



ALTO MAIPO HYDROELECTRIC PROJECT
Analysis of Alternatives

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Contents

General Information3

Analysis of the “without Project” situation4

 Economic analysis of alternate energy sources.....5

 Analysis of the Alternative Situation to the PHAM.....8

Chronology of Alternatives Analyzed 9

Methodology for the analysis of alternatives 25

 Determination of the assessment criteria..... 27

 Technical and economic criteria..... 28

 Environmental criteria..... 30

 Social and contextual criteria..... 32

Alternatives for the Alfalfal II Power Plant 33

 Summary of Alternatives for the Alfalfal II Power Plant..... 43

Alternatives for the Las Lajas Power Plant 48

 Summary of Alternatives for the Lajas Power Plant..... 53

Description of the Alternative Selected 59

General Information

The Alto Maipo Hydroelectric Project (hereinafter PHAM or the Project) is a hydroelectric complex comprised of two run-of-river power plants, the Alfalfal Power Plant II and the Las Lajas Power Plant, positioned in hydraulic series. The Project's main works will be sited almost completely underground and will consist of pressure tunnels and powerhouse caverns, as well as a network of headraces, most of which are also underground. The Project will be located in the south-southwest sector of the city of Santiago in the Municipality of San José de Maipo, Cordillera Province, in the Metropolitan Region of Santiago, Chile. It will have a total installed capacity of 531 MW, which will be injected into the Central Interconnected Grid (SIC) through a transmission system connected to the existing 110 and 20 kV system owned by AES Gener.

The Project was approved by the Chilean environmental authorities in 2009 under Exempt Resolution 256 dated March 30, 2009 (hereafter RCA256) issued by the Metropolitan Region Environmental Commission, based on an Environmental Impact Study (hereafter EIS) that was submitted on May 29, 2008 to the country's Environmental Impact Assessment System (hereafter SEIA).

The Project's rationale is based on the increasing demand for electrical energy in Chile. In this regard, the Project will inject into the SIC an average of 2500 GWh per year, with the added advantage of being located very close to the grid that consumes the largest amount of energy. Thus, the PHAM will prevent the need for new thermoelectric plants to be installed.

The use of the water resources of the Maipo River basin to generate hydroelectric energy for the Central Interconnected Grid by both AES Gener and the generating companies that preceded it has a long history, dating back to the 1920s. The El Volcán, Queltehues and Maitenes Power Plants were installed in the middle of the last century and then in 1991 the Alfalfal Power Plant entered into operation, generating 160 MW of power with water from the Olivares River and the upper Colorado River basin.

In regard to new developments that take advantage of the attractive hydroelectric potential that exists in the upper Maipo basin, since the 1980s several different alternatives have been studied, all of them with similar features and based mainly on capturing water from the Volcán and Yeso rivers and channeling it to the intermediate basin of the Colorado River¹ through tunnels and conduits. The energy would be generated in a power plant with a large head in the middle reaches of the Colorado River. The same flows would then be added to those discharged by the Alfalfal Power Plant and any contributions from the intermediate

¹ It should be noted that the water resources described previously are located in the high mountain zone in streams and rivers that are all tributaries of the Maipo River at different points along a 37 km stretch of that river, approximately (from the confluence of the Volcán and Maipo rivers to the confluence of the Colorado and Maipo rivers).

basin of the Colorado River and its lesser tributaries, and then channeled to the Las Lajas Power Plant, also located in the intermediate basin of the Colorado River, then ultimately sent to a tailrace tunnel to be discharged into the Maipo River.

In the analysis of alternatives of the different possible configurations of the Project, technical, environmental and economic criteria were gradually incorporated, as were comments and observations from local communities and the general public that emerged in both formal and informal public participation processes. In this regard, it should be noted that the first draft of the project dates back 1990.

This report presents details of the alternatives that have been analyzed in the course of the conceptual development and engineering design of the Project before the final configuration was approved and implemented; in addition, it sets out the criteria that were used in the analysis of alternatives, describing the methodology employed and how those criteria have been effectively incorporated during the design and development of the Project, as well as during the period of studying alternatives.

It should be recalled that the Analysis of Alternatives² enables the systematic comparison of the alternatives in terms of: the siting, technology, design, and operation of the Project—including the "without Project" situation—in terms of its potential environmental effects; the feasibility of mitigating its impacts; the capital and operating costs; its advisability, given the conditions of the Project area; and institutional, resource, and follow up requirements. According to the CFI, the objective is to demonstrate through this analysis that the option ultimately adopted addresses all potential effects on both human wellbeing and the environment, taking into consideration the standards that have been established by the Corporation in these areas. Thus, for each of the alternatives the analysis looked at the main environmental effects while taking into account the feasibility of the Project from different perspectives. The result was a comprehensive overview and increased understanding of the conditions and potential conditions of impacts and risks involved in the alternative selected. The last issue analyzed was whether the project was sustainable over time.

Analysis of the “without Project” situation

Before analyzing the PHAM in particular, in order to contextualize the scenario without the Project, a brief economic analysis of alternative sources of energy sources is presented.

² As defined by the International Finance Corporation (IFC), OP 4.01, October 1998.

Economic analysis of alternate energy sources

In response to the challenge to sustainably develop the electricity sector in Chile while taking into consideration the need to meet the growing demand for energy and keep energy costs competitive, a multidisciplinary body was formed—the Advisory Committee for Electrical Development (CADE)—which has analyzed the problem and produced information and points for discussion in the development of Chile’s current Energy Policy. In November 2011 the Committee issued its final report, which presents a broad-based vision of the future development and feasibility of alternate energy sources, specifically Non-Conventional Renewable Energies (NCREs). This chapter transcribes some of the Committee’s analyses and conclusions, which provide simple and independent forecasts at the national level for NCREs. To view or obtain a copy of the detailed Report and find more information about CADE and its members, please visit the website of the Ministry of Energy of Chile at <http://www.minenergia.cl/documentos/estudios/informe-de-la-comision-asesora-para-el.html>.

From a general perspective, it should be noted that current electricity prices have reduced the competitiveness of Chile’s economy. The analysis of the competitiveness of the electricity market and the conditions required to obtain better electricity prices are a central element in policy development, but also figure prominently in projects, which need to be competitive on the market and in terms of investment at both the national and international level.

In effect, to achieve economic efficiency the idea is to encourage the development of open, competitive markets for energy generation and commercialization without central planning and with regulation of the transmission and distribution segments that seeks to reflect the long term mean cost of these activities. Another key element is to plan for the expansion of trunk transmission lines on the basis of generating projects that are possible and/or already planned.

In this regard, each of the energy sources must, on its own merit, adhere to this general principle, and it is the role of the State to correct imperfections or distortions that result from the concentration of the energy supply and, in turn, to fulfill the commitments that the country has adopted to meet global challenges, such as the measures adopted to minimize the effects of Climate Change.

It should be noted that, historically, the main resources used to produce electricity in Chile have been hydropower, coal, natural gas and petroleum. Among these, only hydropower is a local source, while all the others are imported. The crisis provoked by the shortage of gas from Argentina led to the immediate replacement of this fuel with petroleum and liquid petroleum gas (LPG), and in the years following led to the construction of coal-based power plants as well as some medium-scale hydroelectric power plants. In 2007, Law 20.257 was

passed to encourage the adoption of NCREs, and since then there has been an increase in the development of projects focused on wind, minihydro, and biomass-based power plants.

To envision the future inclusion of NCREs in the energy grid, the above-mentioned Committee conducted a series of case studies based on projected demand. Details of these studies can be reviewed in the abovementioned Report.

These studies concluded that, in terms of generating costs alone, without considering either transmission costs or environmental costs, the lowest-cost options were hydroelectricity, biomass, and coal generation. In regard to the cost of geothermal energy, this would depend on the features of the sites currently under assessment, while the cost of wind power continued to depend heavily on the characteristics of the resource itself, which would determine the plant factors that could be achieved.

It should be noted that different scenarios were defined in preparing the studies, beginning with a baseline scenario that was determined using the BAU concept (Business As Usual), which sought to represent electricity development under current policies for the analysis horizon of 2012–2030. Subsequently, the BAU scenario was combined with different types of instruments that seek to promote NCREs, restrict CO₂ emissions or limit the use of a particular type of technology, such as nuclear energy.

The BAU scenario considers the requirements for incorporating NCREs under the current Law 20,257, which stipulates that by 2024, 10% of the electrical energy injected into the grid should derive from NCREs. This the analysis offered by CADE defined two possible BAU scenarios, each with a different annual development rate for NCRE projects, which in turn were based on the potential and characteristics of the resource in question. That information was collected from different domestic sources with due consideration for the pace at which these technologies could be deployed, based on limitations in the speed at which projects could be developed and the entrepreneurial capacity to develop them. In this regard, the analysis identified a conservative scenario and an optimistic scenario in the rates of annual penetration of NCREs. By way of example, beginning in 2021 the conservative scenario envisions a maximum of 100MW annually from the integration of geothermal energy, while under the optimistic scenario an estimated 135MW is seen as the maximum amount of energy that could be incorporated per year from this source.

In addition, two NCRE policies were analyzed: one corresponding to the implementation of the 20/20 goal under Law 20.257, which establishes that by the year 2020, 20% of the energy injected into Chile's energy grids should derive from NCREs (the TC2020 Scenario in the Study), and the other corresponding to the implementation of the 20/20, taking into account quotas for individual technologies, as follows: 20% solar, 30% wind and the rest optimized according to cost (TCCuotas Scenario in the Study). All scenarios used respect the availability

of NCRE resources by type of technology employed, based on the best information available on the availability of those resources.

In regard to the policy that seeks to limit CO₂ emissions in energy generation in both the SING and the SIC, the scenario analyzed included a tax on emissions for all thermoelectric plants at the rate of 20 dollars per ton of CO₂ (TCImpCO₂ Scenario).

Depending on the BAU considered (pessimistic, conservative or optimistic), the calculations presented in the Report indicate that the penetration of NCREs could range from 12% to 20% by 2024. For this reason, the CADE deemed it was reasonable to recommend the modification of the percentages found in the current law, to a goal of 15% by 2024. It did not recommend a higher percentage, as this could force the introduction of non-competitive projects and increase the cost of energy supplied.

Point 3.3 of the aforementioned Report mentions in detail the results of the Study. Point 3.4 offers Conclusions and Recommendations (as does Annex 3 of the Report). In that regard, the following points should be noted, among others, for the different energy sources:

- Large scale hydroelectric generating, geothermal and mini hydroelectric technologies are the predominant NCREs in the SIC. Consequently, it is crucial to gather evidence on the potential of these energies and rates of penetration, conjugating this analysis with a study of their environmental impacts.
- The order of predominance, according to the results of the analysis, is as follows: Geothermal, Hydro-Minihydro, Biomass, Coal, Nuclear, Wind, LPG – Fuel Oil - Solar.
- The observed profitability of hydroelectric projects under all scenarios studied is between 14% and 22%, which shows that this is a profitable technology that has not been developed to its full economic penetration rate owing to limitations in the pace at which projects can be developed.
- Limiting the development of hydroelectric projects increases the cost by 7.0% to 7.5% and increases emissions by 37% to 39%, depending on the rate of penetration of NCREs.
- According to the analysis, for the BAU cases studied, 10% of the penetration of NCREs must be achieved within the deadline established under Law 20.257. However, the 20/20 could be achieved by around 2025, balancing the effects on both systems. Furthermore, it can be seen that the cost of forcing the 20/20 goal through the scheme set out in the current law, from the point of view of centralized planning, is low.
- The delay by a single year in the investment calendar translates into an increase of more than 20% in the price, an issue that could be even more significant in terms of its impact on costs and prices.
- It is worth noting the sensitivity of the scenarios to emissions in the system. A case in point is the high estimated demand in the SING (this translates into the incorporation of nuclear energy) and constraints in the development of hydroelectric projects for the SIC.

Based on the above conclusions, in regard to the analysis of profitability under different scenarios it can be observed that hydropower generating projects are a feasible, necessary, and profitable option compared to other sources of energy.

Analysis of the Alternative Situation to the PHAM

The criteria employed for the “without Project” situation address the option of injecting into the Central Interconnected Grid (SIC) from other energy generation sources a total of 531 MW (Alfalfal II 264 MW / Las Lajas 267 MW), with annual expected energy of 2465 GWh/year (equal to 50% of the current household consumption of electricity in the Metropolitan Region and to 35% of the current household consumption across the SIC), assuming a supply that is efficient and secure.

According to the Government of Chile’s Ministry of Energy, by 2020 energy demand is expected to rise at a rate of 6 to 7%, which translates into nearly 100,000 GWh of total electrical energy demand by that year, which will require an increase in the supply of energy, only over that period, of more than 8,000 MW through new generating projects. The figure below was prepared by the Ministry and displays this situation:

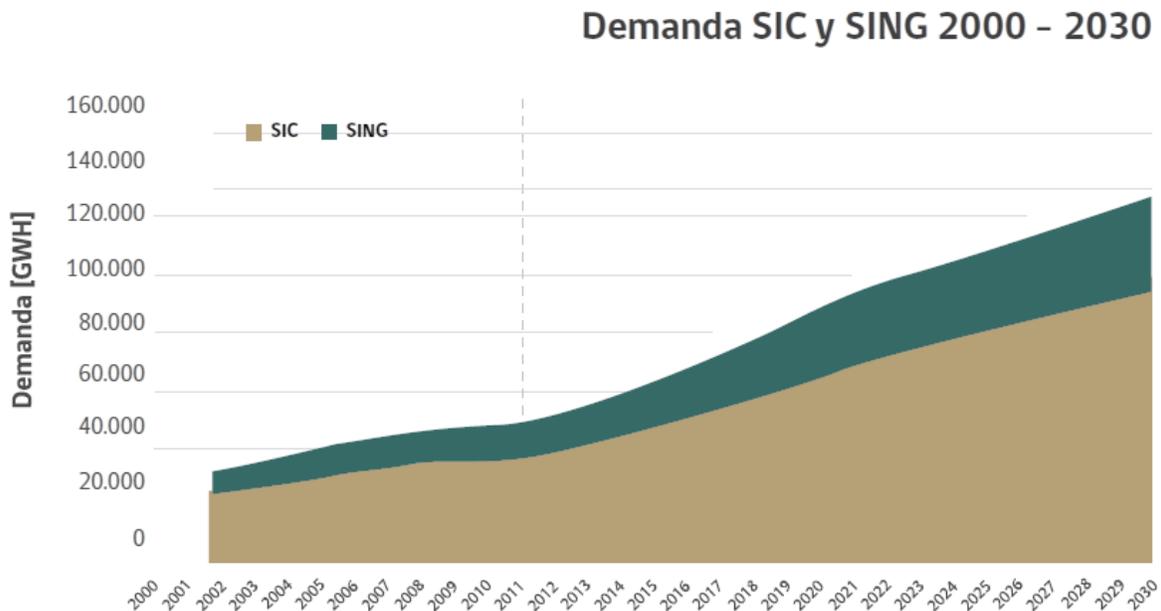


Figure 1. Projected demand for electricity (in GWh).

Source: Ministry of Energy, 2012.

For its part, the price of energy has been impacted by the abrupt shortage in the supply of natural gas from Argentina and the increase in the cost of investing, which has led Chile to

have the most expensive electricity in Latin America, and even higher than the average for OECD member countries.

Today, the sources of energy in the grid are as follows: 3% from non-conventional renewable energies (NCREs), 34% from hydroelectricity, and 63% from thermoelectric generation. Given the characteristics of the PHAM in terms of its contribution to the SIC, and the current and projected demand for energy, the option of not implementing the Project can only be envisioned if the demand is met by thermopower.

While both types of energy generation, thermopower and hydropower, make a significant contribution to the energy grid and are expected to grow steadily, the PHAM has evident strengths that point to the conclusion that the “without Project” situation, with energy supplied by a Thermoelectricity Project, would have a greater impact, for the following reasons, among others:

- The PHAM contributes to Chile’s electricity security and its independence from fossil fuels, with negligible operating costs compared to thermoelectric generation.
- Given the proximity of consumption centers, the need to construct transmission lines is less. It should be noted here that it would be highly problematic to develop and build thermoelectric power plants within the Metropolitan Region.
- Less impact on climate change (its operation will not generate emissions).
- Low visual impacts, as most of the Project works, are situated underground.
- More profitable in the long run. The flows show that there is a need for intense investment initially, owing to the construction of the Project, followed by a period of increasing benefits, and then a period of constant benefits.
- Contributes to the optimum use of water resources in the Maipo River basin; in the “without Project” situation, potential energy is not taken advantage of.

