ALTO MAIPO HYDROELECTRIC PROJECT

Cumulative Impact Assessment

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Introduction

One of the hypotheses that seeks to explain the main environmental and social challenges facing humanity—the loss of biodiversity, the depletion of fish populations in the world's oceans, the threats to our water resources, and climate change—is based on the cumulative impacts caused by the combination of activities that, individually, are deemed largely insignificant (Cardinale and Greig, 2012). From this perspective, the assessment of cumulative environmental impacts (CEIs) has become increasingly important in the evaluation of investment projects, and has even been incorporated into the guidelines of the International Finance Corporation (IFC), which requires the analysis of CEIs for projects financed by this institution.

This document presents an assessment of the CEIs of the Alto Maipo Hydroelectric Project (PHAM) developed by the AES Gener Company. The Project consists of a hydroelectric complex that includes two run-of-river power plants in hydraulic series: the Alfalfal II Power Plant and the Las Lajas Power Plant. The Project's main works are sited almost entirely underground and consist mainly of pressure tunnels and powerhouse caverns, as well as a series of headraces, most of them also underground. The Project is located south-southeast of the city of Santiago in the municipality of San José de Maipo, Cordillera Province, in the Metropolitan Region of Chile. The total installed capacity of the project is 531 MW, which will be delivered to the Central Interconnected Grid (SIC) along a transmission line.

The project obtained environmental approval from the Chilean authorities in Exempt Resolution 256 dated March 30, 2009 (hereinafter referred to as RCA 256/09 or environmental permit), issued by the Metropolitan Region Environmental Commission. Approval was based on an Environmental Impact Study (EIS) that was submitted to the Environmental Impact Assessment System (SEIA) in May 29, 2008.

Chile's SEIA is a regulatory process that was established under Law 19.300 on the General Environmental Framework. All projects that can potentially cause an environmental impact must be processed through this system. Under the provisions of the abovementioned Law, projects are required to submit an Environmental Impact Study (EIS) when they may generate or represent significant environmental effects. The SEIA approval procedure also incorporates a public participation process that facilitates the inclusion of observations and comments from stakeholders who wish to participate in the environmental impact assessment process. These comments and observations may later be translated into mitigation, compensation and/or restoration measures when they are duly approved by the environmental authorities. One of the requirements set out in the regulations governing the Chilean SEIA is that direct, indirect, cumulative and synergistic impacts must also be taken into account, as appropriate, when predicting or assessing environmental impacts.

While the SEIA in Chile requires that CEIs be assessed, this requirement does not make any direct reference to the IFC documents related to this issue;[1] however, in the SEIA's environmental processing of the PHAM Project, most of the demands and requirements of the IFC are addressed.

In carrying out the assessment of the PHAM's CEIs, the following existing and potential projects were considered to potentially have cumulative effects: power plants in operation that comprise AES Gener's "Complejo Cordillera" (Alfalfal I, Maitenes, Queltehues and Volcán power plants and their associated transmission lines and substations), the Guayacán hydropower plant, mining activities in the area, the Yeso reservoir, the mining exploration project Los Piches, the project to connect the Yeso Reservoir and the Laguna Negra Aqueduct, the improvement of Route G-25, and the Condor mining exploration project.

For each cumulative environmental impact detected for the PHAM in combination with other projects reviewed, the reviewers analyzed its effects on valued components in the project area, which were identified following the recommendations of the IFC. These included the continuity of waterways, the flow rates in waterways, the quality of surface water, sediment dynamics, the social-economic environment, local infrastructure, air quality, and climate change.

Lastly, in cases where cumulative impacts were detected that could affect one or more valued components in the project area, the effect of this impact on other activities or stakeholders that are operating or present in the basin was analyzed. These included activities such as rafting, trekking, restaurants, hotels, campgrounds, and already identified existing or potential projects in the area.

This document therefore reports on the analysis of the environmental assessment conducted on the Project in the Chilean SEIA and verifies the fulfillment of international standards recommended for assessing CEIs. The analysis paid particular attention to aspects that were not included in the assessment but that might require a complementary analysis. Additionally, the analysis also assessed cumulative environmental impacts that were not explicitly considered in the Chilean SEIA process and/or in the Project's EIS but are required under the IFC guidelines, and proposed mitigation or compensation measures as necessary.

This report therefore complements the PHAM EIS in regard to CEI assessment and meets the pertinent guidelines of the IFC.

Objectives of the Study

The general objective of this document is to assess the cumulative environmental impacts (CEIs) of the Alto Maipo Hydroelectric Project (PHAM) that is being implemented by AES

[1] IFC, Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts (2012).

Gener in the mountainous zone of the Metropolitan Region of Chile on valued components of the ecosystem.

To achieve its intended aim, the study includes the following specific objectives:

a) Identify the application of IFC standards for the assessment of CEIs in the processing of the PHAM in the SEIA

b) Identify the differences between the environmental assessment carried out and international standards for the assessment of CEIs

c) Identify potential projects in the PHAM's area of influence that could have adverse environmental impacts when combined with the Project being assessed

d) Conduct an assessment of those CEIs on valued components of the ecosystem, following IFC guidelines, in order to complement the analyses carried out during the environmental processing of the Project under the SEIA.

e) Where it is verified that one or more of the project's environmental impacts creates effects that act synergistically or cumulatively with the effects of other projects or activities, analyze whether these have the potential to affect, in the short or long term, the valued ecosystem components identified previously and/or activities, and/or other stakeholders in the Project's area of influence, and finally, determine the likelihood that these will occur.

Methodology

Identification of the IFC requirements for Cumulative Environmental Impact Assessment (CEIA)

Identification of the criteria and/or requirements established in the IFC guidelines was carried out by a review of the following documents:

a) Performance Standards on Environmental and Social Sustainability, Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts, IFC, January 2012.

b) Good Practice Note: Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets – International Finance Corporation Cardinales et al, presented at the International Conference of the IAIA, Energy Future: The Role of Impact Assessment, Porto, Portugal, May-June 2012.

c) Managing cumulative effects of cascade hydropower development. Challenges and options, Boulet, E. and Beaulac, G., Energy Future: The Role of Impact Assessment, Porto, Portugal, May-June 2012.

Identification of gaps and/or differences

Once the criteria and/or requirements established under the IFC guidelines for assessing CEIs were identified, a review was conducted of all of the documents included in the environmental assessment of the Alto Maipo Hydroelectric Project that were available on the website of the Chilean Environmental Impact Assessment Service. This process identified the criteria and/or requirements that were fully applied as well as those that were partially applied or not applied at all (because they were not required under the Chilean SEIA). The last two groups mentioned were identified as gaps.

The main documents reviewed were as follows:

a) Environmental Impact Study (EIS) of the Alto Maipo Hydroelectric Project

b) Addendum Nº1 of the EIS of the Alto Maipo Hydroelectric Project

c) Addendum Nº2 of the EIS of the Alto Maipo Hydroelectric Project

d) Addendum Nº3 of the EIS of the Alto Maipo Hydroelectric Project

Identification of other projects in the Project's area of influence

The other projects identified in the PHAM's area of influence were divided into: those already implemented and/or under implementation, and future projects that could potentially be implemented.

Projects already implemented were identified by having been included in the description of the PHAM itself, whether in its environmental assessment or in the description of the baseline. In light of the above, the environmental assessment conducted for the PHAM can in fact be considered an assessment of cumulative impacts.

In order to identify potential future projects in the PHAM's area of influence, all projects submitted to the SEIA were reviewed, including those approved, those rejected, and those currently in progress that were not necessarily considered within the environmental assessment of the PHAM. This criterion was intended to produce a conservative selection, as in the long term it is possible that even rejected projects could be resubmitted and obtain environmental approval.

Cumulative Environmental Impact Assessment

As indicated in the section on methodology, the assessment of cumulative environmental impacts was based on the application of criteria and/or requirements established in the IFC guidelines, which are described briefly below:

> *"Where the project involves specifically identified physical elements, aspects, and facilities that are likely to generate impacts, environmental and social risks and impacts will be identified in the context of the project's area of influence. This area of influence encompasses, as appropriate:*
>
> *(…)*
>
> *Cumulative impacts that result from the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted. " (IFC, 2012)*

In regard to CEIs, the IFC defines them as follows:

> *"Cumulative impacts are limited to those impacts generally recognized as important on the basis of scientific concerns and/or concerns from Affected Communities. Examples of cumulative impacts include: incremental contribution of gaseous emissions to an air shed; reduction of water flows in a watershed due to multiple withdrawals; increases in sediment loads to a watershed; interference with migratory routes or wildlife movement; or more traffic congestion and accidents due to increases in vehicular traffic on community roadways." (IFC, 2012)*

It should be noted that these criteria are in line with those proposed by Cardinales et al (2012), and therefore the assessment followed the same criteria established by the IFC (2012).

Therefore, to identify the CEIs associated with the PHAM, the reviewers focused on identifying the specific impacts discovered during the environmental assessment of the Project and during the public participation process, as well as on general aspects identified by Boulet and Beaulac (2012) for managing the cumulative effects of cascade hydropower development, which is precisely what the PHAM is deemed to be.

Description of the Alto Maipo Hydroelectric Project

The Project consists of a hydroelectric complex comprised of two run-of-river power plants in hydraulic series: the Alfalfal II power plant and the Las Lajas power plant. The Project works are situated almost entirely underground, in the form of pressure tunnels, powerhouse caverns, and head works that are also mainly underground. The Project is located south-southeast of the city of Santiago, in the municipality of San José de Maipo, Cordillera Province, in the Metropolitan Region of Santiago (see Figure 1). The PHAM will have an installed capacity of 531 MW and will generate an average of 2350 GWh per year, which will be delivered to the Central Interconnected Grid (SIC) along a transmission line.

General description of the Project works

The Project will be situated within the upper Maipo River basin. The new "Alfalfal II" power plant will be sited in the Colorado River sub basin, downriver from the current Alfalfal I power plant, owned by AES Gener, while the second power plant, "Las Lajas," will be situated on the southern bank of the Colorado River in the El Sauce sector. The Alfalfal II power plant will take advantage of water from the upper Volcán and Yeso river basins, while the Las Lajas power plant will use water discharged from the Alfalfal I and II power plants, along with contributions from the intermediate basin of the Colorado River and the Aucayes Stream sub-basin (see Figure 2).

Most of the works will be underground, including the powerhouse and head works. The main works and facilities on the surface will be water intakes and access roads. The Project also foresees the construction of an encapsulated electrical substation, muck piles, construction sites and temporary workers camps on the surface.

Details of each of the Project's works are provided below.

