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## **CHAPTER 6**

# **IMPACT EVALUATION AND ENVIRONMENTAL MANAGEMENT MEASURES**

### 6.1 INTRODUCTION

This section contains a chapter comprised of environmental impacts and management measures, whose structure permits the identification of the sources of impacts associated with the execution of the Project as well as the corrective and/or control measures that it will incorporate. This structure has the objective of maintaining a complete vision of the PHAM and its global effect, facilitating in this way the understanding and work of the environmental evaluation.

In that regarding the evaluation of impacts, this is done in accordance with letter g) of Article 12 of the Regulations of the Environmental Impact Evaluation System (EIES), which indicates that “the prediction and evaluation of the environmental impacts will consider the effects, characteristics or circumstances of Article 11 of the Law, relating to the Project or activity and will consider, as applicable, the direct, indirect, accumulative and synergic impacts”. The environmental management measures will incorporate actions for the mitigation, repair and/or compensation of the adverse effects of the project when applicable.

## 6.2 METHODOLOGICAL CONSIDERATIONS

### 6.2.1 Environmental Impact Evaluation

The prediction and evaluation of the environmental impact was done by contrasting each one of the environmental elements (characterized in the baseline) with its potential transformation derived from the execution of works and/or activities of the PHAM.

The prediction and evaluation of the environmental impacts was done on the basis of models, simulations or measurements considering the condition of the environmental elements in their most unfavorable condition. The quantifiable effects are assessed as a function of the regulations in effect. The non-quantifiable impacts were assessed in qualitative terms.

Given the nature of the project and the specific characteristics of its area of insertion, the environmental evaluation conducted pays special attention to the impact of the works on the quality of the air, biotic environment, landscape and economic activities, in its construction as well as in its operations phase.

The methodological sequence applied for the Environmental Impact Evaluation is indicated below.

- a) Analysis of the actions and works included in the Project to identify their potential sources of impact on the different stages of construction and operation. The effect described is situated temporally and spatially.
- b) Identification of the environmental components that may be affected by each source of impact, on the basis of the baseline conditions previously described.
- c) Identification of impacts through action – effect – impact methods. In this EIE we briefly describe the impact and identify the sources that generate it, differentiating those foreseen for the stage of construction and operation.
- d) Description of the applicable environmental management possibilities, whether these are included for the engineering of the Project or whether they arise in the environmental evaluation.
- e) Classification of the impacts in each environmental element on the basis of the technical considerations applied by each specialist. From this, the nature of the impact is concluded on (negative and/or positive) and its significance (high, medium or low). The latter is an integrating criterion that considers the impact assessed in the global context of the study, that is, taking into account the parameters established by the legislation in effect and by the environmental protection criteria currently used. The classification of the impact considers the environmental management measures that will form part of the PHAM, whether they are included in the design or whether they derive from this EIE.

## **6.2.2 Environmental Management Measures**

Once we identified the potential impact, we listed the environmental management measures that it would be necessary to implement. These consist of the systematic and structured preparation of a series of actions that mitigate, restore and/or compensate for the negative environmental impacts produced by the implementation of the Project in its surroundings.

The mitigation measures have the purpose of decreasing the significant adverse effects of the Project, whatever its stage of execution. These measures will be oriented towards the following:

- Completely avoiding the adverse effect through the non-execution of an action or of those parts of an action that generate the effect foreseen.
- Decreasing the adverse effect through an adequate limitation or reduction of the magnitude or duration of the action that generates this effect.
- Reduction or elimination of the adverse effect through the implementation of specific actions.

The reparation and/or restoration measures have the objective of restoring to the environment one or more of its components at a quality similar to that which it had prior to the damage caused, or if this is not possible, reestablishing their basic properties.

The compensation measures have the objective of producing or generating a positive alternative effect that is equivalent to the significant identified adverse effect. These measures will include the replacement or substitution of the natural resources or elements affected of the environment, including actions to substitute the natural resources of affected environmental elements by others with similar characteristics, class, nature and quality.

## 6.3 ACTIVITIES OF ENVIRONMENTAL IMPORTANCE AND SENSITIVE ZONES

### 6.3.1 Works and Activities that may Potentially Generate Impacts

In accordance with the characteristics and size of the PHAM (chapter 2, section 2.2), it is considered that the works and activities indicated in Table 6.3.1.1 are those with potential to generate environmental impacts.

**Table 6.3.1 1**  
**Works and Activities that may Potentially Generate Impacts**

Stage	Works or Activity
Construction	Excavations and construction of underground works (tunnels, machines cavern)
	Construction civil engineering works on the surface (intakes, siphons and ducts).
	Transport of equipment and machinery.
	Installation and operation of worksite facilities and camps
	Setup and operation of muck stockpiling.
	Setup and maintenance of service roads for the works.
	Road traffic associated with the construction of the works.
Operation	Modification of flows in rivers and streams with the project's intakes and discharges.
	Road traffic associated with the operation of the plants and auxiliary facilities.
	Maintenance of facilities.

The project does not include special areas for the extraction of loan minerals or aggregates. Nor does it include the transmission system, that is, the electrical wiring.

### 6.3.2 Identification of the Components that may be Affected

It is highlighted that the surroundings of the area of insertion of the PHAM present the following singularities, which have been addressed with emphasis in the evaluation conducted:

- Presence of areas under official protection.
- Presence of tourist activities in the surroundings.
- Presence of natural environments of conservation interest.
- Presence of sites of archaeological and paleontological interest in the surroundings.

### 6.3.3 Areas of Restriction of the Project

The information indicated above, plus that generated during the environmental evaluation, has allowed the definition of areas of environmental restriction, which house singularities or areas of environmental value whose safeguard will be guaranteed by the Project (see figures 6.4.1.1 and 6.4.1.2). The components that are located outside the area of direct influence of the works form part of these areas, but given their proximity involve a special system of care that will be imposed on the Contractors. In these areas, none of the activities indicated in table 6.3.1.1 can be carried out.

**Insert Figure 6.4.1.1 “Areas of restriction, upper Volcán sector”**

**Insert Figure 6.4.1.2 “Areas of Restriction, Lo Encañado – Yeso River sector”**

#### 6.4 EVALUATION OF ENVIRONMENTAL IMPACTS AND MANAGEMENT MEASURES

The PHAM is inserted in the upper basin of the Maipo River. In general, the project area has characteristics typical of mountain landscapes, uninhabited, and with highly rural environments, where anthropic use is restricted to the upper terraces of the main water courses, particularly the Maipo and Colorado Rivers.

The existence of small livestock in areas with seasonal grass stands out, especially at the bottoms of ravines and in sectors neighboring the mountain lakes and streams (summer grazing). In this category are highlighted the summer grazing areas associated with the El Yeso dam and the Lo Encañado lagoon, as well as the area of the Morado, Las Placas, La Engorda and Colina streams (see figures 5.4.1.21 to 5.4.1.29, attached in Chapter 5).

The natural environment presents external factors of human intervention represented by the existence of road infrastructure, mining activity, run-of-the-river hydroelectric plants (e.g. Los Maitenes and El Alfalfal), and development of pasturage in the summer grazing areas.

In general, the area presents an increase in tourism development, exploring the landscape aspects and natural attractions; contrasted with the meager presence of infrastructure and tourist facilities, and of associated services.

The effects foreseen on the environmental components are described in the following sections of this chapter, indicating in each case the applicable environmental management measures. In addition, a summary of these measures is described in Chapter 7.

For the case of the environmental risks attributable to the project, and which do not constitute impacts of the evaluation, Chapter 7 indicates the risk prevention and control actions that will be assumed by GENER.

Table 6.4.1.1 presents a cause-effect relationship that orients the evaluation conducted and focusses the efforts of the Project's environmental management strategy.

**Table 6.4.1 1**  
**Identification of Cause-Effect Relationships**

		Air quality	Sound pressure and vibrations	Risks	Soil	Hydrology and water quality	Limnology	Flora and vegetation	Ground Fauna	Population	Community Infrastructure and equipment	Tourism activity	Cultural heritage	Landscape Units
Construction	Excavations and construction of underground works (tunnels, machines cavern)		■	■					■	■				
	Construction of civil engineering works on the surface (intakes, siphons, substation and bridges).	■	■	■	■	■	■	■	■	■	■	■	■	■
	Installation and operation of worksite facilities and camps		■					■	■					■
	Setup and operation of muck stockpiling.			■				■	■					■
	Setup and maintenance of service roads for the works.	■						■	■					■
	Traffic flow associated with the construction of the works	■	■	■						■	■	■		
Operation	Modification of flows in the rivers and streams with intakes and discharges from the project.					■	■	■				■		■
	Traffic flow associated with the operation of the plants and auxiliary facilities.													■
	Maintenance of facilities.							■						■
	General operation of the project					■				■				

## 6.4.1 Construction Stage

### 6.4.1.1 Alteration of the Air Quality

#### i) Identification and Sources of impact

During the construction stage of the project, the main emissions into the atmosphere correspond to the particulate material generated by the movement of land associated with the construction of works and excavations, and the transport of materials, equipment and vehicles along non-paved roads. In addition, low emissions of CO, HC and NO<sub>x</sub> will be generated due to the functioning of motors of equipment and machinery.

Given that the project is located in the Metropolitan Region, it is subject to the Metropolitan Region Atmospheric Decontamination and Prevention Plan (PPDA). In this respect, article 51 of the PPDA, in its last update published in the Official Gazette in 2004, states that all projects that enter the Environmental Impact Evaluation System (EIES) must compensate 150% for the emissions generated, if the emission limits established in Table 6.4.1.2 are exceeded.

**Table 6.4.1.2**  
**Emission Limits Determined by the PPDA**

Contaminant	Emission Limit (ton/year)
MP-10	10
CO	100
NO <sub>x</sub>	50
HC	100
SO <sub>2</sub>	150

Due to the above, the emissions generated by the project in the construction stage are compared with the maximum values established in the above table, with the objective of defining the emissions compensations.

Regarding the estimate of emissions, due to the singularities of the area of influence and the characteristics of the project, the methodology for the calculation has integrated some important general considerations that make the environmental evaluation more precise. These considerations are summarized in:

- Emissions for the concept of transport of muck are considerably reduced, given the use of shuttle car wagons and conveyor belts. In this regard, most of the muck generated during the construction of tunnels is transported through this method, considerably decreasing the generation of emissions that would be generated by using trucks due to re-suspended dust.
- Most of the works are underground. Although activities are generated that emit particulate material inside the tunnels, only a fraction of these emissions are dispersed outside them, corresponding to those generated in the area close to the halls.

- Added to the above, the project has minimized the length of the service roads between the muck stockpile sites and the work fronts, allowing the transit of vehicles to be decreased for the concept of transport of personnel and muck.
- Since the majority of the project works are located in a high mountain area, it is possible to affirm that there is a reduction in emissions in a natural manner during the winter period, due to the contribution of humidity due to precipitations of water and snow.
- The estimate of emissions includes the improvement of current access routes to the project area corresponding to sections of highway G-25 and the El Yeso Dam, and the section of highway G-25 between the El Yeso bridge and the project worksite area, through the reconstitution of the platform, plus watering with Magnesium Chloride (Bischofite).

### Gas Emissions

Considering the above, the following tables are obtained from the study “Estimate of Emissions in the atmosphere” attached in Annex 4, which summarize the total emissions of gases and PM10 for each year of the construction of the project. These correspond to those produced by the functioning of motors of vehicles and machinery.

**Table 6.4.1.3  
Summary of Emissions (Ton/Year) of CO**

Activity	Emissions per year (kg)					
	2008	2009	2010	2011	2012	2013
Motors of equipment for roads	824	4.109	4.315	3.747	1.278	0
Motors of vehicles	46	171	225	205	161	2
Motors of construction equipment on the surface	0	2.325	5.426	5.426	3.100	0
<b>Total Emissions of CO (kg)</b>	<b>871</b>	<b>6.606</b>	<b>9.966</b>	<b>9.377</b>	<b>4.539</b>	<b>2</b>
<b>Total emissions of CO (Ton)</b>	<b>0,87</b>	<b>6,61</b>	<b>9,97</b>	<b>9,38</b>	<b>4,54</b>	<b>0,00</b>

**Table 6.4.1.4  
Summary of Emissions (Tons/Year) of HC**

Activity	Emissions per year (kg)					
	2008	2009	2010	2011	2012	2013
Motors of equipment for roads	77	276	295	251	86	0
Motors of vehicles	26	97	128	116	91	1
Motors of construction equipment on the surface	0	221	515	515	294	0
<b>Total Emissions of HC (kg)</b>	<b>103</b>	<b>594</b>	<b>938</b>	<b>882</b>	<b>471</b>	<b>1</b>
<b>Total Emissions of HC (Ton)</b>	<b>0,10</b>	<b>0,59</b>	<b>0,94</b>	<b>0,88</b>	<b>0,47</b>	<b>0,00</b>

**Table 6.4.15  
Summary of Emissions (Ton/year) of NOx**

Activity	Emissions per year (kg)					
	2008	2009	2010	2011	2012	2013
Motors of equipment for roads	612	3.025	3.182	2.763	939	0
Motors of vehicles	184	663	868	786	634	7
Motors of construction equipment on the surface	0	1.722	4.018	4.018	2.296	0
<b>Total Emissions of NOx (kg)</b>	<b>796</b>	<b>5.410</b>	<b>8.068</b>	<b>7.567</b>	<b>3.869</b>	<b>7</b>
<b>Total Emissions of NOx (Ton)</b>	<b>0,80</b>	<b>5,41</b>	<b>8,07</b>	<b>7,57</b>	<b>3,87</b>	<b>0,01</b>

When the above tables are observed, it can be seen that the emissions rates of contaminating gases of CO, HC and NOx are within the limit established by DS 58 of MINSEGPRES PPDA, in its article 51.

Emissions of particulate material

There are natural factors that function as mitigation measures in the emission of particulate material into the atmosphere, and precipitation is among these factors. According to EPA recommendations, the days of precipitation must be deducted from the total of emissions of particulate matter into the atmosphere.

In order to analyze this effect, the records of the meteorological station located at the Queltheues plant were considered as representative of the area of the project's location; the period of time analyzed is from 1984 to 2004. On average during this period 34 days were recorded annually with precipitations. Deducting those days with precipitation from the total emissions generated by year, a reduction of these is obtained of close to 10% of emissions.

Table 6.4.1.6 below details the final emissions generated for each year of construction of the project, considering the reduction due to the effects of the meteorology.

**Table 6.4.1.6  
Summary of Emissions of MP10 Considering Natural Mitigation Measures (Ton/Year)**

Activity	Emissions per year (kg)					
	2008	2009	2010	2011	2012	2013
Preparation of new roads	15.746	7.111	0	0	0	0
Drilling and Blasting	0	4.187	1.381	356	0	0
Loading and Unloading of Materials	7.654	13.196	10.443	8.205	1.040	0
Circulation de Vehicles	15.253	130.229	190.993	163.404	46.943	389
Transport of Muck	21.897	36.036	27.377	23.977	3.477	0
Construction of Surface Works	2.886	5.243	1.028	179	102	0
Erosion in muck stockpiling sites	4.398	10.848	10.591	9.572	1.697	0
Motors of equipment for roads	621	3.324	3.488	3.047	1.038	0
Motors of Vehicles	6	23	29	27	22	0
Motors of construction equipment on the surface	0	1.809	4.222	4.222	2.413	0
Construction of Estanque Aucayes Alto and Access Road	0	0	28.947	0	0	0
<b>Total Emissions of MP10 (kg)</b>	<b>68.462</b>	<b>212.005</b>	<b>277.118</b>	<b>212.989</b>	<b>56.733</b>	<b>390</b>
<b>Total Emissions of MP10 (Ton)</b>	<b>68,5</b>	<b>212,0</b>	<b>277,1</b>	<b>213,0</b>	<b>56,73</b>	<b>390</b>

The final value, after applying the proposed weighting factors, reaches in a worst case 277.1 tons per year, and corresponds to the year 2010, due to the materialization of the different Works and activities required by the project.

When considering the limit value for emissions of MP10 (10 ton/year), which establishes the PPDA of the Metropolitan Region, the current Project exceeds this limit by 267 tons/year in the worst case, so the Titular proposes the compensation measures detailed in the following sections.

On the other hand, no effect whatsoever is foreseen on the glaciers existing in the area due to the atmospheric emissions. The horizontal distances and mainly the differences in altitudes between the work fronts and the glaciers, determine that the emissions of particulate material will not reach the glacier area, since the ventilation conditions of the high mountain facilitate the dispersion of dust, particularly of that small fraction that does not sediment gravitationally in the surroundings of the emission sectors. For example, the work front located in the Upper Volcán sector is located at a horizontal distance of 10 to 12 km from the Marmolejo Glacier, while the work front of the El Yeso dam sector is located at a horizontal distance of between 8 to 10 km from the San Francisco and El Morado glaciers. Along with the horizontal distances, the difference in altitudes existing between the work fronts and the glaciers must be considered, the sector of Upper Volcán is located at an altitude of 2,500 m.a.s.l., while the lowest part of the Marmolejo glacier is at an altitude of 4,500 m.a.s.l., and the El Yeso sector is located also around altitude 2,500 m.a.s.l., while the San Francisco and El Morado glaciers are located at altitudes 4,400 and 3,800 m.a.s.l. respectively. The La Paloma and El Altar glaciers (see section 5.3.1.5 of chapter 5) are located even more distant from the project area, in the "Santuario de la Naturaleza Yerba Loca" sector.

## ii) **Environmental Management Measures**

### Compensation of emissions

As indicated, in accordance with the results of the study of emissions, the rate of emissions of MP10 attributable to the construction of the PHAM exceeds the limits established by the PPDA, by 267 Ton/year. Due to this, the project must compensate its emissions by 150% (see Annex 5).

The emissions compensation proposal consists of the improvement of the current access routes to the project area, which correspond to 22 km of the section between highways G-455, between highway G -25 and the El Yeso Dam, and to 21 km of the section of the highway G-25 between the El Yeso Bridge and the area of the project worksite facilities. The improvement consists of the reconstitution of the platform (through a layer of leveled granular aggregate), plus watering with Magnesium Chloride (Bischofite)<sup>1</sup>. As well as the

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<sup>1</sup> The use of Magnesium Chloride is considered to be one of the stabilizers and dust suppressors most used by the Roadway Authority. The use of this product in the setup of bases and sub-bases will be done only for the implementation of new roads for the exclusive use of the project. For more details on the considerations of the use of magnesium chloride in the treatment of existing and projected roads, please refer to Annex 19. This product is currently used by the Roadway Authorities of the I, II, III, IV, VII and IX regions, in projects such as "Improvement of Highway 21 CH of Access to the county of Ollagüe, II region"<sup>1</sup>, "Basic Roads Program" of the MOP1, "Improvement of Road B-165 of access to the village of Ayquina, II region"<sup>1</sup>, "Improvement of the section road Puente 7-Road, County of Florida, VIII region"<sup>1</sup> and "Improvement of road J-55, VII region"<sup>1</sup>, among other projects. Along with the above, the use of bischofite is considered to be within the possibilities of surface treatment of roads that are under the supervision by the MO Highways Authority mentioned in section 5.002.207 "Works Entry Card" of the MO Highways Manual MOP (2003).

reconstitution of the platform, signs and road guardrails will be incorporated. The complete detail of the measures associated with the improvement of roads is presented in Annex 19, while Annex 1 contains sheets that illustrate the sections of roads to improve.

The current conditions of these sections, added to the transit of heavy vehicles that access the mining worksites, represent the main source of emissions of particulate material in the zone. In this sense, the implementation of the compensation measures will have an immediate effect on the total emissions generated by this emissions source.

According to the analysis done (see Annex 4 and 5), the current PM10 emissions corresponding to the two sections indicated previously and considering the improvement works, will be reduced by 1,170 ton/year. This number leads to compensating in its totality the 150% of the project emissions (415.5 ton/year) and allows compliance with article 51 which establishes the PPDA of the Metropolitan Region. To estimate in a conservative manner the emissions that will be reduced, only the reduction of emissions due to the improvement of the roads was considered.

It is expected that this proposal of compensation which has been estimated following the calculation procedures and criteria recommended by CONAMA will be validated before the corresponding authorities. Annex 5 appends an Emissions Compensation Plan (PCE) prepared in consensus with the Department of Atmospheric Decontamination of CONAMA RM, which defines the exact manner in which the compensation and the associated timeframes will be materialized, as well as the mechanism which will be used to follow-up compliance with the measures. On the other hand, it represents all the activities that generate emissions within the project, the expressions used to estimate the emissions and the parameters that feed them.

### Mitigation of emissions

Without prejudice to the compensation proposed, the Titular of the project has also considered the following measures for the abatement of particulate material:

- Trucks with material that move outside the work fronts and that access public roads will be covered with canvas to avoid the detachment of material;
- The internal surfaces of the works, platforms and work fronts will be wetted, particularly in the dry season. The Titular of the project considers the use of a tanker truck in the following way: a) during the first year of construction of the project and limited to the construction and improvement of roads. It will be used daily in the areas where these works are carried out, that is, in the El Volcán, El Yeso – Lo Encañado sector and in Aucayes (Upper and Lower). Once the construction and improvement of roads is finished, the transit of the truck will not be necessary, since both roads will have agglomerates in their surface that allow the emission of dust to be mitigated; ii) In the work fronts of the surface works and in fronts located in the halls of the tunnels and in the camp areas. It will be used daily during the construction stage of the works.
- Instructions will be given to the contractors so that trucks parked for a prolonged period at the worksite keep their engines turned off.
- Inside the camps and work fronts, the outdoor burning of waste and combustible materials will be prohibited (wood, surplus plant material, paper, leaves or waste and any

other waste originating in the construction stage) during the execution of the works. Food will be heated with gas or electrical devices.

### **iii) Classification of the Environmental Impact**

The results of the Emissions Estimates Study (Annex 4) indicate that during the PHAM construction stage, the rates of emission of CO, HC, NOx remain within the limits established by the PPDA.

Although the emissions of PM10 will exceed the limits established by the PPDA, the compensation proposal that the project will assume allows that established in the PPDA to be complied with.

It must also be indicated that the area of location of the project presents good ventilation conditions that will allow the dispersion of the diffused emissions of articulate matter, so the emissions will not constitute a local source of impact. Most of the sources of diffused emission will be located at a height of over 1000 m.a.s.l. No effects are foreseen on the glaciers existing in the area.

Also, the different work fronts will be located distant from inhabited areas, so there will not be any direct receptors.

Considering all of the above, the environmental impact associated with the emissions into the atmosphere is classified as negative of average significance.

#### ***6.4.1.2 Increase in the Sound Pressure Level***

##### **i) Identification and sources of impact**

###### **a) Methodology**

###### **— Stationary Sources**

The stationary sources of noise considered in the analysis are grouped into two types of stationary emissions sources; the work fronts and the worksite facilities. The work fronts correspond to onsite facilities where all the construction works will be executed of the surface works as well as the underground works. The worksite facilities will function as the basis of operations of the work fronts, where the areas for warehouse, parking, personnel care and administration in general will be installed.

The main activities that generate noise in the work fronts correspond to movements of vehicles and machinery, functioning of the concrete plant and the power generators, works of movement of land, loading and unloading of material, and construction works in general. In the work fronts associated with the construction of tunnels an internal flow of machinery and trucks was considered, limited between the work fronts and muck stockpiling sites. In the case of the worksite facilities, the main activities that generate noise correspond to: the internal circulation of trucks, functioning of the power generators and activities of the workers in the areas of storage of fuels and machinery, offices, gatehouse, sanitary services, dining halls, etc.

The power levels associated with the work fronts and worksite facilities are shown in Table 6.4.1.2.1, and consider the most unfavorable emissions scenario, that is, the simultaneous functioning of the above-indicated activities.

Other methodological considerations are the following:

- All the sound powers entered in the model correspond to measurements of equipment measured by Control Acústico Ltda. and are completely compatible with the sound emissions proposed by the British Regulations B.S. 5228: part 1/1984.
- For the analysis of this impact, a model was applied based on the ISO 9613 standard, parts 1 and 2, which uses the principles of divergent attenuation, along with extra attenuation introduced by obstacles and attenuation by air.
- The software used is SoundPLAN see 6.3
- The meteorological parameters are set at a temperature of 10° C and a relative humidity of 80%, constituting an unfavorable scenario due to the low attenuation by meteorological effects. The regulation used also considers wind between 3 and 4 (m/s) in favor of propagation. With this combination of temperature, humidity and wind values the results are obtained that most favor the propagation of sound waves by having the lowest values of sound absorption. This supported by that established in ISO 9613:1993 Acoustics – Attenuation of Sound during Propagation Outdoors and in other international technical standards.
- The acoustic impact foreseen is assessed in accordance with the contrast of the noise levels projected with the limits or considerations established by the D.S. 146/97 of the MINSEGPRES.
- The activities considered within the construction stage of the tunnel and the facilities of the hydroelectric project are:
  - Blasting in tunnel Access windows;
  - Transit of trucks between worksites and muck stockpiling areas;
  - Transit of trucks and buses between work fronts, camps, worksite facilities and Puente Alto;
  - Heavy machinery (backhoe) for the construction of surface works;
  - Loading and unloading of material with hopper trucks in stockpiling areas;
  - Work fronts in windows and intakes, with 1 concrete plant and 1 soundproofed power generator.

The transport of muck along conveyor belts and railway lines will not generate important noise emissions.

