develop and preserve public lands and national property designated for public use in remote places that have a high natural, scenic, historic and/or cultural value. The program seeks to achieve this aim by creating circuits that can be completed on foot, bicycle and horseback for the purpose of valuing and preserving, expanding and improving their usage through outdoor and recreational activities.

Under the program’s objectives, heritage routes provide access to relatively unknown territories or local cultures while contributing to the development and dissemination of local identities. As public property they encourage the development and diversification of small and medium sized local and regional enterprises while boosting sustainable tourism.

Each Heritage Route includes low-impact signage and has a guide with essential information about the route itself, localities along it, and area landmarks. Using this material, visitors can enjoy safe self-guided tours of some of the most spectacular places in the territory.

ii. General Description of the Route

The Olivares River Heritage Route is located 86 km northeast of Santiago. Access to the area is along Route G-345 to the village of El Alfalfal, and from there along a limited access road controlled by GENER S.A. Prior permission must be obtained from the Ministry of National Property. After registering at the checkpoint, visitors follow the two-lane gravel road on the northern bank of the Colorado River for 7 km until reaching the first crossroads, taking the left hand road to the access point for the Olivares River valley. From here, visitors continue a further 12 km to the north (gaining 400 m in altitude) along a single lane road that runs alongside the Olivares River until reaching the water intake on the Olivares River at the Olivares Substation, owned by GENER S.A.

The Olivares River Heritage Route departs along the small trail that runs to the left just before the Olivares Substation. The 27 km route follows old trails used historically for mining, cattle driving and hunting. This mountain route offers high Andean scenery including rock towers, Andean meadows, waterfalls, glacial evidence and moraines, while condors fly above.

The route is divided into 4 segments that are well signed to indicate points of interest and guide visitors along the route, for a safe, self-guided visit.

5.7.3 Conclusions

Considering the rural nature of the zone and the predominantly mountainous relief of the Project area, where the population is limited to occupations on the terraces of the zone's main waterways, it can be affirmed that the main land use in the PHAM area of influence is "**No Defined Use.**"

At the same time, specific zones include recognized land uses such as **residential**, in the main localities identified in the Project's area of influence. These localities usually include a more densely inhabited town center and isolated dwellings on the periphery or between centers. Another notable use in the area is **mining** (mainly in the area of the Volcán and Yeso rivers), which is characteristic in the area located east of the villages of San Gabriel and El Romeral.

One use that is important for the local economy is **agriculture and livestock activity**, which is commonly practiced near the area's main waterways. Agriculture and livestock activity consists mainly of cultivation of annual and perennial crops, grasslands sown on a permanent or rotating basis, and fallow land. The main types of crops grown in the sector include grains, small- and large-scale vegetables and fruits, annual and perennial forage, and vineyards. Other agricultural activities include nurseries, seed production, and forestry. Livestock species raised in the territory include bovine cattle, sheep, hogs, horses, goats and camelids. It is worth noting the use of seasonal grasslands for smaller livestock, especially at the bottom of ravines and on the floodplains, shores and banks of mountain lakes and creeks, in "summer pastures" (*veranadas*). Included in this category are the Andean meadows associated with the Yeso reservoir and Laguna Lo Encañado, as well as the area alongside the Morado, Las Placas, and La Engorda and Colina streams.

Land is also used for existing **energy infrastructure**, especially around Los Maitenes and El Alfalfal. The study also registered commercial land use in the area, mainly alongside Route G-25, with more intense commercial activity at the center of more densely populated localities along that route.

One growing land use is **tourism**, which takes full advantage of the attractions in the municipality of San José de Maipo. Included in this category are a significant number of tourists lodging establishments and recreational areas. Despite this, it must be noted that within the Project's area of direct influence tourism infrastructure and installations are rare.

In regard to planning instruments, the PHAM falls within San José de Maipo municipality, which has no Municipal Master Plan in force (it is currently being drafted) and only has town limits established for the localities of San Alfonso, La Obra, San José de Maipo, El Melocotón, San Gabriel and Las Vertientes.

Furthermore, the Santiago Metropolitan Master Plan (PRMS) establishes a series of land use regulations for the Project's location, most of which are related to ecological conservation and protection or risks. The largest land area in the municipality falls under the category of Area of Ecological Preservation, the aim of which is to keep the land in its natural state to safeguard and contribute to the balance of nature and environmental quality, as well as to preserve the landscape heritage.

Superimposed on this protected area are those protected under the Santiago Andino Project and the priority sites for biodiversity conservation, both with the similar protection and conservation objectives of preserving the environmental value of these mountain ecosystems.

5.8 CULTURAL HERITAGE

ARCHAEOLOGICAL RESOURCES

5.8.1 Introduction

Information regarding cultural heritage is presented in this section, including in the heritage a search for, and identification of, national monuments (archaeological paleontological, and historical elements, typical zones and nature sanctuaries), and religious monuments represented by houses of worship near the project like churches, cemeteries, grottoes and shrines.

5.8.2 Methodology

The methodology of the study consisted of the following activities:

- Compilation of bibliographic information to determine the areas most likely to have National Monuments and other relevant elements of cultural heritage. Special emphasis was given to a review of multiple scientific publications made about the area by archaeologist Mr. Luis Cornejo and his team, who investigated the area more than twenty years ago. Environmental impact studies were also reviewed, which have contributed information about the area, and other background information already collected for the project.

- Review of MOP Cadastre on National Monuments in the Metropolitan Region. This cadaster compiles and organizes a great deal of the scientific information distributed among multiple publications and reports.

- Archaeological prospections in sectors where the PHAM works are located, consisting of walks through those sectors. These prospections were carried out following the adaptations to the Project, in order to avoid interfering with archaeological sites or other elements of value to the heritage in the area.

The sectors that are part of the area of influence of the project and, therefore, were prospected archaeologically are listed below:

- La Engorda Meadow Sector
- El Yeso Lake – El Yeso River Sector
- Lo Encañado Lake – El Manzanito Stream Sector
- Colorado River – Aucayes Stream Sector
- Alfalfal II Pond - Alto Aucayes Sector
- Road – Aucayes Stream Sector

The sectors studied are located between 1,700 m.a.s.l. and 2,500 m.a.s.l. corresponding to high plains, terraces, dry meadows, ravines, and areas considered part of the foothills and mountains of the Andes, southeast of the city of Santiago.

In general, the prospected areas where the project is developed include very steep slopes, several of which contribute important erosion that constantly fills in the bottom of the ravines leaving very little space for the development of meadows or pastures, to extensive terraces where it is easy to find rock blocks or ledges able to provide shelter.

According to the geomorphological and meteorological characteristics prevailing in the sectors being studied and the bibliographical information compiled, one can conclude that most of the probable pre-Hispanic archaeological occupations in the area should be associated with camps for activities such as hunting and mining, transit routes, or others related to ritual or symbolic activities in the high peaks of the Andes. The conditions also exist to find settlements from the historical, current, and sub-recent period, related to mining, livestock-raising and sports activities, like mountaineering.

5.8.3 General Background Information about the Area of Study

The settlement pattern of the pre-Hispanic populations in the area of the Project tends to prefer places like corners; sites near minor water courses; places of transit; rocky ledges; and sites for extraction of lithic or mineral raw materials. Between the high and medium part of the watershed of the Maipo River, there is a gradient of sites from the maximum heights, with Inca Altitude Sanctuaries (Cabeza, A. 1984: 1998); mountain passes (Thomas, C. et al 1995); settlements in the interior affluents and small valleys (Saavedra, M. 1993; Saavedra, M. et al 1991; Stehberg, R. 1978); sites with limited development in the area where the Cajón opens up into the central valley, in the areas of the Mapocho, Clarillo and Pirque rivers (Cabeza, A. and P. Tudela 1985; Cabeza, A. et al 1992) and; extensive residential sites from the Early Pottery period to the Historical period, located on interfluvial terraces on the southern bank of the Maipo River (Vasquez, M. and L. Sanhueza, 1999, Comunicación Personal).

There is archaeological research and prospections in the area in general and also near the works of the Project, both scientific and within the framework of the EIAS.

Among the general background information, there are studies of the Olivares River: the sector called Cantera Infiernillo Norte, east of Mina La Disputada and; also in the La Yerba Loca stream (Sanchez, R. 2000a; 2000b; 2002; 2004), which make it possible to estimate a priori that the probabilities of a discovery of archaeological sites are low, in the sectors involved in the Project. However, this does not mean there are no settlements in the area; in fact, several important archaeological sites have been found in the sector of Farellones and the Cerro El Plomo (Domínguez, G. 1965; Reyes, F. 1958). Also, in the high mountains of the Metropolitan Region and Region V there are archaeological sites from the Archaic Period to the horizon of Inca presence (Cabeza, A. 1984), both with housing settlements, cemeteries and others with specific functionalities like the extraction of lithic or mineral raw materials (Cornejo, L. and J. Simonetti. 1992; 1997-98).