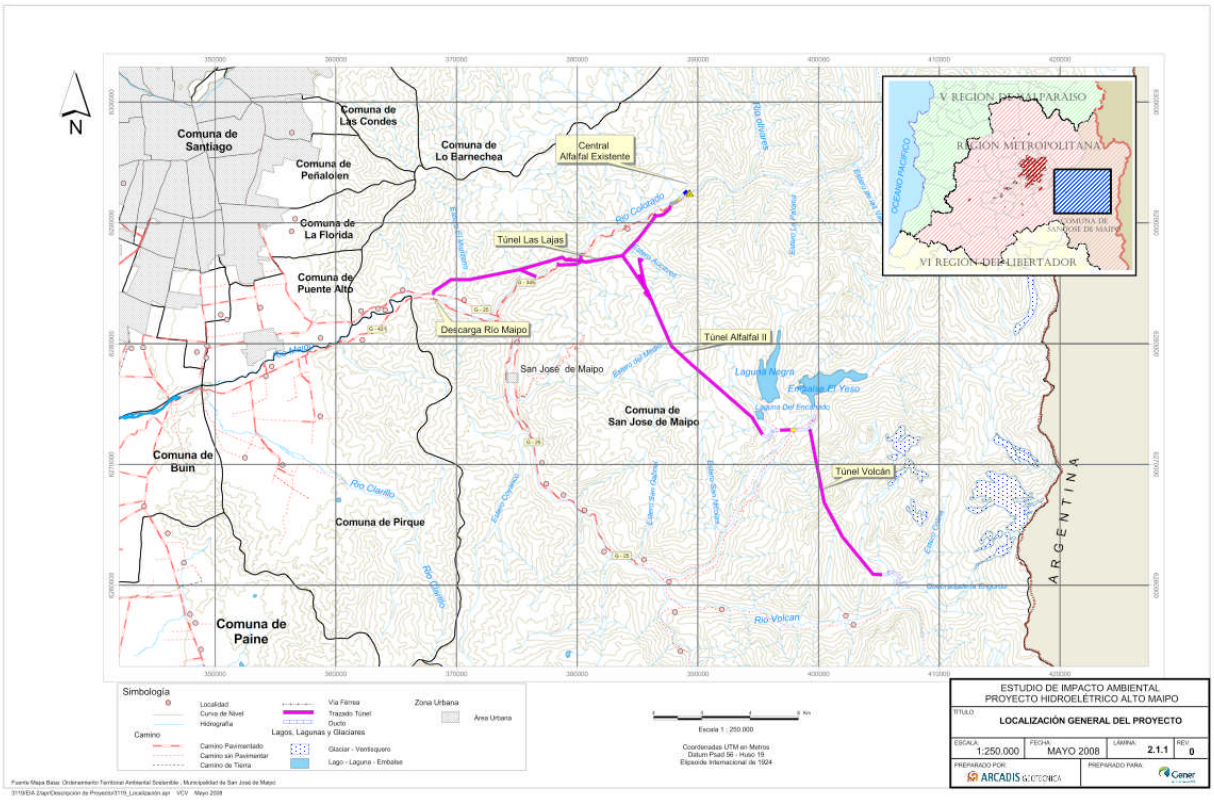

Figure 1: Location of the Alto Maipo Hydroelectric Project

Alfalfal II Power Plant

The Alfalfal II power plant, designed for a flow rate of 27 m^3/s, receives water captured from the streams located in the upper Volcan River basin. This water is then channeled to the Yeso River valley through the Volcán tunnel. In the upper Volcán River, a maximum of 12.8 m^3/s is captured by 4 intake pipes that intercept the different arms of the streams that ultimately join together to make up the northern arm of the Volcán River, which in turn flows into the Maipo River. The four streams mentioned are: La Engorda, Colina, Las Placas and El Morado. The water collected is channeled to the Volcán tunnel along a buried aqueduct. The water is degravelled at each intake and desanded collectively before entering the Volcán tunnel. The Volcán tunnel receives the water captured in the upper Volcán River sector and channels it to the Yeso River valley, where water from the Yeso River itself is added by way of a buried conduit that runs from the intake on the Yeso River to the outlet of the Volcán tunnel, where the two flows are joined.

From this point, the water is channeled to the Alfalfal II tunnel along a pressure conduit, to the head tunnel of the Alfalfal II power plant, which is 13,600 m in length, until reaching the upper

edge of the pressure shaft. Slightly upstream of the pressure shaft are the surge shaft and the forebay of this power plant, which has a gross head estimated at 1146 m.

The powerhouse is installed in a cavern excavated from the rock mass in an area 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 water to the head tunnel of the Las Lajas power plant. The water flow generated by the Alfalfal II power plant can be channeled to the powerhouse of Las Lajas power plant, or to its forebay, located on the right side of the Colorado River, in both cases along the aforementioned tunnel.

Las Lajas Power Plant

The Las Lajas power plant is designed for a flow rate of 65 m^3/s and receives the water coming from the Alfalfal I and Alfalfal II power plants, as well as contributions from the intermediate basin of the Colorado River, located between the intake points of the Alfalfal power plant (Colorado and Olivares rivers) and the current intake of the Maitenes power plant. Water from the Aucayes Stream is also added to this flow.

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 side of the Colorado River and receives the water from the Alfalfal Power Plant through a conduit that connects with that plant's discharge spillway.

The water channeled from the existing Channel 1 of the Maitenes power plant is channeled along a canal and desanded by a desander located on the left hand side of the Colorado River. The water is transported to the Las Lajas forebay along an existing siphon that runs underneath the river.

The headrace of the Las Lajas power plant begins at the forebay of the same name, in the form of a concrete pressure pipe. This pipe crosses the Colorado River through a siphon and joins the Las Lajas tunnel, which operates under pressure. The Las Lajas tunnel receives water discharged from the tailrace of the Alfalfal II power plant. This tunnel, which also receives along its course water from Aucayes Stream, includes a surge shaft and ends in a pressure shaft that feeds the turbines.

The powerhouse is located near the left hand side of the Colorado River in a cavern excavated from the rock mass. The generating equipment includes to two six-nozzle, 300-rpm turbines with a nominal flow rate of 32.5 m^3/s for each unit. The gross head is 485 m.

The tailrace tunnel of the Las Lajas power plant discharges its water directly into the Maipo River. This free-flowing, horseshoe-section tunnel is 13.3 km long.

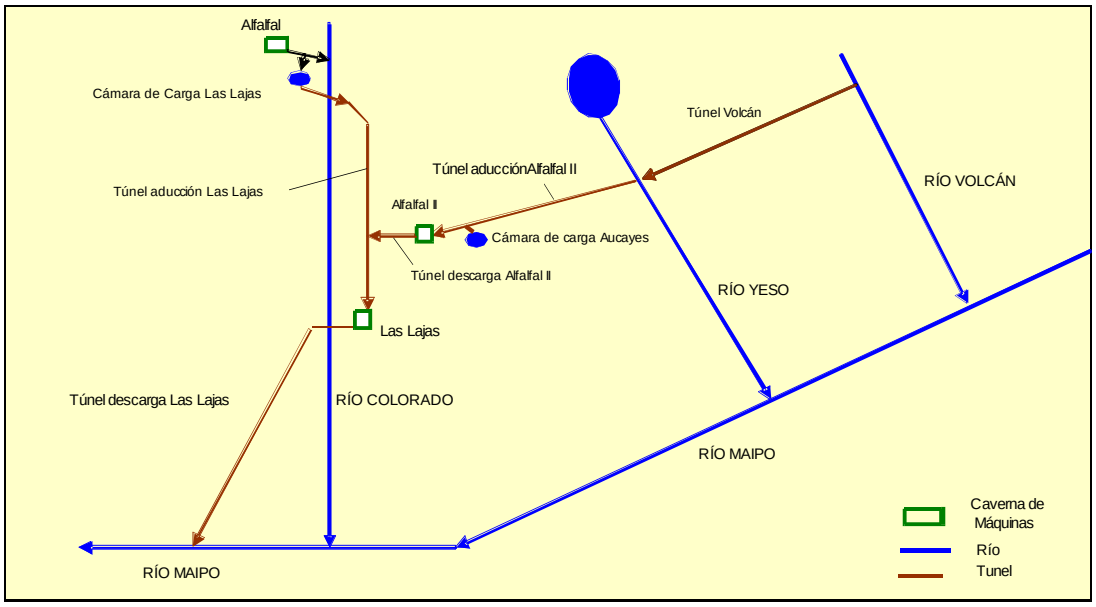

Figure 2: Simplified diagram of the Alfalfal II – Las Lajas system

Surface works

The area to be occupied by aboveground Project works is 105 ha, of which approximately 50% will be only temporarily occupied and will be restored once construction is completed.

Permanent aboveground works envisioned in the Project include water intakes, pipes, forebays, siphons and bridges, each of which is detailed below.

Water Intakes

The Project envisions the capture of water at eight different points in the upper Maipo River basin, five associated with the Alfalfal II power plant (El Morado and La Engorda canyons, Colina Stream, Las Placas Stream and Yeso River) and three with the Las Lajas power plant (Alfalfal tailrace, Colorado River at the Maitenes intake, and Channel 2 of the Maitenes power plant). Of these eight intakes, only five intake points require the construction of new water intakes—those located in the Volcán and Yeso river valleys. In the Colorado River valley (Las Lajas power plant), all of the intakes are based on already existing works.

- Upper Volcán River Basin:

The "Alto Volcán" System of the Alfalfal II power plant comprises a set of four water intakes to capture water from the Upper Volcán River basin, in particular, from the La Engorda, Colina, Las Placas and El Morado streams. The water captured by the intakes is channeled through aqueducts. The first section channels water from La Engorda to Colina Stream, and the

second channels water captured from La Engorda and Colina streams, which is added to the water captured in Las Placas Stream. After crossing the El Morado Stream through a siphon, water from the same stream is added, and all the water then flows into a common desander. The desanded water is then channeled to the Volcán tunnel.

- Yeso River Valley: El Yeso water intake

On the Yeso River the Project envisions the construction of a single water intake (El Yeso), which will be located some 700 m downstream of the Yeso Reservoir. Its objective is to capture the Yeso River's contribution and channel it to the Alfalfal Power Plant.

- Colorado River Valley

Three water intakes will be used on the Colorado River: the intake of the Maitenes power plant, the extension of the discharge spillway of the Alfalfal power plant, and Channel 2 of the Maitenes power plant. The Maitenes intake was built in 1923 and rebuilt in 1989 after a mudslide occurred in 1987. The connection to the Alfalfal discharge channel consists of an extension of the spillway of the Alfalfal power plant, with a design flow of 30 m^3/s. It is connected to the right wall of the spillway in the area adjacent to the siphon that crosses the Colorado River. This canal currently delivers some of the water from Alfalfal to the channel leading to the Maitenes power plant. Channel 2 of the Maitenes power plant currently channels up to 2 m^3/s of the water of the Aucayes Stream, from the existing intake to the forebay of the Maitenes power plant. This water will be used by connecting the aforementioned channel to the Las Lajas head tunnel by a vertical shaft around 150 m deep.

Conduits

The PHAM envisions the construction of several conduits to connect the intake works with the tunnels. In general, these will consist of concrete pipes and steel tubes that will be buried on platforms at least ten meters wide excavated on undisturbed land. Details of these conduits are presented below.

- La Engorda-Colina aqueduct

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

- El Volcán Aqueduct

Section I: Consists of a circular reinforced concrete pipe 2.4 m in diameter and 1760 m long and channels the water received from the La Engorda and Colina intakes to Section II of the aqueduct, which begins at the Las Placas intake point.

Section II: Consists of a circular reinforced concrete pipe 2.4 m in diameter and 1060 m in length that channels the water received from 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 2.6 x 2.6 m concrete viaduct 646 m long that channels the water received from all of the system's intakes to the Volcán tunnel.

- Yeso River Conduit

Consists of a 2.8 x 2.8 m reinforced concrete viaduct 1350 m long, that channels the water captured at the Yeso River water intake to a point located immediately downriver of the Volcán tunnel sluice gate.

- Feedstock for the Las Lajas forebay

Consists of an extension of the discharge spillway of the Alfalfal power plant, with a design flow rate of 30 m^3/s. The work is connected by the right hand wall of the discharge spillway (bed altitude of 1321.82 m.a.s.l.), in the area facing the siphon that crosses the Colorado River, and that currently delivers part of the water from Alfalfal to the channel of 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.