The characteristics mentioned above are not intended to ignore the important contribution that thermoelectric power plants make to the country’s energy grids, but are only for the purposes of comparison with the PHAM. In conclusion, the “without Project” situation appears to be significantly worse than its alternative.

Chronology of Alternatives Analyzed

The conceptualization of the hydroelectric project for the upper Maipo River basin was envisioned from the beginning as an attempt to take full advantage of the resources available in that basin by rationalizing water use among different users and using the resources in the most efficient way possible. The first detailed configuration of the Project dates to 1990; since

then, and even today, the Project has had the involvement of multidisciplinary teams in the fields of engineering and other specialties such as geology, soil mechanics, hydrology, biodiversity, social studies and the environment, among other fields. This has allowed the different alternatives that were proposed over time to be reviewed and evaluated from different perspectives and ultimately resulted in Project's current detailed configuration.

The list below outlines the alternatives analyzed over the years:

- a) Alternative 1: Prefeasibility Study of the Alfalfal II – Las Lajas Hydroelectric Complex. Engineering and Works Department, Construction and Engineering Division, CHILGENER. June 1990. (see Figure 1)
- b) Alternative 2: Hydroelectric Expansion of the SIC: Alfalfal II Power Plant, Nueva Maitenes Power Plant, and Las Lajas Power Plant. CHILGENER. 1994. (see Figure 2)
- c) Alternative 3: Feasibility Study. Alto Maipo Hydroelectric Project. Arcadis. April 2006. This Study analyzed the most profitable configuration, prioritizing the configuration of the Alfalfal II and Las Lajas Power Plants positioned in hydraulic series and ruling out the Nueva Maitenes Power Plant. (see Figure 3)
- d) Alternative 4: Configuration of the Project described in the Environmental Impact Study (EIS) of the Alto Maipo Hydroelectric Project, presented to the SEIA in June 2007, and withdrawn by the company in May 2008. It should be mentioned that the withdrawal of the Project was a decision made by AES Gener based on the new adjustments to the Project that resulted from the incorporation of the requirements of local community, specifically the location of some of the Project works (these are detailed below). In order to ensure that the environmental approval process was as transparent as possible from the beginning, the decision was made to re-submit the adjusted Project to the SEIA. This allowed the formal public participation process (which is an integral part of the environmental assessment conducted under the SEIA) to be carried out on the basis of the updated Project description. (see Figure 4)
- e) Alternative 5: Configuration of the Project described in the EIS of the Alto Maipo Hydroelectric Project, submitted to the SEIA in May 2008. Environmental approval granted in March 2009. (see Figure 5)

The alternatives listed have one factor in common—the basic project scheme, which is to capture water from the Volcán and Yeso Rivers at approximately 2,500 m.a.s.l. and channel it to the intermediate basin of the Colorado River through tunnels, and then use it to generate electricity in the intermediate basin of the Colorado River in power plants that take advantage of the aforementioned water in addition to that of the Colorado River itself. All of the water would then be returned to the Maipo River. This basic design was chosen because of the

hydrological, geological, and geomorphological features of the zone, which give rise to its hydroelectric potential.

It is evident that the alternatives analyzed sought mainly to: optimize the configuration of the base project with the sustainable incorporation of existing resources; identify the best location for the different works required, both principal and complementary, in order to minimize impacts; define the most suitable kinds of works; define the construction method, etc., taking into account the most feasible technical-economic options, available information on potential environmental impacts, and the expectations and concerns of the community.

The chapters that follow provide details of the alternatives presented for both the Alfalfal II Power Plant and the Las Lajas Power Plant.

To assist understanding of the works and their components, tables 1 and 2 below show each of the alternatives analyzed in relation to the two power plants involved. Table 1 compares the information for the Alfalfal Power Plant II and Table 2 provides comparable information for the Lajas Power Plant.

Figure 1. PHAM Alternative 1 (1990)

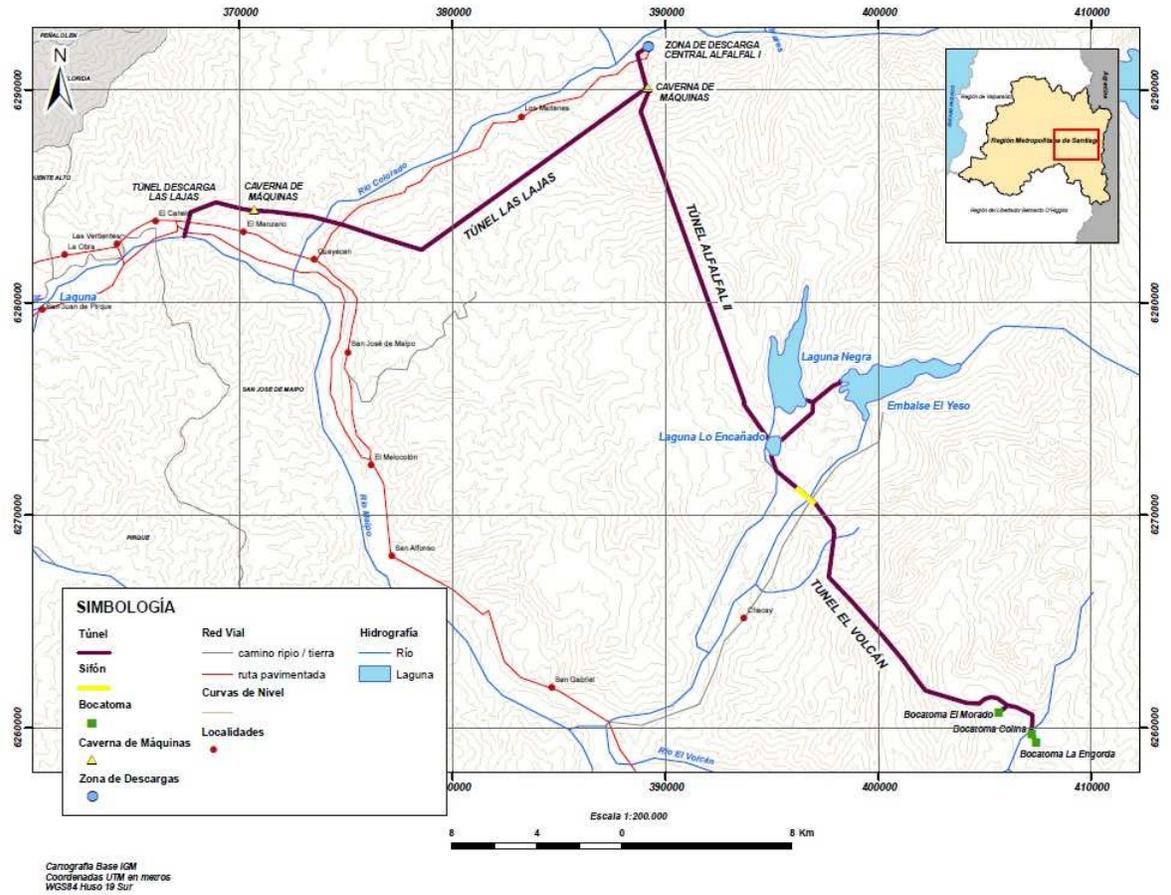


Figure 2. PHAM Alternative 2 (1994)

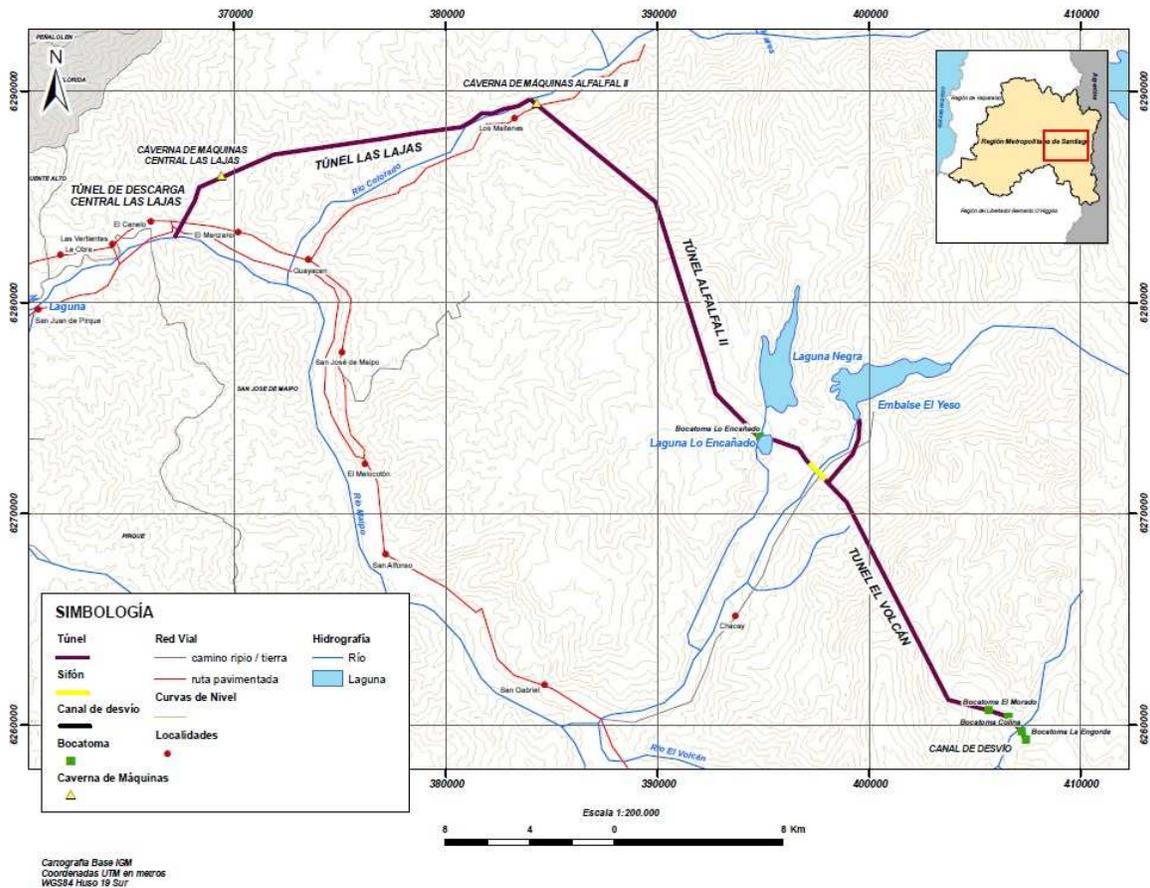


Figure 3. PHAM Alternative 3 (2006)

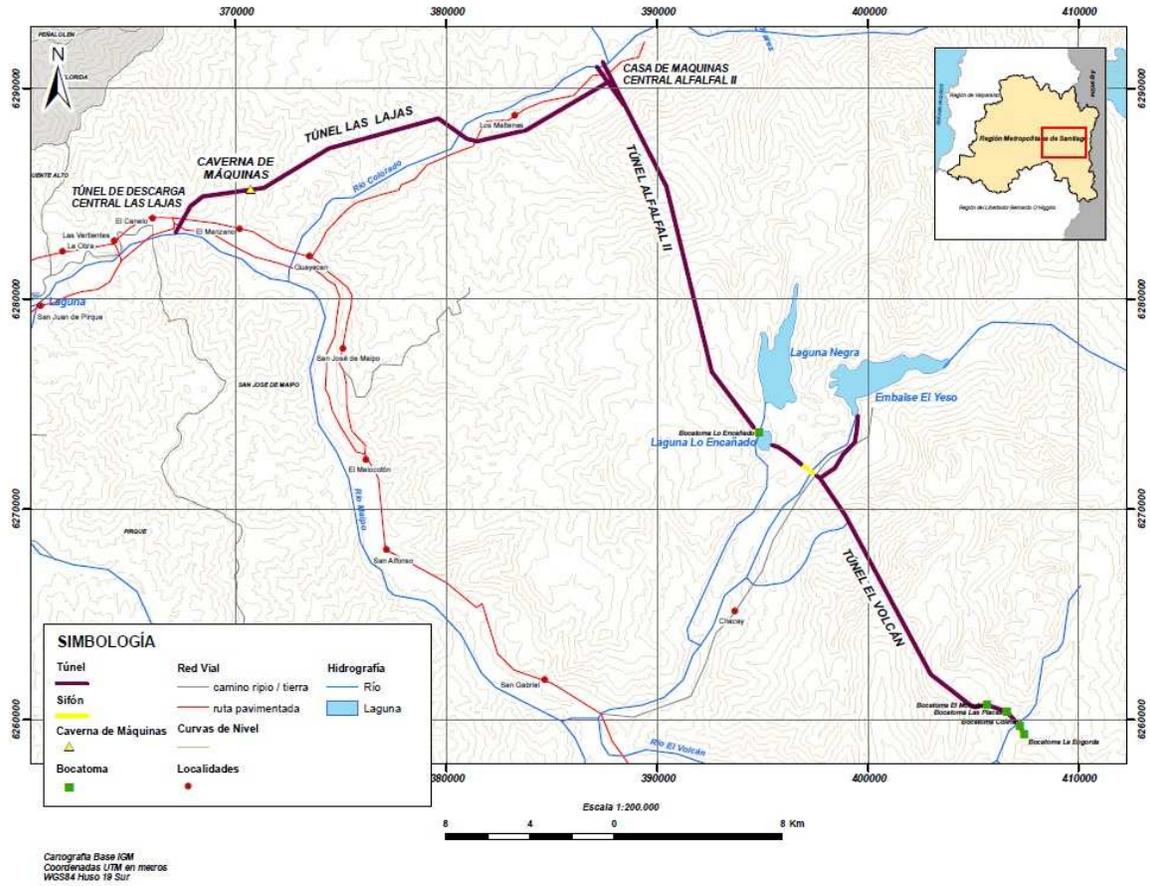


Figure 4. PHAM Alternative 4 (2007)