5.8.4 Specific Background Information about the area of the PHAM

5.8.4.1 Bibliographical Information

There is information about the presence of archaeological sites near four of the sectors involved in the Project, which are: El Yeso Lake, Lo Encañado Lake, Colorado River, and El Manzano Stream. In the upper part of the Yeso River there are several Ledges with occupations by hunters, some from the archaic period. Regarding the sector of the Del Encañado Lake, Luis Cornejo has revealed the presence of an Inca road or *capac ñam*, which joins the eastern and western springs of the Andes and an architectural facility that might correspond to an inn (Cornejo et al 2006). Also, the presence of a number of ledges called Las Morrenas, on the eastern bank of the Manzanito Stream, with occupations from the Late Archaic, 1725-1260 B.C. to the Early Pottery Period, around 0 – 1000 years A.D. (Cornejo et al 2003; Peralta et al 2000; Galarce et al 2005).

Regarding the Colorado River sector, there is information about archaeological sites from the Early Pottery Period on the Quempo Stream although they are far from the works of the Project (Cornejo et al 1997). For the El Manzano Stream sector, which the same archaeologist has studied for years, an infinite number of housing settlements are recorded, like ledges and open camps, which document more than 11,000 years of Andean pre-history. In fact, there are records from the Early Archaic period to the Late Pottery period (Cornejo 2000; Cornejo et al 1992; 1997-98).

Regarding the presence of National Monuments with Declaration in the area of influence of the Project, on the basis of the bibliographical analysis and a review of the Archives of the National Monuments Council on the direct area of influence of the Project it was possible to clarify that no national monuments have been declared: historical, nature sanctuary, and typical zone (Cabeza, A and M. Vega 1997)

Finally, the closest archaeological site to the works of the project is called Aucayes 1, approximately 2 km northwest of the route of the road (SAM 56 384.081 E 6287.687 N). The site corresponds to a small pre-Hispanic camp on the southern edge of the Aucayes Stream (Sánchez, R. 2007).

5.8.4.2 Results of Archaeological Prospection

As the background information suggests, the archaeological prospection carried out in the area of influence of the Project showed the following differential results for the different sectors prospected.

i) La Engorda Meadow Sector

Corresponds to a sector with low obtrusiveness, which only increases in the sector of the Meadow. The rest corresponds to steep, rocky sectors with little vegetation. No archaeological sites were recorded.

ii) El Yeso Lake – El Yeso River Sector:

Corresponds to a sector with low obtrusiveness, with little vegetation. The area of the Project occupies the two eastern terraces of the Yeso River which surrounds the old military shelter of Los Chorreados. No archaeological sites were recorded in this area despite the fact there is a meadow and pronounced rocky ledges. The area showed multiple alterations resulting from the activities of the old military shelter, which adjoins the works of the project.

iii) Lo Encañado Lake – Manzanito Stream Sector:

Corresponds to a sector with low obtrusiveness, which increases only in the Meadow sector near the El Manzanito Stream. The rest corresponds to plains and hills with little vegetation where sites were recorded with a presence of archaeological remains. These sites correspond to camps from the Archaic IV and Early Pottery periods, which take advantage of the protection offered by a number of big rock blocks on an extensive plain, located on the eastern bank of the Manzanito Stream and a stretch of the Inca road. These camps correspond to the ones called Morrenas 1, 2, 4 and 5 according to the researcher of the area, Luis Cornejo (See Table 5.8.4.1). The same plain is crossed from northeast/southwest by the Inca Road, a branch of the capac ñam located between the El Yeso River and the Manzanito Stream, which joined the two Andean springs in pre-Hispanic and colonial times, with a total extension of approximately 4 Km. This road was also discovered by Luis Cornejo (See Table 5.8.4.2).

The works (siphon and muck disposal) are near one of the sites in this Complex, called Site Morrenas 2. In the case of the Inca Road, these works are located approximately 20 m from it.

Tables 5.8.4.1 and 5.8.4.2 provide the information that makes it possible to characterize the sites of the Morrenas Complex and the Inca Road. Their location, in relation to the works, is indicated on Figure 5.8.4.1.

Table 5.8.4.1
Las Morrenas Archaeological Site

Las Morrenas archaeological site
MANZANITO STREAM SECTOR
TYPE: Camps around Ledges
This is a scattered area, with low to medium density, of lithic and ceramic materials around several rock blocks that provide ledges and protection on the plain east of the Manzanito Stream. Regarding cultural material, the lithic material is matrix-derived without modification in silica, basalt, fossil, and obsidian wood. A triangular arrowhead with a straight base is noteworthy. The ceramic material corresponds to polished brown monochromes made of a fine mixture, some of which are probably painted. Regarding the specific functionality of the site in pre-Hispanic times, it was clearly used as a camp, taking advantage of the protection of the big rock blocks in the area. The site corresponds to the camps called Morrenas 1, 2, 4 and 5 by Luis Cornejo. These sites showed occupations from the Late Archaic IV period (1725-1260 B.C.) to the Early Pottery Period, around 0 – 1000 years A.D. According to observations made in the field and bibliographic information, the pre-Hispanic nature of the evidence recorded, specifically from the Archaic and Early Pottery periods, can be assured. The site was also occupied in modern times, as evidenced by cans, nails, glass and china.
COORDINATES
SAM 56: 396.245 E – 6273.049 N Approximate Altitude: 2,466 m.
TOTAL DIMENSIONS DEFINED
North – South Axis: 250 m. East - West Axis: 30 m. Approximate Total: 7,500 m^2.
LOCATION
The site is located on a plain, approximately 100 m east of the Manzanito Stream, adjacent to the hill that borders the watershed on the North. Blocks were also recorded with ledges and materials, in a small area farther south (see figure 5.8.4.1).
AREA OF INFLUENCE
Indirect
CONDITION OF CONSERVATION: VERY GOOD
The general condition of conservation of the site is Very Good; it shows some interventions from the sub-recent historical occupation, and it is sure that cultural materials are conserved in their original matrix of deposition.

Table 5.8.4.2
Inca Road Archaeological Site

Inca Road archaeological site
MANZANITO STREAM SECTOR
TYPE: Pre-Hispanic Road
This is a road or branch of the *capac ñam* located between the El Yeso River and the Manzanito Stream, which joined the two Andean springs in pre-Hispanic and colonial times, with a total extension of approximately 4 Km. The road presents a simple clearing of material, sand or rock, towards its ends, with a width of 0.5 m and 3m. Its straightness, orientation, and maintenance of elevation are noteworthy, giving the road the characteristic features of the Inca road system. No associated features are observed, except for the Inca installation, known as the Laguna del Indio, located approximately 1.5 km northeast of the area of the Project (see Figure 5.8.4.1).
COORDINATES
SAM 56: 396.480 E – 6272.860 N Approximate Altitude: 2,454 m.
MINIMUM DIMENSIONS OBSERVED (Dispersion of the Feature in the area of the Project)
North/East Axis – South/west: 800 m. Width: 0.5 – 3 m.
LOCATION
The site is located on a plain on the east bank of the Manzanito Stream (see Figure 5.8.4.1).
AREA OF INFLUENCE
Indirect
CONDITION OF CONSERVATION: GOOD
The general condition of conservation of the site is Good. Nevertheless, in the area near the works of the project, the site shows interventions resulting from the construction of an aqueduct, currently unused, which altered approximately 30 m. of the route of the road (see Figure 5.8.4.1).

Photo 5.8.4.1 and Photo 5.8.4.2: General view, Las Morrenas site, Lo Encañado-El Manzanito Stream sector: lithic and ceramic materials were recorded in the area, around several rock blocks that provide ledges and protection on the plain east of the Manzanito Stream. This site was used as a camp, taking advantage of the protection of the big, rock blocks in the area.

Photo 5.8.4.3: Cultural material recorded on the Las Morrenas site, which corresponds to lithics, basalt, fossil wood, and obsidian. The ceramic material corresponds to polished brown monochromes of a fine mixture, some of which were probably painted.

Photo 5.8.4.4: Inca Road in the Lo Encañado sector. The general condition of conservation of the site is good, but in the area near the works of the project the site shows interventions resulting from construction of an aqueduct.

Insert Figure 5.8.4.1 “Archaeological prospection– Lo Encañado Lake- El Manzanito Stream Sector”.

iv) Colorado River – Aucayes Stream Sector:

This is a sector with medium obtrusiveness, due to the presence of pastures and native forest. The area includes the terrace west and east of the Colorado River in the locality of El Alfalfal. It also includes the Aucayes Stream, an affluent east of the Colorado River, from its mouth to its origins, and the Las Buitreras Ravine, an affluent west of the Colorado River. Prospection made it possible to record an archaeological site, corresponding to a small camp with a presence of lithic and ceramic material and grinding material on the southern bank of the Aucayes stream, located now approximately 100 m south of a tunnel exit and a projected bridge (see Table 5.8.4.3).