- Head works 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

The PHAM envisions the construction of forebays for both power plants. These are described below:

- 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 m^3 in an area of 75,000 m^2. 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 m^3 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 (SIL)

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). It will be a gas-insulated substation (GIS).

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.

Additionally, 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.

Table 1: General Characteristics of the PHAM Siphons

Sector	Description	Section (m^2)	Total length (m)
El Morado Stream	Steel pipe	4.5	70
Yeso River	Steep pipe	7.5	130
Colorado River	Concrete viaduct	4.0	95
Colorado River (Colorado River—Las Lajas tunnel siphon)	Concrete viaduct	9.0	170

Discharge Works

Under normal operating conditions, the Alfalfal 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 67 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 discharge tunnels for the two power plants.

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 conduit leading from the water intake 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 Lo Encañado lagoon, at an altitude of approximately 2432 m.a.s.l., and ends at the headrace shaft 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 pressure shaft 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 m^2 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 m^2 wide.

Alfalfal II tailrace tunnel: 3.4 km long and 21 m^2 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 m^2 wide and 13.5 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 Cavern

The powerhouses will each be installed in caverns excavated from the rock and will occupy a total area of 1500 m^2 in the case of the Alfalfal II power plant and 1700 m^2 in the case of Las Lajas. The powerhouse caverns will house the plant's electromechanical equipment, which consists of Pelton turbines.

Workforce

As a preliminary figure, during the construction phase a total of 5 workers camps each housing approximately 200 to 400 workers are envisioned, for a total of around 2000 workers out of a maximum of 2500 workers to be hired.

During the operational phase, a total of 50 workers will be required to perform duties related to the maintenance and operation of the two power plants. These staff will complement the existing staff at the Alfalfal power plant and will work out of the same office building.

Description of Project Phases

For the purpose of assessing CEIs, impacts have been assessed for the construction and operational phases. The main activities of each phase are outlined below.

Construction Phase

During the construction phase the Project envisions the implementation of these key activities:

- Site preparation: Cleanup and clearing of sites in preparation for the installation of preliminary works (worker camps, muck pile sites, roads and other works).
- Set-up of five camps to house workers and seven construction sites. The five camps will be adjacent to their respective construction sites and two construction sites will stand alone. The construction sites will include offices, storehouses, lockers, maintenance shops, etc. The camps will be equipped with drinking water and sanitary services, parking, and other facilities and will include all services and accommodations that are required by law and appropriate for the conditions of the high mountain environment.
- Construction of a total of 31 km of new access roads to allow worker access and the delivery of supplies and materials to the work sites.
- Road improvements to routes G-25 and G-455: these roads will be resurfaced with granular pavement fill; route G-25, for its part, will be improved from the El Yeso Bridge to the Colina Bridge (23 km) and route G-455 from the Romeral intersection to Los Chorreados camp (23 km). Both road improvement projects include signage, road defense works, and the construction of artwork, the annual application of bischofite as a dust-control measure, and other works and actions.
- Road maintenance will be carried out during the entire construction period in the Colorado, Yeso and Volcán sectors.
- Preparation of 14 muck pile sites that will receive the material resulting from tunnel boring and from surface works. The final location of these piles will be chosen with due consideration for their distance from local settlements and year-round and seasonal dwellings, low visual impact, natural slope, low soil value and lack of botanical or cultural value.

Operational Phase

The electricity generation process will consist of the operation of hydraulic turbines that transform the potential energy of water into mechanical rotational energy. This mechanical energy is then transformed into electricity by a generator coupled to the turbine axis inside the powerhouse cavern.

As run-of-river power plants, the flow rates effectively captured will depend on the hydrological conditions of the basin. The power plants will have a maximum design flow of 27 m^3/s (Alfalfal II) and 65 m^3/s (Las Lajas), in order to maintain the ecological flow rates needed to preserve the natural habitats and environmental functions of the waterways involved, in accordance with each water right used in the Project. In the case of the Yeso River, the additional flow released from the reservoir of the same name will be used but without affecting the operating conditions of the dam. This will ensure the volume and security of the potable water supply currently provided to the city of Santiago.

Materials, Equipment and Services

The main materials required for the Project works are: steel (4,800 tons), cement (86,000 tons), aggregates (105,000 tons), and steel tubing (6,000 tons), among others. The equipment required includes bulldozers, backhoes, front loaders, hoppers and cistern trucks, cement mixers, jumbos, TBM, drills, compaction rollers, and rail cars, among others.

During the construction phase, electricity will be supplied along temporary 23 kV lines. The fuel used will be diesel and gasoline, manly at the construction sites and worker camps. Sanitary services in each camp will include a sequential sedimentation system connected to modular treatment plants. The work sites will have chemical toilets.

Road Traffic

In regard to the external flow of traffic from the Metropolitan area to the different work sites and camps, it is estimated that three trucks per hour will be used for transporting materials to all work sites and other Project venues during the 5 years programmed for the Project's construction phase. These vehicles will transit on routes G-25 (El Volcán), G-345 (Colorado River canyon) and G-455 (Yeso River canyon) and will be monitored in accordance with the Environmental Permit.

Emissions, Effluents and Waste

The generation of emissions, effluents and waste will occur mainly during the construction phase of the Project. Contractual obligations have been established for subcontractors to ensure that solid waste is properly managed and disposed of. The table below summaries the types of emissions, effluents and waste involved and how they will be managed.

Table 2: Type of Waste and Waste Management

Type	Description of Waste and Waste Management Measures
Solid waste	Muck: This inert material consists of wet and crushed rock extracted during tunnel construction. It is to be deposited in the Project's muck piles. Estimated volume is 1.7 million m^3.

	Construction waste: Timber, pipe ends, debris, wires, packing material, metal scrap, etc. will be reused or sold to third parties. Estimated volume is 30-40 m^3/month. Industrial waste: Priority will be given to its reuse and/or sale to third parties. It may be stored temporarily in a specially equipped patio, after which it must be removed and disposed of in authorized dumps by companies authorized to transport this type of waste. Hazardous waste: Proportionally low volumes of hazardous waste will be generated during the construction and operational phases of the Project. It will be stored in special, chemically and structurally resistant containers. The temporary storage warehouses will be duly authorized and the conditions in place as established in Ministry of Health DS N°148. The hazardous waste will be transported by specialized authorized companies. Domestic waste or similar: This refers to food waste from cafeterias, containers, paper, carton, etc. It is estimated that the generation of this type of waste will peak at 2,500 kg/day. This waste will be stored in containers and regularly removed by the contractor to be finally disposed of in an authorized site. Plant waste: remains of shrubs, weeds and, to a lesser extent, trees that are removed from the work sites will be redistributed in the surrounding areas.
Liquid waste	During the construction phase, wastewater will be generated in the sanitary facilities available for workers such as toilets, showers, cafeterias and other activities inside the worker camps and facilities. An estimated maximum volume of 60 m^3/day is expected per work camp. Wastewater will be treated in modular treatment plants installed in each camp until it reaches a quality that allows it to be evacuated or reused to wet roads without posing a risk to human health and the environment. During the operational phase, the already existing sanitary facilities at the Alfalfal and Maitenes power stations will be used. Industrial wastewater and effluents: These originate from construction activities such as preparing concrete, washing and preparing aggregates, washing truck beds and bodies, machinery, tools and during tunnel construction, when water will be generated in the interior. The generation of this type of effluent will be limited to the work sites only, while no effluents will be generated in the camps since the activities carried out on these premises are limited to the accommodation of personnel. Effluents will be treated in a sequential sedimentation system that will be set up at each work site and include a decanting pool that will separate the liquid industrial waste into clear water and sedimentable sludge. The clear water will be reused in preparing concrete, wetting surfaces, washing vehicles, etc. During the operational phase, the generation of industrial wastewater is not foreseen.

Air emissions	Atmospheric emissions refer to suspended dust caused by earth moving activities (due to excavation, loading and unloading, etc.), and vehicle traffic at work sites. Emissions will be controlled by: i) improving existing roads currently being used by mining trucks, ii) stabilizing new roads with granular pavement fill and bischofite, iii) using tarps on dump trucks, iv) prompt mechanical maintenance of equipment, machinery and vehicles, v) wetting surfaces, and vi) using wagons and conveyor belts to discharge the muck from inside the tunnels, among other methods.
Noise	The Alfalfa sector has been identified as a potential noise receptor. The sources of noise would be: vehicles and machinery and work sites. This will be controlled through periodic machine maintenance, use of acoustic screens in the El Alfalfal sector, minimizing the operation of heavy machinery and restricting noisy activities on holidays and on night shifts, among other measures. Noise emissions will be regularly monitored during the construction phase, according to the provisions set forth in the project's Environmental Approval Resolution.

Description of the Area of Influence

This section briefly describes the main features of the area of influence of the PHAM.

Physical Environment

Climate and Meteorology

According to the general classification, two types of climate are recognized in the Project area: "mild to hot, with a long dry season" and "ice due to altitude". Information taken from available meteorological records indicates that wind is predominantly NE; annual average temperature is 13°C; annual average rainfall is 600 mm; humidity is over 40% all year round, with fog concentrating in the winter months and the maximum solar radiation values recorded in summer.

Air Quality

San José de Maipo is an extensive rural area with urban centers that do not pose as relevant sources of emissions. However, in the vicinity of the project facilities (over 1,000 m.a.s.l.) industrial activities have been identified such as mining (extraction of non-metallic minerals) and the extraction of aggregates, which could affect air quality. In both activities, the open transportation of material (even though transporting material in tarped trucks is legally mandated under DS 75 MINETRANS) is the activity that generates the most particulate

matter, followed by truck traffic on unpaved roads. There are no air-quality monitoring stations near the work sites as this is, in general, an unpopulated area.

Noise

There are currently two noise levels that are well-defined in terms of location: in the sectors close to the main road and vehicle traffic, the levels reach 72 dB(A), while all other points do not exceed 54 dB(A) during the day and 55 dB(A) during the night. In general, noise levels are determined by the presence of birds, the flow of nearby watercourses, tree leaves, and community noise and vehicle traffic.

Soil

According to information from the Instituto de Investigaciones de Recursos Naturales (Natural Resource Research Institute), because of its topographical and geomorphological characteristics, the municipality of San José de Maipo has very low quality soil that consists mainly of dryland, non-arable soils. In general, in the area of direct influence of the Project the soils registered have a usage capacity of VI to VII, which refers to low-quality soils that display some limitation to their use associated with factors such as topography, slope and/or erosion.

Water Resources

The Project area contains four large water systems. The first is the Upper Maipo River Sub-basin, which has a nival flow regime and an annual mean flow rate of 77.8 m^3/s, measured at the San Alfonso gauging station, and 111 m^3/s at the El Manzano gauging station, both of which are operated by Chile's General Water Directorate (DGA). The Maipo River receives contributions from three main tributaries with headwaters high in the mountains, which also correspond to the remaining subsystems (the basins of the Volcán, Yeso and Colorado rivers). In general, both the Yeso and Colorado rivers have altered natural flow regimes, the former owing to the existence of the Yeso Reservoir and the latter owing to the presence of the Maitenes and Alfalfal power plants.