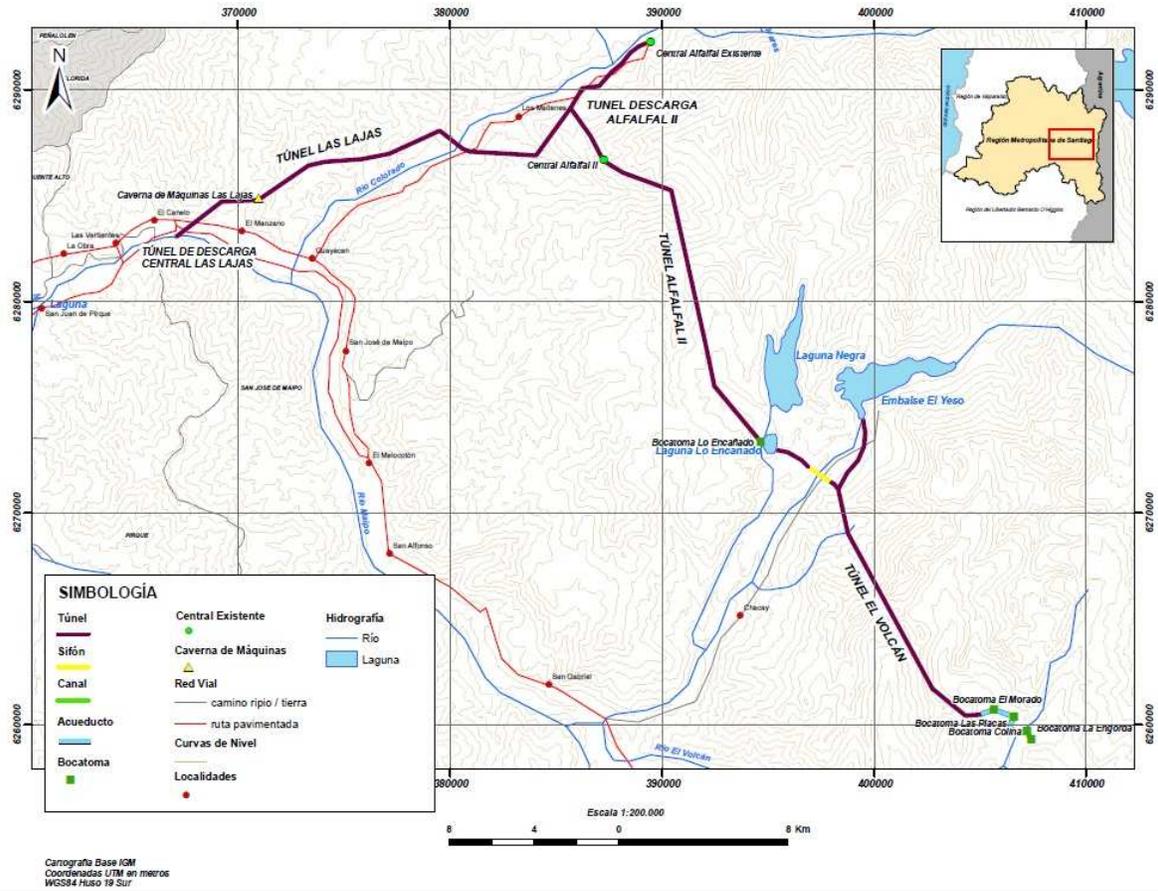
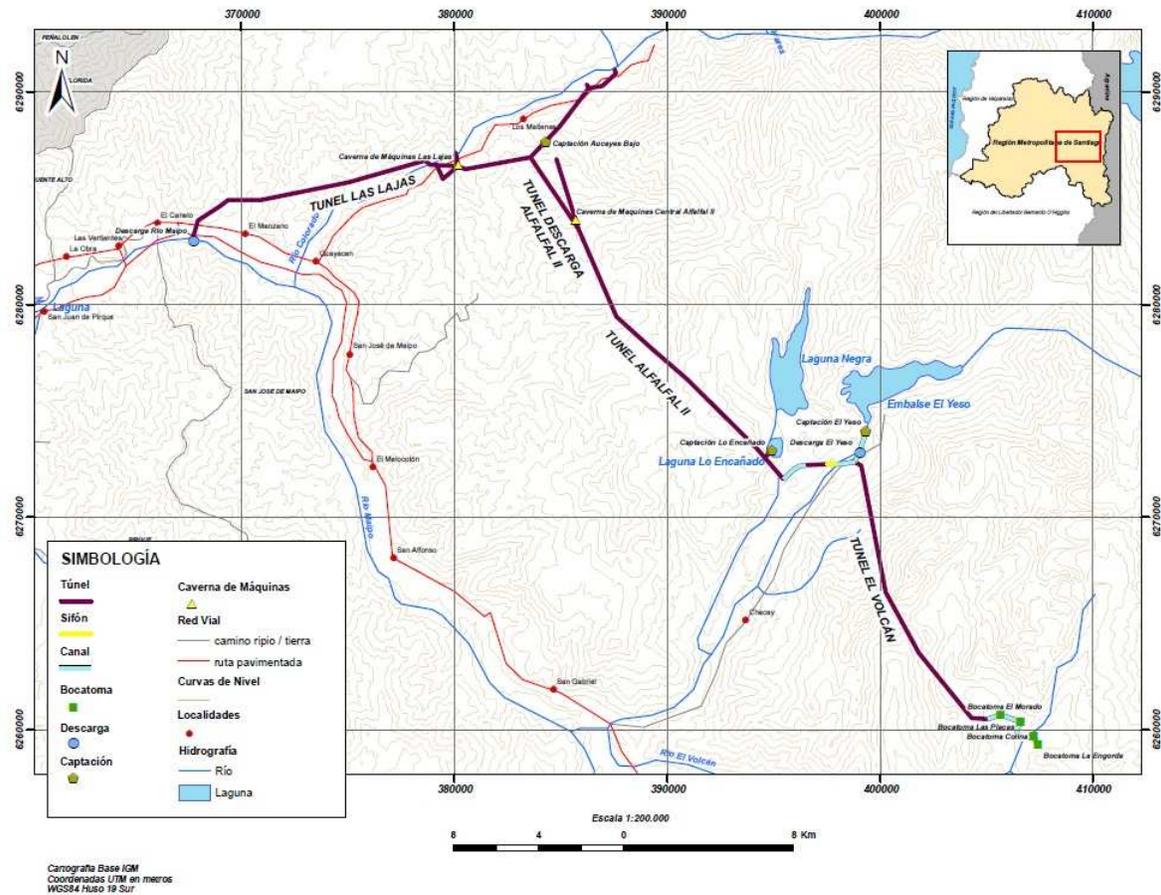


Figure 5. PHAM Alternative 5 (2008)



Power Plant II

Volcán Tunnel	Water Collection and Channeling Works from the Yeso River	Yeso Siphon	Volcán Tunnel Discharge and Alfalfal II Headrace Tunnel	Alfalfal II Tunnel	Alfalfal II Tailrace Tunnel	Regulating Reservoir
Two pressure tunnels with a total length of 17 km channel the water collected to Laguna Lo Encañado. Along the way, water is also collected from Las Cortaderas canyon (via a high mountain water intake).	Tunnel that channels water from the Yeso Reservoir - Laguna Negra and connects with Laguna Lo Encañado	Work crossing the Yeso River, 2000 m long, connecting to the Volcán Tunnel and Laguna Lo Encañado.	Includes the following works and configurations: - Lo Encañado Tunnel, which channels water from the Yeso River to Laguna Lo Encañado. - Embankment of Laguna Lo Encañado through the construction of a dam approximately 70 m high to reach the same level as the Yeso Reservoir and Laguna Negra. -Connection of the abovementioned lakes with Laguna Lo Encañado (this would have allowed the capacity of the Yeso Reservoir to increase by around 100 million m ³ , but would have dropped the level of Laguna Negra, with its contribution reintegrated after being used to generate power in the Las Lajas Power Plant).	Pressure tunnel 14,200 meters long that runs from Laguna Lo Encañado to the powerhouse cavern located on the left side of the Colorado River, in front of the Alfalfal Power Plant.	1700 m long, comprises the beginning of the Las Lajas Power Plant headrace.	No regulating reservoir is envisioned. Surge shaft 600 m long.

Volcán Tunnel	Water Collection and Channeling Works from the Yeso River	Yeso Siphon	Volcán Tunnel Discharge and Alfalfal II Headrace Tunnel	Alfalfal II Tunnel	Alfalfal II Tailrace Tunnel	Regulating Reservoir
<p>A pressure tunnel 14 km long extends from the Morado Canyon to the Yeso River. It includes water from Las Cortaderas Canyon (using a high mountain water intake)</p>	<p>Envisioned the following works: - Water diversion work for Laguna Negra: intake works, water conduit and discharge work for the Manzanito stream, downstream of Lo Encañado dam. -Connection with the Yeso Reservoir discharge – delivery to the Lo Encañado Reservoir.</p>	<p>Steel tube 1 km long that connects the Volcán Tunnel with the Yeso - Lo Encañado headrace channel</p>	<p>Embankment of Laguna Lo Encañado with a dam 33 m high and 190 m long on the crown. Water collection work for Alfalfal II tunnel in the form of a deep intake located in Laguna Lo Encañado.</p>	<p>Pressure tunnel 16,000 meters long that runs from Laguna Lo Encañado to the powerhouse cavern, the location of which was changed to the same rock mass that contains the forebay of the Maitenes Power Plant. This would allow the turbined water to be delivered to the forebay of this power plant without the plant having to shut down during construction of the Alfalfal II Power Plant. While this alternative was being developed, consideration was given to designing a third power plant called Nueva Maitenes, to be located before the Las Lajas Power Plant headrace. This project was ultimately abandoned. The location of the powerhouse cavern of Alfalfal II was also planned to allow the flows to be used by the Nueva Maitenes Power Plant.</p>	<p>Free-flowing tunnel 2700 m long.</p>	<p>Regulating reservoir with a maximum capacity of 270,000 m³, located downriver of the Maitenes Power Plant on the left bank of the Colorado River.</p>

Volcán Tunnel	Water Collection and Channeling Works from the Yeso River	Yeso Siphon	Volcán Tunnel Discharge and Alfalfal II Headrace Tunnel	Alfalfal II Tunnel	Alfalfal II Tailrace Tunnel	Regulating Reservoir
<p>A tunnel 13.6 km long that runs to a connection with the El Yeso Tunnel. The water collected from Las Cortaderas Stream is collected in a steel-lined vertical shaft 114 m long located at km 11.9 of the tunnel.</p> <p>Before crossing the Yeso River it receives water discharged from the Yeso Reservoir (15 m³/sec). Connects to Laguna Lo Encañado.</p>	<p>Tunnel from the Yeso Reservoir to a vertical shaft that connects it to the Volcán tunnel.</p>	<p>The 1370 m-long Yeso siphon begins at the junction of the two tunnels and discharges into a vaulted channel. This siphon was designed as a steel pipe.</p>	<p>This alternative involved the following works:</p> <ul style="list-style-type: none"> - Conduit to Laguna lo Encañado: vaulted channel 2.9 km long that received the water discharged by the Yeso siphon and delivers it to Laguna Lo Encañado. - Laguna Lo Encañado: allows the hourly regulation of flow rates entering the Alfalfal II Power Plant. Requires embankment of Laguna Lo Encañado with a low wall 2.5 m in height and 300 m long. - Lo Encañado Collection: reinforced concrete water intake for 27 m³/s submerged, to collect water from Laguna Lo Encañado and deliver it to the Alfalfal II Tunnel and then to the power plant. 	<p>The water collected from Laguna Lo Encañado is channeled under pressure through the Alfalfal II tunnel, 16.0 km long, to the surge shaft and beginning of the penstock, before delivery to the plant's powerhouse cavern.</p> <p>The powerhouse of the Alfalfal II Power Plant has been planned as a cavern located east of the Aucayes Stream and contains a tailrace tunnel 2 km long and 45 m² in cross-section that channels the water to the forebay of the Las Lajas Power Plant or, alternately, to its regulating reservoir.</p>	<p>At the outlet of the penstock, the tailrace tunnel of Alfalfal II begins, with a length of 2.4 km and section of 45.5 m². Direct access from the existing road.</p>	<p>This is located between the existing road that leads to the Alfalfal Power Plant and the Colorado River. The reservoir will be excavated on land and have a volume of 518,000 m³ and a surface area of approximately 12 ha.</p>

Volcán Tunnel	Water Collection and Channeling Works from the Yeso River	Yeso Siphon	Volcán Tunnel Discharge and Alfalfal II Headrace Tunnel	Alfalfal II Tunnel	Alfalfal II Tailrace Tunnel	Regulating Reservoir
<p>Volcán Tunnel channels water to the Yeso River valley. Along the way it receives 1 m³/s of water from Las Cortaderas Stream. 14 km long.</p>	<p>At the Yeso Reservoir discharge, a maximum flow of 15 m³/s is captured, and then channeled through a conduit and tunnel until connecting with the Volcán tunnel.</p>	<p>The entire flow would be channeled through a siphon under the Yeso River (steel pipe). The planned course was changed to avoid: a) Crossing the Inca Trail in an undisturbed area b) Intervening in archeological sites that were identified in the literature and in the baseline survey</p>	<p>From the siphon, the water would be channeled through a short tunnel and a canal to Laguna Lo Encañado. This lake would serve as a forebay and hourly regulator for water sent to the Alfalfal II Power Plant. From Laguna Lo Encañado, a deep water intake would collect a maximum flow of 27 m³/s, which also includes water from Volcán and Yeso of approximately 2 m³/s from the basin flowing into the lake.</p>	<p>The flow will be channeled through a pressure tunnel to a sloped shaft of the Alfalfal II Power Plant. Below the penstock a cavern will be constructed to house the generating equipment. The powerhouse cavern was originally located east of the Aucayes Stream and during assessment of the EIS it was relocated to the west side of the stream.</p>	<p>The Alfalfal II tailrace tunnel channels the water to the headrace tunnel of the Las Lajas Power Plant. The tailrace tunnel of Alfalfal II also can discharge the water from this power plant into the Colorado River in cases where the Las Lajas Power Plant goes out of service. To do so it uses a safety spillway located at the entrance to the forebay of the Las Lajas Power Plant.</p>	<p>The reservoir is located west of the existing Alfalfal I Power Plant and will have a total capacity of 425,000 m³. The reservoir would operate as a forebay for the Las Lajas Power Plant.</p>

Volcán Tunnel	Water Collection and Channeling Works from the Yeso River	Yeso Siphon	Volcán Tunnel Discharge and Alfalfal II Headrace Tunnel	Alfalfal II Tunnel	Alfalfal II Tailrace Tunnel	Regulating Reservoir
<p>The Volcán Tunnel collects the water captured in the upper zone of the Volcán River and channels it to the Yeso River valley. This tunnel is 14 km long and begins at an altitude of approximately 2,500 m.a.s.l. and ends at the connection with the forebay at an altitude of 2,480 m.a.s.l. in the Yeso sector. The Las Cortaderas water intake is eliminated.</p>	<p>Yeso Water Intake: The Yeso water intake is located some 700 m downriver of the Yeso Reservoir, and its function is to collect the water contributed by the Yeso River and channel it to the Alfalfal II Power Plant system.</p>	<p>Steel pipe 5000 m. long that begins at the intake weir and runs to the entrance to the Alfalfal II head tunnel</p>	<p>From the intake weir (located at the outlet of the Volcán Tunnel, that combines the flow with flow from the Yeso River), water is channeled to the Alfalfal II Tunnel.</p>	<p>Pressure tunnel 13.6 km long that runs to the penstock of the Alfalfal II Power Plant. The powerhouse is located inside a cavern excavated from the rock mass in an area west of Aucayes Stream in the Colorado River valley. The forebay of the Alfalfal II Power Plant lends stability to the hydraulic system and to the power plant and acts as the expansion chamber of the surge shaft. It is located in the Alto Aucayes sector some 2 km to the west of that stream, at an altitude of 2450 m.a.s.l. The forebay, with a total volume of 48,100 m³, would be completely excavated from the rock. The forebay would be fed by a work connecting it to the Alfalfal II tunnel, which would channel water collected from the Yeso River intake and the Volcán II tunnel.</p>	<p>The tailrace tunnel of the Alfalfal II Power Plant is approximately 2.5 km long and delivers its flow to the head tunnel of the Las Lajas Power Plant. The flow generated by the Alfalfal II Power Plant can be channeled to the powerhouse of Las Lajas Power Plant, or to the plant's forebay, which is located on the right bank of the Colorado River. In both cases it will be channeled through the aforementioned tunnel. Under normal operation, the Alfalfal II Power Plant will discharge its water into the tunnel of the Las Lajas plant through a tailrace tunnel. In emergency situations or when the operation of Las Lajas Power Plant is interrupted, the water can be discharged into the Colorado River through the forebay of the Las Lajas Power Plant through a delivery flume that includes features to dissipate energy and protect the bed and banks of the river.</p>	<p>Corresponds to the forebay of the Las Lajas Power Plant, which also functions as a regulating reservoir for the Alfalfal II Power Plant. This tank, which is located on the right bank of the Colorado River, receives water from the Alfalfal Power Plant through a connecting channel with the latter's discharge spillway. The useful volume of the reservoir is 300,000 m³, over an area of 75,000 m².</p>

Las Lajas Power Plant

	Colorado River Crossing	Las Lajas Tunnel	Las Lajas Power Plant	Las Lajas Tailrace Tunnel	Las Lajas Regulating Reservoir
at 1,325 m.a.s.l.	Not specified	Begins at the tailrace of the Alfalfal II Power Plant with a pressure tunnel 15.4 m long. The powerhouse cavern is sited in a rock mass on the left hand side of the Colorado River approximately 5 km from the confluence with the Maipo River.		Aqueduct tunnel that discharges into the Maipo River, 9.8 km long, crossing the Colorado River and El Manzano Stream underground. Discharges at Las Lajas sector (right hand bank of the Maipo River, downriver from its confluence with El Manzano Stream).	Not planned
Alfalfal II and Nueva Maitenes (water from the intermediate comes from the existing Aucayes Stream).	In preliminary form it includes a forebay of 10,000 m ³ . Las Lajas siphon crosses underneath Colorado River on the right hand side of the river. The siphon is 180 m long.	Pressure tunnel 9.9 km long that begins at the 1,100 m mark and is located between the right hand side of the Colorado River and the El Manzano Stream valley. Ends in a vertical shaft that connects it to the powerhouse cavern, which is sited with a minimum rock ceiling and distant from faults, among other aspects, and is some 700 m from the watercourse of El Manzano Stream.		Aqueduct tunnel that crosses underneath the bed of the El Manzano Stream and discharges into the Maipo River in front of the Las Lajas substation.	Tank with a capacity of 270,000 m ³ located on flat land between El Toro and El Canelo ravines, on the right hand bank of the Maipo River.