Table 5.8.4.3 below provides the information that characterizes the site. Its location, in relation to the works, is indicated in Figure 5.8.4.2.

Photo 5.8.4.5: Cultural material cultural recorded at the Aucayes 1 site, composed almost solely of lithic material.

Table 5.8.4.3
Aucayes 1 Archaeological Site

Aucayes 1 archaeological site
AUCAYES STREAM SECTOR
TYPE: Open Camp
This is a scattered area with low density where an archaeological record is detected that is composed almost solely of lithic material. Only one undefined ceramic fragment is detected. This area is located on a small terrace located south of the Aucayes stream where two roads of the project converge. This lithic material is matrix-derived, without any modification on the edges, made of local raw materials that are mostly andesites. The presence of a broken grinding instrument made of granodiorite is also recorded. No diagnostic material is recorded, but it is clearly a pre-Hispanic settlement.
COORDINATES
SAM 56 384.081 E 6287.687 N Approximate Altitude: 1,416 m.a.s.l.
TOTAL DIMENSIONS DEFINED
North – South Axis: 30 m. East – West Axis: 40 m. Approximate Total: 1,200 m^2.
LOCATION
The site is located on a plain on the southern bank of the Aucayes stream, in the sector where two projected roads will converge (see figure 5.8.4.2).
AREA OF INFLUENCE
Indirect
CONDITION OF CONSERVATION: VERY GOOD
The general condition of conservation of the site is very good as no anthropic or natural alteration is observed.

Insert Figure 5.8.4.2 Archaeological Prospection– Colorado River Sector – Aucayes Stream

See figure 2 annex 25

vi) Alfalfal II Surge Tank - Aucayes Stream road Sector:

Despite the fact that bibliographic information suggested that archaeological settlements would probably be detected, the archaeological prospection showed no presence of them on the surface, and no isolated findings were recorded. The area corresponds to a sector of low to medium obtrusiveness, due to the presence of pastures and native shrubs.

The prospection gave special relevance to the search for places in the area of indirect influence of the project that stood out as important in the analysis of the bibliography, especially ledges and rock blocks, suitable for shelter or practicing rock painting, respectively. This kind of finding was expected to be recorded mostly in the area north of the Estanque and the Paso los Hoyos sector.

PALEONTOLOGICAL RESOURCES

i) Introduction

Available information on paleontological findings existing in areas near the project is provided in this section. The fact that historical, scientific, land registry, and cartographic sources related to sites of paleontological interest in the commune of San José de Maipo are scarce should be pointed out.

The main sources of information consulted included the Paleontological Society of Chile 8SPACH), some sources of geological information, and tourist data, which provided a general overview of the area of the PHAM in the paleontological sphere.

The available information and/or field knowledge of professionals of the SPACH was relevant.

The methodology used consisted of:

- Identification of sources of paleontological information in Chile, mainly aimed at the sector of the Central Andes and the area where the project is located.
- Consultation of original source, mainly with the Paleontological Society of Chile.

ii) Available Information

- General Aspects

The fact that there are abundant fossils in the area of the Cajón del Maipo, as well as Lo Valdés and the North of Chile, is well known. The explanation for their presence is that the whole national territory was submerged under the Pacific Ocean, which gradually receded, raising land that had been the ocean bed before.

There were also big dinosaurs in the territory, and although their bones are not abundant – due to a lack of field research that would make it possible to find them –they left their tracks stamped in some areas like the Termas del Flaco.

- Background Information about the Area of Study

As we have stated, there are places in the area of the Cajón del Maipo where it is possible to find very old fossil material although much of this material has been removed by tourists and residents of nearby areas. The sector of Baños Colina toward the slopes of the Cerro Puntiagudo, Lo Valdés, and Baños Morales are some of those places.

In accordance with the information available from the Paleontological Society of Chile (SPACH) for the Valle del Arenas, resources that would be interesting to conserve are also identified in this area

The Colimapu, Lo Valdés, and Río Damas Formations (Lower Cretassic to Upper Jurassic) are known for their high content of fossils, especially ammonites, which are studied extensively in scientific literature.

Fossils from those formations have served for years in teaching classes on sedimentology and paleontology to geology students. Occasionally, bear remains and traces of marine and land Mesozoic reptiles have been found (i.e. Rubilar, 2007[1] and literature described there). This material is essential for the paleoecological reconstruction of the period. Especially in the Jurassic-Cretassic transition, where findings of continental vertebrates are scarce in Gondwana (Africa, America, Antarctica, Australia and India). Other contemporary sites in Chile are the Chacarilla Formation, Region 1; the San Salvador Formation, Region II, and the Baños del Flaco Formation, Region VI, which have recently revealed important data about the continental fauna of the Mesozoic period (e.g. Moreno and Pino, 2002; Moreno and Benton, 2005; Moreno and Blanco, 2004)[2].

In the Arenas valley in the Alto Volcán sector, the PHAM envisages the installation of surface works and a place to deposit material, near the sites identified by the SPACH, but without direct intervention. This was ratified at a meeting with the SPACH on January 3, 2008.

[1] Rubilar, A. 2007. Material docente de la Universidad de Chile: Salida a Terreno al Cajón del Maipo.
[2] Moreno, K.; Benton, M. J. 2005. Occurrence of a sauropod dinosaur in the Upper Jurassic de Chile (re-identification de Iguanodonichnus frenki). Journal of South American Earth Sciences 20:253-257.
Moreno, K.; Blanco, N. 2004. Nuevas huellas de dinosaurios en el norte de Chile. Ameghiniana 41(4):535-543.
Moreno, K.; Pino, M. 2002. Huellas de dinosaurios en la Formación Baños del Flaco (Titoniano, Jurásico Superior), Region VI, Chile: Paleoambiente y Paleoetología. Revista Geológica de Chile 29(2):191-206.

5.8.5 Conclusions

According to the results of the archaeological prospection and the information compiled on the subject, two sensitive areas were identified in the area of influence of the Project, which had resources of cultural interest. Those areas are part of the indirect area of influence of the project, in other words, in areas not used by the works of the PHAM. Those areas are: Lo Encañado Lake sector where two (2) sites of archaeological interest were recorded (Las Morrenas site and Camino del Inka site); the Colorado River – Aucayes Stream sector, where a site called Aucayes 1 was recorded.

Regarding the condition of conservation of those sites, “Las Morrenas” is rated “very good” except for the presence of some interventions resulting from the sub-recent historical occupation. The “Camino del Inka” site, located near the area that will be occupied by the project, shows relevant interventions resulting from the construction of an aqueduct, currently in disuse, which altered approximately 30 m of the road. The general condition of conservation of the Aucayes 1 site is “very good,” since no anthropic or natural alteration is observed.

In conclusion, the archaeological prospection carried out in the sector of the pond and roads of the Aucayes stream does not show any evidence of findings, despite the fact they were suggested in the bibliographic information reviewed.

Regarding the presence of fossil materials in the area, the conclusion is that the works and activities of the PHAM will not generate any direct intervention.

5.9 LANDSCAPE

5.9.1 Introduction

In this section, a landscape characterization is presented, where the Project will be carried out considering its aesthetic and perceptual dimension.

5.9.2 Methodology

The used methodology in this study is within the general framework of the landscape studies performed in the country, for projects entering into the Environmental Impact Assessment System (SEIA). As demanded by Act Nº 19.300 of General Bases on Environment and the D.S. 30/97 SEIA Regulations, emphasizes the characterization and assessment of the visibility, quality and visual fragility issues of the landscape.

In terms of the specifics, the methodologies used comprise adaptations of the USDA Forest Service (1974) [1]proposals, and Bureau of Land Management of the United States (1980)[2], as well as proposals for the Landscape assessment by the Ministry of Public Works, Transports and Environment from Spain[3] and the National Environmental Commission from Chile (CONAMA)[4] all of them widely used on the country and of international recognition[5].

Characterization of the visibility conditions was performed through in-field work, analysis of topographic charts and photographies of the area. The land recognition permitted to define visual lands or watersheds, and the setting up of elements which characterize the area of study. The main objective is the definition of the visual watersheds to determine the visible areas from a determined point or group of points. These points or groups of points help the landscape perception and the characterization of the land on visual terms.

On the other hand, for the visual quality and fragility valuation of the landscape, indirect methods of valuation through pre-established guidelines were used (Annex 5.9.1). The valuation was done through qualitative methods which assess the landscape, analyzing and describing its components, taking into considerations the categories high (3), medium (2) and low (1). Weighting and final classification is done according to the following scale ranges:

[1] United States, Department of Agriculture (USDA). 1974. Visual Management System. Forest Service. Agriculture handbook. 462. Washington.
[2] Bureau of Land Management. 1980. Visual Resource Management Program. Div. Of Recreation and Cultural Resource. Washington.
[3] Ministry of Public Works, Transport and Environment of Spain. 1995. Guidelines for the elaboration of Physical Means Studies.
[4] National Environmental Commission (CONAMA). 1994. Environmental Impact Assessment Manual. Concepts and Basic Background.
[5] For analysis effects, it will be understood:
Landscape Unit: Portion of geographic space presenting a configuration of elements characteristic to it and, therefore, different to those constituent of another unit.
Visual Watershed: It corresponds to the watched surface from different points of observation which allows defining a spatial unit with defined limits.
Visual Quality: It is defined by the aesthetic features of the constituent elements of a determined landscape.
Visual Fragility: It is defined as the visual absorption capacity of elements foreign to it, which has a determined landscape.