The Volcán River basin is divided into 2 main upper sub-basins (La Engorda Stream and Volcán River), which give rise to the Volcán River. The zone of interest for the PHAM is the La Engorda Stream system, which includes the El Morado Canyon, Las Placas Ravine, Colina Stream and La Engorda Stream itself. This zone has a glacial-nival flow regime that includes approximately 36 km^2 of glaciers. This means that the principal mean monthly flows of the natural flow regime of each of these sub-basins occur between November and March when temperatures are higher; in winter their flows are significantly less.

The Yeso River system contains major water mirrors: Laguna Negra, Laguna Lo Encañado and the Yeso Reservoir. Laguna Lo Encañado displays a nival hydrological behavior, with maximum discharge flows in November, leading to an annual mean flow rate of 0.76 m^3/s in a natural flow regime. Laguna Negra, which displays similar hydrological behavior, has a

volume of approximately 600 million m³ and contributes water to Laguna Encañado, mainly through seepage. The basin that controls the Yeso Reservoir is fed by a glacial-nival flow regime; the Yeso River registers an increased flow rate from November to March and a decrease during winter months, for an annual mean flow rate of 8.4 m³/s. The three bodies of water described are considered the drinking water reserve of Santiago and are administrated by Aguas Andinas, a private company that holds the concession to supply drinking water to the city.

The system that feeds the Colorado River basin originates in the high peaks of the Tupungato Volcano and its principal tributary is the Olivares River. The Colorado River basin is divided into different sections: the Olivares River sub-basin, with an annual mean flow rate of 10.1 m^3/s; the Colorado River basin before its confluence with the Olivares River, with an annual mean flow rate of 17.6 m^3/s; and the Colorado River before its confluence with the Maipo River, with an annual mean flow rate of 32.7 m^3/s.

Current uses and requirements of these systems are related to irrigation activities in the lower parts of the valley, hydropower generation, and the water required to operate mining operations and supply drinking water.

Water Quality

The area of the PHAM displays variable degrees of human intervention. The systems most affected by human activity are the Maipo, Colorado, and Yeso rivers and the Aucayes Stream; in contrast, the systems least affected by human intervention are the Volcán River and the Colina, La Engorda and El Morado streams, most likely owing to their remoteness from human settlements and lack of agricultural activity. Except for the suspension of particulate matter, which increases markedly during the thaw period, the quality of water in all watercourses in the area of study is favorable for the development of aquatic biota. In all zones and sampling points, levels of dissolved oxygen, pH, alkalinity and specific conductivity meet the standards established for irrigation water and for maintaining aquatic life.

Hydrogeology

In general, the aquifers fed by surface waterways, snowmelt and direct precipitation seepage are not limited to the waterways themselves, but occupy large zones of unconsolidated quaternary fill in the depression. Runoff of the aquifers basically occurs in parallel to that of surface water, i.e. downhill to the sea.

The valleys of the Colorado, Yeso and Volcán rivers display a type of permeability that is highly important for water availability. The occurrence of groundwater is associated with

unconsolidated fill deposits, fluvial, glacial, alluvial, lacustrine, alluvional, and eolic sediment. In general, the aquifers here are unconfined and semi-confined and their permeability is variable.

Associated with the zone's volcanic activity, the area of study contains several hot springs that are linked to recent volcanism in the Tupungato and San José volcanoes. The main hot springs in the area are Baños Colina, Baños Morales, Baños Tupungato, Baños Salinilla, Baños Azules and Vertientes Piuquenes.

Geology and Geomorphology

Geologically, the Project area contains primarily outcrops of stratified sequences of volcanic, continental and marine sedimentary rock, intruded by abundant veins, stratum, laccolyths, dikes and stocks. The sequences present in the area of study correspond to stratified sections of varying ages ranging from Upper Jurassic to Upper Tertiary, with 7 lithostratigraphic units or formations outcropping as north-south bands: the Colina River, Damas River, Lo Valdés, Colimapu, Abanico, Farellones and Colorado – La Parva.

In regard to geomorphology, two morphogenetic domains were identified: High Mountain and Middle Mountain. In the first, erosive processes predominate, including the breakdown of slopes and transportation of materials (the areas around the Upper Volcán River, Yeso and Lo Encañado). The second morphogenetic domain is found in the area around the Colorado River, El Manzano and Las Lajas and corresponds to a more stable medium with a greater predominance of pedogenetic, soil-forming processes on hillsides, corresponding to areas with continuous plant cover, and therefore with more biological activity in the soil.

Biotic Environment

Flora and Vegetation:

In regard to the flora present in the Project's area of influence, a total of 258 species were identified. Below 1700 m.a.s.l. forest formations predominate (trees), while above 2000 m.a.s.l. low-growing bushes less than 50 cm tall predominate, alternating with hard-leafed grass in tuft formations. In wet zones perennial herbs predominate.

Native species are more abundant though there are some non-native species growing wild as well, mainly in areas already altered by human activities, particularly under 2000 m.a.s.l. It is notable that 40% of the species recorded in the Colorado River sector are non-native species growing wild, which can be explained by the human alteration of the zone. Endemic species decrease with altitude. At lower altitudes they are most frequently found as sclerophyllous forest formations (43%), and occur much less in the highlands (15% in the Yeso and La

Engorda sectors). Non-native species in the Colorado-Alfalfal sector consist mainly of annual herbs, although there are also perennial herbs and even bushes and trees here, too. Higher up in the Andes, most herbs are perennial and are found in wet zones. Today, a total of 4 threatened species have been recognized, 2 in the Colorado River-Alfalfal sector, corresponding to the chagual (*Puya berteroniana*) and guyacan (*Porlieria chilensis*), and 2 in the high Andes (Volcán River sector), the llareta de Santiago (*Laretia acaulis*) and liuto de cordillera (*Alstroemeria exerens*).

In regard to vegetation, taking into account Gajardo's proposal (1994) the El Colorado-El Alfalfal zone consists of Andean Sclerophyllous Forest formations (upper limit 1300-1800 m.a.s.l.) and higher zones display Andean Sclerophyllous Scrubland formations. In addition, in the high Andean zones (Volcán and Yeso rivers and Upper Aucayes Stream), the High Andean Steppe of Santiago is found, distributed at altitudes above 2000 m. Regarding plant formations of interest for conservation, forests of guayacán (*Porlieria chilensis*) and populations of quillay (*Quillaja saponaria*) have been identified in the area of the Colorado River, while highland meadows are found in the area of the Yeso River, with the latter displaying intense intervention due to pasturing activities. The meadows ("vegas") in the La Engorda sector correspond to bushy scrubland, with a particularly abundant plant stratum and the presence of wetland species such as *Juncus arcticus*. True meadows with a predominance of grasslands occur only alongside watercourses and in the lowest zone of the La Engorda canyon. These are seasonal meadows that tend to disappear in late summer and early autumn due to the reduction of seasonal water flows and overgrazing.

Fauna

In regard to fauna, in the Project's area of influence a total of 86 species were identified, including three amphibians, nine reptiles, and 70 bird species, nine of which correspond to birds of prey (raptors), 10 to aquatic birds and 51 to non-raptors. Four mammal species were also identified.

Of these 86 species, in the areas of the Colorado River, La Engorda Canyon, El Morado Stream, Laguna Lo Encañado, El Manzanito Stream, Yeso River and Reservoir, and Aucayes Stream, 16 species in a conservation category were recorded, most of them in the reptile class, followed less frequently by amphibians, mammals and birds. Only two of these species are classified as Endangered (Cururo and Sapito cuatro ojos), 8 are considered Vulnerable (two amphibians, four reptiles, one raptor and one non-raptor bird), 4 are Rare (three reptiles and one raptor), one is classed as Insufficiently Known (culpeo fox), and one is not currently threatened (lagartija oscura).

Limnology

In regard to the richness and abundance of aquatic flora, the El Manzanito Stream and the Maipo River display the greatest wealth of phytobenthic taxa in the area of study, while other areas display less, indicating that the former systems are more favorable habitats for fish populations. In contrast, the lowest abundance of benthos is found in the Colorado River and in the Aucayes, Colina and El Morado streams, indicating that these habitats are less favorable as fish habitats. In all other systems species are moderately abundant.

In relation to ichthyous fauna, the presence of fish in the area of study was not linked directly to the availability of food, as these species were not found in watercourses with more abundant food supplies, such as the Maipo River and the La Engorda Stream; rather, they were found in zones with a more limited food supply such as the Colorado River and Aucayes Stream. These results suggest that the presence of fish depends on factors other than the food supply, such as the load of suspended particles.

The introduction of highly invasive fish species that are also very aggressive to native species has been detrimental to native fish assemblages in Chile, both historically and in the present. As these species have intensely affected the area, in terms of biological conservation the area of study can be seen to have a low environmental value.

Human and Social Environment

Human Environment

A characterization was undertaken at the municipal (San José de Maipo) and then the local level of the localities existing in the PHAM's area of direct influence. In both instances this characterization covered geographical, demographic, anthropological, socio-economic and basic welfare aspects.

The PHAM's area of direct influence includes towns with small populations but consists mainly of rural settlements. High mountain zones have been used since early times by local cattle drivers for pasturing, through this activity that has declined and the zone is increasingly being used by trekkers and tourists, to whom the drivers offer their services as outfitters and guides. Other relevant activities in the zone include the sale of homemade dairy products. Each locality is equipped with basic goods and services; in some cases these are rudimentary, while in others, which act as micro-centers, they are more developed. All of localities have access to the natural surroundings and associated tourism infrastructure, although there is a remarkable lack of walking trails.

Built Environment

More than 84% of the dwellings located in the PHAM's area of direct influence are connected to a sewer system or have septic tanks, wells and/or other solutions. Drinking water is usually supplied through the public water main (to over 70% of residents), while the remaining homes obtain water through intakes from mountain springs and streams. The main supplier of drinking water in the area is Aguas Andinas, which has installed water intake works on the Maipo, Yeso and Volcán rivers. Only 5.5% of homes are not connected to the public energy grid.

Regarding economic and productive activities, the economy of San José de Maipo municipality is based on agriculture and livestock raising, which is carried out primarily in the Maipo and Colorado River valleys. The extraction of aggregates and non-metallic minerals are also important in the zone, as is the production of energy, drinking and irrigation water. Grazing activities in the livestock sector are based around the traditional use of land owned by local families, while livestock raising in general is carried out in different areas, depending on the time of year (summer pasturing and wintering).

The road network is relatively undeveloped, with one main paved highway (G-25) that connects and provides access all populated localities, and two secondary roads, G-455 and G-345. Interior roads within each locality are minimal. There is only one public bus line, and three collective taxi routes. In regard to general services, the sector is typically rural, with a limited array of services and educational, sports and public recreation facilities.

Tourism is a major economic activity from October to February and on weekends throughout the year, though weather conditions from March to September limit it significantly.

Land Use and Land Use Planning Instruments

The main land uses identified in the PHM's area of direct influence are as follows: residential uses (concentrated ad isolated); mining (gypsum and limestone in the upper Volcán, Yeso and Colorado river basins) and aggregate extraction; agriculture and livestock raising (Los Maitenes, El Alfalfal, San Gabriel, El Manzano) and summer pasturing (highland meadows associated with the Yeso Reservoir and Laguna Lo Encañado, the Morado, Las Placas, La Engorda and Colina streams); energy generation (Los Maitenes, El Alfalfal, Queltehues and Volcán); commerce (both sides of route G-25); community services and facilities (basic community services and facilities in each locality); and tourism and recreation activities.