- The sound power levels for each source of noise during the construction stage are:

**Table 6.4.1.2.1**  
**Sound Power levels from Stationary Sources Considered for the Model.**  
**The Values are in dB(A) by Octave Bands**

Source of the Noise	Central Frequency [Hz]								Total
	63	125	250	500	1k	2k	4k	8k	
Backhoe	74	82	91	94	99	99	97	92	104
Interior transit of trucks	38	51	53	58	62	62	57	51	66
Blasting	91	94	97	99	97	91	84	82	104
Loading and unloading of truck	82	90	99	102	107	107	105	100	112
Power generators	69	79	86	92	95	96	96	94	102
Concrete plant	87	97	104	110	113	114	114	112	120

— Mobile Sources

Regarding the analysis of mobile sources, for the flow of cargo trucks and buses along public roads, the calculation of emissions was based on the methodology recommended by the European Union, according to the Guide du bruit of France (see Appendix 1 of Annex 30). An average speed of displacement for trucks and buses of 40 Km/hr was considered, taking into account the curves and the condition of the road. The calculation of emissions of flow of heavy vehicles considers only the speed of displacement and the type of vehicle (level of power associated), and not the flow condition. The results of the projection of noise levels due to the flow of heavy vehicles is delivered for receptors located at the edge of the road, that is some 6 m from the axis of the road, constituting the most critical case regarding emissions.

To consider a truck in movement, it is assumed that the energy is distributed according to the trip. This calculation is similar to considering a source in movement at a speed of displacement of, for example, 40 km/h, covering 40,000 m in 1 hour. For this, the energy emitted of  $L_w = 110$  dB(A) must be distributed at 40,000 m for each vehicle. The estimate of 110 dB(A) of elastic sound power  $L_w$  was done by own measurements of cargo trucks and buses at the construction worksites<sup>2</sup>.

In this way, the calculation of sound emissions is obtained by lineal meter  $L_w/m$  of flow for a truck/bus in a lapse of 1 hour considering the flows in Table 6.4.1.2 (sum of the flow of supplies and personnel for peak month). We now give examples of calculations of sound emission for the Puente Alto - Las Lajas section. The detail of the road traffic calculations is contained in Annex 30 of this EIE.

<sup>2</sup> Source: Measurements done by Control Acústico Ltda comparable to values included in "Update of Noise database for prediction of noise on construction and open sites (contained in Annex C, Part 1 of BS5228). Department For Environment, Food and Rural Affairs (DEFRA), 2004", part of the British Standard, BS 5228: 1984, "Noise and vibration control on construction and open sites".

Puente Alto – Las Lajas Sector (includes Las Lajas + Aucayes + Alfalfa traffic): 196 vehicles/month, equivalent to 0.7 trucks/hour (1 truck/hour) for a period of 9 hours of work.

$$\begin{aligned}
 Lw/m &= 110 - 10 \text{ Log (length) } + 10 \text{ Log (no. of trucks day)} \\
 &= 110 - 10 \text{ Log (40.000) } + 10 \text{ Log (0,7)} \\
 &= 110 - 46 - 1,5 \\
 &= \mathbf{63 \text{ dB(A)}}
 \end{aligned}$$

The calculations of sound emissions exemplified are identical to the result calculated according to GdB or modified French method, and recommended by the CEE.

For example, the calculation for the sector: Puente Alto – Las Lajas is the following:

$$\begin{aligned}
 Lw/m &= 110 - 10 \text{ Log (length) } + 10 \text{ Log (no. of trucks day)} \\
 &= 110 - 10 \text{ Log (40.000) } + 10 \text{ Log (0.7)} \\
 &= 110 - 46.02 - 1.54 \\
 &= \mathbf{62,4dB(A)}
 \end{aligned}$$

Lw corresponds to the sound power of a truck at the respective velocity Lw=110dBA (adjusted to Chile) since the French standard GdB uses a Lw factor of 109.9dBA

The value is an average of NPSmax values measured at 7.5 m from the axis of the road, which is of NPSmax = 84.5dBA (this value is measured by octave bands and shows the total value in dBA). With this, the calculation of emissions is made according to the GdB.

The emission of noise is defined as follows:

$$E = (L_w - 10 \log V - 50)$$

Where V is the velocity of the vehicle in Km/h

$$E = (110\text{dBA} - 10 \log 40 - 50) = 110 - 16 - 50 = 44$$

The values are by octave bands and only show the total value in dBA.

$$Law /m = 10 \text{Log} (10^{(Eiv + 10 \text{ Log } Qiv)/10} + 10^{(Ehv + 10 \text{ Log } Qhv)/10}) + 20$$

- Eiv is the sound emission of the light vehicles adapted to Chile; 31 dBA
- Ehv is the sound emission of the heavy vehicles adapted to Chile; 44 dBA
- Qiv is the volume of light traffic during the interval of reference; 0 veh/h
- Qhv is the volume of heavy vehicles during the interval of reference, 0.7veh/h
- $\Psi$  is the correction realized to take into account the sound level produced by the paving, 0 dBA
- l, is the length of the section of the line of sources represented by a source of components points l in meters, = 1 meter (does not affect the calculation since it is always a lineal meter)
- R(j) is the spectral value, in dB(A), by band of octave j,

Addition of all the bands (Lw /m)

$$Lw/m = 10\text{Log} (10^{(31v + 10 \text{Log} 0)/10} + 10^{(44 + 10 \text{Log} 0.7)/10}) + 20$$

$$= 10\text{log} (0 + 17.378) + 20 = 42.4 + 20 = 62,4 \text{ dBA}$$

On the other hand, the detail of the estimates of vehicle traffic and its distribution in each one of the sectors is described in the Road Impact Evaluation Study, attached in Annex 14 of this EIE.

We now set out the level of lineal power for each sector considered:

**Table 6.4.1.2.2**  
**Calculation of the Level of Lineal power, in dB(A), from the projected Vehicle Traffic for each Sector**

Sector / Section	Projected traffic (vehicles/hour)	Lw/m dB(A)
El Volcán	15	64
El Yeso	15	64
Colorado Siphon	15	64
Las Lajas Tunnel	36	68
Maipo River Discharge	20	66
Alfalfal Access	30	67
Main road (road G-25)	3	57
Road G-455 (Pte. Alto-El Yeso)	7	58
Road G-25 (San Gabriel - El Volcán Sector)	0.13	55
Road G-25 (Pte. Alto-Las Lajas)	0.7	63
Road G-345 (Las Lajas-Maitenes)	0.5	61
Road G-345 (Maitenes-Alfalfal)	0.08	53

With these values of lineal sound emission levels, a profile of propagation to different distances is obtained through the following formula:

$$Leq = Lw - 10 \text{Log} (d) - 5$$

Where:

*Leq* is the level equivalent in the receptor, in dB(A)

*Lw* is the lineal level of power, in dB(A)

*d* is the distance from the axis of the road used to the receptor identified.

b) Estimate of the emission level

— Stationary sources

The sectors considered in the modeling of stationary sources associated with the construction of the Project are indicated in the following table:

**Table 6.4.1.2.3**  
**Activities Associated with the Construction Stage of the project in the Different Sectors Considered**

Works or Activity	Sector					
	El Volcán	El Yeso	Las Lajas Tunnel V1 and V2	Alfalfal	Colorado River (siphon and windows)	Discharge Maipo River
Excavations to set up tunnels	X	X	X		X	X
Construction of intakes and minor works	X	X		X		
Construction of canals	X	X		X	X	
Construction of siphon		X		X	X	
Construction of bridges			X			

The noise maps presented in Annex 30 graphically represent the exclusive contributions of the sources of noise in the receptors associated with the points measured during the Baseline, close to the noise sources, which constitute the most unfavorable scenario regarding emission.

It must be mentioned that the El Volcán sector does not have nearby receptors that are affected by the Project Works (the closest receptor is located some 3 km away). Despite this, the sector of the works was modeled, ruling out non-compliance with the regulations in effect, in consideration of the distance of location of this receptor.

The following table relates the measurement points presented in the Baseline (see section 5.3 of Chapter 5) with the contribution projected during the Works included in the construction stage, making the distinction regarding the contribution of the blasting (considering NPSeq of 9 minutes, for unforeseen noise).

**Table 6.4.1.2.4**  
**Contribution of Sound Pressure Level in each Sector from the Noise Maps Obtained**

Point	Works Sector	Levels of noise modeled dB(A)	
		NPSmax Blasting	NPSeq Construction
1	Forebay Alfalfal sector	—	61
2	Duct-tunnel connection El Torrejón sector	37.6	35
3	Window El Trescientos sector	18.0	36
4	Aucayes (Maitenes)	7.4	20
5	Las Lajas (El Sauce sector)	30.4	48
6	El Yeso	47	45
7	Alfalfal canal sector	—	75
8	Maipo River discharge	76	61

It is important to indicate that the blasting that will generate a perceptible noise will be the blasting done to open the halls of the tunnels. Once inside them, the excavation Works (including detonations) will not be perceptible, and will therefore not constitute a relevant emissions source, with its manifestation temporarily limited to the period of the excavation of the tunnel halls.

— Mobile Sources

Considering the vehicle flow projected at the receptors located in the proximities of the public roads that will be used by the PHAM, the following table presents the expected noise level at receptors close to the roads, considering the house facades 6 m from the axis of the road, constituting the most critical case.

**Table 6.4.1.2.5**  
**Projected Noise Values due to Vehicle Flow for Receptor Close to the Road**  
**(6 m from the axis of the road)**

Section	Projected flow trucks/hour	NPSeq hour dB(A)
El Volcán	15	52
El Yeso	15	52
Colorado Siphon	15	52
Las Lajas Tunnel	36	55
Maipo River Discharge	20	53
Alfalfal Access	30	55
Main Road (road G-25)	3	45
Puente Alto - El Yeso	0.3	45
El Yeso - El Volcán	0.13	42
Puente Alto - Las Lajas	0.7	50
Las Lajas - Maitenes	0.5	48
Maitenes - Alfalfal	0.08	40

c) Acoustic Impact Evaluation

— Stationary Sources

The sector where the project is located as well as its surroundings (area of influence) corresponds to a type of Rural Area<sup>3</sup>. For this type of zone, DS 146/97 MINSEGPRES, establishes the following in its Title III Article 5: *“In rural areas, the corrected sound pressure levels that are obtained from the emission of a stationary noise emission source, measured in the place where the receptor is located, cannot exceed the background noise by 10 dB(A) or more”*.

<sup>3</sup> In accordance with that discussed with personnel from the Municipality of San José de Maipo, the only territorial planning document in effect in the county is the Metropolitan Santiago Zoning Plan PRMS. In this sense, and for the effects of defining the zones established in DS 146/97 of the MINSEGPRES “Emission Regulations on Annoying Noise Generated by Stationary Sources”, in accordance with the uses defined by this planning instrument, the areas where the project corresponding to rural zones will be developed.

Annex 13 contains a certificate of homologation of permitted soil usages, in accordance with the PRMS, in the sectors or receptor points at noise levels according to the zoning established in DS 146/97 of the MINSEGPRES “Emissions Regulations on Annoying Noise Generated by Stationary Sources”, issued on 19/03/2008 by the Municipality of San José de Maipo.

The maximum permitted levels were delivered based on that simulated above, determined from the current sound environment situation. In the case of point 8, the minimum level measured was used, since it represents the most unfavorable scenario, that is, without the influence of vehicle traffic.

The evaluation of the results obtained in the modeling was done through the comparison of the maximum sums permitted and the total levels at each point; this latter is the result of the sum of energy of the exclusive contribution of the project and the Background Noise).

The exclusive contributions for each stage correspond to the NPSeq obtained according to the measurement periods established in the regulation, in this way, for the construction stage, the values modeled of NPSeq are used based on a temporary window of 15 minutes (fluctuating noise), while in the blasting scenario the NPSeq is used, based on a temporary window of 9 minutes (impulsive noise) from the maximum modeled value.

During the construction stage of the Project Works, two work systems will operate; the first referring to the surface works, such as canals, forebay, intake, bridges, etc., which are limited to daytime working hours, and the second corresponds to the construction of tunnels and their respective activities at the work fronts, which will function continuously 24 hours a day in rotating shifts. In this sense, the interior construction of the tunnels and associated works will be imperceptible from the surface, so the activities realized on these fronts during the night hours will be limited to unloading material removed from inside it.

In the case of the Colorado River sector works, since night work will be done in worksites close to inhabited centers, the acoustic emissions levels were determined considering a day and night scenario. We now set out the results of this evaluation.

**Table 6.4.1.2.6**  
**Evaluation of the Levels Modeled for the Construction Stage (Day Period), under DS 146/97. The values are in dB(A)**

Point	Modeled level dB(A)	Background Noise dB(A)	Maximum permitted level dB(A)	Evaluation
1	61	54	64	<i>Complies</i>
2	35	53	63	<i>Complies</i>
3	36	47	57	<i>Complies</i>
4	20	49	59	<i>Complies</i>
5	48	51	61	<i>Complies</i>
6	51	44	54	<i>Complies</i>
7	75	52	62	<i>Exceeds by 13 dB(A)</i>
8	66	72	82	<i>Complies</i>

**Table 6.4.1.2.7**  
**Evaluation of the Levels Modeled for the Construction Stage (Night period), under DS 146/97. The Values are in dB(A)**

Point	Modeled level dB(A)	Background Noise dB(A)	Maximum permitted level dB(A)	Evaluation
1	61	55	65	<i>Complies</i>
2	35	49	59	<i>Complies</i>
3	36	39	49	<i>Complies</i>
4	20	40	50	<i>Complies</i>
5	48	51	61	<i>Complies</i>
7	75	53	63	<i>Exceeds by 12 dB(A)</i>

From the results of the evaluation of the levels modeled for the construction scenario, an acoustic impact is expected in point 7 (Alfalfal sector houses), due to its proximity to the worksite and that these levels exceed the Background Noise by 13 dB(A) for the day period and 12 dB(A) for the night period, in accordance with the maximums permitted by DS 146/97 of the MINSEGPRES.

In this way, when considering the use of acoustic barriers as the main measure of decreasing the noise emissions on the houses located nearby the work fronts (for the case of point 7) an attenuation is expected of between 10 and 15 dB(A), as indicated in Figure 6.4.1.2.1 and Table 6.4.1.2.9.

**Table 6.4.1.2.8**  
**Evaluation of the Levels Modeled for the Blasting Event (Day period), according to DS 146/97. The Values are in dB(A)**

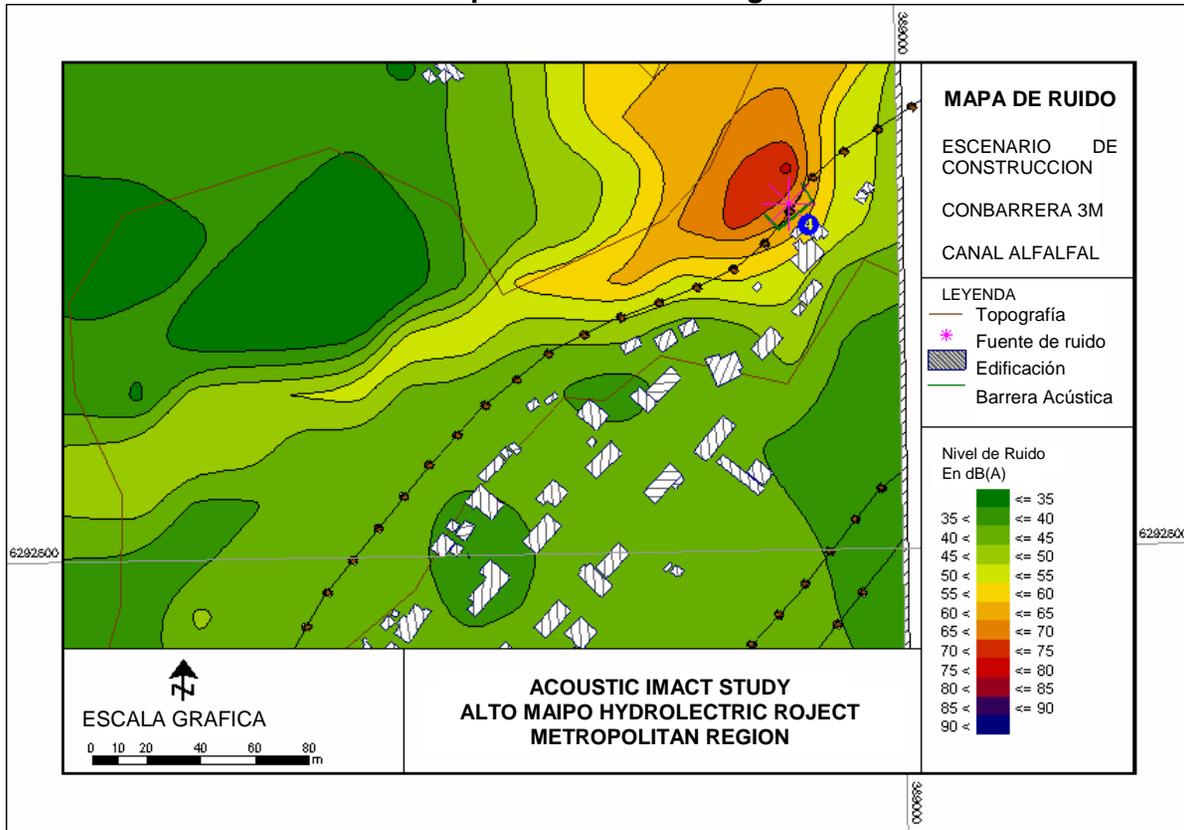
Point	Modeled level dB(A)	Background Noise dB(A)	Maximum permitted level dB(A)	Evaluation
2	38	53	63	<i>Complies</i>
3	18	47	57	<i>Complies</i>
4	7	49	59	<i>Complies</i>
5	30	51	61	<i>Complies</i>
6	47	44	54	<i>Complies</i>
8	76	72	82	<i>Complies</i>

Although the sound emissions from blasting are much louder than that of construction machinery, it must be considered that they correspond to the sound pressure of a gunshot, that is, the sound energy of a particular event in time equivalent to the sound exposure level (SEL); on the other hand, the sound pressure of the machinery is equivalent to the sound energy from a mobile noise source functioning during a determined time (in this case, some 15 minutes).

In this regard, the results obtained from the noise maps (which are obtained in turn from the sound energies considered initially) are temporarily weighted on the basis of the measurement periods of the regulation, which is equivalent to weighting the SEL (blasting event) in a time of 9 minutes (impulsive noise). The levels modeled for machinery are already weighted from the beginning in the lower levels used.

In the case of the blasting scenario, no acoustic impact is expected since these levels, added to the Background Noise of each sector, do not exceed the maximum amounts permitted by DS 146/97 of the MINSEGPRES. Without prejudice to the above and in particular for the surface works of the Alfalfa sector that are less than 35 m from some nearby house (between 35 m and 7 m), and in order to comply with DS 146/97, the implementation of mobile acoustic barriers is recommended, whose specifications are provided in Annex 30.

**Figure 6.4.1.2.1**  
**Noise Map Alfalfal Canal Sector.**  
**Scenario with Implementation of Mitigation Measures**



**Table 6.4.1.2.9**  
**Attenuations Expected in the Daytime Hours due to the Implementation of Barrier and Evaluation of Final Levels in accordance with that established in D. S. 146/97 of the MINSEGPRES. Construction Stage**

Point	NPSeq Without barrier dB(A)	NPSeq with barrier dB(A)	Maximum permitted dB(A)	Expected Attenuation dB(A)	Evaluation
7	75	60	62	15	<i>Complies</i>

**Table 6.4.1.2.10**  
**Attenuations Expected in the Night Hours due to the Implementation of Barrier and Evaluation of Final Levels in accordance with that established in D. S. 146/97 of the MINSEGPRES. Construction Stage**

Point	NPSeq Without barrier dB(A)	NPSeq with barrier dB(A)	Maximum permitted dB(A)	Expected Attenuation dB(A)	Evaluation
7	75	60	63	15	<i>Complies</i>

- Case of mobile sources

To assess the noise level emitted by the mobile sources, a reference parameter was used of the FHWA regulations<sup>4</sup>, which consider that an impact will be produced when the future levels are close to or exceed the limit values presented in the following table:

**Table 6.4.1.2.11**  
**Noise Reduction Criteria (Noise Abatement Criteria, NAC) of the FHWA.**  
**The values correspond to the Hourly Sound Pressure Level in dB(A)**

Activity Category	Leq (h)	L <sub>10</sub> (h)	Description of the activity category
A	57 (Exterior)	60 (Exterior)	Land in which serenity and silence are of extraordinary importance and are used for an important public need and where the consideration of these qualities is essential if the area is to continue to be used for this purpose.
B	67 (Exterior)	70 (Exterior)	Camp area, recreational areas, games yards, active sports areas, parks, residences, motels, hotels, schools, churches. Libraries and hospitals.
C	72 (Exterior)	75 (Exterior)	Developed land, properties or activities not included in Categories A or B above.
D	—	—	Undeveloped areas.
E	52 (Interior)	55 (Interior)	Residences, motels, hotels, public meeting centers, schools, churches, libraries, hospital and auditoriums.

The projected values of Leq<sub>hora</sub> for receptors close to the road where the trucks pass for the Puente Alto – Construction worksites journey is compared with the maximum recommended by the FHWA, considering these receptors as category B for houses or residences, parks and hospitals, in accordance with the above table.

**Table 6.4.1.2.12**  
**Evaluation of the Projected Levels with the FHWA Criteria**

Section	Leq <sub>hora</sub> Projected dB(A)	FHWA Criteria dB(A)	Evaluation
El Volcán	52	67	<i>No impact</i>
El Yeso	52	67	<i>No impact</i>
Colorado Siphon	52	67	<i>No impact</i>
Las Lajas Tunnel	55	67	<i>No impact</i>
Maipo River Discharge	53	67	<i>No impact</i>
Alfalfal Access	55	67	<i>No impact</i>
Main road (road G-25)	45	67	<i>No impact</i>
Puente Alto-El Yeso	45	67	<i>No impact</i>
El Yeso - El Volcán	42	67	<i>No impact</i>

<sup>4</sup> Federal Highway Administration, "Procedures for Abatement of Highway Traffic Noise and Construction Noise", 23 C.F.R., Part 772, Federal Register, vol. 47, pp. 29653-29657, 8 July 1982.

Section	Leq <sub>hora</sub> Projected dB(A)	FHWA Criteria dB(A)	Evaluation
Puente Alto - Las Lajas	50	67	No impact
Las Lajas - Maitenes	48	67	No impact
Maitenes - Alfalfal	40	67	No impact

It is expected that the flow of trucks will not generate an acoustic impact on the receptors closest to the road.

The FHWA considers a one-hour LEQ noise level (Leq<sub>3600</sub>), which is completely in line with the descriptor used by the French Method GdB (emissions model). At the same time, the transit noise models are comprised of noise emission calculation rules, of propagation and of evaluation, which can be combined if the descriptors are spatially and temporally consistent. The FHWA classification values are Leq<sub>3600</sub> values.

ii) Environmental Management Measures

Actions considered by the project engineering

With the objective of minimizing the effects of the noise emissions on the houses located near the area of works of the Alfalfal canal and the receptors located less than 35 m from the work front where construction work is being done with heavy machinery, acoustic barriers will be implemented, with which an attenuation of between 10 and 15 dB(A) is expected. This screen will be built in opaque panel and without acoustic leaks, with a density of 15 kg/m<sup>2</sup>, in OSB wood or plywood or steel, and with a minimum height of 3 m.



**Photographs 6.4.1.2.1 and 6.4.1.2.2: Mobile Acoustic Panel Screen – Plywood or OSB**



**Photograph 6.4.1.2.3:** View of Acoustic Screens

#### Supplementary Environmental Management Measures

Even through the evaluation made indicates that the noise level will not be exceeded in the sensitive sectors, GENER will instruct its contractors to assume a set of actions as a preventive criteria, to avoid conflicts with the community. These actions will be implemented in particular in point 7 were there are houses close to the work fronts and they correspond to the following:

- Generate specific semi-enclosures of the noisiest machinery, such as cranes, power generators, compressors, jackhammers and hopper trucks. These screens consist of lateral panel closures of plywood, panels made of planks or fiberboard panels.
- Prioritize carrying out works on the surface in the daytime (8:00 – 21:00 h).
- The machinery used will be reviewed and tested by the contractor company in order to detect mechanical faults that could alter the established noise levels. The above will be established in the employment contracts.
- For the 8 sensitive points of the Project, prior to beginning the works, a “works execution Works Program” will be presented in order to reduce the impacts and minimize the disturbance that the project activities may cause the community. This in order to integrate it into the development of the Project, communicating the occurrence of sporadic noise sources.
- To verify the effectiveness of the mitigating measures, noise will be monitored at the 8 sensitive points in accordance with the procedure established by DS 146/97 of the MINSEGPRES, in order to verify compliance with the maximum permitted limits of sound pressure (see detail in section 8.2.2 of Chapter 8).

### iii) Classification of the Environmental Impact

The only sector sensitive to noise corresponds to point 7 (El Alfalfal zone). In accordance with the evaluation done, (and in the rest of the points assessed) the maximum permissible levels established in regulation DS 146/97 will be complied with in this sector.

Also, it is expected that the sound levels from the flow of trucks and buses along main and secondary roads do not exceed the criteria of the rule FHWA<sup>5</sup> (67 dB (A) in the exterior), for which the emission of noise from mobile sources associated with the Project is considered to be *acceptable*.

Therefore, the acoustic impact is classified as negative with low significance.

Lastly, during the operations stage of the project, no impacts are foreseen associated with the increase in sound pressure.

#### **6.4.1.3 Effect of Vibrations**

##### i) Identification and sources of impact

Vibrations will be generated by the detonations used in the excavations works, mainly those closest to the surface of the land, that is, those executed when opening the hall of the tunnel. Therefore, this variable has been analyzed for the sectors with the presence of receptors where excavation works will be carried out.

In addition, it is theoretically verified that the construction of underground works under the El Morado Natural Monument (El Volcán tunnel) and under the Santuario de la Naturaleza San Francisco (Alfalfal tunnel), will not have effects on the surface.

##### a) Methodology

For the case of the sectors close to events of blasting, a modeling of the VVP (Vertical Particle Velocity, in mm/s) values expected of vibration will be done at the closest receptor. Then the modeled values will be assessed regarding the limits established in the regulation “Title 30: Mineral Resources; Part 816—Permanent Program Performance Standards—Surface Mining Activities; § 816.67 Use of explosives: Control of adverse effects”<sup>6</sup>, of the United States of America, one of the countries indicated in Article 7 of D.S. 95/2001 of the MINSEGPRES “Regulations of the Environmental Impact Evaluation System” (see Appendix 2 of Annex 30).