	Colorado River Crossing	Las Lajas Tunnel	Las Lajas Power Plant	Las Lajas Tailrace Tunnel	Las Lajas Regulating Reservoir
ing that takes the water fal Power Plant to the ower Plant II, and, in turn, to nt.	Crossing the Colorado River via a steel tube siphon 152 m long. The siphon is buried under the riverbed and is covered with protective rockfill.	Las Lajas Tunnel, 22.2 km long, through which water is channeled under pressure to the surge shaft and the beginning of the penstock before reaching the powerhouse of the Las Lajas Power Plant.	Located inside the rock mass of El Manzano, between the Colorado River and the El Manzano Stream	Discharges water from the power plant and restores it to the Maipo River along a 4 km long tunnel that becomes a channel in the final segment, delivering water to the river at 817 m.a.s.l.	Sited on the northern bank of the Maipo River at the exit to the tailrace tunnel of the Las Lajas Power Plant. With a useful volume of 425,000 m ³ and an area of approximately 14 ha.
l prior to its connection with ow of 38 m ³ /s, corresponding fal I Power Plant and from t, along with contributions ater of Alfalfal I and from the hat will operate as a forebay regulating reservoir for the is operating at peak. ower Plant will also receive 's).	Crosses under the Colorado River in a tunnel.	The Las Lajas tunnel, approximately 20 km long, begins at the connection point with the siphon of the Colorado River. Along its course, the tunnel crosses the Colorado River, underneath the riverbed.	The Las Lajas Power Plant, as planned, is located in a cavern and equipped with two turbines rated for a flow of 65 m ³ /s and a gross head of 454 m. Its location is the same as in Alternative 3.	Discharge of the water flowing from this power plant directly into the Maipo River at an altitude of approximately 820 m.a.s.l. through a tunnel that crosses the El Manzano Stream 100 meters below the surface.	Not planned

	Colorado River Crossing	Las Lajas Tunnel	Las Lajas Power Plant	Las Lajas Tailrace Tunnel	Las Lajas Regulating Reservoir
<p>e Alfalfal I power plant as mediate basin of the water intakes of the Alfalfal and the existing water intake</p> <p>) Channel 1 to the Maitenes l and desanded in a desander lo River.</p> <p>n of water resources from the</p>	<p>The headrace of the Las Lajas Power Plant begins at the forebay of the same name and consists of a concrete pressure pipe. This conduit crosses the Colorado River through a siphon.</p>	<p>Pressure tunnel. The Las Lajas tunnel receives water contributed from the tailrace of the Alfalfal II Power Plant; in addition this tunnel, which along its course also receives water from the Aucayes Stream, has a surge shaft and ends in a penstock that feeds the turbines.</p> <p>The forebay of the Las Lajas Power Plant lends stability to the hydraulic system of this power plant and also acts as a regulating reservoir, reestablishing the natural regime of the Maipo/Colorado rivers when the Alfalfal II Power Plant is operating at peak. The water is collected from this forebay through a concrete pipe that conveys the water to the headrace tunnel of the Las Lajas Power Plant (Colorado siphon).</p> <p>It is located alongside the right bank of the Colorado River and is partially excavated and partially built from earth embankments. The useful volume of the forebay is 300,000 m³ with a surface area of 75,000 m². The plan calls for the installation of an impermeable membrane on the entire water surface of the tank, a concrete bottom, and features for emptying the tank and for security.</p>	<p>The location of the powerhouse is shifted towards the left bank of the Colorado River (El Sauce Stream sector) and is sited in a cavern excavated from the rock mass.</p>	<p>The tailrace tunnel of the Las Lajas Power Plant discharges its water directly into the Maipo River. It is a free-flowing tunnel 13.3 km long and 35 m² in horseshoe cross-section (excavated from the rock).</p>	<p>Not planned</p>

Methodology for the analysis of alternatives

The analysis of alternatives for hydroelectric projects in the upper Maipo River basin dates back to 1990, when a series of studies were conducted to address the complexities of siting this kind of project in a high mountain zone. As a basic element, each alternative requires Energy and Power studies (installed and firm capacity), based on the water resources that are usable (Hydrological Studies), the available head, and loss of load. Following this analysis, economic assessment of a project is carried out at the prefeasibility level.

The above must be adjusted according to the geological characteristics that will define the location and type of project possible, based on construction and risk parameters. Risk is extremely important, as the zone is known to contain different geological features that will determine the feasibility of the location of Project works.

Once the technical and economic prefeasibility is verified (at the conceptual level), environmental criteria are incorporated, such as how the viability of the Project will be affected by the definition of the most restrictive ecological flow rates (greater than those established by the General Water Directorate for each water usage right); the state of each environmental component in the places where works will be sited (the existence of plant formations of importance, fauna under protection, archeological sites, places with significant environmental value, and others); and the existence of regulatory conditions or other limitations on the location of the works involved in the Project.

A detailed analysis of each of these criteria for each particular work in the Alto Maipo Project enabled the adjustment of the design initially proposed according to recommendations made at the basic engineering stage.

At the same time as the engineering advanced, expectations, concerns and considerations raised by the community were incorporated. It should be mentioned that for the initial Project alternatives no public meetings were held with the community or with other stakeholders, as they were very preliminary drafts. However, it should be emphasized during that stage elements arising from the perceptions and concerns of the community were effectively incorporated into the original design. This was possible because AES Gener has operated in the zone for several decades and therefore has a long history of involvement with local communities and is aware of local conditions and/or considerations. Indeed, the existing power plants in the area that are owned by AES Gener date from the last century (the Maitenes Power Plant entered into service on March 16, 1923, the Queltehues Hydroelectric Plant in 1928 and the Volcán Power Plant in 1940).

The methodology used therefore followed a similar logic over time and incorporated more detailed criteria as the Project became more precisely defined, always from a comprehensive perspective. The diagram below illustrates the analysis that was used in practice:

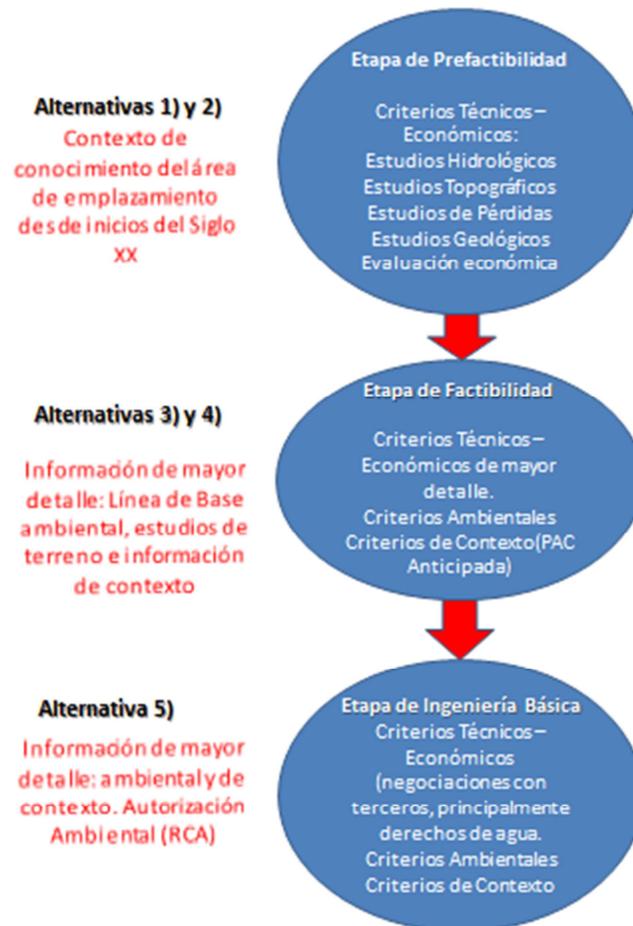


Diagram 1. Stages of development of the Project and incorporation of assessment criteria

In regard to the criteria used, these were separated into four types: technical, economic, environmental and contextual (related to stakeholders and the local and regional context in which the Project is to be implemented). As will be explained below, the most important of these criteria were defined and then modeled under the different alternatives to obtain their potential environmental effects and determine the feasibility of mitigating those impacts. This was carried out up to and including the final alternative that was officially approved by the authorities, which even afterward experienced adjustments in response to engineering advancements and observations submitted by government agencies and by the community.

Determination of the assessment criteria

Determination and prioritization of criteria is directly related to the specific conditions of the site chosen for the Project and its individual works. This means that, according to the features of each of the works, the assessment must take into account their interaction with the surroundings and with local communities in order to define viable alternatives from a technical and economic perspective that are in line with those particularities. To ensure this happens in a timely manner, project development teams work in a coordinated, synchronized manner across all fields. This was verified during the different stages of the Project design phase.

In subsequent phases, more detailed criteria were incorporated, especially those related to context. This occurred as more precise information was collected about the expectations and concerns of community members regarding the technical feasibility of the Project.

This last point is extremely important because, as indicated in the previous chapter, the methodology for analyzing alternatives requires that the Project being examined has been deemed technically and economically feasible, at least at the prefeasibility level. This is especially important because of the complex aspects of the zone, which include a high mountain environment, geological diversity, the feasibility of obtaining the water rights required, and the ecological conditions in the sub basins involved, among others. This allows the Project team to work with the communities involved using the most detailed information possible, to ensure that any adjustments made to the Project are carried out within a realistic and responsible framework.

As will be explained in greater detail below, this work with the community was carried out earlier than required under current legislation, even before the Project feasibility phase. In this regard, it was determined that concerns could be addressed realistically in the Project design and mitigation measures, thereby ruling out its impracticability.

Thus, the different criteria that were gradually incorporated were arrived at in consensus with stakeholders. In the case of environmental criteria, these correspond to aspects consulted about and analyzed in collaboration with the public services responsible for each environmental area and were formally applied in the environmental impact assessment process that is mandated under Law 19.300 and the SEIA. In regard to contextual criteria, these emerged from interactions with local communities and other stakeholders and stakeholder groups during both formal and informal public participation processes.

It is worth noting that the decision making process internal to AES Gener involved not only the participation of Company and Project senior executives but also members of AES Gener's engineering department, external engineering groups, members of AES Gener's environmental department, external consultants, legal advisors, experts in community outreach, and other experts. To facilitate this work, the Project team organized a series of

internal workshops, planning sessions and other meetings that allowed the expertise of each team to be integrated into the decision making. Details of the many activities carried out are provided in the document Consultation and Disclosure Report, which is included as part of the information submitted for analysis.

The sections below describe the criteria employed, according to their type—technical, economic, environmental and contextual.

Technical and economic criteria

Technical criteria

Under technical criteria, the following variables were analyzed:

- **Hydrology:** in the hydrological studies the mean monthly flow rates were determined for a natural flow regime and in terms of real availability, considering the existing works at all intake points required by the PHAM.
- **Geology and geotechnics:** in these studies the geology of the Project area was analyzed. It should be noted that in the area surrounding the power plants there are outcrops of stratified sedimentary, volcanic sedimentary, volcanic, and intrusive rock, which are covered with soils of different kinds. In other words, the area has a high geological diversity. The seismic situation was also assessed in detail (seismotectonic environment, historic seismicity, probabilistic analysis, deterministic analysis, and others) as was the risk of avalanches and debris flows.

As indicated, the technical and economic aspects define the preliminary viability of hydroelectric projects, especially those located in high mountain zones. Thus, the hydrology and geological and geotechnical aspects—which incorporate the experience accumulated during the design and construction of the Alfalfal I Power Plant, in operation since 1991—established the following technical criteria for the PHAM:

Hydraulic design criteria: loss of load, hydraulics of channels, tunnels, pressure pipes, siphons, open conduits, ravine conduits, canals, energy dissipaters, sluice gates and the efficient use of the resource. Modeling was carried out that included generating matrices and differences in firm power when certain elements were included, such as regulating reservoirs.

Criteria for the construction of tunnels and service windows: Optimization of tunnel routes, design of intake sluices, classification of rock types, definition of rock types for tunnel

excavation, estimation of types of tunnel supports and accessibility, prioritizing the least possible above-ground interventions, among other aspects.

Design criteria for the construction of access roads: definition of the percentage of rock, geometric criteria in road estimations, standards in accordance with national road building codes (Highway Manual).

Using the above, the configuration of the Project and its alternatives was defined, including the types of equipment, the types of works and their placement (hydraulic head, location of the powerhouse, requirements for regulating reservoirs, types of surge shafts, etc.), the feasibility of constructing the different works (tunnels, roads, caverns), and other aspects. At the same time, the economic feasibility of the Project was analyzed, with greater detail added as the works and their basic engineering requirements were defined.

Economic criteria

For each alternative the economic feasibility and profitability was defined. As the Project became more precisely defined, more detailed analyses of the investment were carried out; even beforehand, however, it was possible to verify the economic feasibility of each of the alternatives analyzed. It is notable that the profitability of the PHAM was recognized from the very first alternative, with one observation: studies progressed and decisions were made based on the scenario for thermoelectricity generation associated with the feasibility of natural gas supply from Argentina in the 1990s.

For alternatives that included greater detail about the works involved, the detailed economic assessment and sensitivity analyses used different parameters, arranged in the following groups:

- Technical parameters: that included, for each alternative, firm power, installed capacity, plant factor, transmission losses, and year of entry into service, among others.
- Financial assessment: this included verification of the discount rate, percentage of indebtedness, interest rate, and loan period, amortization, and payment of dividends, assessment horizon, and income tax rate.
- Costs: including operation and maintenance, administration and sales, CDEC, VAT, annual tax and financial depreciation rate, equipment operation and maintenance.
- Energy production: analysis of monthly energy volumes produced by each power plant.
- Energy sales per contract: shows the volume of monthly energy sales for particular contracts.
- Selling prices: includes estimated energy and power selling prices.
- Investments: includes capital costs of each power plant, acquisition costs for property and easements, costs of studies and engineering, procurement costs, construction management and investment costs.

Environmental criteria

In the initial analyses and configurations of the hydroelectric scheme, hydrology and geology were included as essential factors in determining the feasibility of the Project. Once more viable alternatives had been identified from a technical and economic perspective, environmental criteria were used to modulate the feasibility analysis and narrow down potential alternatives.

The environmental components considered were those used in the environmental impact assessment process for investment projects, as set out in Law 19.300 on the General Environmental Framework and in MINSEGPRES D.S. 95/2001, Regulations of the Environmental Impact Assessment System (SEIA), with due consideration given to the following components and their associated characteristics:

- Physical environment
- Human environment
- Built environment
- The use of environmental elements contained in the Project's area of influence
- Natural and artificial elements that comprise the historic, archeological, anthro-archeological, paleontological, and religious heritage, and all those that comprise the cultural heritage in general
- The landscape
- Areas where contingencies may be generated on the population and/or the environment among others.
- Key considerations related to environmental provisions applicable to the Project.

It should be noted that the depth and detail in which these components were examined during the different stages and evolution of the Project's configuration and engineering increased over time.

Thus, at the feasibility level the most important environmental aspects were identified and characterized in order to allow the impact assessment to be carried out. These key environmental aspects were as follows:

- Hydrology and Limnology: the PHAM makes use of water resources in the basins of the Volcán, Yeso and Colorado rivers, where the Project Owner holds water Rights. All of them are tributaries of the Maipo River.
- Water Quality: the quality of water in the upper Maipo River basin varies according to the stream or sub basin in question. In this regard, the El Yeso – La Negra – Lo Encañado lake system is notable for the high quality of water, given that it constitutes the main source of drinking water for Greater Santiago.

- **Specific Land Use Declarations:** The area of study lies within the Municipality of San José de Maipo, which is subject to the provisions of the Metropolitan Santiago Master Plan (PRMS) which sets out zoning requirements for Areas of Ecological Preservation. The Plan also establishes an Area of Ecological Protection with Controlled Development, which mandates the preservation of the natural environment. Also notable in this regard are the declarations and ordinances of the Municipality of San José de Maipo related to zones of interest for tourism.

In the initial Project alternatives, the assessment of impacts was conducted on the basis of those components that could evidently be affected by the Project itself, and configurations were ruled out that presented significant impacts that would be difficult to mitigate or that were defined *a priori* to be unfeasible or unacceptable. As more information was collected in the field and more detailed engineering for the Project was formulated, a more in-depth assessment of impacts was carried out.