In regard to planning instruments, the municipality of San José de Maipo currently has no Municipal Master plan in place and is only governed by the Urban Boundaries in force for the localities of San Alfonso, La Obra, San José de Maipo, El Melocotón, San Gabriel and Las Vertientes. Under the Metropolitan Santiago Master Plan (PRMS), part of the PHAM is located

in an Area of Ecological Preservation that is intended to maintain the natural state of the landscape in order to guarantee and contribute to the natural balance and environmental quality and preserve the landscape heritage. Overlapping these areas are Priority Sites for biodiversity conservation, which possess the same objectives of protection and conservation.

Analysis of Cumulative Environmental Impacts

Identification of Potential Cumulative Environmental Impacts

After applying the methodology described above, the following were identified as existing or implemented projects within the area of influence of the PHAM.

- Cordillera Complex (AES Gener), comprised of: Alfalfal I, Maitenes, Queltehues and Volcán power plants
- Queltehues – Maitenes – Florida high voltage transmission line and its associated substations (S/S Queltehues, S/S Maitenes, S/S Florida)
- Alfalfal – Alto Jahuel high voltage transmission line and S/S Alfalfal
- Guayacán Hydroelectric Plant (Energía Coyanco S.A.)
- Non-metallic mining operations
- Yeso Reservoir (Aguas Andinas)
- Gas Andes gas pipeline

Also identified were the following projects that may be implemented in the future, whether because they have obtained or are currently processing the necessary environmental permits, or because they have been denied an environmental permit but may reapply for one in the future.

- Project: "Electricity Transmission Lines S/S Maitenes – S/S Alfalfal & Alfalfal II power plant - S/S Alfalfal"
- Electricity Transmission Lines S/S Maitenes-S/S Alfalfal and Alfalfal II power plant-S/S Alfalfal," with environmental approval as per Exempt Resolution Nº443/2010 issued by the Metropolitan Region COREMA.
- Los Pilches mining exploration project, submitted for environmental approval on September 26, 2011 and currently in progress.
- Aggregate Extraction Project on Camino El Volcán, San José de Maipo, submitted for environmental approval on January 13, 2012 and not admitted for processing.

- Yeso Reservoir –Laguna Negra Aqueduct Interconnection Project, with environmental approval as per Exempt Resolution Nº594/2010 issued by the Metropolitan Region COREMA on September 27, 2010.
- Route G-25 Improvement Project, for the Yeso Bridge – El Volcán sector, submitted for environmental approval on November 9, 2011 and currently in progress.
- Cóndor Mining Exploration Project, denied environmental approval as per Exempt Resolution Nº189/2012 issued by the Metropolitan Santiago Assessment Commission on May 4, 2012.

In regard to the identification of valued ecosystem components, following the methodology described above and the recommendations of the IFC, it was established that potential CEIs of all projects identified, including the PHAM, could affect the following valued components:

- Continuity of the river (includes effects on ichthyofauna)
- Flow rates of watercourses
- Surface water quality
- Sediment dynamics
- Social-economic environment
- Local infrastructure, especially routes G-25 (El Volcán), G-345 (Colorado River Canyon) and G-455 (Yeso River Canyon)
- Air quality
- Cultural and archeological heritage
- Climate change

Lastly, stakeholders who could be affected by the CEIs identified and indicated above include:

- Communities in the area of influence (localities of San José de Maipo, El Canelo, El Manzano, Los Maitenes, El Alfalfal, San Gabriel, El Romeral, El Volcán, Baños Morales and Lo Valdés, as well as cattle drivers and those who use the summer highland pastures)
- Cordillera Complex (AES Gener), comprised of the Alfalfal I, Maitenes, Queltehues and Volcán power plants, and their associated transmission lines and substations
- Guayacán power plant (Energía Coyanco S.A.)

- Mining of non-metallic minerals and mining exploration projects, including those involving the extraction of aggregates
- Yeso Reservoir (Aguas Andinas)
- Yeso Reservoir –Laguna Negra Aqueduct Interconnection Project
- Route G-25 Improvement Project, for the Yeso Bridge – El Volcán sector
- Rafting activity on the Maipo River
- Trekking activities
- Restaurants and lodging, including campgrounds
- Sport fishing activities

Relationship of Potential CEIs to Ecosystem Components, Other Projects and Other Stakeholders

Once the projects that may cause CEIs when operated jointly with the PHAM were identified, along with the valued ecosystem components and stakeholders that could be affected by those impacts, each potential CEI was analyzed for the implementation phase of the PHAM. This analysis included the activity causing the impacts and the valued ecosystem component(s) and stakeholders that could be affected. A summary of the results of this analysis are presented in Table 3 and described in greater detail in the section following.

It should be noted that for the purpose of this analysis, only negative CEIs were considered, as they require greater attention. Positive CEIs such as the impact on employment and the improvement of the quality of life of nearby communities were not analyzed. This does not mean that these CEIs do not exist, or they are unimportant, or that their impacts are less intense than those of negative CEIs.

Table 3: Identification of potential Cumulative Environmental Impacts

PHAM phase	PHAM work or activity	Valued Ecosystem Component	Potential additional projects or activities	Stakeholders or projects that may be affected by additional environmental impacts
1. Construction	1.1 Construction of civil works above ground (intakes, siphons, etc.)	Continuity of the river	Cordillera Complex Yeso Reservoir Guayacán power plant Yeso-ALN Interconnection	Rafting Sport fishing
		Quality of surface water	Construction of Yeso-ALN interconnection	Sport fishing Guayacán power plant Cordillera Complex Rafting
		Air quality	Mining activity Route G-25 improvement	Local communities Trekking
		Impact on roadways	Mining activity Route G-25 Improvement	Local communities Hotel industry Restaurants Route G-25 improvement
		Social-economic environment	Cordillera Complex and Guayacán power plant operation Development of mining projects Construction of Yeso-ALN interconnection	Local communities Mining activity Other projects currently under construction

	1.2 Excavation and construction of underground works	Impact on roadways	Mining activity Route G-25 improvement	Hotel industry Restaurants Route G-25 improvement Local communities
		Social-economic environment	Cordillera Complex and Guayacán power plant operation Development of mining projects Construction of Yeso-ALN interconnection	Local communities Mining activities Other projects currently under construction
	1.3 Installation and operation of worker camps	Impact on roadways	Mining activities Route G-25 improvement	Hotel industry Restaurants Route G-25 improvement Local communities
		Social-economic environment	Operation of the Cordillera Complex and Guayacán power plant Development of mining projects Construction of Yeso-ALN interconnection	Local communities Mining activities Other projects currently under construction
	1.4 Construction and maintenance of service roads for work sites	Air quality	Mining activities Route G-25 improvement	Local communities Trekking activities
		Impact on roadways	Mining activities Route G-25 improvement	Hotel industry Restaurants Route G-25 improvement Local communities

	1.5 Vehicular traffic associated with the construction of Project works	Air quality	Mining activities Route G-25 improvement	Local communities Trekking activities
		Impact on roadways	Mining activities Route G-25 improvement	Hotel industry Restaurants Route G-25 improvement Local communities
		Social-economic environment	Operation of the Cordillera Complex and Guayacán power plant Development of mining projects Construction of Yeso-ALN interconnection	Local communities Mining activities Other projects currently under construction
2. Operation	2.1 Modification of flow rates of rivers and streams	Continuity of the river	Operation of the Cordillera Complex and Guayacán power plant Construction and operation of Yeso-ALN interconnection	Rafting Sport fishing
		Quality of surface water	Construction of Yeso-ALN interconnection Operation of the Cordillera Complex and Guayacán power plant Yeso Reservoir	Sport fishing Guayacán power plant Cordillera Complex
		Flow rates of watercourses	Operation of the Cordillera Complex and Guayacán power plant and Yeso-ALN interconnection	Guayacán power plant Rafting Sport fishing Cordillera Complex

		Sediment dynamics	Operation of the Cordillera Complex and Guayacán power plant and Yeso-ALN interconnection Yeso Reservoir	Guayacán power plant Cordillera Complex Yeso Reservoir
	2.2 Vehicular traffic associated with the operation of power plants	Impact on roadways	Mining activities Route G-25 improvement	Hotel industry Restaurants Route G-25 improvement Local communities
		Social-economic environment	Operation of the Cordillera Complex and Guayacán power plant Development of mining projects Construction of Yeso-ALN interconnection	Local communities Mining activities
	2.3 General project operation	Flow rates on watercourses	Operation of the Cordillera Complex and Guayacán power plant and Yeso-ALN interconnection	Guayacán power plant Rafting. Sport fishing Cordillera Complex
		Climate change	Operation of the Cordillera Complex and Guayacán power plant Mining activities	Global impact, no direct impacts on local stakeholders

Analysis of CEIs during the Construction Phase

In the sections below, each of the CEIs identified in Table 3 for the construction phase of the PHAM will be analyzed, even though some of them are cumulative with impacts occurring during the operational phase of other projects reviewed. For the purposes of this analysis, the impacts are identified first of all in terms of the valued ecosystem component that they affect.

CEIs on the Continuity of Watercourses

The PHAM will have an impact on the continuity of watercourses because of the construction of the following civil works, which were described above.

- Eight water collection points (including five water intakes—four on streams of the upper Volcán basin and one on the Yeso River)
- Four siphons

These works could have cumulative impacts when combined with the following existing projects in the area of influence:

- Cordillera Complex
- Yeso Reservoir
- Guayacán Power Plant

In addition, this project could have CEIs with one project that has yet to be built –the Yeso-Laguna Negra Aqueduct Interconnection Project.

For the purposes of this analysis, any watercourse that may have its continuity affected by PHAM works was identified and then it was determined whether that same watercourse was also affected by any other project that was reviewed, whether upriver or downriver. Where a cumulative impact was identified, the environmental impact assessment contained in the PHAM's Environmental Impact Study (EIS) was reviewed to verify whether this situation had been addressed in the assessment.

The PHAM will implement civil works that affect the continuity of the following watercourses:

- Colina Stream, with the construction of the new Colina water intake
- La Engorda Stream, with the construction of the new La Engorda water intake
- Las Placas Stream, with the construction of the new Las Placas water intake

- El Morado Stream, with the construction of the new El Morado water intake and one siphon
- Yeso River, with the construction of the new Yeso water intake and one siphon
- Colorado River, with the construction of two siphons

Among these, only the Yeso and Colorado rivers could potentially present CEIs owing to the existence of projects and water collection points that affect the continuity of their watercourses. A detailed description of all existing water collection points in the PHAM's area of influence was provided in Annex 12 of its EIS.

In the Yeso River, in addition to the Yeso Reservoir, in operation since 1967, there are three water collection points downriver of the future Yeso intake associated with the PHAM—the El Manzanito, Los Piuches and San Gabriel intakes.

The Colorado River, in turn, contains the Cordillera Complex, owned by AES Gener and in operation since 1923. This project uses, jointly with other users, five intakes called respectively Aucayes, De las Casas, Maitenes 2, El Maurino and El Manzano.

Given that all of these projects and water intakes were included in the Baseline Study of the PHAM, the cumulative environmental impacts associated with these works have already been adequately considered in the PHAM's environmental impact assessment process. As such, the potential to generate cumulative environmental impacts that could affect rafting and/or sport fishing activities as a result of the interruption of the continuity of the rivers within the Project's area of influence was not considered.

For the Maipo River, where the Guayacán hydropower plant is located (see Figure 3), the PHAM does not include any work that could affect the continuity of its flow regime, and therefore no cumulative environmental impacts are envisioned that might affect the continuity of the watercourse in combination with this project. The PHAM's only intervention in the waterway of the Maipo River is the construction of the Las Lajas tunnel sluice gates, which discharges the water used in the Las Lajas power plant into the Maipo River, and will not require any interruption to the watercourse's continuity during its construction. Furthermore, the impacts of this discharge work on activities such as rafting and sport fishing were already assessed in the PHAM's EIS.