In order to predict the vibrations produced by blasting, there is a need to have a mathematical model that predicts vibration in a determined point, for which a review was done of the formulae available in the literature related to the subject. Among the formula studied, the most used in the area of mining corresponds to that of Devine, where the vertical Particle velocity (*VVP*) is expressed as follows:

<sup>5</sup> Federal Highway Administration, “Procedures for Abatement of Highway Traffic Noise and Construction Noise”, 23 C.F.R., Part 772, Federal Register, vol. 47, pp. 29653-29657, 8 July 1982.

<sup>6</sup> “Title 30, part 816, section 816.67 of the Code of Federal Regulations

$$VVP = K \left( \frac{d}{\sqrt{P}} \right)^{-\alpha} \quad [\text{mm/s}]$$

Where:

$d$  is the distance from the source to the receptor [m]

$P$  is the charge of explosives [kg]

$K$  and  $\alpha$  are variables determined statistically dependent on the geological conditions of the soil. The respective constants used in each model are shown in Table 6.4.1.3.1.

**Table 6.4.1.3.1**  
**Values of the Constants of the Soil  $K$  and  $\alpha$  according to Devine**

Formula	K	$\alpha$
Devine	357	2.07

The values of the constants of the model are those proposed by the author, from on-site measurements and theoretical calculations in accordance with the type of soil studied.

The VVP values modeled through the Devine formula present a good correlation with values measured on-site<sup>7</sup> with soil characteristics similar to those of this project, finding an average error equal to 0.005 [mm/s] in the cases studied, which constitutes an acceptable margin of error for the effects of modeling. The estimated value of the charge of explosives to consider for this case is 30 kg delayed.

**Table 6.4.1.3.2**  
**Projected Value of VVP at the Receptor Closest to the Blasting**  
**For the Points under Evaluation**

Point	Distance Blasting-receptor, in meters	VVP, in mm/s
1 and 7	1472	0.18
2	331	1.98
3	367	1.68
4	1633	0.15
5	154	6.73

Points 6 and 8 (El Yeso sector and Maipo River discharge) are not close to inhabited centers of houses, so no large effects are expected produced by the vibrations from blasting, for which the VVP was not projected for the closest receptor.

b) Evaluation at receptors close to worksites.

The rule used to assess the vibration levels during blasting corresponds to the regulation "Title 30: Mineral Resources; Part 816—Permanent Program Performance Standards—Surface Mining Activities; § 816.67 Use of explosives: Control of adverse effects"<sup>8</sup>, currently in effect in the entire territory of the North American country, which establishes the maximum particle velocity values permitted for different distances, as well as a formula to determine the maximum charge, considering the distance to the closest receptors.

<sup>7</sup> Measurements of vibrations generated by blasting carried out in the central zone between January 2005 and March 2006.

<sup>8</sup> "Title 30, part 816, section 816.67 of the Code of Federal Regulations

The following table shows the maximum values permitted by this regulation.

**Table 6.4.1.3.3**  
**Maximum Values Permitted by the Regulation “Title 30, Part 816, Section 816.67 of the Code of Federal Regulations”**

Distance (D), from the place of blasting, in feet (m)	Peak maximum particle velocity permitted (V max) for the vibration of land, in inches/second	Distance factor scaled to apply without seismic monitoring (Ds)
0 – 300	1.25	50
301 – 5000	1	55
5001 and over	0.75	65

This regulation establishes that the peak values weighted with C curve considering the response of the slow detector should not exceed 105 dB(C) in the points of evaluation. The following table shows the peak values in dB(C) for each one of the points of evaluation considered.

**Table 6.4.1.3.4**  
**Peak Levels in dB(C) Associated with each one of the Points Sensitive to Noise Located in the Project Surroundings**

Point of Evaluation	Description	Regulation Limit dB (C)	Peak level dB(C)
1 and 7	Forebay and Alfalfal canal sector	105	—
2	Connection duct-tunnel El Torrejón sector	105	78.6
3	Window El Trescientos sector	105	59
4	Aucayes (Maitenes)	105	48.4
5	Las Lajas	105	71.4

From the above table it is observed that all the values are kept well below the maximum value permitted by the rule in the reference used for the evaluation. On the other hand, given that points 6 and 8 (El Yeso sector and Maipo River discharge) are not close to inhabited centers, large effects produced by the vibrations from blasting are not expected.

We now detail the evaluation of compliance with the regulation in accordance with the sensitive points detected for the project.

**Table 6.4.1.3.5**  
**Evaluation of Compliance with the Regulation in accordance with the Sensitive Points Detected by the Project**

Point	Distance (m)	Distance (ft)	VVP LJ (mm/s)	VVP LJ (inch/s)	Peak maximum particulate velocity permitted (V max) for vibration of ground in inches/second
1 and 7	1472	4829	0.18	0.007	1
2	331	1086	1.98	0.078	1
3	367	1204	1.68	0.066	1
4	1633	5358	0.15	0.006	0.75
5	154	505	6.73	0.265	1

From the above table it is observed that the totality of the values are below the limits imposed by the regulation.

Also, when using the formula to calculate the maximum charge of explosives to be detonated in 8 milliseconds, which is:  $W = (D/D_s)^2$ , it is determined for the case of the project that the closest receptor would be 505 feet away, falling into the category of DS=55, for which the maximum charge estimated would be 84.3 pounds, equivalent to 38 kg, in accordance with the calculations set out below.

$$W = \left( \frac{D}{D_s} \right)^2 = \left( \frac{505}{55} \right)^2 = 84.3 \text{ pounds}$$

*Evaluation of effects on the El Morado nNatural Monument and the Santuario de la Naturaleza San Francisco de Lagunillas*

The Natural Monument El Morado and the Santuario de la Naturaleza San Francisco de Lagunillas will be crossed by the El Volcán Tunnel and by the Alfalfal Tunnel respectively.

In the specific case of these tunnels, due to reasons of construction and in order to minimize the intervention of the surface by eliminating windows (tunnels) of access, the project includes the use of the most modern technology for the construction of underground works existing in the present day. This is achieved through the use of a tunneling machine denominated the Tunnel Boring Machine (TBM), which allows excavations without the use of explosives. In the particular case of the El Morado Monument and the Santuario San Francisco de Lagunillas, most of these areas will be excavated using the latter method.

In the zone of tunnels that will be excavated with the traditional drill and blast (D&B) method, no vibrations will be produced that generate risks of avalanche or landslides due to the construction of tunnels in the areas mentioned, the above since these activities will be executed at great depth. In this regard, in the section under the El Morado Monument, the depth of the tunnel varies between 550 and over 1,500 m; regarding the tunnel under the Santuario de la Naturaleza San Francisco, the depth will vary between 400 and 450 m. In both cases there will not be any access windows to the tunnel, nor any other surface works.

In this regard, it is important to indicate that depths of less than 300 m will have the maximum vertical velocities (mm/s) indicated in the following table, which will also indicate the maximum charge of explosives by delay:

**Table 6.4.1.3.6**  
**Ratio of Depth vs. Estimated Vibration**

<b>Depth m</b>	<b>Maximum vibration VVP LJ mm/s</b>	<b>Maximum Charge Kg</b>
50	2.24	0.8
100	2.13	3
150	2.19	7
200	2.27	13
300	2.31	30

As a consequence, and considering the minimum vertical distances between both tunnels and the surfaces of the protected areas, no effect whatsoever is foreseen on the surface due to the vibrations that could be caused by the excavation works under the El Morado Natural Monument and the Santuario de la Naturaleza San Francisco, in accordance with the regulations considered as a reference.

## **ii) Environmental Management Measures**

In accordance with the evaluation of the vibration levels when the blasting is done, no adverse effects are expected due to the realization of these activities. Without prejudice to this, the works Contractor will be instructed regarding the sensitivity that must be shown regarding the attitude of the receptors. In this sense and prior to the execution of these works, the owners will be notified in writing regarding the need to carry out this work, its duration and times of execution.

On the other hand, a noise and vibration monitoring program will be established associated with the blasting described in section 8.2.2 of Chapter 8. The information generated by this monitoring will be presented to the Environmental Authorities, along with the rest of the project follow-up information.

## **iii) Classification of the Impact**

In accordance with the analysis realized, the project will comply with the rule used as a reference to assess the impact of the vibrations, for which no impacts associated with vibrations is foreseen.

Lastly, this effect does not exist during the project's operations stage.

#### **6.4.1.4 Temporary modification of flows and/or water quality**

##### **i) Identification and sources of impact**

###### Associated with the construction of works

This impact refers to the temporary alteration of the morphology of flows and of the physical-chemical quality of its water, due to the removal of land necessary during excavations and other works constructions. It will present in all surface flows where the placement of intakes, bridges, siphons and fluvial barriers is projected.

The intervention will be caused by the temporary detour of the river or stream for the construction of works, and then by restitution to the original water course, being therefore an intervention that is limited in spatial extent and is of a temporary type since it will only last for the time period taken for the construction of these works. The detail of the works in water courses is indicated in Annex 11.

Works in this water course, especially the removal of riverbeds and river banks, will affect the physical quality of the water related exclusively to the increase in solids, due to the increase in the concentration of solids in suspension and the turbidity of the water.

###### Associated with the discharge of treated wastewater

After sanitary authorization, the wastewater treated in the modular plants will be discharged into surface water courses, in strict compliance with the maximum limits established by DS 90/2001 in its Table 1. The discharge points will be located in the proximities of the sites provided for the camps (see Annex 15). In these points, the PHAM will monitor the treated water prior to its discharge.

It is important to indicate that the sections of rivers and streams where discharges are projected from the Project, are located in high and/or medium mountain range sectors (between 1,000 and 2,250 m.a.s.l.), uninhabited and which therefore will not interfere with uses or activities carried out there.

The sludge generated in the treatment of the water will not be dumped into water flows, these will be removed periodically by the works contractor for their transport and final disposal at authorized sites (Annex 18).

In summer, part of the treated wastewater will be used to wet roads or other surfaces inside the worksites, since the efficiency in the treatment will guarantee parameters of quality below the permissible limits established in NCh 1333, which establish the water quality requirements for different uses, and which can be used as a reference. The wetting of roads or other surfaces inside the worksite will contribute to decreasing the emissions of dust or re-suspended particulate matter. This measure will have the respective sanitary authorization.

It is important to indicate that in the thaw season, a natural change in the water quality is recorded in the rivers in the area, due to more washing away of sediments<sup>9</sup>.

No other impact is foreseen on the quality of the water in the courses intervened by the works, or in other bodies of water existing in the area.

## **ii) Environmental Management Measures**

### Actions considered by the project engineering

- The placement of the bridges will be done minimizing the intervention of the water flow. The project has defined the optimal section of the crossing in relation to the width of the bridge.
- The treated wastewater from each one of the work camps and worksite facilities will be reused in the process of construction or used for watering surfaces. The disposal of the wastewater treated in the points identified in section 3.3.2 and in Annex 18 will be done exclusively in the winter season, since it is foreseen that this water will be reused during the rest of the year. This treated wastewater management system will be submitted for the approval of the Sanitary Authorities prior to implementation, through the corresponding technical-administrative channels.

### Supplementary Environmental Management Actions

- Works in river courses will be given priority to realize at the end of the summer and beginning of the fall; the time of year in which the flow of the rivers is reduced, leaving a greater area of the river bed exposed. This will allow the construction of works in the river bed to be done mainly on “dry ground” and not on the wet width.
- The execution of works on the banks of rivers and streams will be reduced to the minimum possible, also procuring that construction materials (pipes, concrete and others), machinery and temporary truck parking are not done on the river banks.
- The programming by the Contractor will ensure that the works in the riverbeds are of short duration and have a small spatial expression.
- The execution of works in riverbeds will be minimized, ensuring that the pieces that comprise the crossing are assembled in sites enabled for this and then transported when the construction work is to be carried out.
- While the works are carried out in riverbeds, special precautions will be required to prevent accidental spills, such as: prohibiting stockpiling drums of lubricants in the riverbed or next to it, and prohibiting parking machinery in the riverbed.

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<sup>9</sup> Available records on water quality in rivers and streams reveal that the values indicated in the draft project of regulation for the case of solids in suspension, is found naturally above the maximum limits proposed by the Secondary regulation Draft Project, considered only as a reference. This is the case of the Maipo, Colorado and Volcán Rivers, where the total solids in suspension in natural conditions, during the thaw period, exceed the limits established by the draft Project for this parameter by 300%. In particular for the Maipo River, in the sector of the future discharge of the Project (Las Lajas sector), the concentration of solids in suspension currently exceeds the levels established for the two areas of vigilance of the Draft project (144 mg/L). This behavior is repeated in the Colorado River where the concentration of total solids in suspension reaches values of around 218 mg/L per the DGA.

- The Negra and Lo Encañado lagoons as “restriction zones” will have access restriction for the workers. Coordination will be done with the company Aguas Andinas for the use of the access road to the area (see Chapter 7). It is important to indicate that this company does not realize collection for potable water directly from this sector, so there will be no interference or risk of the project works with the Aguas Andinas facilities. As has been indicated in the baseline, the Laguna Negra aqueduct is out of use in its first 2.5 kilometers. The collections that currently operate in the sector are: Azulillos, Romaza, Manzanito and San Nicolás, all far from the worksites (see figure 5.6.1.1 “Location of Water Potabilization Infrastructure” attached in Chapter 5 “Baseline”).

### iii) Classification of the Impact

This impact is classified as negative with low significance, since the flows intervened will be restored to their initial condition once the works are finalized, and while they are developed, the natural capacity of self-purification of the flows will keep the water quality within acceptable conditions.

#### **6.4.1.5 Intervention of Vegetation**

##### **i) Identification and Sources of Impacts**

The PHAM project will generate a loss of surface area of plant formations, due to the requirements of land of the Project or work areas associated with the construction of service roads, intake works, window ducts and access halls, forebay, installation of worksite facilities and muck stockpiles. A differentiated work front is assumed for each type of work, in which, as well as the placement of facilities or materials, a minimum surface area is considered for use for the transit of people and machinery.

The following table sets out the criteria used to estimate the surface area required by the works or work front:

**Table 6.4.1.5.1  
Estimate of Surface Area Required by the PHAM Works**

Works	Work front
Roads	5 m to each side, measured from the axis of the projected road.
Siphon	20 m around the center of the pipe.
Ducts (includes adduction canal)	5 m from the center of the projected pipe
Collection works	10 m from the center of the pipe
Access halls	40 m to the front and sides of the works
Las Lajas and Alfalfal II forebay	10 m measured from the external edge of the works.
Installation of worksite facilities/camp	Surface defined for each camp
Muck stockpiling	Surface defined for each muck stockpiling site in particular.

In figures 5.4.1.3.21 and 5.4.1.3.31, attached in Chapter 5, “Baseline”, the location of each one of these works is illustrated in relation to each one of the plant covers.

The implementation of the work and construction areas of the works included in the project considers the loss of surface areas occupied by plant formations. These formations are presented in a gradient of communities determined mainly by variations in altitude, presenting differences which are furthermore attributable to the exposure of the hillsides.

In the low area of the area of influence, the project mainly affects sclerophyll vegetation, while above 200 mamsl the work fronts will affect vegetation of low Andean bushes.

#### a) Intervention of vegetation that constitutes forest

As described in section 5.4.1 of this EIE, the vegetation of the area of the Colorado River corresponds mainly to sclerophyll forest, comprised of evergreen trees and bushes with hard leaves and resistant to large changes in temperature and humidity that the region presents. The dominant species correspond in general to quillay (*Quillaja saponaria*), frangel (*Kageneckia angustifolia*), bollén (*Kageneckia oblonga*), guayacán (*Porlieria chilensis*), huingán (*Schinus polygamus*), espino (*Acacia caven*) and litre (*Lithraea caustica*), trees that are accompanied by a stratus of bushes, annual grass and seasonal, and some succulents. Among the bushes are adesmia (*Adesmia confusa*), chilca (*Baccharis salicifolia*), chilquilla (*Baccharis pingraea*), crucero (*Colletia hystrix*), palqui (*Cestrum parqui*), huañil (*Proustia cuneifolia*), bio – bio (*Gymnophyton isatidicarpum*). Among the grass: *Avena barbata*, pasto largo (*Bromus berterianus*), alfilerillo (*Erodium cicutarium*), falso yuyo (*Hirschfeldia incana*), *Hydrocotyle sp*, among the succulents are chagual (*Puya berteroniana*), quisco (*Echinopsis chilensis*) and quisquito (*Erioseye curvispina*) (see tables in Chapter 5).

Among the species that comprise these plant formation some can be found in the state of conservation, these corresponds to *Kageneckia angustifolia* (frangel), *Puya berteroniana* (chagual), *Erioseye curvispina* (quisquito) and *Cryptocarya alba* (peumo).

In accordance with the estimate of surface area required by the project works (see figures 5.4.1.3.21 to 5.4.1.3.31, attached in Chapter 5), it is possible to define the surfaces of plant formations that will be affected by each one of these elements, as set out in the following table:

**Table 6.4.1.5.2**  
**Surface of Forests Affected by the Project, according to Units of Vegetation (Chapter 5.4.1 and Annex 7, Forestry Management Plan)**

Unit	Forest type and dominant species	Surface area (ha)
LL - 1	Plantation <i>Eucalyptus globulus</i>	0,48
CL - 1	Sclerophyll (espino - quillay - litre)	4,02
CL - 6	Sclerophyll (quillay - litre - espino - maitén)	0,17
CL - 8	Sclerophyll (guayacán - litre - quillay)	1,85
CM - 1	Sclerophyll (maitén - quillay – foreign peumo)	2,05
AU - 7	Sclerophyll (huingán - frangel)	1,42
AU - 8	Sclerophyll (huingán - frangel - quillay)	10,05
AU - 10	Sclerophyll (quillay - frangel - litre - huingán)	0,91
AU - 11	Sclerophyll (frangel - quillay - litre)	1,07
AU - 14	Sclerophyll (frangel - litre - quillay - huingán)	4,78

Unit	Forest type and dominant species	Surface area (ha)
CA - 1	Sclerophyll (frangel - huingán - quillay)	1,78
CA - 4 A	Sclerophyll (huingán - quillay - maitén)	2,16
CA - 4 B	Sclerophyll (quillay - huingán - maitén)	0,23
LP - 1	Sclerophyll (bollén - litre - quillay - maitén)	0,1
LP - 4	Sclerophyll (bollén - litre - quillay)	0,07
LP - 5	Sclerophyll (bollén - quillay - litre)	0,09
<b>Total surface area of affected forest</b>		<b>31,23</b>

In accordance with the above, it is possible to affirm that the project in the construction stage will affect a total surface area of 31,23 ha. of forests, whose detail and management measures are found in section 5.4.1 and in the Forestry Management Plan to execute Civil Engineering Works (Annex 7).

All these formations are found in the Colorado River valley and correspond to native forest of the Sclerophyll type, excepting the forest in the Las Lajas sector that corresponds to a forestry plantation.

#### **b) Intervention of vegetation that does not constitute forest (Sclerophyll and Andean bushes)**

In the area of the Sclerophyll forest, bushes develop that are associated with north exposure hillsides, that present mainly bush vegetation and in some individual cases, isolated tree areas with less than 10% cover. These areas present mainly in the Maitenes sector and some areas adjacent to the Colorado River.

They correspond mainly to Sclerophyll bushes, dominated by *Proustia cuneifolia*, *Trevoa quinquinervia*, *Baccharis linearis*, and appearing in sectors with more slopes *Gymnophyton isatidicarpum* and the succulents *Echinopsis chilensis* and *Puya berteroniana*, in some sectors there are isolated specimens of *Quillaja saponaria* and *Acacia caven*. Some gravel materials are also found dominated by *Baccharis salicifolia*.

The characteristic vegetation of the Andean zone between 2000 and 2500 meters altitude is comprise of low Andean Mediterranean bushes. Luebert and Pliscoff (2006) indicate for this floor the dominance of low bushes, with a plant cover that oscillates between 20 and 40%. Among the species are hierba blanca (*Chuquiraga oppositifolia*) and chilca (*Nardophyllum lanatum*), as well as neneo (*Mulinum spinosum*), caulia (*Tetraglochin alatum*), pingo-pingo (*Ephedra chilensis*) and oreganillo (*Viviania marifolia*). As intra-zonal units are the coirón wetlands (*Patosia clandestina*) and the forests in the ravines with ñipa (*Escallonia myrtoidea*) and maitén (*Maytenus boaria*). The floor extends to the Andes mountain range, from the south of the 4<sup>th</sup> to the 6<sup>th</sup> regions between 2000 and 2600 m altitude.

The Andean shrubland formations identified in the project's influence area have the aspect of low shrubland, of up to 30 cm high where bushes and herbs create a mosaic, with variable cover that in some cases amounts to 80 %. The Dominant Species consist in hierba blanca, pingo-pingo, *Haplopappus anthylloides* and llareta (*Laretia acaulis*) among the bushes and, coirón (*Poa gayana*) and coirón amarillo (*Stipa chrysophylla*), between the herbs. They distribute in the hillside areas which constitute the local relief (see Chapter 5).

According to the areas to be required by the project works, the following tables describe the sclerophyll shrubland and Andean shrubland areas to be affected by the project during the construction stage:

**Table 6.4.1.5.3  
Sclerophyll shrubland areas affected by the Project (chapter 5)**

Unit	Hectares	Vegetation Type	Dominant Species
<b>AU - 12</b>	5.7	Spaced Thorny Shrubland with Soapbark Forest	QS Gi Tq Ta vm
<b>AU - 13</b>	3.41	Thorny Shrubland	QS Tq Sp Cs ha
<b>AU - 15</b>	0.003	Succulent Shrubland	Pc Gi ec vm eC pB
<b>CA - 2</b>	0,01	Chilca Shrubland (River Bottom)	Ba Bp hy ec
<b>CA - 6</b>	0.51	Soapbark-Bollen forest	QS KO Ac Pc Ch ab eC pB
<b>CA - 7</b>	1.05	Gymnophyton Shrubland-Quisco	Gi eC
<b>CL - 4</b>	0.86	Sclerophyll shrubland	QS AC BI
<b>CL - 5</b>	1,25	Post-cultivation espinal	AC BI
<b>CL - 9</b>	1.22	Thorny Shrubland	QS Tq vm eC
<b>CM - 2</b>	0.03	Sclerophyll shrubland	QS KA mc
<b>Total</b>	<b>14.043 ha.</b>		

**Table 6.4.1.5.4  
Andean Shrubland Area Affected by the Project (Chapter 5)**

Unit	Hectares	Vegetation Type	Vegetation Type
<b>AU-16</b>	2,44	Andean shrubland	KA Gt Ta Ci pg nC
<b>AU-17</b>	5,38	Andean shrubland	KA Ta Hu as nC
<b>AU-18</b>	2,65	Andean shrubland	Ta Gi pg
<b>AU-19</b>	2,12	Andean shrubland	Hv Ta as pg
<b>EE - 1</b>	0,05	Stream border shrubland	Rc ja pa
<b>EE - 2</b>	4,73	Low shrubland	Be Co Ec py
<b>EE - 3</b>	3,14	Low shrubland	Be Ec Co py pg al
<b>EE - 4</b>	2,1	Low shrubland	Ag, Ec, pg, aa, ap, py
<b>EE - 8</b>	0,03	Andean shrubland	Co Ec Ag ph as
<b>EY - 2</b>	1,28	Low shrubland	Be Co bt py
<b>EY - 3</b>	1	Low shrubland	Co py sc
<b>EY - 4</b>	7,5	Low shrubland	Co Ta Ha py bt
<b>LE - 1</b>	11,44	Low shrubland	Co Ha py bt sc
<b>LE - 2</b>	11,94	Low shrubland	Be Ec Co sc py
<b>AU - 4</b>	0,55	Sub-Andean shrubland	Gt Ci Ta ms, pg, bb
<b>Total</b>	<b>56,35 has</b>		

<b>Abbrev. Trees</b>	<b>Abbrev. Shrubs</b>	<b>Abbrev. Herbs</b>
MB: Maytenus boaria AC: Acacia caven KA: Kageneckia angustifolia KO: Kageneckia oblonga PC: Porlieria chilensis QS: Quillaja saponaria SP: Schinus polygamus	Ac: Adesmia confusa Ag: Adesmia gracilis Ba: Baccharis salicifolia Be: Berberis empetrifolia Bg: Buddleja globosa Bl: Baccharis linearis Bp: Baccharis pingraea Br: Baccharis rhomboidalis Bs: Baccharis sagittalis Ch: Colletia hystrix Ci: Colliguaja integerrima Co: Chuquiraga oppositifolia Cp: Cestrum parqui Cy: Calceolaria hypericina Ec: Ephedra chilensis Gf: Gochnatia foliolosa Gi: Gymnophyton isatidicarpon Gt: Guindilia trinervis Ha: Haplopappus anthylloides Hu: Haplopappus uncinatus Hv: Haplopappus velutinus Js: Junellia scoparia La: Laretia acaulis Ms: Mulinum spinosum Ni: Nardophyllum lanatum Pc: Proustia cuneifolia Rc: Ribes cucullatum Sg: Senecio glaber Ta: Tetraglochin alatum Tq: Trevoa quinquinervia	cc: Cynoglossum creticum lv: Lactuca virosa ab: Avena barbata al: Agrostis leptotricha al: Alstroemeria exerens am: Acaena magellanica ap: Acaena pinnatifida as: Acaena splendens bb: Bromus berterianus bt: Bromus tunicatus ce: Centaurea melitensis cg: Carex gayana cm: Conium maculatum ds: Deyeuxia sp. ea: Eleocharis albibracteata ec: Erodium cicutarium ec: Eschscholzia californica ha: Helenium aromaticum hi: Hirschfeldia incana hm: Hordeum murinum ho: Hordeum sp. hy: Hydrocotyle sp. ja: Juncus arcticus ls: Lathyrus subandinus ms: Madia sativa pa: Polypogon australis pg: Plantago grandiflora pg: Poa gayana pp: Poa pratensis py: Poa gayana rc: Rumex crispus sc: Stipa chrysophylla tr: Trifolium repens vm: Vulpia myuros
<b>Siglas Succulents</b> eC: Echinopsis chilensis pB. Puya berteroniana eC: Erioseyde curvispina		
<b>Siglas sectores</b> <b>AU</b> Aucayes Stream <b>EE</b> Lo Encañado <b>LE</b> La Engorda <b>EY</b> El Yeso <b>CA</b> El Alfalfal <b>CM-CL-LP</b> Río Colorado <b>LL</b> Las Lajas		

As a whole, a total of 70.39 has of shrubland will be affected, of which 14, 04 has consist in sclerophyll shrubland. Out of the total sclerophyll shrubland 1, 57 has are in El Alfalfal, 9.11 has in the lower section of Aucayes, and the remainder (3.36 hectares) is distributed around Río Colorado and Los Maitenes.