In this way, environmental impacts were gradually identified as the engineering of the PHAM advanced. The impacts identified for each environmental component were as follows:

Component	Impact identified	Observations
Social, Economic and Infrastructure	Improved electricity supply	Meeting the growing demand for electrical energy and minimizing Chile's energy dependence on foreign countries.
	Increase in available employment and local commerce	The generation of employment will minimize local and regional unemployment and increase the diversity of business activity.
	Alteration of local roads	Route G-25 between Puente Alto and San José de Maipo shows a growing volume of vehicle traffic.
Surface Water	Reduction of the surface flow rate in the Colorado River between the Alfalgal water intake and the discharge of the Las Lajas Power Plant	Permanent impact while the Project is in operation.
Groundwater	Probable reduction in the level and flow rates of groundwater underneath the segments of rivers and streams from which water is collected.	The recharging of aquifers from surface waterways could be affected. Ultimately, underground water capture along the length of the rivers affected could be impacted by the reduction in the levels and flow rates of groundwater.
Air Quality	Alteration in air quality due to emissions of particulate matter and combustion gases due to earth moving and the operation of vehicles and machines.	Controlled by mitigation measures during the construction phase.
Noise Levels	Increase in the noise level in inhabited places near Route G-25 in the Las Lajas sector	Controlled by mitigation measures during the construction phase.
Vegetation, Flora and Fauna	Loss of plant cover in the area around the Lajas Power Plant and its associated works.	The area that will be affected by the Project will be small, considering that most of the Project works are underground. The sector contains native sclerophyllous scrubland and forest. Plant formations important to the ecosystem and

Component	Impact identified	Observations
		currently limited in their distribution.
	Loss of plant cover due to the construction of access roads to the work sites.	Owing to the requirements for new roads.
Landscape and aesthetic value	Introduction of anthropic elements into the existing natural and semi-natural landscape.	Mainly roads, as most of the works are underground. Permanent impact.

As more information was collected from the field, which can be observed in the greater detail accompanying the alternatives for which environmental impact studies were prepared, changes in the courses and locations of Project works were made to mitigate or even prevent impacts identified. This is described in the analysis of alternatives for each power plant.

The alternative that was officially approved by the authorities includes environmental management measures that are intended to minimize, repair or compensate for the adverse effects of the PHAM.

Social and contextual criteria

During the analysis of the different alternatives of the PHAM, as the configuration and types of works became more certain, an effort was made to communicating and disseminating the Project to the community, public authorities and other stakeholders and interested parties. The intention was to enter into dialogue and forge agreements that were practical and responsible. Through these efforts, the main aspects and concerns were gathered from different stakeholder groups in the community, including public authorities, municipal actors, and local residents.

The following were the main concerns collected that influenced the configuration of the Project alternatives:

- Effects on third party water rights
- Control of sub-contractors
- Location of high voltage transmission lines
- Location of muck piles
- Effects of blasting
- Inconvenience caused by truck traffic
- Inconvenience caused by substations
- Effects on summer pastures and cattle drivers

- Impact on highland meadows
- Availability of water in the Aucayes Stream
- Environmental impact of road construction
- Respect for the rights of Aguas Andinas water company
- Effects on archeological sites
- Reductions and interference in flow rates in waterways
- Effects on third-party water intakes
- Effects on recreational and tourism activities

The successive alternatives gradually incorporated these concerns to a greater or lesser degree (some of them “historic” concerns). In some cases this involved changes to the design of the PHAM; in others it involved the adoption of measures to control, mitigate or compensate for impacts, where necessary. In the description of changes defined for each alternative and each of the power plants that are outlined in the chapters below, it can be seen how the previous concerns modified the alternatives over time.

The following section outlines the analysis that was undertaken for each of the two power plants, Alfalfal II and Las Lajas.

Alternatives for the Alfalfal II Power Plant

A reading of Table 1 allows one to visualize how the Alfalfal II Power Plant was modified over time in response to the application of the criteria described and the increasing availability of information. The main adjustments were made primarily in accordance with criteria of a technical (feasibility of water resource availability, geology), environmental (ecological flow rates, archeological sites, environmental value of the work sites, and others) and contextual nature (concern about ecological flow rates and summer pasturing sites, primarily).

The following paragraphs provide a description of the main elements (Project works and main parts) that were gradually modified in the successive alternatives, along with the criteria that determined those modifications.

Alfalfal II - Alternative 1

This alternative corresponds to the most preliminary level of the Project design (in 1990), and was based mainly on documentary information. Conceptually, the Project at this stage sought to take maximum advantage of the available water resources while taking into account local conditions that could affect the feasibility of the Project from an engineering standpoint (particularly the types of geological formations and how these could determine its configuration). In regard to the application of environmental criteria, it should be noted that the SEIA did not enter into operation until the late 1990s; before that time, environmental and social matters went relatively unaddressed. However, the same professionals who prepared the initial Project configuration had in-depth knowledge of the characteristics of the zone, as they had been in charge of the construction of the Alfalfal I Power Plant.

One notable aspect of this alternative is that it proposed a major intervention in the Yeso River valley, the main aspects of which are as follows:

- Raising the water level of Laguna Lo Encañado through the construction of a dam (approximately 70 m high) to bring the lake to the same level as the Yeso Reservoir and Laguna Negra.
- Connecting the abovementioned lakes to Laguna Lo Encañado (this would have increased the capacity of the Yeso Reservoir by around 100 million m³, but would have reduced the water level in Laguna Negra, returning the water after it was used for generation in the Las Lajas Power Plant).

It should be noted that this plan would have had an extensive area of intervention, was complicated in terms of its technical feasibility and even more so from the environmental and contextual perspectives (the Yeso Reservoir and Laguna Negra supply drinking water to the city of Santiago).

In regard to the water intakes in the Volcán River valley and its transport to the Yeso River valley, this alternative incorporated water from Las Cortaderas Stream as well as water collected from the Colina, La Engorda and El Morado Streams.

The water from the Volcán Tunnel flowed to Laguna Lo Encañado (which under this design was interconnected with Laguna Negra and the Yeso Reservoir), from where it would be channeled to the Alfalfal II Tunnel and the powerhouse cavern, situated on the left bank of the Colorado River facing the Alfalfal Power Plant.

While this configuration would have required more information collected in the field to define its feasibility and associated costs, the economic assessment concluded that it was profitable and even recommended that the company begin immediately to acquire the water rights, to negotiate with the entities involved (EMOS at that time, and other private parties) and to

conduct the basic studies. In regard to technical considerations, it acknowledged the risks associated with the geological complexes involved even while it always proposed that the Project have an underground design.

Alfalfal II – Alternative 2

In general, this alternative included technical and environmental criteria that modified the design in terms of the interconnection of the water bodies. This emerged because the quality of the water in Laguna Negra was found to be significantly different from that of the Yeso Reservoir and Laguna Lo Encañado. The first two of these were of much higher quality, which was important considering that they were used for human consumption (drinking water). Furthermore, the design recognizes the risk of intervening in Laguna Negra from a geotechnical and environmental perspective by extracting 100 million m³ and the resulting drop in the water reserve, which has a low recharge capacity.

Therefore, under this Alternative the Project works in the Yeso River valley were therefore modified, as follows:

- Diversion works to channel water from Laguna Negra: intake works, water channel and spillway into the Manzanito Stream, downstream of the Lo Encañado dam.
- Connection between the Yeso Reservoir discharge and Lo Encañado Reservoir inflow (reducing the dam to 33 m in height and 190 m in length at the crown).

The profitability of the Project was also analyzed, with and without the headworks from the tributaries of the Volcán River, as were the advantages of alternatives with and without a regulating reservoir (initially 270,000 m³). The economic assessment found that the more profitable design was the one that included the headworks from the Volcán River and the regulating reservoir, and the estimated economic results were found to be as favorable as Alternative 1.

In regard to the location of the powerhouse cavern, this was moved inside the same rock mass where the forebay of the Maitenes Power Plant is located. This was done in response to technical criteria, as this made it possible to deliver water to the Nueva Maitenes Power Plant, the alternative to the Las Lajas Power Plant that was later ruled out (this decision is explained in the chapter on the Analysis of Alternative 2 for Las Lajas).

Lastly, the Alfalfal II Alternative 2 points out the need to review the design and location of the penstock that connects the surge shaft with the powerhouse cavern, mainly owing to technical criteria (geological information).

Alfalfal II – Alternative 3

This Alternative is the outcome of the feasibility studies (2005), which enabled the incorporation of information from the field (technical, environmental and social aspects) to the initial design. An important point at this stage is that the feasibility study adds technical, environmental and economic criteria. The study's conclusion indicates the following:

- The scenario or configuration that was the most attractive from an economic perspective and in terms of profitability is the combination of power plants in series, Alfalfal II and Las Lajas, with a nominal output of 531 MW.
- The sensitivity analyses carried out with the economic indicators as a result of the potential risks inherent to the Project show that these indicators displayed limited variability and were reliable for decision making.
- The analysis of environmental aspects that was carried out reviewed the feasibility of the Project, although it recognized the need to address some issues and aspects early in the process in order to arrive at solutions that were satisfactory to the parties involved. These aspects were related to the existence of areas having different levels of legal protection, or areas close to the Project. Each situation was reviewed on its merits, which included a legal-environmental analysis. It was concluded that none of the scenarios made the implementation of the PHAM impossible, but they would require the corresponding public agencies to be informed of certain aspects, such as the following:
 - The Project is sited in an area of Ecological Preservation. In this regard, meetings were subsequently held with the sectorial authority (SEREMI of Housing and Planning for the Metropolitan Region) in order to present the PHAM and explain that it would not interfere with the objectives of ecological preservation of the areas involved.
 - El Morado Natural Monument and the presence of Priority Sites for Biodiversity Conservation: talks with CONAMA and CONAF to present the aspects of the Project related to areas of ecological importance.
 - El Morado Natural Monument: it was recommended that above-ground Project activities be carried out outside of the boundaries established for this protected area, particularly all activities related to the installation of work sites, material deposits and muck piles, and roads, among other elements.
 - Regarding the designation of the entire Municipality of San José de Maipo as a Zone of Interest for Tourism: meetings were held with stakeholders (private entities and individuals involved in tourism activities) to inform them of the features of the Project and the measures that had been considered to minimize its impact on these activities.

Given these considerations, this Alternative of the PHAM included the following aspects:

Water intake in the Volcán River Valley: the environmental value of the summer pastures in this zone were recognized and it was recommended that the water intake works be designed to minimize any intervention in the pastures (water intakes located as far downstream as possible to minimize the effect on the area's natural drainage).

Conduit from the Volcán Tunnel and into the Alfalfal II Tunnel: involves the following works:

- Conduit to Laguna lo Encañado: vaulted channel 2.9 km long that receives the water delivered by the Yeso siphon and channels it to Laguna Lo Encañado.
- Laguna Lo Encañado: allows hourly regulation of the flow entering the Alfalfal II Power Plant. The increase in the water level of Laguna Lo Encañado is reduced (a 2.5 m high retaining wall 300 m long at the crown)
- Lo Encañado water intake: a reinforced concrete water intake rated for 27 m³/s submerged, to collect water from Laguna Lo Encañado and deliver it to the Alfalfal II Tunnel and then to the power plant.

For its part, the regulating reservoir had its capacity increased significantly owing to design criteria (technical), and was sited between the existing road to the Alfalfal I Power Plant and the Colorado River, excavated from the land, with a volume of 518,000 m³ and covering an area of approximately 12 ha.

This Alternative does not offer more detailed descriptions of construction aspects of Project works and activities, but it does provide criteria for the location and environmental management of certain aspects, mainly worker camps, muck piles, potential sites of archeological value, and other aspects.

Alfalfal II - Alternative 4

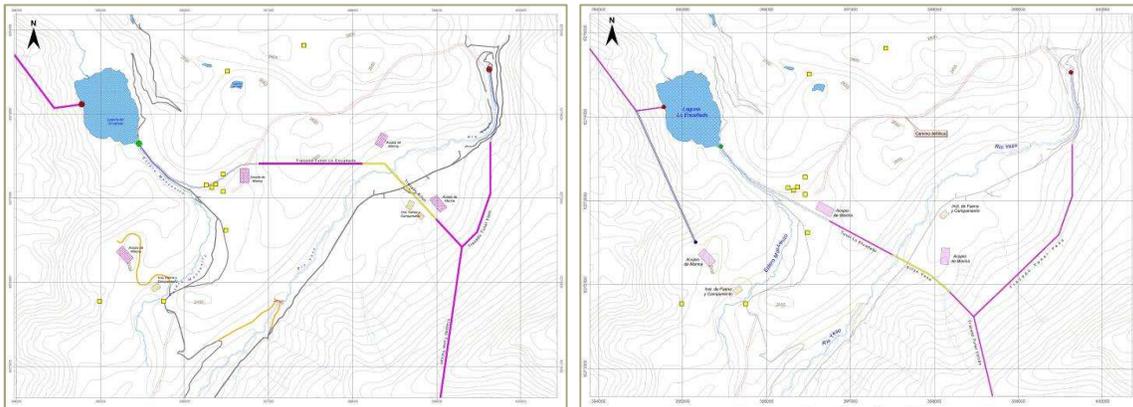
This Alternative includes environmental and contextual criteria in its design based on information collected in the field, which enabled the basic engineering to be defined and a description of the Project to be formulated for inclusion in the Environmental Impact Study of the Alto Maipo Hydroelectric Project, submitted to the SEIA in June 2007.

The main difference that this Alternative offers is that the final design does not include a reservoir in the Lo Encañado sector, although it continues to make use of Laguna Lo Encañado as a forebay and for hourly regulation of the Alfalfal II Power Plant. The decision to remove the embankment of the Laguna was made in consideration of the environmental sensitivity of

the area (different levels of protection in the area in which the PHAM is located, scenic value, environmental value of the area, and other factors).

For their part, the baseline studies provided more detailed information about the characteristics of the different areas in which the main and secondary Project works would be located. It defined the most important environmental criteria as the presence of high mountain meadows and summer pastures and the existence of elements of cultural heritage. Owing to these considerations, the following adjustments were made to the works and general layout of the PHAM:

- High mountain water intakes located in the summer pastures and high mountain meadows: while this aspect was taken into account in the previous alternative, using information collected in the field it became possible to improve the design even more, minimizing the intervention and effects on related vegetation. The adjustments made to the Project works allowed the continuation of the surface and sub-surface runoff of the water that irrigates the vegetation layer of the Andean scrubland in this sector.
- Change in the route of the Yeso River crossing: in the field, a segment of the Inca Trail was identified.³ Initially the plan was to cross the Yeso River using the same flat area that is crossed by a branch of the Inca Trail running Northeast/Southwest. While the site has already been affected by the construction of an aqueduct, currently in disuse, the works were adapted to prevent any intervention and to distance the Project from all identified archeological sites in the area.



³ According to the EIS of 2007, this corresponds to a branch of the *capac ñam* (Inka Trail) located between the Yeso River and the Manzanito Stream. The trail connected two Andean valleys in pre-Hispanic and colonial times and is approximately 4 km long in total. The trail is a cleared area 0.5 m to 3 meters across with sand and rock along its edges. It is remarkable for its straightness, orientation and small change in altitude, all features which are typical of the Inca Trail. No associated features were identified except for the Inca site called “Laguna del Indio,” located approximately 1.5 km northeast of the Project area.

Figures 2 and 3. Change in the course of the works associated with the Yeso River crossing in response to the discovery (Branch of the Inca Trail). Modification of the Project in order to ensure the preservation and protection of the cultural heritage.

For its part, the elimination of the embankment for Laguna Lo Encañado caused a change in the regulating reservoir, which was re-sited to the west of the current Alfalfal I Power Plant, and given a total capacity of 425,000 m³. The design of this tank allows it to operate as a forebay for the Las Lajas Power Plant.

Due to technical considerations, it was necessary to change the location of the powerhouse cavern of the Alfalfal II Power Plant, moving it to a cavern excavated from the rock mass to the West of Aucayes Stream in the Colorado River valley.

Alfalfal II - Alternative 5

This Alternative was the one that was included in the EIS submitted for environmental assessment in 2008, which corresponds to the Project authorized under RCA 256. In this alternative, modifications are introduced in the design of the previous Alternative 4, related specifically to:

Upper Volcán System: in the conduit towards the Yeso valley, the use of water from Las Cortaderas canyon is eliminated in order to help maintain the ecological flow rate in the area of the Yeso River identified as an Area of Environmental Importance (AIA) in the study of ecological flow rates conducted for the Project (Annex 17 of the EIS).