Table 5.9.2.1
Categories and Ranges of Weighting for Landscape Valuation

Category	Weighting range
Low	1 - 1,2
Low - Medium	1.3 - 1,5
Medium - Low	1.6 - 1,8
Medium	1.9 - 2,1
Medium - High	2.2 - 2,4
High - Medium	2.5 - 2,7
High	2.8 - 3

5.9.3 Results

Even when each one of the areas of the Project are distanced from each other, all of them are carried out within a mountain landscape domain, which means that they have some common features and generalized, such as, for instance, morphological features of the valleys, abiotic features marked in the hillsides and biotic elements restricted, usually, to the bottom of the valley and mid hillside. Vegetation starts showing vegetational beds according to the height ,from areas with herbaceous formations and low bushy in the higher sections of the watersheds (El Volcán, EL Yeso, Lo Encañado) up to arborean and bushy strata in the areas located to a lower level (El Colorado, EL Manzano, Las Lajas).

5.9.3.1 Landscape Unit Characterization

According to infield work performed, and the analysis of the topographic charts and aerial photographies from the different areas of the Project, 7 landscape units were identified which are analyzed next.

A. High Landscape Unit Volcán River

Type of Landscape: The area corresponds to a set of sub-watershed in the high part of Volcán River. It is a high mountain landscape (>2000m) with predominance of abiotic features associated to the mountain range relief typical from Chile's Central Andes (Picture 5.9.3.1 and 5.9.3.2). During autumn and winter, big part of the area is covered by snow; during the rest of the year this happens only in the highest parts of it. Elements structuring the relief correspond to rocky and rugged hillsides, narrow and winding valleys, rocky materials in general, valley floors dominated by river materials and water courses of torrent type, comprised in intermittent mode, a group of summer grazing areas.

Picture 5.9.3.1 North-East view from the current road towards El Morado stream.

Picture 5.9.3.1 East view from the current road towards El Morado stream.

General Conditions of Visibility: The area corresponds to a confluence sector of some streams (El Morado, Las Placas, Colina and La Engorda) therefore it has a wide valley with a very irregular topography which allows to have views from different height levels. The visual watersheds have irregular forms, some rounded (Colina- La Engorda Streams) and other some longer (El Morado Stream) with general views at long distance (>2000 m). It is a visually exposed landscape. The elements providing greater visual concealment are given by topographic irregularities associated to the relief.

Picture 5.9.3.3 East view from the current road towards El Morado stream.

Basic Visual Characteristics of the Landscape Components: At hillside level, grey colors (different ranges) stand out, shades, and is mainly light, matt gloss, complex shapes as well, three-dimensional and irregular in terms of relief. Greens (general grass and low bushes) are dominant at floor valley and in some hillsides generating fine grain textures. The rest of the landscape, where abiotic features are dominant, generally has a mid and coarse grain.

Picture 5.9.3.4 View towards SE in the area of Colina and La Engorda Streams

Figure 5.9.3.1
Landscape Unit Volcán River Upper Watershed sector

Quality and Visual Fragility: This unit presents a High Medium Visual Quality (Table 5.9.3.2.) qualification. It is a highly natural landscape, structured specially by abiotic elements associated to a very irregular topography relief and some abiotic features related to summer grazing areas, specific to the valley floor, which in these days have animals (goats, cows and horses). Visual milestones correspond to rocky hillsides repeating along the whole valley, the presence of seasonal snow and in specific areas, the existence of summer grazing and seasonal small lakes.

With regards the Visual Fragility, almost all elements with value have a medium range. The important differences of height and abrupt slopes of the hillsides are the only elements with high qualification.

Table 5.9.3.2
Quality and Visual Fragility High Landscape Unit Volcán River

Visual Quality		
Valued Component	**Description**	**Value**
Morphology or Topography	Mountain range relief, abrupt hillsides, wide valley floors.	3
Vegetation Presence	Summer grazing at valley floors, herbaceous vegetation and low bushes irregularly located in hillsides	2
Anthropic Action	Highly Natural Landscape	3
Chromatic Variability	Color diversity in rocks and greens concentrated in valley floors	3
Visual Marks	Structural and morphological features of the mountain ranges	3
Visual Incidence Scenic Background	Important. Snowed mountain ranges	3
Singularity or Rarity	Slightly recurrent landscape in Chile's Central Andes	2
High-Medium Visual Quality (2,7)		
Visual Fragility:		
Valued Component	**Description**	**Value**
Slope (Morphological or topographic features)	Important topographic differences. Narrow valleys, abrupt hillsides	3
Visual watershed Size	Medium range Views (>2000 m)	2
Visual watershed shape	Irregular watershed visuals	2
Compactness	Medium. Very open areas such as Colina-La Engorda and El Morado. More concealed areas such as Las Placas and intermediate sectors	2
Uniqueness	Landscape elements are fairly singular	2
Traditional Value	Correspond to areas where seasonal grazing is done	2
Physical Accessibility	Low physical accessibility. Restricted access area	1
Visual Accessibility	Fairly exposed landscape	2
Medium Visual Quality (2,0)		

Note: See guidelines for Visual Fragility characterization in Annex 5.9.1.

B. Yeso River Landscape Unit

Type of Landscape: It is a characteristic landscape from Chile's Central Andes developed at 2000 m.a.s.l., with strong abiotic features (rocks outcrop, rocky materials over the hillsides and valley floors, gravitational deposits), narrow valleys, torrential water courses, little vegetation, herbaceous and low bushed, irregularly distributed and, in general, low human population.

General Conditions Visibility Characterization: In this area the visual watershed are with a long character, following the position and form of the valley. Due to the windings of the valley, views are usually of short distance (>2000 m).

Basic Visual Characteristics of the Landscape Components: Different ranges of greys are widely distributed in the landscape, green colors have low distribution. Shades are mostly light, matt gloss, complex shapes, three-dimensional and irregular due to the type of relief. Textures are mixed in the hillsides; the rocky outcrop generates coarse textures and gravitational deposits (generally cones and talus of gravity) produce mid and fine grain textures. In the valley floor the situation is more marked into the mid grain textures.

Picture 5.9.3.5. View towards North by Yeso River

Picture 5.9.3.6 View towards SW by Yeso River

Picture 5.9.3.6 View towards N by the Valley of Yeso River

Picture 5.9.3.8 View towards N. El Yeso Reservoir close up

Quality and Visual Fragility: Landscape in this area presents a Medium-High Visual Quality (Table 5.9.3.3). This is, mainly, structured by biotic elements related to the narrow valley morphology and some biotic features with regards summer grazing in specific areas of the valley floor.

Visual milestones correspond to rocky hillsides repeating along the whole valley, the presence of seasonal snow and, in specific areas, the existence of summer grazing and small lakes. Due to the narrowness of this valley the scenic floors are related to the surrounding relief and change according to the observant movement.

The Medium-High Visual Fragility shows that the area presents a susceptible condition to absorb modifications of landscape elements done in its interior. The features contributing greater fragility correspond to the valley morphology in the long visual watersheds, with near views, and the value as unit as recreational route area, grazing area and drinking water reservoir zone; it is outstanding its high accessibility due to its proximity to a highly tourist area and leisure activities, such as the diverse locations in the Maipo river valley.

Figure 5.9.3.2
Yeso River Valley Landscape Unit

Table 5.9.3.3
Quality and Visual Fragility Yeso River Valley Landscape Unit

Visual Quality		
Valued Component	**Description**	**Value**
Morphology or Topography	Mountain range reliefs, abrupt hillsides, narrow valley floors.	3
Vegetation Presence	Low vegetation of restricted and disperse location	1
Anthropic Action	Generally scarce, but regularly distributed along the valley (roads, electric line, flocks, abandoned buildings, reservoir)	2
Chromatic Variability	Chromatic homogeneity. Predominance of greys, changing sky, torrent river beds	3
Visual Marks	The visual milestones of importance are the rocky mountaintops with permanent snow, hanging glacier, summer grazing, El Yeso Reservoir, and Yeso river which can be seen occasionally.	3
Visual Incidence Scenic Background	Important. Snow relief are permanently present on the scene	3
Singularity or Rarity	Recurrent landscape with the exception of very particular elements such as El Yeso Reservoir	1
Medium-High Visual Quality (2,3)		
Visual Fragility:		
Valued Component	**Description**	**Value**
Slope (Morphological or topographic features)	Important topographic differences. Narrow valleys, abrupt hillsides	3
Visual watershed Size	The visual watershed presents conditions for high range observations	1
Visual watershed shape	Long visual watershed	3
Compactness	Medium capacity of concealing	2
Uniqueness	Is generally predominant with recurrent features or elements	1
Traditional Value	Landscape with varied cultural value (grazing areas, tourist routes, water reservoir area for Santiago)	3
Physical Accessibility	High physical accessibility	3
Visual Accessibility	Landscape is slowly appearing. Occasional Visibility	2
Medium-High Visual Fragility (2,3)		

Note: See guidelines for Visual Fragility characterization in Annex 5.9.1.