The total Andean shrubland area the project will affect amounts to a total of 56.35 has, out of these 23.38 has are in the area named La Engorda; 13.14 has in the Aucayes ravine basin; 10.05 has in the Lo Encañado lagoon and 9.78 has in the Yeso River basin (See section 5.4.1)

Among the flora species in conservation status, in the high Andean area Inca lily (*Alstroemeria exerens*) was recognized, consisting in a species classified as “**insufficiently known**”. *Laretia acaulis*, “Ilareta de Santiago” was also recognized, a bush that grows forming cushions on the ground, it is in the **vulnerable** category at national level. The location of these species in the project area is quite specific and rare. According to the baseline results, there are no specimens of this species at the work site.

### c) Meadows

The meadow formations consist in formations established in edaphic, mainly organic environment, characterized by a permanent saturation water condition. Then it consists in an azonal biological ecological system<sup>10</sup>, with characteristic vegetation growing thanks to a high and permanent content of edaphic humidity (due to the existence of water sources or shallow aquifers). Generally, its appearance is dense to very dense herbaceous stratum (vegetation covers over 50 %), of low to high height (5–100 cm), over a usually flat or very scarce micro-relief. The water courses, when present, are restricted to small grooves, fully vegetated or else a single big one.

**Table 6.4.1.5.5  
Meadow area Affected by the Project (Chapter 5)**

Unit	Hectares	Vegetation Type	Vegetation Type
<b>EY - 5</b>	1	Humid grassland	Bp Bs ea cg ja
<b>LE - 3</b>	3.64	Low shrubland with dense Herbaceous Stratum	Ag Co Be ja py hc
<b>LE - 4</b>	2.64	Grassland, Stream Border	ja al pa ds
<b>Total</b>	<b>7,28</b>		

En el project's influence area, it was found there were formations consisting in wetlands, located specifically in the El Yeso river basin (formation EY – 5) and La Engorda area (formation LE – 4 and LE – 3 ), the latter with wider area. Generally, said zones are anthropized and are currently quite affected by shepherding.

During the construction stage, the project shall affect a minor section of meadows located in the Engorda area. The vegetation units with presence of meadows consist in units LE-3 (Andean shrubland with seasonal meadows) and LE-4 (stream border meadows). The area to be affected is estimated in 3.64 and 2.64 has for LE-3 and LE-4 respectively, which would be affected directly by collection works and water canal. This calculation of area considers the worst scenario possible including seasonal meadows, presence of which has been verified in the last field campaigns of Spring 2007.

It should be noted that the area named “La Engorda summer pasture”, “Vegas de La Engorda” or “Cajón de La Engorda” is located between the Colina and La Engorda streams, and to the south of La Engorda stream, particularly the lower portion of the basin, as a consequence of the sediment accumulation. At the Las Placas stream meadows also develop associated to the stream and other side water courses. However, it is the Cajón de La Engorda area which is most sensitive to the construction of collection works and water canal. Said structures are the ones that could cause a strong impact on the vegetation growing downstream.

<sup>10</sup> Azonal Vegetation: vegetal formations occurring locally in reduced extensions, associated with some determined environmental factor. This definition comprises vegetal formations which are fully discontinuous respect the surrounding units appearance of which reflects clearly quite localized conditions (example of which are: wetlands or meadows; vegetation anthropically altered).

**d) Affected Flora in some conservation status**

A number of 5 species in conservation status were found at the project area, detailed below:

**Table 6.4.1.5.6**  
**General Information on Conservation status Species and Compensation Procedure**

Species	Presence in Project Area					Compensation Procedure	Common Name / Family	Conservation Status	Growth Form	Geographic origin	Distribution Range (Per regions)
	Maitenes Aucayes	El Alfalfal	Cajón Lo Encañado	Cajón Río Yeso	Cajón La Engorda						
<i>Kageneckia angustifolia</i>	X	X				Nursery Transplant of individuals	Olivillo Franjel / Rosaceae	Vulnerable**	Tree	E	IV to VI and RM
<i>Puya berteroniana</i>	X					Nursery	Chagual / Bromeliaceae	Vulnerable	Succulent	E	IV to VIII and RM
<i>Neoporteria curvispina</i>	X	X				Transplant	Quisquito / Cactaceae	Vulnerable	Succulent	E	V and RM
<i>Laretia acaulis</i>			X	X	X	Nursery	Llaretia / Umbelliferae	Vulnerable	Bush	N	III a IX and RM
<i>Porlieria chilensis</i>	X					Nursery Transplant of individuals	Guayacán / Zygophyllaceae	Vulnerable	Tree	E	IV to VI and RM
<i>Alstroemeria exerens</i>			X	X	X	Transplant and nursery	Liuto / Alstroemeriaceae	Insufficiently known	Perennial herb	N	VI to VII and RM

\* Only individual of up to 1 meter tall.

\*\* Vulnerable at regional level

E: Endemic

N: Native

The quantification of the affected areas where the species under conservation status are found according to the Land Occupation Cartography is shown in Table 6.4.1.5.7. In relation to the number of affected individuals and georeference, this datum constitutes a high scale survey which is considered in at the Micro-Routing Stage and that is submitted to the Authority before works beginning. The number of affected specimens in the forest areas is represented in Attachment 7, Forest Felling and Reforestation Management Plan.

The table below shows units under conservation status, areas affected by works in each unit and density of species found.

**Table 6.4.1.5.7**  
**Affected Area per Vegetation Unit (according to Land Occupation Cartography), of**  
**Specimens under Conservation Status**

Unit COT	Species under conservation status	Affected area (hectares)	Density (individuals/has)	Affected Individuals
CL-1	<i>Porlieria chilensis</i>	4,02	2	8
CL-6	<i>Porlieria chilensis</i>	0,17	5	1
CL-8	<i>Porlieria chilensis</i>	1,85	290	537
CA-1	<i>Kageneckia angustifolia</i> and <i>Eriosyce curvispina</i>	1,78	275 and 6	490 and 11
CA-4A	<i>Kageneckia angustifolia</i> and <i>Eriosyce curvispina</i>	2,16	8 and 3	18 and 7
CA-4B	<i>Kageneckia angustifolia</i> and <i>Eriosyce curvispina</i>	0,23	15 and 2	4 and 1
CA-6	<i>Puya berteroniana</i>	0,51	Micro-Routing*	Micro-Routing
CA-7	<i>Puya berteroniana</i>	1,05	Micro-Routing*	Micro-Routing
CM-1	<i>Kageneckia angustifolia</i>	2,05	Micro-Routing*	Micro-Routing
CM-2	<i>Kageneckia angustifolia</i>	0,03	Micro-Routing*	Micro-Routing
AU-7	<i>Kageneckia angustifolia</i>	1,42	550	781
AU-8	<i>Kageneckia angustifolia</i>	10,05	150	1508
AU-10	<i>Kageneckia angustifolia</i> and <i>Eriosyce curvispina</i>	0,91	12 and 4	11 and 4
AU-11	<i>Kageneckia angustifolia</i> and <i>Eriosyce curvispina</i>	1,07	25 and 6	27 and 7
AU-14	<i>Kageneckia angustifolia</i> and <i>Eriosyce curvispina</i>	4,78	36 and 5	172 and 24
AU-15	<i>Puya berteroniana</i>	0,003	Micro-Routing*	Micro-Routing
AU-16	<i>Kageneckia angustifolia</i> and <i>Eriosyce curvispina</i>	2,44	Micro-Routing*	Micro-Routing
AU-17	<i>Kageneckia angustifolia</i> and <i>Eriosyce curvispina</i>	5,38	Micro-Routing*	Micro-Routing
EY-2	<i>Alstroemeria exerens</i>	1,28	Micro-Routing*	Micro-Routing
EY-4	<i>Alstroemeria exerens</i> and <i>Laretia acaulis</i>	7,5	Micro-Routing*	Micro-Routing
EE-3	<i>Alstroemeria exerens</i> and <i>Laretia acaulis</i>	3,14	Micro-Routing*	Micro-Routing
LE-1	<i>Laretia acaulis</i>	11,44	Micro-Routing*	Micro-Routing
LE-3	<i>Alstroemeria exerens</i> and <i>Laretia acaulis</i>	3.64	Micro-Routing*	Micro-Routing
Total Affected Areas of species under conservation status		66,9**		

\* The number of individuals affected by works in this unit shall be defined at the Micro-Routing Stage.

\*\* Out of the total of 66.9 hectares, 28.4 consist in forest formations included in the forest management plan, and remaining 42.1 hectares consist in Andean shrubland, xerophyte shrubland or sclerophyll shrubland with low tree cover.

## ii) Environmental Management Measures

### Actions considered by the project engineering

- a) Most of the permanent civil works of PHAM shall be underground which shall reduce the surface requirements, therefore minimizing the elimination of vegetation.

- b) Special training activities shall be carried out for the contractor personnel so they become aware of the importance and conservation value of the flora, fauna and sclerophyll and high Andean vegetation that may be found in the project area, especially in relation to the species found under some conservation status. Said training shall be intended as identification, conservation value, associated laws, protection actions and sanctions.
- c) The work facilities and camp sites adapted to the project area environmental sensitivities.
- d) The project considers the restoration of vegetation in areas that should be cleared for the work facilities. Restoration comprises a number of activities intended as regeneration, as much as possible, the natural environment existing before the project intervention, and for that purpose, the corresponding management plans shall be processed, considering reforestation with native species.
- e) According to environmental pre-feasibility studies carried out in 2005, and results of the present EIA baseline, the PHAM has made a decision to utilize the water inlet of the “alta cordillera (*High Mountain*)” type at the Alto Volcán area, disregarding the use of surface run-off interception drains at the La Engorda summer pastures. That will avoid the interruption of drainage or water run-off in anastomosan courses, facilitating the irrigation to downstream points from the projected collection areas. Additionally, the interred water canal shall have drains over and below to facilitate the superficial drainage.
- f) The location of the water inlets in the Colina, La Engorda and Las Placas streams, in ht summer pasture area, projects itself onto the lowest height possible, avoiding thus the environmental intervention of meadows which is more evident in the place were water courses generate disperse run-off.

#### Compensation through Forest management plan (Attachment 7)

The area to be reforested shall amount to a total of 36 hectares, five hectares more than the ones compromised in the management plan, due to the compensation, 10 per one of the species *Kageneckia angustifolia* (Franjel) and *Porlieria chilensis* (guayacán). The Principal hall plant 30.5 of the 36 hectares (exclusively *Kageneckia angustifolia*) in the El Durazno area, which consists in the natural habitat of Franjel, and were there are still ample populations of the species, this area is in the same plot where the felling is to occur. In the remaining 5.5 hectares, consisting in guayacán forest shall be planted in the Los Maitenes area, around the Maitenes reservoir. Both places belong to the plot where 98% of the felling occurs, belonging to the National Assets Ministry and managed by the Army (see Letter in Attachment 41 certifying authorization from the Army to reforest).

The species to utilize in the reforestation shall consist in the same forestry type of species intervened and compensating exclusively with species under conservation status (*Porlieria chilensis* and *Kageneckia angustifolia*), which shall be replaced in a proportion of 10 specimens per each one intervened, exceeding approximately 60% the mean density of the forest formations intervened (mean density measured on site of these formations is 626 trees per hectare, with a minimum of 200 and a maximum of 1.125). In the forest formations a total of 3.011 *Kageneckia angustifolia*, 549 *Porlieria chilensis* and 55 *Eriosyce* (*Neoporteria*)

*curvispina* will be affected. The latter shall be planted in areas to be defined at the Micro-Routing. The species *Eriosyce (Neoporteria) curvispina* shall also be compensated 10 per 1 of the species.

The Principal shall assume the compromise that the specimens planted in the reforestation areas shall enjoy a high survival percentage, so all actions which allow meeting this goal shall be taken, like: periodical watering, installation of individual protection, control of lagomorphs (hares and rabbits), fertilization and periodical evaluation of the plantation status to apply the corresponding remedial measures.

#### Vegetation Restoration Plan (Attachment 29)

compensation measures are considered for all affected areas which do not constitute forest (therefore not included in the forest management plan), total cover of which spreads around 75 hectares, a vegetation restoration plan intended as stabilization of soil after works and restoration as much as possible of vegetation existing previously to control erosion, visual mitigation and restoration of the fauna habitat. Consideration is also made of areas where the forest was removed and can be recovered after the project's construction stage, or those where intervention has resulted in potential erosion areas.

This vegetation restoration plan shall be implemented in all the project's intervention areas (marine stockpiles, road slopes, camp sites, etc.), except for those where the cover vegetal is very scarce, and there the existing soil does not allow the expected restoration. The above shall be verified during the Micro-Routing activities.

The vegetation activities shall be planned and developed by application of the basic ecological succession principles, understood as the natural gradual change in the composition and structure of a community in time, and after a disruption.

The vegetation restoration plan is structured as below:

1. Micro-Routing of vegetation
2. Restoration nursery plan for species
3. Revegetation plans for the marine stockpiles and camp sites, slopes and tunnel access platforms.

Specific management measures for the La Engorda Summer Pasture Area (*La Engorda summer pasture*)

In addition to the measures considered in the Vegetation Restoration Plan, the following was taken into account.

- a. In the sites of permanent works of this area (roads, water inlet and ducts), consideration shall be made of the extraction and reserve of the original soil layer before the execution of work, said material shall be restored in the meadow zones that can be restored after the construction stage (worksite, road sides, etc), so the 6.2 affected hectares considered for this zone may be reduced then from this management.
- b. The use of drains over the canal to be located at the La Engorda summer pasture shall prevent interruption of drainage or run-off of water in those anastomosing courses. This duct that connects water inlets shall be interred at least one meter deep.
- c. Verification of the expected effects shall be by monitoring of vegetation during the construction stage and the first 5 years of the Project operation.
- d. Instructions shall be given to the Contractor to utilize in an unrestricted or exclusive manner the personnel transit ways that shall be prepared, but avoiding the workers to create new paths or tracks in the summer pasture area. Said measures shall be applied together with training sessions intended to create awareness on the established environmental protection regulations.

Complementary Environmental Management Actions

- a. Respect timber resulting from the felling and uprooting, the trunks and branches of trees and bushes shall be cut and disposed as firewood for the community. The thinnest branches, twigs, leaves and other vegetal debris shall be chipped and spread on soil build-up areas together with the soil organic layer in order to increase the organic matter to improve the growth of plants during the vegetation restoration. Because the soil build-up areas will be in place for at least 2 years, the vegetal debris will already be incorporated into the soil at the time of restoration (see Attachment 29 Vegetation Restoration Plan).
- b. The PHAM shall establish restriction zones in the La Engorda summer pasture, outside the physical work location. In this zone, the development of other construction activities shall be prohibited under a rather preventive criterion. The restriction zones shall be marked out *on site* with clearly distinguished and visible signalling for all persons employed by the Contractor at the construction stage. Particularly, the presence of vegetation constituting habitat or sheltering fauna of interest was considered as criterion to determine this restriction zone.

- c. Vegetation removed from the work sites or facilities (clearing), that is, debris and leaves shall be disposed at neighbouring zones with absence or very little vegetal cover, carriage and storing in some dump site should be averted. Disposal thereof shall be carried out manually by a team of workers, distributed on a uniform and thin layer. This shall be made at locations chosen near the work sites. This measure shall be intended as a contribution to the organic soil formation process, and act as seed capturing “mini barriers” in an environment where wind is the main propagation agent. This measure shall apply to work carried out over 2,000 meters above sea level.
- d. In the case of places affected by work or camp site facilities, an initial recovery of said locations is considered by scarification of the surface and deposit of plant debris or else are left *on site*. In low lying areas, if applicable, said zones shall be reforested according to the corresponding management plans.
- e. The species *Austrocedrus chilensis* (Cordilleran Cypress) has not been considered an impacted species because it has not been found in the project’s direct influence area, since the specimens nearest the project’s interventions are found in the San Gabriel area, over 10 kilometres away from the nearest worksites. Notwithstanding the above, the Contractor involved in the Yeso river sub-basin shall include information on this species and its restricted location in the borough.
- f. All individuals belonging to species under conservation status shall be replaced in a proportion of 10 to each one intervened, including individuals of tree species not found in the areas covered by the Forest management plan.
- g. A proportion of 30% Guayacán individuals (around 170 individuals) taller than 1 meter that have to be removed because of the project shall be transplanted to nearby places on an experimental basis. Record shall be kept of individuals transplanted, indicating date, size of individuals and relocation sites. Said records shall be submitted to the Authority.

### **iii) Qualitative Rating of Impact**

According to the analysis made, PHAM will affect a total of 105 vegetation hectares, out of which 0.48 consist in a forestry plantation and the rest native vegetation.

Out of the total affected native vegetation 31.23 hectares consist in sclerophyll forest and 14.04 sclerophyll shrubland. Both are formations widely distributed in the Central Zone.

A number of 56.35 has of Andean shrubland shall be intervened, which is widely distributed in the Central Zone and the project area, so the impact of works shall not compromise them much in conservation terms.

Finally, the meadow areas affected by the works shall be 7.28 has, out of which 6.28 are found in the La Engorda summer pasture (Alto Volcán area), and the remaining hectare in the Yeso river valley. Although the meadows grow in restricted places related to water, since they consist in azonal vegetation formations, they are widely distributed in the country, and in the La Engorda area itself, just a minimum portion of local meadows shall be affected.

It should also be noted that in the most sensitive area, Cajón de La Engorda, at least 50% of the intervened meadow area shall be recovered, corresponding to the water canal and worksites area, vegetation of which will be mostly restored.

In view of the above, and taking into account the environmental management measures, this impact is considered negative, of medium relevance.

#### ***6.4.1.6 Local Displacement of Fauna Species***

##### **i) Identification and Source of Impact**

Impact on the fauna existing in the Project area shall consist in the movement or retreat of local fauna specimens, mainly reptiles and amphibians, due to the modification of their natural habitat and/or scaring by human presence. Eventually, some specimens of minor mobility could be lost or their burrows be destroyed. However, based on the experience of similar projects, most of the fauna will tend to move away to nearby areas from the places intervened by the project construction works.

Over 2,000 meters above sea level, occupying low woody sub-Andean shrubland and high Andean grassland, the dominant group are the birds, then the reptiles and, finally, mammals. In these environments, fauna will tend to move to non-intervened nearby areas.

A similar situation is expected for intervention in works of other places below 2,000 meters above sea level, particularly in sub-Andean sclerophyll environments, where the availability of a wider rocky cover causes the species to behave like saxicola lichens.

Carnivorous amphibians prefer water habitats, that is, water bodies in flooded areas, ponds and river and stream banks. According to the project, the specimens inhabiting areas right next to water courses, when the have their flow reduced and therefore the wet section of the course will move locally to lower sections looking for permanently flooded places, according to their trophic or reproductive requirements. No migration is expected to farther places.

No adverse impacts are expected from PHAM over land arthropods justifying Environmental Management Measures.

## ii) Environmental Management Measures

### Measures considered by the Project's Engineering

- a) The project, during the preparation of the Environmental Impact Assessment, has redesigned some works and defined the location of the work and camp locations for marine stockpiling, according to environmental criteria in order to minimize habitats of the highest fauna concentration.
- b) Control measures indicated to minimize effects on vegetation are applicable to this impact, like: the establishment of restriction zones (see Figures 6.4.1.1 and 6.4.1.2), Contractor vehicle displacement, replacement of vegetation to be cut, rescue of plants and soil, etc. The above is supported on the principle that maintenance of vegetation in the most pristine condition possible, or else its recovery, shall assure the maintenance of the habitats and therefore the subsistence of the local fauna.
- c) Maintenance of an environmental flow ( $Q_e$ ) in streams to be intervened by the Project is a multipurpose measure intended to support water life and maintenance of biotic environment associated with water courses. In the case of PHAM, a decision was made to establish a  $Q_e$  for each of the streams, including those which do not shelter fish life due to their altitude (e.g. streams Colina, La Engorda, etc.). Maintenance of an environmental flow will allow maintenance of local habitats of amphibians.
- d) As explained above, PHAM made the decision to utilize "Alta cordillera (High Mountain)" type water inlets in the Alto Volcán area, disregarding thus the use of superficial run-off drain interceptors at the La Engorda summer pasture. This shall avoid the interruption of water drainage or run-off in those anastomosing courses, avoiding a fragmenting effect of habitats in the summer pasture zone. For that purpose, the canal connecting the water inlets shall be interred at least one meter deep.
- e) Instructions shall be issued to the Contractor to avoid interruption of ravines or intermittent courses draining to grassland and high-Andean steppe zones during the construction of service roads, building a drainage work allowing run-off under or over platforms.

### Complementary Environmental Management Measures

Generally, the Complementary Environmental Management Measures assumed by the project are focused on: minimizing the intervention area, optimization of the internal environmental management of the contractors and their workers, restoration of intervened areas and relocation of affected specimens. The effectiveness of this type of measures and their compatibility with investment projects have been assessed by SAG in "Wild Fauna Environmental Impact Mitigation Measures" (*Medidas de Mitigación de Impactos Ambientales en Fauna Silvestre*), 2006.

a) Minimization of Intervened Zones

- Intervention in river bank and Andean shrubland at the summer pasture zone areas shall be minimized by definition of the restriction zones for Contractors (see Figures 6.4.1.1 and 6.4.1.2). The summer pastures comprise mainly Andean shrubland that are not relevant from a botanical point of view, their ecological relevance is recognized as habitats for land vertebrates.
- Part of the crossings of water courses and/or ravines shall be made with minimum intervention works (sewage-like crossings).
- In the particular case of Cururo<sup>11</sup> (*Spalacopus cyanus*), monitoring of colonies in direct influence areas shall be made by tracking colonies through time (Valverde et al. 1991)<sup>12</sup>. For this purpose, the advance borders of these colonies shall be georeferenced in addition to characterization of the colony location. This method has been utilized previously with a high degree of natural relocation of individuals in events of habitat alteration (Escobar & Lobos, data not published)<sup>13</sup>. Said monitoring shall be made in the Yeso River works, area where this species has been recorded. The survey shall be made before the works, and shall complement the baseline generated by the EIA. No rescue shall be made, but conditions shall be created to favour spontaneous migration of individuals that may exist in the zones to be intervened, through supervision of specialized personnel on site. Upon completion of the local surface works, a field campaign shall be made to verify the restoration of population. Previous colony tracking experiences of this species show a high degree of mobility of colonies and natural relocation in events of habitat intervention. Therefore it is expected the colonies near the disruption areas to move away naturally upon beginning of the intervention. Should this pattern not be observed, interventions shall be made to force this movement.

b) Adequate Environmental Behaviour

- The project's workers shall be trained (through brochures and talks) in order to create awareness and protection procedures for land and water fauna, and restrictions concerning pursuit, keeping away, hunting and fishing. Contractors shall keep an updated record of training activities and parties in camps or worksites.
- Ingress of domestic animals (cats or others) into camp sites and work facilities which may depredate the native species or incur in insalubrious conditions shall be prohibited.
- As part of the correct environmental performance, the Contractors shall be required to respect the restriction zones or areas established for the PHAM. This shall be subject to field contractual requirements and supervision.

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<sup>11</sup> Species of endemic fossorial rodent in Chile, which prefers well drained open habitats with soft soil and thick vegetal cover (>60%) (Valverde 1990). Said rodent also inhabits swampy zones and hard grounds (Muñoz-Pedrerros & Yáñez 2000). It is a colonial species that that establishes family groups of variable size, being a characteristic of the species the mobility of the colonies in search of food.

<sup>12</sup> Valverde, V. M., J. Gutiérrez, L. C. Contreras & O. Contreras. 1991. Perturbación espacial and temporal del suelo por el roedor subterráneo *Spalacopus cyanus*. Archivos de Biología and Medicina Experimentales 24(2): R-201. Valverde, V. M. 1990. Ritmos de actividad del roedor subterráneo *Spalacopus cyanus* and su efecto sobre la vegetación herbácea. Archivos de Biología and Medicina Experimentales 23(3): R-263.

<sup>13</sup> Muñoz-Pedrerros, A. & J. Yáñez. 2000. Mamíferos de Chile. Ediciones CEA, Valdivia, Chile.

- The use of fire during construction work to eliminate vegetation as preparation of land for work installation shall be prohibited.
- To favour disclosure of environmental protection measures compromised by the Project, the Contractor shall install road signs with images of species of conservation interest existing in the zone and information about the hunt prohibition and their biological importance. Said signalling shall be installed in tourist or visitor affluence areas.