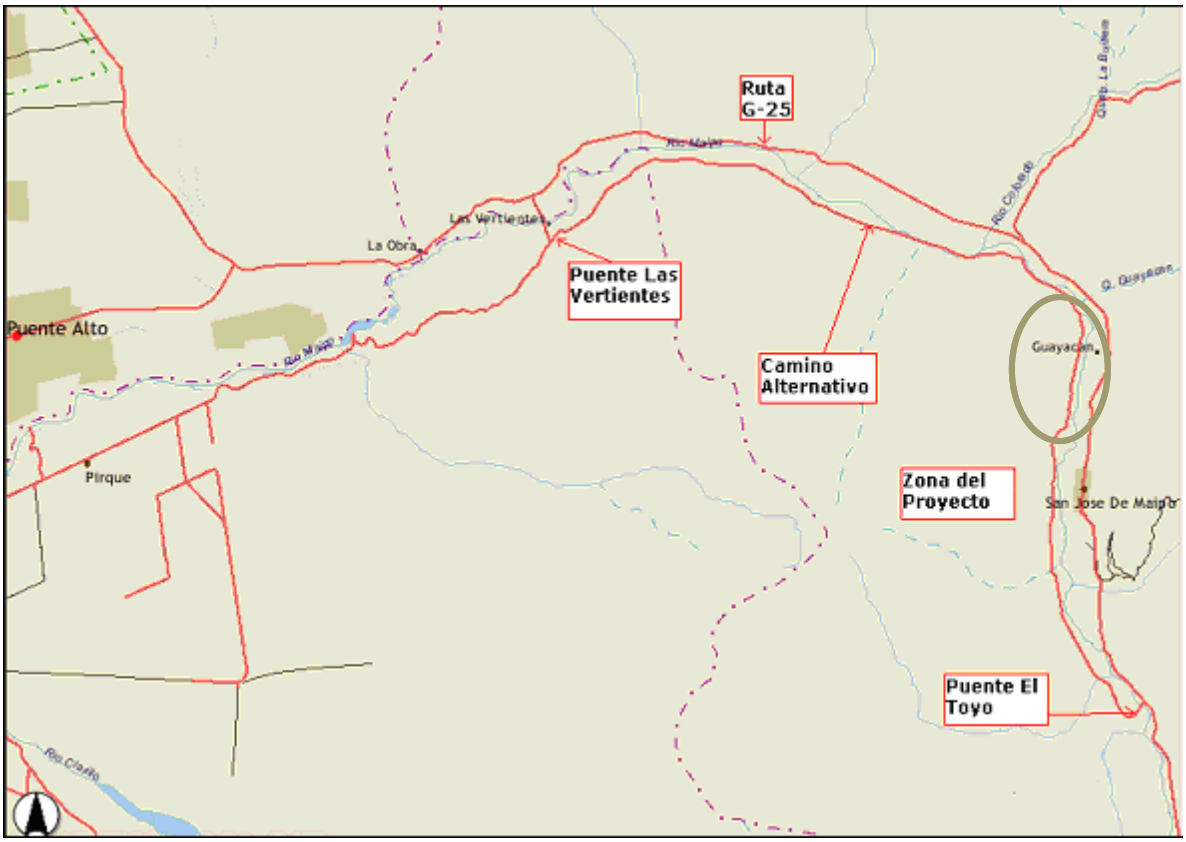

Figure 3: Location of the Guayacán Hydropower Plant

In the case of the Yeso-Laguna Negra Aqueduct Interconnection Project, while there are no associated CEIs that may affect the continuity of the Yeso River, as the interconnection project does not envision the construction of any works that may affect this aspect of the river, it must be noted that this project is incompatible with the PHAM, owing to the fact that the location of its water intake is exactly at the base of the Yeso Reservoir, upriver of the PHAm's Yeso River water intake. For this reason, the two companies have signed an agreement that restricts the operation of the interconnection to cases of emergency, such as at times when the Maipo River displays excessive turbidity that could affect Aguas Andinas' operations and alter the quality of water in the Maipo River, and/or extreme drought events, which could threaten the drinking water supply of the city of Santiago.

CEIs on the Quality of Surface Water

The PHAM plans to implement the following activities that will affect the quality of water during the construction phase of the Project:

- Construction of eight water collection works
- Construction of four siphons
- Construction of three discharge works

Among the other projects identified in the basin, only one potential CEI was identified—with the Yeso –Laguna Negra Aqueduct Interconnection Project, as the other projects are already in the operational phase and their impact on water quality was considered in the PHAM's environmental impact assessment process.

The Yeso –Laguna Negra Aqueduct Interconnection Project envisions the construction of a bridge that crosses the Yeso River, and therefore it will not affect the quality of water of this river. Therefore, it is deemed unlikely that there will be any CEIs on water quality as a result of the combined operation of the PHAM and the interconnection project.

Another aspect analyzed was the impact on water quality resulting from the discharge of wastewater treated in the modular plants used in PHAM work sites. This was deemed to represent no significant environmental impact as its magnitude is insignificant in comparison to the Project's other works and activities, and because the Project is designed to comply with the maximum limits established by DS 90/2001, which ensures that these discharges will have no impact on the quality of surface water.

In summary, no additional CEIs on surface water quality other than those assessed during processing of the PHAM's EIS are expected as a result of the Project's civil works. Therefore, it is unlikely that unassessed impacts on water quality will occur that could affect sport fishing, rafting activities, or electricity generation at the Guayacán Hydropower Plant and/or the Cordillera Complex.

CEIs on Air Quality

During the PHAM's construction phase, the following activities and/or works were identified that could potentially affect air quality:

- Construction of above-ground civil works
- Construction and maintenance of service roads for Project works

- Vehicle traffic associated with the construction of Project works

Among these general works and activities, the following specific activities that generate emissions affecting air quality were identified, with the type of emission generated identified in each case:

- Earth moving associated with the construction of Project works and excavating activities (release of particulate matter, PM)
- Transportation of materials, equipment and vehicles on unpaved roads (release of PM)
- Equipment and machine motors (release of gases such as CO, HC and NO_X)

Given that the Project is located in the Metropolitan Region and therefore is subject to the Metropolitan Region Air Pollution Prevention Plan (PPDA), in addition to mitigation measures already envisioned to minimize the release of particulate matter and gases into the atmosphere, a compensation of 150% was included for emissions generated by PHAM activities, to be achieved by improving the current access routes in the Project area:

- 23 km of Route G-455 between Route G -25 and the Yeso Reservoir
- 23 km of Route G-25 between the Yeso Bridge and the Project work sites

The road improvements consist of rebuilding the roadbed (using a leveled granular pavement fill) and the use of irrigation to suppress dust suspension (Magnesium chloride - *Bischofite*). These are considered adequate mitigation measures for the PHAM's impact on air quality that is generated by the re-suspension of particulate matter associated with vehicular traffic.

As a consequence of these measures to compensate 150% of its emissions, the net impact of the PHAM on the air quality component is completely compensated for, and therefore there are no CEIs with other projects in the area of influence. It should also be taken into account that any other projects are implemented in the area will also have to compensate their emissions by 150%; therefore, no significant cumulative environmental impact is deemed to exist for the air quality component.

It can therefore be concluded that no CEIs on air quality are expected to result from the Project's construction activities that could affect localities or trekking activities in the PHAM's area of influence.

CEIs on Traffic Flow

The PHAM's construction phase will result in an increase of traffic flows on the roads immediately surrounding the work sites, which could change the serviceability of these roads and subsequently increase traffic congestion. This impact may be caused by the following works and/or general activities:

- Construction of aboveground civil engineering works
- Excavation and construction of underground works
- Installation and operation of worker camps
- Implementation and maintenance of service roads for Project works
- Traffic flow associated with the construction of other works or other activities

Given that the implementation of any investment project entails an impact on road traffic, especially during its construction phase, the occurrence of CEIs is to be expected in conjunction with other projects, especially those associated with mining exploration and/or extraction, as well as with the Route G-25 road improvement project.

It is therefore important to consider the details of the methodology and scope of the road impact assessment of the PHAM that was carried as part of the preparation of the EIS, which is summarized as follows:

Summary of PHAM's Road Impact Assessment

The area of influence for this impact was defined in PHAM's EIS as a series of existing road sections and intersections that potentially will be used by the Project, as set out in Table 4 below.

Table 4: Area of Influence for Selected Segments of Public Roadways

Seg-ment	Route	Between	Munici-pality	Kilometer		Length (km)
				Start	End	
1	G-25	Departamental & Diego Portales	La Florida	0	6	6
2	G-25	Diego Portales & Eyzaguirre	Puente Alto	6	11.5	5.5
3	G-25	Eyzaguirre (Las Viscachas) & Ruta G-345	Puente Alto	11.5	28.3	16.8
4	G-25	Ruta G-345 and northern entry to San José de Maipo	San José de Maipo	28.3	32.7	4.4
5	G-25	Northern and southern entry to San José de Maipo	San José de Maipo	32.7	38.1	5.4
6	G-25	Southern entry to San José de Maipo and Yeso Bridge	San José de Maipo	38.1	56.8	18.7
7	G-25	Yeso Bridge and Baños Morales	San José de Maipo	56.8	83.3	26.5
8	G-345	Ruta G-25 y Acceso a Central Alfalfal	San José de Maipo	0	22.8	22.8
9	G-455	Ruta G-25 and the Yeso Reservoir sector	San José de Maipo	0	23	23

Source: EIS of the Alto Maipo Hydroelectric Project

To determine the degree of impact that the Project will have on traffic in its area of influence, the EIS of the PHAM analyzed projected traffic levels during the construction and operation of the Project for peak times, not including the traffic produced by the Project construction itself. Later, the level of traffic including peak flows generated by the Project was determined and then the difference between these two was analyzed to determine the scope of the Project's impact.

Peak traffic generated by the Project during the construction phase includes the following vehicle flows:

- Transport of equipment and supplies from suppliers in the municipality or other parts of the Metropolitan Region. Both public roads and service roads will be used for this.

- Transport of Muck: a smaller volume of traffic will use an approximately 2-kilometer stretch of Route G-345 to transport muck equal, in the worst-case scenario, to a flow of two trucks per hour.
- Transportation of workers: Workers employed in project construction activities will be taken from urban areas to worker camps and from there to and from the different work sites.
- Miscellaneous transport, which includes the movement of minor supplies required during the construction phase of the Project.

Details of transportation requirements and traffic flows were analyzed in Annex 14 of the PHAM EIS, "Study of Roadway Impacts." The results of that study produced the following estimated traffic flows: 3 trucks/hour, 2 buses/hour and 1 light vehicle/hour. However, to assess the impact on roadways, the figures actually used were significantly higher than the averages indicated above, namely 7 trucks per hour, 19 buses per hour and 14 vehicles per hour.

The result of this assessment indicated that the Project would produce a low impact on the roadways as a result of its works, as the volume of traffic on roadway and intersections, both existing and new, would be slight. This impact was therefore assessed as minor and negative.