Project works in the Yeso River Valley: the main difference is the elimination of Laguna Lo Encañado from the PHAM. While the previous alternative had eliminated the embankment, the intervention in the lake continued to be a point of contention. Without the lake serving as a forebay, it was necessary to incorporate a forebay for the Alfalfal II Power Plant, in order to lend stability to the hydraulic system of the power plant. This forebay also acts as the expansion chamber for the surge shaft. The forebay is located in the Alto Aucayes sector around 2 km west of that stream at an altitude of 2450 m.a.s.l. The forebay has a total volume of 48,100 m³ and will be completely excavated from the rock.

Water will be supplied to the forebay through a connection with the Alfalfal II Tunnel, which delivers water from the Yeso River intake and the Volcán Tunnel.

Additionally in this alternative, meetings were held with representatives of public agencies with jurisdiction in environmental matters related to the Project and with local institutions and entities, as reported in the EIS that was submitted.

The main concerns that were collected in that process regarding the Project are:

- The location of the Project in an Area of Ecological Preservation defined in the Metropolitan Santiago Master Plan (PRMS). In this regard, it was necessary to demonstrate that the Project complies with current land use planning provisions and meets all of the requirements indicated in the PRMS.
- The need for muck piles to be sited so as not to affect hydrographic basins.
- Effects on protected flora and fauna species: implementation of rescue and relocation plans under the technical supervision of qualified professionals and the implementation of an environmental follow up plan that would ensure the survival of these species.
- Ensuring the wetness and continuity of drainage in the area of high mountain meadows: mentioned above.
- No Effect on El Morado Natural Monument: the Volcán Tunnel will cross underneath the monument at a depth of around 600 meters and has no access windows, roads or other installations that could affect this protected area.
- Prioritize hiring of local labor: hiring local workforce during Project construction.

In addition, the Project collected the concerns of the community while the EIS was being prepared through a series of approaches to members of the community who were interested in the Project. These sessions consisted of open assemblies, meetings, and interviews, from which the concerns expressed by community members were collected (see Annex 44 of the 2008 EIS)

The main concerns expressed by local communities and their implications for the Project are as follows:

- Risk of avalanches: The Project incorporated the avalanche risk probability as an essential condition of its design criteria for locating works.
- Effects on Tourism: While no effects on tourism are expected, the PHAM includes compensation measures to promote tourism development.
- Effects on third party water rights and the need for ecological flows: addressing this is a requirement under current legislation.
- Control of sub-contractors: strict contractual control of subcontractors is required to ensure that environmental provisions are met by sub-contractors.
- Location of muck piles: the Project includes 14 muck pile sites. Their final location will take into account the distance from human settlements and both seasonal and permanent

dwellings, will favor zones with low visual impact with natural elevations, zones with low soil value, and be distant from waterways.

- Effects of blasting: no significant effects are expected.
- Inconvenience caused by trucks: the Project envisions a series of measures to mitigate atmospheric emissions and the traffic impact associated with truck traffic.
- Visual impact of the electrical substation: the Project envisions a series of measures to mitigate the visual impact of the S/S (encapsulated substation design).
- Loss of animals due to theft and road accidents: subcontractors will be required to meet special contractual provisions to avoid this and to coordinate activities with herders and cattle drivers.
- Effects on the summer pastures and cattle drivers: in addition to the Project's design elements, the PHAM includes environmental monitoring of these formations.
- Availability of water in the Aucayes Stream: defined by third party water rights and the ecological flow rates validated by the authorities.
- Environmental impact of road construction: definition of control measures for environmental components- air, noise, soil, flora and fauna- associated with the layout and construction of roads.
- Effects on archeological sites: actions have been planned in case any finds of this nature occur during construction of Project works.
- Reduction of flow rates and interference with other activities: this issue was reviewed and consultations with the authorities were held during processing of the EIS. The conclusion was that no significant alteration of these environmental elements would occur as a result of the Project.
- Effects on third party water intakes: the PHAM includes provisions to ensure that the water intakes of third parties, where present, will not be undermined as a result of the Project.

It should be mentioned that, after environmental approval of the Project was granted, a series of minor adjustments were made to address concerns expressed by the community and the authorities. Notable among these is concern about the effects on rivers of the uncontrolled discharge of water from the power plants (each plant separately, or both in the case of a blackout of the SIC). This meant that a series of studies had to be carried out and elements incorporated into the design, such as control devices and instrumentation, implementation of a communication system, and the definition of operating protocols, such that:

- a) the continuity of the flow rate of the Maipo River will be maintained downriver of the discharge works
- b) “water hammers” will be prevented on the Maipo River downriver of the discharge works

In the case of the Alfalfal II Power Plant, when the plant is operating at peak load and stops suddenly, the flow of 27 m³/s that this plant delivers to the Las Lajas Power Plant will be cut, and therefore the latter plant will be supplied solely by the total flow of 38 m³/s transferred from the Alfalfal I Power Plant (30 m³/s) and the Maitenes water intake (8 m³/s).

For its part, the flow of 27 m³/s that is not used by the Alfalfal II Power Plant and that comes from the Yeso and Volcán headworks will be discharged into the Yeso River and will reach the Maipo River and continue along its course. The water discharged into the Yeso River will not reach the discharge point of the Las Lajas Power Plant until 5.1 hours after the wave has begun, 5.7 hours when it is at peak. According to the studies conducted, the wave caused by the increase in the flow rate will move at an average speed of 3 m/s, similar to the natural flow regime of these kinds of rivers. The flow discharged into the Yeso River will increase gradually until reaching the flow rate of 27 m³/s.

To offset the flow that will not be contributed by the Alfalfal II Power Plant, the Las Lajas Power Plant will have a volume of 300,000 m³ stored in its forebay and a volume of 270,000 m³ inside the tailrace tunnel, controlled by sluice gates. Therefore, there will be a total volume of 570,000 m³ that can be used to regulate the flow of the Maipo River downriver of the power plant discharge point during the time it will take the remaining 27 m³ that was contributed by the Alfalfal II plant to reach this point.

In consequence, where the Alfalfal II Power Plant experiences a stoppage, it will still be possible, for the entire time this temporary phenomenon occurs, to maintain the flow rate of the Maipo River downriver of the Las Lajas Power Plant discharge point.

In the case of a blackout, i.e. when both power plants stop operating simultaneously, the flows to both that were used for generation will be discharged through spillways located on the Yeso and Colorado rivers.

At the same instant, the Las Lajas Power Plant will go into by-pass mode, delivering up to 50% of the design flow of this plant (65 m³/s) through the use of jet deflectors, and occupying the volume of water accumulated in both the forebay and the tailrace tunnel, according to the operating sequence displayed in the table below:

Table 4. Power Plant Operating Sequence during Blackout

Tiempo min	Tiempo horas	C.Carga m3	Tunel Desc. m3	Alfalfal II		Las Lajas				En rio Maipo m3/s	Comentarios
				Q Yeso + Vocan (m3/s)		Q Col (m3/s)		Central m3/s	Descarga m3/s		
				Rio	Captacion	Rio en Capt.	Captacion				
-1		300.000	270.000	0,0	27,0	0,0	38,0	65,0	65,0	65	
0	0,0	300.000	270.000	27,0	0,0	32,5	5,5	32,5	65,0	65	blackout
15	0,3	275.700	240.750	27,0	0,0	32,5	5,5	32,5	65,0	65	
30	0,5	251.400	211.500	27,0	0,0	32,5	5,5	32,5	65,0	65	
45	0,8	227.100	182.250	27,0	0,0	32,5	5,5	32,5	65,0	65	
60	1,0	202.800	153.000	27,0	0,0	32,5	5,5	32,5	65,0	65	
75	1,3	178.500	123.750	27,0	0,0	32,5	5,5	32,5	65,0	65	
90	1,5	154.200	94.500	27,0	0,0	32,5	5,5	32,5	65,0	65	
105	1,8	129.900	65.250	27,0	0,0	32,5	5,5	32,5	65,0	65	
120	2,0	105.600	36.000	27,0	0,0	32,5	5,5	32,5	65,0	65	
135	2,3	81.300	6.750	27,0	0,0	32,5	5,5	32,5	65,0	65	
150	2,5	57.000	6.750	27,0	0,0	32,5	5,5	32,5	32,5	32,5	
165	2,8	32.700	6.750	27,0	0,0	32,5	5,5	32,5	32,5	32,5	Llega Onda Col.
174	2,9	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	Peak Onda Col.
175	2,9	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	
195	3,3	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	
210	3,5	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	
225	3,8	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	
240	4,0	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	
255	4,3	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	
270	4,5	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	
285	4,8	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	
300	5,0	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	
305	5,1	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	Llega Onda Yeso
342	5,7	32.700	6.750	27,0	0,0	5,5	32,5	32,5	32,5	65	Peak Onda Yeso
343	5,7	32.700	6.750	27,0	0,0	5,5	32,5	0,0	0,0	65	
360	6	32.700	6.750	27,0	0,0	5,5	32,5	0,0	0,0	65	

Lastly, it should be mentioned that the reserve volumes will be recovered using an operating protocol that is the inverse of that described above, so that the delivery of water to the Maipo River will occur when its flows begin to decrease, as the delayed effect of reopening the water intakes becomes evident at the point where the water is to be reintroduced into the Maipo River. The principle of this operation is exactly the same, which is not to alter the flow regime of the Maipo River at the water collection points used by third parties downriver.

Thus, as indicated initially, after the environmental permit was obtained and the configuration of Alternative 5 was chosen as the final one for the Project, a series of adjustments were made to the PHAM, some because of technical criteria and others in response to requests made by the authorities, which were not modifications subject to assessment by the SEIA. Notable among these are the reduction in volume of the Alfalfal II forebay, the relocation of the La Engorda water intake, the elimination of the intake weir, and the change in the altitude of the turbine.

Summary of Alternatives for the Alfalfal II Power Plant

Table 5 below summarizes the analysis of alternatives according to the different criteria used for each of them:

different Alternatives for the Alfalfal II Power Plant

Criteria	Analysis of Economic Criteria	Analysis of Environmental Criteria	Analysis of Contextual Criteria (community, general public)
<p>ation of geological aspects in the field, as comprised of run-of-river power series in which most of the works and ground. This alternative prioritizes a rational use of water resources from a generating perspective (collection of water zones in the Volcán River valley, from Las Cortaderas canyon and So River valley, interconnection of the Laguna Negra and Laguna Lo Encañado).</p>	<p>Given the problem with the supply of natural gas from Argentina and the comparative advantages of the PHAM (mainly due to its strategic location close to consumption centers and the security it implies for the electricity supply of the SIC at a time when demand is growing), the Project is seen as more feasible and worth advancing. Subsequently, after reviewing the specific economic criteria (according to the firm power and other characteristics of the project and the market), the advantages of the PHAM in regard to its profitability become clear.</p> <p>The PHAM was designed from the beginning as power plants in series, where profitability was based on the operation of both plants. In this regard, no alternatives to the Alfalfal II Power Plant were considered.</p>	<p>This alternative prioritizes the design based on the rationalization of water resources from a hydraulic and generating perspective.</p> <p>The Project recognizes the main environmental aspects that could directly impact its design and profitability (geology, feasibility of water availability, high mountain environment, etc.).</p>	<p>The existence of other AES Gener projects since the beginning of the previous century (Cordillera Complex, including the Alfalfal I, Maitenes, Queltehues and Volcán power plants and their associated transmission lines and substations) means that the company has a history of interacting with the local community.</p>
<p>interconnection of water bodies, among other intervention in Laguna Negra</p> <p>on of the powerhouse cavern (it is a rock mass where the Maitenes Powerhouse cavern) in order to connect with the power plant in later series.</p>	<p>The profitability of the Project was analyzed with and without the capture of water from the tributaries of the Volcán River, and with and without the regulating reservoir (initially with a volume of 270,000 m³). The economic assessment found that the most profitable configuration was to be found in the alternatives with the water from the Volcán River tributaries and with the inclusion of the regulating reservoir. The economic results indicated its profitability, as in Alternative 1.</p>	<p>Taking into consideration the high quality of the water of Laguna Negra in comparison to the Yeso Reservoir and Laguna Lo Encañado, and the fact that this water is for human consumption (drinking water), the decision is made not to intervene in Laguna Negra, and the interconnection of these water bodies is eliminated from the Project.</p>	<p>The details of this alternative were not disseminated as its configuration was still very basic.</p>

Criteria	Analysis of Economic Criteria	Analysis of Environmental Criteria	Analysis of Contextual Criteria (community, general public)
<p>Technical criteria obtained from basic information collected in the field. Availability of the projected underground advantage of the water resources on the basis of feasibility information from comparative analyses and studies.</p>	<p>The sensitivity analyses carried out for the economic indicators on potential risks inherent to the Project showed that the range of the indicators was very limited and reliable for decision making.</p> <p>The scenario or configuration for using the water resources that was the most attractive from an economic and profitability perspective was the combination of the Alfalfal II and Las Lajas Power Plants in series with a total nominal output of 531 MW.</p>	<p>Using information collected in the field it was possible to formulate detailed environmental criteria. Notable among these were the presence of areas of environmental value (areas with some level of legal protection, declarations of tourism zones, the presence of high mountain meadows and summer pastures, the identification of the environmental value of the Lo Encañado sector, etc.). Based on these, this alternative presented adjustments such as: improvements to the high mountain intake works located in the basin of the Volcán River and a reduction in the height of the embankment to raise the water level of Laguna Lo Encañado. Thus, the Project would not affect the normal supply of drinking water required by the water company. The sensitivity of the ecological flow rates is recognized, as well as their potential further limitation with consideration for environmental issues.</p>	<p>Given the identification of areas with different levels of legal protection, or sensitive areas near the Project works, the main singularities of the zone in which the Project would be located were analyzed with the corresponding official entities in order to ensure that the Project took into account any concerns that could arise in this regard.</p>

Criteria	Analysis of Economic Criteria	Analysis of Environmental Criteria	Analysis of Contextual Criteria (community, general public)
<p>that this alternative presents is that not envision a reservoir in the Lo though it does continue using Laguna ebay and for hourly regulation of the t.</p> <p>the embankment to raise the water level do provoked a change in the which was sited west of the current ; with a total capacity of 425,000 m³. k allows it to operate as a forebay for Plant.</p>	<p>The profitability conditions remain the same, and no notable economic elements were modified in this alternative.</p>	<p>The decision to remove the embankment to raise the water level of the Laguna was made because of the environmental sensitivity of the area (different levels of legal protection in the PHAM project area, landscape value, environmental value of the area, and other considerations).</p> <p>Elements of cultural heritage were identified that required, for example, modifications to the planned route of the works crossing the Yeso River to avoid intervening in a branch of the Inca Trail.</p> <p>In regard to the high mountain water intakes located in the summer pastures and high mountain meadows, the design of the water intakes was improved even more to minimize intervention in this zone and in its associated vegetation.</p>	<p>A series of meetings was held with different stakeholder groups in the community, represented by various authorities and municipal figures. This was carried out in two stages- a preliminary stage prior to the formal public participation process required for the EIS subject to assessment, and a 60-day period of formal public participation as stipulated by the Rules of the SEIA. In response to concerns that arose, a series of improvements and modifications were made to the Project.</p>

Criteria	Analysis of Economic Criteria	Analysis of Environmental Criteria	Analysis of Contextual Criteria (community, general public)
<p>ental value of the Lo Encañado sector veys and reflected in the interest unity), this alternative eliminates the una Lo Encañado. This leads to a series ain one of which is the introduction lfalfal II Power Plant to lend stability hydraulic system. This water body ansion chamber for the surge shaft. d in the Alto Aucayes sector, some 2 m at an altitude of 2450 m.a.s.l. The total volume of 48,100 m³, will be d from the rock.</p>	<p>The profitability conditions remain the same, and no notable economic elements were modified in this alternative.</p>	<p>In addition to the environmental criteria assessed by experts, the contextual criteria enabled the community to make known their assessment and the company to respond to their legitimate concerns. It should be noted that this alternative was able to incorporate these issues because of the two-stage public participation process that was carried out - both preliminary and formal—in the context of the presentation of the previous EIS (2007) to the SEIA. The main concerns and the company’s responses are outlined in the description of this alternative contained in this chapter.</p> <p>The use of water resources from Las Cortaderas canyon is eliminated in order to preserve the ecological flow regime of the Yeso River zone, identified as a zone of environmental importance (AIA) in the study of ecological flow rates carried out for the Project (Annex 17 of the EIS).</p> <p>It bears mention that, since the Project was granted its environmental permit, the company has continued to receive concerns from the authorities and the community and in response has made additional adjustments to the chosen Alternative 5. Notable in this process is the concern about the potential effects on the rivers involved of sudden stoppages in the operation of the power plants (either individually or both, in the case of a blackout in the SIC). To address this, control devices and instrumentation were incorporated into the Project, a Communication System was implemented, and operating protocols for these situations were defined, such that:</p> <p>a) the continuity of the flow regime of the Maipo River would be maintained downriver of the discharge work b) “Water hammers” would be prevented on the Maipo River downriver of the discharge works</p>	

Alternatives for the Las Lajas Power Plant

As for the Alfalfal II Power Plant, Table 6 below summarizes the main changes in the works and parts of the Las Lajas Power Plant for each of the different alternatives analyzed.