#### c) Habitat Restoration

- Vegetation removed from the worksite and facilities (clearing), that is, debris and branches, shall be placed at nearby zones with none or very little vegetal cover, avoiding its carriage and dumping in some dump site. Its disposal shall be carried out manually by a team of workers, as an attempt to create a uniform and thin layer. Attempts shall be made that the selected sites are located next to the work sites and shall not be intervened. Accordingly, the vegetal material shall constitute shelters for local fauna. This measure shall be applied to work carried out over 2,000 meters above sea level.
- The restoration of land occupied on a temporary basis shall consider the replacement of rocky habitats utilized normally by reptiles. Small stone walls will be built in open areas next to the work sites, especially at high-Andean shrubland in the Yeso and El Volcán River basins.
- Before the beginning of works, the Principal shall compromise a population survey and about habitat conditions of toad *Alsodes nodosus*; *Spalacopus cyanus* (cururo) and *Merganetta armata* (torrent duck), in the direct influence areas of the project works. On a preliminary basis, at the beginning, the Principal shall compromise a campaign to seek the species *Pristidactylus volcanensis* in the project influence area of El Volcán area, should it be found, it shall be considered in the population and habitat condition survey. The method and scope of this survey shall be defined together with SAG (Servicio Agrícola and Ganadero).

#### d) Expert Supervision during Construction

- A special measure shall be applied in places particularly sensitive for fauna, supervision by a fauna specialist on site, who shall supervise on site, at the beginning and during its development on a quarterly basis. In the event that during this supervision it is found there are conservation interest species, complementary removal measures or others shall be taken, as applicable, according to the vulnerability of specimens found and type of works involved. The expert supervision reports shall be sent to the pertinent Authorities. Should it be deemed necessary, extra reports shall be issued to obtain permits. The expert supervision shall be applied in the following areas:
  1. Colorado river area considering the presence of sapito cuatro ojos *Pleurodema thaul* (vulnerable species found in ponds or reservoirs in the zone where a marine stockpile, camp site and siphon are projected near the Central Alfalfal and Quempo stream areas, the latter not intervened by the Project).

2. La Engorda summer pasture and Yeso river areas because of presence of black-green *Lilolaemus nigroviridis* lizard (Vulnerable).
3. Aucayes area at site of works near the course, due to presence of toad *Alsodes nodosus* (Endangered) and Chilean toad *bufo spinolosus* (Vulnerable).
4. "Road" in Aucayes-Maitenes area, due to presence of *Liolaemus monticola* mountain lizard, jewel lizard *Liolaemus tenuis* and short tail *Phyllodria camissonis* snake (vulnerable).

d) Relocation of species

— A Monitoring, Rescue and Relocation Program shall be carried out of specimens with conservation interest having low mobility, plus other ecological criteria indicated in Table 6.4.1.6.1 and other characteristic criteria of the project and the area where the species are located. The program in the aforementioned table includes a proposal for the rescue method and the time (date/period) for its execution. The species and sites involved are the following:

1. Rescue and carriage of reptile individuals to areas of La Engorda summer pasture (Alto Río Volcán) for the species of El Morado, Lo Valdés and Negroverdosa lizards, all of them under some conservation status, endemic and of restricted distribution.
2. Rescue and carriage of reptile individuals *Callopistes palluma* (Iguana) in Colorado River and Aucayes-Maitenes road areas, a Vulnerable species which lives in reduced populations.
3. Rescue and carriage of amphibian individuals, Sapito de cuatro ojos (*Pleurodema thaul*) and Chilean toad (*Bufo spinolosus*), in the Colorado River, Aucayes stream and La Engorda summer pasture areas, respectively.

- The fauna rescue tasks by capture shall be carried out before using explosives, construction of penetration paths and permanent modification of flows, for the amphibian and reptile groups. The species Negroverdosa lizard (*Lilolaemus nigroviridis*) and Cururo (*Spalacopus cyanus*), shall be given the conditions to favour spontaneous migration of individuals (before beginning of works) that may exist in the zones to be intervened under supervision of specialized field personnel. In the case of *Spalacopus cyanus* (cururo), the method of controlled disturbance shall be utilized, which has proven to be the most effective for said species.
- The Principal shall be in permanent coordination with SAG (*Servicio Agrícola and Ganadero*) should any rescue capture and wild fauna relocation be needed, with supply of resources for deal with and the maintenance of rescued species.
- The areas where the fauna species are relocated shall be agreed between the project's Principal and SAG. In this respect, the environment where they are released shall be the nearest as possible from the capture site, outside the project's direct influence area and shall provide adequate resources for the species feeding, reproduction and shelter.
- Before rescue operations of species with conservation problems begin, an analysis shall be made together with CONAF respect the feasibility of transferring and establishing flora individuals of high survival rates, at the Natural Monument El Morado, if the species is present in the protected area.
- A specific tracking shall be implemented to asses the effectiveness of the rescue and relocation program in order to asses the success of survival and eventually, reproduction of the relocated specimens. Said analysis shall allow also detecting the seasonal variation and natural migration of the species, data that nourish the scarce knowledge of some species due to the actual lack of long-term studies.

**Table 6.4.1.6.1**  
**Rescue Program for Specimens with Conservation Interest and other Measures**

Species	Criterion justifying the Measure								Place where Measure is Applied				Measure Type	Time
	C.C.			D.R.	P.R.	EN.	P.F.	B.M.	RC	EN-MO	RY	EA		
	P	V	R											
<i>Sapo Alsodes nodosus</i>	X					X		X				X	Transfer in conservation buckets.	Between Spring and beginning of Summer; 2 o 3 campaigns.
Four-eyed toad - <i>Pleurodema thaul</i>		X						X		X			Transfer in conservation buckets.	Between Spring and beginning of Summer; 2 o 3 campaigns.
Chilean toad - <i>Bufo spinulosus</i>		X						X				X	Rescue in conservation buckets for transfer	Between Spring and beginning of Summer; 2 ó 3 campaigns.
Lo Valdés lizard - <i>Liolaemus valdesianus</i>			X	X	X	X				X			Rescue with lace, manual and Pitfall traps	Spring and Summer; 2 ó 3 campaigns.
El Morado lizard - <i>Liolaemus moradoensis</i>			X	X	X	X				X			Rescue with lace and Pitfall traps	Spring and Summer; 2 ó 3 campaigns.
Negroverdosa lizard - <i>Lilolaemus nigroviridis</i>		X				X				X	X		Supervision during operations	Construction Stage
Iguana - <i>Callopistes palluma</i>		X			X	X	X		X				Rescue with lace and Pitfall traps	Spring and Summer; 2 ó 3 campaigns.
Cururo - <i>Spalacopus cyanus</i>	X					X						X	Supervision during operations	Construction Stage

**Notes:**

Criteria justifying the measure

CC: Conservation status (P= Endangered; V=Vulnerable; R=Rare)

DR: Restricted Distribution

PR: Reduced Population

EN: Endemic

PF: Infrequent

BM: Low Mobility

Lugar/sector

RC: Río Colorado

EN-MO: La Engorda - Stream El Morado

LE-EM: Lo Encañado lagoon - Stream El Manzanito

RY: El Yeso river

EA: Aucayes Stream

### **iii) Impact Qualification**

According to the present analysis, the impact on fauna existing in the Project area, shall consist in the movement or retreat of local fauna specimens mainly reptiles and amphibians, due to the modification of their natural habitat conditions and/or scared by human presence. To mitigate this impact, the project has defined a number of Environmental Management Measures intended as mitigation and compensation of effects on fauna, like minimization of the intervention area, optimization of internal environmental management of contractors and their workers, restoration of intervened areas and relation of specimens potentially affected.

This impact is qualified as negative, of medium significance, since the Environmental Management Measures shall allow that most species migrate and/or re-populate progressively the intervened areas, or others defined by a specialist or SAG.

Finally, no impacts are expected on the land fauna during the operations stage. The species will tend progressively to assimilate the presence of permanent works and will adapt to the local changes in the environment, like: renovation of the vegetal cover and recovery of soils intervened temporarily.

#### **6.4.1.7 Effects of the Project on Ictic Fauna**

##### **i) Identification and Sources of Impact**

At this stage, an eventual alteration of the ictic fauna in the rivers and streams which shelter this type of organisms, would be caused by the temporary alteration of the water quality resulting from the earth removal during excavations and other construction works, like detour, inlets, etc.

It is estimated the change in the sediment load resulting from works will not be significant or deviating from the normal run-off condition of the mountain rivers. As explained (see section 6.4.1.4), the effect on the habitat of the species shall be momentary, temporary and related exclusively to the increase of the concentration of solids in suspension and water cloudiness.

It should be noted that the PHAM is inserted in an area with noteworthy singularities from an environmental and anthropic point of view. For example, one of them is that the ictic fauna in the water courses is comprised mainly by a mixture of foreign species due to the introduction of species attractive for fishermen and predation of these on the native fauna.

##### **ii) Environmental Management Measures**

In relation to this impact, the same measures indicated in Section 6.4.1.4 “Temporary Modification of Water Courses and/or Quality” are applied.

### iii) Impact Qualification

This impact is qualified as negative, of low significance, since works would not affect the flow continuity for the displacement of nektonic species (fish) and changes in the habitat condition for benthic assemblies would be highly restricted spatially and temporarily, so it is predictable the abundance and richness levels of these assemblies are not altered.

#### ***6.4.1.8 Generation of Employment and New Income***

##### **i) Identification and Source of Impact**

###### Labour Demand

The PHAM labour demand during the construction stage is estimated in the estimated mean amount of 2,000 direct job positions, distributed in the different worksites. Figure 6.4.1.8.1 shows a labour requirement timeline for the whole construction stage (personnel occupation curve).

On a preliminary basis, a number of 5 camp sites is expected (see Attachment 5), including work facilities, housing between 300 and 400 workers, including professionals, technicians, workers, drivers and operators engaged in work related to canteen, camp maintenance and health auxiliaries.

Personnel engaged in construction work shall be carried on buses to and from the worksites. The camps shall have a permanent staff of 20 persons, who shall render vigilance services and general maintenance of the facilities.

Due to the Project characteristics and size, qualified personnel shall be required especially for the operation of machines and plants. On the other hand, it is estimated that 30 to 40% of required personnel shall not be qualified, mainly to perform tasks of day labourers and assistants.

This offer of new job positions shall imply an increase of the source of direct and indirect income in the borough of San José de Maipo. The direct jobs consist in those resulting from the direct labour hiring whilst indirect jobs are related to the demand for services which could be offered by local persons or companies.

On the other hand, the characteristics of the area that constitutes the project's direct influence area has instruction and specialization levels (occupation as per Code CIIU) which would allow, eventually, apply for qualified and non-qualified jobs required by the project.

A high percentage of the inhabitants of El Canelo, El Manzano, Los Maitenes and El Volcán villages are classified as non-qualified workers in sales and services, while in the villages of San Gabriel, El Romeral and Lo Valdés are people classified as vehicle drivers, heavy equipment operators and mobiles and machinery and erection operators.

As for indirect jobs, there is 12.9 % of PEA (economically active population) in the borough who works in commerce-related activities, just like 54 % of the local companies. That allows us to infer that it is possible that part of services required by the Project could be obtained from the local area.

Additionally, materials, consumables and associated services would have to be purchased for the construction work. Most of the consumables and services shall be purchased in the city of Santiago, and it is estimated the need for arid materials, among others, shall be covered by plants near the Project area.

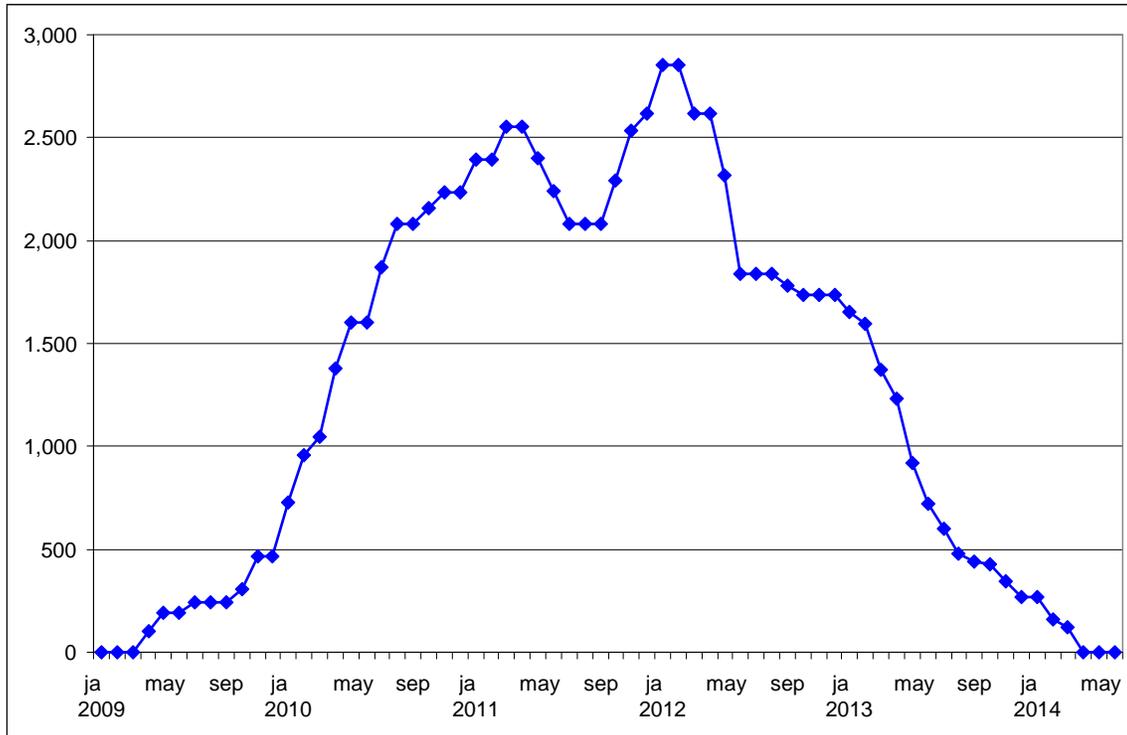
This situation becomes relevant in view of the fact that the borough has poverty indexes higher than the total Metropolitan Region of Santiago, with an unemployment rate of 10,11% in 2002 (INE, 2002). On the other hand, in the borough there are informal and unstable work sources related to tourism, production and marketing of food products, handicraft, nut and almond harvest, where usually non-qualified labour is hired on a temporary basis.

The incorporation of local labor into the construction should not alter the current labor structure, since the most traditional lower-income population tends to work in the construction area to supplement their income.

Another important consideration is that the creation of new income sources could reduce the migration or frequent travelling of traditional families to the city searching for work offers, so that would contribute to the preservation of attachment to the territory. That could imply an improvement in the life quality of the traditional inhabitants by avoiding their travelling of long distances to reach their jobs outside the borough and in turn it would allow them to continue activities related to their condition of *arrieros*, not necessarily in charge of cattle, but taking advantage of their knowledge and expertise in the mountain and the use of horses and mules as transportation.

As far as the Project concerns, the occurrence of indirect employment in the minor localities will be moderate considering the nearness of the city of Santiago, and the isolation degree of the camps and worksites.

**Figure 6.4.1.8.1**  
**Occupation Curve of Personnel as Required by PHAM**



Demand of Social Services

Due to work schedule, it is estimated there would be a low demand for lodgement services, catering and other services in general. However, based on the experience of the construction of Central Alfal, it is believed that the project will require mountain guides and transport assistance.

**ii) Environmental Management Measures**

To promote this positive impact and after hearing the community representative views during the early citizen participation activities, the following is considered:

- a) Priority in hiring local labour.

For that purpose, the Principal shall coordinate with the labour office of the Municipality of San José de Maipo, the offer or search for local labour, as per the Contractor requirements.

b) Promotion of Job Offer

To facilitate the contractors receive property information concerning the existing labour offer in the borough, meetings have been held with the Municipality of San José de Maipo so they update their available personnel and their specialities. Similarly, AES Gener has a web site ([www.aesgener.cl](http://www.aesgener.cl)) receiving information from parties interested in working for the project.

**iii) Impact Qualification**

The PHAM will generate an important labour demand during the construction stage. This, in addition to the creation of new income sources, could reduce the migration of traditional families and/or avoid their travelling of long distances to work outside the borough. Then, for the traditional inhabitants, the project appears as a big labour alternative, an expectation based on one part on the experience gained during the construction of Central El Alfalfal that created local job sources, as well as job positions being created by companies associated with the early stages of the project design (topography and environmental surveys) employing local labour as guides and carriage of implements on mules.

Finally, the project will mean a capital injection to the borough or local economy, probably with greater influence on activities related to construction and transport operating in the borough, classified as a positive impact of high significance.

**6.4.1.9 Interference with Tourist Activity**

**i) Identification and Source of Impact**

The PHAM shall not have direct effects on the local tourist activities, that is, it shall not interrupt or suspend the normal development of them during the whole construction stage. Notwithstanding, it is deemed probable that in view of the tourist vocation of the Cajón del Maipo borough, in some specific places there could be some interference, mainly in the area of transit between the PHAM activities and the transit of visitors. This would convey some discomfort for visitors, who could suffer delays in their travel times or particularly, longer waits at intersections.

The analysis of the transit impact of the project is assessed separately in an independent section; however, even when the modelling developed reflect that there will be no significant impact on transit (saturation of roads and intersections), it is assumed that the simultaneity of certain construction activities with the rest of users of roads in specific road sections could cause some discomfort so the PHAM has assumed environmental management measures.

As stated in the Baseline of this EIA, tourism in the area consists in routing and contemplation by visitors on weekends and holidays. There are two particular tourism attraction places near the worksites, where special measures shall be taken. Said places are: Embalse El Yeso and in a lesser degree, the Alto Volcán area, where the following has been considered:

- Embalse El Yeso: Activities in the reservoir and neighbouring areas shall not be interrupted. Collection works in the Yeso River shall be minor, since the existing infrastructure will be utilized. Additionally, work necessary for the construction of the connection of the tunnel to the siphon shall be temporary and partial, on the G-455 road, meaning eventually a restricted transit along one lane or a short detour (approximately 500 m), but only as long as work is being carried out. This could cause eventual discomfort to the motorists in places where works are being carried out. This effect shall be minor, since work shall be carried out during week days when transit along the G-455 road is quite reduced compared to holidays and weekends. Additionally, the workers' camp site shall not have any effect on the local tourist activities, which, as commented, it consists in touring activities. On the other hand, construction activities in hits zone are considered for the whole year, which will create the need to keep Ruta G-455 road permanently clear (of snow and rocks) and passable, allowing this way the visit by tourists in the winter season, situation that is not possible currently due to the road blocks caused by stream and minor course overflows in addition to snow accumulation and rockslides.
- Alto Volcán: The construction of the water inlet works, desanders and canals in this area shall not interrupt the access or transit in this place by professional, amateur climbers or visitors. The only access restriction for third party persons shall be to the worksites due to security reasons. Also, the climbing sites in the area will not be affected, and the same applied to Paleontological cultural interest resources acknowledged by the Chilean Paleontological Society.

In relation to the other high places involved in the project, it can be said that no impact is identified in them, since said places do not have any tourist infrastructure that could be affected and, at the same time, they receive a lesser number of visitors. In these zones, spontaneous, individual and/or group tourism is practiced, without meaning exploitation or use of signalling, tracks or any other type of tourist infrastructure. An exception is the Baños Morales, Baños Colina and Monumento Natural El Morado areas in the Volcán River Valley; however, the PHAM does not consider any relevant works or intervention here, so the underground works are practically unnoticed.

It should be noted that the El Volcán tunnel shall cross the El Morado Natural Monument and the Alfalfal tunnel under Santuario de la Naturaleza San Francisco at a depth of around 1,000 and 450 meters respectively, without consideration of windows, roads or other facilities that may affect this protected area or else activities carried out in that place.

Other tourist attraction centres or zones in the zone (Parque Río Olivares, Termas El Plomo, San José de Maipo, etc.) are at a distance from the worksite, and have no effect at all on the tourist activities carried out at that place.

It is not considered that the PHAM interferes with the Rutas de Chile project. Information provided by CONAMA<sup>14</sup> states that the study determining the track that crosses the borough of San José de Maipo is currently under development, so no further details can be given about the official path. In view of the local characteristics, it is presumed the alternatives or a future track could be at the Yeso river basin. Generally, in these places the PHAM works will be mostly underground and in a lesser degree, superficial, temporary, the latter over 2,000 meters above sea level and located on the water courses or neighbouring areas.

Finally, the PHAM shall not interrupt the access of permanent or occasional excursionists or visitors who visit the place for recreational, sports, cultural or other purposes. For security reasons, the PHAM shall restrict only the access of persons to their facilities and worksites.

The improvement of part of the roads and their maintenance during the year in the most remote areas of the G-455 road to El Yeso and G-25 road from El Yeso bridge to El Volcán will improve the access conditions, which could attract a bigger number of visitors or else, a wider temporary distribution of them, since these areas are away from tourists most of the winter season.

## **ii) Environmental Management Measures**

### Actions considered by the Project engineering

- a) The PHAM shall fully agree to the vehicle traffic restrictions for trucks over 4 tons, established by the Municipal Ordinance, Exempt Decree No. 130 of June 12, 1997. In particular, these restrictions are related to the suspension of such vehicles on holidays and weekends (from Saturday noon to Sunday 12 pm).
- b) Other measures to minimize impacts on roads shall have a multipurpose result, avoiding inconvenience to visitors to the area, and thus reducing any kind of interference with the tourist activity in the area (see Section 6.4.1.11 "Project Impact on Roads").

### Supplementary Environmental Management Measures

#### a) Support to tourist ventures

AES Gener, through its Maitenes Foundation (Annex 26), is committed to make a concrete contribution to promotion of tourism, since this sector has a significant potential for growth that should be addressed in a comprehensive and long-term vision. As specified in the baseline, there are small tourist operators in the borough who provide services with limited resources, at a small scale, or under a completely informal scheme. Under this approach, the company will boost the development of Tourism, particularly Ecotourism, Development Program, which takes advantages of these experiences, but mostly which prepares, accompanies and partly finances the ventures of local operators arisen in this field. This concept also includes the possibility to make infrastructure improvements such as trails, shelters, signs, etc. For this purpose, the company is committed to allocate, through Maitenes Foundation, an annual fund of US\$200,000 for a 10-year term from 2010, to benefit those local entrepreneurs who submit tourist development projects in the area, aimed at improving local employability of the borough considered within the Municipality of San José

<sup>14</sup> Consultation made to the Natural Resource Department of CONAMA Nacional, 26<sup>th</sup> February 2008.

de Maipo programs. These projects will be channeled through competitive funds and evaluated on their own merit.

Initiatives to be implemented by Maitenes Foundation may be linked to those projects or ventures that are being developed by other Services or Public Institutions operating in the borough, in the areas of work involved. This linkage would strengthen the initiatives being conducted by the State and promote sustainability over time of the actions boosted by the Foundation, during the period of the program application.

b) Promotion of tourist activities

To compensate any potential interference with tourist activities that may be caused by the PHAM, actions are considered to promote tourist attributes of the borough. To this end, the Owner proposes that, in conjunction with the Municipality of San José de Maipo staff, a tourist promotion and development program is formulated, where contributions by GENER will be as follows:

- Training of tourist monitors in local educational establishments or other institutions related to the subject (e.g. Chamber of Tourism, Sernatur, etc.), for a period of 3 years from 2010.
- Design and edition of a Tourist Promotion Guide for the borough. This shall consist in printed material produced in conjunction with the Municipality, where information on the borough's tourist offer will be territorially outlined. Information shall be included about landscape attractions, craftworks, gastronomic spots, traditional or heritage sites, among others. GENER shall finance the design and edition of this material and the printing of 5,000 copies which will be available in 2010.
- Production and design of a web page which focuses on all tourist attractions and offer of the borough. This page shall be the responsibility of local tourist agencies or the like, which may update the information contained in this digital tool. This material will be available in 2010.

c) Avoid potential interference with the Sendero de Chile Project

The Project considers a priori corrective actions if, at the date of construction of the works, there is a section of Sendero de Chile in operation in the area, in which case, the Owner agrees to avoid, where possible, that its works or activities affect the layout or, failing that, to perform adjustment and/or restoration of the Sendero.

### iii) Impact Rating

The impact on tourist activities refers to possible inconvenience to users of public roads due to vehicle movement and the presence of works and works facilities. These aspects are anticipated not to cause a disincentive for visitors and tourists. Strictly speaking, there will be no interruption of the activities themselves, or any deterioration of the tourist attributes of the area.

The fact that most of the works are underground, located in upper areas, have a “mining” working system or time, in addition to the suspension of the road flow on weekdays, and other special measures to minimize the road impact, will ensure that the impact of the PHAM interference with tourists activities has a low negative significance.

Given the nature of the actions in the PHAM operation stage, no impact is expected on the tourist activities.

#### **6.4.1.10 Alteration of the Landscape**

##### **i) Identification and Sources of Impact**

###### *a) Assessment Methodology*

Landscape impacts associated with infrastructure projects are divided into those with a limited period, usually implemented during the construction stage, and those to be developed during the operation stage, of a permanent nature and whose effects are manifested throughout the life of the Project.

The methodology for assessment of impacts on the landscape component is structured both for the construction and operation stages of the Project. The methodology is qualitative and considers a first stage of Identification of Impact Sources and a second stage of Identification and Qualification of Environmental Impacts. The latter, in turn, is divided in several stages corresponding to:

- Qualification of the Project’s effects on the landscape and visual attributes, particularly on the visual contrast and artificiality<sup>15</sup>. Qualification is qualitative (Low, Medium and High Impact).
- Obtaining a landscape sensitivity value from the values of visual fragility and quality (Baseline). A mean is obtained from both variables and qualified according to the following scale:
  - High sensitivity: (2..4-3)
  - Medium sensitivity: (1.7-2.3)
  - Low sensitivity: (11-1.6)

<sup>15</sup> Visual Contrast: This is the degree of differentiation of an object or element respect to the landscape context in which it is inserted. Artificiality: This refers to how far from a natural condition is an object or element inserted into the landscape.

- Obtaining a preliminary (intrinsic) landscape impact considering a combination of individual qualifications of the landscape and visual attributes and the landscape sensitivity. To give a greater range of qualifications, an increasing binomial nomenclature is used that results from the combination of the Low, Medium and High qualifications, which corresponds to: Low, Low-Medium, Medium-Low, Medium, Medium-High, High-Medium, High.
- Obtaining a final landscape impact, combining preliminary landscape impacts with accessibility (physical and visual) to the place, following the same procedure for obtaining the preliminary landscape impact. The areas with low accessibility decrease or reduce the preliminary landscape impact obtained.
- Finally, some considerations on landscape management are added to the Project.