C. Lo Encañado Landscape Unit

Type of Landscape: Lo Encañado type of landscape is similar to the existing one in Yeso River. Both are mountain landscape, mainly structured with abiotic elements in hillsides and valley floors, presence of water courses of torrent type, reservoir and seasonal snow in the highest sectors. Vegetation is restricted to the banks of the water courses and to some hillsides.

General Conditions of the Visibility Characterization: Due to the shape of the Manzanito Stream valley, the visual watersheds are long. Due to the windings of it, views are usually of short distance (>2000 m).

Picture 5.9.3.9 View towards NW by the valley of Manzanito stream

Picture 5.9.3.10 View towards SE from Manzanito Stream valley

Picture 5.9.3.11 Views towards N in Lo Encañado small lake area

Basic Visual Characteristics of the Landscape Components: Grey colors are highly stood out (different ranges); green colors, associated to vegetation are distributed irregularly in hillsides and valley floor. Shades are, in general, light, matt gloss, complex shapes, three-dimensional and irregular due to the characteristic Andean landscape. Textures are a combination of coarse and fine and grain depending on the materials present in hillsides and valley floors.

Quality and Visual Fragility: This area presents a Medium-High Visual Quality (Table 5.9.3.4). The elements of greatest value are the morphological features, the high naturalness of the landscape, chromatic heterogeneity of the elements and the presence of some visual milestones such as rocky structures in hillsides and snow mountaintops zones.

Visual Fragility of the unit has a Medium qualification. Features adding greater fragility correspond to morphological features of the mountain range valley and to the shape of the visual watershed which generates views positioned towards the shape of the valley (long in direction to the valley).

Table 5.9.3.4
Quality and Visual Fragility Lo Encañado Landscape Unit

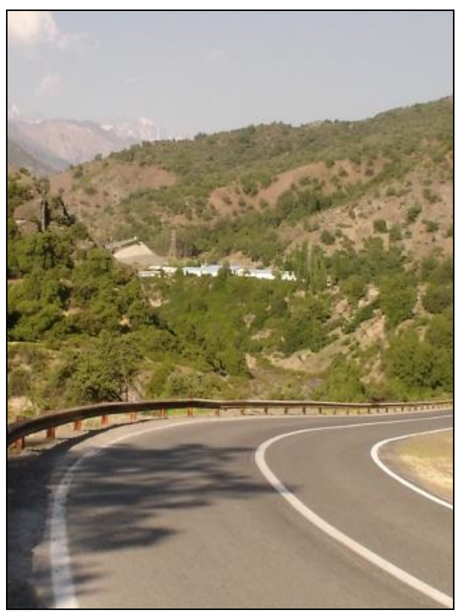
Visual Quality		
Valued Component	**Description**	**Value**
Morphology or Topography	Mountain range reliefs, abrupt hillsides, narrow valley floors.	3
Vegetation Presence	Restricted location vegetation	1
Anthropic Action	Scarce. Highly Natural Landscape	3
Chromatic Variability	Chromatic homogeneity. Predomination of greys, greens, changing sky, water courses and mirrors	3
Visual Marks	The only visual milestones of importance correspond to rocky structures in hillsides, snow on mountaintops	3
Visual Incidence Scenic Background	Important. Snow relief are permanently present on the scene	3
Singularity or Rarity	In general, it does not have particular features by exception of Lo Encañado Small Lake	1
Medium-High Visual Quality (2,4)		
Visual Fragility:		
Valued Component	**Description**	**Value**
Slope (Morphological or topographic features)	Important topographic differences. Narrow valleys, abrupt hillsides	3
Visual watershed Size	The visual watershed presents conditions for medium range observations	2
Visual watershed shape	Long visual watershed	3
Compactness	Medium capacity of concealing	2
Uniqueness	In general, it is predominated by recurrent features or elements by exception of Lo Encañado Small Lake	1
Traditional Value	Restricted access area Water reservoir for Santiago	2
Physical Accessibility	Low physical accessibility. Restricted access area	1
Visual Accessibility	Landscape is slowly appearing	2
Medium Visual Fragility (2,0)		

Note: See guidelines for Visual Fragility characterization in Annex 5.9.1.

D. Colorado River Valley Landscape Unit in Inferior Section

Type of Landscape: General typology of mountain landscape is kept, with the difference regarding the rest of the units that in these ones there is a greater preponderance on biotic features characterized by arborean vegetation formations and bushes typical of the sclerophyllous forest. Abiotic features are present only in landscapes of higher altitude or in steeper hillsides. Besides, anthropic elements are added widely distributed along the valley, nevertheless, the general condition of high naturally of the landscape is kept, aspect generated mainly by the visual effect of the vegetation.

Picture 5.9.3.12 View towards NE in Colorado River valley in Alfalfal I Power Plant sector.



Picture 5.9.3.13 View towards NE in Colorado River valley in Río Colorado Mine.

Visual watershed features: The narrow and winding mountain range valley morphology is kept, therefore the visual watersheds have a long character following direction and shape of the valley; due to windings of it, the visuals are, generally, of short distance (>2000 m). The arborean vegetation presence located at valley floor level generates greater compactness, that is to say, there are greater zones with visual shade or non-seen landscape spaces.

Basic Visual Characteristics of the Landscape Components: The greatest preponderance of the arborean vegetation and bush adds to the scene an important predominance of green colors, dark shades because of the vegetation effect. Glosses are matt, complex shapes, three-dimensional and irregular. Textures are, generally, of coarse grain by the same vegetation effect.

Picture 5.9.3.14 View towards NE in Colorado River valley

Picture 5.9.3.15 View towards NE in Colorado River valley

Quality and Visual Fragility: This unit presents a High Visual Quality (Table 5.9.3.5.). It has some morphological and visual features characteristic from mountain range valleys and similar to the previous units, adding to the scene vegetation elements of high aesthetic value. It is a landscape which keeps a balance with anthropic features, with exception of specific points where Río Colorado Mine is located and the areas of Los Maitenes and El Alfalfal Power Plants, which do not affect in a significant way the rest of the attributes of the valley. It has a high singularity due to the presence of Sclerophyllous Forest formations.

The High-Medium Visual Fragility shows that the area presents a susceptible condition to absorb modifications of its landscape elements. Practically, all elements of valuation have a High qualification. The feature presenting lower susceptibility is the unit related to the visual concealing effect generated by the vegetation in parallel with topographic irregularities of the valley, which produces a high compactness of the landscape.

Table 5.9.3.5
Quality and Visual Fragility Colorado River Valley Landscape Unit in Inferior Section

Visual Quality		
Valued Component	**Description**	**Value**
Morphology or Topography	Mountain range character relief, heterogeneity of morphologic features	3
Vegetation Presence	Arborean vegetation and bush corresponding to forest and sclerophyllous scrubland predominance	3
Anthropic Action	Most in balance with natural features of the landscape Areas with negative anthropic features and with a high footprint correspond to Río Colorado Mine and to Los Maitenes and El Alfalfal Power Plants areas. These areas correspond to particular points in the landscape of the valley	3
Chromatic Variability	Chromatic homogeneity Greys, greens and browns	3
Visual Marks	Scarce. Generally in rocky and steep hillsides	2
Visual Incidence Scenic Background	Important. Increasing the visual quality	3
Singularity or Rarity	Scarce landscape because of Sclerophyllous Forest presence	3
High Visual Quality (2,9)		

Visual Fragility:		
Valued Component	**Description**	**Value**
Slope (Morphological or topographic features)	Important. Topographic differences. Narrow valleys, abrupt hillsides	3
Visual watershed Size	The visual watershed presents conditions for medium range observations	2
Visual watershed shape	Long visual watershed	2
Compactness	Medium to High capacity of concealing	1
Uniqueness	Presence of sclerophyllous forest formations confers a scarce character	3
Traditional Value	Recurrent transit of people area for leisure goals	3
Physical Accessibility	Low physical accessibility. Restricted access area	3
Visual Accessibility	Landscape is slowly appearing	3
High-Medium Visual Fragility (2,5)		

Note: See guidelines for Visual Fragility characterization in Annex 5.9.1.