The main adjustments were carried out mainly in response to criteria that were technical (feasibility in terms of water and geological resources), environmental (mainly ecological flow) and contextual (location of the powerhouse cavern, point at which the water was returned to the river).

The sections below describe the main elements (main works and parts of the Project) that were modified in the different alternatives, along with the criteria that were applied to configure them.

Las Lajas Alternative 1

This alternative, like Alternative 1 of the Alfalfal II Power Plant, corresponds to the most preliminary design of the Project (1990), and was based mainly on documentary information. As mentioned, it sought to maximize the use of available water resources while taking into account local conditions that could affect the feasibility of the Project from an engineering standpoint (particularly geological features and how these would define the Project's configuration).

The general scheme of this power plant involves capturing the water discharged from the Alfalfal I and II power plants and incorporating additional resources from the intermediate basin of the Colorado River and the intake of the Maitenes Power Plant, and channeling this water across the Colorado River and into Las Lajas Tunnel, by the surge shaft, through the penstock and powerhouse cavern, and finally to the Las Lajas tailrace tunnel.

Under this alternative, the works channeling water to the Las Lajas Tunnel begin at the discharge of the Alfalfal II Power Plant, where water is collected from the spillways of the operating plants then channeled into a pressure tunnel 15.4 m long.

The powerhouse cavern is located in the rock mass on the left bank of the Colorado River, approximately 5 km from its confluence with the Maipo River. This location was subsequently changed, as will be explained below. The aqueduct discharging the water into the Maipo River is 9.8 km long and crosses underneath the Colorado River and the El Manzano Stream. The discharge spillway is at Las Lajas (on the right bank of the Maipo River downriver from its confluence with the El Manzano Stream). No regulating reservoir is included in the design.

While this configuration would require more information from the field to define its feasibility and associated costs, the economic assessment indicated that it was profitable and even recommended that basic studies be initiated. In regard to technical considerations, the risks associated with the geological complexes are recognized, although the design was always based on underground works.

Las Lajas Alternative 2

More information collected in the field is incorporated, improving the design from a technical standpoint (mainly hydraulics, with additional detail about geological aspects). This involves water from the Alfalfal I, Alfalfal II and Nueva Maitenes Power Plants (the plant that was studied as complementary in the PHAM, which uses water from the intermediate basin of the Colorado River, which comes from the existing Maitenes Power Plant and from Aucayes Stream).

This alternative includes a forebay of 10,000 m³ and the Las Lajas siphon, which crosses underneath the Colorado River to the right bank. The pressure tunnel, 9.9 m long, runs from the right bank of the Colorado River to the El Manzano Stream valley. It ends at a vertical shaft that connects to the powerhouse cavern which was designed to have a minimum rock ceiling, be distant from fault lines, and located 700 m from the El Manzano streambed. The tailrace tunnel was envisioned as an aqueduct that crosses underneath the streambed of the El Manzano Stream with an outlet at the Maipo River in front of the Las Lajas substation. It included a regulating reservoir with a capacity of 270,000 m³ located on flat land between the El Toro and El Canelo ravines on the right bank of the Maipo River.

With greater precision about the works, the Project's profitability was reassessed and found to be the same as the initial alternative, and it was therefore recommended that the feasibility studies for the projected configuration be carried out.

Las Lajas Alternative 3

As in the case of Alternative 3 of the Alfalfal II Power Plant, Alternative 3 for the Las Lajas Power Plant emerged as a result of feasibility studies (2005), which allowed information collected in the field to be incorporated (on technical, environmental, and social aspects) into the initial design. In that regard, the general definitions provided for Alfalfal II apply in the same way to the Las Lajas Power Plant.

After the results of the feasibility study, it was determined that the scenario or configuration that was the most attractive from an economic and profitability perspective was the

combination of the two plants in series, meaning the Alfalfal II and Las Lajas Power Plants, as construction of the Nueva Maitenes plant was ruled out.

This Alternative involved building a free-flowing channel 2.4 km long to channel the water collected from the spillway of the Alfalfal I Power Plant to the regulating reservoir of the Alfalfal II Power Plant, which would operate as a forebay for the Las Lajas Power Plant. A steel tubular siphon 152 m long would be used to transport the water across the Colorado River. The siphon would be located underneath the riverbed and covered with protective rockfill. For its part, the Las Lajas Tunnel, 22.2 km long, is a pressure tunnel that channels the water to the surge shaft at the top of the penstock, from where it flows into the powerhouse of Las Lajas Power Plant, located inside the El Manzano rock mass between the Colorado River and the El Manzano Stream.

To discharge the water from the power plant and return it to the Maipo River, this Alternative envisions a 4-km long tailrace tunnel that becomes a channel in the final stretch. A regulating reservoir with a useful volume of 425,000 m³ and an approximate area of 14 ha is also included at the outlet of the tailrace tunnel of the Las Lajas Power Plant. The final location of this reservoir was chosen because it is in a section of the Maipo River that is already impacted by human activity.

Las Lajas Alternative 4

In its design, this alternative adds mainly technical criteria that are intended to optimize the use of water resources.

The main difference in this Alternative is the use of water from the Quempo Stream (1 m³/s), as well as contributions from the Aucayes Stream (2 m³/s). It does not include a regulating reservoir. This design was included in the Project description in the EIS of the Alto Maipo Hydroelectric Project, submitted to the SEIA in June 2007.

Las Lajas Alternative 5

This alternative was incorporated into the EIS that was submitted for environmental assessment in 2008, and corresponds to the Project configuration that was ultimately approved under RCA 256. In this Alternative modifications are made to the design of Alternative 4, related to:

- *Forebay*: also operating as a regulating reservoir for the Alfalfal II Power Plant. Its location is planned for the right bank of the Colorado River and is partly excavated from rock and partly using embankments. The useful volume of the tank is 300,000 m³ (in the previous

alternative, the volume was 425,000 m³), and it covers an area of 75,000 m². The design also includes the installation of an impermeable membrane across the entire surface of the tank and a concrete floor on the bottom, as well as works for evacuation and for security.

- *Change in the location of the powerhouse:* this was moved to the left bank of the Colorado River (near El Sauce Stream) in a cavern excavated from the rock mass. This change in location was made in response to concerns expressed by residents of El Manzano community.

In effect, the Project, mindful of the environmental sensitivity of the El Manzano sector (essentially its social component), had to review feasible alternatives from a technical and construction standpoint as well as conduct new environmental studies before relocating the powerhouse cavern. In the end, based on the results of drilling and engineering studies, it was possible to assess alternate locations for the powerhouse of the Las Lajas Power Plant and, consequently, the electrical substation and control building, which had previously been sited in the El Manzano sector. The access window originally located in this sector was also eliminated, which in turn eliminated the work site, and hence the vehicle traffic associated with it.

All of the above was done in response to concerns expressed by residents of El Manzano, who expressed their disagreement with the works planned in the area, even though these complied with legal and regulatory provisions in force in regard to their construction and operation.

The adjustments described involved a rectification in the course of the Las Lajas and Alfalfa II tunnels and the relocation of some access windows, which in turn caused the relocation of certain stretches of access roads and muck pile locations.

- *Tailrace tunnel of the Las Lajas Power Plant:* designed to discharge water directly into the Maipo River. This free-flowing tunnel is 13.3 km long and 35 m² in horseshoe cross-section and excavated from the rock.

The final discharge point of the flows generated by the Las Lajas Power Plant into the Maipo River is located downriver of the confluence of the river with El Manzano Stream, in the sector called Las Lajas. This discharge point is envisioned as a channel excavated from the rock, and is 7.0 m wide at the base.

It should be noted that the Las Lajas Power Plant was planned for an area (El Manzano) with a higher population density. Given this situation, after listening to the concerns of the community regarding the other alternatives studied, as well as those of the local and regional authorities, the Project's control measures were adjusted, mainly in regard to minimizing the effects on road traffic, noise impacts during the construction phase, the effects on water

quality during the construction of bridges and other interventions in waterways, the operation of workers camps, intervention in flora and fauna, etc.

Following environmental criteria, the Project eliminates the collection of water from the Quempo Stream, which was always included in the PHAM. The decision was made to ensure the ecological flow rate of the Colorado River, which was defined not only based on water values but also on environmental ones, and considering the needs of other stakeholders.

In the alternative that was ultimately chosen, concerns that arose after the environmental permit was issued for the Project were also adjusted (incorporation of control devices and instrumentation, the implementation of a communications System, the definition of operating protocols, etc.) in order to counteract potential effects on the rivers involved when one or both of the power plants experiences a sudden stoppage (individually or both, in the case of a blackout in the SIC), such that:

- a) a) the continuity of the flow regime of the Maipo River would be maintained downriver of the discharge work
- b) “Water hammers” would be prevented on the Maipo River downriver of the discharge works.

Thus, if the Las Lajas Power Plant goes out of service, initially the water would flow into the Colorado River through a safety spillway that will be installed at the entrance to the forebay. Immediately afterwards, the Las Lajas Power Plant will go into by-pass mode, allowing a maximum flow of 32.5 m³/s (50% of the plant’s design flow rate) to pass through the turbines and leaving the other 38 m³/s from the Alfalfal I discharge and the Maitenes intake out of the system. In this way, using the volume of water available in the forebay and in the tailrace tunnel, as well as the jet deflectors, which would allow water to by-pass without being used for generation, the continuity of the flow regime of the Maipo River would be assured, provided that the predefined operating sequence is followed.

Therefore, as with the Alfalfal II Power Plant, as indicated initially, after the environmental permit was issued, and once Alternative 5 was established as the final configuration of the Project, a series of adjustments were made to the PHAM, some as a result of technical and other criteria and some in response to concerns expressed by the authorities. These were not modifications that were required under the SEIA. Notable among these was the change in the altitude of the turbine, the adjustments to the Maipo River spillway and the final stretch of the tailrace tunnel, the increase in the expansion chamber of the surge shaft of the Las Lajas Power Plant, the incorporation of gauging stations on the Maipo River upriver and downriver of the Maipo River spillway, and the use of jet deflectors during service stoppages of the Las Lajas Power Plant to control the release of water during potential operations.

Summary of Alternatives for the Lajas Power Plant

Table 6 below summarizes the analysis of alternatives according to the different criteria used for each one:

different Alternatives for the Las Lajas Power Plant.

Criteria	Analysis of Economic Criteria	Analysis of Environmental Criteria	Analysis of Contextual Criteria (community, general public)
<p>The verification of geological aspects in the field, the location of run-of-river power plants in hydraulic systems, and the majority of works and parts are sited in the area. This alternative prioritizes a design in which water is used efficiently from a hydraulic and generating perspective.</p>	<p>Given the problem with the supply of natural gas from Argentina and the comparative advantages of the PHAM (mainly due to its strategic location close to consumption centers and the security it implies for the electricity supply of the SIC at a time when demand is growing), the Project is seen as more feasible and worth advancing. Subsequently, after reviewing the specific economic criteria (according to the firm power and other characteristics of the project and the market), the advantages of the PHAM in regard to its profitability become clear.</p> <p>The PHAM was designed from the beginning to include power plants in series, where profitability was based on the operation of both plants. In the case of the Las Lajas Power Plant, the Project also considered adding another plant, called the Nueva Maitenes. However, as the Project was deemed profitable without the Nueva Maitenes plant, although it continued to be included in the plan in this Alternative, it was ultimately ruled out in the feasibility studies (Alternative 3).</p>	<p>This alternative prioritizes the design that makes most rational use of the water resources in terms of hydraulics and energy generation.</p> <p>The Project recognizes the main environmental aspects that could directly affect design and profitability (geology, feasibility of water availability, high mountain conditions, etc.).</p>	<p>The existence of other AES Gener projects since the beginning of the previous century (Cordillera Complex, including the Alfalfa I, Maitenes, Queltehues and Volcán power plants and their associated transmission lines and substations) means that the company has a history of interacting with the local community.</p>

Criteria	Analysis of Economic Criteria	Analysis of Environmental Criteria	Analysis of Contextual Criteria (community, general public)
<p>From the field, this alternative shows an design from a technical standpoint (mainly ore detail on geological aspects). It makes use of Alfal I, Alfal II and Nueva Maitenes plant, the is considered as a complement to the PHAM. It also is located in the intermediate basin of the Colorado River, downstream from the existing Maitenes Power Plant and dam).</p>	<p>With greater precision regarding the Project works, profitability could be analyzed more accurately, and this was deemed as attractive as the initial proposal. It was therefore recommended that feasibility studies be conducted on the configuration projected.</p>	<p>Environmental conditions applied were those related to the incorporation of water resources, considering conservative ecological flow regimes. Geological aspects and risk criteria were incorporated in the placement and design of Project works.</p>	<p>Details of this alternative were not disseminated as the configuration was still very basic.</p>

Criteria	Analysis of Economic Criteria	Analysis of Environmental Criteria	Analysis of Contextual Criteria (community, general public)
<p>Technical criteria obtained from basic studies conducted in the field.</p> <p>Priority of planning the design mainly underground, and the use of the water resources available based on the technical criteria and the respective analyses and studies.</p>	<p>As a result of the feasibility studies, it was determined that the most attractive scenario or configuration for making use of the water resources available, from an economic and profitability perspective, was the combination of the two plants –the Alfalfal II and Las Lajas –in series, ruling out the construction of the Nueva Maitenes plant.</p>	<p>The Las Lajas Power Plant is located in a place with a higher population density. As a result, the environmental criteria were assessed not only in technical terms but according to the value that local stakeholders give to the place because they live there, earn their livelihood there, and visit the place. In this regard, the alternatives studied made their adjustments based on the combination and interaction of environmental and contextual criteria.</p> <p>In light of the above, in this alternative consideration was given to siting the discharge works of the Las Lajas Power Plant in an already disturbed area on the Maipo River.</p>	

Criteria	Analysis of Economic Criteria	Analysis of Environmental Criteria	Analysis of Contextual Criteria (community, general public)
<p>criteria to the design that seek to optimize resources.</p> <p>the incorporation of water from the Quempo well as water from the Aucayes Stream (2) as a regulating reservoir.</p>	<p>The profitability conditions remain the same, and no notable economic elements were modified in this alternative.</p>	<p>In the preliminary public participation process to gather input from local and regional authorities, the PHAM was made aware of other uses and interests and identified key concerns, which were addressed through measures included in the design and operation of the Project.</p> <p>The main concern expressed for the operational phase of the Project was to ensure the availability of water for all verified users in the zone and respect for all legally constituted water rights. The Project was designed with ecological flow rates that took these needs into account.</p> <p>Another concern is related to the potential effects during construction of the PHAM, including the impact on road traffic, noise levels from blasting, water quality, particulate matter emissions, etc. This Alternative includes measures to control these aspects that are similar to those presented in the EIS submitted in 2008, which were assessed by the authorities and deemed to be adequate.</p>	

Criteria	Analysis of Economic Criteria	Analysis of Environmental Criteria	Analysis of Contextual Criteria (community, general public)
<p>Concerns expressed by the community, the powerhouse initially sited near the El Manzano sector was located on the bank of the Colorado River, in a cavern to be excavated from a muck mass, in the area of El Sauce Stream.</p> <p>Adjustments had to be made in the placement of the powerhouse and the control building. The course of the Las Lajas channels also had to be corrected, and some modifications were implemented, which in turn required the rerouting of the road and relocation of muck piles.</p>	<p>The profitability conditions remain the same, and no notable economic elements were modified in this alternative.</p>	<p>Residents of El Manzano expressed their dissatisfaction with the works planned in the area, even though these complied with legal and regulatory provisions in force in regard to their construction and operation. In response some feasible alternatives were reviewed from a technical and construction standpoint, and new environmental studies were carried out to change the location of the powerhouse cavern. Based on the results of drilling and engineering studies, it was possible to assess options for the relocation of the powerhouse cavern of the Las Lajas Power Plant and make the consequent modifications to related works.</p> <p>Also notable in this alternative is that the Quempeo Stream intake was eliminated in order to guarantee the ecological flow defined for the Colorado River.</p> <p>Control measures for the Project were defined, mainly in regard to minimizing the impact on road traffic, acoustic impacts during construction, and effects on water quality during the construction of bridges and other interventions in waterways, the operation of worker camps, and the Project's impacts on vegetation and fauna, etc.</p> <p>As with the Alfalfal II Power Plant, stakeholder concerns were taken into account even after the environmental permit was obtained, particularly those related to the Project's effects on rivers in the case of a sudden stoppage in the operation of the power plants. Control devices and instrumentation were incorporated to the design of this power plant also, as well as a communications system, and operating protocols, in order to counteract any potentially negative effects on the Maipo River.</p>	

Description of the Alternative Selected

The alternative selected, and the one that was approved by the Metropolitan Region Environmental Commission (COREMA), is described in Recital 3 of the Exempt Resolution approving the EIS of the PHAM. This Alternative is configured as follows:

Alfalfal II Power Plant

The Alfalfal II Power Plant, designed for a flow rate of 27 m³/s, receives water collected at the intakes on streams located in the upper Volcán River basin, then channels the water to the Yeso River valley through the Volcán Tunnel. In the Volcán River sector, a maximum of 12.8 m³/s will be collected through 4 water intakes that intercept different branches of the streams that ultimately flow together to form the northern arm of the Volcán River, which in turn flows into the Maipo River. The four streams from which water will be collected are the Engorda, Colina, Las Placas and El Morado. The flow collected will be channeled to the Volcán Tunnel along a buried aqueduct. The flows captured are degreaved at the intake points and desanded collectively before entering the Volcán Tunnel. The Volcán Tunnel receives the water collected in the area of the upper Volcán River and channels it to the Yeso River valley, where water from the Yeso River itself is added through a buried pipe located between the Yeso River intake and a weir located at the outlet of the Volcán Tunnel, where both flows meet.