*b) Identification of sources of impact*

In the Project construction stage, the sources of impact are short-lived. For the purposes of evaluating this component, the following works are included within this stage: movement of machinery and vehicles, operation of works facilities and camps. Once this stage is completed, the activities will cease and the facilities will be dismantled and/or removed.

The Project remaining works which, by their nature, shall remain in the area, are analyzed in the operation stage. In this sense, part of the service roads will be used later during the operation stage for this situation; assessment is performed on such stage.

As a general scope for the assessment of sources of impact for this component, it is necessary to indicate that all works to be developed underground have no effects on landscape, a situation due to which they are not included in this assessment. Among the major facilities to be developed underground are: tunnels and caverns for machines, as well as related works.

The following table presents a summary of the landscape units identified in the area of influence of the PHAM and the sources of impact associated to the construction stage.

**Table 6.4.1.10.1  
Summary of Landscape Units – Sources of Impact**

<b>Landscape Units</b>	<b>Project Works to be Constructed</b>
Valleys in Volcán river upper sector	Intakes, seacoast storage, works facilities, pipelines, roads, windows.
Yeso river valley in the Reservoir sector	Roads, seacoast storage, works, windows, intakes
Lo Encañado	Seacoast storage, works, windows, roads.
Colorado river valley in Lower Section	Las Lajas load chamber, seacoast storage, works, window.
Colorado river in El Sauce sector	Window and electrical substation
Aucayes stream gully	Alfalfa II load chamber, seacoast storage, works, window, road
Maipo river (Las Lajas sector)	Unloading, seacoast storage and works facilities

Source: Prepared by the Author

c) *Analysis of the Alteration of Landscape and Visual Attributes*

The alteration of landscape attributes is evaluated considering two different aspects that correspond to the Visual Contrast of the Works and their Artificiality. Below we analyze the Project works in relation to both aspects.

Visual Contrast

*Works, Camps, Movement of Vehicles and Machinery:* These correspond to facilities and activities that have significant sizes and intensity, and which will be inserted temporarily on each of the landscape units identified.

Artificiality

For the Construction Stage, both works facilities and camps and the movement of vehicles and machinery are artificial works and activities, especially in relation to markedly natural landscapes in the area of El Volcán, Lo Encañado, Aucayes and, to a lesser extent, Yeso and Colorado. Artificiality is given by the rectilinear shapes, volumes, textures and colors of the buildings. In general, vehicles and machinery are elements commonly present in the current landscape situation, except in units where there is less presence and development of human activities, such as the upper sector of El Volcán river. In this regard, we can highlight the heavy traffic flow provided by mining companies operating in the area (e.g. La Perla mining company in the Colorado river valley, gypsum mining in the Volcán river valley).

d) *Landscape Sensitivity*

As noted above, landscape sensitivity is obtained from a combination of the visual fragility and quality qualifications (Baseline Chapter). Table 6.4.1.10.2 shows these values and the final sensitivity value for each landscape unit.

**Table 6.4.1.10.2**  
**Qualification of Landscape Sensitivity**

<b>Unit</b>	<b>Visual Quality Qualification</b>	<b>Visual Fragility Qualification</b>	<b>Landscape Sensitivity Qualification</b>
Upper Volcán river	High-Medium 2.7	Medium 2.0	2.4
Yeso river valley	Medium-High 2.3	Medium-High 2.3	2.3
Lo Encañado	Medium-High 2.4	Medium 2.0	2.2
Colorado river valley	High 2.9	High-Medium 2.5	2.7
El Sauce	Medium 2.0	Medium 1.9	2.0
Aucayes stream gulley	Medium-High 2.4	Medium 2.0	2.2
Las Lajas Maipo river	Medium 2.0	Medium 2.1	2.1

e) *Physical and Visual Accessibility*

Physical Accessibility: All landscape units present a high accessibility because there are established routes to facilitate access and travelling, except for the Aucayes stream gully unit, which has no access route, and Lo Encañado, whose access is restricted by Aguas Andinas S.A.

Notwithstanding the foregoing, there are areas that are distant from the centers of greater concentration and movement of people, such as the upper Volcán river area, which have low standard roads, non-passable during the winter. In the remaining Landscape Units identified in the area of influence of the PHAM, that is, Las Lajas, El Sauce, Colorado and El Yeso, the roads have a good standard and are passable most of the year (except for Route G-455 to the El Yeso reservoir and certain sections of Route G-25). On the other hand, the area of the Lo Encañado lake has a restricted traffic because the access route is private.

Visual Accessibility: Below we analyze the visual accessibility of the Project works according to the site area:

- Upper Volcán river: This corresponds to a moderately exposed landscape which allows for extensive views, so the works, especially those to be developed in the construction stage, will be easily perceived.
- Yeso river: The works will be developed adjacent to Route G-455, so they will be very visible, especially those aspects related to the movement of vehicles and machinery, as well as the construction of new roads. The storage site and works facilities will be located on a terraced level at an elevation higher than Route 455, so there will be no visual access from this route.
- Lo Encañado: The seacoast storage and works facilities will be located in a gully, so they will not be well visualized from the existing road. The projected roads and channels are developed in areas of high exposure, so they will have a major access. The same will apply to the movement of vehicles and machinery.
- El Colorado: Seacoast storage, works facilities and some of the roads will be developed below the altitude of existing Route G-345, so they will not be seen clearly, with only irregular views (towards them) from certain specific angles. The sinuosity of the valley will also help to minimize the exposure of the remaining works and activities, such as: windows, vehicle traffic and some sections of roads (e.g. road projected toward the Aucayes stream). Regarding the loading chamber of Las Lajas power station, due to its size and the morphology of the valley, this work will be visible to observers travelling along Route G-345, however, given its characteristics (water surface), this work is considered not to bring any negative landscape elements.
- Aucayes stream gully: As indicated, there is no road through this valley, whereby visual accessibility is reduced.

- El Sauce area: This area will host a window of access to the underground cavern of machines of Las Lajas power station and an enclosed electrical substation. The tunnel window will be a drill in the base of the hillside, about 3 m wide and 7 m high. Regarding the electrical substation, this covers an approximate area of 0.5 ha and will consist mainly of electrical equipment, power transformers and protection and control equipment, used to raise the output voltage of the Power Station generators.
- Maipo river discharge area: The works will be developed below the elevation of the existing Route G-25 to San José de Maipo, so they will not be visible from it. On the other hand, the movement of vehicles to the work will be directly visible, however, the sinuosity of the valley and the presence of visual obstacles, such as vegetation, will help these elements to be perceived locally and not at a distance.

Finally, the fact remains that, given the characteristics of the area landscape, as well as the types and location of the PHAM works, there will no major visual obstruction of the landscape elements existing in the area or any significant interference on panoramic or scenic views of the surrounding landscape.

## ii) Environmental Management Measures

### Environmental considerations included in the Project engineering

- For the location of the PHAM temporary works and facilities, efforts have been made to use areas without the presence of high Andean shrub formations and mature forests of sclerophyllous flora, due to the significant aesthetic value of these units.
- For both technical and cost reasons, as well as environmental and safety considerations, the extension of service roads required for the movement of Contractors has been minimized. Also, the opening of new roads in hillsides has been reduced.
- The PHAM will meet the minimum requirements established by the Regional Roads Directorate of the MR regarding the location of material storage facilities respect to public roads, particularly as referred to i) the storage sites shall not affect the stability of the embankment supporting the road or imply any risk of sliding or falling of materials that could affect its functionality or safety standard, and ii) the storage sites near public roads shall not reduce or block side or panoramic views from the road or berm, that is, the storage shall consist of an element of visual obstruction for the road users. This is because, in all cases of storage projected near roads, they shall have a fill closure level above the road level.
- The Project engineering considers stabilizing slopes for embankments generated by cuts or spills of material on roads or other works. The design of layout and embankment, slope and maximum speeds will be made as set out in the Roads Manual. Similarly, geotechnical studies associated to the type of rock and soil in the road layout area will be carried out. Embankments generated by cuts or spills of material on roads or other works are included in the plan to restore vegetation, which considers stabilization of soil and restoration of existing vegetation, for the purposes of erosion control, visual mitigation and the fauna habitat restoration (see Annex 29: Plan to Restore Vegetation). Identification of the sites where vegetation restoration measures may be implemented will be established as a result of the micro-routing,

discarding those areas where natural restrictions of the area determine little or no vegetation cover, and where the existing soil does not guarantee the expected degree of engraftment.

- In the case of the Project electrical substation (enclosed), there will be a 25% of wooded area with native species. This shall meet the technical and safety requirements imposed by the sectoral Authority for this type of facilities.

#### Complementary Measures to Mitigate the Impact on Landscape

- GENER shall instruct Contractors regarding a proper dismantling of the temporary works facilities and camps, developing, in addition to cleaning or sanitation of the occupied sites, landscape restoration works consisting of the topographic recovery and revegetation of the intervened areas, using shrubs or grasses of the area for such purpose (if the application of forest management plans is not appropriate). This recovery considers profiling works, minimization of right angles and heights according to the local landscape, where appropriate (see Annex 29).
- While final road mitigation measures shall be approved by the Regional Road Directorate of the Metropolitan Region, it is considered a priori, without neglecting the aspects of road safety, to use mixed defenses to minimize a local effect on the area landscape.
- In the case of the upper Volcán area, due to the presence of summer pastures, the PHAM has taken special considerations to minimize the intervention of vegetation (see Section 6.4.1.5). These measures should be understood as multipurpose in nature since they tend to minimize the effect of works on the area landscape, characterized by a high degree of naturalness.

#### **iii) Qualification of Impact**

According to the analysis, impacts during this stage are temporary, have a negative nature and show qualifications ranging from Moderate to High. Particularly sensitive landscape units are upper Volcán river, Lo Encañado and Aucayes stream, mainly because they exhibit high naturalness.

Regarding accessibility, weights range from Medium to High. Major physical and visual accessibilities develop in the Colorado river and Yeso river unit, mainly because it combines the existence of common traffic routes and proximity of the works to views of potential observers.

In general, the impact on landscape in the construction stage is considered to be negative with a medium significance level, mainly due to the seasonality of the sources of impact, the degree of naturalness of some areas, and a relatively low visual and physical accessibility in a large part of the intervened area.

#### **6.4.1.11 Road Impact**

##### **i) Identification and sources of impact**

When the Pham construction starts, there will be an increase of traffic flows in the roads near the area of the works, which could change the level of service of the roads involved, and consequently, increase traffic congestion. This movement of vehicles will be primarily related to the transportation of supplies and equipment to the works facilities, the transportation of excavation material to the storage sites, and, to a lesser extent, the transportation of staff to the worksites.

According to this, the Project area of influence consists of a set of sections of existing roads and intersections, which will be potentially used by the Project. These roads are indicated in the following tables 6.4.1.11.1 and 6.4.1.11.2 (see details in Section 5.6.1.3, indicated in Chapter 5 of the EIS).

**Table 6.4.1.11.1  
Area of Influence for Some Sections of Public Roads**

Section	Route	Between	Borough	Kilometer		Length (Km)
				Beginning	End	
1	G-25	Departamental and Diego Portales	La Florida	0	6	6
2	G-25	Diego Portales and Eyzaguirre	Puente Alto	6	11.5	5.5
3	G-25	Eyzaguirre (Las Viscachas) y Route G-345	Puente Alto	11.5	28.3	16.8
4	G-25	Route G-345 and north access to San José de Maipo	San José de Maipo	28.3	32.7	4.4
5	G-25	North and south access to San José de Maipo	San José de Maipo	32.7	38.1	5.4
6	G-25	South access to San José de Maipo and El Yeso bridge	San José de Maipo	38.1	56.8	18.7
7	G-25	El Yeso bridge and Baños Morales	San José de Maipo	56.8	83.3	26.5
8	G-345	Route G-25 and access to Alfalfal Power Station	San José de Maipo	0	22.8	22.8
9	G-455	Route G-25 and El Yeso reservoir area	San José de Maipo	0	23	23

**Table 6.4.1.11.2  
Area of Influence for Relevant Intersections**

Checkpoint	Intersection	Borough
1	Av. La Florida/Departamental	La Florida
2	Av. La Florida/ Rojas Magallanes	La Florida
3	Av. La Florida/ Av. Trinidad Oriente	La Florida
4	Av. La Florida/ San José de la Estrella	La Florida
5	Av. La Florida/ Av. Diego Portales	La Florida
6	Av. La Florida/ Av. El Peñón	Puente Alto
7	Route G-25/ Eyzaguirre (Las Vizcachas)	Puente Alto
8	Route G-25/ Access to Route G-421 (Las Vertientes)	Puente Alto
9	Route G-25/ Route G-345 (Access to Los Maitenes)	San José de Maipo
10	Road to Volcán (Route G-25)/Cañada Norte	San José de Maipo
11	Comercio / Cañada Norte	San José de Maipo
12	Route G-25 / Route G – 421 (El Toyo)	San José de Maipo
13	Route G-25 / Route G – 455 (Access to El Yeso reservoir)	San José de Maipo
14	Route G-25 / Route G – 465 (Access to Queltehues)	San José de Maipo

To identify the degree of road impact produced by the Project on the roads in the area of influence, traffic demand levels were analyzed in peak periods, not including demands generated by the Project construction. Subsequently, the level of service, including the maximum traffic generated by the Project, was identified, to finally review the differences between both and determine the magnitude of the impact.

Current levels of service and traffic demand in peak periods in the Project area of influence are detailed in the Road Impact Study, attached to Annex 14 and in Section 5.6.1.3 of Chapter 5, respectively.

On the other hand, maximum traffic generated by the Project in its construction stage is referred to the following traffic flows:

- Transportation of supplies and equipment: It will be done from suppliers within the borough or other places in the Metropolitan Region, so public roads and service roads will be used.
- Seacoast transportation: As stated in the EIS (Chapter 2), there will be a lower flow on Route G-345 in a section of about 2 kilometers due to seacoast transportation. This traffic will occur from the worksite for the construction of the Door of Access to Las Lajas tunnel (VL2) towards the seacoast storage site 14. The amount of material to be transported is about 159,000 tons, in a period of 15 months, which, in the worst case scenario, is equivalent to a flow of 2 trucks per hour.
- Transportation of staff: The staff working in the Project construction activities will be transported from urban areas to the camps, and from the latter to the different worksites.

- Transportation of miscellaneous items, which includes transportation of minor supplies, used during the Project construction stage, either for the operation of camps and works facilities or for the operation of works. This item also includes the transportation of waste to final disposal sites approved by the Health Authority.

Detailed requirements on transportation and traffic flows are indicated in Tables No. 8, 9 and 10, of Annex 14 "Road Impact Study", attached to this EIS, that is, transportation of cargo (trucks), people on buses and light vehicles, to each of the worksites. For estimation purposes, the vehicle fleet necessary to meet all the works requirements has been considered, that is, all the activities to be developed within the 5 years scheduled for the Project construction stage (see Project's Gantt letter).

Moreover, it is important to note that the Project, from its engineering design, has considered some measures which, from the point of view of road impact, have allowed to minimize the generation of traffic flows, that is:

- Most of the material extracted in the construction of ditches and embankments will be reused as filling material in the same works, that is, self-compensatory movements will be carried out, thus, transportation of large volumes of material from and to other areas will not be necessary. The works subject to this type of construction method are pipelines, intakes, small stretches of roads and loading chamber of Las Lajas Power Station. Particularly, in the case of the construction of this last work, the extracted material will be used for the construction of protection parapets. This implies that the distances traveled in the transportation of material to be used in the construction works will be minimal.
- In the case of transportation of aggregates, it should be noted that most of these supplies will be generated in the same worksites from cutting and excavation surplus, thereby avoiding the transportation through public roads from other third party sites operating in the area. In the case of aggregates purchased from third parties, the Owner shall require the transportation company to meet the weight limits set by the regulations.

In view of the above, a calculation is carried out respect to the total required traffic, in addition to the daily and hourly traffic per type of vehicle, which will serve as the Project flow to be used in modeling and estimation of the capacity in road sections. In real terms, the calculation of the traffic flow is 3 trucks/hour, 2 buses/hour and 1 light vehicle/hour. However, and in a way to obtain the worst case scenario, to be used in air, noise and road modeling, the results have been overestimated to 7 trucks per hour; 19 buses per hour and 14 vehicles per hour, in one traffic direction for the transportation of supplies. These will be distributed to the 7 works facilities along Routes G – 25 and G – 345.

It is worth noting that this calculation includes trucks considered for the transportation of aggregates for the Colorado area works, coming from the extraction well located in La Obra town, and traffic flows from transportation of concrete.

With these traffic flows provided by the Project and the new intersections, the effect of these new sources of impact is evaluated, considering the critical conditions of traffic, that is, the Project maximum flow during peak traffic demand hours, which gives an adequate safety margin, separately analyzing the existing and new road sections and intersections.

Especially in the case of intersections, the analysis focused on determining whether the potential reduction in capacity and the increased traffic flow associated to the Project flow result in a decrease in the current service level. For such purpose, the SIDRA traffic simulation model is used.

Road sections and isolated intersections were analyzed separately, concluding that, from the point of view of the sections capacity, there are no changes in service levels by adding the Project flow.

Details on this evaluation are indicated in Annex 14 “Road Impact Study”, whose results conclude the following:

- The levels of service on Routes G-25 and G-345, in the sections between Las Vizcachas – La Obra and Los Maitenes access, will not vary substantially over time. Regarding Route G– 455, the level of service is expected to vary moderately due to additional flows generated by the Project.
- As for the existing intersections, taken from the intersection of La Florida with Avenida Departamental in La Florida borough, as we move towards Cajón del Maipo, the levels of service improve because the incorporation of vehicles is steadily decreasing. When adding the Project flow, the overall service levels remain unchanged, except for intersections No. 4 and 5, where these drop slightly. While at intersections located in the rural part of Route G-25, there are no substantial changes in the service levels, which reflects a low incidence of the Project flows.
- For new intersections generated by the Project, the service level and degree of saturation are expected to be good.

Therefore, a significant road impact is not expected during the construction stage, which considers a lower traffic flow distributed over the next 5 years.

It should be noted that the Roads Directorate of the MOP considers a paving Project between San Gabriel and El Volcán. Currently, the Engineering Study “Improvement of Route G-25, El Yeso – El Volcán bridge area” is being developed, commissioned by the Roads Directorate of the MOP.

The Project consists of asphalt paving, over a total length of 12 kilometers of road, and the Project aims to guarantee trafficability and connectivity of Route G-25 between El Yeso bridge and kilometer 69.3 past El Volcán town, projecting geometric improvement works in floor and elevation, paving according to load requirements, and the platform expansion, among other aspects.

## ii) Environmental Management Measures

### a) Improvement of existing access roads:

Implementation of the Project considers the improvement of Route G-25 (El Volcán area) and Route G-455 on the way towards El Yeso reservoir, this is because today both routes have a deteriorated condition. In effect, the road to El Yeso reservoir has a gravel paving layer, with poor sanitation, similarly, Route G-25, in the above section, exhibits a paving layer made of granular material, apparently with a salt treatment only in populated areas to avoid dust raising as a result of passing vehicles. Details on the current condition of each of these routes are indicated in Section 5.6 of Chapter 5, and information is further supplemented in Annex 19 “Road Improvement Program”, both attached to this EIS.

### **Current condition of Route G-25, El Volcán tunnel door area, and Route G-455, road towards El Yeso reservoir**



**Photograph 6.4.1.11.1 and 6.4.1.11.2:** Road to El Yeso reservoir and Route G-25, El Volcán area, respectively. Deteriorated condition of both layers is clear, where there is currently an important traffic flow, attributed to mining activities, located in the upper basin of Yeso and Volcán rivers. Coupled with the deteriorated condition of their layers and given their elevated location, some sections of these roads remain closed during winter period, due to landslides, heavy rain and heavy snowfall.

In view of the above, the Project considers the improvement of these routes in sections indicated in the following table:

**Table 6.4.1.11.3**  
**Details on existing roads to be improved on the occasion of the Project**

Route	Length (km)	From	To
G-25	22.0	Romeral , intersection G-25 with G-455	Colina bridge over El Volcán river
G-455	21.0	Romeral, intersection with G-25	Los Chorreados camp
<b>Total</b>	<b>43.0</b>		

Regarding improvement activities, these are detailed in Annex 19 “Road Improvement Program”. In general, they are summarized in the following measures:

- Clearing and profiling of the routes: Both routes will be cleared and profiled. This activity will be carried out using motor graders and road rollers.
- Repair of sewers: On the road to El Yeso reservoir, there will be an extension of three (3) sewer trunks with a slab-type trunk of 4 to 7 m. While in Route G – 25, necessary works will be carried out for the construction of a rainwater sewer at Km 2.4 of the route. This sewer will be built of concrete and extend across the whole width of the road.
- Binder application: Binder will be applied to both routes, in the sections indicated in Annex 19, Road Improvement Program. It consists of irrigation with bischofite (magnesium chloride), which will be used as a dust suppressant. Details of the technical characteristics relating to magnesium chloride or bischofite and its application (durability, handling, efficiency percentage, etc.) are indicated in Annex 21 “Dust Suppressant Application Program”, attached to the EIS.
- Implementation of signs: Vertical signs will be implemented in both sections, relating to the identification of risks and elements of the route. Prior to implementation, the Project Owner will agree with the Traffic Department of the Municipality of San José de Maipo on the exact dates and type of signs to be implemented.
- Clearing of roads during the winter period: Given the elevated location of these routes, these roads remain closed in some sections during the winter period, due to landslides, heavy rain and heavy snowfalls. Therefore, the Project Owner considers the clearing of roads, during the winter period, by using motor graders and backhoe excavators, which will clean the snow and other elements from the road. This activity will be carried out throughout the duration of the construction of the works.

- Roadside defenses: In addition to the implementation of signs for identification of risks, the Owner considers, in sectors showing narrowing of the road and dangerous curves, the implementation of roadside defenses. The implementation of these defenses will be previously agreed with the Traffic Department of the Municipality of San José de Maipo on terms and type of elements to be implemented.
- Construction of Works of Art: Consisting of the implementation of works of art, of the corrugated tube type.
- Replacement of paving layers: In the case of Route G-25 on the road to El Volcán, the replacement of the layer considers granular material CBR $>$  or equal to 60% from Km. 13.8 to Km. 20 in a width of 7 m and a thickness of 15 cm. While on Route G-455, the improvement of the route considers a replacement of the granular layer  $>$  to 60% from Km. 17.8 to Km. 18.3 in a width of 7 m and a thickness of 15 cm.

It should be noted that the improvement of roads does not involve urban areas. The road improvement works will focus on mountain roads, particularly routes of access to high Volcán area and El Yeso reservoir (Route G-25 and G-455, respectively).

On the other hand, it is important to note that the improvement of routes will not involve the narrowing, because, according to the details of the Project Basic Engineering Study, the routes to be improved have a suitable section width for truck traffic, as defined by the Roads Directorate. Therefore, there will be no expropriation of land which may interfere with homes located near the roads affecting the improvement.

As for the term and period of implementation of each of these activities of improvement and maintenance, these are detailed in the Project Gantt letter, attached in Annex 2.

With regard to new projects of improvement in the Project area, conducted by the Roads Directorate of the MR in the El Yeso – El Volcán section, the Project will take into account the following considerations:

- In the section subject to the improvement projected by the Roads Directorate (between Km. 57.3 and 69.3), there will be works that do not interfere with the original conditions upon which the engineering study mentioned in the observation has been developed. This improvement includes profiling of the road and placement of dust suppressant binder, of the bischofite type.
- For the remaining section of Route G-25, that is, from kilometer 69.3, to the Colina bridge, the Owner considers the replacement of the granular layer for one such as CBR $>$  or equal to 60% from Km. 13.8 to Km. 20.0 in a width of 7 m and a thickness of 15 cm.
- Full details of the improvement measures for this route are given in the Road Improvement Program, attached to Annex 19.

### Actions considered from the Project engineering

#### b) Implementation of service roads:

The Project considers the implementation of a total of 31 Km. of service roads, as described in Chapter 2, “Description of the project”, and details shown in the following table:

**Table 6.4.1.11.4  
Details of new roads to be constructed by the Project**

<b>Sector</b>	<b>Length (km)</b>	<b>Type of layer</b>
El Volcán – Access to Window V1 and Intake	7.0	Granular
El Yeso – Access to Lo Encañado	4.2	Granular
Low Aucayes – Access to Alfalfal II Engine House	5.80	Double treatment or similar
Low Aucayes – Detour to Maitenes Loading Chamber	1.0	Granular
High Aucayes – Access to Window VA2 High Aucayes Alto	4.60	Granular
Colorado river – Access to Window AL2 Las Puertas	0.35	Granular
Access to Las Lajas Engine House	0.47	Double treatment or similar
Access to Alfalfal II Loading Chamber	7.8	Granular

In all cases, the new road sections will include the application of a road stabilizer, of the bischofite type. Unlike the application of Bischofite as dust suppressant, considered for the improvement of roads, the application of this substance as stabilizer layer enhances durability, since this substance (magnesium chloride) is mixed with the granular material and not treated as separate elements as with irrigation. The application of this stabilizer will be made with companies specialized in this type of solutions. In this sense, we seek to make the application according to technical criteria of the product and of suppliers (see Annex 21 “Dust Suppressant Application Program”).

Regarding the section width of all new roads, this will be 10 m.

As indicated in Section 2.3.2.5 of the EIS, these routes will be used for seacoast transportation and earthworks in general, movement of staff, machinery, equipment and supplies required by the Contractor in the camps, works facilities and worksites. Also, some of these roads will be used during the operation stage for the transportation of staff performing works related to maintenance and monitoring of permanent facilities.

According to schedule (see Annex 2 attached to this EIS), all roads will be functional during the first year of construction of the Project.