E. Aucayes Stream Canyon Landscape Unit

Type of Landscape: The Aucayes ravine is affluent to Colorado River and it is developed over 2000 m.a.s.l. It corresponds to a mountain landscape and as well as the analyzed units in Upper Volcán, Yeso and Lo Encañado sector, the abiotic elements are predominant, that is to say, rocky outcrops, loose material hillsides, scarce vegetation, torrent water courses and no human occupation, therefore, it has a high naturalness.

General Conditions of the Visibility Characterization: Due to the shape of the valley, the visual watersheds are long. Windings of it, allow views usually of short distance (>2000 m).

Basic Visual Characteristics of the Landscape Components: Grey and green colors are predominant, light shades, matt gloss, irregular shapes, three-dimension and complex. Textures are a combination of coarse grain in the upper parts of the hillsides and fine grain in the medium and low parts of the hillside and in the valley floor.

Quality and Visual Fragility: Both aspects of the landscape have a Medium qualification. The elements of great value are the morphological features, the high naturalness of the landscape, and chromatic heterogeneity of the elements and the presence of some visual milestones such as rocky structures in hillsides. Features adding greater fragility correspond to morphological features of the mountain range valley and to the shape of the visual watershed which generates views positioned towards the shape of the valley (West-east direction) Low physical access is the feature which gives it a lower susceptibility.

Table 5.9.3.6
Quality and Visual Fragility Aucayes Stream Canyon Landscape Unit

Visual Quality		
Valued Component	**Description**	**Value**
Morphology or Topography	Mountain range reliefs, abrupt hillsides, narrow valley floors.	3
Vegetation Presence	Restricted location vegetation	1
Anthropic Action	Scarce. Highly Natural Landscape	3
Chromatic Variability	Chromatic homogeneity. Predomination of greys, greens, changing sky, water courses	3
Visual Marks	The only visual milestones of importance corresponds to rocky structures on hillsides	2
Visual Incidence Scenic Background	Important. Surrounding relief is permanently present on the scene	3
Singularity or Rarity	It does not have singular features in general	1
Medium-High Visual Quality (2,4)		
Visual Fragility:		
Valued Component	**Description**	**Value**
Slope (Morphological or topographic features)	Important topographic differences. Narrow valleys, abrupt hillsides	3
Visual watershed Size	The visual watershed presents conditions for medium range observations	2
Visual watershed shape	Long visual watershed	3
Compactness	Medium capacity of concealing	2
Uniqueness	Recurrent elements	1
Traditional Value	Grazing area	2
Physical Accessibility	Low physical accessibility	1
Visual Accessibility	Landscape is slowly appearing	2
Medium Visual Fragility (2,0)		

Note: See guidelines for Visual Fragility characterization in Annex 5.9.1.

Figure 5.9.3.3
Aucayes Ravine - Colorado River Landscape Units

F. El Manzano Ravine Landscape Unit in Route G-25 Area

Type of Landscape: The area presents a landscape with anthropic features with a combination of natural features, being preponderant the first ones over the second ones. Because of its closeness to Santiago city, this area, as well as many other locations of the Maipo valley, have experience during the last years, important processes of human occupation and, in general, slow landscape deterioration, which has been translated into a gradual loss of natural aesthetic values, for instance, decrease of native vegetation, due to the insertion of low visual value elements such as road signs, electric or communications posts, densification of buildings, among others.

General Conditions of the Visibility Characterization: Shapes, sizes and degrees of compactness are strongly influenced by the structure of the valley and the presence of side visual obstacles to the areas where views are generated, for instance, arborean vegetation and buildings in general.

Basic Visual Characteristics of the Landscape Components: Mainly green colors stand out, adding into the scene colors related to infrastructure and existing buildings. Textures are mainly coarse grain.

Quality and Visual Fragility: Both aspects present a Medium qualification. Features with greater aesthetic value are related to the landscape framework which gives the surrounding relief, besides the scenic backgrounds predominating the views, both aspects are very recurrent in mountain landscape. For fragility, on the contrary, the high traditional value in El Manzano area is the one giving greater sensitivity; the sector has been historically a leisure area and in the last years a second residency location as well.

Table 5.9.3.7
Quality and Visual Fragility El Manzano Ravine Landscape Unit Route G-25 Area

Visual Quality		
Valued Component	**Description**	**Value**
Morphology or Topography	Low and Medium mountain relief with smooth slope hillsides. Scarce rocky outcrop	3
Vegetation Presence	Native arborean vegetation in the hills and introduced, and crops over the valley floor.	2
Anthropic Action	Dominant	2
Chromatic Variability	Colors diversity. Colors are added into the infrastructure and buildings	2
Visual Marks	Scarce	1
Visual Incidence Scenic Background	Important. Increasing the visual quality	3
Singularity or Rarity	Rural features (certain degree of anthropic-natural balance) gives a Medium value	2
Medium Visual Quality (2,1)		
Visual Fragility:		
Valued Component	**Description**	**Value**
Slope (Morphological or topographic features)	Mountain Landscape. Wide valleys. Smooth slopes	2
Visual watershed Size	Low range visibility	1
Visual watershed shape	Irregular visual watershed	2
Compactness	High capacity of concealing	1
Uniqueness	Fairly scarce landscape. Landscape deterioration in progress	2
Traditional Value	It has a high traditional value as an area destined for leisure and cottage houses	3
Physical Accessibility	Route G-25	3
Visual Accessibility	Scarce Only locally visible	1
Medium Visual Fragility (1,9)		

Note: See guidelines for Visual Fragility characterization in Annex 5.9.1.

G. Maipo River Valley Landscape Unit in Las Lajas Area

Type of Landscape: The area is located in the mid-section of Maipo River downstream of the intersection with El Manzano Stream, corresponding to a landscape with similar features than El Manzano ravine Unit. It is a landscape with low and medium mountain features and anthropic elements widely distributed, for instance, roads, electric lines, crops, various buildings, and other types of human activities typical from it (river works, for example)

Picture 5.9.3.16 View towards W in Las Lajas area in second level we can see river works for the de-sanding of waters from the river.

General Conditions of the Visibility Characterization: As with the rest of the characterized units, visuals are generated from the valley floor following the morphologic shape of them, that is to say, long and narrow valleys oriented from east-west and restricted on the sides by the margins of the valley.

Irregularities of the valley and the visual obstacles produced by arborean vegetation or existing buildings on the edge of the road do not allow long distance views (>1000 m).

Basic Visual Characteristics of the Landscape Components: It is an area where the predominant formations are arborean and bushy with an important presence of introduced species, for instance, poplar and fruit crops, therefore the predominant colors correspond to greens. Grey colors are presented in different ranges and are mainly located in the higher sections of the hillsides and river banks.

Shades are light; glosses are matt, complex shapes, three-dimensional and irregular. Textures are coarse, mainly, as consequence of greater heterogeneity of native vegetation elements, introduced and existing crops in the area.

Quality and Visual Fragility: Qualification of both aspects is Medium. The most important aesthetic values area related to relief, colors and scenic background. Susceptibility, on the other hand, is related to its traditional value as tourist area, its high accessibility as well as characteristic features of the mountain range valley, in terms of morphology and visual watershed attributes.

Table 5.9.3.8
Quality and Visual Fragility Maipo River Valley Landscape Unit in Las Lajas Area

Visual Quality		
Valued Component	**Description**	**Value**
Morphology or Topography	Mountain range character relief. Wide valley	3
Vegetation Presence	Widely distributed vegetation. Generally, introduced and crops on the valley floor.	2
Anthropic Action	Important. Road works, housing, crops, electric lines and others	1
Chromatic Variability	Chromatic heterogeneity	3
Visual Marks	Scarce	1
Visual Incidence Scenic Background	Important. Increases the visual quality with views towards the mountain ranges	3
Singularity or Rarity	Recurrent landscape	1
Medium Visual Quality (2,0)		
Visual Fragility:		
Valued Component	**Description**	**Value**
Slope (Morphological or topographic features)	Minor topographic differences. Low mountain	3
Visual watershed Size	Extension of the valley allows long distance views	2
Visual watershed shape	Long visual watershed	3
Compactness	Diversity of elements which allow the visual concealing	1
Uniqueness	Recurrent landscape	2
Traditional Value	The Maipo Canyon presents an important traditional value as leisure sector	3
Physical Accessibility	High, Route G-25	3
Visual Accessibility	Extension of the valley allows wide views Landscape is slowly appearing	2
Medium Visual Quality (2,1)		

Note: See guidelines for Visual Fragility characterization in Annex 5.9.1.

Figure 5.9.3.4
Las Lajas Landscape Unit in Tailrace Tunnel Area

5.9.4 Conclusion

7 landscape units were identified in the different areas of the Project, all of them with characteristic features from medium to high Andean mountain landscape.