From this weir the water is channeled to the Alfalfal II Tunnel along a pressurized head tunnel 13,600 m long until reaching the upper end of the penstock. Slightly upriver of the top of the penstock is the surge shaft and forebay of this power plant. The gross head of this plant is estimated at 1,146 m.

The powerhouse is installed in a cavern excavated from the rock massif west of the Aucayes Stream in the Colorado River valley.

The tailrace tunnel of the Alfalfal II Power Plant is approximately 2.5 km long and delivers its flow to the head tunnel of the Las Lajas Power Plant. The flows generated by the Alfalfal II Power Plant can be directed either directly to the powerhouse of the Las Lajas Power Plant or to the forebay of the plant, which is located on the right bank of the Colorado River. In both cases the water runs through the aforementioned tunnel.

Las Lajas Power Plant

The Las Lajas Power Plant is designed for a flow rate of 65 m³/s, and receives the waters used for generation in the Alfalfal and Alfalfal II Power Plants, as well as contributions from the intermediate basin of the Colorado River, between the intakes of the Alfalfal Power Plant (Colorado and Olivares) and the existing intake of the Maitenes Power Plant. Water from the Aucayes Stream is added to this.

The Las Lajas Power Plant includes a forebay, which also operates as a regulating reservoir for the Alfalfal II Power Plant. This tank is located on the right bank of the Colorado River and receives the water discharged from the Alfalfal Power Plant through a connection with that plant's spillway.

The water from the existing Channel 1 of the Maitenes Power Plant is directed along a channel and desanded by a desanding system located on the left hand bank of the Colorado River. The water crosses the river to the forebay of Las Lajas via a siphon running underneath the river.

The headrace of the Las Lajas Power Plant begins at the plant's forebay and consists of a concrete pressure pipe. This conduit crosses the Colorado River through a siphon and joins the Las Lajas Tunnel, which is also pressurized. Las Lajas Tunnel receives water from the Alfalfal II Power Plant's tailrace tunnel and along its course, water from the Aucayes Stream. It includes a surge shaft and ends at the penstock that feeds the turbines.

The powerhouse is located near the left bank of the Colorado River in a cavern excavated from the rock massif. The generating equipment consists of two, 6-nozzle, 300-rpm turbines with a nominal flow rate of 32.5 m³/s each, and a gross head of 485 m.

The tailrace tunnel of the Las Lajas Power Plant discharges its water directly into the Maipo River. This free-flowing tunnel is 13.3 km long and 35 m² in horseshoe cross-section.

Above-ground works

The above-ground works envisioned in the Project correspond to water intakes, water pipes, forebays, siphons and bridges.

Water Intakes

The Project envisions collecting water at eight different points in the upper Maipo River basin.

Alfalfal II Power Plant:

- El Morado Canyon
- La Engorda Canyon
- Colina Stream
- Las Placas Ravine
- Yeso River

Las Lajas Power Plant:

- Alfalfal Tailrace
- Colorado River at the Maitenes Intake

- Chanel 2 of Maitenes Power Plant (Aucayes Stream branch)

Only five intake points require the construction of new water intake works: those located in the Volcán and Yeso river valleys. In the Colorado River valley (Las Lajas Power Plant) all intakes that will be used already exist.

- Upper Volcán River Basin:

The Upper Volcán system of the Alfalfal II Power Plant comprises a set of 4 water intakes designed to capture flows from the upper Volcán River basin, particularly from La Engorda, Colina, Las Placas and El Morado streams. The water collected at the intakes is channeled along aqueducts. The first stretch channels water from the La Engorda Stream to the Colina Stream, and the second takes the water collected from the La Engorda and Colina streams and adds it to water collected from the Las Placas Stream. After crossing the El Morado stream through a siphon, water from that stream is added to the flow, then discharged into a common desander. The desanded water is then channeled to the Volcán Tunnel.

- Yeso River Valley: Yeso Water Intake

The Yeso water intake is located approximately 700 m downriver of the Yeso Reservoir and is designed to capture flow from the Yeso River and channel it to the Alfalfal II Power Plant system.

- Colorado River Valley: Maitenes Power Plant Water Intake

Corresponds to the water intake for the Maitenes Power Plant on the Colorado River. The intake was built in 1923 and rebuilt in 1989 after a mudslide in 1987.

- Connection to the Alfalfal discharge channel

Consists of an extension of the Alfalfal Power Plant spillway, with a design flow of 30 m³/s. The work is connected on the right hand wall of the spillway (at an altitude of 1,321.82 m.a.s.l. at bottom) across from the siphon that crosses the Colorado River, and currently is used to channel part of the water from the Alfalfal Power Plant to the Maitenes Power Plant.

- Channel 2 of the Maitenes Power Plant:

This channel currently takes 2 m³/s from the Aucayes Stream from the existing water intake to the forebay of the Maitenes Power Plant. This water will be used by connecting this channel to the Las Lajas head tunnel via a vertical shaft 150 m deep.

Conduits

The PHAM envisions the construction of different conduits that connect the intake works with the tunnels. In general, these consist of concrete ducts and steel pipes that are buried on platforms with a maximum width of 10 m and excavated from undisturbed land. Details of these conduits are as follows:

- Engorda-Colina Aqueduct

The water collected at the La Engorda intake will be channeled through a circular reinforced concrete duct 1.4 m in diameter and 400 m long to the Colina water intake, to connect with the Volcán aqueduct, which begins at this intake.

- Volcán Aqueduct

Section I: Consists of a circular reinforced concrete duct 2.4 m in diameter and 1,760 m long that channels the water collected from the La Engorda and Colina intakes to Section II of the aqueduct that begins at the Las Placas water intake.

Section II: Consists of a circular reinforced concrete duct 2.4 m in diameter and 1,060 m long that channels water collected at the La Engorda, Colina and Las Placas intakes to Section III of the aqueduct that begins at the El Morado intake.

Section III: Consists of a squared concrete duct 2.6 x 2.6 m and 646 m long that channels the water from all of the intakes in the system to the Volcán Tunnel.

- Yeso River Conduit

Consists of a reinforced squared concrete duct 2.8 x 2.8 m and 1,350 m long that channels the water collected at the Yeso River intakes to the intake weir located immediately downstream of the Volcán Tunnel sluice gate.

- Feedstock of the Las Lajas forebay

Consists of an extension of the spillway of the Alfalfal Power Plant, with a design flow of 30 m³/s. The work is connected along the right wall of the spillway (at an altitude of 1,321.82 m.a.s.l. at its bottom), across from the siphon crossing the Colorado River, and that currently delivers some of the water from the Alfalfal plant to the channel that feeds the Maitenes Power Plant.

- Diversion channel from Channel 1 of the Maitenes Power Plant

The diversion channel is located approximately 400 m downriver of the Maitenes water intake; it feeds into a desander composed of two parallel basins, then continues on to cross the Colorado River along the existing siphon to the Las Lajas forebay.

- Headworks of the Las Lajas Power Plant

Consists of a 3.2 x 3.2 m concrete pipe 1000 m long that runs between the forebay of the Las Lajas Power Plant and the entry sluice gate of the head tunnel of this plant, crossing underneath the Colorado River through a siphon.

Forebays

- Las Lajas Power Plant

The forebay of the Las Lajas Power Plant provides stability to the plant's hydraulic system and also serves as a regulating reservoir, maintaining the natural flow regime of the Maipo /Colorado rivers when the Alfalfal II Power Plant operates at peak. The water is captured from the forebay into a concrete pipe that channels it to the head tunnel of the Las Lajas Power Plant (Colorado siphon).

This forebay is situated on the northern bank of the Colorado River, and is partially excavated and partially formed by earth embankments. The useable volume of the tank is 300,000 m³ in an area of 75,000 m². The tank's design includes the use of an impermeable membrane on the entire surface of the water, a concrete bottom, and works to ensure safety and for emptying the tank.

- Alfalfal II Power Plant

The forebay of the Alfalfal II Power Plant provides stability to the hydraulic system of the plant and constitutes the expansion chamber of the surge shaft. It is located in the Alto Aucayes sector, some 2 km east of that Stream at an altitude of 2450 m.a.s.l. The forebay has a total volume of 48,100 m³ and will be entirely excavated out of the rock.

Water is sent to the forebay from the connection with the Alfalfal II tunnel, which will channel the waters from the Yeso River and the Volcán II Tunnel.

Electrical Substation (S/S)

The Alto Maipo substation covers approximately 0.5 Has and will consist mainly of electrical protection and control equipment used to determine the output voltage of the Alfalfal II and Las Lajas Power Plant generators. It will be located on the eastern side of the Colorado River at coordinates N: 6,287,130 E: 380,170 (Datum WGS 1984).

Bridges and Minor Spanning Works

The PHAM envisions the construction of bridges over the Colorado and Yeso rivers and over the Manzanito and Aucayes streams, all of them sited on private roads.

Siphons

the PHAM includes the construction of four siphons that will cross the El Morado Stream and the Yeso and Colorado rivers. The general characteristics of these siphons are set out in the Table below

General Characteristics of the Siphons:

Sector	Description	Section (m²)	Total length (m)
El Morado Stream	Steel pipe	4.5	70
Yeso River	Steel pipe	7.5	130
Colorado River (siphons forebay)	Concrete duct	4	95
Colorado River (Colorado River — Las Lajas Tunnel siphon)	Concrete duct	9	170

Discharge Works

Under normal operating conditions, the Alfafal II Power Plant will release its water to the Las Lajas tunnel through its tailrace tunnel. During emergencies, or when operation of the Las Lajas Power Plant is interrupted, the water can be released into the Colorado River from the Las Lajas Power Plant forebay through a delivery flume that is equipped with features to dissipate energy and protect the bed and banks of the river.

The Las Lajas Power Plant itself will discharge water directly into the Maipo River through an outlet channel carved from the rock.

- Colorado River Discharge Work

The Colorado River discharge work is comprised of reinforced concrete weirs that include hydraulic energy dissipaters in their design to ensure that the water is delivered to the watercourse without generating any hydraulic disturbance.

- Yeso River Discharge Work

The Yeso River discharge work is to be located 400 m downstream from the intake point and is designed to evacuate the water from both the Volcán tunnel and the Yeso intake itself.

- Maipo River Discharge Works

The final discharge point for the flows generated by the Las Lajas Power Plant is located on the Maipo River downriver from its confluence with El Manzano Stream, in the sector called

Las Lajas. The discharge work will consist of a canal excavated from the rock with a base width of 7.0 m.

Underground Works

The underground works of the PHAM consist of tunnels, shafts, surge shafts, and caverns. A general description of each of these underground works is provided below.

- Tunnels

The Project envisions the construction of a total of 70 km of tunnels, including approximately 60 km of hydraulic tunnels, with the rest comprised of access tunnels; the powerhouse cavern access tunnels; and the respective tailrace tunnels for the two power plants.

Headrace, access and tailrace tunnels

The Volcán Tunnel is a pressure tunnel that is designed to channel water from the La Engorda, Las Placas, Colina and El Morado streams. This tunnel is 14 km long. It begins at approximately 2500 m.a.s.l. and ends at the junction with the intake weir situated at 2480 m.a.s.l. in the El Yeso sector.

The Alfalfal II head tunnel is 15 km long and carries pressurized water from the Volcán and Yeso rivers. This tunnel begins around 1100 m south of Laguna Lo Encañado, at an altitude of approximately 2432 m.a.s.l., and ends at the top of the penstock of the power plant.

The Las Lajas head tunnel is approximately 9.6 km long and begins at its coupling with the Colorado River siphon. It channels water discharged from the Alfalfal Power Plant and from the Maitenes intake to the penstock of the Las Lajas Power Plant. Along its course it receives water discharged from the Alfalfal II Power Plant.

Armored penstocks: The penstock of the Alfalfal II Power Plant is 850 m long and will be positioned at 1950 m.a.s.l. to 1340 m.a.s.l., the altitude of the Alfalfal II tunnel and powerhouse cavern, respectively. A steel tube will be installed inside the excavated tunnel; together, these make up the so-called “armored penstock.” There will also be an armored penstock between the head tunnel and the powerhouse cavern of the Las Lajas Power Plant, which will be 162 m long. As with the Alfalfal II Power Plant, this tunnel will be lined with steel tubing.

Access tunnel for the Alfalfal II Power Plant: this tunnel will run from the access gate in the Aucayes Stream Valley at 1506 m.a.s.l. to the powerhouse cavern that will house the plant’s generating equipment. It is 2.4 km long and 38 m² wide.

Access tunnel for the Las Lajas Power Plant: this tunnel will run from the access gate in the Colorado River valley, at an altitude of 1025 m.a.s.l., to the powerhouse cavern that will house the plant's generating equipment. It will be 2.0 km long and 38 m² wide.

Alfalfal II tailrace tunnel: 3.4 km long and 21 m² wide, this tunnel discharges the water released by the Alfalfal II Power Plant into the head tunnel of the Las Lajas Power Plant.

Las Lajas tailrace tunnel: The tailrace of this power plant is 33 m² wide and 13.54 km long. It channels the free-flowing water released by the Las Lajas Power Plant to the discharge point on the Maipo River.

Surge Shafts

Surge shafts are needed to absorb temporary surges during power plant operation (load pick-ups and rejections).

Both power plants will have surge shafts with specific features that will be defined in the detail engineering phase. In general, these consist of vertical shafts connected to the respective head tunnels and having an expanded area in the upper part.

- Alfalfal II Surge Shaft

The Alfalfal II surge shaft is located at the following coordinates E: 385,550 N: 6,284,325 and is comprised of an sloping, circular shaft more than 500 m long with a diameter of 3.4 m. that is connected to the head tunnel.

- Las Lajas Surge Shaft

The Las Lajas surge shaft is located at the following coordinates: E: 380,380 N: 6,286,850 and will consist of a communicating shaft 5 meters wide and 152.7 meters long between the surface and the body of the tunnel.

Powerhouse Caverns

The powerhouses will each be installed in caverns excavated from the rock and will occupy a total area of 1500 m² in the case of the Alfalfal II Power Plant and 1700 m² in the case of Las Lajas.

The powerhouse caverns will house the plant's electromechanical equipment, which consists of Pelton turbines.

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