Furthermore, in this context the PHAM envisions the implementation of environmental management measures such as:

- Improvements to current access routes (Route G-25, El Volcán sector, and Route G-455, running to the Yeso Reservoir)
- Clearing and leveling of roads
- Repairing of sewer systems
- Application of dust suppressors
- Installation of signage
- Plowing of roads during winter
- Road defense works
- Building of art works
- Replacement of roadbeds
- Building of 31 km of service roads that includes stabilization with products such as bischofite

- Monitoring of traffic impact on roadways

Assessment of CEIs on Roadways Caused by the PHAM and by Other Projects Planned in the Area

The primary CEIs expected are associated with the possible simultaneous construction of the PHAM and the Route G-25 Improvement Project, as the latter will require the partial interruption of approximately 12 kilometers of Route G-25 within the PHAM's area of influence (between the Yeso Bridge and the locality of El Volcán). If the PHAM is implemented after the Route G-25 improvement is completed, this CEI will not exist; if they are implemented simultaneously, the PHAM's impact on both road traffic and air quality will be significantly reduced.

If the implementation of these two projects overlaps, it is recommended that the two project owners agree to specific mitigation measures that can be implemented to reduce the scale of these CEIs on road traffic in accordance with the advancement of each project.

In terms of other projects, the CEIs of traffic flows between the PHAM and other investment projects cannot be adequately estimated, as the nature of other projects that may be implemented in the area of influence is unknown. Notwithstanding the above, it is deemed that none of the projects identified will have a significant cumulative environmental impact that exceeds the local traffic limits established in the PHAM's Study of Roadway Impacts.

It is also worth noting that no CEIs are expected for tourism activities such as restaurants, lodging, campgrounds and similar enterprises, as the peak demand for tourism services occurs on Saturday afternoons and Sundays, when trucks are prohibited from using Route G-25 Puente Alto-Volcán and Route G-421 San Juan de Pirque - El Toyo, as established under Exempt Decree 130 issued by the Municipality of San José de Maipo (prohibiting the transit of trucks greater than four tons from 2:00 p.m. on Saturdays to 12:00 a.m. on Sundays). As both the PHAM and any other project must comply with this Municipal Decree, CEIs on roadways will be prevented.

It should be mentioned that the Study of Roadway Impacts was updated and described in detail in Annex 9 of Addendum 1 of the PHAM's EIS. That document presents an overall analysis of traffic flows, all of which have been assessed in the EIS. The methodology used in the assessment followed the guidelines currently in force for Studies of Roadway Impacts issued by the SEREMI (Regional Secretary) of the Ministry of Transportation and Telecommunication, the SEREMI of the Housing and Planning Ministry, and the Road Directorate of the Ministry of Public Works.

In regard to potential CEIs resulting from the deterioration of civil works due to truck traffic, this impact was considered irrelevant as the PHAM includes, as an operational measure, the ongoing control of vehicle weights in order to ensure compliance with the provisions of DS Nº158 (January 1980), which establishes the maximum gross weight of vehicles traveling on highways, and decrees 200 (June 1993) and 396 (November 1993), which set out the maximum gross weight for vehicles traveling on urban roadways.

CEIs on the Social and Economic Environment

The PHAM construction phase may produce an increase in the demand for local goods and services and a subsequent impact on the social-economic environment. This impact may be caused by the following general works and/or activities:

- Construction of aboveground civil engineering works
- Excavation and construction of underground works
- Installation and operation of worker camps
- Traffic flow associated with the construction of other works and activities

Additionally, the hiring of labor will have a positive impact on the local population as it will increase the purchasing power of these workers. However, this aspect is not analyzed here for reasons stated in the methodology.

Given that the construction phase will have an approximate duration of five years, and that most probably during this period another investment Project will be developed in PHAM's area of influence, it is worth reviewing potential CEIs on basic services in the area, in order to verify that they do not impact the provision of basic services in local communities. This analysis did not include any other specific project but rather was reviewed in general, as it was difficult to estimate which project(s) might be developed in conjunction with PHAM.

PHAM's requirement for labor during the construction phase is estimated at around 2,000 direct jobs with a maximum hiring of 2,500 jobs, distributed among the different work sites. Most of these workers will live in a total of 5 camps located beside work sites and housing 300-400 workers each, including professional and technical personnel, workers, drivers and support staff such as cafeteria workers, maintenance personnel, and medical assistants.

Personnel working in construction activities will be driven in buses to and from the work sites. The camps will have a permanent staff of 20 people who will oversee their operation and general maintenance.

Due to the nature and scope of the Project, skilled personnel will be required especially for the operation of machinery and plants. It is also estimated that 30%-40% of the workforce will be unskilled workers who will mainly work as day laborers and helpers.

The supply of new jobs will increase the direct and indirect income of households in the municipality of San José de Maipo. Direct jobs are those generated by the direct hiring of labor while indirect jobs are associated with the demand for services and may be offered by community residents or local enterprises.

The use of locally hired workers in the construction of the Project is not expected to alter the current employment structure, as traditionally the local low-income population has sought employment in construction projects as a way of complementing their income.

Another important consideration is that the creation of new income sources could reduce migration in the zone, or the need for frequent trips to the city in search of employment. This would therefore contribute to preserving local residents' sense of attachment to the land. This could result in an improved quality of life for traditional local families, as they would not have to travel large distances to jobs outside the district and could continue with their work as cattle drivers and outfitters, not necessarily herding livestock but making use of their expertise and knowledge of the mountains and skill with horses and mules to transport goods and services.

Given the Project plan, it is expected that there will be a low demand for food, lodging, and other services in general. However, based on the Project Owner's experience in the construction of the Alfalfal I power plant, the need for mountain guides and transportation assistance is expected.

In terms of the impact on local health services, workers will be covered by the occupational health services available in the construction field, and therefore the demand for local services will not increase.

As the above analysis shows, the PHAM will take proper charge of its negative impacts on the economic environment and local basic services by setting up camps to house its workers and offering transportation to move them around; thus, no CEIs are expected that may affect local communities, mining activities or any other projects that may emerge in the PHAM's area of influence.

Analysis of CEIs during the Operational Phase

In the section below, each of the CEIs identified in Table 3 for the Operational Phase of the PHAM is analyzed. As with the analysis of potential CEIs during the construction phase, this

analysis is carried out notwithstanding the fact that some of them are cumulative with impacts produced during the operational phase of other projects reviewed. They are identified in relation to the valued ecosystem component that they affect.

CEIs on the Continuity of Watercourses

As with the analysis of potential CEIs on the continuity of watercourses generated during the Project's construction phase, this potential CEI is associated with the operation of the water intakes that will be built on the Yeso and Volcán rivers.

Furthermore, for the same reasons set out above, and primarily because the works that could generate CEIs have already been constructed at the time the PHAM was environmentally assessed, during the operation of this project no CEIs on the continuity of watercourses are expected to occur that could potentially affect the stakeholders identified (rafting, kayak and sport fishing activities).

It should be noted here that, in the case of run-of-river power plants such as those envisioned in the PHAM, the continuity of waterways is affected primarily during the Project construction phase by preliminary works such as cofferdams and other works, especially in the case of watercourses of interest to other stakeholders. The effect on flow rates related to the operation of these power plants is assessed in the impact entitled "Reduction of flow rates in watercourses."

CEIs on the quality of surface water

During its operational phase, the PHAM will affect the quality of surface water along some stretches of watercourses as a result of the transfer of flows from the Volcán and Yeso rivers to the Maipo River at Las Lajas. This will change the quality of water of the Maipo River from its confluence with Volcán River to the point where the water used by the PHAM is returned to that river. Thus, it is worth reviewing the scope of this impact on sport fishing and on the Guayacán Hydropower Plant, located on the stretch of the Maipo River that will see its quality affected.

After reviewing Table 5.3.5.25 of the PHAM's Environmental Impact Study and comparing the quality of the tributaries of the Volcán and Yeso river basins with that of the Maipo River, considering the proportional contributions of each tributary in terms of the water rights available to the Project Owner, the following conclusions can be drawn:

- The pH parameter remains virtually constant at 8.4 throughout the basin, and therefore the operation of the PHAM will not affect the pH of the Maipo River.

- Conductivity values are higher in the Volcán River basin (999 µS/cm) than in the Yeso and Maipo (910 µS/cm and 905 µS/cm, respectively). Nevertheless, this difference is not significant, as it is less than 10% and does not imply a difference in class, according to CONAMA's guide for establishing secondary water quality standards, under which all of these rivers would be classified as Class 2 (750 µS/cm – 1500 µS/cm) for this parameter.

- Values for total suspended solids (TSS) are lower in both the tributaries of the Volcán River and in the Yeso River (94 mg/l and 5.3 mg/l, respectively) than in the Maipo River (144 mg/l). The impact of transferring the water from those basins to the Colorado River will therefore mean that solids will be less diluted than presently, and therefore it is estimated that on average the concentration of TSS could rise[2] in the Maipo River (at Las Lajas) from 144 mg/l to approximately 196 mg/l. However, even with this rise, the water would maintain the same quality (Class 3) as it would remain above 80 mg/l.

- Values for the sulfur parameter, in contrast, show higher values for the tributaries of the Volcán and Yeso rivers (112 mg/l and 106 mg/l, respectively) than for the Maipo River (59 mg/l). All of these values, however, are situated within the Exceptional Class (< 120 mg/l of sulfate). Therefore, while it is deemed that the operation of the PHAM could reduce the concentration of sulfate in the waters of the Maipo River (from 59 mg/l to around 34 mg/l), water quality will not be altered due to the change in this parameter.

It is therefore possible to conclude that the operation of the PHAM will not significantly change the quality of surface water in waterways, and therefore should not generate CEIs with other projects such as the Guayacán Hydropower Plant, which takes its water from the Maipo River downriver from its confluence with the Yeso River. Furthermore, this effect on water quality is not expected to have any impact on fish species, and therefore will not affect sport fishing, as was determined in the EIS of the PHAM itself.

CEIs on the Instream Flow Rate of Waterways

As with the analysis of CEIs on surface water quality during the construction phase that could potentially result from the transfer of water from tributaries of the Volcán and Yeso rivers to the Maipo River downstream of its confluence with the Colorado River, the flow rates of the

[2] It should be noted that this estimation is based exclusively on a mass balance of the TSS parameter and does not incorporate the entrainment of sediments by the Maipo River itself, which could significantly reduce this potential variation in TSS in the Maipo River below the level estimated.

Maipo River between its confluence with the Volcán River and the point at which the PHAM returns that water to the waterway at Las Lajas will decrease slightly. It is therefore important to analyze the effect of this reduction on the Guayacán Hydropower Plant and on other activities in the basin, such as rafting and sport fishing (which is indirect through the potential effect of flow rates on fish species of interest to sport fishers).

In regard to the effect of the reduction of flow rates in the Maipo River, the following should be noted:

- The effect on ichthyofauna was assessed adequately when the PHAM's EIS was processed, and the reviewers concluded that no significant impact would occur, and therefore no effects are expected on sport fishing as a result of this reduction of flow rates.
- The effect on the Cordillera Complex does not need to be assessed, as this complex is owned by the owner of the PHAM, and therefore no eventual impacts will have any effect on third parties other than the Project Owner.
- Therefore, the main potential impact to be assessed is the effect that could be generated on the Guayacán Hydropower Plant, owned by the company Coyanco S.A. This aspect is analyzed below.

The PHAM has legally pledged not to affect the availability of water for water users within the Project's area of influence, meaning that it will ensure that all water needed by users holding water rights downstream of the Project's intake points will have a sufficient supply while maintaining the minimum ecological flow rates required. As the PHAM will respect all legally constituted third-party water rights, users of the canals located between the PHAM's intake points and discharge point will be able to fully exercise their rights.