Similarly, intersections generated by the crossing or junctions between public roads and service roads of the Project will be paved. In this regard, these paving projects will fully comply with the requirements established by the Roads Directorate, especially in regard to regulation of intersections, regulatory, prevention, information signs and geometric aspects, such as turning radii and channeling. Appendix 2 of Annex 14, Road Impact Study, presents an outline of typical junctions and crossings.

Finally, Figures 1, 2 and 3, attached to Annex 1, clearly illustrate the difference of those new roads to be constructed respect to existing roads to be improved and their spatial relationship with respect to sites of tourist, archaeological and landscape interest in these areas, to make sure that there will be no interference (see Chapter 2 of the EIS).

c) Monitoring compliance with maximum weights

The degree of intervention generated by the Project was determined from the degrees of saturation and deterioration of service levels, due to the increase in traffic flows generated by the implementation of the Project<sup>16</sup>, and, therefore, wearing of the paving layer was not considered in the Project road evaluation, since this parameter is not relevant when truck traffic complies with the minimum requirements of weights per road established by the Roads Directorate of the MOP. In this regard, the Owner shall supervise the control of weights on an ongoing basis, to ensure compliance with the provisions of SD No. 158, of January, 1980, which sets maximum gross weights on roads, and decrees N° 200, of July, 1993 and N° 396, of November, 1993, which set maximum gross weights on urban roads. In both cases, 45-ton limit cannot be exceeded. Measures considered by the Owner for compliance with this regulation shall be as follows:

- For the transportation of supplies and materials, the Owner shall require the company responsible for transportation, the implementation of a procedure for monitoring the weight per road, in accordance with the methods established by the Roads Directorate of the MOP. The Project Environmental ITO will request compliance records of these procedures and the inspection records made by the Roads Directorate, to keep a single centralized record, which may be submitted to the environmental Authority where appropriate. In addition, weighing of trucks will be made at random, using any of the weighing systems prepared by the Project, as detailed in the following paragraph.
- For seacoast transportation to the seacoast storage site 14, that is, on worksites for construction of the Access Door to Las Lajas Power Station (VL2), the works Contractor shall have a vehicle weighing system previously approved by the Roads Directorate and in accordance with the general rules of calibration provided by the Ministry of Public Works. This weighing system will record the weight per road, as established in Decree 18 of 1993 of the Ministry of Public Works. This is because, in such worksite, a quantity close to 159,000 tons will be transported to storage site No. 14 using a small section of Route G-345. The weighing site, plus its period and frequency, will be agreed with the Roads Directorate.

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<sup>16</sup> Under current requirements for the development of Road Impact Studies of the SEREMI of Transportation and Telecommunications of the Metropolitan Region, the SEREMI of Housing and Urban Development and the National Urban Roads Subdirectorate of the Ministry of Public Works.

### Supplementary Environmental Management Actions

- Any new Project facilities, whose location has been defined a priori, or any change of layout and junction of service trucks to roads, shall include equipping works established by the Traffic Department of the Municipality of San José de Maipo or the Roads Directorate of the MOP.
- Traffic of trucks of more than 4 tons will be suspended from 14:00 hrs. on Saturdays to 24:00 on Sundays by Routes G-25 high Volcán bridge and G-421 San Juan de Pirque El Toyo, as indicated by Exempt Decree No. 130 of the Municipality of San José de Maipo. In this regard, Gener, by way of the Inspection, will monitor the compliance with such provision through a systematic registration, verifying date and traffic route.
- Service roads in El Yeso - Lo Encañado area will be restricted to the traffic of vehicles outside the Project, during the Project construction and operation stage.

### **iii) Qualification of the Environmental Impact**

According to the analysis of points i) and ii), the Project is considered to generate a low road impact on the roads required by the works, because only minor increases in the degrees of saturation of new and existing sections and intersections will occur. Therefore, this impact is considered negative and insignificant.

Finally, no adverse environmental impacts are expected during the PHAM operation stage, since traffic flows provided by the Project are considered minor and do not change the traffic flow conditions.

#### ***6.4.1.12 Effects of PHAM on traditional activities***

##### **i) Identification and sources of impact**

###### Intervention in the traditional labor structure

Creation of jobs for mule drivers as mountain guides and transportation on mules and horses is an extension of the activities that decades ago they incorporated as part of its production diversification, which has allowed them to use their knowledge and remain embedded in the mountain environment, taking advantage of the flow of tourists, visitors, researchers, etc.

This has been reflected in the temporary involvement of mule drivers in other energy projects realized in the borough.

Currently, the borough has the mountain guide and cargo transportation services, which is carried out in part by groups of farmers and mule drivers working independently.

Therefore, the PHAM is estimated to report additional revenues for the community of mule drivers, causing no radical intervention in their labor structure. The PHAM will become a temporary source of employment which will coexist with the other traditional activities, causing no loss or abandonment.

#### Interference of works with traditional grazing activities

The PHAM will not restrict the access to third parties' lands used for grazing, and for which their owners usually charge for felling, that is, conditions of use for summer and winter pasture lands have always been a matter of agreement between farmers and landowners, and such conditions will not be modified by the Project.

In this regard, the PHAM effect on grazing activities is analyzed in terms of the interference works may cause in traffic or herding through public roads or tracks leading to summer or winter pasture sites. In this regard, Annex 34, "Ethnographic Study of the Project Area", details the routes and places traditionally used, as well as seasonality and conditions of use. This analysis has concluded that:

- The road impact study presented in Annex 14 shows that the construction stage, which will concentrate the largest movement of vehicles for cargo and transportation of staff, will not generate significant adverse impacts, partly because the Project transportation will take place from Monday to Friday, while most of the sports and tourist trips occur on weekends and holidays, so there will be no overlapping.
- Most farmers in the area will not experience any risk of interference in their movements, since transportation and final destination of herdsman do not match geographically with the movement of vehicles and machinery included in the Project.
- For the case where the flow of cargo vehicles will occasionally match the transportation of animals by herding sharing the same section of public road, interruption or other impact on farmers is not expected, since this type of activity coexists today and takes account of a historical experience that farmers have with traffic flows generated by the movement of tourists, mining trucks, and previous projects in the area. A current example of this is the case of farmers moving their animals in vehicles to the town of Maitenes ("coastal"), and from there they continue by herding, joining the farmers from other towns, all of them using Route G-345.
- A different case involves the construction of the new road projected in the valley of the Aucayes stream and near the town of Maitenes, which will favor the movement of farmers who may eventually use it for easy access to the summer pasture area.

Moreover, the only works of the Project that will affect summer pasture areas are the intakes and channels that will be located at the base of La Engorda summer pasture area. In this area, the construction of works will last for 1 year, and proceed sequentially through stages during summer times. As projected, the works in this area begin in October, 2009, to April, 2010, with the first section, then from October, 2010, to April, 2011, with the second section, and finally between October, 2011, and April, 2012, with the last section. Once construction is completed, the pipeline will be covered so there will be no risks of falls during the operation. During construction of works in this area, a portion of the land will not be available for traffic or grazing of animals for safety reasons. This will mean a reduced area next to the sites for the location of the works. Under no circumstances, the Project will prohibit access to other areas of Engorda summer pasture, which covers a large surface area, and is also a private property.

## **ii) Environmental Management Measures**

- The Project includes instruction for works supervisors to minimize any interference with shepherds passing to the upper area of these summer pastures. This will be set in the Agreement with each contracting company and its compliance will be verified in the field.
- The construction stage considers the use of protective fences to prevent animals from falling into the excavation sites, in the working area of La Engorda summer pasture.
- Regarding cattle herding through public roads, this action currently coexists with the flow of cargo vehicles, which accounts for an experience already known by farmers.
- In order to verify the expected impact, the PHAM considers the development of the Monitoring of Social Indicators (MIS), as described in Chapter 8 and Annex 39.

## **iii) Qualification of the Impact**

From the recognition of the organizational structure and characterization of the group of traditional mule drivers in the area, and the overlapping of their activities with the PHAM works, we conclude that this will not have any adverse effects on their traditional labor structure. The Project will bring additional revenues to the community of mule drivers on a temporary and supplementary basis respect to other current activities.

No interference is expected from traditional grazing activities, due to the traffic flow considered by the Project, works on roads or closing of the crossing point to certain mountain areas. A specific exception to the above will be the works in the lower section of La Engorda summer pasture, which involves a sequential intervention that will temporarily limit on the immediate surroundings of worksites.

Thus, this adverse impact is considered insignificant because it does not affect the performance of traditional grazing activities in relation to the Project.

## 6.4.2 Operation Stage

### ***6.4.2.1 Effects of flow reduction on dragging frequency***

#### **i) Identification and Sources of Impact**

Flow reduction on certain river stretches and streams tributary to Maipo River will cause an effect on the sediment dragging frequency. To estimate the magnitude of this phenomenon, Gener has developed a sedimentological study of Maipo River in the section intervened by the works, that is, between the junction with Volcán River and the Independent Intake in the area of Las Vertientes. The conclusions of this study, as well as the methodology, procedure, data and parameters used are included in Annex 20.

The analysis concludes that in such section, Maipo River will slightly decrease its dragging rate without creating situations of bed degradation. Downstream of the Independent Intake, the Project sediment export is still greater than the extraction of aggregates currently taking place in the river. The latter has reached critical levels that make it impossible to increase extraction.

Given the lack of plans for comprehensive management of the activity of extraction of aggregates in Maipo River, the current exploitation rates would apparently be within the sustainable limit for the riverbed, as deduced from the studies reviewed. In this scenario, any disturbance to the system could generate local problems of riverbed erosion, as those occurred in the past due to overexploitation during some periods. Therefore, if estimated reductions in the availability of sediments in the area downstream of the Independent Intake introduced by the Project are effective, although relatively minor, they could generate local problems if measures are not taken for a more rational management of the riverbed and the water resources and aggregates available. Clearly, this management should be conducted at the basin level by the competent Authority.

#### **ii) Environmental Management Measures**

According to the analysis, the Owner does not consider environmental management measures for this purpose. However, given that the same study concludes that the complexity and dynamics of behavior of the bottom and suspended sediment discharge require larger studies that incorporate all the river elements, Gener proposes supporting the development of global studies determined by the competent Authority and necessary for a comprehensive management of sedimentological resources of Maipo River and the erosion-sedimentation balance, provided that this is developed in conjunction with all stakeholders involved in the use of Maipo River resources.

#### **iii) Qualification of the impact**

Given that the effect of the PHAM on the dragging rate of Maipo River will slightly decrease, without creating situations of bed degradation, this impact is qualified as negative with a low significance.

### **6.4.2.2 Intervention of Vegetation**

#### **i) Identification and Sources of Impact**

The operation stage does not have a significant adverse environmental effect on vegetation located near the riverbeds (Annex 10). In general, Colorado, Maipo, Yeso Rivers and Aucayes streams, under the abiotic conditions of the Andean environment, have a predominantly snowy supply showing significant fluctuations in flow. Lowest flows are registered in winter, while the highest occur in spring. In case seasonal vegetation, mainly colonizing herbaceous plants, occupies the river trunk in the dry portion of the riverbed, during flooding due to thaw, this vegetation is dragged by the force of water, beginning a new cycle per season. This dynamics is less marked in rocky riverbeds and high areas (>2,500 masl) where there is more snow for much of the year and less vegetation. The river bank vegetation is not sufficient to form a permanent structure and has been described as riparian thickets; in the areas of Andean gullies, over 1800 m high, *Escallonia myrtoidea* is dominant, and *E. illinita*, in low gullies; at the level of rivers and streams with larger trunks, *Baccharis salicifolia* (ragwort) and *Psoralea glandulosa* (culen) are established species. This vegetation would not be affected, since it is adapted to fluctuations in flow of the water bodies. Proof of this is the low section of Aucayes Stream, which shows flow reductions from the operation of Maitenes Power Plant for several decades, without exhibiting significant changes in the associated vegetation.

Regarding the PHAM effect on high Andean vegetation, the source of potential impact would be local modification of the irrigation conditions in the areas intervened by surface works. This is because high Andean vegetation and, to a lesser extent, flood meadow vegetation, between El Morado, Las Placas, Colina and La Engorda streams, draw water from these water bodies and many talweg<sup>17</sup> of intermittent runoff generated by thaws and rainfall (occurring throughout the year, with a substantial increase in the winter).

The flood meadows have in their composition typical elements of the Andean thicket formation, although in a low proportion, where *Berberis empetrifolia* and *Acaena pinnatifida* species stand out, which confirms its seasonal nature, with less water availability in the summer.

This high Andean area has a snowy and glacial hydrological regime, fed by approximately 36 km<sup>2</sup> of glaciers, most notably Marmolejo and Loma Larga, and other snowfields coming from San José volcano (see Chapter 5 “Volcán River Basin System”). In general, water runoff is superficial and sub-superficial, which is seen in the extensive networks of minor runoffs associated to the main streams, and small isolated seepages appearing in the vegetation. The geological material in this area is characterized by the presence of alluvial-torrential deposits formed by thick accumulations in the shape of fans or half cones made of thick deposits. This surface would allow the formation of a semi-confined underground water table (see Chapter 5).

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<sup>17</sup> Talweg: this is an imaginary line formed by all the lowest points of a valley (hydrological basin), where the water drains.

Therefore, vegetation areas located downstream of the Project works (intakes and distribution channel) will be kept irrigated by the different stream branches forming floodplains, and by streams descending from the hillsides that enclose the valley. To verify this, a stereoscopic photo-interpretation of the area for the El Morado, Las Placas, Colina y La Engorda stream collections was conducted, whose results are shown in Figure 6.4.2.2.1. This activity allowed us to identify and characterize the drainage network, and estimate the effect of water extraction on vegetation. SAF 1990 aerial photographs, 1:20,000 scale, and 2006 orthophotos were used.

The main results of the analysis are:

- Given the conditions of relief, the area between Colina and La Engorda streams is mainly irrigated by the course of La Engorda stream, which is anastomosed, that is, el the water flow spreads among elongated banks of alluviums or sediments, some of these water flows or branches feed the Colina stream. In this area, the presence of a gentle slope facilitates the deposition of sediments dragged from higher grounds, forming a floodplain of approximately 500 meters wide. La Engorda stream develops a unique riverbed near its confluence with Colina stream, downstream of the intake. This stream is fed mainly by melting ice from high mountains, though an important number of intermittent streams descending from the hillsides that enclose the course.
- Colina stream has a prevailing north-south direction, being flanked by mountains whose sides are covered by large drift fans. Then, it changes to a prevailing east-west direction. This course runs parallel to La Engorda stream before converging into El Morado stream. Colina stream develops a unique riverbed at the height of the projected intake, coinciding with a marked change of slope, which determines that waters flow into El Morado stream, presumably contributing to a reduced irrigation to the area between the Colina and La Engorda streams. This is evident in the change of vegetation units recorded for this area (see Figure 5.4.1.29, Chapter 5).
- Las Placas stream develops in a east-west direction, with an extension smaller than the other streams, converging into El Morado stream.
- El Morado stream extends in a prevailing south direction forming, at the height of the projected intake, a unique riverbed. Upstream of this point, the course is anastomosed. Downstream of this point, the stream receives the contributions of various streams. This stream does not have flood meadows associated to its riverbed.

- The analysis indicates that the area covered with Andean thicket vegetation and flood meadows receives water from different sources. On the other hand, there are the water bodies from Colina and La Engorda streams, the talwegs or short-development streams with an intermittent behavior which drains water from thaws, solid and liquid precipitation, and existing underground runoffs.

In summary, the PHAM potential impact in the area of La Engorda is described as follows:

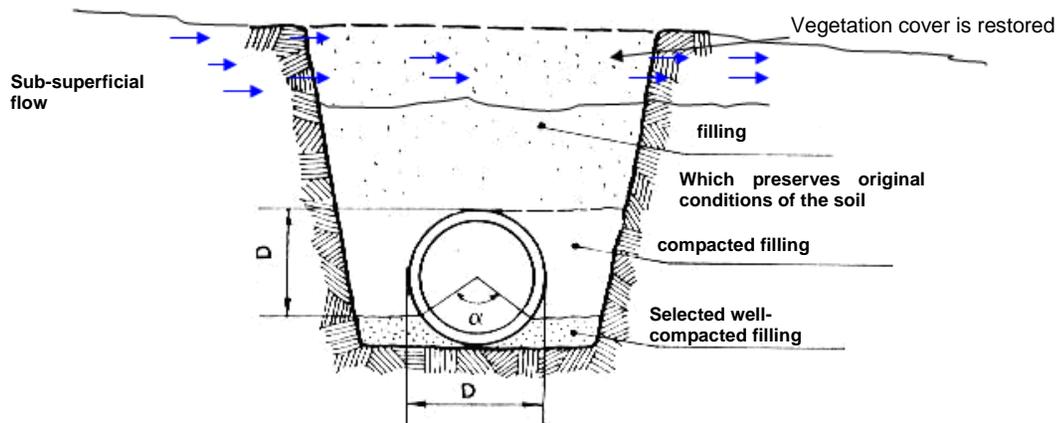
- a) Decrease in the flow of streams will reduce the water contribution to the immediate or bank areas, which involves a lower water availability. In an adverse scenario, there will be a reduction in the vegetation cover currently found in the flood meadow in this area, in a plane perpendicular to the main riverbed, moving towards the flow. This effect will likely not be significant, because the flood meadow feeds from other side water contributions. This is predictable given the formation of the sub-superficial aquifer in the area, and it can be seen in El Morado stream, which has no flood meadow vegetation associated to its natural riverbed. Another example of non-dependence of the flood meadows from Colina and La Engorda streams is that these riverbeds are about 1 m and more below the level where the flood meadows adjacent to these streams are found, therefore, these are likely to have contributions and live on the superficial or sub-superficial runoffs forming the floodplain, and also feeding the streams. For this reason, these flood meadows would not be impacted since they do not depend directly on the water flowing through the streams (see Photograph 6.4.2.2.1). In this regard, this area will be irrigated by the different branches of streams forming floodplains, and by streams descending from the hillsides that enclose the valley, and which feed the sub-superficial aquifer.



**Photograph 6.4.2.2.1:** La Engorda stream, the stream bed irregularity is observed respect to the level of the terrace where flood meadows develop (1 meter above). Consequently, this terrace receives water from different sources that keep the superficial or sub-superficial runoffs forming the floodplain, in addition to the contributions of Colina and La Engorda streams.

- b) The channeling connecting the collections in each stream will not cause an interruption of the runoff as it will be located buried a meter deep and have a layer that will keep the original conditions of the subsoil, preserving the natural downstream drainage (see Diagram 6.4.2.2.1). Thus, no water accumulation outside the streams and upstream of the collections is expected, neither a total reduction of the superficial and sub-superficial runoff outside the riverbeds, downstream of the collections, since the conditions of the soil will remain unaltered, which make possible drainage and water runoff that generate this floodplain, allowing the irrigation of the vegetation areas located downstream of the channel and the intakes.

**Diagram 6.4.2.1**  
**La Engorda area channeling works.**



**Figure 6.4.2.2.1**

**“Drainage network, Volcán river upper basin area”**

## ii) Environmental Management Measures

### Actions considered by the Project engineering

- The Project considers the establishment of an ecological flow in each water body which materializes the collection of streams.
- Verification of the expected effects will be made through monitoring of the vegetation during the construction stage and the first 5 years of operation of the Project.

### Supplementary Environmental Management Actions

The Contractor will be instructed to use, on an unrestricted or exclusive basis, the roads for staff movement to be opened up, preventing workers from creating new tracks or trails in the summer pasture area. These measures will be supported by training sessions aimed at raising awareness and respect for the environmental protection standards established.

Workers will be instructed with special preventive measures for the facilities maintenance tasks to be carried out in La Engorda summer pasture area, in order to minimize changes in vegetation and/or avoid any type of interference with the users in the area (small-scale grazing). GENER workers will regularly receive training on environmental issues, aimed at raising awareness and educating staff on the set of requirements or commitments endorsed by the Project during its environmental assessment.

## iii) Qualification of the Impact

The channeling connecting the collections in each stream is expected not to cause an interruption of the runoff as it will be located buried a meter deep and covered with the natural material, which favors downstream drainage. Thus, no water accumulation outside the streams and upstream of the collections is expected, neither a total reduction of the superficial and sub-superficial runoff outside the riverbeds, downstream of the collections. Vegetation areas located downstream of these intakes will remain irrigated by the different branches of the streams forming floodplains, and by streams descending from the hillsides that enclose the valley, and feeding the sub-superficial aquifer.

Therefore, according to the analysis, the effect of the reduction of flow in the wastewater to Volcán River is estimated no to cause a significant impact on the vegetation forming La Engorda summer pasture.

Therefore, this impact is qualified as adverse or negative with a medium significance.

### **6.4.2.3 Project Effects on the Ichthyic Fauna**

#### **i) Identification and sources of impact**

##### **a) General**

During summer or thawing time, the snow regime of the streams will allow intakes to have flows available near or above those of the design, applying, as operational criteria, the collection and generation of the whole flow available in each intake, available flow means that delimited at the top by water rights and at the bottom by ecological flows, in each collection point.

The Project involves the extraction of water from rivers and streams according to GENER water rights, and the maintenance of ecological flows. Therefore, the source of impact will be the reduction of flows related to the Project, modifying the natural runoff regime and in certain cases the regulated regime of some rivers.

The analysis of the remaining flows in each of the riverbeds mentioned and the ecological flows of each of the intervened riverbeds, their proposed analysis and methods are described in detail in Annex 10 "Analysis of Ecological Flow and Flow Requirements".

For the Qe hydrological analysis, the Owner has used a comprehensive statistical base, with data records on riverbeds of more than 50 years, and adjustments based on the conventional statistical analysis methods.

The proposed Qe have been validated assuming criteria other than hydrological ones, linked to the preservation of natural habitats and environmental functions of the water resources, especially because the PHAM is inserted into an area showing well-known singularities from an environmental and anthropic intervention point of view. In this regard, the following stands out:

- i) Presence of riverbeds with a regulated flow: The Yeso reservoir is a drinking water reserve for the Metropolitan Region, so the waters discharged from this reservoir are regulated by Aguas Andinas, depending on the supply requirements or safety. The storage volume of El Yeso reservoir is approximately 250 mill. m<sup>3</sup>. Historical statistics of discharges from the reservoir indicate that the river flow is 0 (zero) for a few months. The Yeso River shows a flow increase during the months of November to March and a decrease of the same during winter months, with an average annual flow flowing to the reservoir of 8.1 (m<sup>3</sup>/s). There is some presence in the area of the Alfalfa and Maitenes run-of-river plants, both taking advantage of the waters from Colorado River since 1991 and 1923, respectively; and the Volcán and Queltehue plants, both in the Volcán River sub-basin, operating from the late 40's.

- ii) Presence of areas of interest from the landscape and recreational point of view: The area where the Project is inserted is of a landscape interest, the riverbeds being an attribute that gives value to the mountain landscape, due to the presence of surface runoff, water bodies and falls, the latter being abundant in the thawing season. In general, there is in the area a development of tourism: travelling, camping, climbing, mountaineering, and other ecotourism expressions with a strong seasonality, the most important being some recreational activities associated with riverbeds consisting of: spa, fishing and sailing.
- iii) Environmental valuation of the limnological system: The high degree of intervention of the water system in the area, coupled with the natural conditions of elevation, runoff speed and variability of the physical-chemical characteristics, determine that, in general, in the Project area, there is a low richness and abundance of aquatic life. The ichthyic fauna present in the riverbeds is mainly composed of a multitude of allochthonous species, which has been exacerbated by the incorporation of desirable species for fishing, and the predation they have on native fauna.
- iv) Poor development of bank vegetation: Naturally, the slope conditions and seasonal variation of the riverbeds, plus other abiotic variables, determine that in mid-mountain areas there is no significant development of bank vegetation, being represented mainly by colonizing herbaceous species occupying certain areas in riverbed sections with less slope.

#### Characterization of the area under study

From the theoretical point of view, it is possible to state that the differences in abundance of benthic biota indicate differences in the habitat conditions, particularly food supply for fish. However, the results indicated that the presence of fish in the area under study was independent of the food supply, since there was fish in places with a high and low abundance of benthos. These results suggest that the presence of fish during the period under study is due to factors alternatives to the availability of food, such as a higher or lower load of suspended particles. Proof of the above is the fact that in areas with a low load of suspended particles, such as Aucayes, Cortaderas, El Manzanito streams and Yeso River, a larger presence of fish was detected.

Thus, poor fish fauna found in the area under study during the spring period would be modulated mainly by the physical conditions of the habitat, primarily by the load of suspended particles, natural condition in the mountain sections of basins with temperate climates where there is an increased surface runoff during the thawing period, which significantly affects the dispersion of fish causing them to move to places with lower turbidity.

Environmental requirements of native species differ from the requirements presented by introduced species. A favorable habitat for the populations of *T. areolatus* is a heterogeneous bedrock, with gravel and pebbles between 3 and 10 cm, high transparency and concentration of oxygen in the water column and a low runoff speed. These attributes were found predominantly in the surveyed area of El Volcán and El Yeso Rivers, however, none of these systems showed the presence of *T. areolatus* and the only specimens found were those of the introduced species *Salmo trutta* in the Yeso River. The only sampling area where *T. areolatus* was detected was Colorado River, which did not show a favorable substrate for development. These results indicate that the type of substrate is not modulating the fish populations during the current period of study.

A characteristic of the upper section of the Maipo River basin, a sector where the area under study is found, is the presence of a fish assemblage dominated by introduced species *O. mykiss* and *S. trutta* (Duarte et al 1971). The introduction of these ichthyic species, highly invasive and aggressive for native species, has had historical and current adverse effects on the native fish assemblages in the country (Soto et al 2006), this due to planting of eggs for sports and recreational purposes, mainly in the Maipo River section located between La Obra and Tejas Verdes area (Duarte et al 1971). These species have generated a highly intervened condition in the area under study and, therefore, today there is a low presence of fish in the upper sections (from the source of Maipo River to La Obra area) and lower half sections (from La Obra to Tejas Verdes) of the basin (Duarte et al 1971). The area under study is located in the upper area and, thus, the findings of these introduced species, *O. mykiss* and *S. trutta*, are in line with the information about this basin, Duarte et al (1971), Vila et al (1999) and DGA (2004). These results state that biological assemblages of the area under study have often been disturbed by natural and anthropic conditions, mainly associated to irrigation, power generation and recreation activities in the basin (DGA, 2004). Therefore, from a biological preservation point of view, it is possible to assign the area under study a low environmental valuation.