Visual quality varies between Medium and High qualification, which shows that the analyzed units have significant landscape and aesthetic attributes. The units with greater value and relevance correspond to Colorado River and Upper Volcán, followed by Yeso River, Lo Encañado and Aucayes units (It should be noted that this last one does not count with clear access, therefore is not visible for the different users of the area of the Colorado river canyon, area where is located). Finally, El Manzano and Las Lajas units have a Medium visual qualification, mainly because of the greater amount of features and anthropic elements.

With regards the visual fragility, it varies in Medium to High-Medium ranges, being Colorado River the unit with highest qualification. This qualification is based on high physical and visual accessibility, and by constituting a used route for leisure goals.

Linking both characteristics of quality and visual fragility, that is to say, its aesthetic value and deterioration susceptibility, the most sensitive area is Colorado River, followed by Upper Volcán River and Yeso River Valley.

5.10 RISK AREAS

5.10.1 Introduction

In this section, information related to natural risks existing in the carry out area of the Project is presented.

5.10.2 Methodology

Taking into consideration the close relation between the Geomorphology-Geology components with the existence and development of the risk areas both in the municipal territory as well as the areas of different works and actions considered by PHAM, the same methodology used for the characterization of those components was used. In this way, the methodology to address this environmental component consisted, in first place, in collecting bibliographic background obtained from the studies done in the zone. Special interest was given to the review of the geologic chart of Santiago done by Ricardo Thiele, scale 1:250.000 and its corresponding description.

Additionally, the geologic prospecting reports done by specialists in the area of the carry out area of the Project were consulted, photo interpreting of the aerial photographs to 1:20.000 and 1:100.000 scale and in field visits. Likewise, environmental studies such as the Geomorphological Study by the Military Geographic Institute and the information provided by the Communal Development Plan (PLADECO) of San José de Maipo were consulted.

5.10.3 Results

5.10.3.1 Risk Areas in territory of the Municipality

In the territory of the municipality of San José de Maipo is possible to recognize natural risks associated to processes or factors related to relief, topography and meteorological conditions. A description of the main natural risks present in the communal territory is presented next.

a) Mass Removal Risk

Taking into consideration the mass removal definition established in the Metropolitan Regulating Plan of Santiago (PRMS), these processes can be presented as phenomenon such as: avalanche, floods, collapse, landslides, rock slides, or other type of sliding material, these processes can be trigger together and/or by separate, due to earthquakes, precipitations, snow accumulation and thaw or acceleration of the run-off levels in ravine areas. The characterization of these processes is incorporated to this paragraph.

In the municipality of San José de Maipo are observed and registered processes of erosion of the Andean massif, which make possible the dissection of the landscape and development of deep valleys and variable width. Considering these processes, the natural run-off transporting materials and flows from different origin, volume, speed and power, restricting habitable sectors for mankind. Because of this, the high and mid zone of the debris cones of the most actives ravines have risk zones for urbanization or anthropic action of space.

Those sectors of coalescent to the debris cones in the ravines stand out. These are topographically represented by low depressions towards the slope, which is where usually water flows and floods currents of mud and rocks are currently canalized.

In Table 5.10.3.1 the risk areas and restrictions by PRMS area presented for the municipality of San José de Maipo, associated to mass removal events.

Table 5.10.3.1
Areas Susceptible to Mass Removal Processes

NAME OF THE AREA
Mountain Area - La Obra
Mountain Area - El Añil Ravine
Mountain Area - La Buitrera Ravine / Colorado River
Mountain Area - Guayacán Ravine
Mountain Area - El Almendro Ravine / Guayacán
Mountain Area - San José de Maipo
Mountain Area - Lagunillas
Mountain Area - San José Stream
Mountain Area - San Alfonso
Mountain Area - El Ingenio
Mountain Area - San Gabriel
Mountain Area - Las Amarillas Ravine

i. Rocks Falling Risk

This phenomenon corresponds to the individual or a number of rocks falling down, in separate aggregates or fragment mode, whose dimensions can reach from rocks greater than gravel up to blocks of important size and even cubic meters of volume. In this phenomenon, gravitational instability of the fragments or bocks of rocks, and water intervene, when debilitating or making fluidity the support substratum of them, contributing to the loss of stability. Some blocks in metastasizing balance can also be destabilized as consequence of seismic movement greater than 5.

The occurrence of this type of phenomenon is related to areas of great slopes, being more likely during thaw or rain seasons.

ii. Rocks Avalanche Risk

This phenomenon consists on the mass removal in a violent way of great volume of disaggregate rocks (Rigolith) from the rocky substratum on the hillsides, which, usually, is in strong slope hillsides where important volumes of rock area in a metastasized balance over the hillside. Generally, the main cause of this phenomenon is thaw or snow joining in spring; in the same way, rock avalanches by sudden increases of temperature together with rains over the snowed hillsides are generated.

iii. Landslides Risks

Landslides are produced in hillsides with high load of detritic material (fine and coarse) from the colluvial deposits (side debris and/or crionival deposits area) with unstable slopes (greater than 35°). In this phenomenon, the most frequent direct agent is water which saturates sediments, originating a dramatic decrease on cohesion of the fine materials making them fluid. The most frequent cause is excess of rain on the sides or violent thaws during spring.

iv. Snow Avalanche Risk

This phenomenon is associated to the excess accumulation of snow in protected hillsides and to hillsides zones where accumulation of snow by wind is produced. When accumulations exceed the balance threshold, avalanche processes are triggered.

b) Flood Risk

Determination of flood risk areas in the municipality of San José de Maipo was done according to the geomorphological and hydrodynamic studies as per the definitions incorporated in PRMS. In this way, areas that could potentially be affected by flood processes, associated to low river terraces sectors, debris cones sectors and side coalescence corridors of these debris cones were determined. Risk areas by floods are defined next.

Table 5.10.3.2
Flood Risk as per PRMS

Type of Area:	Definition
High risk area by floods of natural origin	a.- Recurrently flooded b.- Signs of floods Both in the river beds (mid to upper course) especially in the Maipo river. In San José there are consolidated settlements that must not be in this area (Los Pitufos and El Barrio Chino)
High risk area due to geophysics risk associated to natural events	Of geophysics risk associated to recurrent floods. In this sense, areas such as Guayacán or La Obra, at rising of the river course level can generate erosion or undermining, generating a decrease of the river terraces affecting private property. Besides, it is associated to it the existence of de-sanding operations.

Source: Metropolitan Regulation General Ordinance of Santiago, April 2002. MINVU

c) Seismic Risk

The main seismicity of the zone is related to the subduction mechanism of the oceanic plate of Nazca under the South American continent, convergence which is developed at speed near 10 cm/year, generating inter-plate earthquake in the Benioff plane. The distribution of the seismic focuses show an activity deepening towards the interior part of the continent, reaching from approximately 50 kilometers depth in the coast, up to near 100 kilometers under the border with Argentina.

The deepest activity is typically related to the deeper inter plate zone or "mountain range", and to breakages associated to the tensional state of the underlying plate which sinks into the magma in the upper part of the mantle, generating inter plate events. Enquiries over this plate are complex; on one hand the is a potential state of traction due to the weight of the frontal portion of the plate and due to its eventual dragging towards the inside of the magma; besides, an eventual compressional state to the opposition of sinking in a possible encounter with material of greater density, and finally, a flexional state due to the curve that the Nazca plate must adopt when underlying under the South American plate and adopting a projection condition when enters into the magma. Inter plate events are also characteristics which are denominated as cortex earthquake because they occur in the South American plate. They are superficial, with focal depth lower than 50 km depth. They occur due to the compressional state induced in the South American plate by the Nazca plate convergence. Such state has caused the folding of its cortex, giving rise to mountain ranges and eventual superficial fault. This activity, although disperse, happens mainly to the east of the Andes.

Of particular relevance for the Project, the cortex activity located superficially in the South American plate in the mountain range zone. Historically, the most serious earthquake and better document one in the zone is from September 4th, 1958. Previous to this earthquake, and with a similar epicenter, was the one in December 1850, denominated the Maipo Valley earthquake, which Lomnitz (1970) gave 7 to 7.5 magnitude.

The epicenter of the earthquake of 1958 was located near Las Melosas town. The earthquake consisted in a sequence of three events originated during 4 minutes with magnitudes Ms = 6.9, 6.7 and 6.8 respectively. Surface breaking was not observed, not being able to associate the event to any visible faults in the zone.

5.10.3.2 Characterization of Natural Risks for the Carry out Areas of the Project

It is understood the natural risk as the phenomenon or event, manifesto or potential, whose development has effects over health and physical integrity of people, its activities and infrastructure and/or the ecosystem as a group. Risk is understood, therefore, as the susceptibility of the human mean and built to the development or manifestation of a certain type of event of natural character. In this sense, what is interesting to assess is the vulnerability of people or built mean to suffer from any damage or be affected by a determined dynamic and processes of the natural mean.

Thus, risks that are possible to identify in the carry out areas of the Project of PHAM are described next. In the same way, in Figures 5.10.3.1 to 5.10.3.4. Location of the main natural risk areas recognized near the carry out area of the different works and facilities of the Project are presented.