In regard to the Guayacán Hydropower Plant in particular, it should also be noted that the water rights are non-consumptive water rights, and therefore using them will not affect the availability of water in the river downstream of the discharge point. Furthermore, these rights were obtained by DGA resolution in 2007, subsequent to all water rights to be used by the PHAM, which were obtained between 1931 and 2006 (see Table 2.3.4 of the EIS).

Lastly, in terms of the actual availability of water in the Maipo River in the section affected by the PHAM, it is estimated that the annual average will be greater than 50 m^3/s, a flow rate that is adequate for ensuring not only all water rights but also sporting activities such as rafting and kayaking. In fact, when preparing Addendum 1 the Project Owner conducted a study on the continuity of activities such as rafting and kayaking (attached to that Addendum as Annex 17) that concluded that the continuity of those activities would not be affected, given the minimum ecological flow rate required.

In summary, the reduction in flow rates in the Maipo River is not expected to produce any CEIs on the Guayacán Hydropower Plant or on other stakeholders operating in the basin, such as sport fishing, rafting and kayaking operations.

CEIs on Sediment Dynamics

The alteration of the flow rates on some sections of the rivers within the PHAM's area of influence as a result of the Project's operation could also have an impact on sediment dynamics in the basin. This situation could produce CEIs when combined with the effects currently generated by the Yeso Reservoir, the Cordillera Complex, and the Guayacán Hydropower Plant, and with the potential future effects of the Yeso-Laguna Negra Aqueduct Interconnection Project.

In regard to the impact of the Yeso-Laguna Negra Aqueduct Interconnection Project, the potential impact is deemed to be minimal or non-existent, as the agreement between Aguas Andinas and AES Gener mentioned above stipulates that these two projects will only interact under exceptional and highly unlikely circumstances (events that generate excessive turbidity in the Maipo River, contamination of the Maipo River and/or extreme drought events that could threaten the supply of drinking water to the city of Santiago).

The dynamics of entrainment sediments was studied in detail as part of the PHAM. The issue was addressed in the report "Sedimentological Study of the Maipo River," prepared by the Faculty of Physical Sciences and Mathematics of the Universidad de Chile and published in March 2008. This study was included under Annex 20 of the Project's EIS. Its objective was to compare the current sediment entrainment regime (without the Project) with that of the PHAM under operation. It concluded that due to the operation of the Project "*a reduction [is expected] (…) in the solid streambed entrainment of around 1.3 million tons/year, corresponding to 15% of the entrainment in the scenario without the project,*" and therefore in the PHAM's EIS it was deemed that "*the change in sediment load produced by the [Project's] works will not be significant nor beyond what could be considered normal entrainment for mountain rivers*" (Section 6.4.1.7 of the EIS).

It should also be noted that according to this study, the contribution of sediment from the Maipo River, with the Project in operation, will continue to be higher than the reduction caused by the extraction of aggregates that is currently carried out on the river.

Nevertheless, the same Universidad de Chile report also addresses the potential cumulative impact that the Yeso Reservoir would have on sediment dynamics in the basin, stating that:

> *"It should be borne in mind that, with or without the Project, in the long term the effect of the reservoir will be felt on the Yeso River and a state of static armoring reached in which*

the waterway will cease to contribute sediments to any significant degree. This will mean a reduction of between 0.2 and 0.5 million tons/year in the rates of streambed erosion estimated for the current situation, without the project. When that will occur is difficult to estimate, above all considering that after 43 years of the reservoir in operation, there are still no evident signs of static armoring."

Therefore, the presence of CEIs between the Alto Maipo and Yeso Reservoir projects is to be expected, given the phenomenon of static armoring of the latter, which will occur in any case with or without the Project, as the Universidad de Chile report indicated.

In regard to potential CEIs from the PHAM acting in combination with the power plants of the Cordillera Complex and the Guayacán Hydropower Plant, no risk of cumulative impacts is foreseen, as all of these are run-of-river power plants that will not transfer flows between different sub-basins of the Maipo River. In other words, these projects can only affect sediment dynamics in the stretch of the river in which they operate, which does not receive or remove sediment to or from an intermediate point with the addition of the PHAM. Thus, the environmental impact associated with the flow of sediments was adequately assessed in each project separately, with no synergies or CEIs identified that could be assessed in addition to those.

In summary, the PHAM's environmental impact assessment process identified sediment dynamics as an impact of the Project itself, though it could become a CEI in combination with the Yeso Reservoir project at some point in the future. The measures required in the environmental permit to manage this aspect were as follows:

- Conduct an Advanced Sedimentological Study of the Maipo River in order to identify possible effects, measures and mitigation works that may be necessary to counteract unforeseen effects. It should be noted that, as of the date that this CEIA was published, that study was already under implementation.

- Design and apply a monitoring program that enables the identification of potential unforeseen environmental impacts and define possible mitigation, compensation and/or follow up measures and works. For this, the baseline sedimentological situation must be completely characterized for the scenario "without the project" for the waterways involved. This is part of the scope of the advanced sedimentological study that is currently underway.

These measures were approved with the understanding that the sedimentological estimates have differing degrees of certainty and interact in a complex way in the Maipo River with both natural and artificial elements.

In light of the above, the measures required for the Project can be considered adequate to manage any CEIs generated by the PHAM that may arise in relation to sediment dynamics and

to promptly detect any unforeseen impact on other stakeholders in the basin, such as the Guayacán Hydropower Plant, among others.

CEIs on Road Traffic

Considering the results of the analysis of CEIs on road traffic during the construction and operational phase of the PHAM, with the road traffic impact expected being significantly lower during the latter, it is possible to conclude that no adverse CEIs are foreseen in this category during the PHAM operational phase, as vehicle traffic attributable to the Project will not change the basic traffic flow.

CEIs on the Social and Economic Environment

Like the analysis of CEIs on road traffic during the construction phase, it can be affirmed that the impact of the PHAM during the Operational Phase will be significantly lower than during the former phase, which was analyzed in detail in the analysis of CEIs on the social-economic environment.

It is therefore possible to conclude as well that the PHAM is adequately addressing its impacts on the social and economic environment and that no CEIs of this nature will occur in combination with other projects are expected during its operational phase.

CEIs on Climate Change

Given its particular characteristics, the phenomenon of climate change is cumulative and global, and therefore it can be seen to have cumulative effects with any other project on the planet, not only those located in the PHAM's area of influence. Therefore, in practice this type of CEI can be treated as a direct impact of this project.

In the case of the PHAM, the impact of the Project is positive, as it prevents the emission of CO_2 by injecting renewable energy (hydropower) into an energy grid that also has a thermal power component and a marginal dispatch system. Thus, by injecting hydropower into the system, the PHAM lowers the need for additional thermoelectric plants that burn fossil fuels (coal, diesel, natural gas and LPG) to supply the same quantity of energy.

In approximate terms, considering a carbon factor in the SIC of 300 tonCO_2/GWh[3] generated, and considering that the PHAM will generate an average of 2,350 GWh per year, this Project will prevent the emission of an estimated 900,000 tons of CO_2 per year.

It is worth mentioning that the PHAM's Environmental Impact Study indicated that the Project would access the Clean Development Mechanism offered under the Kyoto Protocol, with the objective of "*collaborating economically to overcome the aforementioned barriers to enable the implementation of the Alto Maipo Hydroelectric Project.*"

Conclusions

A study was conducted on the Cumulative Environmental Impacts (CEIs) of the Alto Maipo Hydroelectric Project (PHAM), located in the mountainous zone of the Metropolitan Region of Santiago, Chile. The analysis conducted identified five general works and/or activities to be implemented during the construction phase of the Project and three during its operational phase that could potentially generate CEIs in combination with other projects. These are:

- Cordillera Complex (AES Gener), comprised of the Alfalfal I, Maitenes, Queltehues and Volcán power plants
- High Voltage Transmission Line Queltehues – Maitenes – Florida and the associated substations (S/S Queltehues, S/S Maitenes, S/S Florida)
- High Voltage Line Alfalfal – Alto Jahuel and S/S Alfalfal
- Guayacán Hydropower Plant
- Mining of non-metallic minerals
- Yeso Reservoir
- Gas Andes Gas Pipeline
- Los Piches Mining Exploration Project
- Aggregate Extraction Project Camino El Volcán, San José de Maipo
- Yeso Reservoir –Laguna Negra Aqueduct Interconnection Project

[3] Figure taken from the average estimate for 2018 arrived at by the UC's Centro de Cambio Global and POCH by the Ministry of the Environment in its report "Análisis de opciones futuras de mitigación de gases de efecto invernadero para Chile en el Sector Energía," August 2010, Section 5.1, Table 14.

- Route G-25 Improvement Project, Yeso Bridge – El Volcán segment
- Condor Mining Exploration Project

In turn, it was determined that these works and/or activities could potentially affect nine valued ecosystem components, which were identified as follows:

- Continuity of the river (includes effects on ichthyofauna)
- Flow rates on waterways
- Quality of surface water
- Sediment dynamics
- Social-economic environment
- Local infrastructure, especially Route G-25 (El Volcán), Route G-345 (Colorado River canyon) and Route G-455 (Yeso River canyon)
- Air quality
- Cultural and archeological heritage
- Climate change

Lastly, the following stakeholders were identified as those who could potentially be affected if the CEIs were verified. A detailed analysis for each of the CEIs for each stage of the Project was then undertaken.

- Communities in the area of influence (the localities of El Canelo, El Manzano, Los Maitenes, El Alfalfal, San Gabriel, El Romeral, El Volcán, Baños Morales and Lo Valdés, as well as the cattle drivers and herders and other users of the summer highland pastures)
- Cordillera Complex (AES Gener), comprised of the Alfalfal I, Maitenes, Queltehues and Volcán power plants, and their associated high voltage transmission lines and substations
- Guayacán Hydropower Plant (Energía Coyanco S.A.)

- Mining of non-metallic minerals and mining exploration projects, including those associated with the extraction of aggregates
- Yeso Reservoir (Aguas Andinas)
- Yeso Reservoir–Laguna Negra Aqueduct Interconnection Project
- Route G-25 Improvement Project, Yeso Bridge – El Volcán segment
- Rafting on the Maipo River
- Trekking activities
- Restaurants and lodging enterprises, including campgrounds
- Sport fishing activities

The results of this study indicated that the assessment of environmental impacts undertaken in the context of Chile's Environmental Impact Assessment System captured most of the CEIs identified. This is because the majority of the projects that could cause these impacts are the works or activities currently under implementation or in operation, and were therefore included in the PHAM Baseline and as such were considered in the impact assessment.

The only CEI that may require further analysis or management measures, if verified during Project implementation, is the following:

- Impact on road traffic during the construction phase of the PHAM, especially where the construction occurs at the same time as the execution of the Route G-25 Improvement Project.

Given this situation, an agreement is currently being formulated between the Ministry of Public Works Roads Directorate and the PHAM that includes paving of a stretch of Route G-25 and another stretch of Route G-345. Furthermore, it is expected that the activities to be carried out in this area will be coordinated with roadway activities, and therefore no cumulative impacts are expected. Even so, where impacts do occur, mechanisms will be in place to mitigate them virtually immediately.

Additionally, the impact identified in the environmental assessment of the Project that was associated with the change in sediment dynamics as a result of variations in the flow rates on some stretches of surface waterways, while it includes management measures, must ensure that any monitoring carried out is done so under the terms approved by the authorities.

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