#### b) Methodology

The methodology for  $Q_e$  calculation is based on the requirements established by the DGA for the calculation of the ecological flow and environmental water demand. The characterization of the area under study consists in performing an analysis of the water, habitat quality and biological conditions, in order to determine the most affected areas by the reduced river flow.

The definition of the  $Q_e$  is focused on the estimation of the minimal flow that must run in sensitive areas or ecological flow areas, according to the DGA criteria and the international experience. Considering the result of the ecological flow for the sensitive area and the contributions by intermediate basins, the flow is estimated in the point of ecological flow control, to meet the requirements of such area. The description of each method used to estimate the  $Q_e$  calculation is shown in Annex 10. This description is based on the research of Ángela Haro "Methods to evaluate the impact of water extractions on biodiversity in natural riverbeds" (Haro, 2003).

### **b.1) Hydrological Method**

DGA recommends the hydrological criteria for estimating ecological flows, for the resolution of water use right applications, which are mentioned in the document “Standards and Procedures for Resource Management” (DGA, 2005). These criteria correspond to a minimal flow of 10 % of the average annual flow.

### **b.2) Habitat Simulation Methods**

The methods used in the EIS for the calculation of the ecological flows correspond conceptually to the Instream Flow Incremental Methodology (IFIM) and the Physical Habitat Simulation (PHABSIM) method. The IFIM/PHABSIM method consists in quantifying the changes that may occur in habitat availability in a river system in terms of changes in the system flow (Bovee 1982, Stalnaker et al. 1995). This brings a method suitable both for determining the effects that may have a flow regime on the resources of interest of a river system and for evaluating the various flow options to maintain aquatic ecosystems. This method uses fish as its main environmental indicator of habitat quality, under the assumption that, by keeping minimum environmental requirements, the remaining aquatic organisms will also meet these requirements. Thus, we can state that fish would be an ecosystem environmental indicator (status variable), where the fish habitat condition would be a reflection of the global condition of the aquatic ecosystem.

This allows us to state that criteria for sustainability of habitats used in the EIS would be extended to aquatic birds (e.g. torrent ducks and cinclodes), since they use the same trophic niche (Naranjo L. and V. Avila. 2003. Housing distribution and diet of the Torrent Duck (*Merganetta Armata*) in the Natural Regional Park Ucumari in the Colombian Central Cordillera. Colombian Ornithology No. 1 22-28). While it is true that these extensibility criteria based on trophic requirements comparable across species (e.g. competition) does not consider the habitat requirements of aquatic birds, however, aquatic birds are less loyal to specific habitats and their housing environments are higher than those for aquatic organisms.

Details of the used methodology are presented in Annex 10. This analysis was applied to riverbeds directly affected by the reduction of flow when implementing collection works, and also in Volcán and Maipo Rivers that could be indirectly affected by the intervention of some of their wastewater.

### **c) Results**

The results obtained for the case of rivers and streams directly affected by the flow reduction are summarized below:

- *Yeso River:*

For this river, the ecological flow necessary to meet the conditions of the habitat in the section selected as sensitive area was 2.6 m<sup>3</sup>/s.

Considering that in the area of ecological flow, the Yeso River will have, in relation to the Project, an average annual flow at around 4.2 m<sup>3</sup>/s and a minimum average monthly flow at around 2.7 m<sup>3</sup>/s, we can say that the runoff will maintain a minimum depth of 20 cm and a speed greater than 1 m/s.

Although the speed condition is not met, it is not verified under natural conditions either, since the average annual flow of the Yeso River in the sensitive area is about 10 m<sup>3</sup>/s, while speeds above 1 m/s are verified from 2 m<sup>3</sup>/s approximately, so changes in the habitat quality would be more related to changes in the runoff depth than to speed variations.

Additionally, statistics show that the intermediate basin alone sufficiently provides the ecological flow required in the sensitive area, which would make it unnecessary to allow the passage of an ecological flow in the intake, from the habitat point of view.

However, to ensure that the riverbed will not dry in the section located immediately downstream of the collection works, the PHAM proposes to allow the passage of 200 permanent lt/s in the Project intake when the reservoir discharges the water.

- *Río Colorado*

When considering the hydraulic parameters of the Colorado River, we obtain that the conditions of the riverbed in the section of ecological interest are the following: minimum depth of 20 cm and maximum speeds of less than 1 m/s. Both parameters are guaranteed with a flow of 0.6 m<sup>3</sup>/s and meet the thresholds proposed in Section 4.2, to maintain aquatic ecosystems.

Moreover, the average flow in this area, related to the Project, is 6 m<sup>3</sup>/s, with a variability fluctuating between 0.4 and 0.5 m<sup>3</sup>/s.

Under this conditions and as a way to guarantee the minimum flows required for the habitat condition, the PHAM has decided to stop collecting its legally established rights on the Quempo stream, which would help to maintain at least the current situation in that section of the river that, moreover, has allowed the existence of the native species *Trichomycterus aerolatus*.

Finally, if necessary, the PHAM would allow the passage of 0.3 m<sup>3</sup>/s in the Maitenes Power Plant intake

- *La Engorda, Colina, Las Placas and El Morado Canyon Streams*

Water lines calculated for the La Engorda Canyon, Colina, Las Placas and El Morado Canyon streams make it possible to state that flow variations do not significantly change the runoff conditions, mainly due to their high slope (torrent runoff). These conditions severely limit the development of aquatic organisms, because the cutting force generated by such runoff prevents the establishment of aquatic flora and fauna. Additionally, the high sediment load creates a low quality environment for the aquatic biota.

Similarly, due to morphological characteristics of these riverbeds, it is proved that quality conditions of aquatic habitat for ichthyic fauna were not met naturally, corroborating the statements in the Baseline with respect to the non-detection of fish.

Based on the above, we proposed to establish ecological riverbeds including this large seasonal variation, which show flows in these riverbeds, so a flow of 10% of the average monthly flow was considered, integrally controlled at the confluence of same.

In the case of those riverbeds that will not be directly intervened by the PHAM implementation, we obtained the following results:

- *Volcán River*

Considering that in the area of the ecological flow, the Volcán River will have, in relation to the Project, an average annual flow at around 8.8 m<sup>3</sup>/s and an minimum average monthly flow at around 4.5 m<sup>3</sup>/s, we can state that the PHAM will not change the habitat conditions for aquatic organisms.

- *Maipo River*

Considering that in the area of the ecological flow, the Maipo River will have, in relation to the Project, an average annual flow of 78.5 m<sup>3</sup>/s and a minimum flow in dry year conditions at around 29.1 m<sup>3</sup>/s, we can state that the PHAM will not change the habitat conditions for aquatic organisms

In order to establish a comparative analysis of the current situation respect to the project scenario in the area close to San Alfonso town, we have considered the flow and runoff elevation variables as valid indicators to establish the conditions for practicing navigation in the Maipo River. The result of this analysis shows that, assuming an average flow reduction of 15.5% and an elevation reduction of 8.3%, it may be predicted that navigation in the Maipo River will not be significantly interrupted or affected in winter months where lower flows are observed. At other times of year, this effect will not be inconsiderable.

This analysis is considered conservative, given that contributions received by the Maipo River in the section under analysis, such as Coyanco stream, San José and others, have not been accounted for.

Consequently, we anticipate that the Project will not interfere with the development of tourist activities conducted in the Maipo River.

Finally, it is important to state that we do not anticipate a significant impact of the PHAM on the ichthyic fauna and amphibians from suction that may be caused by the intakes, this is due to the following considerations:

- In general, the collection works have gates that prevent the passage of bodies and/or elements of sizes larger than 7 cm and do not cause water suctions. In the streams of the high Volcán area, the absence of fish due to abiotic conditions of the area results in no loss of specimens.
- In the case of the Colorado River, we will use the existing facilities so no adverse changes are expected in relation to the Project. In the case of the Yeso River, we will implement a side intake consisting of a front runoff barrier, made of rockfill or concrete, which produces a local elevation of the flow and the generation of a pool needed to conduct the water collection. In this place, there will be a side intake, which is supplied with a fence that prevents the entrance of solid material of a size larger than 7 cm. The Yeso River currently exhibits anthropic intervention due to flow regulation by El Yeso reservoir. Under this condition, biological populations are currently affected by an artificial discharge regime that meets the requirements of the resource users. In this area, we detected individuals of the introduced salmonid species *Salmo trutta* (brown trout). This type of work could possibly cause the loss of some specimens, although given the location of the intake (700 m downstream of El Yeso reservoir), we estimate that the low value of the fish assemblage, both for the elevation of the area and its high degree of intervention, will not involve a significant impact for the species.
- Regarding the amphibians present in the riverbeds, we have recorded the presence of the toad *Alsodes nodosus* in the Aucayes stream, the spiny toad in the High Volcán and Lo Encañado areas, and the four-eyed frog in the Colorado river area. The habitat of these species is represented by moist environments such as bank areas and puddles. Once the intakes are built, the disruption of the bank environment in the area for the location of each intake will cause the amphibian specimens to move into surrounding areas in search of areas without a bank intervention.

## **ii) Environmental Management Measures**

### *Actions considered by the Project engineering*

The main environmental protection action for water bodies intervened by the PHAM is the maintenance of an ecological flow approved by the DGA. In the case of the PHAM, in addition to hydrological criteria, the Qe analysis has included biological information needed for the maintenance of the aquatic biota associated to the water bodies.

We have chosen to establish a Qe for each of the streams, including those that do not host fish populations due to the elevation at which they are found (e.g. Colina, La Engorda streams, etc.).

Consequently, both in rivers and streams that keep their flow to date under a natural regime and those whose natural regime is altered by the existence of anthropic uses (e.g. by Aguas Andinas), a  $Q_e$  will be maintained provided that the availability of water so permits.

Precautionary measures that guarantee the ecological flow are the following:

- The intakes consider a discharge work for discharging the ecological flow. This work will consist of a hole located at a depth such that, when the water level reaches the intake threshold, the hole collects the ecological flow.
- To guarantee the ecological flow, Gener proposes the installation of fluviometric stations in La Engorda stream at its confluence with the Volcán River, and in the Yeso River at the height of the projected bridge.
- To verify the riverbed conditions in the Yeso river section analyzed, defined as a sensitive area, the Owner intends to conduct a monthly level run for one year, prior to the Project operation and after it.

#### Supplementary Environmental Management Measures

No supplementary measures are considered, because we do not expect a significant impact on the fauna species. Environmental monitoring programs will allow us to verify this statement. If a significant change in the presence of specimens with preservation problems in the areas to be intervened by the Project is detected, and these may be related to the PHAM works, the Owner agrees to adopt special measures such as the reintroduction of specimens or others, agreed in consultation with the SAG. Environmental monitoring reports will be submitted periodically to the SAG and CONAMA.

#### **iii) Qualification of the Impact**

The PHAM impact associated with reduced flows on the biological system is qualified as adverse with a low significance, based on the following considerations:

- According to the analysis of the hydraulic parameters of rivers and streams that will be intervened by the Project, we can conclude that the maintenance of ecological flows in any event by the Owner will guarantee compliance with the thresholds needed to maintain aquatic ecosystems. This also applies to the rivers affected indirectly (Maipo and Volcán).

- According to available information on rivers and streams in the Project area of influence, we note the presence of a small fish assemblage dominated by the introduced species *O. mykiss* and *S. trutta*, due to planting of eggs for sports and recreational purposes. These are highly invasive and aggressive for native species, and their introduction has had historical and current adverse effects on the native fish assemblages. These species have generated a highly intervened condition in the area and, therefore, we currently detect, in general, a low presence of fish in the upper and lower half sections of the Maipo river basin. Thus, given that biological assemblages of the Project area have often been disturbed by natural and anthropic conditions, from the point of view of biological preservation, we can assign it a low environmental valuation.

#### ***6.4.2.4 Generation of Employment and Additional Revenues***

##### **i) Identification and Sources of Impacts**

During the operation stage, we expect that the workforce reaches a total of 50 people, required for the power plant operation and maintenance tasks.

Unlike jobs for the construction stage, those for the operation stage will be permanent.

##### **ii) Environmental Management Measures**

As a means for enhancing the Project positive effects, Gener, through the Maitenes Foundation (Annex 26), is committed to make a tangible contribution to education for local employability, assuming this is a determining factor for the growth of the commune and the improvement of the life quality of its inhabitants in the medium- and long-term.

This support to employability will result in a Gener contribution to job training for young and adults, through the allocation of resources to finance initiatives for improvement of education in the commune (education management). These initiatives should aim at restructuring the technical-professional and job offer, in the light of the skills necessary to support local employability.

In particular, Gener, through its Maitenes Foundation, will develop a Training Program for Employability aimed mainly at people whose family, social or economic status has not allowed them to finish their education or acquire the skills needed to get a job. To do this, and for those projects aimed at improving local employability and/or social projects in the commune considered in the programs of the Municipality of San José de Maipo, AES Gener will provide for such purpose US\$200,000 to the Maitenes Foundation from 2010, for a period of 10 years.

The initiatives implemented by the Maitenes Foundation may be linked to those projects or ventures being developed by third parties or public institutions operating in the commune in this matter. This linkage would strengthen the initiatives taken forward by the State and promote sustainability of the actions driven by the Foundation over time, during the period of application of the program.

### **iii) Qualification of the Impact**

Employment generation will positively affect the commune of San José de Maipo. We estimate that its promotion through the training program for employability will encourage the creation of new local competences in the technical-professional y job field. This effect is qualified as positive with a low significance.

## ***6.4.2.5 Modification of Landscape***

### **i) Identification and Sources of Impact**

For this stage, the Project works have an areal and linear nature; the first basically include seacoast storage, and the second are roads and channeling. There are also some specific location and smaller size works such as intakes, windows and tunnel entrances.

Impact sources for this stage correspond mainly to the location of the works within the local landscape for each of them.

Finally, included as an impact source are the water collections from rivers and streams respect to the reduction of flows and the consequences of this reduction on the landscape, by changing a landscape feature (water body) directly and other elements depending on it indirectly.

As indicated for the construction stage, for the purpose of evaluating landscape impacts, we consider the work and the Landscape unit where this will be developed (Baseline Chapter).

### **a) Analysis of Landscape and Visual Attributes**

The modification of landscape attributes is evaluated for this Stage, considering two different aspects that correspond to the Visual Contrast of the Works and their Artificiality. We also add an aspect related to the disappearance of landscape attributes for those river sections where a flow reduction will occur.

## Visual Contrast:

### *a.1) Seacoast storage*

This is the excavation material that will be disposed following specific criteria for location and topographic recovery, so it will not generate significant visual contrasts. These are works that will be re-vegetated, especially those located at an elevation where vegetation can develop important covers and bush and tree strata as dominant formations (Colorado River valley). The final shape of each deposit shall conform to the topography of the place. Each terrace of the site will be leveled to achieve a flat surface, and the embankments resulting from the stacking and compaction of the material will be profiled to achieve a 45° slope, avoiding hillsides, landslides or erosion of the material by rainwater.

### *a.2) Pipelines and roads*

The type of channeling to be developed in the PHAM corresponds to an underground buried work, so it will not generate landscape impacts.

In the roads, greatest contrasts are generated by the topographic modifications required for the construction of cuts and embankments. The most important visual contrasts are produced by their rectilinear geometric features and by the structures of the cut and fill embankments. Contrasts will occur in all landscape units analyzed, especially in the Aucayes and El Colorado area.

### *a.3) Intakes and windows (tunnel entrance):*

These are mainly smaller works constructed in concrete, a situation which, although some visual contrast is expected, will be limited to the site area.

### *a.4) Loading chambers*

The loading chamber of Las Lajas will generate a visual contrast due to the insertion of a water body of approximately 7.5 has adjacent to the Colorado riverbed and El Alfalfal town. The contrast will result from differences in shape, texture and color respect to the surrounding landscape.

### *a.5) Modification of the flow regime*

This situation will be verified downstream of the intakes in the streams where the Project intakes or collections are located (e.g. El Morado, Las Placas streams, etc.) to the confluence of these streams with other tributaries. We consider that Maipo River, between El Volcán area and the discharge into Maipo River, Las Lajas area, will keep its landscape attribute condition. A similar situation will occur in the case of the Colorado and Yeso rivers. Annex 10 presents an analysis of this impact for each of the rivers and streams intervened by the PHAM.

Taking the example of the Colorado River, according to the hydrological analysis in relation to the Project, a visual effect is actually expected from the runoff reduction, which will lead to a detriment of the landscape value in the area. According to the assessment, this impact will not be significant, being distinguishable only in a short section from the road, being mitigated by the following aspects:

- The morphology of the valley is narrow and sinuous, with elongated visual basins which follow the orientation and formation of the valley. Access to the area is through Route G-345 which connects Route G-25 with the Alfalfal power plant. Observation points may be fixed from this route including the riverbed as a landscape attribute, particularly in the high part of the section, because its middle and lower sections present a riverbed with a steeper slope and markedly boxed unobservable from the road. Therefore, the flow reduction will only be distinguishable from the road in the high section of the river, especially in the last 2 kilometers before reaching El Alfalfal bridge. Except for the last two kilometers of the road, along the route there are only occasional or partial views of the river, where the river flow reduction will be less perceptible. In parking sites and viewpoints informally used at the side of the road, an observer must walk and find a place to have visibility of the river due to vegetation and the steepness of the place. Importantly, the Colorado River bed develops (in most of the section analyzed) at an elevation significantly different from the road elevation (between 30 and 50 m).
- The guaranteed ecological flow is exceeded most of the year, in fact, as can be seen in Annex 10, during the summer months, the Colorado river flow, with the Project operating, will be larger than the winter flow, without the Project, so the effect of the flow reduction in the Colorado river will be significantly minimized in the spring-summer season, due to the natural increase of flows as a result of thawing.
- In relation to the Project, we will generally maintain a condition of high landscape naturalness, since the Project does not include major works in the area and that areas affected by Contractors will be restored. Thus, we will maintain a control of the characteristic morphological and visual features of mountain valleys where the presence of tree and bush vegetation formations of sclerophyllous forest stands out.

### Artificiality

For the operation stage, all the works considered by the PHAM, regardless of the landscape unit where they are inserted, present artificiality in varying degrees depending on the location and landscape context where they are implemented. Artificiality is normally given by the same features defining its contrast, that is, by the rectilinear geometric shapes inserted into the landscape, volumes, textures and colors.

### Landscape Attributes

The main change in the landscape attributes will be the flow reduction in rivers and streams where there will be water collections. The most important collections in terms of landscapes are:

- Volcán river between intake area of El Morado, Las Placas, La Engorda and Colina streams and the confluence with Volcán river.
- Yeso River between intake of El Yeso reservoir and the confluence of Yeso River with Maipo River.

We consider that the water body of Maipo River between El Volcán area and the discharge in Las Lajas area will maintain its landscape attribute condition despite reduced flow. A similar situation is expected for Colorado River.

At the same time, we expect the emergence of a new element with positive landscape attributes that corresponds to the tailstock pond in El Colorado area and that will involve the development of a water body.

#### b) Landscape Sensitivity

The description of this variable is similar to that indicated for the construction stage.

#### c) Physical and Visual Accessibility

Regarding physical and visual accessibility, we consider the same statements indicated for the construction stage, in particular, the high physical accessibility showed by the landscape units, since there are established routes of frequent traffic, except for the Aucayes stream valley unit where there is no road.

### **ii) Environmental Management Measures**

- Both for technical and cost reasons, and for environmental and safety considerations, we have minimized the extension of service roads necessary for the movement of Contractors. Similarly, the opening of new roads in hillsides has been reduced.
- The maintenance of an ecological flow both in rivers and streams keeping to date their flow under a natural regime, and in those with a regulated flow, a  $Q_e$  will be maintained guaranteed by the Owner for all seasons and in any event. The first case has included the streams where fish was found, and those that do not host fish populations given the elevation at which they are found (e.g. Colina, La Engorda streams, etc.). This multipurpose measure will minimize the landscape effect associated with the flow reduction, mainly in those areas with a greater visual accessibility.

### iii) Qualification of the Impact

According to the analysis, impacts during this stage will be permanent, negative in nature and with mostly low qualifications. The highest qualifications are obtained in the High Volcán units and the streams in the area of high Volcán.

#### **6.4.2.6 Effects of flow reduction on tourist activities**

##### **i) Identification and Sources of Impact**

In this stage of the PHAM works or activities, these will not interfere, directly or indirectly, with the development of tourist activities in the commune, that is, these will be conducted in the manner they are implemented today or according to the projected trend. In this sense, the only possible effect is related to the introduction of artificial elements in the landscape (effect analyzed independently), and from this perspective, a potential detriment of the degree of naturalness of the area where certain tourist activities are developed, perceived only in the surrounding projected works, but this will not interfere with the conduction of such activities.

Moreover, the PHAM will not have a significant adverse effect on the navigation activities in the Maipo River from the flow reduction. Annex 10 presents an analysis for different hydrological scenarios<sup>18</sup> which concludes that the PHAM will not modify the current development of rafting and kayak activities developed in the area between San Gabriel and San José de Maipo. These activities are conducted throughout the year and more intensively in the spring-summer season.

In order to establish a comparative analysis of the current situation respect to the Project scenario for navigation in the Maipo River, we have considered the flow and runoff elevation variables, as valid indicators to establish the conditions for practicing navigation in the Maipo River.

In this regard, in terms of flow, Maipo River in San Alfonso has an average flow of 72 m<sup>3</sup>/s. In relation to the Project, the average flow will be 60.9 m<sup>3</sup>/s, which represents a variation of about 15.5%. For a dry year, the variation of the average flow without/with the Project (41.2/33.0) is equivalent to 20%.

As an example, using the discharge curve of the Maipo plant in San Alfonso, of the General Water Authority, we can calculate the variation of the runoff elevation due to the reduction of the river flows in this section, which, under no circumstances, will exceed 15 cm for an average year and 20 cm for a dry year, both peaks expected in the October-March period, where lower flows are registered.

Consequently, we anticipate that the Project will not interfere with the development of the tourist activities conducted in the Maipo River, estimating that even in a dry year, the magnitude of the water elevation and flow variations will not interfere with the development of the navigation activities.

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<sup>18</sup> This hydrological analysis through which we have evaluated the flow reduction is based on statistical information 50 years old, which guarantees the incorporation of the seasonal and annual variability in the analysis conducted.

## **ii) Environmental Management Measures**

No mitigation measures are considered for this impact, because the PHAM will not interfere, directly or indirectly, with the development of tourist activities in the commune, Gener.

Notwithstanding the foregoing, the Owner will foster the development of Tourism, particularly an Ecotourism, Development Program, which takes advantages of these experiences, but mostly which prepares, accompanies and partly finances the ventures of local operators arisen in this field. This concept also includes the possibility to make infrastructure improvements such as trails, shelters, signs, etc.

For this purpose, the company is committed to allocate, through Maitenes Foundation, an annual fund of US\$200,000 for a 10-year term from 2010, to benefit those local entrepreneurs who submit tourist development projects in the area, and for those projects aimed at improving local employability and/or social projects of the commune considered within the Municipality of San José de Maipo programs. These projects will be channeled through competitive funds and evaluated on their own merit.

Initiatives to be implemented by Maitenes Foundation may be linked to those projects or ventures that are being developed by Services or Public Institutions operating in the commune. This linkage would strengthen the initiatives being conducted by the State and promote sustainability over time of the actions boosted by the Foundation, during the period of the program application.

## **iii) Qualification of the Impact**

The PHAM will not interrupt, directly or indirectly, the development of tourist activities in the commune, that is, these will be conducted in the manner they are implemented today or according to the projected trend. The only possible effect is a change in the degree of naturalness of those areas near the sites for implementation of surface works, provided that these are located in areas that receive visitors. This could be unfavorably perceived by visitors, but it will not interfere in any way with the conduction of activities, mainly trekking, climbing and/or mountaineering. This situation will be very specific, occurring in high or mid-mountain areas. This is the case of works in the High Volcán area, located in the lower section of the plain occupied by La Engorda summer pasture, and which, during summer season, is visited by (or in the path of) mountain climbers.

According to the above considerations, this impact is qualified as negative with a low significance.

## 6.5 HIERARCHY OF IMPACTS

The following is a summary of the environmental impacts generated by the Project, arranged according to the qualification performed by the multidisciplinary team participating in the EIS.

**Table 6.5.1**  
**Hierarchy of Environmental Impacts**

<b>Elements or Variables</b>	<b>Impact</b>	<b>Qualification</b>
<b>Construction Stage</b>		
Air quality	Alteration of air quality.	Negative; low significance
Noise	Increase in the sound pressure level	Negative; low significance
Water	Temporary modification of riverbeds and/or water quality	Negative; low significance
Vegetation	Intervention of vegetation	Negative; medium significance
Terrestrial fauna	Local displacement of fauna species	Negative; medium significance
Ichthyic fauna	Alteration of some specimens of ichthyic fauna	Negative; low significance
Population	Generation of employment and additional revenues	Positive: high significance
Population	Interference with tourist activity	Negative; low significance
Landscape	Alteration of landscape	Negative; medium significance
Infrastructure	Road Impact	Negative; low significance
Cultural heritage	Alteration of traditional activities	Negative; low significance
<b>Operation Stage</b>		
Water	Alteration of the sedimentation regime	Negative; low significance
Ichthyic fauna	Alteration of some specimens of ichthyic fauna	Negative; low significance
Population	Generation of employment and additional revenues	Positive: low significance
Landscape	Alteration of landscape	Negative; low significance
Tourism	Effects of flow reduction on tourist activities	Negative; low significance