Figure 5.10.3.1 Natural Risks. Volcán River Upper Watershed Area

Figure 5.10.3.2 Natural Risks. Yeso River Valley Area

Figure 5.10.3.3 Natural Risks. Qda. Area. Aucayes - Colorado River

Figure 5.10.3.4 Natural Risks. Las Lajas Tailrace Tunnel Area

a) Mass Removal Processes Risk

These processes are widely distributed in the area of the Project. Within this category it is included a set of phenomenon associated to material movements over the hillside. These movements could be fast for instance collapses and landslides, or slow character such as solifluction, which by their characteristics are more difficult to observe. For the case of landslides, its more frequent cause is saturation of materials due to excess of rains over the hillsides or violent thaws during spring. In the case of collapses, the causing agents correspond to the combined effect of the strong slope, presence of rocky materials on the hillsides and some agent of movement or breakage of balance such as rain, snow or seismic movements.

Also, in strong slope zones, with rocky materials unstably arranged in the hillsides, could give rise to recurrent phenomenon of rock falling, especially in rainy periods, thaws or help by seismic movements. Materials can also have a variable granulometry from gravel to blocks.

- **Volcán River Upper Area** Most of the hillsides of the valley both in El Morado stream, Las Placas and Colina-La Engorda, have risk of gravitational phenomenon, both landslides, collapses and rock falling, these last ones are applied to a set of materials of heterogeneous granulometry and of great size which give rise to deposits covering different levels of the valley floor in this area. As it has been indicated, these materials have been generated from sub vertical stratum in the Damas River Formation, with sequences of coarse massive stratum and weak slims, besides fault planes, all of it configures a high risk of landslides of big blocks.

  The most mountainous areas present a greater possibility of snow avalanche risk. The risks are presented as avalanche corridors and cones associated to strong slopes, usually in high parts of the valleys in general above 3000 m.a.s.l. It corresponds to forms susceptible to channel, violently a determined amount of snow and rocks, especially before favorable conditions of snow supply, slope and exposure to sunshine.

- **Yeso River Valley Area:** The most generalized risk is the mass removal, especially for those hillsides constituted by dissection of deposits associated to mega collapses covering the Yeso river valley. These materials have low cohesion; they present a strong slope and are subject to permanent erosion by baseline effect which increases the changes of breaking of balance of the hillsides.

  The intense erosion triggered by the Yeso River in the deposits of landslides and its effects over the stability of the hillside is possible to be observed in a most notorious tranche of approximately 5 km from the reservoir downstream.

  Binding to the mountain chain of Mesón Alto Hill, is observed an environment with probability for development of avalanche risks.

- **Lo Encañado Small Lake Area:** This area also presents a potential risk of mass removal. The west flank of the valley upstream of it is exposed to landslides whose influence could reach the margins of the small lake. Likewise, upstream of the small lake, it is added to this potential risk the one associated to snow avalanches.

- **Colorado River and EL Manzano valley Area:** This sector is within a morphoclimate domain of mid-mountain therefore the morphogenetic processes are less erosive than those in the areas previously mentioned. Because of this reasons, there are no natural risks of wide distribution besides those linked to the level rise of Colorado river and its potential effects over erosion of the valley margins, generally used by deposits if the talus base and debris cones.

  For El Manzano area, the same characteristics than Colorado River are applied.

- **Maipo River in Las Lajas Area:** The most evident risks area related to the rise of Maipo river levels which could cause erosions in its margins, movement of mid and side banks and floods in its works and infrastructures.

Detail of the areas with geological risk associated to processes of mass removal are presented in the "Geologic Risks" Planes attached to Annex 22 of EIA. In this planes the "Declared Risks" are identified, this is the deposits of mass removals occurred in the past and the "Potential Risks" of mass removals that might happened in the future, based on the acknowledgement of the previous ones.

In relation to the potential risk assessed in the mentioned planes, it could be established that if future removals occur, these will be clearly of low magnitude and would not reach the extension that those in the past had, and which today are identified as "Declared Risk" zones. Those big removals of the past, indicated in the risk map, were, without a doubt, facilitated by the physical conditions of the sides of the valleys, generated after the withdrawal of snows of the last ice age.

b) Avalanche or Snow Avalanche Risk

This phenomenon is associated to the excess accumulation of snow in protected hillsides or shady and to hillsides zones where accumulation of snow by wind is produced. When accumulations exceed the balance threshold, avalanche processes are triggered. Risks of this type are located in the higher sectors of the valleys where there are snow accumulations and permanent ice.

c) Seismic Risk

The main seismicity zone is related to the subduction mechanism of Nazca's oceanic plate under the South American continent. Historically, the most serious earthquake and better document in the zone is from September 4th, 1958. Previous to this earthquake, and with a similar epicenter, was the one in December 1850, denominated the Maipo Valley earthquake, which Lomnitz (1970) gave 7 to 7.5 magnitude. The epicenter of the earthquake of 1958 was located near Las Melosas town and consisted in a sequence of three events originated in a lapse of about 4 minutes with magnitudes of Ms = 6.9, 6.7 and 6.8, correspondingly. The earthquake caused severe damage in El Volcán town and its maximum intensity in the epicenter zone was estimated in X Degree in the Modified Mercalli Scale.

Surface breaking was not observed, not being able to associate the event to any visible faults in the zone.

d) Volcanic and Lahars Risk

This type of risk is associated to the presence of active volcanoes and to the existence of glacial excess areas or permanent snow accumulations. For the area of study, the volcanic risk is associated to the Volcanic Complex San José. In the presence of important volcanic activity, a merge of snows, ices and mud masses run-off could be produced, with high load in suspension downstream the Volcán river and Maipo Valley.

As it has been indicated, the volcanic risk is associated to the Volcanic Complex San José, which has mainly an effusive and explosive activity, being the only eruptive center of the zone adjoined to the area of the Project which evidences post glacial activity. The main cone of the volcano has four craters from the Holocene age. It has had low magnitude eruptions of phreatomagmatic type in historic times, with an approximate frequency of 20 years per each eruption, with periods between 5 and 40 years between eruptions. The behavior of the volcano in these last eruptions has been moderate explosivity, with scarce generation of pyroclastic flows. The east flank of the complex shows several glacial, the biggest one is in La Engorda ravine, which makes up a lahar danger. The geologic recognition of the volcano allows to presume the eruptive activity in a near future would generate, essentially, ash falling and lapilli, bombs and blocks falling in the nearest area to the crater, minor lahars and lava flow, and pyroclastic of scarce extension and reduced volume.

Along its history, the San José volcano has manifested a number of historic eruptions of low magnitude and phreatomagmatic type. There is a record of those events in 1722, 1822-1838, 1881, 1889-1890, 1885-1897, 1931, 1959 and 1960. That is to say, the volcano has had eruptions with an approximate frequency of one eruption every 20 years, with minimum periods of 5 years and maximum periods of 40 years between eruptions[1].

Out of the available information, there is a potential risk of lahar generation which would be canalized downstream through Colina stream, La Engorda and Volcán River. In the same zone, a minor danger is associated to pyroclastic flows. The confluence area of La Engorda and Colina streams limits the probable maximum reach of lava flows according to the existing records.

e) Overflow and Flood Risk

The overflow risk is located in erratic water courses, especially in the streams in the upper part of Volcán River where the water courses are not canalized. Violent rises of levels due to rains or thaws can generate abrupt changes to this water courses retaking abandoned channels or opening new ones. Floods are produced in areas associated to low river terraces, where there are settlements and present a potential risk of floods before a rise of level. The analyzed water courses in those areas where the works of the project will be carried out, by exception of streams in the upper part of the Volcán river, have narrow valleys and an important degree of canalization therefore the risk of overflows is scarce, nevertheless, the characteristic of these torrential water courses is to increment considerable

[1] Geologic and Volcanic Risks and Mass Removal Study", 199 Department of Geology and Geophysics of Universidad de Chile.

on situations of sudden rises using abandoned channels, opening some other and running-off important volumes of suspended materials (solid load). With this features, any settlement of the areas adjacent to the water courses, increases considerable the flood risk in the area.

5.10.4 Conclusion

According to the analysis performed to the different areas of the Project, geomorphological terms are identified, two morphogenetic ones corresponding to Upper mountain and Mid-Mountain. The first of them, operate with dominant erosive processes of wearing of the hillsides and transport of materials. Within this domain, there are the Upper Volcán River, Yeso and Lo Encañado areas.

The second morphogenetic domain corresponds to a more stable means with a greater importance the pedogenetic processes or ground formers over the hillsides; these are areas with a continuous vegetation cover therefore there is greater biologic activity on the grounds.

Over these means it has been developed a set of natural risks which area coherent with these features. The most recurrent feature is the presence of mass removal processes in the high mountain domain which due to their characteristics can affect some of the works of the Project, especially those of lineal character such as roads and canals, if the necessary technical measurements are not taken.